

A Novel Method for Placement of Batteries in a Distribution Network

Abstract— That storage device like batteries can substantially improve performance of power distribution system is well established. These improvements can include attributes like reduction in line loading, reduction in losses, improved voltage profile, better voltage control by minimizing voltage deviations. The extent of improvement can provide clue to placement of the batteries. In the literature, the placement are generally based on only considering one of these attributes. This paper attempts to take an integrated approach considering simultaneous effect of all the above attributes. The feasible plans are generated by eliminating a number of generated configurations. Analytical Hierarchy Process (AHP) is used to assign the weights to different attributes. Data Envelop Analysis (DEA) is used to judge the feasible plans on common platform considering normalized values of the attributes. The plans with high efficiency can help in decision on placement in an integrated manner with proper trade-off of attributes. The proposed methodology is illustrated on a IEEE 14 and 30 bus distribution system.

Index Terms— AHP-Analytical Hierarchy Process, DEA-Data Envelop Analysis, DN-Distribution Network, DG-Distributed Generation, PV-Photovoltaics, CR-Consistency ratio, CI-Consistency Index, RI-Reliability Index

1 INTRODUCTION

THIS document is a template for Microsoft Word versions 6.0 or later. If you are reading a paper version of this document, please download the electronic file from the [template download page](#) so you can use it to prepare your manuscript.

When you open the document, select "Page Layout" from the "View" menu in the menu bar (View | Page Layout), which allows you to see the footnotes. Then type over sections of the document or cut and paste from another document and then use markup styles. Please keep the template at 8.5" x 11" –do not set the template for A4 paper. The pull-down style menu is at the left of the Formatting Toolbar at the top of your Word window (for example, the style at this point in the document is "Text"). Highlight a section that you want to designate with a certain style, then select the appropriate name on the style menu. The style will adjust your fonts and line spacing. Use italics for emphasis; do not underline. **Do not change the font sizes or line spacing to squeeze more text into a limited number of pages. Please be certain to follow all submission guidelines when formatting an article or it will be returned for reformatting.**

To modify the running headings, select View | Header and Footer. Click inside the text box to type the name of the journal the article is being submitted to and the manuscript identification number. Click the forward arrow in the pop-up tool bar to modify the header or footer on subsequent pages.

-
- Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com
 - Co-Author name is currently pursuing masters degree program in electric power engineering in University, Country, PH-01123456789. E-mail: author_name@mail.com
- (This information is optional; change it according to your need.)

IJSER staff will edit and complete the final formatting of

your paper.

2 PROCEDURE FOR PAPER SUBMISSION

2.1 Review Stage

Detailed submission guidelines can be found on the author resources Web pages. Author resource guidelines are specific to each journal, so please be sure to refer to the correct journal when seeking information. All authors are responsible for understanding these guidelines before submitting their manuscript. For further information on both submission guidelines, authors are strongly encouraged to refer to <http://www.ijser.org>.

2.2 Final Stage

For papers accepted for publication, it is essential that the electronic version of the manuscript and artwork match the hard-copy exactly! The quality and accuracy of the content of the electronic material submitted is crucial since the content is not recreated, but rather converted into the final published version.

All papers in IJSER Transactions are edited electronically. A final submission materials check list, transmission and compression information, and general publication materials can be found at: <http://www.ijser.org>.

2.3 Figures

All tables and figures will be processed as images. You need to embed the images in the paper itself. Please don't send the images as separate files.

2.4 Copyright Form

An IJSER copyright form must accompany your final submission. You can get a .pdf, .html, or .doc version at <http://computer.org/copyright.htm>. Authors are responsible for obtaining any security clearances.

For any questions about initial or final submission requirements, please contact one of our staff members. Contact information can be found at: <http://www.ijser.org>.

3 SECTIONS

As demonstrated in this document, the numbering for sections upper case Arabic numerals, then upper case Arabic numerals, separated by periods. Initial paragraphs after the section title are not indented. Only the initial, introductory paragraph has a drop cap.

4 CITATIONS

IJSER style is to not citations in individual brackets, followed by a comma, e.g. “[1], [5]” (as opposed to the more common “[1, 5]” form.) Citation ranges should be formatted as follows: [1], [2], [3], [4] (as opposed to [1]-[4], which is not IJSER style). When citing a section in a book, please give the relevant page numbers [2]. In sentences, refer simply to the reference number, as in [3]. Do not use “Ref. [3]” or “reference [3]” At the beginning of a sentence use the author names instead of “Reference [3],” e.g., “Smith and Smith [3] show” Please note that references will be formatted by IJSER production staff in the same order provided by the author.

5 EQUATIONS

If you are using Word, use either the Microsoft Equation Editor or the MathType add-on (<http://www.mathtype.com>) for equations in your paper (Insert | Object | Create New | Microsoft Equation or MathType Equation). “Float over text” should not be selected.

Number equations consecutively with equation numbers in parentheses flush with the right margin, as in (1). First, use the equation editor to create the equation. Then, select the “Equation” markup style. Press the tab key and write the equation number in parentheses. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Use parentheses to avoid ambiguities in denominators. Punctuate equations when they are part of a sentence, as in

$$\int_0^{r_2} F(r, \varphi) dr d\varphi = [\sigma r_2 / (2\mu_0)] \cdot \int_0^\infty \exp(-\lambda |z_j - z_i|) \lambda^{-1} J_1(\lambda r_2) J_0(\lambda r_i) d\lambda \quad (1)$$

Be sure that the symbols in your equation have been defined before the equation appears or immediately following. Italicize symbols (*T* might refer to temperature, but *T* is the unit tesla). Per IJSER, please refer to “(1),” not “Eq. (1)” or “equation (1),” except at the beginning of a sentence: “Equation (1) shows” Also see *The Handbook of Writing for the Mathematical Sciences*, 1993. Published by the Society for Industrial and Applied Mathematics, this handbook provides some helpful information about math typography and other stylistic matters. For further information about typesetting mathematical equations, please visit the IJSER style guide: <http://www.ijser.org>.

Please note that math equations might need to be reformatted from the original submission for page layout reasons. This includes the possibility that some in-line equations will be made display equations to create better flow in a paragraph. If display equations do not fit in the two-column format, they will also be reformatted. Authors are strongly encouraged to ensure that equations fit in the given column width.

6 HELPFUL HINTS

6.1 Figures and Tables

Because IJSER staff will do the final formatting of your paper, some figures may have to be moved from where they appeared in the original submission. Figures and tables should be sized as they are to appear in print. Figures or tables not correctly sized will be returned to the author for reformatting.

Detailed information about the creation and submission of images for articles can be found at: <http://www.ijser.org>. We strongly encourage authors to carefully review the material posted here to avoid problems with incorrect files or poorly formatted graphics.

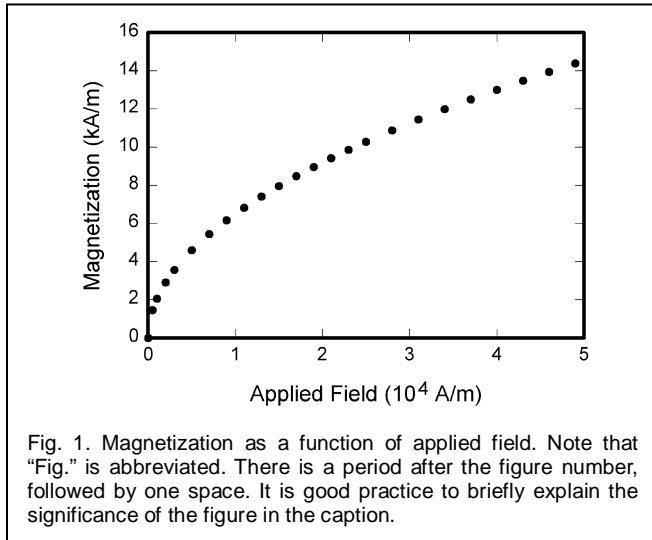
Place figure captions below the figures; place table titles above the tables. If your figure has two parts, include the labels “(a)” and “(b)” as part of the artwork. Please verify that the figures and tables you mention in the text actually exist. Figures and tables should be called out in the order they are to appear in the paper. For example, avoid referring to figure “8” in the first paragraph of the article unless figure 8 will again be referred to after the reference to figure 7. **Please do not include figure captions as part of the figure. Do not put captions in “text boxes” linked to the figures. Do not put borders around the outside of your figures.** Per IJSER, please use the abbreviation “Fig.” even at the beginning of a sentence. Do not abbreviate “Table.” Tables are numbered numerically.

Figures may only appear in color for certain journals. Please verify with IJSER that the journal you are submitting to does indeed accept color before submitting final materials. **Do not use color unless it is necessary for the proper interpretation of your figures.**

Figures (graphs, charts, drawing or tables) should be named fig1.eps, fig2.ps, etc. If your figure has multiple parts, please submit as a single figure. Please do not give them descriptive names. Author photograph files should be named after the author’s LAST name. Please avoid naming files with the author’s first name or an abbreviated version of either name to avoid confusion. If a graphic is to appear in print as black and white, it should be saved and submitted as a black and white file (gray-scale or bitmap.) If a graphic is to appear in color, it should be submitted as an RGB color file.

TABLE 1
UNITS FOR MAGNETIC PROPERTIES

Symbol	Quantity	Conversion from Gaussian and CGS EMU to SI ^a
Φ	magnetic flux	1 Mx \rightarrow 10^{-8} Wb = 10^{-8} V·s
B	magnetic flux density, magnetic induction	1 G \rightarrow 10^{-4} T = 10^{-4} Wb/m ²
H	magnetic field strength	1 Oe \rightarrow $10^3/(4\pi)$ A/m
m	magnetic moment	1 erg/G = 1 emu \rightarrow 10^{-3} A·m ² = 10^{-3} J/T
M	magnetization	1 erg/(G·cm ³) = 1 emu/cm ³ \rightarrow 10^3 A/m
$4\pi M$	magnetization	1 G \rightarrow $10^3/(4\pi)$ A/m
σ	specific magnetization	1 erg/(G·g) = 1 emu/g \rightarrow 1 A·m ² /kg
j	magnetic dipole moment	1 erg/G = 1 emu \rightarrow $4\pi \times 10^{-10}$ Wb·m
J	magnetic polarization	1 erg/(G·cm ³) = 1 emu/cm ³ \rightarrow $4\pi \times 10^{-4}$ T
χ, κ	susceptibility	1 \rightarrow 4π
χ_g	mass susceptibility	1 cm ³ /g \rightarrow $4\pi \times 10^{-3}$ m ³ /kg
μ	permeability	1 \rightarrow $4\pi \times 10^{-7}$ H/m = $4\pi \times 10^{-7}$ Wb/(A·m)
μ_r	relative permeability	$\mu \rightarrow \mu_r$
w, W	energy density	1 erg/cm ³ \rightarrow 10^{-1} J/m ³
N, D	demagnetizing factor	1 \rightarrow $1/(4\pi)$



Statements that serve as captions for the entire table do not need footnote letters.

^aGaussian units are the same as cgs emu for magnetostatics; Mx = maxwell,

G = gauss, Oe = oersted, Wb = weber, V = volt, s = second, T = tesla, m =

meter, A = ampere, J = joule, kg = kilogram, H = henry.

Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity "Magnetization," or "Magnetization M," not just "M." Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write "Magnetization (A/m)" or "Magnetization (A·m⁻¹)," not just "A/m." Do not label axes with a ratio of quantities and units. For example, write "Temperature (K)," not "Temperature/K." Table 1 shows some examples of units of measure.

Multipliers can be especially confusing. Write "Magnetization (kA/m)" or "Magnetization (103 A/m)." Do not write "Magnetization (A/m) × 1,000" because the reader would not know whether the top axis label in Fig. 1 meant 16,000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 12 point type. When creating your graphics, especially in complex graphs and charts, please ensure that line weights are thick enough that when reproduced at print size, they will still be legible. We suggest at least 1 point.

6.3 Footnotes

Number footnotes separately in superscripts (Insert | Footnote)¹. Place the actual footnote at the bottom of the column in which it is cited; do not put footnotes in the reference list (endnotes). Use letters for table footnotes (see Table 1). Please do not include footnotes in the abstract and avoid using a footnote in the first column of the article. This will cause it to appear of the affiliation box, making the layout look confusing.

6.4 Lists

The IJSER style is to create displayed lists if the number of

¹It is recommended that footnotes be avoided (except for the unnumbered footnote with the receipt date on the first page). Instead, try to integrate the footnote information into the text.

items in the list is longer than three. For example, within the text lists would appear 1) using a number, 2) followed by a close parenthesis. However, longer lists will be formatted so that:

1. Items will be set outside of the paragraphs.
2. Items will be punctuated as sentences where it is appropriate.
3. Items will be numbered, followed by a period.

6.5 Theorems and Proofs

Theorems and related structures, such as axioms corollaries, and lemmas, are formatted using a hanging indent paragraph. They begin with a title and are followed by the text, in italics.

Theorem 1. *Theorems, corollaries, lemmas, and related structures follow this format. They do not need to be numbered, but are generally numbered sequentially.*

Proofs are formatted using the same hanging indent format. However, they are not italicized.

Proof. The same format should be used for structures such as remarks, examples, and solutions (though these would not have a Q.E.D. box at the end as a proof does).

7 END SECTIONS

7.1 Appendices

Appendices, if needed, appear before the acknowledgment. In the event multiple appendices are required, they will be labeled "Appendix A," "Appendix B," etc. If an article does not meet submission length requirements, authors are strongly encouraged to make their appendices supplemental material.

IJSER Transactions accepts supplemental materials for review with regular paper submissions. These materials may be published on our Digital Library with the electronic version of the paper and are available for free to Digital Library visitors. Please see our guidelines below for file specifications and information. Any submitted materials that do not follow these specifications will not be accepted. All materials must follow US copyright guidelines and may not include material previously copyrighted by another author, organization or company. More information can be found at <http://www.ijser.org>.

7.2 Acknowledgments

The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank" Instead, write "F. A. Author thanks" Sponsor and financial support acknowledgments are included in the acknowledgment section. For example: This work was supported in part by the US Department of Commerce under Grant BS123456 (sponsor and financial support acknowledgment goes here). Researchers that contributed information or assistance to the article should also be acknowledged in this section.

7.3 References

Unfortunately, the Computer Society document translator cannot handle automatic endnotes in Word; therefore, type the reference list at the end of the paper using the "References" style. See the IJSER's style for reference formatting at: <http://www.ijser.org> [transref.htm](http://www.ijser.org). The order in which the references are submitted in the manuscript is the order they will appear in the final paper, i.e., references submitted nonalphabetized will remain that way.

Please note that the references at the end of this document are in the preferred referencing style. Within the text, use "et al." when referencing a source with more than three authors. In the reference section, give all authors' names; do not use "et al." Do not place a space between an authors' initials. Papers that have not been published should be cited as "unpublished" [4]. Papers that have been submitted or accepted for publication should be cited as "submitted for publication" [5]. Please give affiliations and addresses for personal communications [6].

Capitalize all the words in a paper title. For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [7].

7.3 Additional Formatting and Style Resources

Additional information on formatting and style issues can be obtained in the IJSER Style Guide, which is posted online at: <http://www.ijser.org/>. Click on the appropriate topic under the Special Sections link.

4 CONCLUSION

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclu-

sion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper.

ACKNOWLEDGMENT

The authors wish to thank A, B, C. This work was supported in part by a grant from XYZ.

REFERENCES

- [1] J.S. Bridle, "Probabilistic Interpretation of Feedforward Classification Network Outputs, with Relationships to Statistical Pattern Recognition," *Neurocomputing – Algorithms, Architectures and Applications*, F. Fogelman-Soulie and J. Herault, eds., NATO ASI Series F68, Berlin: Springer-Verlag, pp. 227-236, 1989. (Book style with paper title and editor)
- [2] W.-K. Chen, *Linear Networks and Systems*. Belmont, Calif.: Wadsworth, pp. 123-135, 1993. (Book style)
- [3] H. Poor, "A Hypertext History of Multiuser Dimensions," *MUD History*, <http://www.ccs.neu.edu/home/pb/mud-history.html>. 1986. (URL link *include year)
- [4] K. Elissa, "An Overview of Decision Theory," unpublished. (Unpublished manuscript)
- [5] R. Nicole, "The Last Word on Decision Theory," *J. Computer Vision*, submitted for publication. (Pending publication)
- [6] C. J. Kaufman, Rocky Mountain Research Laboratories, Boulder, Colo., personal communication, 1992. (Personal communication)
- [7] D.S. Coming and O.G. Staadt, "Velocity-Aligned Discrete Oriented Polytopes for Dynamic Collision Detection," *IEEE Trans. Visualization and Computer Graphics*, vol.14, no.1, pp. 1-12, Jan/Feb 2008, doi:10.1109/TVCG.2007.70405. (IEEE Transactions)
- [8] S.P. Bingulac, "On the Compatibility of Adaptive Controllers," *Proc. Fourth Ann. Allerton Conf. Circuits and Systems Theory*, pp. 8-16, 1994. (Conference proceedings)
- [9] H. Goto, Y. Hasegawa, and M. Tanaka, "Efficient Scheduling Focusing on the Duality of MPL Representation," *Proc. IEEE Symp. Computational Intelligence in Scheduling (SCIS '07)*, pp. 57-64, Apr. 2007, doi:10.1109/SCIS.2007.367670. (Conference proceedings)
- [10] J. Williams, "Narrow-Band Analyzer," PhD dissertation, Dept. of Electrical Eng., Harvard Univ., Cambridge, Mass., 1993. (Thesis or dissertation)
- [11] E.E. Reber, R.L. Michell, and C.J. Carter, "Oxygen Absorption in the Earth's Atmosphere," Technical Report TR-0200 (420-46)-3, Aerospace Corp., Los Angeles, Calif., Nov. 1988. (Technical report with report number)
- [12] L. Hubert and P. Arabie, "Comparing Partitions," *J. Classification*, vol. 2, no. 4, pp. 193-218, Apr. 1985. (Journal or magazine citation)
- [13] R.J. Vidmar, "On the Use of Atmospheric Plasmas as Electromagnetic Reflectors," *IEEE Trans. Plasma Science*, vol. 21, no. 3, pp. 876-880, available at <http://www.halcyon.com/pub/journals/21ps03-vidmar>, Aug. 1992. (URL for Transaction, journal, or magazine)
- [14] J.M.P. Martinez, R.B. Llavori, M.J.A. Cabo, and T.B. Pedersen, "Integrating Data Warehouses with Web Data: A Survey," *IEEE Trans. Knowledge and Data Eng.*, preprint, 21 Dec. 2007, doi:10.1109/TKDE.2007.190746. (PrePrint)