YAYASAN BRATA BHAKTI DAERAH JAWA TIMUR
UNIVERSITAS BHAYANGKARA SURABAYA
LEMBAGA PENELITIAN DAN PENGABDIAN PADA MASYARAKAT (LPPM)

Kampus : Jl. A. Yani 114 Surabaya Telp. 031 - 8285602, 8291055, Fax. 031 - 8285601

SURAT KETERANGAN

Nomor: Sket/ 9 /I/2023/LPPM/UBHARA

Kepala Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) Universitas Bhayangkara Surabaya menerangkan bahwa:

Nama	: Dr. Amirullah, ST, MT.
NIP	: 197705202005011001
NIDN	: 0020057701
Unit Kerja	: Universitas Bhayangkara Surabaya

Benar telah melakukan kegiatan:

1. Menulis jurnal berjudul High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic Using Artificial Intelligent Controller (Amirullah, Ontoseno Penangsang, dan Adi Soeprijanto) yang telah dipublikasikan di International Review on Modelling and Simulations-IREMOS), Vol. 11, No. 4, August 2018, pp. 221-234, ISSN 1974-9821, Publisher: Praise Worthy Prize. Terindeks Scopus.**Terindeks Scopus Q2.**
2. Telah melakukan korespondensi melalui email dalam proses penerbitan jurnal tersebut. Bukti korespondensi email dan bukti pendukung adalah benar sudah dilakukan oleh yang bersangkutan serta sudah dilampirkan bersama surat ini.

Demikian surat keterangan ini dibuat untuk kepentingan kelengkapan pengusulan Guru Besar.

Surabaya, 20 Januari 2023
Kepala LPPM

Drs. Heru Irianto, M.Si.
NIP. 9000028

Lampiran 1

Bukti Korespondensi Email dengan Editor/Pengelola Jurnal

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

[IREMOS] Submission Acknowledgement

1 pesan

Editorial Staff <editorialstaff@praiseworthyprize.com> 10 Februari 2018 pukul 13.09
Kepada: amirullah@ubhara.ac.id

Amirullah Amirullah:

Thank you for submitting your manuscript entitled "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" to our journal International Review on Modelling and Simulations (IREMOS).

With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Manuscript URL:
http://www.praiseworthyprize.org/jsm/index.php?journal=iremos&page=author&op=submission&path[]=14742
Username: 10_feb-amirullah-iremos_2018

and clicking on My Journals->Active submissions.

With this submission the review process starts.
According to the review procedures, your proposal will be send to the Editor-in-Chief that, after evaluated the publication suitability of the paper, will indicate three reviewers for a full evaluation.
More info regarding the review process can be found at the following link:
http://www.praiseworthyprize.org/jsm/index.php?journal=iremos&page=about&op=editorialPolicies#peerReviewProcess

If you have any questions, please don't hesitate to contact me. In all the correspondence please indicate in the subject of your e-mail the identification number of the paper that is Id 14742.

Thank you for considering this journal as a venue for your work.

Best regards,

Editorial Staff
International Review on Modelling and Simulations (IREMOS)

PRAISE WORTHY PRIZE
PUBLISHING HOUSE
Editorial Staff
editorialstaff@praiseworthyprize.com

Paper ID 14742 Review Progress

4 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 11 April 2018 pukul 10.57
Kepada: editorialstaff@praiseworthyprize.com
Cc: info@praiseworthyprize.com
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear Ireaco Editorial Staff,

On Saturday Feb 20, 2018 I had sent paper tiltle: High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller (Amirullah, Ontoseno Penangsang, Adi Soeprijanto) to IREMOS (Scopus Q2).

The paper ID is **14742.**

The paper status now is **in review** depend on your online submission system.

I need your information about the review progress of this paper.

Thanks a lot for your responding.

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 11 April 2018 pukul 11.03
Kepada: editorialstaff@praiseworthyprize.com
Cc: info@praiseworthyprize.com
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear IREMOS Editorial Staff.

I am sorry the previous email sent to IREMOS Editorial Staff not IREACO.

And I am apologize for this mistake.

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia

[Kutipan teks disembunyikan]

Praise Worthy Prize (Editorial Staff) <editorialstaff@praiseworthyprize.com> 11 April 2018 pukul 15.57
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Surabaya,

thank you for your e-mail

The evaluation of your paper is still pending but I've already solicited the reviewers to send their comments.
As soon as they will be ready, I will send the reviewers evaluation to your e-mail address.
Thanks in advance for the patience

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

PRAISE WORTHY PRIZE S.r.l.
PUBLISHING HOUSE
Editorial Staff

editorialstaff@praiseworthyprize.com

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 11 April 2018 pukul 17.23
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear Dr. Angela Tafuro

I am sorry my name is **Amirullah** not Surabaya.

As you know Surabaya is second largest city in Indonesia after Jakarta (capital city).

Thanks a lot for your respon and I will be waiting next information about final status of my paper.

Amirullah
PhD Student ITS
Surabaya-Indonesia

[Kutipan teks disembunyikan]

Paper ID 14742 Review Progress

4 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 26 Juni 2018 pukul 11.12
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>

Dear IREMOS Editorial Staff,

On Saturday Feb 10, 2018 I had sent paper tiltle: High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller (Amirullah, Ontoseno Penangsang, Adi Soeprijanto) to IREMOS (Scopus Q2).

The paper ID is **14742.**

The paper status now is **in review** depend on your online submission system.

I need your information about the review progress of this paper.

Thanks a lot for your responding.

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia

Praise Worthy Prize (Editorial Staff) <editorialstaff@praiseworthyprize.com> 26 Juni 2018 pukul 13.41
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Surabaya

thank you for your e-mail
The evaluation of your paper is still pending but I've already solicited the reviewers to send their comments.
As soon as they will be ready, I will send the reviewers evaluation to your e-mail address.
Thanks in advance for the patience

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

PRAISE WORTHY PRIZE S.r.l.
PUBLISHING HOUSE
Editorial Staff

editorialstaff@praiseworthyprize.com

+++++++++++++++++++++++ ATTENTION +++++++++++++++++++++

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 28 Juni 2018 pukul 07.46
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>, Amirullah Amirullah <am9520012003@yahoo.com>

Dear Dr. Angela Tafuro,

Thanks a a lot for your responding.

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Mail Delivery Subsystem <mailer-daemon@googlemail.com> 28 Juni 2018 pukul 07.47
Kepada: amirullah@ubhara.ac.id

Pesan diblokir

Pesan Anda untuk **editorialstaff@praiseworthyprize.com** telah diblokir. Lihat detail teknis di bawah untuk informasi lebih lanjut.

Tanggapan dari server jarak jauh adalah:

```
550 5.1.0 <amirullah@ubhara.ac.id> sender rejected: domain does not have neither a valid MX or A record
```

Final-Recipient: rfc822; editorialstaff@praiseworthyprize.com
Action: failed
Status: 5.1.0
Remote-MTA: dns; mx.mgm.tiscali.com. (213.205.36.137, the server for the

domain praiseworthyprize.com.)
Diagnostic-Code: smtp; 550 5.1.0 <amirullah@ubhara.ac.id> sender rejected: domain does not have neither a valid MX or A record
Last-Attempt-Date: Wed, 27 Jun 2018 17:47:21 -0700 (PDT)

---------- Pesan Yang Diteruskan ----------
From: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
To: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc:
Date: Thu, 28 Jun 2018 07:46:36 +0700
Subject: Re: Paper ID 14742 Review Progress
Dear Dr. Angela Tafuro,

Thanks a a lot for your responding.

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia

2018-06-26 13:41 GMT+07:00 Praise Worthy Prize (Editorial Staff) <editorialstaff@praiseworthyprize.com>:
> <pre cols="72" style="text-decoration-style:initial;text-decoration-color:ini ----- Message truncated -----

Thanks for your responding

1 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 30 Juni 2018 pukul 08.57
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <praiseworthyprize@gmail.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>, amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>

Dear Dr. Angela Tafuro,

Thanks a a lot for your responding about progress of my paper (ID 14742)

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Paper ID 14742 Review Progress

3 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 26 Juli 2018 pukul 05.45
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>

Dear Dr. Angela Tafuro,

On Saturday Feb 10, 2018 I had sent paper tiltled: High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller (Amirullah, Ontoseno Penangsang, Adi Soeprijanto) to IREMOS (Scopus Q2).

The paper ID is **14742.**

The paper status now is **in review** depend on your online submission system.

I need your information about the review progress of this paper.

Thanks a lot for your responding.

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

Praise Worthy Prize Editorial Staff <praiseworthyprize@gmail.com> 26 Juli 2018 pukul 15.37
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah

we are very sorry for the long time passed for the review.
Reviewers have been solicited many times during this period.
I am going to do it once again in order to complete the correction of your paper as soon as possible.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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PUBLISHING HOUSE
Editorial Staff

editorialstaff@praiseworthyprize.com

please contact us at the following address: info@praiseworthyprize.com

----

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 27 Juli 2018 pukul 05.33
Kepada: Praise Worthy Prize Editorial Staff <praiseworthyprize@gmail.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear Dr. Angela Tafuro,

Thanks a lot for your response.

Hopefully, the correction of my paper takes time as soon as possible too.

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

[Kutipan teks disembunyikan]

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

[IREMOS] Editor Decision

7 pesan

Editorial Staff <editorialstaff@praiseworthyprize.org> 28 Juli 2018 pukul 17.08
Kepada: amirullah@ubhara.ac.id

Dear dr. Amirullah Amirullah:

We have reached a decision regarding your paper ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller", submitted to: International Review on Modelling and Simulations (IREMOS).

The paper has been accepted with minor revisions.

You should change the paper according to the remarks of the reviewers included at the foot of this email, then you should re-submit the revised paper by our on-line submission system, selecting the cited paper and uploading the Author Version in the section "Editor Decision".
The new text and the modifications introduced for answering the remarks of the reviewers should be indicated in red colour.

Sincerely,
Dr. Santolo Meo, Editor-in-Chief of International Review on Modelling and Simulations (IREMOS)
santolo.meo@unina.it

Remarks of the Reviewers:

Reviewer: 1

Recommendation: Accepted as it is.
Comments:
The paper is interesting and well structured. I suggest the acceptance.

Reviewer: 2

Recommendation: Accepted with minor revisions.
Comments:
1
English grammar needs to be corrected.

2
In the introduction section the authors should more underline the contribution of the paper to the state of the art on the topic.

Reviewer: 3

Recommendation: Accepted with minor revisions.
Comments:
1
The English needs editing for grammatical errors and style. We suggest to use our service “English Language Editing”. More information can be found to http://www.praiseworthyprize.com/english_service.htm

2
The paper doesn't have a list of symbols therefore it is difficult to follow the explanation of the contents.

3

In the conclusion section the authors should indicate also which are the limits of the proposal. Where are the weak points?

For any questions don't hesitate to contact us.
Best regards,
Editorial Staff
Praise Worthy Prize
Publishing House
editorialstaff@praiseworthyprize.org

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PUBLISHING HOUSE
Editorial Staff
editorialstaff@praiseworthyprize.com

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 29 Juli 2018 pukul 13.50
Kepada: Zenno_379@yahoo.com
Cc: ontosenop@ee.its.ac.id, adisup@ee.its.ac.id
Bcc: adisupits@gmail.com, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Yth.
1. Prof Dr. Ir. Ontoseno Penangsang, M.Sc.
2. Prof. Dr. Ir. Adi Soeprijanto, MT.

Terlampir hasil review makalah jurnal disertasi saya di IREMOS (Scopus Q2) submit 10 Feb 2018.

Hormat: Amirullah
[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 30 Juli 2018 pukul 05.47
Kepada: Editorial Staff <editorialstaff@praiseworthyprize.org>
Cc: santolo.meo@unina.it

Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear:
1. Dr. Santolo Meo
2. Dr. Angela Tafuro

Thanks a lot for your information.

After this what next process that should I do after revise the paper.

This is my email will be happy if you give me a response soon.

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

2018-07-28 17:08 GMT+07:00 Editorial Staff <editorialstaff@praiseworthyprize.org>:
[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 30 Juli 2018 pukul 06.00
Kepada: Editorial Staff <editorialstaff@praiseworthyprize.org>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear Dr. Angela Tafuro,

And I also will use “English Language Editing” service from IREMOS.

Is that procedure held before or after revise the paper?

Thank a lot for your response.

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Praise Worthy Prize Editorial Staff <praiseworthyprize@gmail.com> 30 Juli 2018 pukul 15.18
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah
thank you for your e-mail.
After revised the paper you should upload it on the webpage of your paper (under the label Editor Decision).
Please evidence in red all the changes made in accordance with reviewers request.
Then this new revised version will be checked and if all the corrections made by you will be considered sufficient, the paper wll be accepted for being published and you will receive all the instructions to complete the publication procedure for your paper.
For any further doubt or question I'm at your disposal.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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PUBLISHING HOUSE
Editorial Staff

editorialstaff@praiseworthyprize.com

[Kutipan teks disembunyikan]

Praise Worthy Prize Editorial Staff <praiseworthyprize@gmail.com> 30 Juli 2018 pukul 15.19
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Ouchenane

thank you for your e-mail.
You can decide to purchase the english editing service at the cost of 60 euros.
In such case you should revise the paper according to all other requests except for the english and upload it entering in your profile paper web page..
After received the revised version that reflects all the changes requested, the paper will be accepted and you will receive all the instructions for proceeding to the publication steps.
In the order form you should select the english editing service together with the print or electronic journal of paper.
After received your payment and related documents, the final version of paper will be forwarded to our staff for english editing and who will correct and check eventual problems in the english. Then you will receive a final draft (not formatted in the final version of the Journal.- it will be done in a second time) for a double check and clarifications if needed

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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PUBLISHING HOUSE
Editorial Staff

editorialstaff@praiseworthyprize.com

+++++++++++++++++++++ ATTENTION +++++++++++++++++++

This e-mail is directed uniquely to the interested party, which is the exclusive addressee of any information contained herein. For any abuse about the content of this message, Praise Worthy Prize will claim compensation for damages occurred to third parties as well.
You are receiving this email because you are a Praise Worthy Prize's account holder or email subscriber. In case the e-mail should be addressed to other than you, or the content should reveal any transmission errors or manipulations,

please contact us at the following address: info@praiseworthyprize.com

----

2018-07-30 1:00 GMT+02:00 Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>:

> Dear Dr. Angela Tafuro,
>
> And I also will use “English Language Editing” service from IREMOS.
>
> Is that procedure held before or after revise the paper?
>
> Thank a lot for your response.
>
> Amirullah
> PhD Candidate in Electrical Engineering
> ITS Surabaya Indonesia
> [Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 11 Agustus 2018 pukul 12.11
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <praiseworthyprize@gmail.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro,

Today I just have sent the revised paper titled "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" to International Review on Modelling and Simulations (IREMOS) via online system (Paper ID 14742).

https://www.praiseworthyprize.org/jsm/index.php?journal=iremos&page=author&op=submissionReview&path[]=14742.

I also purchase **english editing service** for my paper.

So I would wait and follow for the next process to publish in IREMOS from you.

This is my email and thanks a lot for your helping.

Best Regards,
[Kutipan teks disembunyikan]
[Kutipan teks disembunyikan]

Ubhara Surabaya

Thanks for your responding

1 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 30 Juni 2018 pukul 08.57
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <praiseworthyprize@gmail.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>, amirullah14@mhs.ee.its.ac.id, Amirullah Amirullah <am9520012003@yahoo.com>

Dear Dr. Angela Tafuro,

Thanks a a lot for your responding about progress of my paper (ID 14742)

Amirullah
PhD Student in Electrical Engineering
ITS Surabaya Indonesia

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Copyright Form + Treatment Personal Data Amirullah IREMOS Paper ID 14742

9 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 31 Agustus 2018 pukul 14.38
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, ontosenop@ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com

Dear Dr. Angela Tafuro,

Here I attach you Copyright Form and Treatment Personal Data (pdf) for title ID14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" signed by hand of authors below:
1. Amirullah, ST, MT. (1st author)
2. Prof. Ir. Ontoseno Penangsang, M.Sc, Ph.D. (2nd author)
3. Prof. Dr. Ir. Adi Soeprijanto, MT. (3rd author).

This is my email and I would wait the next process for paper publishing online.

Thanks a lot for your cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

---

2 lampiran

Copyright Transfer_IREMOS_Amirullah.pdf
1463K

Treatment of Personal Data_IREMOS_Amirullah.pdf
1037K

Mail Delivery Subsystem <postmaster@its.ac.id> 31 Agustus 2018 pukul 14.39
Kepada: amirullah@ubhara.ac.id

Your message to <ontosenop@ee.its.ac.id> was automatically rejected:
Quota exceeded (mailbox for user is full)

---------- Pesan Yang Diteruskan ----------
From: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
To: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, ontosenop@ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com
Bcc:
Date: Fri, 31 Aug 2018 14:38:21 +0700
Subject: Copyright Form + Treatment Personal Data Amirullah IREMOS Paper ID 14742

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 31 Agustus 2018 pukul 15.00
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, ontosenop@ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com

Dear Dr. Angela Tafuro,

I am sorry, here I forward you again Copyright Form with **filling tick one box** (pdf) for paper ID14742 entitled: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" signed by hand of authors.

This is the revised file and thanks a lot for your cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

[Kutipan teks disembunyikan]

Tick Box_Copyright Transfer Agreement_IREMOS_Amirullah.pdf
1514K

Praise Worthy Prize <info@praiseworthyprize.com> 31 Agustus 2018 pukul 16.04
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullahi
thank you for your e-mail.
I confirm you that the procedure for the publication has been completed.
I've forwarded your paper to our technical staff for the english editing.
In the next days you will be contacted to check and correct the final version of the paper.
Thanks in advance for the cooperation

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 31 Agustus 2018 pukul 19.59
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro,

Thanks a lot for your email and cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Praise Worthy Prize <info@praiseworthyprize.com> 31 Agustus 2018 pukul 21.14
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah,

please find in attachment the edited version of your paper with english corrections made.
In yellow you will find all the changes made by our staff .
Please have a look and send us the revised version according to these corrections within two days, so the paper can be published on IREMOS.
Thanks in advance for the cooperation.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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[Kutipan teks disembunyikan]

Id 22175 Amirullah original version.pdf
1236K

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 3 September 2018 pukul 17.30
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, Zenno_379@yahoo.com, adisup@ee.its.ac.id

Dear Dr. Angela Tafuro,

Here I attach you **final revised version** of my paper according to your english corrections (yellow mark) in word. I also add it with little correction of nomenclature parameter (power loss) in Table I (blue mark).

The tiitle of my paper (ID14742) is "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller"
(Amirullah, Ontoseno Penangsang, Adi Soeprijanto).

This is the email and thanks a lot for your cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

14742-28357-1-RV-Jurnal IREMOS Revisi 3 Sep 2018.docx
2300K

Praise Worthy Prize <info@praiseworthyprize.com> 3 September 2018 pukul 19.21
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah
thank you for your e-mail.
I confirm you that I received all the needed and your paper has been included in the current issue of IREMOS (August 2018).
As soon as the issue will be ready you will receive the product you purchased.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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editorialstaff@praiseworthyprize.com

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 4 September 2018 pukul 06.15
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, Zenno_379@yahoo.com, adisup@ee.its.ac.id

Dear Dr. Angela Tafuro

Thanks a lot for your information and cooperation.

I would wait my paper (ID14742) entitled "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" (Amirullah, Ontoseno Penangsang, Adi Soeprijanto) published online in IREMOS (August 2018).

Best Regards,

Amirullah
PhD Candidate in EE
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Paper ID 14742_Amirullah_Revised Paper

1 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 14 Agustus 2018 pukul 07.50
Kepada: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <praiseworthyprize@gmail.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro,

Saturday 11 August 2018 I had sent the revised paper titled "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" to International Review on Modelling and Simulations (IREMOS) via online system.

https://www.praiseworthyprize.org/jsm/index.php?journal=iremos&page=author&op=submissionReview&path[]=14742.

I also purchase **english editing service** for my paper.

So I would wait and follow for the next process to publish in IREMOS from you.

This is my email and thanks a lot for your helping.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

[IREMOS] Editor Decision

5 pesan

Editorial Staff <editorialstaff@praiseworthyprize.org> 22 Agustus 2018 pukul 14.37
Kepada: amirullah@ubhara.ac.id

Amirullah Amirullah:

It is my great pleasure to inform you that your paper ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" has been accepted and will be published on the International Review on Modelling and Simulations (IREMOS) after the english revision by PWP staff.

If you want to publish the paper on the current issue of the Journal, please, accomplish the following requirements as soon as possible:

1. You should order and pay for the Article Publication Fee (you should buy the e-journal or the hard copy containing your paper) by entering into your restricted area with your username and password at: http://www.praiseworthyprize.org/jsm/index.php?journal=IREMOS&page=login, going to the Summary section of your accepted paper and clicking on the "PAY NOW" link.

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Sincerely,
Dr. Santolo Meo, Editor-in-Chief of International Review on Modelling and Simulations (IREMOS)
santolo.meo@unina.it

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In case you decide to order the print copy of the journal, we point out that the shipping will be made with the “regular mail” service, without the possibility to monitor the delivery. In this case the delivery time will take around two months. Otherwise, you can decide to receive it with a “registered mail” service, that will have a cost around 35.00 euros (for one print copy) instead of about 25.00 euros requested for the regular mail. In case of “registered mail” service, the delivery can be monitored and the time delivery is within 30 working days.

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Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 23 Agustus 2018 pukul 09.30
Kepada: Editorial Staff <editorialstaff@praiseworthyprize.org>
Cc: Technical Staff <info@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear IREMOS Editorial Staf

Thanks a lot for your information. In order to pay paper fee online publication (ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller)" , there are some points which I would ask you:

1. My paper consist of 13 pages and it is means in statment "Here" you can order and pay for your product (Article Publication Fee) in link https://www.praiseworthyprize.org/jsm/index.php?journal=iremos&page=author&op=

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in filling box Please type here the <excess pages number>.....
I have to fill **3 pages right**? 10 for normal pages number (300 euros) and 3 for excess pages number (3 x 35 EU = 105 euros).

2. In your email there is **no information** of bank account number or credit card account number (paypal) for pay paper online publishing. Could you give me information about it?

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there is no information about english editing **in word format.** The information in only for **latex format** (» If you need english languge editing for documents in LaTeX format, contact us by e-mail here...) How do I request help editing language **in word format**?

There are my questions and thanks a lot for your answering.

Amirullah
PhD Candidate in EE
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Praise Worthy Prize <info@praiseworthyprize.com> 23 Agustus 2018 pukul 15.05
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah,
thank you for your email.
1. Yes, I confirm you that in the order form, you should select 3 extra pages.
2. After you filled in the order form, you will receive automatically informations to pay with bank transfer (if you choose to pay in that way), or you will be redirected to PayPal page, so you can directly proceed to the payment if you choose to pay with credit card.
3. Do not worry about that: in the acceptance email it is written that you already chose to use our English Language Service: the only thing you should do is to select it in the order form.
So, to recap, you will fill in the order form choosing:
- IREMOS publication Fee= 300 Euros (if you want an E-Journal Copy) or 330 + shipment fee (for the print copy).
- 3 extra pages= 105 Euros
- English Editing Service= 60 Euros
For a total of: 465 Euros.
I hope we have been helpful enough.
If you have any further question, do not hesitate to contact us.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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editorialstaff@praiseworthyprize.com

mail should be addressed to other than you, or the content should reveal any transmission errors or manipulations, please contact us at the following address: info@praiseworthyprize.com
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[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 23 Agustus 2018 pukul 20.41
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro

It is okay and thanks a lot for your informations.

Amirullah
PhD Candidate in EE
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 26 Agustus 2018 pukul 07.11
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro

Today I have pay paper fee for title D 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" via credit card.

This is my email and I will wait the next process for paper publishing online.

Amirullah
PhD in EE
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Fw: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.

4 pesan

amir rullah <am9520012003@yahoo.com> 27 Agustus 2018 pukul 03.10
Kepada: "amirullah@ubhara.ac.id" <amirullah@ubhara.ac.id>
Cc: Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

----- Forwarded message -----
From: Hasti Afianti <hafianti@yahoo.com>
To: Amirullah Amirullah <am9520012003@yahoo.com>
Sent: Sunday, 26 August 2018, 7:35:17 AM GMT+7
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To: "Hasti Afianti" <hafianti@yahoo.com>
Sent: Sun, Aug 26, 2018 at 7:07 AM
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http://www.praiseworthyprize.com
0810030873

Informasi pengiriman:
Hasti Afianti
Universitas Bhayangkara Surabaya
Jl. Sutorejo Timur III/3
Surabaya, EAST JAVA
60113
Indonesia

Metode pengiriman:
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ID Email PayPal PP1469 - db31fcb990f1d

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 27 Agustus 2018 pukul 03.27
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro

Here I forward you proof of paper payment paper for title ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage
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I also would wait the next process for paper publishing online.

Best Regards,

Amirullah
PhD in Electrical Engineering
ITS Surabaya Indonesia

---------- Pesan terusan ----------
Dari: **amir rullah** <am9520012003@yahoo.com>
Tanggal: 27 Agustus 2018 03.10
Subjek: Fw: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.
Kepada: "amirullah@ubhara.ac.id" <amirullah@ubhara.ac.id>
Cc: Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

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From: Hasti Afianti <hafianti@yahoo.com>
To: Amirullah Amirullah <am9520012003@yahoo.com>
Sent: Sunday, 26 August 2018, 7:35:17 AM GMT+7
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To: "Hasti Afianti" <hafianti@yahoo.com>
Sent: Sun, Aug 26, 2018 at 7:07 AM
Subject: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.
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Berbelanja dengan lebih aman
Pedagang tidak akan melihat perincian keuangan Anda karena kami menyimpannya secara aman.

Berbelanja dengan penuh keyakinan

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PRAISE WORTHY PRIZE S.R.L.
info@praiseworthyprize.com
http://www.praiseworthyprize.com
0810030873

Petunjuk untuk pedagang:
Tidak ada yang diberikan

Informasi pengiriman:
Hasti Afianti
Universitas Bhayangkara Surabaya
Jl. Sutorejo Timur III/3
Surabaya, EAST JAVA
60113
Indonesia

Metode pengiriman:
Tidak ditentukan

Keterangan	Harga satuan	Kuantitas	Jumlah
ID 14742- Amount due for 1 e-journal copies of IREMOS: EUR 300,00 + 'Excess page' charge: EUR 105,00 + 'English Language' servi Barang #: 1	€465,00 EUR	1	465,00 EUR

Diskon:	-€0,00 EUR
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Praise Worthy Prize <info@praiseworthyprize.com> 27 Agustus 2018 pukul 16.39
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah

thank you for your e-mail.
I confirm you the good reception of your payment
Now in order to complete the publication procedure and to include the paper on the current issue of IREMOS, I'm looking forward to receive all the documents signed by hand by all the authors of your paper(copyright form and treatment of personal data).
Thanks in advance for the cooperation.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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Editorial Staff

editorialstaff@praiseworthyprize.com

Il giorno dom 26 ago 2018 alle ore 22:27 Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> ha scritto:

> Dear Dr. Angela Tafuro
>
> Here I forward you proof of paper payment paper for title ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage
> Supplied by Photovoltaic using Artificial Intelligent Controller" via credit card owned by Mrs. Hasti Afianti (PhD student in same PSSL Lab ITS Surabaya) as 465 EUR.
>
> I need your confirmation, has the payment fee been received in PWP or IREMOS account?
>
> This is my email and I will be happy if your respond it.
>
> I also would wait the next process for paper publishing online.
>
> Best Regards,
>
> Amirullah
> PhD in Electrical Engineering
> ITS Surabaya Indonesia
>
> ---------- Pesan terusan ----------
> Dari: **amir rullah** <am9520012003@yahoo.com>
> Tanggal: 27 Agustus 2018 03.10
> Subjek: Fw: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.

Kepada: "amirullah@ubhara.ac.id" <amirullah@ubhara.ac.id>
Cc: Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

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From: Hasti Afianti <hafianti@yahoo.com>
To: Amirullah Amirullah <am9520012003@yahoo.com>
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Sent: Sun, Aug 26, 2018 at 7:07 AM
Subject: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.
PayPal

25 Agu 2018 17:07:14 GMT-07:00
No. Resi:0424-4035-4599-0891

Anda telah mengirim pembayaran sebesar €465,00 EUR kepada PRAISE WORTHY PRIZE S.R.L..

Halo Hasti Afianti,

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Informasi pengiriman:
Hasti Afianti
Universitas Bhayangkara Surabaya
Jl. Sutorejo Timur III/3
Surabaya, EAST JAVA

Metode pengiriman:
Tidak ditentukan

60113
Indonesia

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ID 14742- Amount due for 1 e-journal copies of IREMOS: EUR 300,00 + 'Excess page' charge: EUR 105,00 + 'English Language' servi Barang #: 1	€465,00 EUR	1	465,00 EUR
		Diskon:	-€0,00 EUR
		Total:	€465,00 EUR

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ID Email PayPal PP1469 - db31fcb990f1d

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 28 Agustus 2018 pukul 02.04
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuru

Thanks a lot for your confirmation. I would process 3 copyright documents signed by hand soon.

Amirullah
PhD Candidate in EE
ITS Surabaya

2018-08-27 16:39 GMT+07:00 Praise Worthy Prize <info@praiseworthyprize.com>:

> Dear Dr. Amirullah
> thank you for your e-mail.
> I confirm you the good reception of your payment

Now in order to complete the publication procedure and to include the paper on the current issue of IREMOS, I'm looking forward to receive all the documents signed by hand by all the authors of your paper(copyright form and treatment of personal data).
Thanks in advance for the cooperation.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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Editorial Staff

editorialstaff@praiseworthyprize.com

Il giorno dom 26 ago 2018 alle ore 22:27 Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> ha scritto:

> Dear Dr. Angela Tafuro
>
> Here I forward you proof of paper payment paper for title ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage
> Supplied by Photovoltaic using Artificial Intelligent Controller" via credit card owned by Mrs. Hasti Afianti (PhD student in same PSSL Lab ITS Surabaya) as 465 EUR.
>
> I need your confirmation, has the payment fee been received in PWP or IREMOS account?
>
> This is my email and I will be happy if your respond it.
>
> I also would wait the next process for paper publishing online.
>
> Best Regards,
>
> Amirullah
> PhD in Electrical Engineering
> ITS Surabaya Indonesia
>
> ---------- Pesan terusan ----------
> Dari: **amir rullah** <am9520012003@yahoo.com>
> Tanggal: 27 Agustus 2018 03.10
> Subjek: Fw: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.
> Kepada: "amirullah@ubhara.ac.id" <amirullah@ubhara.ac.id>
> Cc: Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

----- Forwarded message -----
From: Hasti Afianti <hafianti@yahoo.com>
To: Amirullah Amirullah <am9520012003@yahoo.com>
Sent: Sunday, 26 August 2018, 7:35:17 AM GMT+7
Subject: Fw: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.

Sent from Yahoo Mail on Android

----- Forwarded Message -----
From: "service@intl.paypal.com" <service@intl.paypal.com>
To: "Hasti Afianti" <hafianti@yahoo.com>
Sent: Sun, Aug 26, 2018 at 7:07 AM
Subject: Pembayaran Anda kepada PRAISE WORTHY PRIZE S.R.L.
PayPal

25 Agu 2018 17:07:14 GMT-07:00
No. Resi:0424-4035-4599-0891

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Pedagang tidak akan melihat perincian keuangan Anda karena kami menyimpannya secara aman.

Berbelanja dengan penuh keyakinan
Dapatkan uang Anda kembali untuk pembelian yang tidak diterima atau ternyata berbeda. Pelajari lebih jauh

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info@praiseworthyprize.com
http://www.praiseworthyprize.com
0810030873

Petunjuk untuk pedagang:
Tidak ada yang diberikan

Informasi pengiriman:
Hasti Afianti
Universitas Bhayangkara Surabaya
Jl. Sutorejo Timur III/3
Surabaya, EAST JAVA
60113
Indonesia

Metode pengiriman:
Tidak ditentukan

Keterangan	Harga satuan	Kuantitas	Jumlah
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Diskon:	-€0,00 EUR
Total:	€465,00 EUR

Nomor Resi: 0424-4035-4599-0891
Simpanlah nomor resi ini untuk rujukan di masa mendatang. Anda akan memerlukannya jika menghubungi layanan pelanggan di PRAISE WORTHY PRIZE S.R.L. atau PayPal.

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PayPal

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ID Email PayPal PP1469 - db31fcb990f1d

Ubhara Surabaya

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Copyright Form + Treatment Personal Data Amirullah IREMOS Paper ID 14742

9 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 31 Agustus 2018 pukul 14.38
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, ontosenop@ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com

Dear Dr. Angela Tafuro,

Here I attach you Copyright Form and Treatment Personal Data (pdf) for title ID14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" signed by hand of authors below:
1. Amirullah, ST, MT. (1st author)
2. Prof. Ir. Ontoseno Penangsang, M.Sc, Ph.D. (2nd author)
3. Prof. Dr. Ir. Adi Soeprijanto, MT. (3rd author).

This is my email and I would wait the next process for paper publishing online.

Thanks a lot for your cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

---

2 lampiran

Copyright Transfer_IREMOS_Amirullah.pdf
1463K

Treatment of Personal Data_IREMOS_Amirullah.pdf
1037K

Mail Delivery Subsystem <postmaster@its.ac.id> 31 Agustus 2018 pukul 14.39
Kepada: amirullah@ubhara.ac.id

Your message to <ontosenop@ee.its.ac.id> was automatically rejected:
Quota exceeded (mailbox for user is full)

---------- Pesan Yang Diteruskan ----------
From: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
To: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, ontosenop@ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com
Bcc:
Date: Fri, 31 Aug 2018 14:38:21 +0700
Subject: Copyright Form + Treatment Personal Data Amirullah IREMOS Paper ID 14742

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 31 Agustus 2018 pukul 15.00
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, ontosenop@ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com

Dear Dr. Angela Tafuro,

I am sorry, here I forward you again Copyright Form with **filling tick one box** (pdf) for paper ID14742 entitled:
"High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" signed by hand of authors.

This is the revised file and thanks a lot for your cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia

[Kutipan teks disembunyikan]

Tick Box_Copyright Transfer Agreement_IREMOS_Amirullah.pdf
1514K

Praise Worthy Prize <info@praiseworthyprize.com> 31 Agustus 2018 pukul 16.04
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullahi
thank you for your e-mail.
I confirm you that the procedure for the publication has been completed.
I've forwarded your paper to our technical staff for the english editing.
In the next days you will be contacted to check and correct the final version of the paper.
Thanks in advance for the cooperation

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 31 Agustus 2018 pukul 19.59
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro,

Thanks a lot for your email and cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Praise Worthy Prize <info@praiseworthyprize.com> 31 Agustus 2018 pukul 21.14
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah,

please find in attachment the edited version of your paper with english corrections made.
In yellow you will find all the changes made by our staff .
Please have a look and send us the revised version according to these corrections within two days, so the paper can be published on IREMOS.
Thanks in advance for the cooperation.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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Id 22175 Amirullah original version.pdf
1236K

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 3 September 2018 pukul 17.30
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, Zenno_379@yahoo.com, adisup@ee.its.ac.id

Dear Dr. Angela Tafuro,

Here I attach you **final revised version** of my paper according to your english corrections (yellow mark) in word. I also add it with little correction of nomenclature parameter (power loss) in Table I (blue mark).

The tiitle of my paper (ID14742) is "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller"
(Amirullah, Ontoseno Penangsang, Adi Soeprijanto).

This is the email and thanks a lot for your cooperation.

Best Regards,

Amirullah
PhD Candidate in Electrical Engineering
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

14742-28357-1-RV-Jurnal IREMOS Revisi 3 Sep 2018.docx
2300K

Praise Worthy Prize <info@praiseworthyprize.com> 3 September 2018 pukul 19.21
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah
thank you for your e-mail.
I confirm you that I received all the needed and your paper has been included in the current issue of IREMOS (August 2018).
As soon as the issue will be ready you will receive the product you purchased.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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editorialstaff@praiseworthyprize.com

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 4 September 2018 pukul 06.15
Kepada: Praise Worthy Prize <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: amirullah14@mhs.ee.its.ac.id, Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, Zenno_379@yahoo.com, adisup@ee.its.ac.id

Dear Dr. Angela Tafuro

Thanks a lot for your information and cooperation.

I would wait my paper (ID14742) entitled "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller" (Amirullah, Ontoseno Penangsang, Adi Soeprijanto) published online in IREMOS (August 2018).

Best Regards,

Amirullah
PhD Candidate in EE
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

PDF File IREMOS_Amirullah_Paper ID 14742

3 pesan

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 17 Oktober 2018 pukul 05.49
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro

My paper entitled: **High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller**
Amirullah Amirullah(1), Ontoseno Penangsang(2), Adi Soeprijanto(3)*
have been avialable online in https://www.praiseworthyprize.org/jsm/index.php?journal=iremos&page=article&op=view&path%5B%5D=22175.

IREMOS Paper ID is 14742.

Therefore, I would ask you when will PDF file of this paper avialable online and sent it to me?

This is my email and thanks for your answering.

Amirullah
PhD Student ITS Surabaya Indonesia

Praise Worthy Prize <info@praiseworthyprize.com> 17 Oktober 2018 pukul 16.25
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah
thank you for your e-mail.
Because of some delays of scheduled authors to complete the publication procedure, the August issue of IREMOS is not ready yet.
Our staff is waiting for the last documents to complete the issue.
As soon as it will be available you will receive a confirmation by e-mail.
Many apologies for any caused inconvenience.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 17 Oktober 2018 pukul 17.14
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro

Thanks a lot for your information.

Amirullah
PhD Candidate in EE ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

[IREMOS] Post-publication services for authors

20 pesan

Editorial Staff <editorialstaff@praiseworthyprize.org> 2 November 2018 pukul 22.02
Kepada: amirullah@ubhara.ac.id

Dear Dr. Amirullah Amirullah,
we are glad to congratulate with you and your colleagues for the publication of the article ID 14742: "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic Using Artificial Intelligent Controller" in our journal International Review on Modelling and Simulations (IREMOS).

In the next days you will receive the purchased copy of the full issue where your paper has been published.

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Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 5 November 2018 pukul 09.52
Kepada: Editorial Staff <editorialstaff@praiseworthyprize.org>
Cc: Technical Staff <info@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id, adisup@ee.its.ac.id, Zenno_379@yahoo.com

Dear Dr. Angela Tafuro

It is okay, thanks a lot for sending us the email and access to download the paper in IREMOS (Paper ID 14742).

Amirullah
PhD Candidate in EE ITS Surabaya
[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 7 Desember 2018 pukul 15.34
Kepada: Editorial Staff <editorialstaff@praiseworthyprize.org>
Cc: Technical Staff <info@praiseworthyprize.com>, "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Tafuro,

I would ask you copy of the full IREMOS issue (Vol. 11 No. 4 2018), where my paper has been published.

The paper entitled "High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic Using Artificial Intelligent Controller" (Paper ID 14742)

In last email you promised me to send that PDF file.

This is my email and thanks a lot for your helping.

Regards,

Amirullah
PhD Candidate in EE
ITS Surabaya Indonesia
[Kutipan teks disembunyikan]

Praise Worthy Prize <info@praiseworthyprize.com> 7 Desember 2018 pukul 16.39
Kepada: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>

Dear Dr. Amirullah
thanky ou for your e-mail.
Please note that dated 03rd December we sent to Dr.Afianti Hasti (as indicated in the order form you 've submitted) the e-mail with all the instructions to download the full issue of IREMOS that includes your paper.
PLease let me know if he received it.

Best Regards

Angela Tafuro
Head of the Editorial Staff

****

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editorialstaff@praiseworthyprize.com

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 8 Desember 2018 pukul 08.53
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>
Bcc: Amirullah Amirullah <amirullah.ubhara.surabaya@gmail.com>

Dear Dr. Angela Tafuro.

It is okay thanks a lot for your information.

I borrowed and used a credit card (paypal) from Dr. Hasti Afianti with her permission to help me
paid the publication fee for the paper. Because I have no credit card.

Dr Hasti Afianti is my friend in the same PSSL Laboratory of ITS Surabaya

This is my email and thanks a lot for your cooperation.

Best Regard.

Amirullah
PhD Candidate in EE
PSSL Lab ITS Surabaya Indonesia

[Kutipan teks disembunyikan]

Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id> 8 Desember 2018 pukul 09.39
Kepada: Technical Staff <info@praiseworthyprize.com>
Cc: "Praise Worthy Prize (Editorial Staff)" <editorialstaff@praiseworthyprize.com>
Bcc: Amirullah Ubhara Surabaya <amirullah@ubhara.ac.id>, hafianti@yahoo.com, amirullah14@mhs.ee.its.ac.id

Dear Dr. Angela Taforo

I have been forwarded email below from Dr. Hasti Afianti.

But I am sorry I can not open and login link to activate and to download my paper IREMOS August 2018 Vol 11 No 4 with my email (amirullah@ubhara.ac.id).

Have I use hafianti@yahoo.com to activate and download my paper?

This is my email and thanks a lot for your answer.

Amirullah

Sent from Yahoo Mail on Android

> ----- Forwarded Message -----
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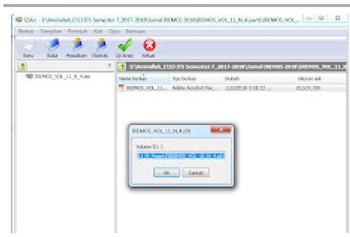

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International Review on Modelling and Simulations (I.RE.MO.S.), Vol. xx, n. x
June 2008

High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller

Amirullah[1], Ontoseno Penangsang[2], Adi Soeprijanto[3]

Abstract – *This paper proposes the use of Battery Energy Storage (BES) on Unified Power Quality Conditioner (UPQC) supplied by Photovoltaic (PV) through to DC link to improve power quality on three phase three wire (3P3W) distribution system. The BES serves to store the excess of power resulted by PV and transfer it to load if necessary, prevent interuption voltage, and adjust charging and discharging energy in battery. Power quality analysis is carried out in two conditions i.e. PV connected to DC link without and with BES. Fuzzy Logic Controller (FLC) is implemented to maintain DC voltage across the capacitor under disturbance scenarios of source and load as well as compare the results with Proportional Intergral (PI) controller. The number of disturbance scenarios are six for each UPQC controller, so the total number are 12 disturbances. The six of disturbances are non-linear load (NL), unbalance and nonlinear load (Unba-NL), distortion supply and non-linear load (Dis-NL), sag and non-linear load (Sag-NL), swell and non-linear load (Swell-NL), and interruption and non-linear load (Inter-NL). FLC method on UPQC supplied by PV with BES is able to result average THD of source voltage slightly better than PI controller. In disturbance scenario 1 to 5, nominal of average THD of load voltage have met IEEE 519. FLC method on UPQC supplied by PV with BES is also capable to give average THD of source current better than PI controller. Under scenario 6 (Inter-NL), FLC is able to reduce average THD of load voltage and source current significantly than PI controller. With the same disturbance, combination of PV and BES is able to generate power to UPQC DC link and injecting full average compensation voltage through injection transformer on series active filter so that average load voltage remains stable. This simulations prove that the proposed artificial intelligent (AI) controller for UPQC with BES is able to improve power quality significantly under varying disturbances especially for interruption disturbance. The performance of the proposed model is validated and investigated through simulations using Matlab/Simulink.*

***Keywords**: Power Quality, UPQC, PV, BES, Total Harmonic Distortion (THD), Disturbance Scenarios*

I. Introduction

The microgrid power systems use distributed generations (DGs) power source where power is supplied to local loads and may operate separately from conventional grid systems. DGs have many benefits, among others, capable of reducing transmission costs, low investment costs, reducing line losses and increasing grid reliability. DGs that use renewable energy (RE) able to generate electrical power are classified as DGs sources. Solar or photovoltaic (PV) generator is one of the most potential DGs sources technologies because it only need sunlight to generate electricity, where the resources are available in abundance, free and relatively clean. Indonesia has enormous energy potential from the sun because it lies on the equator. Almost all areas of Indonesia get sunlight about 10 to 12 hours per day, with an average intensity of irradiation of 4.5 kWh/m^2 or equivalent to 112,000 GW. The weakness of PV generator besides being capable of generating power, it also produces a number of voltage and current disturbances, as well as harmonics due to the presence of several types of PV devices and power converters as well as increasing a number of non-linear loads connected to the grid causing a decrease in power quality.

To overcome and improve power quality due to presence of non-linear loads and integration of PV generator to grid next proposed UPQC. UPQC serves to compensate for problems of source voltage quality, for example sag, swell, unbalance, flicker, harmonics, as well as problems of load current quality such as harmonics, unbalance, reactive currents, and neutral currents. UPQC is one part of the active power filter consisting of shunt and series active power filters connected in parallel and serves as superior controller to overcome a number of power quality problems simultaneously [1]. UPQC series component is responsible for reducing a number of interference on source side; voltage sag/swell, flicker, unbalanced voltage, and harmonics. This equipment serves to inject a number of voltages to keep load voltage fixed at desired level in a balanced and distortion free. UPQC shunt component is responsible for addressing a current quality problems; low power factor, load current harmonics, and unbalanced load. This device serves to inject current on

Manuscript received and revised May 2008, accepted June 2008

AC system so that source current becomes sinosioda balanced and in phase with source voltage [2].

UPQC based on RE has been investigated by many researchers. There are two methods used to overcome problem by using conventional and artificial intelligence controller. Ref. [3] discuss analysis of UPQC and DG combination operations . The proposed system includes a series inverter, shunt inverter, and a DG connected to a DC link through a rectifier using PI controller. The system was capable to increase source voltage quality (sag and interruption) and load current quality, as well as changes in active power on grid and off grid mode. The influence of DG on UPQC performance in reducing the sag voltage under conditions of some phase to ground faults to using distributed static compensator (DSTATCOM) controller has been implemented [4]. The DG was effective enough to help UPQC work in improving sag voltage. DG system is connected in series with load resulting better percentage of sag migitation compared to the system without using DG. Implementation of UPQC using unit vector template generation (UVTG) method with PI controller to improve sag, swell, voltage harmonics and current harmonics have been done [5]. Simulation of voltage distortion was made by adding 5th and 7th harmonics at fundamental source voltage, resulting in a reduction of THD source current and THD load voltage.

UPQC supplied by a 64 panels PV using boost converter, PI controller, perturb and observer MPPT, and instantaneous reactive power theory (p-q theory) has been proposed [6]. The system was capable to compensate reactive power and reduce source current and load voltage harmonics. Nevertheless, the study was not to discuss migitation of sag and interuption caused by penetration of PV. Artificial neural network (ANN) based synchronous reference frame theory (SRF) control strategy to compensate power quality issues in three phase three wire (3P3W) distribution system through UPQC for various balanced/unbalance/distorted conditions on load and source has been proposed [7]. The proposed model was able to mitigate harmonic/reactive currents, unbalanced source and load current/voltage. Investigation on power quality enhancement includes sag and source voltage harmonics on grid using UPQC supplied by PV array connected to DC link using PI compared with FLC have been done [8]. The simulation results that FLC on UPQC and PV can improve source voltage THD better than PI.

Ref. [9] shows a method for balancing current and line voltage, as a result of DGs of a single phase PV generator unit in randomly installed at homes through on a three phase four wire 220 kV and 50 Hz distribution line using BES and three of single phase bidirectional inverter. Both devices was capable to reduce unbalanced line current and the unbalanced line voltage. Both combination was also able to increase current and voltage harmonics on PCC bus. Improvement of power quality UPQC on microgrid supplied by PV and wind turbine has been implemented. PI and FLC is able to to improve power quality and reduce distortion in output power [11].

This research investigates the use of BES on UPQC supplied by PV through to DC link to improve power quality on three phase three wire (3P3W) distribution system. PV array generates power under constant temperature and irradiance as well as connected to BES through a DC/DC boost converter that serves to regulate PV operating point. BES serves to store excess energy produced by PV and distribute it to load if necessary, to prevent interruption voltage, and to adjust charging and discharging of energy in battery. BES is also expected to store excess power produced by PV generator and use them as backup power. FLC is proposed and compared with PI method, because PI controller has weakness in determining of proportional and integral gain constant which still using trial and error. FLC is used as a controller variable of DC voltage and DC reference voltage input to generate reference current source in current hysteresis controller circuit on shunt active filter. FLC methods are used as DC voltage controllers in shunt active filter and series active filter to migitate power quality of load voltage and source current. The number of disturbance scenario is six for each UPQC controller, so the total number is 12.

The power quality performance of two controllers are used to determine load voltage, source current, load voltage THD, and source current THD based on IEEE 519. Section II describes proposed method, model of UPQC supplied by PV and BES, simulation parameters, PV circuit model, control of series and shunt active filter, as well as application of PI and FLC method for proposed model. Section III shows results and discussion about THD analysis on the proposed model of PV connected to DC link circuit without and with BES using PI controller and FLC. In this section, six disturbance scenarios are presented and the results are verified with Matlab/Simulink. Finally, the paper in concluded in Section IV.

II. Proposed Method

II.1. Proposed Model

Fig. 1 shows model proposed in this study. DG based on RE is a PV connected to a 3P3W distribution sistem with 380 volts (L-L) and frequency 50 hertz, through DC link UPQC and BES circuit. PV array generates power under fixed temperature and irradiance as well as connected to BES through a DC/DC boost converter. The maximum power point tracking (MPPT) method with Pertub and Observer (P and O) algorithms helps PV generate maximum power and generate output voltage, as input voltage for the DC/DC boost converter. The converter functions to adjust duty cycle value and output voltage of PV generator as its input voltage to produce output voltage according DC link voltage of UPQC.

The BES connected to UPQC DC link circuit serves as an energy storage and is expected to overcome interruption voltage and overall help UPQC performance to enhance voltage and current power quality at source and load bus. Table 1 shows simulation parameters of proposed model. Power quality analysis is performed on PV connected to 3P3W system through UPQC DC link circuit (on-grid), under two conditions i.e. with and without BES. A single phase circuit breaker is used to connect and disconnect PV with BES. Each condition consists of six disturbance scenarios are NL, Unba-NL, Dis-NL, Sag-NL, Swell-NL, and Inter-NL. FLC is used as DC voltage controls in shunt active filter to improve power quality of load voltage and source current as well as compared them with PI controller. Each scenario uses UPQC controller with PI controller and FLC so total are 12 disturbances. The parameters include i.e. (1) voltage and current on source on PCC bus, (2) voltage and current on load bus, (3) voltage harmonics and current harmonics on source bus and (4) voltage harmonics and current harmonics on load bus. The next step is to compare two controller performances on UPQC to enhance power quality of load voltage and source current under six disturbance conditions.

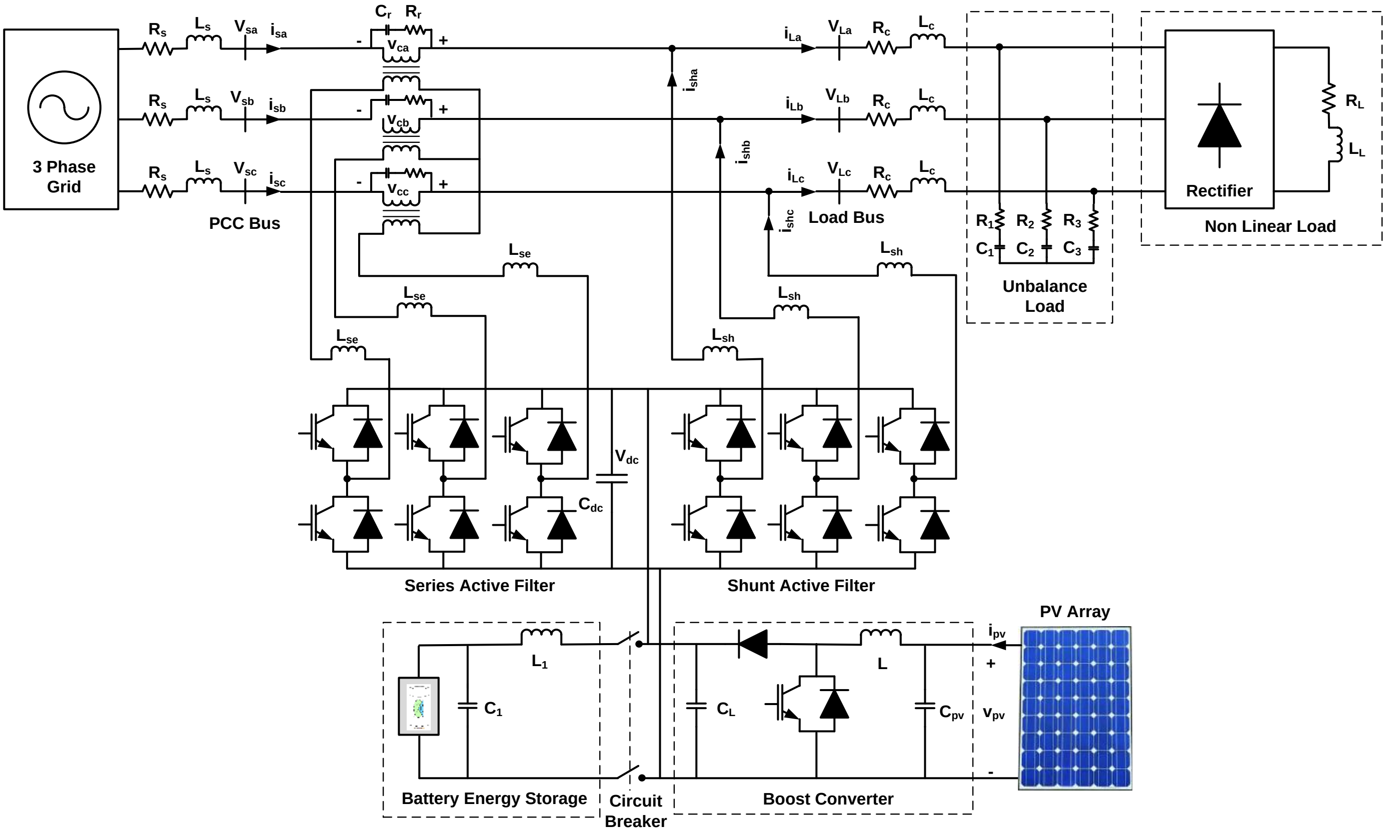

Fig 1. Proposed model of UPQC supplied by PV and BES

TABLE I
SIMULATION PARAMETERS

Devices	Parameters	Design Values
Three Phase Grid	RMS Voltage (LL)	380 Volt
	Frequency	50 Hz
	Line Impedance	R_s = 0.1 Ohm
		L_s = 15 mH
Series Active Filter	Series Inductance	L_{se} = 0.015 mH
Shunt Active Filter	Shunt Inductance	L_{sh} = 15 mH
Injection Transformers	Rating kVA	10 kVA
	Frequency	50 Hz
	Turn Ratio (N_1/N_2)	1 : 1
Non Linear load	Resistance	R_L = 60 Ohm
	Inductance	L_L = 0.15 mH
	Load Impedance	R_c = 0.4 Ohm
		L_c = 15 mH
Unbalance Load	Resistance	R_1 = 24 Ohm
		R_2 = 12 Ohm
		R_3 = 6 Ohm
	Capacitance	C_1, C_2, C_3 = 2200 μF
DC Link	DC Voltage	V_{DC} = 650 Volt
	Capacitance	C_{DC} = 3000 μF
Battery Energy Storage	Type	Nickel Metal Hibrid
	DC Voltage	650 V
	Rated Capacity	200 Ah
	Initial SOC	100%
	Inductance	L_1 = 6 mH
	Capacitance	C_1 = 200 μF
PV Generator	Active Power	0.6 kW
	Temperature	25^0 C
	Irradiance	1000 W/m^2
PI Parameters	K_p Gain Constant	0.2
	K_i Gain Constant	1.5
Fuzzy model	Method	Mamdani
	Composition	Max-Min
Input membership function	Error (V_{dc})	trapmf, trimf
	Delta Error (ΔV_{dc})	trapmf, trimf
Output membership function	Power Loss (P_{loss})	trapmf,trimf

II.2. Photovoltaic Model

Fig. 2 shows the equivalent circuit of a solar panel. A solar panel is composed of several PV cells that have series, parallel, or series-parallel external connections [11].

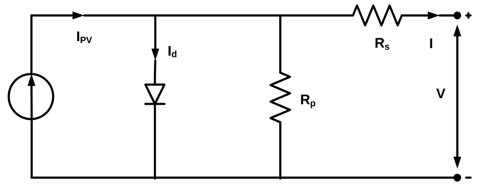

Fig 2. Equivalent circuit of solar panel

Eq. 1 shows V-I characteristic of a solar panel [11].

$$I = I_{PV} - I_o\left[\exp\left(\frac{V+R_S I}{aV_t}\right)-1\right]-\frac{V+R_S I}{R_P} \tag{1}$$

where I_{PV} is the photovoltaic current, I_o is saturated reverse current, 'a' is the ideal diode constant, $V_t = N_S KTq^{-1}$ is the thermal voltage, N_S is the number of series cells, q is the electron charge, K is the Boltzmann constant, T is the temperature of p–n junction, R_S and R_P are series and parallel equivalent resistance of the solar panels. I_{PV} has a linear relation with light intensity and also varies with temperature variations. I_o is dependent on temperature variations. The values of I_{pv} and I_o are calculated as following Eq. 2 and 3 below:

$$I_{PV} = (I_{PV,n} + K_1 \Delta T)\frac{G}{G_n} I \tag{2}$$

$$I_o = \frac{I_{SC,n} + K_I \Delta T}{\exp(V_{OC,n} + K_V \Delta T)/aV_t - 1} \tag{3}$$

In which $I_{PV,n}$, $I_{SC,n}$ and $V_{OC,n}$ are photovoltaic current, short circuit current and open circuit voltage in standard conditions (T_n = 25 C and G_n = 1000 Wm^{-2}) respectively. K_I is the coefficient of short circuit current to temperature, $\Delta T = T - T_n$ is the temperature deviation from standard temperature, G is the light intensity and K_V is the ratio coefficient of open circuit voltage to temperature. Open circuit voltage, short circuit current and voltage-current corresponding to the maximum power are three important points of I-V characteristic of solar panel. These points are changed by variations of atmospheric conditions. By using Eq. 4 and 5 which are derived from PV model equations, short circuit current and open circuit voltage can be calculated in different atmospheric conditions.

$$I_{SC} = (I_{SC} + K_1 \Delta T)\frac{G}{G_n} \tag{4}$$

$$V_{OC} = V_{OC} + K_V \Delta T \tag{5}$$

II.3. Control of Series Active Filter

The main function of series active filter is as a sensitive load protection against a number of interference at PCC bus voltage. The control strategy algorithm of the source and load voltage harmonics in series active filter circuit is shown in Fig. 3. It extracts the unit vector templates from the distorted input supply Furthermore, the templates are expected to be ideal sinusoidal signal with unity amplitude. The distorted supply voltages are measured and divided by the peak amplitude of fundamental input voltage V_m given by Eq. 6 [6].

$$V_m = \sqrt{\frac{2}{3}\left(V_{sa}^2 + V_{sb}^2 + V_{sc}^2\right)} \tag{6}$$

A three phase locked loop (PLL) is used in order to generate a sinusoidal unit vector templates with a phase lagging by the use of sinus function. The reference load voltage signal is determined by multiplying the unit vector templates with the peak amplitude of the fundamental input voltage V_m. The load reference voltage (V_{La} *, V_{Lb} *, V_c *) is then compared against to sensed load voltagr (V_{La}, V_{Lb}, V_{Lc}) by a pulse width modulation (PWM) controller used to generate the desired trigger signal on the series active filter.

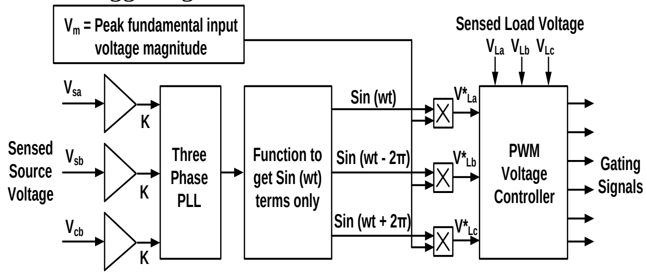

Fig 3. Control strategy of series active filter

II.4. Control of Shunt Active Filter

The main function of shunt active filter is migitation of power quality problems on the load side. The control methodology in shunt active filter is that the absorbed current from the PCC bus is a balanced positive sequence current including unbalanced sag voltage conditions in the PCC bus or unbalanced conditions or non-linear loads. In order to obtain satisfactory compensation caesed by disturbance due to non-linear load, many algorithms have been used in the literature. This research used instantaneous reactive power theory method "p-q theory". The voltages and currents in Cartesian *abc* coordinates can be transformed to Cartesian *αβ* coordinates as expressed in Eq. 7 and 8 [7].

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 1 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \tag{7}$$

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 1 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{bmatrix} \tag{8}$$

Eq. 9 shows the computation of the real power (p) and imaginary power (q). The real power and imaginary are measured instantaneously power and in matrix it is form is given as. Eq. 10 shows the presence of oscillating and average components in instantaneous power [13].

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \tag{9}$$

$$p = \bar{p} + \tilde{p} \quad ; \quad q = \bar{q} + \tilde{q} \tag{10}$$

Where $\bar{p}$ = direct component of real power, $\tilde{p}$ = fluctuating component of real power, $\bar{q}$ = direct component of imaginary power, $\tilde{q}$ = fluctuating component of imaginary power. The total imaginary power (q) and the fluctuating component of real power are selected as power references and current references and are utilized through the use of Eq. 11 for compensating harmonic and reactive power [14].

$$\begin{bmatrix} i_{c\alpha}^* \\ i_{c\beta}^* \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} -\tilde{p} + \bar{p}_{loss} \\ -q \end{bmatrix} \qquad (11)$$

The signal $\bar{p}_{loss}$, is obtained from voltage regulator and is utilized as average real power. It can also be specified as the instantaneous active power which corresponds to the resistive loss and switching loss of the UPQC. The error obtained on comparing the actual DC-link capacitor voltage with the reference value is processed in FLC, engaged by voltage control loop as it minimizes the steady state error of the voltage across the DC link to zero. The compensating currents ($i_{c\alpha}^*, i_{c\beta}^*$) as required to meet the power demand of load are shown in Eq. 11. These currents are represented in α-β coordinates. Eq. 12 is used to acquire the phase current required for compensation. These source phase currents ($i_{sa}^*, i_{sb}^*, i_{sc}^*$) are represented in a-b-c axis obtained from the compensating current in the α-β coordinates presented in Eq. 12 [14].

$$\begin{bmatrix} i_{sa}^* \\ i_{sb}^* \\ i_{sc}^* \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -1/2 & \sqrt{3}/2 \\ -1/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{c\alpha}^* \\ i_{c\beta}^* \end{bmatrix} \qquad (12)$$

Fig. 4 shows a control of shunt active filter.

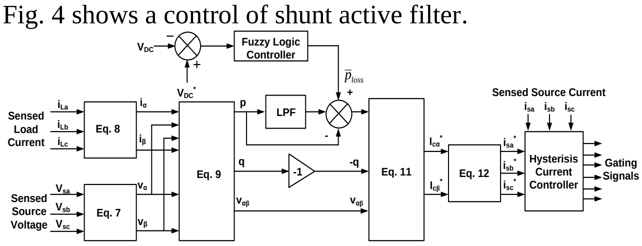

Fig 4. Control strategy of shunt active filter

The proposed model of UPQC supplied by PV and BES is shown in Fig 1. From the figure we can see that the PV and BES are connected to the DC link through a DC-DC boost converter circuit. The PV generator partially distributes power to the load and the remains is transfered to the three phase grid. The load consists of non linear and unbalanced load. The non-linear load is a diode rectifier circuit with the RL load type, while the unbalanced load is a three phase RC load with different R value on each phase. To be economically efficient, PV generator must always work in maximum power point (MPP) condition. In this research, the MPPT method used is P and O algorithm. In order to operate properly, the UPQC device must have a minimum DC link voltage (V_{dc}). The value of common DC link voltage depends on the instantaneous energy avialable to the UPQC is defined by in Eq. 13 [12]:

$$V_{dc} = \frac{2\sqrt{2}\,V_{LL}}{\sqrt{3}m} \qquad (13)$$

where m is the modulation index and V_{LL} is the AC grid line voltage of UPQC. Considering modulation index as 1 and for line to line grid voltage (V_{LL} = 380 volt), the V_{dc} is obtained 620,54 volt and is selected as 650 volt.

The input of shunt active filter showed in Fig. 5 is DC voltage (V_{dc}) and reference DC voltage (V_{dc}^*), while the output is $\bar{p}_{loss}$ by using PI controller. Then, the $\bar{p}_{loss}$ is as one of input variable to generate the reference source current (I_{sa}^*, I_{sb}^*, and I_{sc}^*). The reference source current output is then compared to source current (I_{sa}, I_{sb}, and I_{sc}) by the current hysteresis control to generate trigger signal in IGBT circuit of shunt active filter. In this research, FLC as DC voltage control algorithm on shunt active filter is proposed and compared with PI controller. The FLC is capable to reduce oscilation and generate quick convergence calculation during disturbances. This method is also used to overcome the weakness of PI control in determining proportional constants (K_p) and intergral gain constant (K_i) which still use trial and error method.

II.6. Fuzzy Logic Controller

The research is started by determine $\bar{p}_{loss}$ as the input variable to result the reference source current on current hysteresis controller to generate trigger signal on the IGBT shunt active filter of UPQC using PI controller (K_p = 0.2 and K_i = 1.5). By using the same procedure, $\bar{p}_{loss}$ is also determined by using FLC. The FLC has been widely used in recent industrial processes because it has heuristic, simpler, more effective and has multi rule based variables in both linear and non-linear system variations. The main components of FLC are fuzzification, decision making (rulebase, database, reason mechanism) and defuzzification showed in Fig. 5.

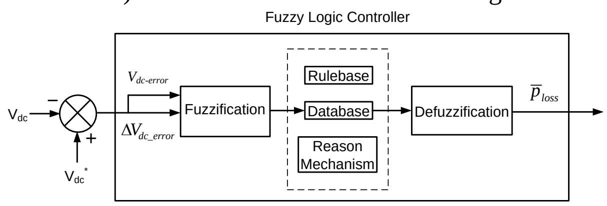

Fig 5. Diagram block of FLC

The fuzzy rule algorithm collects a number of fuzzy control rules in a particular order. This rule is used to control the system to meet the desired performance requirements and they are designed from a number of intelligent system control knowledge. The fuzzy inference of FLC using Mamdani method related to max-min composition. The fuzzy inference system in FLC consists of three parts: rule base, database, and reasoning mechanism. Rule base consists of a number of If-Then rule for proper operation of the controller. The If part of the rule is called antecedent and Then section is called consequence. A number of these rules can be considered as similar responses made by human thought processes and controllers using linguistic input variables, gaining after fuzzification for operation of those rules. The database consists of all user defined membership functions that will be used in a number of these rules. Reasoning mechanisms basically process the rules provided based on certain rules and given conditions that provide required results to user [15].

The FLC method is performed by determining input variables V_{dc} ($V_{dc\text{-}error}$) and delta Vdc ($\Delta V_{dc\text{-}error}$), seven linguistic fuzzy sets, operation fuzzy block system (fuzzyfication, fuzzy rule base and defuzzification), $V_{dc\text{-}error}$ and $\Delta V_{dc\text{-}error}$ during fuzzification process, fuzzy rule base table, crisp value to determine $\overline{p}_{loss}$ in defuzzification phase. The $\overline{p}_{loss}$ is one of input variable to obtain compensating currents $(i^{*}_{c\alpha}, i^{*}_{c\beta})$ in Eq. 11.

During fuzzification process, a number of input variables are calculated and converted into linguistic variables based on a subset called membership function. The error Vdc ($V_{dc\text{-}error}$) and delta error Vdc ($\Delta V_{dc\text{-}error}$) are proposed input variable system and output variable is $\overline{p}_{loss}$. To translate these variables, each input and output variable is designed using seven membership functions: Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (Z), Positive Small (PS), Positive Medium (PM) and Positive Big (PB). The membership functions of crisp input and output are presented with triangle and trapezoid membership functions. The value of $V_{dc\text{-}error}$ range from -650 to 650, $\Delta V_{dc\text{-}error}$ from -650 to 650, and $\overline{p}_{loss}$ from -100 to 100. The input and output MFs are shown in Fig. 6.

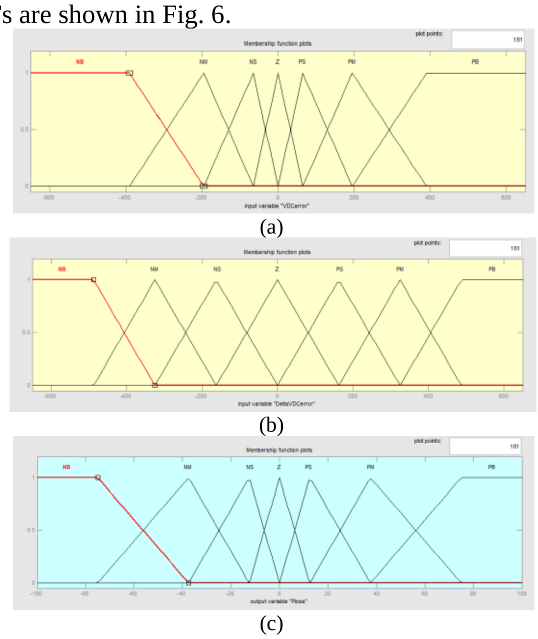

Fig. 6. MFs (a) $V_{dc\text{-}error}$, (b) $\Delta V_{dc\text{-}error}$, (c) and $\overline{p}_{loss}$

After the $V_{dc\text{-}error}$ and $\Delta V_{dc\text{-}error}$ are obtained, then two input membership functions are converted to linguistic variables and uses them as input functions for FLC. The output membership function is generated using inference blocks and the basic rules of FLC as shown in Table II. Finally the defuzzification block operates to convert generated $\overline{p}_{loss}$ output from linguistic to numerical variable again. Then it becomes input variable for current hysteresis controller to produce trigger signal on the IGBT circuit of UPQC shunt active filter to reduce source current and load voltage harmonics. While simultaneously improving power quality of 3P3W system under six interference scenarios due to integration of PV and BES into DC link circuit of UPQC.

TABLE II.
FUZZY RULE BASE

$V_{dc\text{-}error}$ / $\Delta V_{dc\text{-}error}$	NM	NB	NS	Z	PS	PB	PM
PM	Z	PS	PS	PM	PM	PB	PB
PB	NS	Z	PS	PS	PM	PM	PB
PS	NS	NS	Z	PS	PS	PM	PM
Z	NM	NS	NS	Z	PS	PS	PM
NS	NM	NM	NS	NS	Z	PS	PS
NB	NB	NM	NM	NS	NS	Z	PS
NM	NB	NB	NM	NM	NS	NS	Z

III.Result and Discussion

The analysis of proposed model is investigated through determination of six disturbance scenarios i.e. (1) NL, (2) Unba-NL, (3) Dis-NL, (4) Sag-NL, (5) Swell-NL, and (6) Inter-NL. Scenario 1, the system is connected a non-linear load with R_L and L_L of 60 Ohm and 0.15 mH respectively. Scenario 2, the system is connected to non-linear load and during 0.3 s since t = 0.2 s to t = 0.5 s connected to unbalance three phase load with R_1, R_2, R_3 as 6 Ohm, 12 Ohm, 24 Ohm respectively, and value of C_1, C_2, C_3 as 2200 µF. Scenario 3, the system is connected to non-linear load and source voltage generating 5th and 7th harmonic components with individual harmonic distortion values of 5% and 2% respectively. Scenario 4, the system is connected to non-linear load and source experiences a sag voltage disturbance of 50% for 0.3 s between t = 0.2 s to t = 0.5 s. Scenario 5, the system is connected to a non-linear load and source experiences a swell voltage disturbance of 50% for 0.3 s between t = 0.2 s to t = 0.5 s. Scenario 6, the system is connected to non-linear load and source experiences an interruption voltage interference of 100% for 0.3 s between t = 0.2 s to t = 0.5 S. Each scenario uses UPQC control with PI control and FLC so the total number of disturbances are 12 scenarios.

By using Matlab/Simulink, the system is then executed according to desired scenario to obtain curve of source voltage (V_s), load voltage (V_L), compensation voltage (V_c), source current (V_s), load current (I_L), and DC voltage DC link (V_{dc}). Then, THD value of source voltage, source current, load voltage, and load current in each phase as well as average THD value (Avg THD) are obtained base on the curves. THD in each phase is determined in one cycle started at t = 0.35 s. The results of average of source voltage, source current, load voltage, and load current on proposed systes of PV connected to DC link circuit without and with BES are presented in Table III and IV. Futhermore, THD in each phase and average THD of proposed system are showed in Table IV and IV.

TABLE III
VOLTAGE AND CURRENT OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITHOUT BES

Scenarios	Source Voltage V_S (Volt)				Load Voltage V_L (Volt)				Source Current I_S (Ampere)				Load Current I_L (Ampere)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	309.5	309.5	309.5	**309.5**	310.0	310.0	310.0	**310.0**	8.828	8.838	8.858	**8.841**	8.586	8.586	8.585	**8.586**
2. Unba-NL	307.8	307.8	307.8	**307.8**	310.2	310.2	310.3	**310.2**	32.15	26.66	30.71	**29.84**	22.65	34.26	34.70	**30.54**
3. Dist-NL	309.5	309.5	309.5	**309.5**	308.5	312.1	310.5	**310.5**	8.936	8.863	10.73	**9.510**	8.522	8.757	8.601	**8.627**
4. Sag-NL	153.8	153.8	153.8	**153.8**	310.1	310.1	310.1	**310.1**	13.39	13.33	13.41	**13.38**	8.589	8.589	8.588	**8.589**
5. Swell-NL	464.4	464.4	464.4	**464.4**	310.1	310.1	310.1	**310.1**	8.457	8.468	8.460	**8.462**	8.558	8.590	8.558	**8.587**
6. Inter-NL	1.190	1.316	1.237	**1.247**	229.2	249.1	242.8	**240.4**	11.31	11.86	11.91	**35.08**	6.443	6.698	6.289	**6.477**
Fuzzy Logic Controller																
1. NL	309.5	309.5	309.5	**309.5**	310.1	310.1	310.0	**310.1**	8.769	8.738	8.811	**8.773**	8.578	8.588	8.587	**8.584**
2. Unba-NL	307.3	307.8	307.8	**307.8**	310.2	310.3	310.2	**310.2**	32.01	26.66	30.65	**29.78**	22.65	34.65	34.69	**30.66**
3. Dist-NL	309.4	309.5	309.5	**309.5**	309.6	312.1	309.9	**310.5**	8.938	8.820	8.916	**8.891**	8.552	8.766	8.586	**8.635**
4. Sag-NL	153.8	153.8	153.8	**153.8**	310.1	310.0	310.1	**310.1**	13.52	13.46	13.56	**13.51**	8.558	8.587	8.589	**8.578**
5. Swell-NL	464.4	464.7	464.7	**464.7**	310.1	310.1	310.1	**310.1**	8.353	8.371	8.365	**8.363**	8.591	8.588	8.587	**8.589**
6. Inter-NL	1.259	1.285	1.530	**1.358**	209.9	193.7	242.7	**215.4**	13.28	11.49	14.07	**12.95**	6.459	5.003	6.299	**5.921**

TABLE IV
VOLTAGE AND CURRENT OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITH BES

Scenarios	Source Voltage V_S (Volt)				Load Voltage V_L (Volt)				Source Current I_S (Ampere)				Load Current I_L (Ampere)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	309.6	309.6	309.6	**309.6**	307.6	307.8	307.7	**307.7**	7.766	7.793	7.759	**7.773**	8.528	8.529	8.533	**8.530**
2. Unba-NL	307.4	308.0	308.0	**307.8**	308.3	308.7	308.3	**308.4**	31.00	24.84	28.73	**28.15**	22.50	34.12	34.52	**30.38**
3. Dist-NL	309.6	309.6	309.6	**309.6**	313,8	314.3	317.4	**317.4**	7.897	7.919	7.867	**7.895**	8.748	8.704	8.785	**8.746**
4. Sag-NL	154.5	154.5	154.5	**154.5**	307.1	307.3	307.3	**307.2**	7.235	7.276	7.226	**7.246**	8.509	8.514	8.510	**8.511**
5. Swell-NL	464.7	464.7	464.7	**464.7**	308.6	308.7	308.6	**308.6**	7.979	7.980	7.964	**7.975**	8.550	8.553	8.554	**8.553**
6. Inter-NL	0.5359	1.385	0.8501	**0.9238**	310.2	259.8	290.2	**286.7**	7.392	12.67	6.045	**8.703**	8.707	7.747	7.637	**8.031**
Fuzzy Logic Controller																
1. NL	309.5	309.5	309.5	**309.5**	307.7	307.9	307.7	**307.8**	8.420	8.426	8.416	**8.421**	8.527	8.532	8.531	**8.530**
2. Unba-NL	307.4	307.9	308.0	**307.8**	308.5	308.7	308.4	**308.5**	31.66	25.50	29.36	**28.84**	22.52	34.11	35.52	**30.72**
3. Dist-NL	309.6	309.5	309.5	**309.5**	313.4	312.9	315.9	**314.1**	8.516	8.565	8.496	**8.526**	8.741	8.677	8.736	**8.718**
4. Sag-NL	154.4	154.4	154.4	**154.4**	307.3	307.3	307.2	**307.3**	8.563	8.560	8.561	**8.561**	8.514	8.517	8.512	**8.515**
5. Swell-NL	464.6	464.6	464.6	**464.6**	308.6	308.8	308.6	**308.7**	8.396	8.389	8.389	**8.392**	8.552	8.556	8.554	**8.554**
6. Inter-NL	0.4467	0.3918	0.3801	**0.4062**	314.0	293.4	304.9	**304.1**	4.024	3.778	3.608	**3.804**	8.874	8.195	8.193	**8.421**

Table III shows that UPQC supplied by PV without BES in 3P3W system with PI and FLC control for interference scenarios 1 to 5 is able to result stable average load voltages above 310 volt. The difference is that in scenario 6 (Inter-NL), PI control generates load voltage of 240.4 volt and if using FLC drops to 215 volt. Reviewed from source current using PI control, the highest and lowest average source currents are generated by interference scenario 2 (Unba-NL) and 4 (Swell-NL) of 29.84 A and 8,462 A respectively. Otherwise if using FLC the highest and lowest average source current drops on same both disturbance scenarios of 29.78 A and 8.363 A respectively.

Table IV indicates that UPQC supplied by PV using BES in 3P3W system with PI and FLC controls for scenarios 1 to 5 is able to produce average load voltage above 307 V. While in scenario 6 (Inter-NL), FLC produces a higher average load voltage of 304.1 V than when using PI control of 286.7 volt PI. Reviewed from average source current with PI control, the highest and lowest average source current are generated by interference scenarios 2 (Unba-NL) and 4 (Sag-NL) of 28.15 A and 7,246 A respectively. While if using FLC, the highest and lowest average source current are achieved in scenario 2 (Unba-NL) and scenario 5 (Swell-NL) of 28.84 A and 8,392 A.

TABLE V
HARMONICS OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITHOUT BES

Scenarios	Source Voltage THD (%)				Load Voltage THD (%)				Source Current THD (%)				Load Current THD (%)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	0.79	0.79	0.79	**0.79**	0.83	0.83	0.82	**0.83**	11.07	10.79	10.95	**10.94**	22.31	22.31	22.32	**22.31**
2. Unba-NL	0.68	0.70	0.67	**0.69**	0.74	0.77	0.71	**0.74**	4.520	4.540	4.240	**4.44**	5.280	2.050	2.700	**3.34**
3. Dist-NL	5.41	5.44	5.52	**5.46**	4.18	9.93	3.93	**6.02**	10.61	10.91	10.73	**10.75**	22.70	20.86	21.07	**21.54**
4. Sag-NL	1.03	1.03	1.03	**1.03**	0.52	0.52	0.52	**0.52**	11.60	11.57	11.27	**11.48**	22.29	22.29	22.28	**22.49**
5. Swell-NL	0.69	0.69	0.70	**0.69**	1.08	1.09	1.09	**1.09**	11.38	11.42	11.63	**11.48**	22.32	22.30	22.32	**22.31**
6. Inter-NL	98.72	87.77	95.42	**93.97**	13.58	16.61	16.87	**15.69**	15.62	16.56	19.01	**17.07**	18.21	20.16	21.06	**19.81**
Fuzzy Logic Controller																
1. NL	0.79	0.78	0.77	**0.78**	0.82	0.82	0.80	**0.81**	11.73	10.83	11.06	**11.21**	22.23	22.32	22.32	**22.29**
2. Unba-NL	0.68	0.70	0.66	**0.68**	0.71	0.74	0.70	**0.72**	4.560	4.900	4.470	**4.65**	5.290	2.050	2.700	**3.35**
3. Dist-NL	5.41	5.43	5.52	**5.45**	3.54	10.34	3.92	**5.93**	10.92	10.51	10.66	**10.69**	22.78	20.77	21.30	**21.62**
4. Sag-NL	1.02	1.02	1.03	**1.02**	0.52	0.52	0.52	**0.52**	11.99	12.02	11.99	**12.00**	22.31	22.31	22.29	**22.30**
5. Swell-NL	0.67	0.69	0.69	**0.68**	1.06	1.08	1.08	**1.07**	11.65	11.49	11.79	**11.64**	22.30	22.32	22.31	**22.31**
6. Inter-NL	91.76	97.26	82.66	**90.56**	39.40	24.79	42.32	**35.51**	41.57	23.11	43.92	**36.20**	40.18	35.29	42.75	**48.98**

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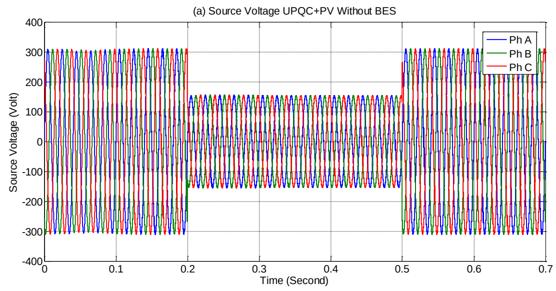
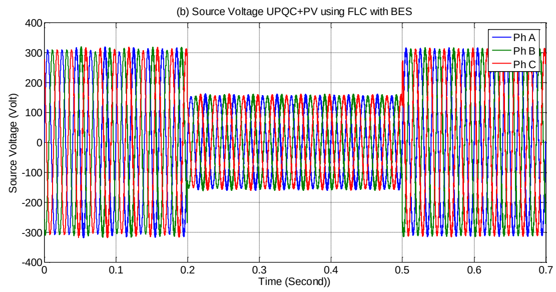
TABLE VI
HARMONICS OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITH BES

Scenarios	Source Voltage THD (%)				Load Voltage THD (%)				Source Current THD (%)				Load Current (%)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	2.35	2.36	2.32	**2.34**	2.48	2.50	2.46	**2.48**	12.89	12.72	12.92	**12.84**	22.32	22.34	22.32	**22.33**
2. Unba-NL	2.29	2.20	2.24	**2.24**	2.43	2.23	2.37	**2.34**	2.660	2.330	2.240	**2.410**	5.230	2.070	2.660	**3.320**
3. Dist-NL	5.84	5.86	5.94	**5.88**	6.36	5.90	6.58	**6.28**	12.75	12.64	13.06	**12.82**	21.92	22.16	22.33	**22.14**
4. Sag-NL	4.69	4.75	4.81	**4.75**	2.46	2.48	2.53	**2.49**	14.26	13.96	14.16	**14.13**	22.28	22.31	22.28	**22.29**
5. Swell-NL	1.56	1.53	1.55	**1.55**	2.47	2.43	2.45	**2.45**	12.51	12.36	12.44	**12.44**	22.34	22.32	22.32	**22.33**
6. Inter-NL	NA	NA	NA	**NA**	32.11	15.09	28.54	**25.25**	270.90	145.89	275.67	**230.82**	47.70	34.58	36.29	**39.53**
Fuzzy Logic Controller																
1. NL	2.35	2.33	2.35	**2.34**	2.48	2.46	2.49	**2.47**	11.83	11.82	11.84	**11.83**	22.33	22.32	22.33	**22.33**
2. Unba-NL	2.25	2.27	2.20	**2.24**	2.39	2.41	2.34	**2.38**	2.620	2.400	2.220	**2.413**	5.230	2.100	2.640	**3.323**
3. Dist-NL	5.83	5.88	5.93	**5.88**	6.23	5.93	6.69	**6.28**	11.83	11.90	12.14	**11.96**	21.84	22.34	22.53	**22.24**
4. Sag-NL	4.71	4.76	4.79	**4.75**	2.46	2.48	2.50	**2.48**	11.91	11.88	11.86	**11.89**	22.27	22.32	22.32	**22.31**
5. Swell-NL	1.55	1.54	1.54	**1.54**	2.45	2.44	2.46	**2.45**	11.90	11.84	11.85	**11.86**	22.36	22.33	22.35	**22.35**
6. Inter-NL	NA	NA	NA	**NA**	13.05	6.60	11.15	**10.27**	30.61	34.72	31.57	**32.30**	24.25	24.25	24.71	**24.40**

Table V presents that the average THD of load voltage (V_L) of UPQC supplied by PV without BES in 3P3W for interference scenarios 1 to 5 using PI control is within limits prescribe in IEEE 519. In this condition PI controller is also capable to maintain and improve the average THD of load voltage within the limits of IEEE 519. The highest and lowest average THD load voltages is achieved under scenario interruption conditions 6 (Inter-NL) and scenario 2 (Unba-NL) as 15.69% and 0.74% respectively. PI controller is also able to reduce average THD source voltage in scenario 6 (Inter-NL) by 93.97% to 15.69% on the load side. The highest and lowest average THD of source current are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) as 17.07% and 4.44% respectively. Table V also shows that average THD of load voltage of UPQC system supplied by PV without BES using FLC in disturbance scenarios 1 to 5, has fulfilled limits prescribed in IEEE 519. FLC method is also capable of maintaining and improving average THD of load voltage within the IEEE 519 limit. The highest and lowest average THD of load voltage are achieved under scenario 6 (Inter-NL) and scenario 4 (Sag-NL) of 35.51% and 0.52. The implementation of FLC method is also able to reduce average THD on source voltage in scenario 6 (Inter-NL) by 90.56% to 35.51% on load side. The highest and lowest average THD source current are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 36.20% and 4.65%. UPQC system supplied by PV without BES in six interference scenarios using PI control and FLC is able to improve average THD of source current better on average THD of load current.

Table VI shows that average THD of load voltage (V_L) of UPQC supplied by PV with BES in 3P3W system for interference scenarios 1 to 5 using PI control is within limits prescribe in IEEE 519. In this condition PI controller is also capable to maintain average THD of load voltage within limit of IEEE 519. The highest and lowest average THD load voltages are achieved under scenario 6 (Inter-NL) and scenario 2 (Unba-NL) as 25.25% and 2.34% respectively. PI controller is also able to migitate average THD source voltage in scenario 6 (Inter-NL) from not accessible (NA) to 25.25% on the load side. The highest and lowest average THD of source current are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) as 230.82% and 2.41% respectively. Table VI also indicates that average THD of load voltage of UPQC system supplied by PV with BES using FLC in disturbance scenarios 1 to 5, has fulfilled limits prescribed in IEEE 519. FLC method is also capable to keep average THD of load voltage within IEEE 519. The highest and lowest average THD of load voltage are achieved under scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 10.27% and 2.38%. The use of FLC method is also able to reduce average THD on source voltage in scenario 6 (Inter-NL) from NA to 10.27% on load side. The highest and lowest average THD of source current are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 32.30% and 2.413%. UPQC system supplied by PV with BES in six interference scenarios using PI control and FLC is able to improve average THD of source current better on average THD of load current. Fig. 7 and Fig. 8 present UPQC-PV performance using FLC without and with BES in scenario 4 (Sag-NL) and scenario 6 (Inter-NL).





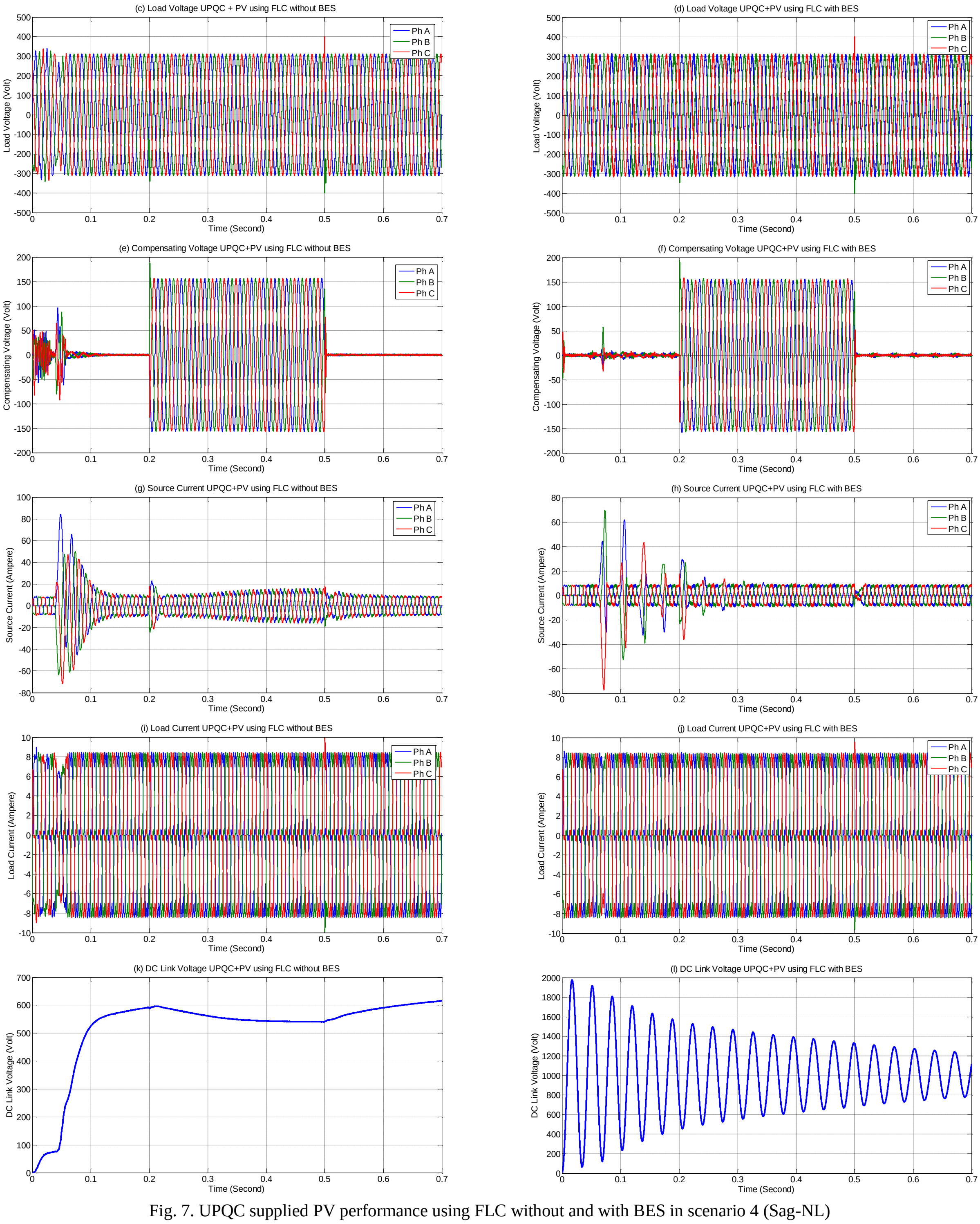
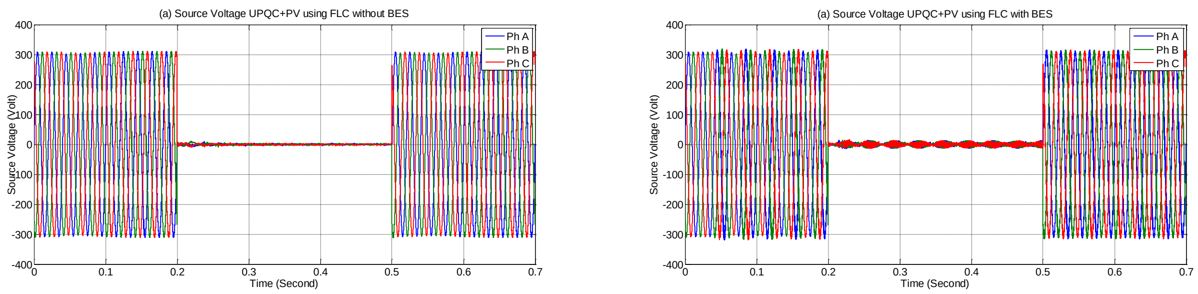


Fig. 7. UPQC supplied PV performance using FLC without and with BES in scenario 4 (Sag-NL)



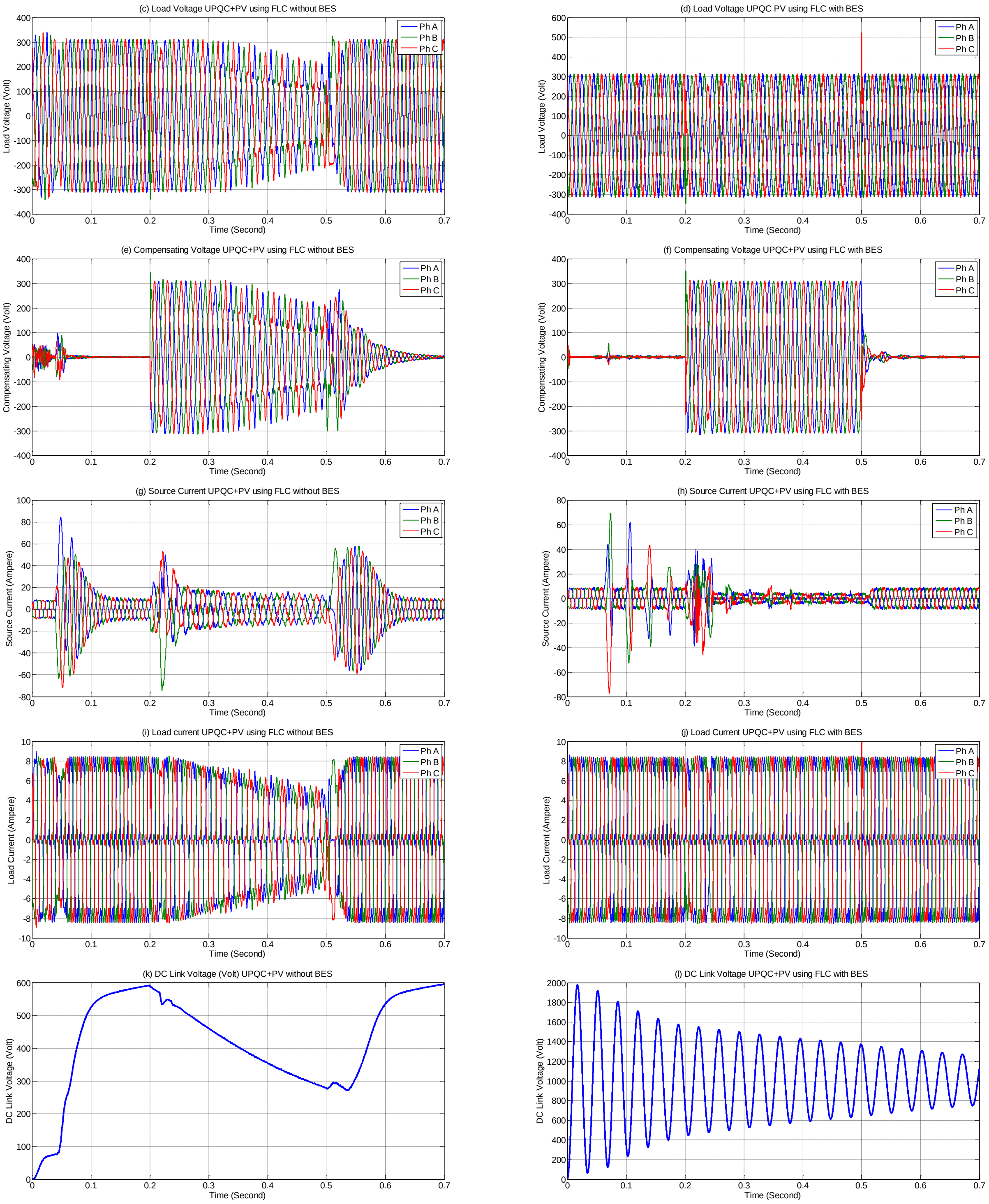
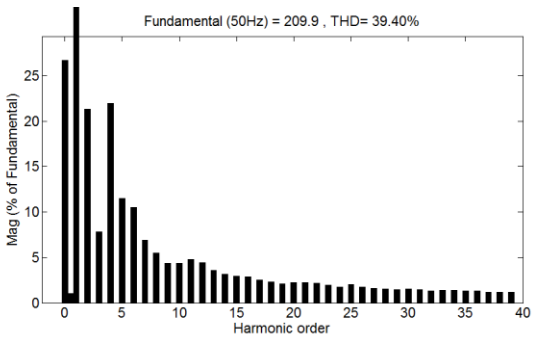


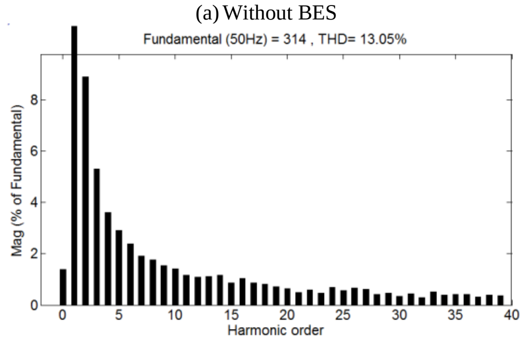
Fig. 8. UPQC supplied PV performance using FLC without and with BES in scenario 6 (Inter-NL)

Fig. 7a presents that in scenario 4 (Sag-NL), UPQC supplied by PV without BES at t = 0.2 s to t = 0.5 s avarage source voltage (V_S) drops 50% from 310.1 V to 153.8 V. In this condition, PV is capable of generating power to the UPQC DC link circuit and injecting compensation voltage (V_C) as 153.8 V (Fig.78e) through injection transformer on series active filter so that average load voltage (V_L) remains stable at 310.1 V (Fig.8c). During this time, FLC on shunt active filter works to keep DC link voltage stable and average source current (I_S) increases approach to 13.28 A (Fig. 7g) in order to keep average load current (I_L) stable by 8.589 A (Fig. 7i). Fig. 8b in scenario 4 (Sag-NL) using BES also shows almost same result performance on average compensated voltage values (V_C), average load voltage (V_L), and average load current (I_L) presented in Fig. 7f, Fig. 7d, and Fig. 7j respectively. The different is average source current (I_S) is slightly decreased to 8.561 A (Fig. 8h). The addition of BES besides capable to store excess power from PV generator, also serves to inject current into load through DC link (Fig. 7l) and shunt ative filter to produce average load current (I_L) equal to 8.515 A.

Fig. 8a shows that in scenario 6 (Inter-NL) UPQC supplied PV by without BES at t = 0.2 s to t = 0.5 s, average source voltage (V_S) falls as 100% to 1.358 V. In this condition PV is unable to generate maximum power to UPQC DC link and inject average compensation voltage (V_C) in Fig 8e through injection transformer on series active filter. So at t = 0.2 s to t = 0.5, average load voltage (V_L) in Fig. 8c decrease to 215.4 V. During the disturbance, implementation of FLC on shunt active filter keeps maintenance a DC link voltage (Fig 8k), interruption voltage causes average source current (I_S) decrease to 12.29 A (Fig. 8g) so that average load current (I_L) also decreases to 5.921 A (Fig. 8i). Fig. 9b on UPQC supplied by PV with BES at t = 0.2 s to t = 0.5 s average source voltage (V_S) also drops 100% to 0.4062 V. During the disturbance, PV is able to generate power to UPQC DC link and injecting full average compensation voltage (V_C) in Fig. 9f through injection transformer on series active filter so that average load voltage (V_L) remains stable at 304.1 V (Fig. 8d). As long fault period, although nominal of average source current (I_S) drops to 3.804 A, combination of PV and BES is able to generate power, store excess energy of PV, and inject current into load through shunt active filter so that average load current (I_L) in Fig. 8l remains as 8.421 A. Fig. 9 shows spectra of load voltage harmonics on phase A of UPQC supplied by PV using FLC without and with BES in scenario 6.



(a) Without BES



(b) With BES

Fig. 9. Spectra of load voltage harmonics on phase A UPQC supplied PV using FLC in scenario 6 (Inter-NL)

Fig. 10 and Fig. 11 show performance of average THD of load voltage and source current on UPQC supplied by PV using PI control and FLC without and with BES in six disturbance scenarios.

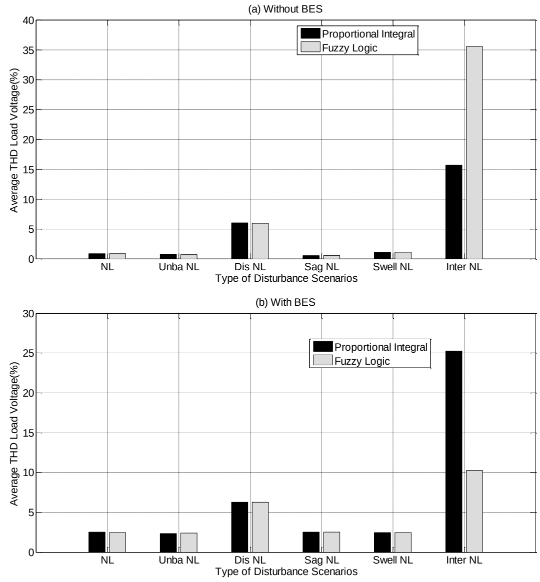


Fig. 10. Performance of average THD of load voltage of UPQC supplied by PV using PI and FLC in six disturbance scenarios

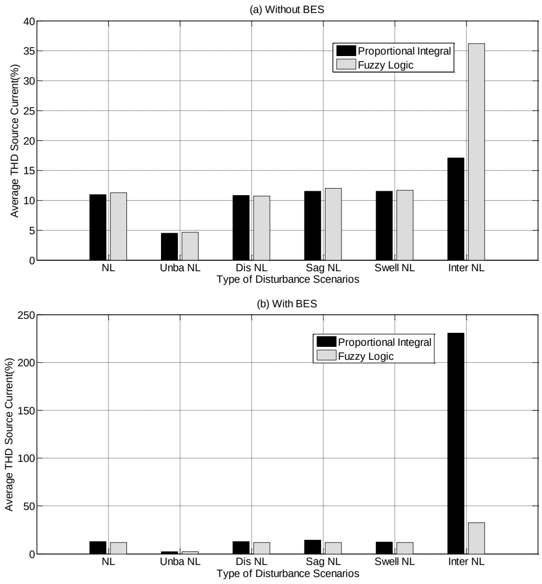


Fig. 11. Performance of average THD of source current of UPQC supplied by PV using PI and FLC in six disturbance scenarios

Fig. 10a shows that in scenario 1(NL), scenario 2 (Unba-NL), scenario 3 (Dis-NL), scenario 4 (Sag-NL), and scenario 5 (Swell-NL), implementation of FLC on UPQC supplied by PV without BES able to result average THD of source voltage slightly better than PI controller and also limits prescribe in IEEE 519. Otherwise under scenario 6 (Inter-LN) PI controller give better significantly result of average THD of source voltage than FLC. Fig. 10b shows that in six scenarios, the use of FLC on UPQC supplied by PV with BES able to result average THD of source voltage slightly better than PI controller. In disturbance scenario 1 to 5, nominal of average THD of load voltage have met IEEE 519. Otherwise under scenario 6 (Inter-NL) FLC able to reduce average THD of load voltage significantly than PI controller.

Fig. 11a presents that in scenario 1(NL), scenario 2 (Unba-LN), scenario 3 (Dis-NL), scenario 4 (Sag-NL), and scenario 5 (Swell-NL), implementation of PI controller on UPQC supplied by PV without BES able to result average THD of source current slightly better than FLC. Otherwise under scenario 6 (Inter-LN) PI controller give better significantly result of average THD of source voltage than PI. Fig. 11b shows that in six scenarios, the use of FLC on UPQC supplied by PV with BES is able to give average THD of source current better than PI controller. Futhermore under scenario 6 (Inter-NL), FLC able to reduce average THD of source current significantly than PI controller.

IV. Conclusion

The use of BES supplied by PV connected to a three phase grid through to DC link of UPQC to improve power quality with PI controller and FLC already have been discussed. In scenario 6, PV is able to generate power to UPQC-DC link and injecting full average compensation voltage through injection transformer on series active filter so that average load voltage remains stable. During interuption voltage, even though there is low source current, combination of PV and BES is able to deliver power, store excess energy of PV, and inject compensation current into load bus through shunt active filter. The implementation of FLC on UPQC supplied PV with BES results average THD of load voltage slightly lower than using PI controller. In disturbance scenario 1 to 5, implementation of FLC method UPQC supplied PV with BES is able to reduce average THD of load voltage slightly better than PI controller and has already met the limits prescribed in IEEE 519. Otherwise under scenario 6, FLC method able to reduce average THD of load voltage significantly than PI controller. In disturbance scenario 1 to 5, this method is able to give average THD of source current better than PI controller. Futhermore under scenario 6, It is also capable to give better performance significantly of average THD of source current than PI controller.

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High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller

Amirullah[1,2], Ontoseno Penangsang[1], Adi Soeprijanto[1]

Abstract – *This paper proposes the use a of Battery Energy Storage (BES) on an Unified Power Quality Conditioner (UPQC) supplied by Photovoltaic (PV) through DC link to improve power quality on a three-phase three-wire (3P3W) distribution system. The BES serves to store the excess of power resulted by PV and to transfer it to load if necessary, preventing voltage interruption, and adjusting charging and discharging energy in battery. Power quality analysis is carried out in two conditions i.e. PV connected to DC link without and with BES. Fuzzy Logic Controller (FLC) is implemented to maintain DC voltage across the capacitor under disturbance scenarios of source and load as well as to compare the results with Proportional Intergral (PI) controller. The number of disturbance scenarios are six for each UPQC controller, so the total number of disturbances is 12. The six disturbances are: non-linear load (NL), unbalance and nonlinear load (Unba-NL), distortion supply and non-linear load (Dis-NL), sag and non-linear load (Sag-NL), swell and non-linear load (Swell-NL), and interruption and non-linear load (Inter-NL). FLC method on UPQC supplied by PV with BES is able to result in an average THD of load voltage slightly better than PI controller. In disturbance scenario 1 to 5, nominal of average THD of load voltage have met IEEE 519. FLC method on UPQC supplied by PV with BES is also capable to give average THD of source current better than PI controller. Under scenario 6 (Inter-NL), FLC is able to reduce the average THD of load voltage and source current significantly than PI controller. With the same disturbance, the combination of PV and BES is able to generate power to UPQC DC link and to inject full average compensation voltage through injection transformer on series active filter so that average load voltage remains stable. This simulations prove that the proposed artificial intelligent (AI) controller for UPQC with BES is able to improve power quality significantly under varying disturbances especially for interruption disturbance. The performance of the proposed model is validated and investigated through simulations using Matlab/Simulink.*

***Keywords**: Power Quality, UPQC, PV, BES, Total Harmonic Distortion (THD), Disturbance Scenarios*

Nomenclature

I_{PV}	Photovoltaic current
I_o	Saturated reverse current
N_S	Number of series cells
q	Electron charge
K	Boltzmann constant
T	Temperature of p–n junction
I_{SC}	Short circuit curret
V_{OC}	Open circuit voltage
$\mathrm{V_m}$	Peak magnitude of fundamental input voltage
$\mathrm{V_{Labc}}^*$	Reference load voltages in *abc*
$\mathrm{V_{Labc}}$	Sensed load voltages in *abc*
V_{abc}	Voltages in cartesian *abc*
I_{abc}	Currents in cartesian *abc*
$V_{\alpha\beta}$	Voltages in cartesian *αβ*
$I_{\alpha\beta}$	Currents in cartesian *αβ*
p	Real power
q	Imaginary power
$\bar{p}$	Direct component of real power
$\tilde{p}$	Fluctuating component of real power
$\bar{q}$	Direct component of imaginary power
$\tilde{q}$	Fluctuating component of imaginary power
$\bar{p}_{loss}$	Instantaneous active power corresponds to resistive loss and switching loss of UPQC
$i^*_{c\alpha\beta}$	Compensating currents in cartesian *αβ*
i^*_{sabc}	Reference source currents in *abc*
i_{sabc}	Sensed source currents in *abc*
$\mathrm{V_{dc}}$	Dc link voltage
$\mathrm{V_{LL}}$	Line-line grid voltage
m	Modulation index
K_p	Proportional gain constant
K_i	Integral gain constant
$\mathrm{V_{dc\text{-}error}}$	Error Vdc
$\Delta\mathrm{V_{dc\text{-}error}}$	Delta error Vdc
$\mathrm{V_S}$	Source voltage
V_L	Load voltage
I_S	Source current
I_L	Load current
V_c	Compensation voltage

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THD Total harmonic distortion
PCC Point common coupling

I. Introduction

The microgrid power systems use distributed generations (DGs) power source where power is supplied to local loads and it may operate separately from conventional grid systems. DGs have many benefits: for example, it is capable of reducing transmission costs, it has low investment costs, it reduces line losses and it increases grid reliability. DGs that use renewable energy (RE) able to generate electrical power are classified as DGs sources. The solar or photovoltaic (PV) generator is one of the most potential DGs sources technologies because it only needs sunlight to generate electricity, where the resources are available in abundance, they are free and relatively clean. Indonesia has an enormous energy potential from the sun because it lies on the equator. Almost all areas of Indonesia get sunlight about 10 to 12 hours per day, with an average intensity of irradiation of 4.5 kWh/m^2 or equivalent to 112,000 GW. Even though PV generator is capable to generate power, it also has a weakness: it produces a number of voltage and current disturbances, as well as harmonics due to the presence of several types of PV devices and power converters as well as increasing a number of non-linear loads connected to the grid causing a decrease in power quality.

In order to overcome this problem and to improve power quality due to presence of non-linear loads and integration of PV generator to grid, UPQC is proposed. UPQC serves to compensate problems of source voltage quality, for example sag, swell, unbalance, flicker, harmonics, as well as problems of load current quality such as harmonics, unbalance, reactive currents, and neutral currents. UPQC is part of the active power filter consisting of shunt and series active power filters connected in parallel and it serves as a superior controller to overcome a number of power quality problems simultaneously [1]. UPQC series component is responsible to reduce a number of interference on source side; voltage sag/swell, flicker, unbalanced voltage, and harmonics. This equipment serves to inject a number of voltages to keep load voltage fixed at the desired level in a balanced and distortion free. UPQC shunt component is responsible for addressing current quality problem: low power factor, load current harmonics, and unbalanced load. This device serves to inject current on AC system so that source current becomes sinosioda balanced and in phase with source voltage [2].

UPQC based on RE has been investigated by many researchers. There are two methods used to overcome the problem by using conventional and artificial intelligence controller. [3] deals with the analysis of UPQC and DG combination operations . The proposed system includes a series inverter, shunt inverter, and a DG connected to a DC link through a rectifier using PI controller. The system has been capable to increase source voltage quality (sag and interruption) and load current quality, as well as to change in active power on grid and off grid mode. The influence of DG on UPQC performance in reducing the sag voltage under conditions of some phase to ground faults to using distributed static compensator (DSTATCOM) controller has been implemented [4]. The DG has been effective enough to help UPQC work in improving sag voltage. DG system is connected in series with load resulting to have a better percentage of sag mitigation compared to the system without using DG. The implementation of UPQC using unit vector template generation (UVTG) method with PI controller to improve sag, swell, voltage harmonics and current harmonics has been done [5]. The simulation of voltage distortion has been made by adding 5th and 7th harmonics at fundamental source voltage, resulting in a reduction of THD source current and THD load voltage.

UPQC supplied by a 64 panels PV using boost converter, PI controller, perturb and observer MPPT, and instantaneous reactive power theory (p-q theory) has been proposed [6]. The system has been capable to compensate reactive power and reduce source current and load voltage harmonics. Nevertheless, the study has not discussed the mitigation of sag and interruption caused by penetration of PV. Artificial neural network (ANN) based synchronous reference frame theory (SRF) control strategy to compensate power quality issues in three phase three wire (3P3W) distribution system through UPQC for various balanced/unbalance/distorted conditions on load and source has been proposed [7]. The proposed model has been able to mitigate harmonic/reactive currents, unbalanced source and load current/voltage. Investigation on power quality enhancement includes sag and source voltage harmonics on grid using UPQC supplied by PV array connected to DC link using PI compared with FLC have been done [8]. The simulation shows that FLC on UPQC and PV can improve source voltage THD better than PI.

[9] shows a method to balance current and line voltage, as a result of DGs of a single phase PV generator unit randomly installed in houses through a three-phase four-wire 220 kV and 50 Hz distribution line using BES and three single-phase bidirectional inverters. Both devices have been capable to reduce unbalanced line current and unbalanced line voltage. Both combination have also been able to increase current and voltage harmonics on PCC bus. Improvement of power quality UPQC on microgrid supplied by PV and wind turbine has been implemented. PI and FLC are able to improve power quality and to reduce distortion in output power [10].

This research investigates the use of BES on UPQC supplied by PV through to DC link to improve power quality on three-phase three-wire (3P3W) distribution system. PV array generates power under constant temperature and irradiance, connected to BES through a DC/DC boost converter that serves to regulate PV operating point. BES serves to store excess energy produced by PV and to distribute it to load if necessary, in order to prevent interruption voltage, and to adjust charging and discharging of energy in battery. BES is also expected to store excess power produced by PV generator, using them as backup power. FLC is proposed and compared with PI method, because PI controller is weak in determining proportional and integral gain constant which still uses trial and error. FLC is used as a controller variable of DC voltage and DC reference voltage input to generate reference current source in current hysteresis controller circuit on shunt active filter. FLC methods are used as DC voltage controllers in shunt active filter and series active filter to mitigate power quality of load voltage and source current. The number of disturbance scenario is six for each UPQC controller, so the total number is 12.

The power quality performance of two controllers are used to determine load voltage, source current, load voltage THD, and source current THD based on IEEE 519. Section II describes the proposed method, the model of UPQC supplied by PV and BES, the simulation parameters, the PV circuit model, the control of series and shunt active filter, as well as the application of PI and FLC method for the proposed model. Section III shows the results and the discussion about THD analysis on the proposed model of PV connected to DC link circuit without and with BES using PI controller and FLC. In this section, six disturbance scenarios are presented and the results are verified with Matlab/Simulink. Finally, the paper is concluded in Section IV.

II. Proposed Method

II.1. Proposed Model

Fig. 1 shows the model proposed in this study. DG based on RE is a PV connected to a 3P3W distribution system with 380 volts (L-L) and a frequency of 50 hertz, through DC link UPQC and BES circuit. PV array generates power under fixed temperature and irradiance and it is connected to BES through a DC/DC boost converter. The maximum power point tracking (MPPT) method with Pertub and Observer (P and O) algorithms helps PV to generate the maximum power and to generate an output voltage, as an input voltage for the DC/DC boost converter. The converter functions to adjust duty cycle value and output voltage of PV generator as its input voltage to produce output voltage according DC link voltage of UPQC.

The BES connected to UPQC DC link circuit serves as an energy storage and it is expected to overcome voltage interruption and to help UPQC performance to enhance voltage and current power quality at source and load bus. The simulation parameters of the proposed model are showed in Table I. Power quality analysis is performed on PV connected to 3P3W system through UPQC DC link circuit (on-grid), under two conditions i.e. with and without BES. A single phase circuit breaker is used to connect and disconnect PV with BES. Each condition consists of six disturbance scenarios: NL, Unba-NL, Dis-NL, Sag-NL, Swell-NL, and Inter-NL. FLC is used as DC voltage controls in shunt active filter to improve the power quality of the load voltage and source current and they are compared to PI controller. Each scenario uses UPQC controller with PI controller and FLC so there are 12 disturbances in total. The parameters include: voltage and current on source or PCC bus, voltage and current on load bus, voltage harmonics and current harmonics on source bus and voltage harmonics and current harmonics on load bus. The next step is to compare the two controller performances on UPQC to enhance power quality of load voltage and source current under six disturbance conditions.

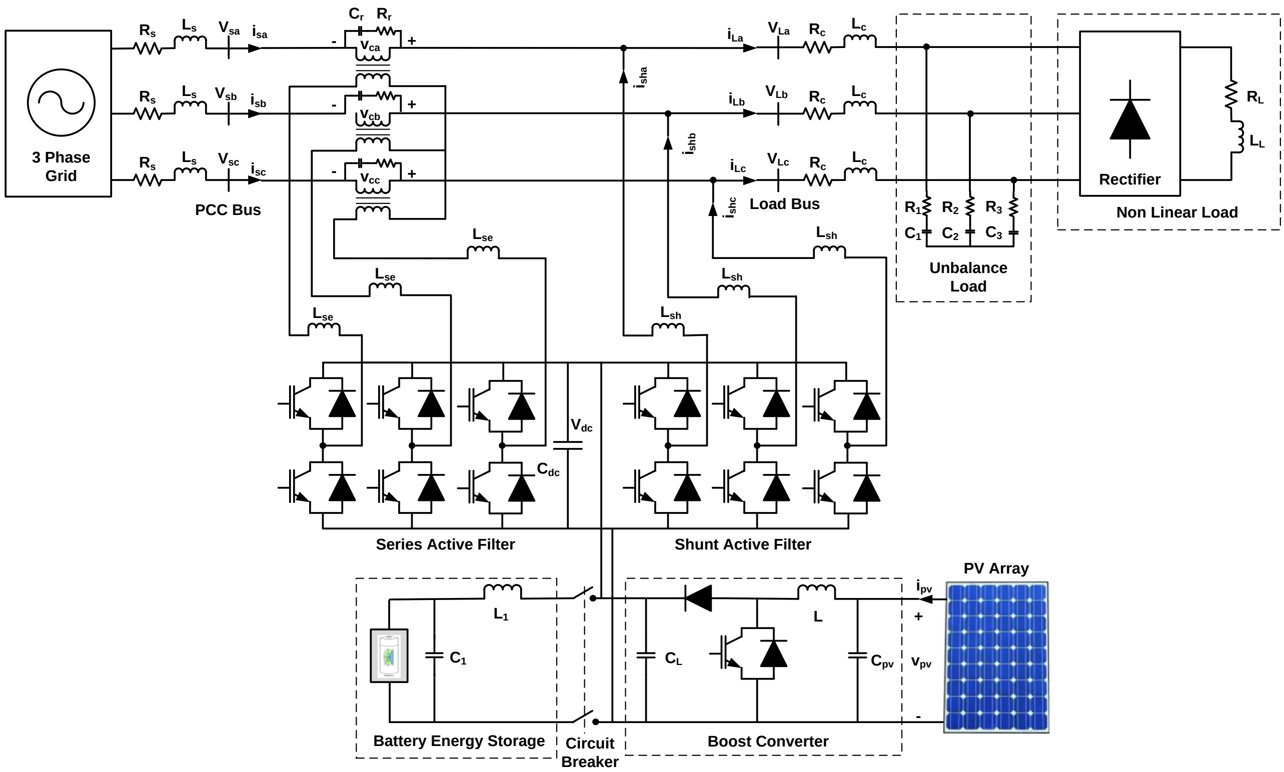


Fig 1. Proposed model of UPQC supplied by PV and BES

TABLE I
SIMULATION PARAMETERS

Devices	Parameters	Design Values
Three Phase Grid	RMS Voltage (LL)	380 Volt
	Frequency	50 Hz
	Line Impedance	R_s = 0.1 Ohm
		L_s = 15 mH
Series Active Filter	Series Inductance	L_{se} = 0.015 mH
Shunt Active Filter	Shunt Inductance	L_{sh} = 15 mH
Injection Transformers	Rating kVA	10 kVA
	Frequency	50 Hz
	Turn Ratio (N_1/N_2)	1 : 1
Non Linear load	Resistance	R_L = 60 Ohm
	Inductance	L_L = 0.15 mH
	Load Impedance	R_c = 0.4 Ohm
		L_c = 15 mH
Unbalance Load	Resistance	R_1 = 24 Ohm
		R_2 = 12 Ohm
		R_3 = 6 Ohm
	Capacitance	C_1,C_2, C_3 = 2200 µF
DC Link	DC Voltage	V_{DC} = 650 Volt
	Capacitance	C_{DC} = 3000 µF
Battery Energy Storage	Type	Nickel Metal Hibrid
	DC Voltage	650 V
	Rated Capacity	200 Ah
	Initial SOC	100%
	Inductance	L_1 = 6 mH
	Capacitance	C_1 = 200 µF
PV Generator	Active Power	0.6 kW
	Temperature	25^0 C
	Irradiance	1000 W/m^2
PI Parameters	K_p Gain Constant	0.2
	K_i Gain Constant	1.5
Fuzzy model	Method	Mamdani
	Composition	Max-Min
Input membership function	Error (V_{dc})	trapmf, trimf
	Delta Error (ΔV_{dc})	trapmf, trimf
Output membership function	Power Loss (P_{loss})	trapmf,trimf

II.2. Photovoltaic Model

Fig. 2 shows the equivalent circuit of a solar panel. A solar panel is composed by several PV cells that have series, parallel, or series-parallel external connections [11].

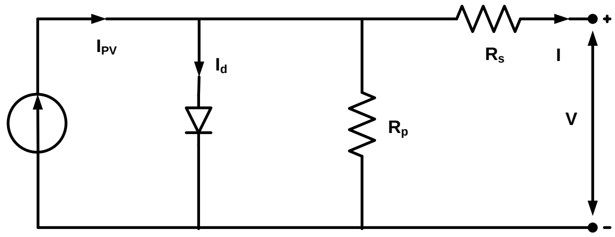


Fig 2. Equivalent circuit of solar panel

Eq. 1 shows V-I characteristic of a solar panel [11].

$$I = I_{PV} - I_o\left[\exp\left(\frac{V + R_S I}{aV_t}\right) - 1\right] - \frac{V + R_S I}{R_P} \tag{1}$$

where I_{PV} is the photovoltaic current, I_o is saturated reverse current, 'a' is the ideal diode constant, V_t = $N_S KTq^{-1}$ is the thermal voltage, N_S is the number of series cells, q is the electron charge, K is the Boltzmann constant, T is the temperature of p–n junction, R_S and R_P are series and parallel equivalent resistance of the solar panels. I_{PV} has a linear relation with light intensity and also varies with temperature variations. I_o is dependent on temperature variations. The values of I_{pv} and I_o are calculated as:

$$I_{PV} = (I_{PV,n} + K_1 \Delta T)\frac{G}{G_n} I \quad (2)$$

$$I_o = \frac{I_{SC,n} + K_I \Delta T}{\exp(V_{OC,n} + K_V \Delta T)/aV_t - 1} \quad (3)$$

In which $I_{PV,n}$, $I_{SC,n}$ and $V_{OC,n}$ are photovoltaic current, short circuit current and open circuit voltage in standard conditions (T_n = 25 C and G_n = 1000 Wm^{-2}) respectively. K_I is the coefficient of short circuit current to temperature, $\Delta T = T - T_n$ is the temperature deviation from standard temperature, G is the light intensity and K_V is the ratio coefficient of open circuit voltage to temperature. Open circuit voltage, short circuit current and voltage-current corresponding to the maximum power are three important points of I-V characteristic of solar panel. These points are changed by the variations of atmospheric conditions. By using Eq. 4 and 5, which are derived from PV model equations, short circuit current and open circuit voltage can be calculated in different atmospheric conditions.

$$I_{SC} = (I_{SC} + K_1 \Delta T)\frac{G}{G_n} \quad (4)$$

$$V_{OC} = V_{OC} + K_V \Delta T \quad (5)$$

II.3. Control of Series Active Filter

The main function of series active filter is the sensitive load protection against a number of interference at PCC bus voltage. The control strategy algorithm of the source and load voltage harmonics in series active filter circuit is shown in Fig. 3. It extracts the unit vector templates from the distorted input supply Furthermore, the templates are expected to be ideal sinusoidal signal with unity amplitude. The distorted supply voltages are measured and divided by the peak amplitude of fundamental input voltage V_m given by Eq. 6 [6].

$$V_m = \sqrt{\frac{2}{3}\left(V_{sa}^2 + V_{sb}^2 + V_{sc}^2\right)} \quad (6)$$

A three phase locked loop (PLL) is used in order to generate sinusoidal unit vector templates with a phase lagging by the use of sinus function. The reference load voltage signal is determined by multiplying the unit vector templates with the peak amplitude of the fundamental input voltage V_m. The load reference voltage ($V_{La}{}^*$, $V_{Lb}{}^*$, $V_c{}^*$) is then compared to the sensed load voltage (V_{La}, V_{Lb}, V_{Lc}) by a pulse width modulation (PWM) controller used to generate the desired trigger signal on the series active filter.

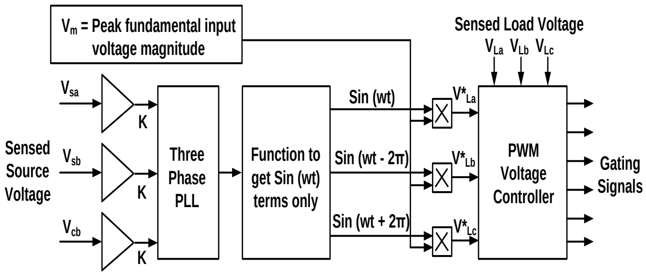


Fig 3. Control strategy of series active filter

II.4. Control of Shunt Active Filter

The main function of shunt active filter is the mitigation of power quality problems on the load side. The control methodology in shunt active filter is that the absorbed current from the PCC bus is a balanced positive sequence current including unbalanced sag voltage conditions in the PCC bus or unbalanced conditions or non-linear loads. In order to obtain satisfactory compensation ceased by disturbance due to non-linear load, many algorithms have been used in literature. This research used the instantaneous reactive power theory method "p-q theory". The voltages and the currents in Cartesian *abc* coordinates can be transformed to Cartesian $\alpha\beta$ coordinates as expressed in Eq. 7 and 8 [6].

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 1 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \quad (7)$$

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 1 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{bmatrix} \quad (8)$$

Eq. 9 shows the computation of real power (p) and imaginary power (q). Real and imaginary power are measured instantaneously in matrix and their form is given. Eq. 10 shows the presence of oscillating and average components in instantaneous power [13].

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (9)$$

$$p = \bar{p} + \tilde{p} \quad ; \quad q = \bar{q} + \tilde{q} \quad (10)$$

Where $\bar{p}$ is the direct component of real power, $\tilde{p}$ is the fluctuating component of real power, $\bar{q}$ is the direct component of imaginary power, $\tilde{q}$ is the fluctuating component of imaginary power. The total imaginary power (q) and the fluctuating component of real power are selected as power references and current references and they are utilized through the use of Eq. 11 to compensate harmonic and reactive power [14].

$$\begin{bmatrix} i_{c\alpha}^* \\ i_{c\beta}^* \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} -\tilde{p} + \bar{p}_{loss} \\ -q \end{bmatrix} \quad (11)$$

The signal $\bar{p}_{loss}$ is obtained from voltage regulator and it is utilized as average real power. It can also be specified as the instantaneous active power which corresponds to the resistive loss and the switching loss of the UPQC. The error obtained on comparing the actual DC-link capacitor voltage with the reference value is processed in FLC, engaged by voltage control loop as it minimizes the steady state error of the voltage across the DC link to zero. The compensating currents ($i^*_{c\alpha}, i^*_{c\beta}$) required to meet the power demand of load are shown in Eq. 11. These currents are represented in α-β coordinates. Eq. 12 is used to acquire the phase current required for compensation. These source phase currents ($i^*_{sa}, i^*_{sb}, i^*_{sc}$) are represented in a-b-c axis obtained from compensating current in the α-β coordinates in Eq. 12 [14].

$$\begin{bmatrix} i^*_{sa} \\ i^*_{sb} \\ i^*_{sc} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -1/2 & \sqrt{3}/2 \\ -1/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i^*_{c\alpha} \\ i^*_{c\beta} \end{bmatrix} \quad (12)$$

Fig. 4 shows a control of shunt active filter.

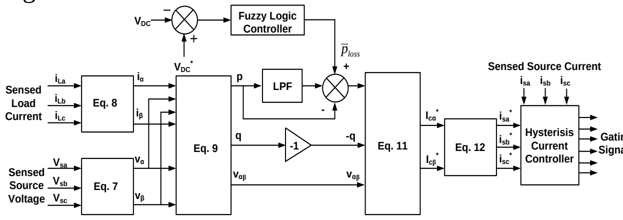


Fig 4. Control strategy of shunt active filter

The proposed model of UPQC supplied by PV and BES is shown in Fig 1. From the figure it can be seen that the PV and BES are connected to the DC link through a DC-DC boost converter circuit. The PV generator partially distributes power to the load and the remaining is transferred to the three phase grid. The load consists of non linear and unbalanced load. The non-linear load is a diode rectifier circuit with the RL load type, while the unbalanced load is a three phase RC load with different R value on each phase. In order to be economically efficient, PV generator must always work in maximum power point (MPP) condition. In this research, the MPPT method used is P and O algorithm. In order to operate properly, the UPQC device must have a minimum DC link voltage (V_{dc}). The value of common DC link voltage depends on the instantaneous energy avialable to the UPQC is defined by Eq. 13 [12]:

$$V_{dc} = \frac{2\sqrt{2}V_{LL}}{\sqrt{3}m} \quad (13)$$

where m is the modulation index and V_{LL} is the AC grid line voltage of UPQC. Considering modulation index as 1 and for line to line grid voltage (V_{LL} = 380 volt), the V_{dc} is obtained 620,54 volt and is selected as 650 volt.

The input of shunt active filter showed in Fig. 5 is DC voltage (V_{dc}) and reference DC voltage (V_{dc}^*), while the output is $\bar{p}_{loss}$ by using PI controller. Then, the $\bar{p}_{loss}$ is a variable input to generate the reference source current (I_{sa}^*, I_{sb}^*, and I_{sc}^*). The reference source current output is then compared to sensed source current (I_{sa}, I_{sb}, and I_{sc}) by the current hysteresis control to generate trigger signal in IGBT circuit of shunt active filter. In this research, FLC as DC voltage control algorithm on shunt active filter is proposed and compared with PI controller. The FLC is capable to reduce oscilation and generate quick convergence calculation during disturbances. This method is also used to overcome the weakness of PI control in determining proportional gain (K_p) and integral gain constant (K_i) which still use trial and error method.

II.6. Fuzzy Logic Controller

The research begins by determining $\bar{p}_{loss}$ as the input variable to result the reference source current on current hysteresis controller to generate a trigger signal on the IGBT shunt active filter of UPQC using PI controller (K_p = 0.2 and K_i = 1.5). By using the same procedure, $\bar{p}_{loss}$ is also determined by using FLC. The FLC has been widely used in recent industrial processes because it has heuristic, simpler, more effective and has multi rule based variables in both linear and non-linear system variations. The main components of FLC are fuzzification, decision making (rulebase, database, reason mechanism) and defuzzification, showed in Fig. 5.

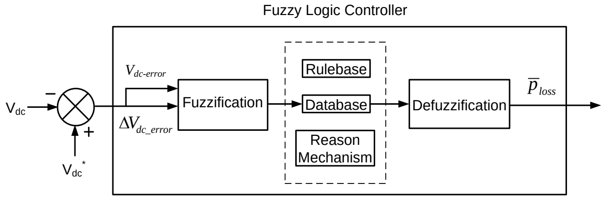
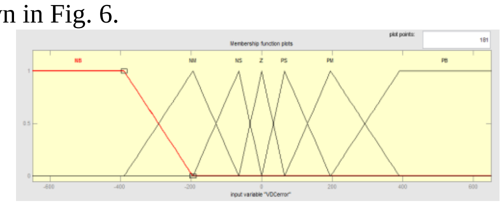


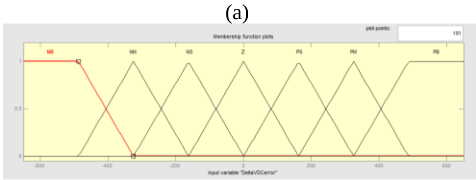
Fig 5. Diagram block of FLC

The fuzzy rule algorithm collects a number of fuzzy control rules in a particular order. This rule is used to control the system to meet the desired performance requirements and they are designed from a number of intelligent system control knowledge. The fuzzy inference of FLC uses Mamdani method related to max-min composition. The fuzzy inference system in FLC consists of three parts: rule base, database, and reasoning mechanism. Rule base consists of a number of If-Then rules for the proper operation of the controller. The If part of the rule is called antecedent and the Then section is called consequence. A number of these rules can be considered as similar responses made by human thought processes and controllers using linguistic input variables, gaining after fuzzification for operation of those rules. The database consists of all user defined membership functions that will be used in a number of these rules. Reasoning mechanisms basically process the rules provided based on certain rules and given conditions that provide the required results to user [15].

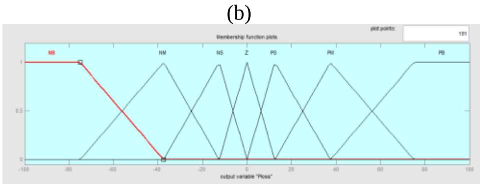
The FLC method is performed by determining the input variables V_{dc} ($V_{dc\text{-}error}$) and delta Vdc ($\Delta V_{dc\text{-}error}$), seven linguistic fuzzy sets, the operation fuzzy block system (fuzzyfication, fuzzy rule base and defuzzification), $V_{dc\text{-}error}$ and $\Delta V_{dc\text{-}error}$ during fuzzification process, the fuzzy rule base table, the crisp value to determine $\bar{p}_{loss}$ in defuzzification phase. The $\bar{p}_{loss}$ is one a variable input to obtain compensating currents $(i^*_{c\alpha}, i^*_{c\beta})$ in Eq. 11. During fuzzification process, a number of input variables are calculated and converted into linguistic variables based on a subset called membership function. The Vdc error ($V_{dc\text{-}error}$) and the delta Vdc ($\Delta V_{dc\text{-}error}$) error are the proposed input variable system and the output variable is $\bar{p}_{loss}$. In order translate these variables, each input and output variable is designed using seven membership functions: Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (Z), Positive Small (PS), Positive Medium (PM) and Positive Big (PB). The membership functions of crisp input and output are presented with triangle and trapezoid membership functions. The value of $V_{dc\text{-}error}$ range from -650 to 650, $\Delta V_{dc\text{-}error}$ from -650 to 650, and $\bar{p}_{loss}$ from -100 to 100. The input and output MFs are shown in Fig. 6.



(a)



(b)



(c)

Fig. 6. MFs (a) $V_{dc\text{-}error}$, (b) $\Delta V_{dc\text{-}error}$, (c) and $\bar{p}_{loss}$

After the $V_{dc\text{-}error}$ and the $\Delta V_{dc\text{-}error}$ are obtained, two input membership functions are converted to linguistic variables and they are used as input functions for FLC. The output membership function is generated using inference blocks and the basic rules of FLC as shown in Table II. Finally the defuzzification block operates to convert generated $\bar{p}_{loss}$ output from linguistic to numerical variable again. Then it becomes an input variable for current hysteresis controller to produce trigger signal on the IGBT circuit of UPQC shunt active filter to reduce source current and load voltage harmonics, while simultaneously improving power quality of 3P3W system under six interference scenarios due to integration of PV and BES into DC link circuit of UPQC.

TABLE II
FUZZY RULE BASE

$V_{dc\text{-}error}$ / $\Delta V_{dc\text{-}error}$	NM	NB	NS	Z	PS	PB	PM
PM	Z	PS	PS	PM	PM	PB	PB
PB	NS	Z	PS	PS	PM	PM	PB
PS	NS	NS	Z	PS	PS	PM	PM
Z	NM	NS	NS	Z	PS	PS	PM
NS	NM	NM	NS	NS	Z	PS	PS
NB	NB	NM	NM	NS	NS	Z	PS
NM	NB	NB	NM	NM	NS	NS	Z

III. Result and Discussion

The analysis of the proposed model is investigated through the determination of six disturbance scenarios i.e. NL, Unba-NL, Dis-NL, Sag-NL, Swell-NL, and Inter-NL. In Scenario 1, the system is connected to a non-linear load with R_L and L_L of 60 Ohm and 0.15 mH respectively. In Scenario 2, the system is connected to anon-linear load and during 0.3 s since t = 0.2 s to t = 0.5 s connected to unbalance three phase load with R_1, R_2, R_3 as 6 Ohm, 12 Ohm, 24 Ohm respectively, and value of C_1, C_2, C_3 as 2200 μF. In Scenario 3, the system is connected to a non-linear load and source voltage generating 5th and 7th harmonic components with individual harmonic distortion values of 5% and 2% respectively. In Scenario 4, the system is connected to a non-linear load and source experiences a sag voltage disturbance of 50% for 0.3 s between t = 0.2 s to t = 0.5 s. In Scenario 5, the system is connected to a non-linear load and source experiences a swell voltage disturbance of 50% for 0.3 s between t = 0.2 s to t = 0.5 s. In Scenario 6, the system is connected to a non-linear load and source experiences an interruption voltage interference of 100% for 0.3 s between t = 0.2 s to t = 0.5 S. Each scenario uses UPQC control with PI control and FLC so the total number of disturbances are 12 scenarios.

Then, by using Matlab/Simulink, the system is executed according to the desired scenario to obtain the curve of source voltage (V_S), load voltage (V_L), compensation voltage (V_C), source current (V_S), load current (I_L), and DC link voltage (V_{dc}). Then, THD value of source voltage, source current, load voltage, and load current in each phase as well as average THD value (Avg THD) are obtained based on the curves. THD in each phase is determined in one cycle started at t = 0.35 s. The average results of source voltage, source current, load voltage, and load current on proposed systes of PV connected to DC link circuit without and with BES are presented in Table III and IV. Futhermore, THD in each phase and average THD of proposed system are showed in Table V and VI.

TABLE III
VOLTAGE AND CURRENT OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITHOUT BES

Scenarios	Source Voltage V_S (Volt)				Load Voltage V_L (Volt)				Source Current I_S (Ampere)				Load Current I_L (Ampere)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	309.5	309.5	309.5	**309.5**	310.0	310.0	310.0	**310.0**	8.828	8.838	8.858	**8.841**	8.586	8.586	8.585	**8.586**
2. Unba-NL	307.8	307.8	307.8	**307.8**	310.2	310.2	310.3	**310.2**	32.15	26.66	30.71	**29.84**	22.65	34.26	34.70	**30.54**
3. Dist-NL	309.5	309.5	309.5	**309.5**	308.5	312.1	310.5	**310.5**	8.936	8.863	10.73	**9.510**	8.522	8.757	8.601	**8.627**
4. Sag-NL	153.8	153.8	153.8	**153.8**	310.1	310.1	310.1	**310.1**	13.39	13.33	13.41	**13.38**	8.589	8.589	8.588	**8.589**

5. Swell-NL	464.4	464.4	464.4	**464.4**	310.1	310.1	310.1	**310.1**	8.457	8.468	8.460	**8.462**	8.558	8.590	8.558	**8.587**
6. Inter-NL	1.190	1.316	1.237	**1.247**	229.2	249.1	242.8	**240.4**	11.31	11.86	11.91	**35.08**	6.443	6.698	6.289	**6.477**
Fuzzy Logic Controller																
1. NL	309.5	309.5	309.5	**309.5**	310.1	310.1	310.0	**310.1**	8.769	8.738	8.811	**8.773**	8.578	8.588	8.587	**8.584**
2. Unba-NL	307.3	307.8	307.8	**307.8**	310.2	310.3	310.2	**310.2**	32.01	26.66	30.65	**29.78**	22.65	34.65	34.69	**30.66**
3. Dist-NL	309.4	309.5	309.5	**309.5**	309.6	312.1	309.9	**310.5**	8.938	8.820	8.916	**8.891**	8.552	8.766	8.586	**8.635**
4. Sag-NL	153.8	153.8	153.8	**153.8**	310.1	310.0	310.1	**310.1**	13.52	13.46	13.56	**13.51**	8.558	8.587	8.589	**8.578**
5. Swell-NL	464.4	464.7	464.7	**464.7**	310.1	310.1	310.1	**310.1**	8.353	8.371	8.365	**8.363**	8.591	8.588	8.587	**8.589**
6. Inter-NL	1.259	1.285	1.530	**1.358**	209.9	193.7	242.7	**215.4**	13.28	11.49	14.07	**12.95**	6.459	5.003	6.299	**5.921**

TABLE IV

VOLTAGE AND CURRENT OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITH BES

Scenarios	Source Voltage V_S (Volt)				Load Voltage V_L (Volt)				Source Current I_S (Ampere)				Load Current I_L (Ampere)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	309.6	309.6	309.6	**309.6**	307.6	307.8	307.7	**307.7**	7.766	7.793	7.759	**7.773**	8.528	8.529	8.533	**8.530**
2. Unba-NL	307.4	308.0	308.0	**307.8**	308.3	308.7	308.3	**308.4**	31.00	24.84	28.73	**28.15**	22.50	34.12	34.52	**30.38**
3. Dist-NL	309.6	309.6	309.6	**309.6**	313,8	314.3	317.4	**317.4**	7.897	7.919	7.867	**7.895**	8.748	8.704	8.785	**8.746**
4. Sag-NL	154.5	154.5	154.5	**154.5**	307.1	307.3	307.3	**307.2**	7.235	7.276	7.226	**7.246**	8.509	8.514	8.510	**8.511**
5. Swell-NL	464.7	464.7	464.7	**464.7**	308.6	308.7	308.6	**308.6**	7.979	7.980	7.964	**7.975**	8.550	8.553	8.554	**8.553**
6. Inter-NL	0.5359	1.385	0.8501	**0.9238**	310.2	259.8	290.2	**286.7**	7.392	12.67	6.045	**8.703**	8.707	7.747	7.637	**8.031**
Fuzzy Logic Controller																
1. NL	309.5	309.5	309.5	**309.5**	307.7	307.9	307.7	**307.8**	8.420	8.426	8.416	**8.421**	8.527	8.532	8.531	**8.530**
2. Unba-NL	307.4	307.9	308.0	**307.8**	308.5	308.7	308.4	**308.5**	31.66	25.50	29.36	**28.84**	22.52	34.11	35.52	**30.72**
3. Dist-NL	309.6	309.5	309.5	**309.5**	313.4	312.9	315.9	**314.1**	8.516	8.565	8.496	**8.526**	8.741	8.677	8.736	**8.718**
4. Sag-NL	154.4	154.4	154.4	**154.4**	307.3	307.3	307.2	**307.3**	8.563	8.560	8.561	**8.561**	8.514	8.517	8.512	**8.515**
5. Swell-NL	464.6	464.6	464.6	**464.6**	308.6	308.8	308.6	**308.7**	8.396	8.389	8.389	**8.392**	8.552	8.556	8.554	**8.554**
6. Inter-NL	0.4467	0.3918	0.3801	**0.4062**	314.0	293.4	304.9	**304.1**	4.024	3.778	3.608	**3.804**	8.874	8.195	8.193	**8.421**

Table III shows that UPQC supplied by PV without BES in 3P3W system with PI and FLC control for interference scenarios 1 to 5 is able to mantain average load voltages above 310 volt. The difference is that in scenario 6 (Inter-NL), PI control generates load voltage of 240.4 volt and if using FLC drops to 215 volt. Reviewed from source current using PI control, the highest and the d lowest average source currents are generated by interference scenario 2 (Unba-NL) and 4 (Swell-NL) of 29.84 A and 8,462 A respectively. Otherwise if using FLC the highest and the lowest average source current drop on same both disturbance scenarios of 29.78 A and 8.363 A respectively.

Table IV indicates that UPQC supplied by PV using BES in 3P3W system with PI and FLC controls for scenarios 1 to 5 is able to produce average load voltage above 307 V. While in scenario 6 (Inter-NL), FLC produces a higher average load voltage of 304.1 V than when using PI control of 286.7 volt PI. Reviewed from average source current with PI control, the highest and lowest average source current are generated by interference scenarios 2 (Unba-NL) and 4 (Sag-NL) of 28.15 A and 7,246 A respectively. While if using FLC, the highest and lowest average source current are achieved in scenario 2 (Unba-NL) and scenario 5 (Swell-NL) of 28.84 A and 8,392 A.

TABLE V

HARMONICS OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITHOUT BES

Scenarios	Source Voltage THD (%)				Load Voltage THD (%)				Source Current THD (%)				Load Current THD (%)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	0.79	0.79	0.79	**0.79**	0.83	0.83	0.82	**0.83**	11.07	10.79	10.95	**10.94**	22.31	22.31	22.32	**22.31**
2. Unba-NL	0.68	0.70	0.67	**0.69**	0.74	0.77	0.71	**0.74**	4.520	4.540	4.240	**4.44**	5.280	2.050	2.700	**3.34**
3. Dist-NL	5.41	5.44	5.52	**5.46**	4.18	9.93	3.93	**6.02**	10.61	10.91	10.73	**10.75**	22.70	20.86	21.07	**21.54**
4. Sag-NL	1.03	1.03	1.03	**1.03**	0.52	0.52	0.52	**0.52**	11.60	11.57	11.27	**11.48**	22.29	22.29	22.28	**22.49**
5. Swell-NL	0.69	0.69	0.70	**0.69**	1.08	1.09	1.09	**1.09**	11.38	11.42	11.63	**11.48**	22.32	22.30	22.32	**22.31**
6. Inter-NL	98.72	87.77	95.42	**93.97**	13.58	16.61	16.87	**15.69**	15.62	16.56	19.01	**17.07**	18.21	20.16	21.06	**19.81**
Fuzzy Logic Controller																
1. NL	0.79	0.78	0.77	**0.78**	0.82	0.82	0.80	**0.81**	11.73	10.83	11.06	**11.21**	22.23	22.32	22.32	**22.29**
2. Unba-NL	0.68	0.70	0.66	**0.68**	0.71	0.74	0.70	**0.72**	4.560	4.900	4.470	**4.65**	5.290	2.050	2.700	**3.35**
3. Dist-NL	5.41	5.43	5.52	**5.45**	3.54	10.34	3.92	**5.93**	10.92	10.51	10.66	**10.69**	22.78	20.77	21.30	**21.62**
4. Sag-NL	1.02	1.02	1.03	**1.02**	0.52	0.52	0.52	**0.52**	11.99	12.02	11.99	**12.00**	22.31	22.31	22.29	**22.30**
5. Swell-NL	0.67	0.69	0.69	**0.68**	1.06	1.08	1.08	**1.07**	11.65	11.49	11.79	**11.64**	22.30	22.32	22.31	**22.31**
6. Inter-NL	91.76	97.26	82.66	**90.56**	39.40	24.79	42.32	**35.51**	41.57	23.11	43.92	**36.20**	40.18	35.29	42.75	**48.98**

TABLE VI

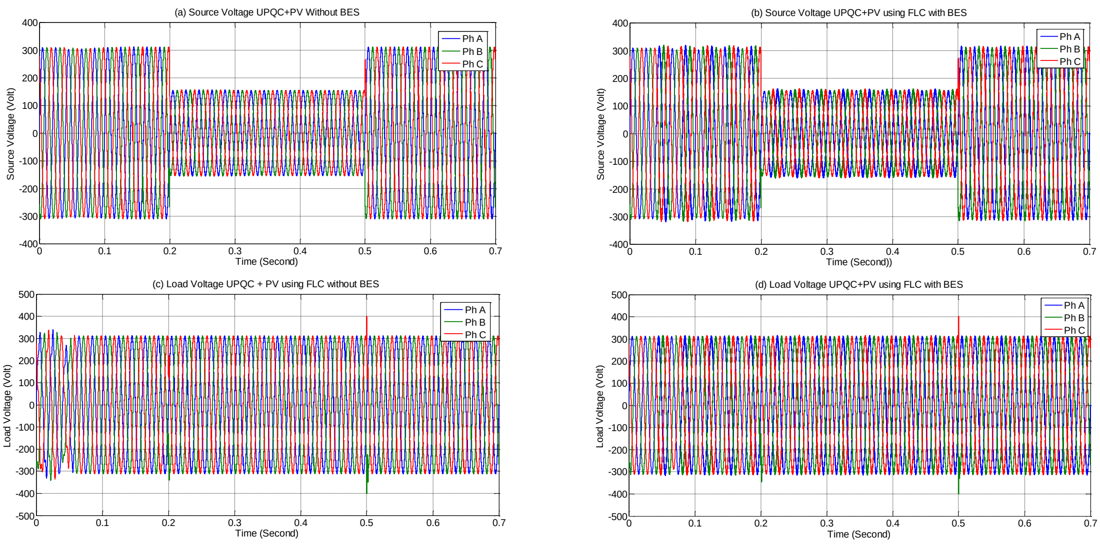
HARMONICS OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITH BES

Scenarios	Source Voltage THD (%)				Load Voltage THD (%)				Source Current THD (%)				Load Current THD (%)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	2.35	2.36	2.32	**2.34**	2.48	2.50	2.46	**2.48**	12.89	12.72	12.92	**12.84**	22.32	22.34	22.32	**22.33**
2. Unba-NL	2.29	2.20	2.24	**2.24**	2.43	2.23	2.37	**2.34**	2.660	2.330	2.240	**2.410**	5.230	2.070	2.660	**3.320**
3. Dist-NL	5.84	5.86	5.94	**5.88**	6.36	5.90	6.58	**6.28**	12.75	12.64	13.06	**12.82**	21.92	22.16	22.33	**22.14**
4. Sag-NL	4.69	4.75	4.81	**4.75**	2.46	2.48	2.53	**2.49**	14.26	13.96	14.16	**14.13**	22.28	22.31	22.28	**22.29**
5. Swell-NL	1.56	1.53	1.55	**1.55**	2.47	2.43	2.45	**2.45**	12.51	12.36	12.44	**12.44**	22.34	22.32	22.32	**22.33**
6. Inter-NL	NA	NA	NA	**NA**	32.11	15.09	28.54	**25.25**	270.90	145.89	275.67	**230.82**	47.70	34.58	36.29	**39.53**
Fuzzy Logic Controller																
1. NL	2.35	2.33	2.35	**2.34**	2.48	2.46	2.49	**2.47**	11.83	11.82	11.84	**11.83**	22.33	22.32	22.33	**22.33**
2. Unba-NL	2.25	2.27	2.20	**2.24**	2.39	2.41	2.34	**2.38**	2.620	2.400	2.220	**2.413**	5.230	2.100	2.640	**3.323**

3. Dist-NL	5.83	5.88	5.93	**5.88**	6.23	5.93	6.69	**6.28**	11.83	11.90	12.14	**11.96**	21.84	22.34	22.53	**22.24**
4. Sag-NL	4.71	4.76	4.79	**4.75**	2.46	2.48	2.50	**2.48**	11.91	11.88	11.86	**11.89**	22.27	22.32	22.32	**22.31**
5. Swell-NL	1.55	1.54	1.54	**1.54**	2.45	2.44	2.46	**2.45**	11.90	11.84	11.85	**11.86**	22.36	22.33	22.35	**22.35**
6. Inter-NL	NA	NA	NA	**NA**	13.05	6.60	11.15	**10.27**	30.61	34.72	31.57	**32.30**	24.25	24.25	24.71	**24.40**

Table V shows that the average THD of V_L of UPQC supplied by PV without BES in 3P3W for interference scenarios 1 to 5 using PI control is within the limits prescribed in IEEE 519. In this condition PI controller is also capable to maintain and to improve the average THD of load voltage within the limits of IEEE 519. The highest and the lowest average THD load voltages are achieved under scenario interruption conditions 6 (Inter-NL) and scenario 2 (Unba-NL): 15.69% and 0.74% respectively. PI controller is also able to reduce average THD source voltage in scenario 6 (Inter-NL) by 93.97% to 15.69% on the load side. The highest and the lowest average THD of source current are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 17.07% and 4.44% respectively. Table V also shows that average THD of load voltage of UPQC system supplied by PV without BES using FLC in disturbance scenarios 1 to 5, has fulfilled the limits prescribed in IEEE 519. FLC method is also capable to maintain and to improve average THD of load voltage within the IEEE 519 limit. The highest and lowest average THD of V_L are achieved under scenario 6 (Inter-NL) and scenario 4 (Sag-NL) of 35.51% and 0.52. The implementation of FLC method is also able to reduce average THD of V_S in scenario 6 (Inter-NL) by 90.56% to 35.51% on load side. The highest and the lowest average THD of I_S are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 36.20% and 4.65%. UPQC system supplied by PV without BES in six interference scenarios using PI control and FLC is able to improve average THD of I_S better on average THD of I_L.

Table VI shows that average THD of V_L from UPQC supplied by PV with BES in 3P3W system for interference scenarios 1 to 5 using PI control is within the limits prescribed in IEEE 519. In this condition PI controller is also capable to maintain average THD of V_L within the limits of IEEE 519. The highest and the lowest average THD of V_L are achieved under scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 25.25% and 2.34% respectively. PI controller is also able to mitigate average THD of V_S in scenario 6 (Inter-NL) from not accessed (NA) to 25.25% on the load side. The highest and the lowest average THD of I_S are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 230.82% and 2.41% respectively. Table VI also indicates that average THD of V_L of UPQC system supplied by PV with BES using FLC in disturbance scenarios 1 to 5, has fulfilled limits prescribed in IEEE 519. FLC method is also capable to keep average THD of V_L within IEEE 519. The highest and the lowest average THD of V_L are achieved under scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 10.27% and 2.38%. The use of FLC method is also useful to reduce average THD on V_S in scenario 6 (Inter-NL) from NA to 10.27% on load side. The highest and the lowest average THD of I_S are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 32.30% and 2.413%, respectively. UPQC system supplied by PV with BES in six interference scenarios using PI control and FLC is able to improve average THD of I_S better on average THD of I_L. Fig. 7 and Fig. 8 present UPQC-PV performance using FLC without and with BES in scenario 4 (Sag-NL) and scenario 6 (Inter-NL).



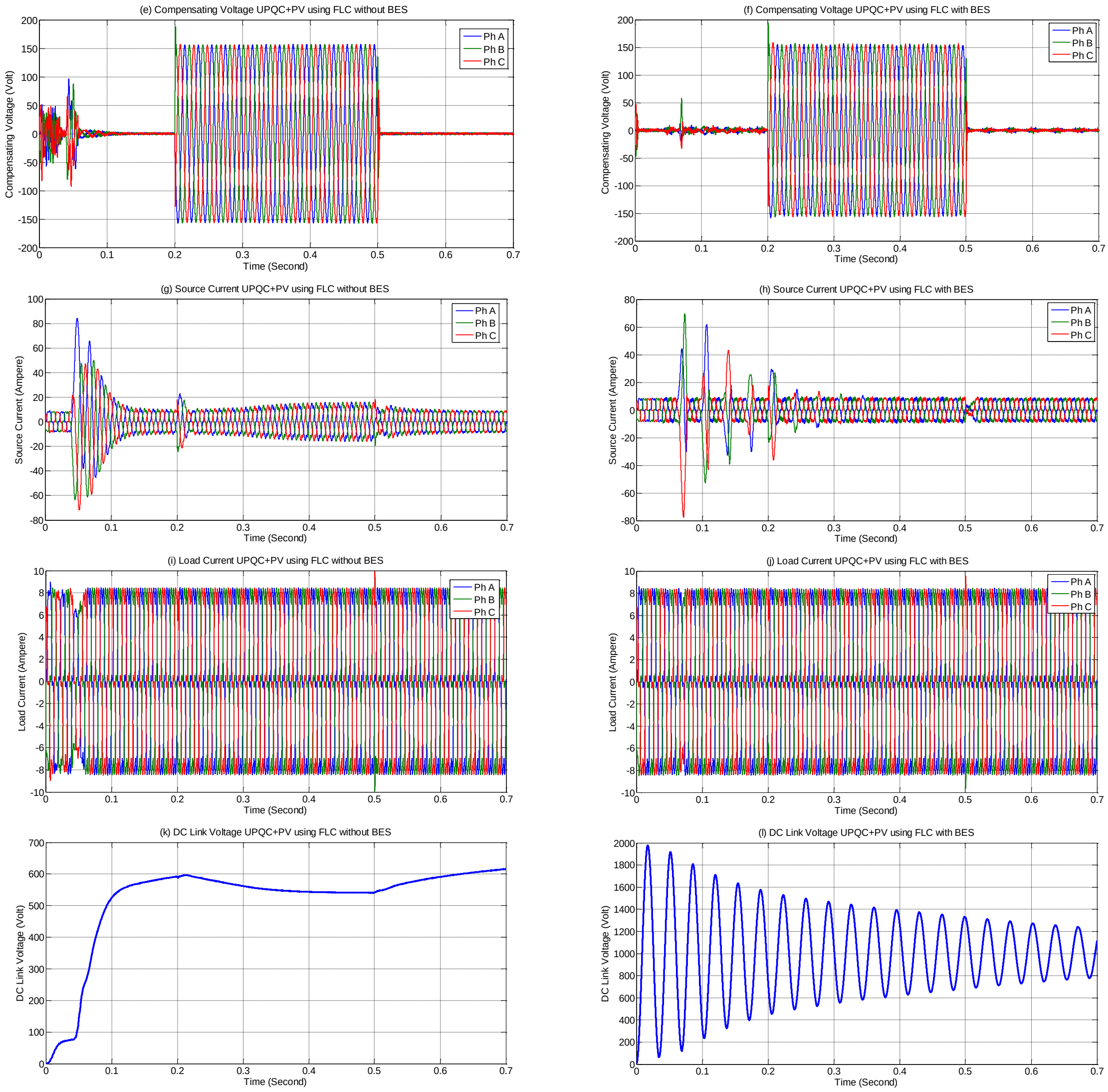
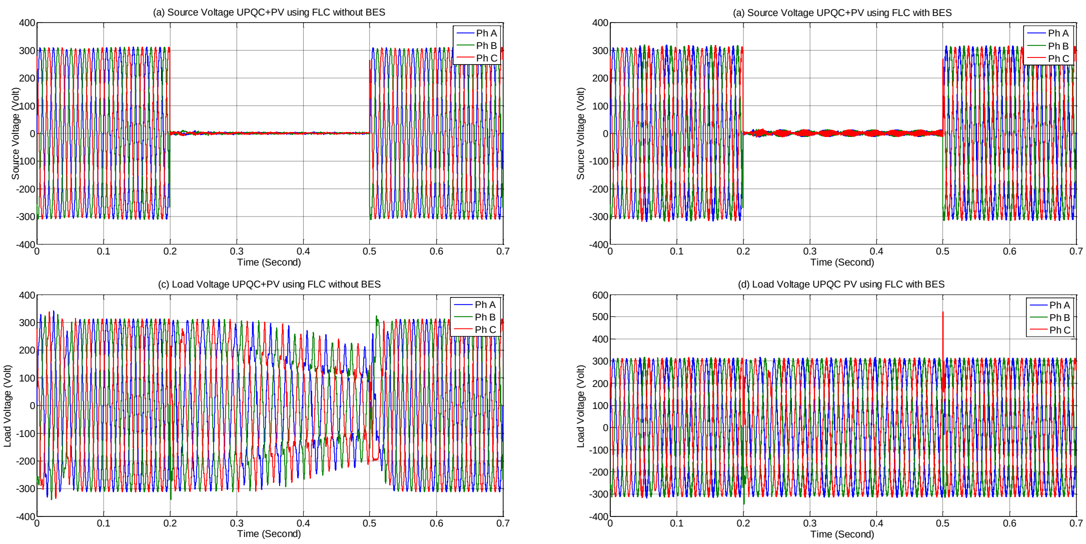


Fig. 7. UPQC supplied PV performance using FLC without and with BES in scenario 4 (Sag-NL)



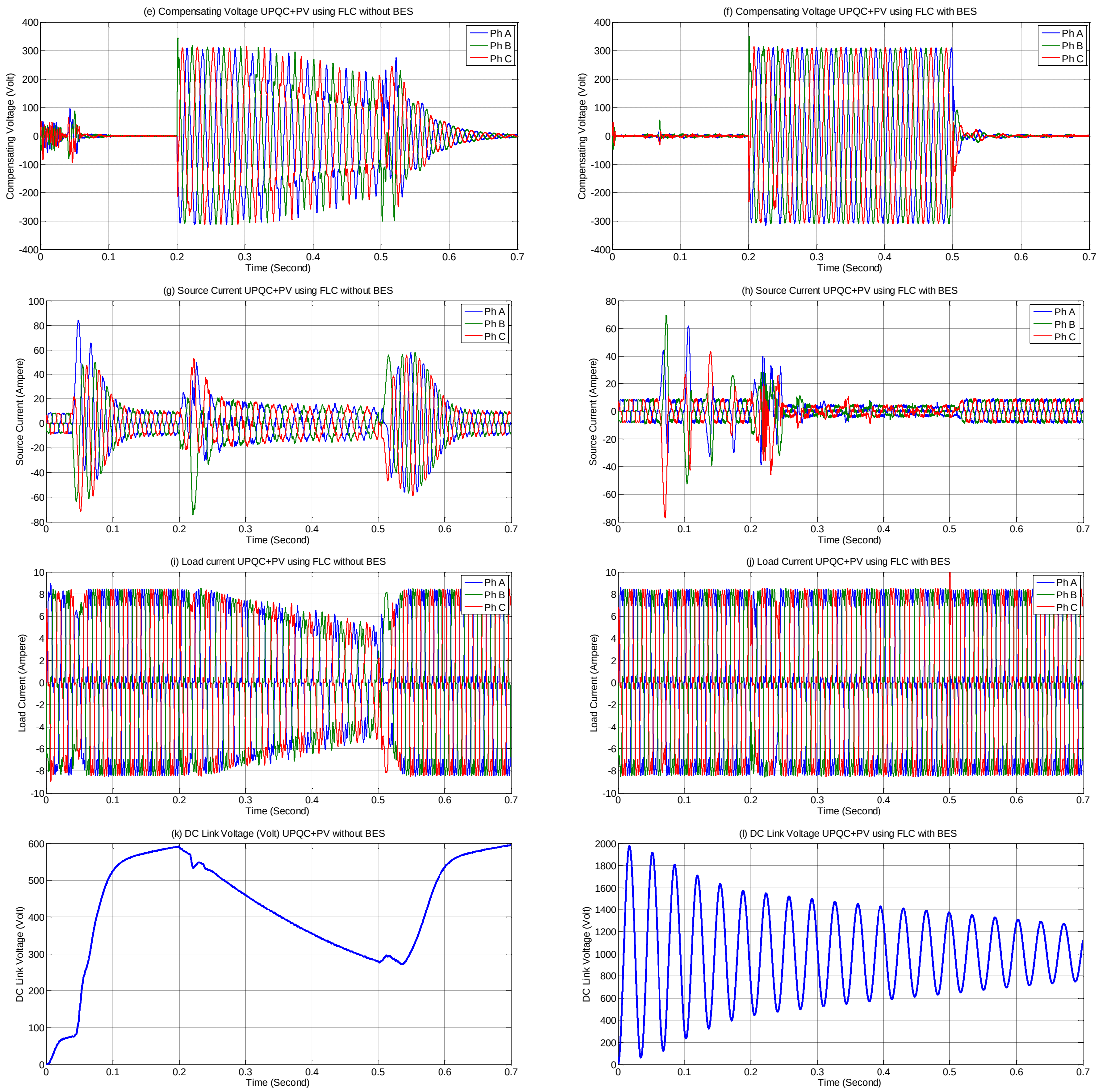
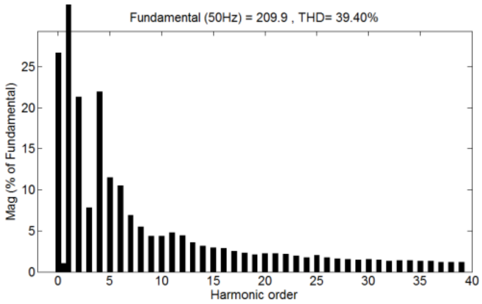


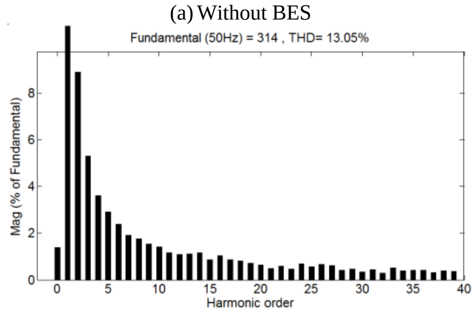
Fig. 8. UPQC supplied PV performance using FLC without and with BES in scenario 6 (Inter-NL)

Fig. 7a shows that in scenario 4 (Sag-NL), UPQC supplied by PV without BES at t = 0.2 s to t = 0.5 s avarage V_S drops by 50% from 310.1 V to 153.8 V. In this condition, PV is capable to generate power to the UPQC DC link circuit and injecting V_C as 153.8 V (Fig.7e) through injection transformer on series active filter so that average V_L remains stable at 310.1 V (Fig.7c). During this time, FLC on shunt active filter works to keep V_{dc} stable and average I_S increases approach to 13.28 A (Fig. 7g) in order to keep average I_L stable by 8.589 A (Fig. 7i). Fig. 8b in scenario 4 (Sag-NL) using BES also shows almost the same performance on average V_C, average V_L, and average I_L presented in Fig. 7f, Fig. 7d, and Fig. 7j respectively. The difference is that average I_S is slightly decreased to 8.561 A (Fig. 7h). The addition of BES, besides the fact of being capable to store excess power from PV generator, also serves to inject current into load through DC link (Fig. 7l) and shunt ative filter to produce average I_L equal to 8.515 A.

Fig. 8a shows that in scenario 6 (Inter-NL) UPQC supplied PV by without BES at t = 0.2 s to t = 0.5 s, average V_S falls as 100% to 1.358 V. In this condition PV is unable to generate the maximum power to UPQC DC link and inject average V_C in Fig 8e through injection transformer on series active filter. So at t = 0.2 s to t = 0.5, average V_L in Fig. 8c decrease to 215.4 V. During the disturbance, the implementation of FLC on shunt active filter keeps the maintenance V_{dc} (Fig 8k), interruption voltage causes average I_S to decrease to 12.29 A (Fig. 8g) and average I_L also decreases to 5.921 A (Fig. 8i). Fig. 9b on UPQC supplied by PV with BES at t = 0.2 s to t = 0.5 s average V_S also drops 100% to 0.4062 V. During the disturbance, PV is able to generate power to UPQC DC link and injecting full average V_C in Fig. 9f through the injection transformer on series active filter so that average V_L remains stable at 304.1 V (Fig. 8d). As long fault period, although nominal of average I_S drops to 3.804 A, the combination of PV and BES is able to generate power, store excess energy of PV, and inject current into load through shunt active filter so that I_L in Fig. 8l remains as 8.421 A. Fig. 9 shows spectra of load voltage harmonics on phase A of UPQC supplied by PV using FLC without and with BES in scenario 6.



(a) Without BES



(b) With BES

Fig. 9. Spectra of load voltage harmonics on phase A UPQC supplied PV using FLC in scenario 6 (Inter-NL)

Fig. 10 and Fig. 11 show the performances of average THD of load voltage (V_L) and source current (I_S) on UPQC supplied by PV using PI controller and FLC without and with BES in six disturbance scenarios.

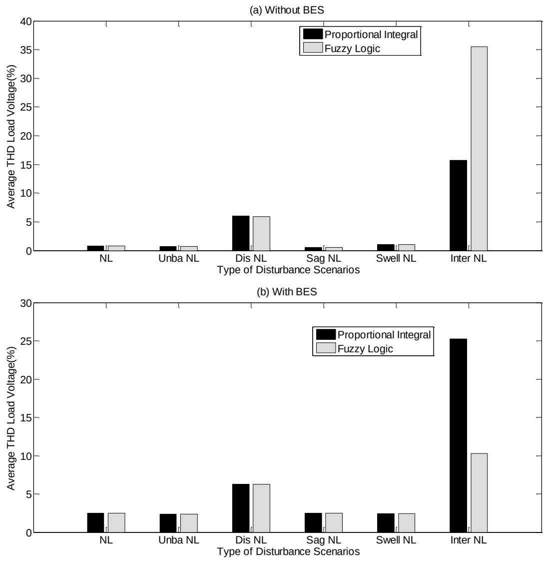
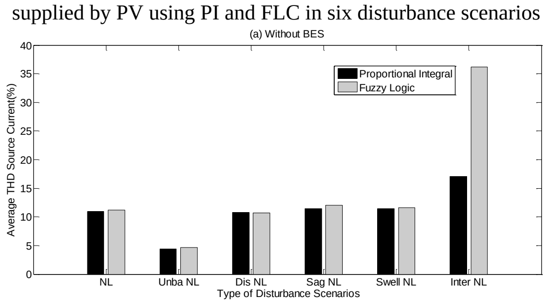


Fig. 10. Performance of average THD of load voltage of UPQC supplied by PV using PI and FLC in six disturbance scenarios



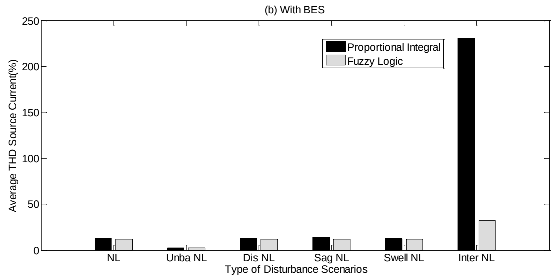


Fig. 11. Performance of average THD of source current of UPQC supplied by PV using PI and FLC in six disturbance scenarios

Fig. 10a shows that in scenario 1(NL), scenario 2 (Unba-NL), scenario 3 (Dis-NL), scenario 4 (Sag-NL), and scenario 5 (Swell-NL), implementation of FLC on UPQC supplied by PV without BES is able to result average THD of source voltage slightly better than PI controller and also limits prescribe in IEEE 519. Otherwise under scenario 6 (Inter-LN) PI controller give better significantly result of average THD of V_L than FLC. Fig. 10b shows that in six scenarios, the use of FLC on UPQC supplied by PV with BES able to result average THD of V_L slightly better than PI controller. In disturbance scenarios 1 to 5, nominal of average THD of V_L has met IEEE 519. Otherwise under scenario 6 (Inter-NL) FLC is able to reduce average THD of V_L significantly than PI controller.

Fig. 11a shows that in scenario 1(NL), scenario 2 (Unba-LN), scenario 3 (Dis-NL), scenario 4 (Sag-NL), and scenario 5 (Swell-NL), the implementation of PI controller on UPQC supplied by PV without BES able to result average THD of I_S slightly better than FLC. Otherwise under scenario 6 (Inter-LN) PI controller gives better significantly result of average THD of source voltage than FLC. Fig. 11b shows that in six scenarios, the use of FLC on UPQC supplied by PV with BES is able to give average THD of I_S better than PI controller. Futhermore under scenario 6 (Inter-NL), FLC able to reduce average THD of source current significantly than PI controller.

IV. Conclusion

The use of BES supplied by PV connected to a three phase grid through to DC link of UPQC to improve power quality with PI controller and FLC have been discussed. In scenario 6, PV is able to generate power to UPQC-DC link and injecting full average compensation voltage through injection transformer on series active filter so that average load voltage remains stable. During voltage interruption, even though there is low source current, combination of PV and BES is able to deliver power, store excess energy of PV, and inject compensation current into load bus through shunt active filter. The implementation of FLC on UPQC supplied PV with BES results average THD of load voltage slightly lower than using PI controller. In disturbance scenarios 1 to 5, the implementation of FLC method UPQC supplied PV with BES is able to reduce the average THD of load voltage slightly better than PI controller and has already met the limits prescribed in IEEE 519. Otherwise under scenario 6, FLC method able to reduce average THD of load voltage significantly than PI controller. In disturbance scenario 1 to 5, this method is able to give average THD of source current better than PI controller. Futhermore under scenario 6, It is also capable to give better performance significantly of average THD of source current more than PI controller.

Nevertheless, except under scenario 2, the average THD of source current on UPQC supplied by PV without/with BES using FLC method still does not meet the limits prescribed in IEEE 519. Implementation of another Fuzzy Method i.e. Type 2 Fuzzy/Fuzzy Sliding Mode to control shunt active filter on UPQC is proposed as one solution to improve it.

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Lampiran 2.5

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International Review on Modelling and Simulations (I.RE.MO.S.), Vol. xx, n. x
June 2008

High Performance of Unified Power Quality Conditioner and Battery Energy Storage Supplied by Photovoltaic using Artificial Intelligent Controller

Amirullah[1,2], Ontoseno Penangsang[1], Adi Soeprijanto[1]

Abstract – *This paper proposes the use of a Battery Energy Storage (BES) on an Unified Power Quality Conditioner (UPQC) supplied by Photovoltaic (PV) through DC link to improve power quality on a three-phase three-wire (3P3W) distribution system. The BES serves to store the excess of power resulted by PV and to transfer it to load if necessary, preventing voltage interuption , and adjusting charging and discharging energy in battery. Power quality analysis is carried out in two conditions i.e. PV connected to DC link without and with BES. Fuzzy Logic Controller (FLC) is implemented to maintain DC voltage across the capacitor under disturbance scenarios of source and load as well as to compare the results with Proportional Intergral (PI) controller. The number of disturbance scenarios are six for each UPQC controller, so the total number disturbances is 12. The six disturbances are: non-linear load (NL), unbalance and nonlinear load (Unba-NL), distortion supply and non-linear load (Dis-NL), sag and non-linear load (Sag-NL), swell and non-linear load (Swell-NL), and interruption and non-linear load (Inter-NL). FLC method on UPQC supplied by PV with BES is able to result in an average THD of load voltage slightly better than PI controller. In disturbance scenario 1 to 5, nominal of average THD of load voltage have met IEEE 519. FLC method on UPQC supplied by PV with BES is also capable to give average THD of source current better than PI controller. Under scenario 6 (Inter-NL), FLC is able to reduce the average THD of load voltage and source current significantly than PI controller. With the same disturbance, the combination of PV and BES is able to generate power to UPQC DC link and to inject full average compensation voltage through injection transformer on series active filter so that average load voltage remains stable. This simulations prove that the proposed artificial intelligent (AI) controller for UPQC with BES is able to improve power quality significantly under varying disturbances especially for interruption. The performance of the proposed model is validated and investigated through simulations using Matlab/Simulink.*

Keywords: *Power Quality, UPQC, PV, BES, Total Harmonic Distortion (THD), Disturbance Scenarios*

Nomenclature

I_{PV}	Photovoltaic current
I_o	Saturated reverse current
N_S	Number of series cells
q	Electron charge
K	Boltzmann constant
T	Temperature of p–n junction
I_{SC}	Short circuit curret
V_{OC}	Open circuit voltage
$\mathrm{V_m}$	Peak magnitude of fundamental input voltage
$\mathrm{V_{Labc}}^*$	Reference load voltages in *abc*
$\mathrm{V_{Labc}}$	Sensed load voltages in *abc*
V_{abc}	Voltages in cartesian *abc*
I_{abc}	Currents in cartesian *abc*
$V_{\alpha\beta}$	Voltages in cartesian $\alpha\beta$
$I_{\alpha\beta}$	Currents in cartesian $\alpha\beta$
p	Real power
q	Imaginary power
$\bar{p}$	Direct component of real power
$\tilde{p}$	Fluctuating component of real power
$\bar{q}$	Direct component of imaginary power
$\tilde{q}$	Fluctuating component of imaginary power
$\bar{p}_{loss}$	Instantaneous active power corresponds to resistive loss and switching loss of UPQC
$i^*_{c\alpha\beta}$	Compensating currents in cartesian $\alpha\beta$
i^*_{sabc}	Reference source currents in *abc*
i_{sabc}	Sensed source currents in *abc*
$\mathrm{V_{dc}}$	Dc link voltage
$\mathrm{V_{LL}}$	Line-line grid voltage
m	Modulation index
K_p	Proportional gain constant
K_i	Integral gain constant
$\mathrm{V_{dc\text{-}error}}$	Error Vdc
$\Delta\mathrm{V_{dc\text{-}error}}$	Delta error Vdc
$\mathrm{V_S}$	Source voltage
V_L	Load voltage
I_S	Source current
I_L	Load current
V_c	Compensation voltage
THD	Total harmonic distortion
PCC	Point common coupling

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I. Introduction

The microgrid power systems use distributed generations (DGs) power source where power is supplied to local loads and it may operate separately from conventional grid systems. DGs have many benefits: for example, it is capable of reducing transmission costs, it is has low investment costs, it reduces line losses and it increases grid reliability. DGs that use renewable energy (RE) able to generate electrical power are classified as DGs sources. The solar or photovoltaic (PV) generator is one of the most potential DGs sources technologies because it only needs sunlight to generate electricity, where the resources are available in abundance, they are free and relatively clean. Indonesia has an enormous energy potential from the sun because it lies on the equator. Almost all areas of Indonesia get sunlight about 10 to 12 hours per day, with an average intensity of irradiation of 4.5 kWh/m^2 or equivalent to 112,000 GW. Even though, PV generator is capable to generate power, it has also weakness: it produces a number of voltage and current disturbances, as well as harmonics due to the presence of several types of PV devices and power converters as well as increasing a number of non-linear loads connected to the grid causing a decrease in power quality.

In order to overcome this problem and to improve power quality due to presence of non-linear loads and integration of PV generator to grid, UPQC is proposed. UPQC serves to compensate problems of source voltage quality, for example sag, swell, unbalance, flicker, harmonics, as well as problems of load current quality such as harmonics, unbalance, reactive currents, and neutral currents. UPQC is part of the active power filter consisting of shunt and series active power filters connected in parallel and it serves as a superior controller to overcome a number of power quality problems simultaneously [1]. UPQC series component is responsible to reduce a number of interference on source side; voltage sag/swell, flicker, unbalanced voltage, and harmonics. This equipment serves to inject a number of voltages to keep load voltage fixed at the desired level in a balanced and distortion free. UPQC shunt component is responsible for addressing current quality problems: low power factor, load current harmonics, and unbalanced load. This device serves to inject current on AC system so that source current becomes sinosioda balanced and in phase with source voltage [2].

UPQC based on RE has been investigated by many researchers. There are two methods used to overcome the problem by using conventional and artificial intelligence controller. [3] deal with the analysis of UPQC and DG combination operations . The proposed system includes a series inverter, shunt inverter, and a DG connected to a DC link through a rectifier using PI controller. The system has been capable to increase source voltage quality (sag and interruption) and load current quality, as well as to change in active power on grid and off grid mode. The influence of DG on UPQC performance in reducing the sag voltage under conditions of some phase to ground faults to using distributed static compensator (DSTATCOM) controller has been implemented [4]. The DG has been effective enough to help UPQC work in improving sag voltage. The DG system is connected in series with load resulting to have a better percentage of sag mitigation compared to the system without using DG. The implementation of UPQC using unit vector template generation (UVTG) method with PI controller to improve sag, swell, voltage harmonics and current harmonics has been done [5]. The simulation of voltage distortion has been made by adding 5th and 7th harmonics at fundamental source voltage, resulting in a reduction of THD source current and THD load voltage.

UPQC supplied by a 64 panels PV using boost converter, PI controller, perturb and observer MPPT, and instantaneous reactive power theory (p-q theory) has been proposed [6]. The system has been capable to compensate reactive power and reduce source current and load voltage harmonics. Nevertheless, the study has not discussed the mitigation of sag and interruption caused by penetration of PV. Artificial neural network (ANN) based synchronous reference frame theory (SRF) control strategy to compensate power quality issues in three phase three wire (3P3W) distribution system through UPQC for various balanced/unbalance/distorted conditions on load and source has been proposed [7]. The proposed model has been able to mitigate harmonic/reactive currents, unbalanced source and load current/voltage. Investigation on power quality enhancement includes sag and source voltage harmonics on grid using UPQC supplied by PV array connected to DC link using PI compared with FLC have been done [8]. The simulation shows that FLC on UPQC and PV can improve source voltage THD better than PI.

[9] shows a method to balance current and line voltage, as a result of DGs of a single phase PV generator unit randomly installed at houses through on a three-phase four-wire 220 kV and 50 Hz distribution line using BES and three single-phase bidirectional inverters. Both devices have been capable to reduce unbalanced line current and unbalanced line voltage. Both combination have also been able to increase current and voltage harmonics on PCC bus. Improvement of power quality UPQC on microgrid supplied by PV and wind turbine has been implemented. PI and FLC are able to to improve power quality and to reduce distortion in output power [10].

This research investigates the use of BES on UPQC supplied by PV through to DC link to improve power quality on three-phase three-wire (3P3W) distribution system. PV array generates power under constant temperature and irradiance connected to BES through a DC/DC boost converter that serves to regulate PV operating point. BES serves to store excess energy produced by PV and to distribute it to load if necessary in oreder to prevent interruption voltage, and to adjust charging and discharging of energy in battery. BES is also expected to store excess power produced by PV generator and using them as backup power. FLC is proposed and compared with PI method, because PI controller is weak in determining proportional and integral gain constant which still uses trial and error. FLC is used as a controller variable of DC voltage and DC reference voltage input to generate reference current source in current hysteresis controller circuit on shunt active filter. FLC methods are used as DC voltage controllers in shunt active filter and series active filter to mitigate power quality of load voltage and source current. The number of disturbance scenario is six for each UPQC controller, so the total number is 12.

The power quality performance of two controllers are used to determine load voltage, source current, load voltage THD, and source current THD based on IEEE 519. Section II describes the proposed method, the model of UPQC supplied by PV and BES, the simulation parameters, the PV circuit model, the control of series and shunt active filter, as well as the application of PI and FLC method for the proposed model. Section III shows the results and the discussion about THD analysis on the proposed model of PV connected to DC link circuit without and with BES using PI controller and FLC. In this section, six disturbance scenarios are presented and the results are verified with Matlab/Simulink. Finally, the paper is concluded in Section IV.

II. Proposed Method

II.1. Proposed Model

Fig. 1 shows the model proposed in this study. DG based on RE is a PV connected to a 3P3W distribution system with 380 volts (L-L) and a frequency of 50 hertz, through DC link UPQC and BES circuit. PV array generates power under fixed temperature and irradiance and it is connected to BES through a DC/DC boost converter. The maximum power point tracking (MPPT) method with Pertub and Observer (P and O) algorithms helps PV to generate the maximum power and to generate an output voltage, as an input voltage for the DC/DC boost converter. The converter functions to adjust duty cycle value and output voltage of PV generator as its input voltage to produce output voltage according DC link voltage of UPQC.

The BES connected to UPQC DC link circuit serves as an energy storage and it is expected to overcome voltage interruption and to help UPQC performance to enhance voltage and current power quality at source and load bus. The simulation parameters of the proposed model are showed in Table I. Power quality analysis is performed on PV connected to 3P3W system through UPQC DC link circuit (on-grid), under two conditions i.e. with and without BES. A single phase circuit breaker is used to connect and disconnect PV with BES. Each condition consists of six disturbance scenarios: NL, Unba-NL, Dis-NL, Sag-NL, Swell-NL, and Inter-NL. FLC is used as DC voltage controls in shunt active filter to improve the power quality of the load voltage and the source current and they are compared to PI controller. Each scenario uses UPQC controller with PI controller and FLC so there are 12 disturbances in total. The parameters include: voltage and current on source or PCC bus, voltage and current on load bus, voltage harmonics and current harmonics on source bus and voltage harmonics and current harmonics on load bus. The next step is to compare the two controller performances on UPQC to enhance power quality of load voltage and source current under six disturbance conditions.

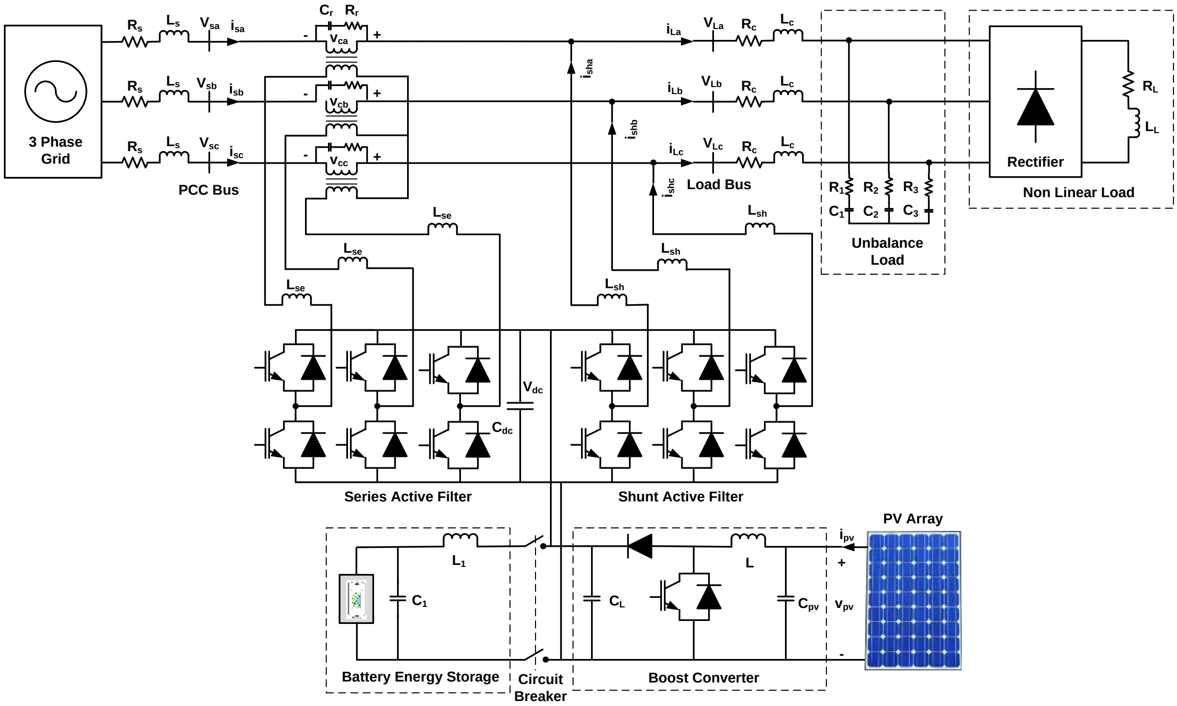

Fig 1. Proposed model of UPQC supplied by PV and BES

TABLE I
SIMULATION PARAMETERS

Devices	Parameters	Design Values
Three Phase Grid	RMS Voltage (LL) Frequency Line Impedance	380 Volt 50 Hz R_s = 0.1 Ohm L_s = 15 mH
Series Active Filter	Series Inductance	L_{se} = 0.015 mH
Shunt Active Filter	Shunt Inductance	L_{sh} = 15 mH
Injection Transformers	Rating kVA Frequency Turn Ratio (N_1/N_2)	10 kVA 50 Hz 1 : 1
Non Linear load	Resistance Inductance Load Impedance	R_L = 60 Ohm L_L = 0.15 mH R_c = 0.4 Ohm L_c = 15 mH
Unbalance Load	Resistance Capacitance	R_1 = 24 Ohm R_2 = 12 Ohm R_3 = 6 Ohm C_1, C_2, C_3 = 2200 μF
DC Link	DC Voltage Capacitance	V_{DC} = 650 Volt C_{DC} = 3000 μF
Battery Energy Storage	Type DC Voltage Rated Capacity Initial SOC Inductance Capacitance	Nickel Metal Hibrid 650 V 200 Ah 100% L_1 = 6 mH C_1 = 200 μF
PV Generator	Active Power Temperature Irradiance	0.6 kW 25^0 C 1000 W/m^2
PI Parameters	K_p Gain Constant K_i Gain Constant	0.2 1.5
Fuzzy model	Method Composition	Mamdani Max-Min
Input membership function	Error (V_{dc}) Delta Error (ΔV_{dc})	trapmf, trimf trapmf, trimf
Output membership function	Power Loss ($\bar{p}_{loss}$)	trapmf,trimf

II.2. Photovoltaic Model

Fig. 2 shows the equivalent circuit of a solar panel. A solar panel is composed by several PV cells that have series, parallel, or series-parallel external connections [11].

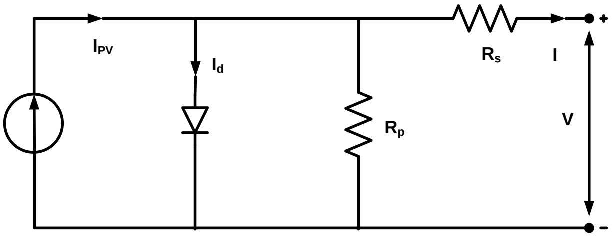

Fig 2. Equivalent circuit of solar panel

Eq. 1 shows V-I characteristic of a solar panel [11].

$$I = I_{PV} - I_o\left[\exp\left(\frac{V + R_S I}{aV_t}\right) - 1\right] - \frac{V + R_S I}{R_P} \qquad (1)$$

where I_{PV} is the photovoltaic current, I_o is saturated reverse current, 'a' is the ideal diode constant, $V_t = N_S KTq^{-1}$ is the thermal voltage, N_S is the number of series cells, q is the electron charge, K is the Boltzmann constant, T is the temperature of p–n junction, R_S and R_P are series and parallel equivalent resistance of the solar panels. I_{PV} has a linear relation with light intensity and also varies with temperature variations. I_o is dependent on temperature variations. The values of I_{pv} and I_o are calculated as:

$$I_{PV} = (I_{PV,n} + K_1 \Delta T)\frac{G}{G_n} I \qquad (2)$$

$$I_o = \frac{I_{SC,n} + K_I \Delta T}{\exp(V_{OC,n} + K_V \Delta T)/aV_t - 1} \qquad (3)$$

In which $I_{PV,n}$, $I_{SC,n}$ and $V_{OC,n}$ are photovoltaic current, short circuit current and open circuit voltage in standard conditions (T_n = 25 C and G_n = 1000 Wm^{-2}) respectively. K_I is the coefficient of short circuit current to temperature, $\Delta T = T - T_n$ is the temperature deviation from standard temperature, G is the light intensity and K_V is the ratio coefficient of open circuit voltage to temperature. Open circuit voltage, short circuit current and voltage-current corresponding to the maximum power are three important points of I-V characteristic of solar panel. These points are changed by the variations of atmospheric conditions. By using Eq. 4 and 5 which are derived from PV model equations, short circuit current and open circuit voltage can be calculated in different atmospheric conditions.

$$I_{SC} = (I_{SC} + K_1 \Delta T)\frac{G}{G_n} \qquad (4)$$

$$V_{OC} = V_{OC} + K_V \Delta T \qquad (5)$$

II.3. Control of Series Active Filter

The main function of series active filter is the sensitive load protection against a number of interference at PCC bus voltage. The control strategy algorithm of the source and load voltage harmonics in series active filter circuit is shown in Fig. 3. It extracts the unit vector templates from the distorted input supply Furthermore, the templates are expected to be ideal sinusoidal signal with unity amplitude. The distorted supply voltages are measured and divided by the peak amplitude of fundamental input voltage V_m given by Eq. 6 [6].

$$V_m = \sqrt{\frac{2}{3}\left(V_{sa}^2 + V_{sb}^2 + V_{sc}^2\right)} \qquad (6)$$

A three phase locked loop (PLL) is used in order to generate sinusoidal unit vector templates with a phase lagging by the use of sinus function. The reference load voltage signal is determined by multiplying the unit vector templates with the peak amplitude of the fundamental input voltage V_m. The load reference voltage (V_{La}^*, V_{Lb}^*, V_c^*) is then compared to the sensed load voltage (V_{La}, V_{Lb}, V_{Lc}) by a pulse width modulation (PWM) controller used to generate the desired trigger signal on the series active filter.

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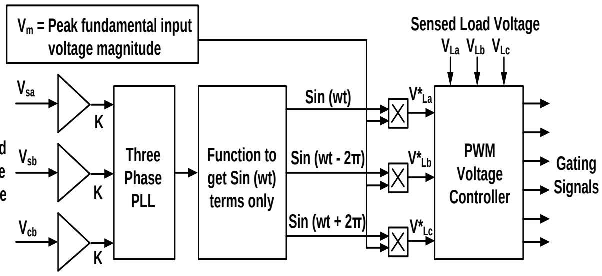


Fig 3. Control strategy of series active filter

II.4. Control of Shunt Active Filter

The main function of shunt active filter is the mitigation of power quality problems on the load side. The control methodology in shunt active filter is that the absorbed current from the PCC bus is a balanced positive sequence current including unbalanced sag voltage conditions in the PCC bus or unbalanced conditions or non-linear loads. In order to obtain satisfactory compensation caused by disturbance due to non-linear load, many algorithms have been used in the literature. This research used the instantaneous reactive power theory method "p-q theory". The voltages and currents in Cartesian *abc* coordinates can be transformed to Cartesian *αβ* coordinates as expressed in Eq. 7 and 8 [6].

$$\begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 1 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \tag{7}$$

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = \begin{bmatrix} 1 & -1/2 & -1/2 \\ 1 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{bmatrix} \tag{8}$$

Eq. 9 shows the computation of real power (p) and imaginary power (q). Real and imaginary power are measured instantaneously in matrix and their form is given. Eq. 10 shows the presence of oscillating and average components in instantaneous power [13].

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \tag{9}$$

$$p = \bar{p} + \tilde{p} \quad ; \quad q = \bar{q} + \tilde{q} \tag{10}$$

Where $\bar{p}$ is the direct component of real power, $\tilde{p}$ is the fluctuating component of real power, $\bar{q}$ is the direct component of imaginary power, $\tilde{q}$ is the fluctuating component of imaginary power. The total imaginary power (q) and the fluctuating component of real power are selected as power references and current references and they are utilized through the use of Eq. 11 to compensate harmonic and reactive power [14].

$$\begin{bmatrix} i^*_{c\alpha} \\ i^*_{c\beta} \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} -\tilde{p} + \bar{p}_{loss} \\ -q \end{bmatrix} \tag{11}$$

The signal $\bar{p}_{loss}$, is obtained from voltage regulator and it is utilized as average real power. It can also be specified as the instantaneous active power which corresponds to the resistive loss and the switching loss of the UPQC. The error obtained on comparing the actual DC-link capacitor voltage with the reference value is processed in FLC, engaged by voltage control loop as it minimizes the steady state error of the voltage across the DC link to zero. The compensating currents ($i^*_{c\alpha}, i^*_{c\beta}$) required to meet the power demand of load are shown in Eq. 11. These currents are represented in α-β coordinates. Eq. 12 is used to acquire the phase current required for compensation. These source phase currents ($i^*_{sa}, i^*_{sb}, i^*_{sc}$) are represented in a-b-c axis obtained from compensating current in the α-β coordinates in Eq. 12 [14].

$$\begin{bmatrix} i^*_{sa} \\ i^*_{sb} \\ i^*_{sc} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -1/2 & \sqrt{3}/2 \\ -1/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i^*_{c\alpha} \\ i^*_{c\beta} \end{bmatrix} \tag{12}$$

Fig. 4 shows a control of shunt active filter.

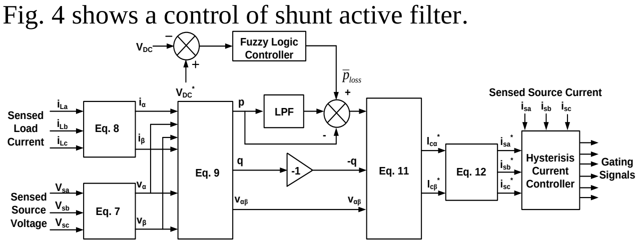


Fig 4. Control strategy of shunt active filter

The proposed model of UPQC supplied by PV and BES is shown in Fig 1. From the figure it can be seen that the PV and BES are connected to the DC link through a DC-DC boost converter circuit. The PV generator partially distributes power to the load and the remaining is transferred to the three phase grid. The load consists of non linear and unbalanced load. The non-linear load is a diode rectifier circuit with the RL load type, while the unbalanced load is a three phase RC load with different R value on each phase. In order to be economically efficient, PV generator must always work in maximum power point (MPP) condition. In this research, the MPPT method used is P and O algorithm. In order to operate properly, the UPQC device must have a minimum DC link voltage (V_{dc}). The value of common DC link voltage depends on the instantaneous energy avialable to the UPQC is defined by Eq. 13 [12]:

$$V_{dc} = \frac{2\sqrt{2}V_{LL}}{\sqrt{3}m} \tag{13}$$

where m is the modulation index and V_{LL} is the AC grid line voltage of UPQC. Considering modulation index as 1 and for line to line grid voltage (V_{LL} = 380 volt), the V_{dc} is obtained 620,54 volt and is selected as 650 volt.

The input of shunt active filter showed in Fig. 5 is DC voltage (V_{dc}) and reference DC voltage (V_{dc}^*), while the output is $\bar{p}_{loss}$ by using PI controller. Then, the $\bar{p}_{loss}$ is a variable input to generate the reference source current (I_{sa}^*, I_{sb}^*, and I_{sc}^*). The reference source current output is then compared to sensed source current (I_{sa}, I_{sb}, and I_{sc}) by the current hysteresis control to generate trigger signal in IGBT circuit of shunt active filter. In this research, FLC as DC voltage control algorithm on shunt active filter is proposed and compared with PI controller. The

FLC is capable to reduce oscilation and generate quick convergence calculation during disturbances. This method is also used to overcome the weakness of PI control in determining proportional gain (K_p) and integral gain constant (K_i) which still use trial and error method.

II.6. Fuzzy Logic Controller

The research begins by determining $\overline{p}_{loss}$ as the input variable to result the reference source current on current hysteresis controller to generate a trigger signal on the IGBT shunt active filter of UPQC using PI controller (K_p = 0.2 and K_i = 1.5). By using the same procedure, $\overline{p}_{loss}$ is also determined by using FLC. The FLC has been widely used in recent industrial processes because it has heuristic, simpler, more effective and has multi rule based variables in both linear and non-linear system variations. The main components of FLC are fuzzification, decision making (rulebase, database, reason mechanism) and defuzzification showed in Fig. 5.

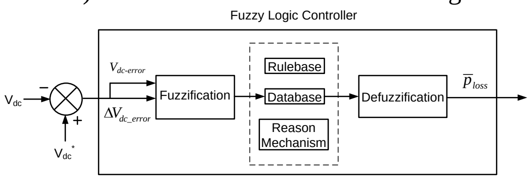
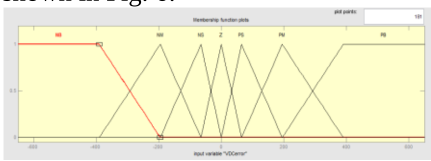


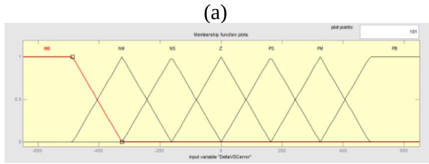
Fig 5. Diagram block of FLC

The fuzzy rule algorithm collects a number of fuzzy control rules in a particular order. This rule is used to control the system to meet the desired performance requirements and they are designed from a number of intelligent system control knowledge. The fuzzy inference of FLC uses Mamdani method related to max-min composition. The fuzzy inference system in FLC consists of three parts: rule base, database, and reasoning mechanism. Rule base consists of a number of If-Then rules for the proper operation of the controller. The If part of the rule is called antecedent and the Then section is called consequence. A number of these rules can be considered as similar responses made by human thought processes and controllers using linguistic input variables, gaining after fuzzification for operation of those rules. The database consists of all user defined membership functions that will be used in a number of these rules. Reasoning mechanisms basically process the rules provided based on certain rules and given conditions that provide the required results to user [15].

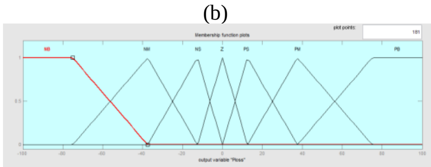
The FLC method is performed by determining the input variables V_{dc} ($V_{dc-error}$) and delta Vdc ($\Delta V_{dc-error}$), seven linguistic fuzzy sets, the operation fuzzy block system (fuzzyfication, fuzzy rule base and defuzzification), $V_{dc-error}$ and $\Delta V_{dc-error}$ during fuzzification process, the fuzzy rule base table, the crisp value to determine $\overline{p}_{loss}$ in defuzzification phase. The $\overline{p}_{loss}$ is one of variable input to obtain compensating currents $(i_{c\alpha}^*, i_{c\beta}^*)$ in Eq. 11. During fuzzification process, a number of input variables are calculated and converted into linguistic variables based on a subset called membership function. The Vdc error ($V_{dc-error}$) and the delta Vdc error ($\Delta V_{dc-error}$) are the proposed input variable system and the output variable is $\overline{p}_{loss}$. In order to translate these variables, each input and output variable is designed using seven membership functions: Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (Z), Positive Small (PS), Positive Medium (PM) and Positive Big (PB). The membership functions of crisp input and output are presented with triangle and trapezoid membership functions. The value of $V_{dc-error}$ range from -650 to 650, $\Delta V_{dc-error}$ from -650 to 650, and $\overline{p}_{loss}$ from -100 to 100. The input and output MFs are shown in Fig. 6.



(a)



(b)



(c)

Fig. 6. MFs (a) $V_{dc-error}$, (b) $\Delta V_{dc-error}$, (c) and $\overline{p}_{loss}$

After the $V_{dc-error}$ and the $\Delta V_{dc-error}$ are obtained, two input membership functions are converted to linguistic variables and they are used as input functions for FLC. The output membership function is generated using inference blocks and the basic rules of FLC as shown in Table II. Finally the defuzzification block operates to convert generated $\overline{p}_{loss}$ output from linguistic to numerical variable again. Then it becomes an input variable for current hysteresis controller to produce trigger signal on the IGBT circuit of UPQC shunt active filter to reduce source current and load voltage harmonics, while simultaneously improving power quality of 3P3W system under six interference scenarios due to integration of PV and BES into DC link of UPQC.

TABLE II
FUZZY RULE BASE

$V_{dc-error}$ / $\Delta V_{dc-error}$	NM	NB	NS	Z	PS	PB	PM
PM	Z	PS	PS	PM	PM	PB	PB
PB	NS	Z	PS	PS	PM	PM	PB
PS	NS	NS	Z	PS	PS	PM	PM
Z	NM	NS	NS	Z	PS	PS	PM
NS	NM	NM	NS	NS	Z	PS	PS
NB	NB	NM	NM	NS	NS	Z	PS
NM	NB	NB	NM	NM	NS	NS	Z

III. Result and Discussion

The analysis of the proposed model is investigated through the determination of six disturbance scenarios i.e. (1) NL, (2) Unba-NL, (3) Dis-NL, (4) Sag-NL, (5) Swell-NL, and (6) Inter-NL. In scenario 1, the system is connected to a non-linear load with R_L and L_L of 60 Ohm and 0.15 mH respectively. In scenario 2, the system is connected to non-linear load and during 0.3 s since t = 0.2 s to t = 0.5 s connected to unbalance three phase load with R_1, R_2, R_3 as 6 Ohm, 12 Ohm, 24 Ohm respectively, and value of C_1, C_2, C_3 as 2200 µF. In scenario 3, the system is connected to non-linear load and source voltage generating 5^{th} and 7^{th} harmonic components with individual harmonic distortion values of 5% and 2% respectively. In scenario 4, the system is connected to non-linear load and source experiences a sag voltage disturbance of 50% for 0.3 s between t = 0.2 s to t = 0.5 s. In scenario 5, the system is connected to a non-linear load and source experiences a swell voltage disturbance of 50% for 0.3 s between t = 0.2 s to t = 0.5 s. In scenario 6, the system is connected to a non-linear load and source experiences an interruption voltage interference of 100% for 0.3 s between t = 0.2 s to t = 0.5 S. Each scenario uses UPQC control with PI control and FLC so the total number of disturbances are 12 scenarios.

Then by using Matlab/Simulink, the system is executed according to the desired scenario to obtain the curve of source voltage (V_S), load voltage (V_L), compensation voltage (V_C), source current (V_S), load current (I_L), and DC link voltage (V_{dc}). Then, THD value of source voltage, source current, load voltage, and load current in each phase as well as average THD value (Avg THD) are obtained based on the curves. THD in each phase is determined in one cycle started at t = 0.35 s. The average results of source voltage, source current, load voltage, and load current on proposed system of PV connected to DC link circuit without and with BES are presented in Table III and IV. Futhermore, THD in each phase and average THD of proposed system are showed in Table V and VI.

TABLE III
VOLTAGE AND CURRENT OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITHOUT BES

Scenarios	Source Voltage V_S (Volt)				Load Voltage V_L (Volt)				Source Current I_S (Ampere)				Load Current I_L (Ampere)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	309.5	309.5	309.5	**309.5**	310.0	310.0	310.0	**310.0**	8.828	8.838	8.858	**8.841**	8.586	8.586	8.585	**8.586**
2. Unba-NL	307.8	307.8	307.8	**307.8**	310.2	310.2	310.3	**310.2**	32.15	26.66	30.71	**29.84**	22.65	34.26	34.70	**30.54**
3. Dist-NL	309.5	309.5	309.5	**309.5**	308.5	312.1	310.5	**310.5**	8.936	8.863	10.73	**9.510**	8.522	8.757	8.601	**8.627**
4. Sag-NL	153.8	153.8	153.8	**153.8**	310.1	310.1	310.1	**310.1**	13.39	13.33	13.41	**13.38**	8.589	8.589	8.588	**8.589**
5. Swell-NL	464.4	464.4	464.4	**464.4**	310.1	310.1	310.1	**310.1**	8.457	8.468	8.460	**8.462**	8.558	8.590	8.558	**8.587**
6. Inter-NL	1.190	1.316	1.237	**1.247**	229.2	249.1	242.8	**240.4**	11.31	11.86	11.91	**35.08**	6.443	6.698	6.289	**6.477**
Fuzzy Logic Controller																
1. NL	309.5	309.5	309.5	**309.5**	310.1	310.1	310.0	**310.1**	8.769	8.738	8.811	**8.773**	8.578	8.588	8.587	**8.584**
2. Unba-NL	307.3	307.8	307.8	**307.8**	310.2	310.3	310.2	**310.2**	32.01	26.66	30.65	**29.78**	22.65	34.65	34.69	**30.66**
3. Dist-NL	309.4	309.5	309.5	**309.5**	309.6	312.1	309.9	**310.5**	8.938	8.820	8.916	**8.891**	8.552	8.766	8.586	**8.635**
4. Sag-NL	153.8	153.8	153.8	**153.8**	310.1	310.0	310.1	**310.1**	13.52	13.46	13.56	**13.51**	8.558	8.587	8.589	**8.578**
5. Swell-NL	464.4	464.7	464.7	**464.7**	310.1	310.1	310.1	**310.1**	8.353	8.371	8.365	**8.363**	8.591	8.588	8.587	**8.589**
6. Inter-NL	1.259	1.285	1.530	**1.358**	209.9	193.7	242.7	**215.4**	13.28	11.49	14.07	**12.95**	6.459	5.003	6.299	**5.921**

TABLE IV
VOLTAGE AND CURRENT OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITH BES

Scenarios	Source Voltage V_S (Volt)				Load Voltage V_L (Volt)				Source Current I_S (Ampere)				Load Current I_L (Ampere)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	309.6	309.6	309.6	**309.6**	307.6	307.8	307.7	**307.7**	7.766	7.793	7.759	**7.773**	8.528	8.529	8.533	**8.530**
2. Unba-NL	307.4	308.0	308.0	**307.8**	308.3	308.7	308.3	**308.4**	31.00	24.84	28.73	**28.15**	22.50	34.12	34.52	**30.38**
3. Dist-NL	309.6	309.6	309.6	**309.6**	313,8	314.3	317.4	**317.4**	7.897	7.919	7.867	**7.895**	8.748	8.704	8.785	**8.746**
4. Sag-NL	154.5	154.5	154.5	**154.5**	307.1	307.3	307.3	**307.2**	7.235	7.276	7.226	**7.246**	8.509	8.514	8.510	**8.511**
5. Swell-NL	464.7	464.7	464.7	**464.7**	308.6	308.7	308.6	**308.6**	7.979	7.980	7.964	**7.975**	8.550	8.553	8.554	**8.553**
6. Inter-NL	0.5359	1.385	0.8501	**0.9238**	310.2	259.8	290.2	**286.7**	7.392	12.67	6.045	**8.703**	8.707	7.747	7.637	**8.031**
Fuzzy Logic Controller																
1. NL	309.5	309.5	309.5	**309.5**	307.7	307.9	307.7	**307.8**	8.420	8.426	8.416	**8.421**	8.527	8.532	8.531	**8.530**
2. Unba-NL	307.4	307.9	308.0	**307.8**	308.5	308.7	308.4	**308.5**	31.66	25.50	29.36	**28.84**	22.52	34.11	35.52	**30.72**
3. Dist-NL	309.6	309.5	309.5	**309.5**	313.4	312.9	315.9	**314.1**	8.516	8.565	8.496	**8.526**	8.741	8.677	8.736	**8.718**
4. Sag-NL	154.4	154.4	154.4	**154.4**	307.3	307.3	307.2	**307.3**	8.563	8.560	8.561	**8.561**	8.514	8.517	8.512	**8.515**
5. Swell-NL	464.6	464.6	464.6	**464.6**	308.6	308.8	308.6	**308.7**	8.396	8.389	8.389	**8.392**	8.552	8.556	8.554	**8.554**
6. Inter-NL	0.4467	0.3918	0.3801	**0.4062**	314.0	293.4	304.9	**304.1**	4.024	3.778	3.608	**3.804**	8.874	8.195	8.193	**8.421**

Table III shows that UPQC supplied by PV without BES in 3P3W system with PI and FLC control for interference scenarios 1 to 5 is able to maintain average load voltages above 310 volt. The difference is that in scenario 6 (Inter-NL), PI control generates load voltage of 240.4 volt and if using FLC drops to 215 volt. Reviewed from source current using PI control, the highest and the lowest average source currents are generated by interference scenario 2 (Unba-NL) and 4 (Swell-NL) of 29.84 A and 8,462 A respectively. Otherwise if using FLC the highest and the lowest average source current drops on same both disturbance scenarios of 29.78 A and 8.363 A respectively.

Table IV indicates that UPQC supplied by PV using BES in 3P3W system with PI and FLC controls for scenarios 1 to 5 is able to produce average load voltage above 307 V. While in scenario 6 (Inter-NL), FLC produces a higher average load voltage of 304.1 V than when using PI control of 286.7 volt PI. Reviewed from average source current with PI control, the highest and lowest average source current are generated by interference scenarios 2 (Unba-NL) and 4 (Sag-NL) of 28.15 A and 7,246 A respectively. While if using FLC, the highest and lowest average source current are achieved in scenario 2 (Unba-NL) and scenario 5 (Swell-NL) of 28.84 A and 8,392 A.

TABLE V
HARMONICS OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITHOUT BES

Scenarios	Source Voltage THD (%)				Load Voltage THD (%)				Source Current THD (%)				Load Current THD (%)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	0.79	0.79	0.79	**0.79**	0.83	0.83	0.82	**0.83**	11.07	10.79	10.95	**10.94**	22.31	22.31	22.32	**22.31**
2. Unba-NL	0.68	0.70	0.67	**0.69**	0.74	0.77	0.71	**0.74**	4.520	4.540	4.240	**4.44**	5.280	2.050	2.700	**3.34**
3. Dist-NL	5.41	5.44	5.52	**5.46**	4.18	9.93	3.93	**6.02**	10.61	10.91	10.73	**10.75**	22.70	20.86	21.07	**21.54**
4. Sag-NL	1.03	1.03	1.03	**1.03**	0.52	0.52	0.52	**0.52**	11.60	11.57	11.27	**11.48**	22.29	22.29	22.28	**22.49**
5. Swell-NL	0.69	0.69	0.70	**0.69**	1.08	1.09	1.09	**1.09**	11.38	11.42	11.63	**11.48**	22.32	22.30	22.32	**22.31**
6. Inter-NL	98.72	87.77	95.42	**93.97**	13.58	16.61	16.87	**15.69**	15.62	16.56	19.01	**17.07**	18.21	20.16	21.06	**19.81**
Fuzzy Logic Controller																
1. NL	0.79	0.78	0.77	**0.78**	0.82	0.82	0.80	**0.81**	11.73	10.83	11.06	**11.21**	22.23	22.32	22.32	**22.29**
2. Unba-NL	0.68	0.70	0.66	**0.68**	0.71	0.74	0.70	**0.72**	4.560	4.900	4.470	**4.65**	5.290	2.050	2.700	**3.35**
3. Dist-NL	5.41	5.43	5.52	**5.45**	3.54	10.34	3.92	**5.93**	10.92	10.51	10.66	**10.69**	22.78	20.77	21.30	**21.62**
4. Sag-NL	1.02	1.02	1.03	**1.02**	0.52	0.52	0.52	**0.52**	11.99	12.02	11.99	**12.00**	22.31	22.31	22.29	**22.30**
5. Swell-NL	0.67	0.69	0.69	**0.68**	1.06	1.08	1.08	**1.07**	11.65	11.49	11.79	**11.64**	22.30	22.32	22.31	**22.31**
6. Inter-NL	91.76	97.26	82.66	**90.56**	39.40	24.79	42.32	**35.51**	41.57	23.11	43.92	**36.20**	40.18	35.29	42.75	**48.98**

TABLE VI
HARMONICS OF 3P3W SYSTEM USING UPQC SUPPLIED BY PV WITH BES

Scenarios	Source Voltage THD (%)				Load Voltage THD (%)				Source Current THD (%)				Load Current THD (%)			
	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg	Ph A	Ph B	Ph C	Avg
PI Controller																
1. NL	2.35	2.36	2.32	**2.34**	2.48	2.50	2.46	**2.48**	12.89	12.72	12.92	**12.84**	22.32	22.34	22.32	**22.33**
2. Unba-NL	2.29	2.20	2.24	**2.24**	2.43	2.23	2.37	**2.34**	2.660	2.330	2.240	**2.410**	5.230	2.070	2.660	**3.320**
3. Dist-NL	5.84	5.86	5.94	**5.88**	6.36	5.90	6.58	**6.28**	12.75	12.64	13.06	**12.82**	21.92	22.16	22.33	**22.14**
4. Sag-NL	4.69	4.75	4.81	**4.75**	2.46	2.48	2.53	**2.49**	14.26	13.96	14.16	**14.13**	22.28	22.31	22.28	**22.29**
5. Swell-NL	1.56	1.53	1.55	**1.55**	2.47	2.43	2.45	**2.45**	12.51	12.36	12.44	**12.44**	22.34	22.32	22.32	**22.33**
6. Inter-NL	NA	NA	NA	**NA**	32.11	15.09	28.54	**25.25**	270.90	145.89	275.67	**230.82**	47.70	34.58	36.29	**39.53**
Fuzzy Logic Controller																
1. NL	2.35	2.33	2.35	**2.34**	2.48	2.46	2.49	**2.47**	11.83	11.82	11.84	**11.83**	22.33	22.32	22.33	**22.33**
2. Unba-NL	2.25	2.27	2.20	**2.24**	2.39	2.41	2.34	**2.38**	2.620	2.400	2.220	**2.413**	5.230	2.100	2.640	**3.323**
3. Dist-NL	5.83	5.88	5.93	**5.88**	6.23	5.93	6.69	**6.28**	11.83	11.90	12.14	**11.96**	21.84	22.34	22.53	**22.24**
4. Sag-NL	4.71	4.76	4.79	**4.75**	2.46	2.48	2.50	**2.48**	11.91	11.88	11.86	**11.89**	22.27	22.32	22.32	**22.31**
5. Swell-NL	1.55	1.54	1.54	**1.54**	2.45	2.44	2.46	**2.45**	11.90	11.84	11.85	**11.86**	22.36	22.33	22.35	**22.35**
6. Inter-NL	NA	NA	NA	**NA**	13.05	6.60	11.15	**10.27**	30.61	34.72	31.57	**32.30**	24.25	24.25	24.71	**24.40**

Table V shows that the average THD of V_L of UPQC supplied by PV without BES in 3P3W for interference scenarios 1 to 5 using PI control is within the limits prescribed in IEEE 519. In this condition PI controller is also capable to maintain and to improve the average THD of load voltage within the limits of IEEE 519. The highest and the lowest average THD load voltages are achieved under scenario interruption conditions 6 (Inter-NL) and scenario 2 (Unba-NL): 15.69% and 0.74% respectively. PI controller is also able to reduce average THD source voltage in scenario 6 (Inter-NL) by 93.97% to 15.69% on the load side. The highest and the lowest average THD of source current are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 17.07% and 4.44% respectively. Table V also shows that average THD of load voltage of UPQC system supplied by PV without BES using FLC in disturbance scenarios 1 to 5, has fulfilled the limits prescribed in IEEE 519. FLC method is also capable to maintain and improve average THD of load voltage within the IEEE 519 limit. The highest and lowest average THD of V_L are achieved under scenario 6 (Inter-NL) and scenario 4 (Sag-NL) of 35.51% and 0.52. The implementation of FLC method is also able to reduce average THD of V_S in scenario 6 (Inter-NL) by 90.56% to 35.51% on load side. The highest and the lowest average THD of I_S are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 36.20% and 4.65%. UPQC system supplied by PV without BES in six interference scenarios using PI control and FLC is able to improve average THD of I_S better on average THD of I_L.

Table VI shows that average THD of V_L from UPQC supplied by PV with BES in 3P3W system for interference scenarios 1 to 5 using PI control is within the limits prescribed in IEEE 519. In this condition PI controller is also capable to maintain average THD of V_L within the limits of IEEE 519. The highest and the lowest average THD of V_L are achieved under scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 25.25% and 2.34% respectively. PI controller is also able to mitigate average THD of V_S in scenario 6 (Inter-NL) from not accessed (NA) to 25.25% on the load side. The highest and the lowest average THD of I_S are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 230.82% and 2.41% respectively. Table VI also indicates that average THD of V_L of UPQC system supplied by PV with BES using FLC in disturbance scenarios 1 to 5, has fulfilled limits prescribed in IEEE 519. FLC method is also capable to keep average THD of V_L within IEEE 519. The highest and the lowest average THD of V_L are achieved under scenario 6 (Inter-NL) and scenario 2 (Unba-NL): 10.27% and 2.38%. The use of FLC method is also useful to reduce average THD on V_S in scenario 6 (Inter-NL) from NA to 10.27% on load side. The highest and the lowest average THD of I_S are achieved in scenario 6 (Inter-NL) and scenario 2 (Unba-NL) of 32.30% and 2.413%, respectively. UPQC system supplied by PV with BES in six scenarios using PI control and FLC is able to improve average THD of I_S better on average THD of I_L. Fig. 7 and Fig. 8 present UPQC-PV performance using FLC without and with BES in scenario 4 (Sag-NL) and scenario 6 (Inter-NL).

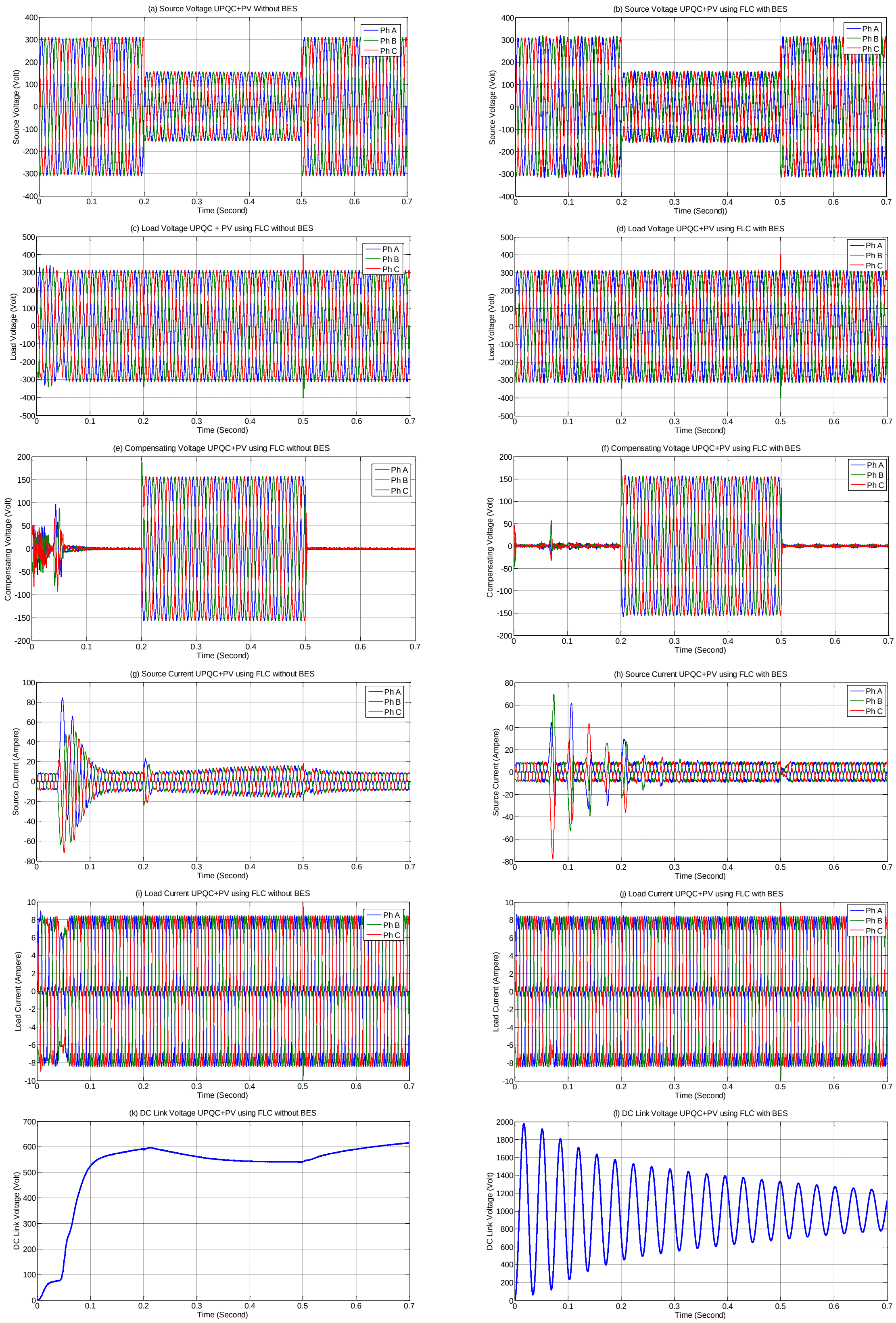


Fig. 7. UPQC supplied PV performance using FLC without and with BES in scenario 4 (Sag-NL)

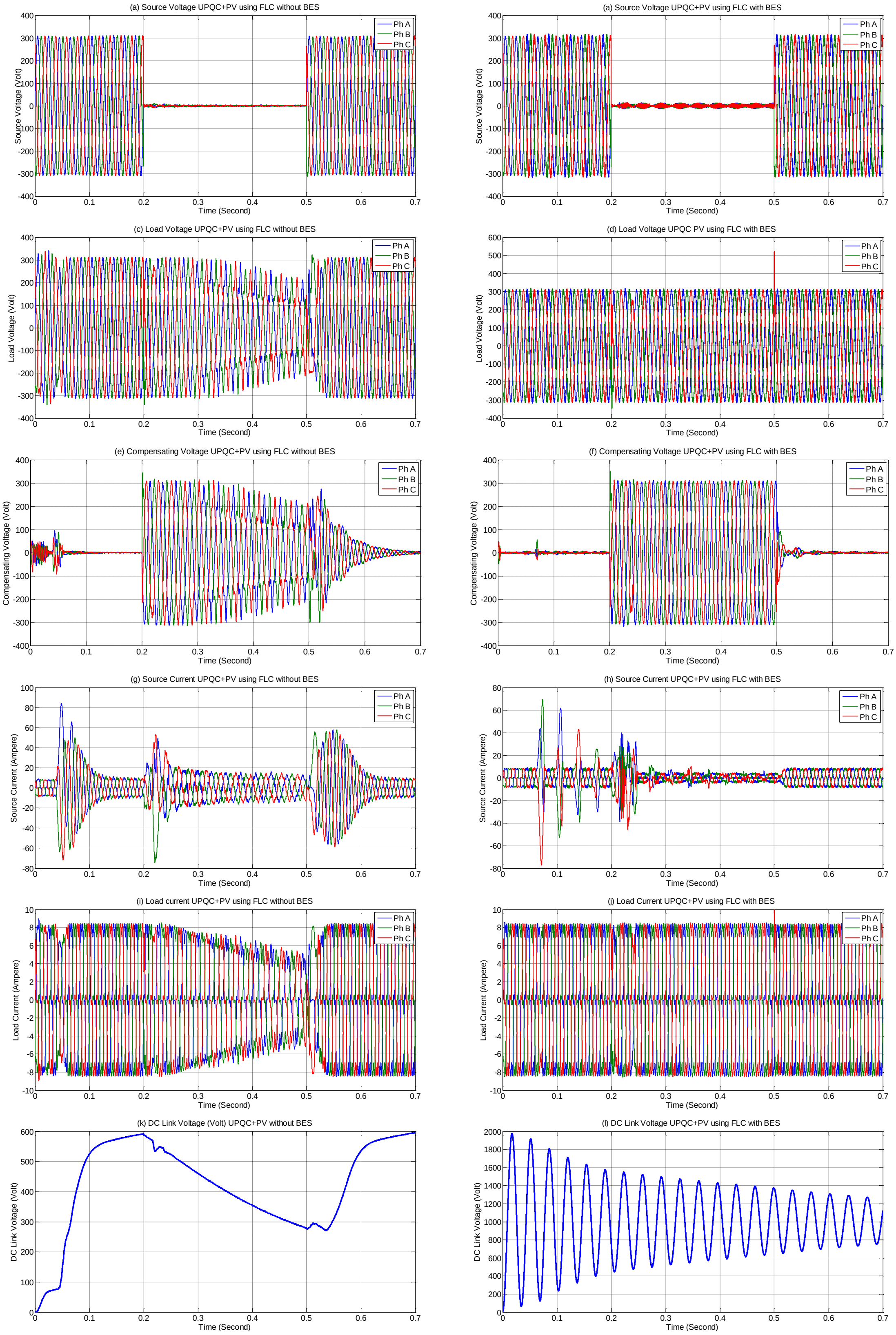
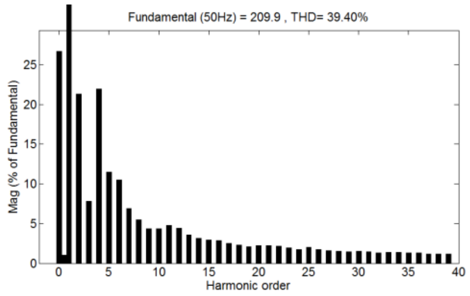


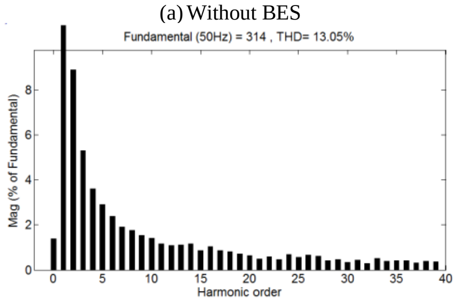
Fig. 8. UPQC supplied PV performance using FLC without and with BES in scenario 6 (Inter-NL)

Fig. 7a shows that in scenario 4 (Sag-NL), UPQC supplied by PV without BES at t = 0.2 s to t = 0.5 s avarage V_S drops by 50% from 310.1 V to 153.8 V. In this condition, PV is capable to generate power to the UPQC DC link circuit and injecting V_C as 153.8 V (Fig.7e) through injection transformer on series active filter so that average V_L remains stable at 310.1 V (Fig.7c). During this time, FLC on shunt active filter works to keep V_{dc} stable and average I_S increases approach to 13.28 A (Fig. 7g) in order to keep average I_L stable by 8.589 A (Fig. 7i). Fig. 8b in scenario 4 (Sag-NL) using BES also shows almost the same performance on average V_C, average V_L, and average I_L presented in Fig. 7f, Fig. 7d, and Fig. 7j respectively. The difference is that average I_S is slightly decreased to 8.561 A (Fig. 7h). The addition of BES, besides the fact of being capable to store excess power from PV generator, also serves to inject current into load through DC link (Fig. 7l) and shunt ative filter to produce average I_L equal to 8.515 A.

Fig. 8a shows that in scenario 6 (Inter-NL) UPQC supplied PV by without BES at t = 0.2 s to t = 0.5 s, average V_S falls as 100% to 1.358 V. In this condition PV is unable to generate the maximum power to UPQC DC link and inject average V_C in Fig 8e through injection transformer on series active filter. So at t = 0.2 s to t = 0.5, average V_L in Fig. 8c decrease to 215.4 V. During the disturbance, the implementation of FLC on shunt active filter keeps maintenance V_{dc} (Fig 8k), interruption voltage causes average I_S to decrease to 12.29 A (Fig. 8g) and average I_L also decreases to 5.921 A (Fig. 8i). Fig. 9b on UPQC supplied by PV with BES at t = 0.2 s to t = 0.5 s average V_S also drops 100% to 0.4062 V. During the disturbance, PV is able to generate power to UPQC DC link and injecting full average V_C in Fig. 9f through the injection transformer on series active filter so that average V_L remains stable at 304.1 V (Fig. 8d). As long fault period, although nominal of average I_S drops to 3.804 A, the combination of PV and BES is able to generate power, store excess energy of PV, and inject current into load through shunt active filter so that I_L in Fig. 8l remains as 8.421 A. Fig. 9 shows spectra of load voltage harmonics on phase A of UPQC supplied by PV using FLC without and with BES in scenario 6.



(a) Without BES



(b) With BES

Fig. 9. Spectra of load voltage harmonics on phase A UPQC supplied PV using FLC in scenario 6 (Inter-NL)

Fig. 10 and Fig. 11 show the performances of average THD of load voltage (V_L) and source current (I_S) on UPQC supplied by PV using PI controller and FLC without and with BES in six disturbance scenarios.

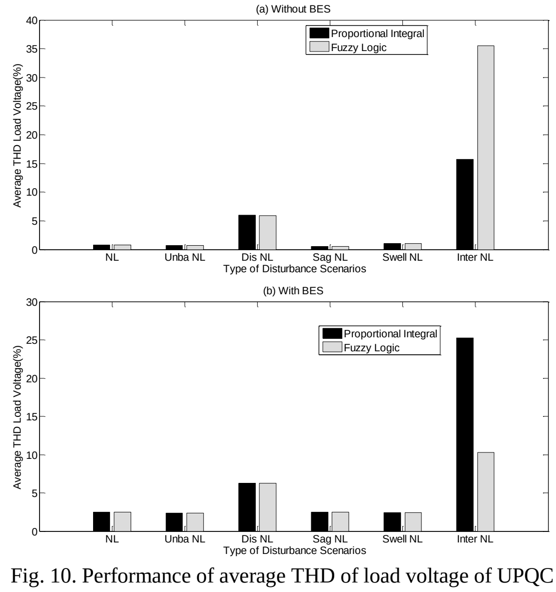


Fig. 10. Performance of average THD of load voltage of UPQC supplied by PV using PI and FLC in six disturbance scenarios

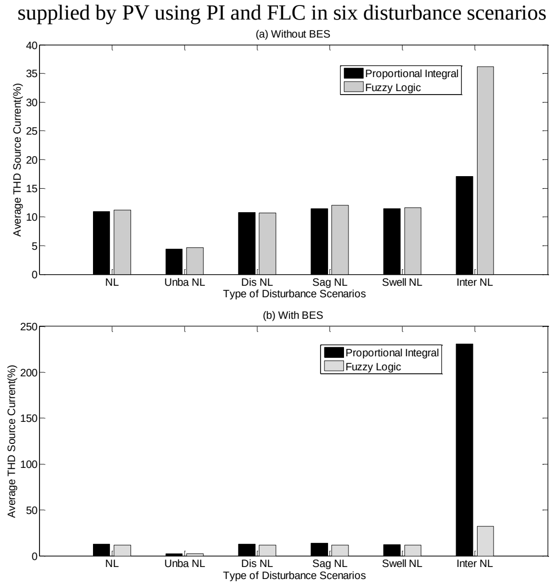


Fig. 11. Performance of average THD of source current of UPQC supplied by PV using PI and FLC in six disturbance scenarios

Fig. 10a shows that in scenario 1(NL), scenario 2 (Unba-NL), scenario 3 (Dis-NL), scenario 4 (Sag-NL), and scenario 5 (Swell-NL), the implementation of FLC on UPQC supplied by PV without BES is able to result average THD of V_L slightly better than PI controller and also limits prescribe in IEEE 519. Otherwise under scenario 6 (Inter-LN) PI controller give better significantly result of average THD of V_L than FLC. Fig. 10b shows that in six scenarios, the use of FLC on UPQC supplied by PV with BES able to result average THD of V_L slightly better than PI controller. In disturbance scenarios 1 to 5, nominal of average THD of V_L has met IEEE 519. Otherwise under scenario 6 (Inter-NL) FLC is able to reduce average THD of V_L significantly than PI controller.

Fig. 11a shows that in scenario 1(NL), scenario 2 (Unba-LN), scenario 3 (Dis-NL), scenario 4 (Sag-NL), and scenario 5 (Swell-NL), the implementation of PI controller on UPQC supplied by PV without BES is able to result average THD of I_S slightly better than FLC. Otherwise under scenario 6 (Inter-LN) PI controller gives better significantly result of average THD of source voltage than FLC. Fig. 11b shows that in six scenarios, the use of FLC on UPQC supplied by PV with BES is able to give average THD of I_S better than PI controller. Futhermore under scenario 6 (Inter-NL), FLC able to reduce average THD of source current significantly than PI controller.

IV. Conclusion

The use of BES supplied by PV connected to a three phase grid through to DC link of UPQC to improve power quality with PI controller and FLC have been discussed. In scenario 6, PV is able to generate power to UPQC-DC link and injecting full average compensation voltage through injection transformer on series active filter so that average load voltage remains stable. During voltage interuption, even though there is low source current, combination of PV and BES is able to deliver power, store excess energy of PV, and inject compensation current into load bus through shunt active filter. The implementation of FLC on UPQC supplied PV with BES results average THD of load voltage slightly lower than using PI controller. In disturbance scenarios 1 to 5, the implementation of FLC method UPQC supplied PV with BES is able to reduce average THD of load voltage slightly better than PI controller and has already met the limits prescribed in IEEE 519. Otherwise under scenario 6, FLC method able to reduce the average THD of load voltage significantly than PI controller. In disturbance scenarios 1 to 5, this method is able to give average THD of source current better than PI controller. Futhermore under scenario 6, it is also capable to give better performance significantly of average THD of source current more than PI controller.

Nevertheless, except under scenario 2, the average THD of source current on UPQC supplied by PV without/with BES using FLC method still does not meet the limits prescribed in IEEE 519. Implementation of another Fuzzy Method i.e. Type 2 Fuzzy/Fuzzy Sliding Mode to control shunt active filter on UPQC is proposed as one solution to improve it.

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