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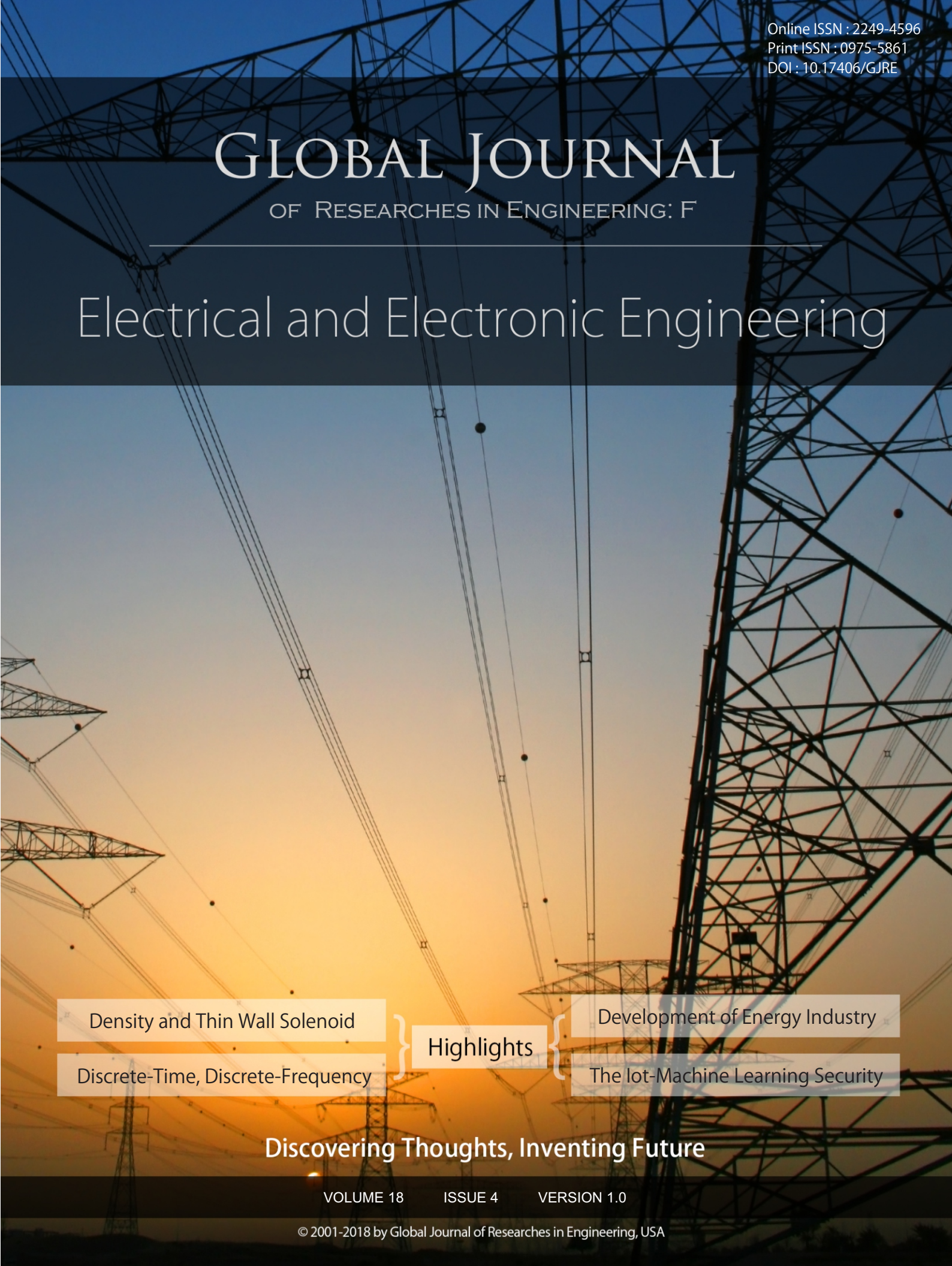

Density and Thin Wall Solenoid

Discrete-Time, Discrete-Frequency

Highlights

Development of Energy Industry

The Iot-Machine Learning Security

Discovering Thoughts, Inventing Future

VOLUME 18 ISSUE 4 VERSION 1.0

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Discrete-Time, Discrete-Frequency Reassignment Method

By Daniel L. Stevens & Stephanie A. Schuckers
Clarkson University

Abstract- The reassignment method is a non-linear, postprocessin technique which cans improve the localization of a time-frequency distribution by moving its values according to a suitable vector field. The reassignment method's scheme assumes that the energy distribution in the time-frequency plane resembles a mass distribution and moves each value of the time-frequency plane located at a point (***tt***, ***ff***)to another point,(***tt*** ℘***ff*** ℘), which is the center of gravity of the energy distribution in the area of (***tt***, ***ff***). The result is a focused representation with very high intensity [11]. During this research it was investigated and determined that the frequency reassignment corrections derived from the Flandrin reassignment method have undesired noise sensitivity at very small noise levels as well as undesired observed distortions. In order to address these issues, a novel approach was derived-the discrete-time, discrete-frequency formulation of frequency reassignment. It is shown that in noise-free tone scenarios, this novel approach eliminates ambiguity and provides less distortion than the Flandrin reassignment method.

Keywords: reassignment method, time-frequency distribution, discrete-time, discrete-frequency reassignment method.

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Discrete-Time, Discrete-Frequency Reassignment Method

Daniel L. Stevens [α] & Stephanie A. Schuckers [σ]

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Keywords: reassignment method, time-frequency distribution, discrete-time, discrete-frequency reassignment method.

I. Introduction

Bilinear time-frequency distributions offer a wide range of methods designed for the analysis of non-stationary signals. Nevertheless, a critical point of these methods is their readability [15], which means both a good concentration of the signal components along with few misleading interference terms. A lack of readability, which is a known deficiency in the classical time-frequency analysis techniques (e.g. Wigner-Ville distribution (WVD), spectrogram), must be overcome in order to obtain time-frequency distributions that can be both easily read by non-experts and easily included in a signal processing application [5]. Inability to obtain readable time-frequency distributions may lead to inaccurate signal detection and metrics extraction.

The reassignment method is a post-processing technique aimed at improving the readability of time-frequency distributions [7].The reassignment method has application to many scientific and engineering fields, including signal processing [16], biology [8], music [9], and mechanical engineering [1].The concept of time-frequency reassignment can be first traced back to Kodera in the 1970's, and was introduced in an attempt to improve the spectrogram [13].The reassignment operations proposed by Kodera could not be applied to discrete short-time Fourier transform (STFT) data, because the partial derivatives that formed these operations could not be computed directly on data that was discrete in time and frequency [6]. It has been suggested that this difficulty was a primary barrier to wider use of the reassignment method.

The next major step forward for the reassignment method was many years later when several papers were written by Auger and Flandrin [2], [4] in which reassignment equations were derived not only for the spectrogram, but also for a number of other time-frequency and time-scale distributions.

The spectrogram can be defined as a two-dimensional convolution of the WVD of the signal by the WVD of the analysis window, as in equation (1):

$$S_x(t, f; h) = \iint_{-\infty}^{+\infty} W_x(s, \xi) W_h(t - s, f - \xi) ds\, d\xi \quad (1)$$

The distribution reduces the interference terms of the signal's WVD, but at the expense of time and frequency localization. However, a closer look at equation 1 shows that $W_h(t - s, f - \xi)$ delimits a time-frequency domain at the vicinity of the (t, f) point, inside which a weighted average of the signal's WVD values is performed. The key point of the reassignment principle is that these values have no reason to be symmetrically distributed around (t, f), which is the geometrical center of this domain. Therefore, their average should not be assigned at this point, but rather at the center of gravity of this domain, which is much more representative of the local energy distribution of the signal [3]. Reasoning with a mechanical analogy, the local energy distribution $W_h(t - s, f - \xi) W_x(s, \xi)$ (as a function of s and ξ) can be considered as a mass distribution, and it is much more accurate to assign the total mass (i.e. the spectrogram value) to the center of gravity of the domain rather than to its geometrical center. Another way to look at it is this: the total mass of an object is assigned to its geometrical center, an arbitrary point

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which except in the very specific case of a homogeneous distribution, has no reason to suit the actual distribution. A much more meaningful choice is to assign the total mass of an object, as well as the spectrogram value, to the center of gravity of their respective distribution [5].

This is exactly how the reassignment method proceeds: it moves each value of the spectrogram computed at any point (t, f) to another point $(\hat{t},\hat{f})$ which is the center of gravity of the signal energy distribution around (t, f)[12](see equations (2) and (3)):

$$\hat{t}(x;t,f) = \frac{\iint_{-\infty}^{+\infty} s\, W_h(t-s, f-\xi) W_x(s,\xi) ds\, d\xi}{\iint_{-\infty}^{+\infty} W_h(t-s, f-\xi) W_x(s,\xi) ds\, d\xi} \tag{2}$$

$$\hat{f}(x;t,f) = \frac{\iint_{-\infty}^{+\infty} \xi\, W_h(t-s, f-\xi) W_x(s,\xi) ds\, d\xi}{\iint_{-\infty}^{+\infty} W_h(t-s, f-\xi) W_x(s,\xi) ds\, d\xi} \tag{3}$$

and thus leads to a reassigned spectrogram (equation (4)), whose value at any point (t', f') is the sum of all the spectrogram values reassigned to this point:

$$S_x^{(r)}(t', f'; h) = \iint_{-\infty}^{+\infty} S_x(t, f; h)\delta\big(t' - \hat{t}(x;t,f)\big)\delta\Big(f' - \hat{f}(x;t,f)\Big)\, dt\, df \tag{4}$$

One of the most interesting properties of this new distribution is that it also uses the phase information of the STFT, and not only its squared modulus as in the spectrogram. It uses this information from the phase spectrum to sharpen the amplitude estimates in time and frequency. This can be seen from the following expressions of the reassignment operators:

$$\hat{t}(x;t,f) = -\frac{d\Phi_x(t,f;h)}{df} \tag{5}$$

$$\hat{f}(x;t,f) = f + \frac{d\Phi_x(t,f;h)}{dt} \tag{6}$$

Where $\Phi_x(t,f;h)$ is the phase of the STFT of x : $\Phi_x(t,f;h) = \arg\ F_x$(t, f; h)). However, these expressions (equations (5) and (6)) do not lead to an efficient implementation, and have to be replaced by equations (7) (local group delay) and (8) (local instantaneous frequency):

$$\hat{t}(x;t,f) = t - \Re\left\{\frac{F_x(t,f;T_h)F_x^*(t,f;h)}{\left|F_{x(t\,f;h}\right|^2}\right\} \tag{7}$$

$$\hat{f}(x;t,f) = f - \Im\left\{\frac{F_x(t,f;D_h)F_x^*(t,f;h)}{\left|F_{x(t,f;h}\right|^2}\right\} \tag{8}$$

Where $T_h(t) = t \times h(t)$ and $D_h(t) = \frac{dh}{dt}(t)$. This leads to an efficient implementation for the reassigned spectrogram without explicitly computing the partial derivatives of phase. The reassigned spectrogram may thus be computed by using 3 STFTs, each having a different window (the window function h; the same window with a weighted time ramp t*h; the derivative of the window function h with respect to time (dh/dt), (also known as the frequency-weighted window)).

Reassigned spectrograms are therefore very easy to implement, and do not require a drastic increase in computational complexity.

Since time-frequency reassignment is not a bilinear operation, it does not permit a stable reconstruction of the signal. In addition, once the phase information has been used to reassign the amplitude coefficients, it is no longer available for use in reconstruction. This is perhaps why the reassignment method has received limited attention from engineers, and why its greatest potential may be where reconstruction is not necessary, that is, where signal analysis is an end unto itself.

The reassignment principle for the spectrogram allows for a straight-forward extension of its use to other distributions as well [10]. If we consider the general expression of a distribution of the Cohen's class as a two-dimensional convolution of the WVD, as in equation (9):

$$C_x(t,f;\Pi) = \iint_{-\infty}^{+\infty} \Pi(t-s, f-\xi) W_x(s,\xi) ds\, d\xi \tag{9}$$

replacing the particular smoothing kernel $W_h(u,\xi)$ by an arbitrary kernel $\Pi(s,\xi)$ simply defines the reassignment of any member of Cohen's class (equations (10) through (12)):

$$\hat{t}(x;t,f) = \frac{\iint_{-\infty}^{+\infty} s\, \Pi(t-s, f-\xi) W_x(s,\xi) ds\, d\xi}{\iint_{-\infty}^{+\infty} \Pi(t-s, f-\xi) W_x(s,\xi) ds\, d\xi} \tag{10}$$

$$\hat{f}(x;t,f) = \frac{\iint_{-\infty}^{+\infty} \xi\, \Pi(t-s, f-\xi) W_x(s,\xi) ds\, d\xi}{\iint_{-\infty}^{+\infty} \Pi(t-s, f-\xi) W_x(s,\xi) ds\, d\xi} \tag{11}$$

$$C_x^{(r)}(t', f'; \Pi) = \iint_{-\infty}^{+\infty} C_x(t, f; \Pi)\delta\big(t' - \hat{t}(x;t,f)\big)\delta\Big(f' - \hat{f}(x;t,f)\Big)\, dt\, df \tag{12}$$

The resulting reassigned distributions efficiently combine a reduction of the interference terms provided by a well adapted smoothing kernel and an increased concentration of the signal components achieved by the reassignment. In addition, the reassignment operators $\hat{t}(x;t,f)$ and $\hat{f}(x;t,f)$ are almost as easy to compute as for the spectrogram [4].

Similarly, the reassignment method can also be applied to the time-scale energy distributions [14]. Starting from the general expression in equation (13):

$$\Omega_x(t,a;\Pi) = \iint_{-\infty}^{+\infty} \Pi(s/a\,, f_0 - a\xi) W_x(t-s,\xi)\, ds\, d\xi \tag{13}$$

we can see that the representation value at any point $(t, a = f_0/f)$ is the average of the weighted WVD values on the points $(t-s,\xi)$ located in a domain centered on (t,f) and bounded by the essential support of Π. In order to avoid the resultant signal components broadening while preserving the cross-terms attenuation, it seems once again appropriate to assign this average to the center of gravity of these energy measures, whose coordinates are shown in equations (14) and (15):

$$\hat{t}(x;t,f) = t - \frac{\iint_{-\infty}^{+\infty} s\,\Pi(s/a\,, f_0 - a\xi) W_x(t-s,\xi) ds\, d\xi}{\iint_{-\infty}^{+\infty} \Pi(s/a\,, f_0 - a\xi) W_x(t-s,\xi) ds\, d\xi} \tag{14}$$

$$\hat{f}(x;t,f) = \frac{f_0}{\hat{a}(x;t,f)} = \frac{\iint_{-\infty}^{+\infty} \xi\,\Pi(s/a\,, f_0 - a\xi) W_x(t-s,\xi) ds\, d\xi}{\iint_{-\infty}^{+\infty} \Pi(s/a\,, f_0 - a\xi) W_x(t-s,\xi) ds\, d\xi} \tag{15}$$

Rather than to the point $(t, a = f_0/f)$ where it is computed. The value of the resulting modified time-scale representation on any point (t', a') is then the sum of all the representation values moved to this point, and is known as the reassigned scalogram (equation (16)):

It can be shown that the reassignment method is theoretically perfectly localized for chirps and impulses.

Fig. 1 clearly shows the improvement in readability that the reassignment method provides over its classical time-frequency distribution counterpart. This is due to the reassignment method's 'smoothing' and 'squeezing' qualities.

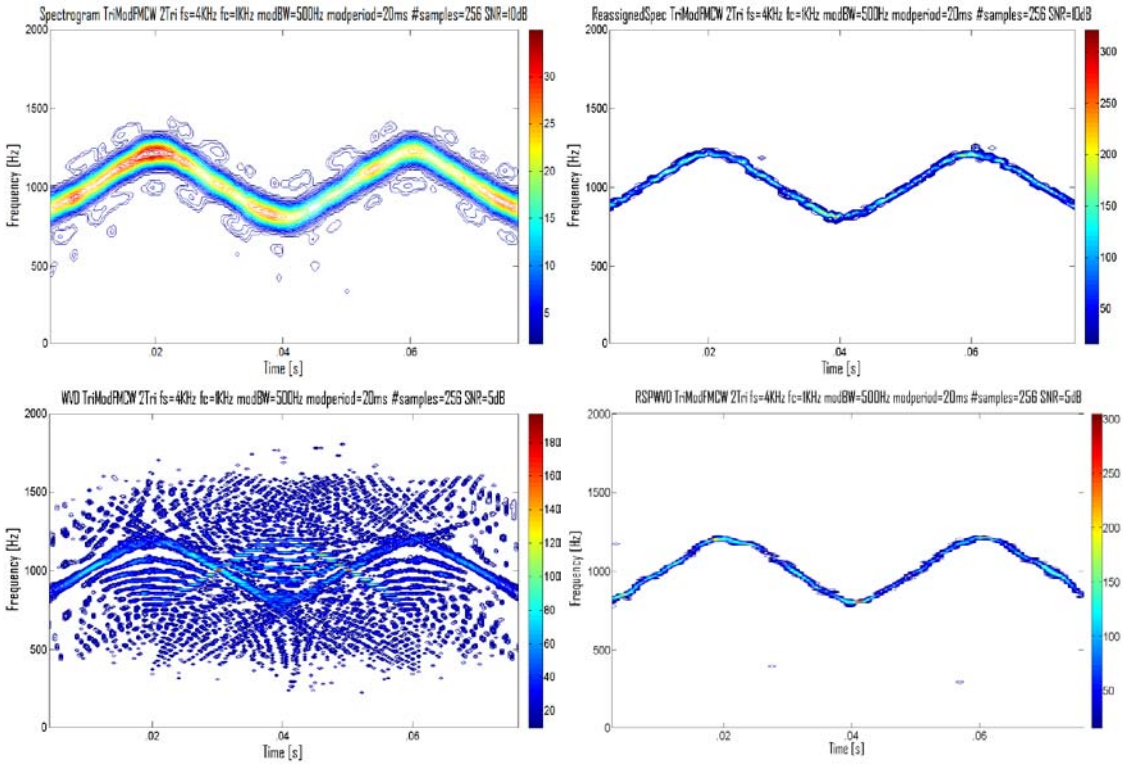

Figure 1: Time-frequency localization comparison between the classical time-frequency analysis tools (left) and the reassignment method (right). The uppper two plots are the spectrogram (left) and the reassigned spectrogram (right) for a triangular modulated FMCW signal (256 samples, SNR=10dB), and the lower two plots are the WVD

(left) and the reassigned smoothed-pseudo WVD (RSPWVD) (right) for a triangular modulated FMCW signal (256 samples, SNR=5dB). The reassignment method gives a much more concentrated time-frequency localization, and produces a reduction in cross-term interference, which makes for an improvement in readability over its classical time-frequency distribution counterpart [17].

Table I supports the hypothesis that the improved readability provided by the reassignment method (shown in Fig. 1) translates to more accurate signal detection and parameter metrics extraction.

Table I: Test metrics comparison between the spectrogram and the reassigned spectrogram and between the WVD and the RSPWVD (> 600 total test runs) [17]
('*' denotes outperformed its counterpart; '∼' denotes performed about equal to its counterpart)

Parameters Extracted	Spectrogram	Reassigned Spectrogram	WVD	RSPWVD
Carrier Frequency (% error)	∼ 1.0%	∼ 1.9%	∼ 2.5%	∼ 3.4%
Modulation Bandwidth (% error)	22.2%	* 1.0%	6.8%	* 3.9%
Modulation Period (% error)	∼ 0.5%	∼ 0.4%	∼ 0.3%	∼ 0.2%
TF Localization (X) (% of entire x-axis)	3.0%	* 1.1%	∼ 0.65%	∼ 0.69%
TF Localization (Y) (% of entire y-axis)	7.1%	* 2.2%	∼ 1.54%	∼ 1.48%
Chirp Rate (% error)	21.7%	* 0.6%	6.6%	* 4.6%
Percent Detection (0,10dB)	93.0%	* 100%	89.3%	* 95.0%
Lowest Detectable SNR	*-3.5 dB	-2.5 dB	-2.0 dB	*-3.0 dB
Plot Time	* 4.0 s	33.0 s	12m:54s	* 34.9 s

Experimental tests and analyses of the reassignment method algorithms in MATLAB (such as those illustrated above) have demonstrated the effectiveness of the reassignment method. Using simple threshold detection methods, visual inspection of a variety of input reassigned signals and detection results led to the conclusion that these results corresponded quite well with human assessment of the reassigned signals.

II. Concerns Discovered with the Flandrin Frequency Reassignment Method

While performing research under this effort for the purpose of obtaining quantitative performance measures for the reassignment method, it was discovered that the frequency reassignment corrections derived from the Flandrinre assignment method had undesired noise sensitivity at very small noise levels as well as undesired observed distortions.

The equation for the standard reassignment method is shown in equation (17):

$$frequency\ reassignment\ correction = \frac{-N}{2\pi} \cdot Im\left\{\frac{X_{hD}[n,k]}{X_h[n,k]}\right\} \quad (17)$$

This value is added to the frequency bin (index k), to correct for frequency assignment. Here, N is the DFT length (and signal segment length when no zero-padding is used). $X_h[n,k]$ is a DFT of the weighted input, formed from an N-length segment of the input x[n], multiplied by the N-length window, h[n]. $X_{hD}[n,k]$ is the DFT of the same input segment, but in this case, weighted (multiplied) by the "derivative" of the data window. The indices n and k are the time (sample) index and the frequency (bin) index respectively.

Figure 2 shows the undesired noise sensitivity at very small noise levels using Flandrin's reassignment method.

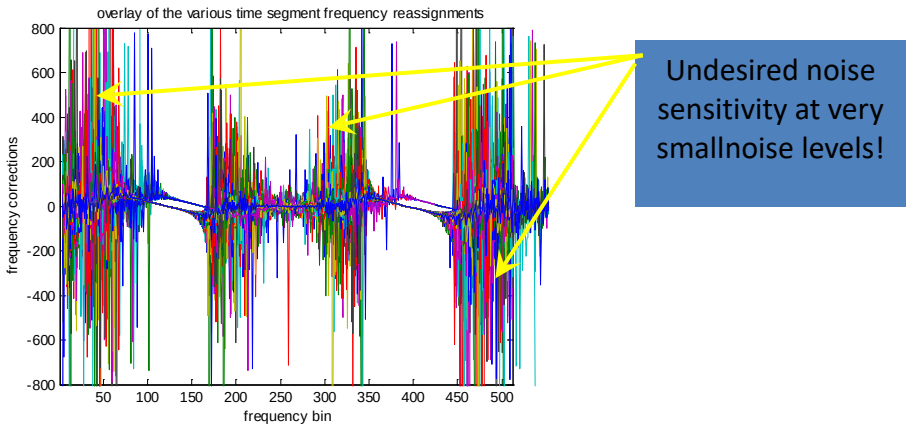

Figure 2: Frequency reassignment corrections derived from Flandrin et. al. algorithm. SNR=97dB and tone is located near bin 121. Undesired noise sensitivity is observed at very small noise levels.

Figure 3 is a plot of frequency bin vs. frequency corrections, again using the Flandrin frequency reassignment corrections algorithm (equation (17)), but this time with noise-free tones located near bin 0. The plot shows undesired observed distortions in noise-free frequency reassignment, as well as multi-valued corrections, implying ambiguity, and making uniquely correcting for distortions impossible.

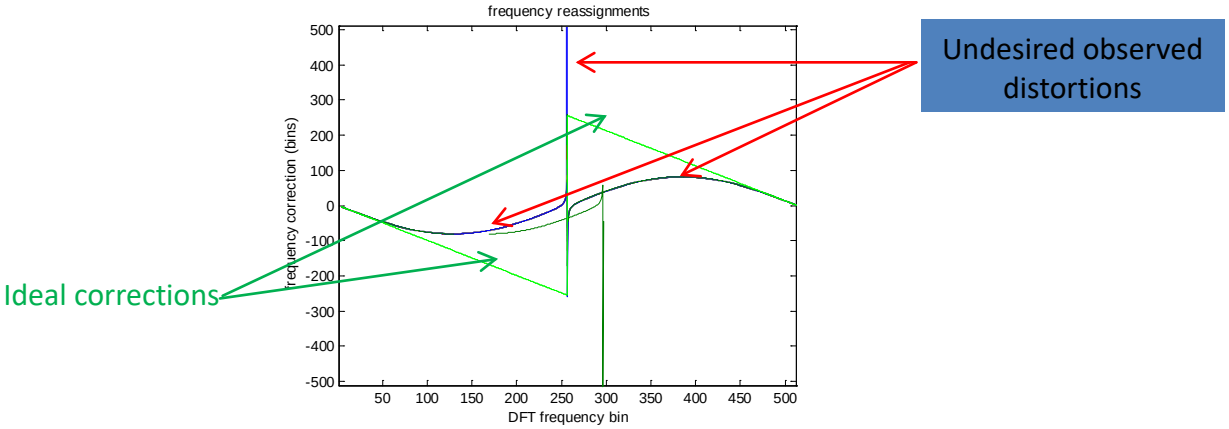

Figure 3: Frequency reassignment corrections derived from Flandrin et. al. algorithm. Noise-free tones located near bin 0. Plot shows distortions in noise-free frequency reassignment.

III. Inception of the Discrete-Time, Discrete-Frequency (D&D) Reassignment Method

Analyzing the frequency reassignments for the DFT of such a weighted data segment we can omit for now the time reassignment, which allows simplification of equation (17) as,

$$R[k] = \frac{-N}{2\pi} \cdot Im\left\{\frac{\mathrm{X}_{hD}[k]}{\mathrm{X}_{h}[k]}\right\} \tag{18}$$

or equivalently

$$R[k] = Im\left\{\frac{-N}{2\pi} \cdot W[k]\right\} \tag{19}$$

With

$$W[k] = \frac{\mathrm{X}_{hD}[k]}{\mathrm{X}_{h}[k]} \tag{20}$$

The sequence domain multiplication from the application of the data window results in circular convolution in the frequency domain, which allows us to write

$$\frac{X_{hD}[k]}{X_{h}[k]} = \frac{X[k] \circledast H_{D}[k]}{X[k] \circledast H[k]} \tag{21}$$

In the continuous-time, continuous-frequency original formulation of the frequency reassignment process, the weighting function, $h'(t)$, is the time-derivative of $h(t)$.

However, this relationship is a result of linear convolutional processes that occur in the domains of continuous-time and continuous-frequency.

For the discrete-time, discrete-frequency (D&D) formulation of frequency reassignment, we need to account for the circular convolutions as identified in equation (21).

Accounting for circular convolution allows us to determine the relationship between

$$h[n] = DFT^{-1}\{H[k]\} \quad (22)$$

and

$$h_D[n] = DFT^{-1}\{H_D[k]\} \quad (23)$$

We first return to the goal of frequency reassignment, which is to eliminate the spreading of sinusoidal components in the frequency representation of $x_h[n]$ as observed in the transform result, $X_h[k]$(i.e. we want localization in frequency).

This tells us that the desired result of Equation (19) is a (modulo-N for complex-valued inputs) ramp sequence, such that an input sinusoid is reassigned to a single frequency bin.

If we impose the requirement that the calculation in Equation (20) is purely imaginary valued for a given input sinusoid, likewise, $W[k]$can be determined from Equation (19).

With $W[k]$ known for an input complex exponential sinusoid, $x_{cs}[n]$, from Equations (20) and (21), we can solve for $h_D[n]$ in terms of $h[n]$, which results in

$$h_D[n] = \frac{DFT^{-1}\{W[k] \cdot DFT\{h[n] \cdot x_{cs}[n]\}\}}{x_{cs}[n]} \quad (24)$$

Note that the above Equation (24) represents a pre-processing step that can be performed as an initialization for determining$h_D[n]$, for a chosen data window,$h\ [n]$. Equation (24) represents the first iteration of the D&D reassignment method.

For any arbitrary input,$x[n]$, these data windows can be considered for use as implied in Equation (19) to accomplish the frequency reassignments.

As a practical matter, caution must be used to ensure that the denominator in Equation (24) does not result in division by zero.

A logical choice for the complex sinusoid, $x_{cs}[n]$, is one that maximally spreads energy across frequency bins, i.e., one that is at a frequency that lies exactly between two bin centers (i.e. choose the worst-case scenario for localization).

In this sense, the chosen sinusoid is a design signal, which allows us to elicit a response from the system of Equation (24), which is used as our "time-derivative" data window.

Observations made by following this method exposes the sensitivity of Equation (17) to the selection of an appropriate derivative of the data window, as can be seen in figure 4.

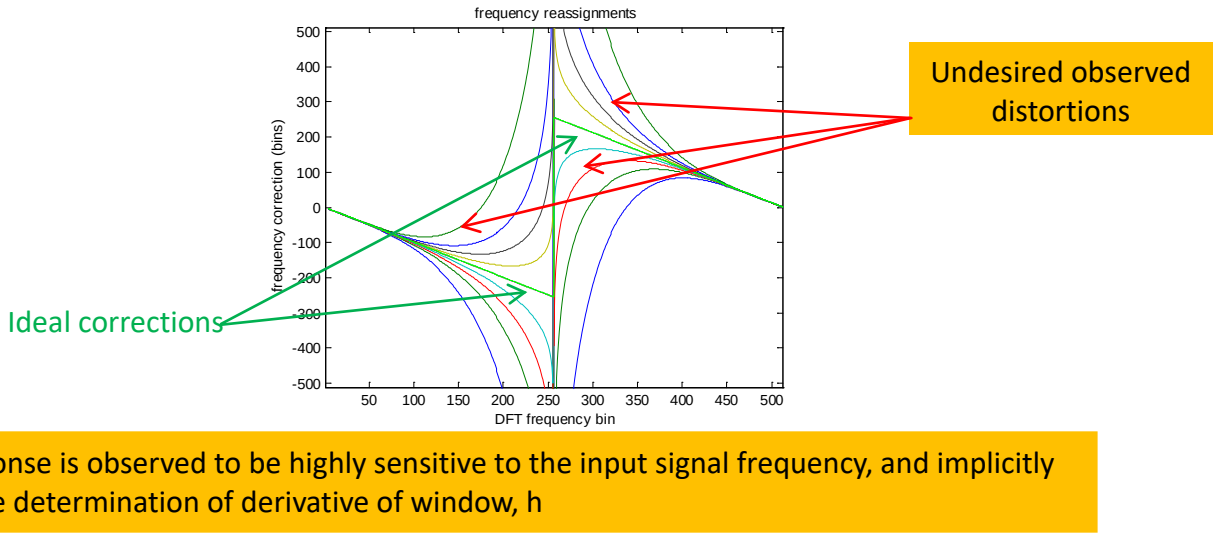

Figure 4: Frequency reassignment corrections derived from above method. Nine noise-free tones located near bin 0. Plot shows undesired observed distortions and that the response is observed to be highly sensitive to the input signal frequency, and implicitly to the determination of derivative of window, h. Note that when he input signal matches the design signal, ideal reassignment is achieved.

IV. Further Enhancement of the D&D Reassignment Method

In an attempt to resolve some of the issues noted in figure 4, frequency reassignment corrections were derived from exact mathematical derivative (i.e. Hanning, derivative of Hanning), followed by sampling. Figure 5 shows the results of this approach.

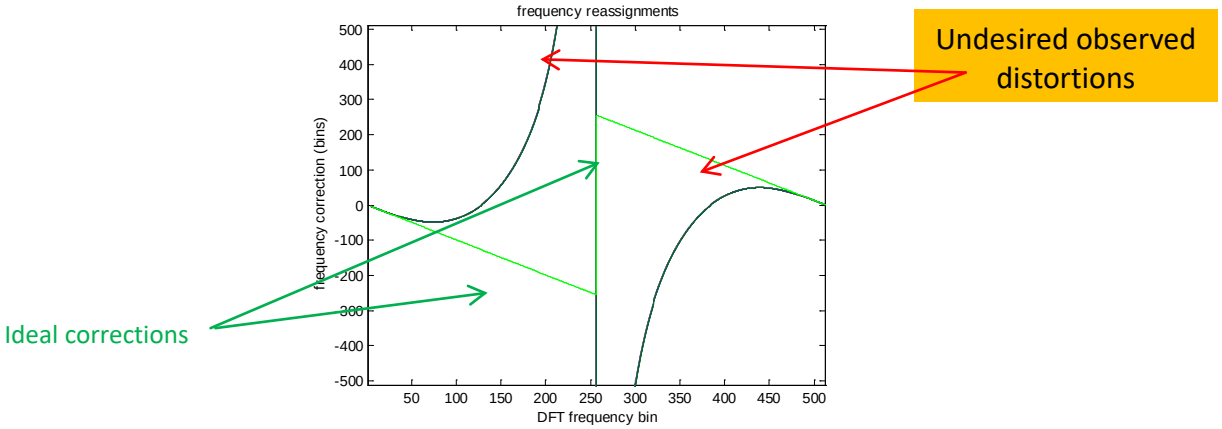

Figure 5: Frequency reassignment corrections derived from exact mathematical derivative (i.e. Hanning, derivative of Hanning), followed by sampling. Nine noise-free tones located near bin 0. The plot shows some improvement over figure 4 (consistent), but still has issues (undesired observed distortions, creates excessive distortion,is multi-valued causing ambiguity).

Continuing in an attempt to resolve issues brought out in figure 4 and figure 5, frequency reassignment corrections were derived from DFT-based scaling by jw as a derivative approximation (represents the most current state of development of the D&D reassignment method). Figure 6 shows the promising results of this approach.

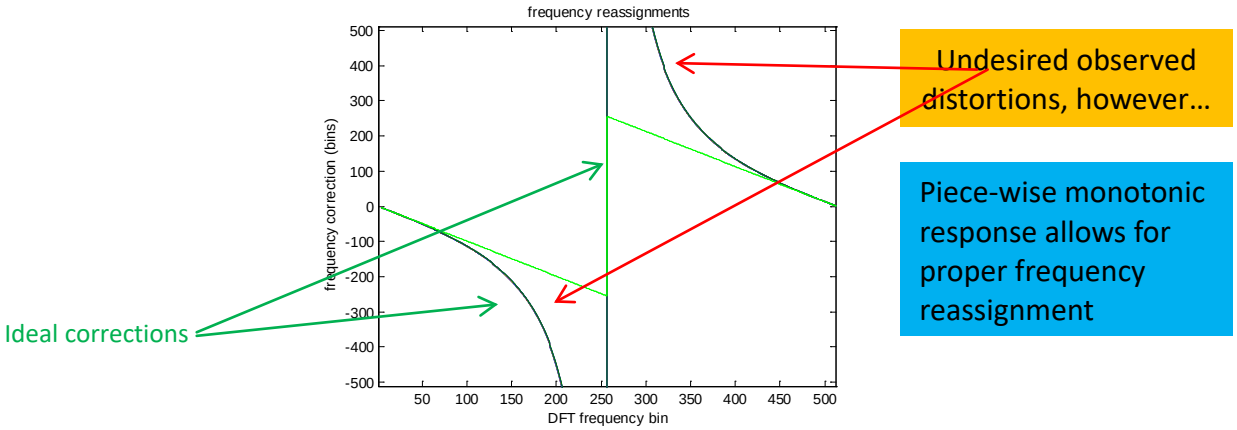

Figure 6: Frequency reassignment corrections derived from DFT-based scaling by jw as a derivative approximation (most current state of development of the D&D reassignment method). Nine noise-free tones located near bin 0. There are undesired observed distortions, however, using piece-wise monotonic response will allow for proper frequency reassignment. Eliminates the ambiguity, is consistent, with less distortion than prior methods. Shows a marked improvement over the methods used to produce figure 4 and figure 5. This most current state of development of the D&D reassignment method will be used to compare reassignment results to Flandrin's method.

Figure 7 shows comparisons of the original spectrogram, the Flandrin frequency reassignment, and the D&D frequency reassignment derived from DFT-based scaling by jw as a derivative approximation (noise-free tone (top row) and 80dB SNR (bottom row)). For the noise-free tone (top row), the D&D frequency reassignment clearly produces better results. For the bottom row, the blue band around the yellow line is more narrow (meaning more of the energy is reassigned) for the D&D frequency reassignment than for the Flandrin frequency reassignment (figure 8 substantiates this).

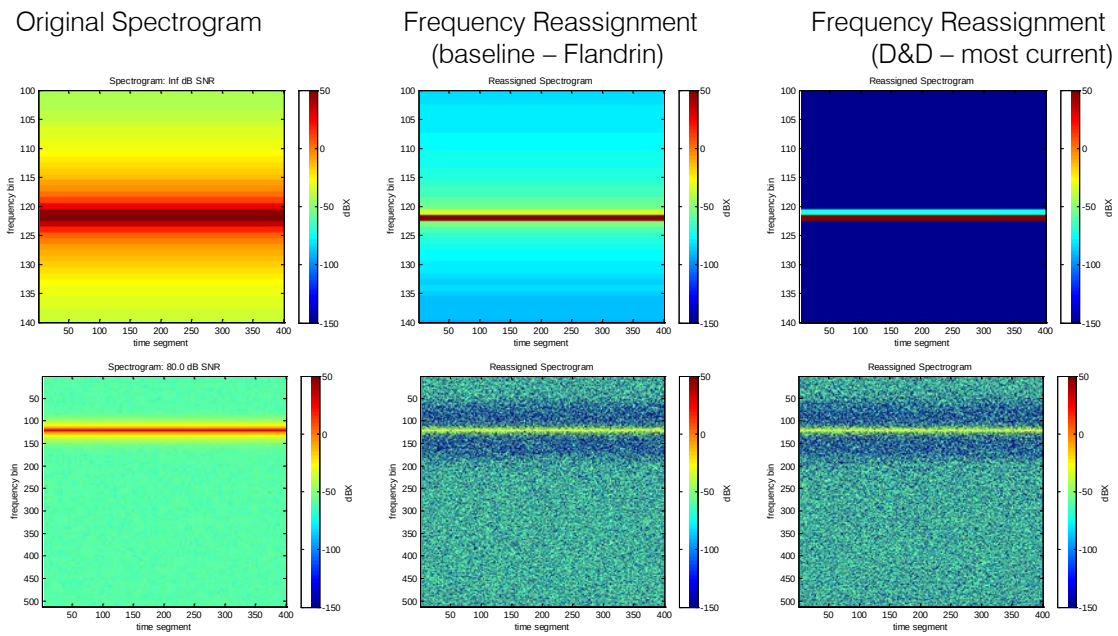

Figure 7: Comparisons of original spectrogram (left), baseline (Flandrin) frequency reassignment (center), and most current D&D frequency reassignment (right). The top row is for a noise-free tone, and the bottom row is for 80dB SNR. For the noise-free tone (top row), the D&D frequency reassignment clearly produces better results. For the bottom row, the blue band around the yellow line is more narrow (meaning more of the energy is reassigned) for the D&D frequency reassignment than for the Flandrin frequency reassignment (figure 8 substantiates this).

Figure 8, which represents new work in the area of preliminary statistical investigation, is a time accumulation comparison (similar to a Hough Transform) between Flandrin's frequency reassignment at 80dB SNR and the D&D frequency reassignment derived from DFT-based scaling by jw as a derivative approximation at 80dB SNR. Though the processing gain is evident for Flandrin's frequency reassignment, the processing gain is even more enhanced for the D&D frequency reassignment, showing both an increase in strength of the reassigned tone and a decrease in noise floor, leading to an improvement in detect ability at a commensurate false alarm rate. This substantiates the findings of figure 7 that more of the energy is reassigned in the bottom right plot (D&D) than in the bottom center plot (Flandrin).

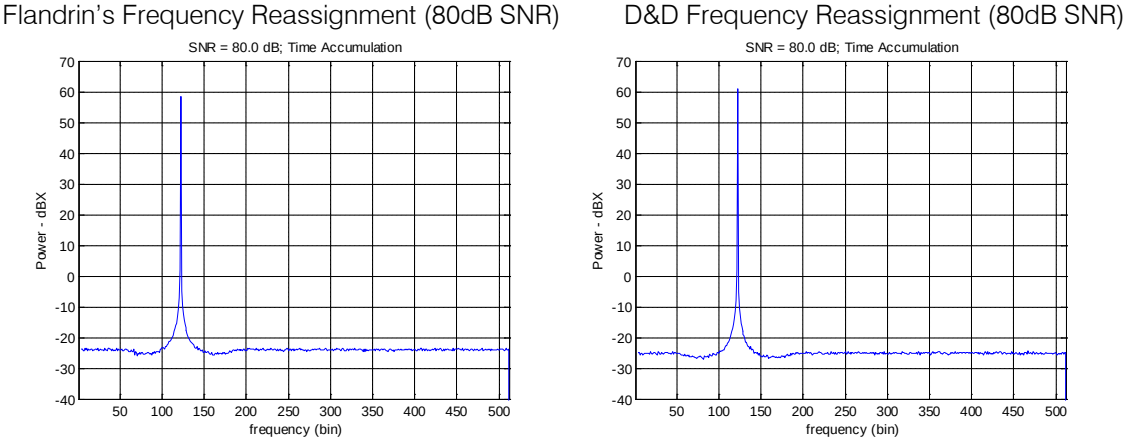

Figure 8: Time accumulation (i.e. representative of Hough Transform) comparison of baseline (Flandrin) frequency reassignment (left), and the most current D&D frequency reassignment (right) (both at 80dB SNR).Though processing gain is evident for Flandrin frequency reassignment, processing gain is even more enhanced for the D&D frequency reassignment, which shows both an increase in strength of reassigned tone and a decrease in noise floor, leading to an improvement in detectability at a commensurate false-alarm rate.

V. Conclusions

During this research it was investigated and determined that the frequency reassignment corrections derived from the Flandrin reassignment method have undesired noise sensitivity at very small noise levels as well as undesired observed distortions. To address these issues, the novel approach of the discrete-time, discrete-frequency (D&D) formulation of frequency reassignment was derived. It is shown that in noise-free tone scenarios, this novel approach (the D&D reassignment method) eliminates ambiguity and provides less distortion than the Flandrin reassignment method.

As a result of the derivation and enhancement of the D&D reassignment method, one of the focus areas for future research efforts will be a comparison between the D&D reassignment method and the standard (Flandrin's) reassignment method for not only frequency reassignment corrections, but also for time reassignment corrections, in both noise-free and high noise (low SNR) environments. Also, investigation will be performed using the D&D reassignment method to further reduce undesired observed distortions for both noise-free and high noise (low SNR) environments.
Publishing and patent efforts have come about as a result of this research [18], and will continue as the research develops.

References Références Referencias

1. Aime, J., Brissaud, M., Laguerre, L., Generation and Detection of Elastic Guided Waves with Magneto elastic Device for the Nondestructive Evaluation of Steel Cables and Bars. In Proc. 15th World Conference on Nondestructive Testing, Rome, Italy, 2000.
2. Auger, F., Flandrin, P., Generalization of the Reassignment Method to all Bilinear Time-Frequency and Time-Scale Representations. In Proc. ICASSP, Volume IV, pages 317-20, 1994.
3. Auger, F., Flandrin, P., the Why and How of Time-Frequency Reassignment. IEEE International Symposium on Time-Frequency and Time-Scale Analysis, pp. 197-200, 1994.
4. Auger, F., Flandrin, P., Improving the Readability of Time-Frequency and Time-Scale Representation by the Reassignment Method. IEEE Transactions on Signal Processing, 43(5):1068-1089, 1995.
5. Boashash, B., Time Frequency Signal Analysis and Processing: A Comprehensive Reference. Elsevier, Oxford, England, 2003.
6. Fitz, K., Fulop, S., A Unified Theory of Time-Frequency Reassignment. Digital Signal Processing, September 30, 2005.
7. Flandrin, P., Auger, F., Chassande-Mottin, E., Time-Frequency Reassignment: From Principles to Algorithms. CRC Press LLC, 2003.
8. Gardner, T., Magnasco, M., Sparse Time-Frequency Representations. Proceedings for the National Academy of Sciences, Vol. 103, No. 16, pp. 6094-6099, April 18, 2006.
9. Hainsworth, S., Macleod, M., Time Frequency Reassignment: A Review and Analysis. Technical Report, Cambridge University Engineering Dept., Cued/F-Infeng/TR.459.
10. Hippenstiel, R., Fargues, M., Moraitakis, I., Williams, C., Detection and Parameter Estimation ofChirped Radar Signals. Final Report, Naval Postgraduate School, Monterey, A, Jan. 10, 2000.
11. Lemoine, O., Auger, F., Flandrin, P., Goncalves, P., Time-Frequency Toolbox Users Manual. CentreNational de la Recherche Scientifique and Rice University, 1996.
12. Li, X., Bi, G., A New Reassigned Time-Frequency Representation. 16th European Signal Processing Conference, Lausanne, Switzerland, pp. 1-4, August 25-29, 2008.
13. Ozdemir, A., Time-Frequency Component Analyzer. Dissertation, Bilkent University, Ankara,Turkey,Sept. 2003.
14. Rioul, O., Flandrin, P., Time-Scale Energy Distributions: A General Class Extending Wavelet Transforms. IEEE Transactions on Signal Processing, Vol. SP-40, No. 7, pp. 1746-1757, 1992.
15. Stephens, J., Advances in Signal Processing Technology for Electronic Warfare. IEEE AES Systems Magazine, pp. 31-38, November 1996.
16. Stevens, D., Detection and Parameter Extraction of Low Probability of Intercept Radar Signals Using the Reassignment Method and the Hough Transform. Dissertation, Clarkson University, Potsdam, NY, 2010.
17. Stevens, D., Schuckers, S., Detection and Parameter Extraction of Triangular Modulated FMCW LPI Radar Signals Using the Reassignment Method. 2nd Annual AOC Symposium on Low Probability of Intercept Radar & Counter-LPI Technology, Naval Postgraduate School, Monterey, CA, pp. 1-4, February 15-17, 2011
18. A. Noga, D. Stevens, "Apparatus for Frequency Measurement," U.S. Patent 9,778,298; 03 October 2017.

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New Formulas for the Mutual Inductance and the Magnetic Force of the System: Thin Disk Coil (Pancake) with Inverse Radial Current Density and Thin Wall Solenoid with Constant Azimuthal Current Density

By Slobodan Babic & Cevdet Akyel

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Strictly as per the compliance and regulations of:

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Slobodan Babic [α] & Cevdet Akyel [σ]

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I. Introduction

The computation of the electromagnetic quantities (magnetic field, self-inductance, mutual inductance, magnetic force, etc.) for the conventional circular coaxial coils with the constant azimuthal current density has been presented in many papers, books, monographs and studies [1-19]. The analytical, the semi-analytical and the numerical methods have been used to calculate these electromagnetic quantities. These calculations are used in many electromagnetic applications (tubular linear motors, magnetically controllable devices and sensors, current reactors, cochlear implants, defibrillators, instrumented orthopedic implants, in magnetic resonance imaging (MRI) systems, superconducting coils, and tokamaks, etc.).

Also, there are the nonconventional circular coils with the nonlinear inverse radial density current which are used in many technical applications such as the superconducting coils, the electromagnets for the production of the extremely powerful magnetic fields (Bitter coils) and the homopolar motors [20-36]. The calculation of the magnetic force and the mutual inductance for these coils is essential for the design of electromagnetic inductors. In this paper, we calculated these electromagnetic quantities for the coil's combination, the disk coil (pancake) with the nonlinear inverse radial current density (Bitter disk coil) and the wall solenoid with the constant azimuthal current density (superconducting wall solenoid). All expressions are obtained in the semi-analytical form (mutual inductance) and the closed form (magnetic force). Also, all singular case has been solved and given in the closed form. The results of these calculations are expressed over the elliptic integrals of the first kind and the Heuman's Lambda function and one simple friendly integral whose kernel function is the continuous function in all interval of the integration. We used the Gaussian numerical integration, [37-38]. The improved modified filament method for the presented configuration is given as the comparative method. We use the Matlab implementation to calculate the mutual inductance and the magnetic force by two independent methods.

II. Basic Expressions

The Bitter disk coil and the wall solenoid in the air are with the inverse radial current density and the uniform current density respectively [29-30], (See Fig. 1) as follow:

$$J_1 = \frac{N_1 I_1}{\ln \frac{R_2}{R_1}} \frac{1}{r_I} \tag{1}$$

$$J_2 = \frac{N_2 I_2}{(z_2 - z_1)} \tag{2}$$

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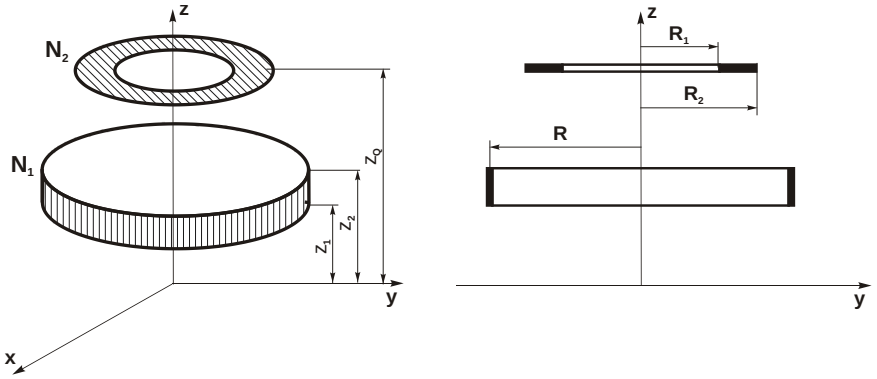

Figure 1: Bitter disk coil and thin solenoidthe mutual inductance and magnetic force between these coils, are respectively [29 30],

$$M=\frac{\mu_0 N_1 N_2 R}{(z_2-z_1)\ln\frac{R_2}{R_1}}\int_0^{\pi}\int_{R_1}^{R_2}\int_{z_1}^{z_2}\frac{\cos\theta dr_I dz d\theta}{r} \tag{3}$$

$$F=-\frac{\mu_0 N_1 N_2 I_1 I_2 R}{(z_2-z_1)\ln\frac{R_2}{R_1}}\int_0^{\pi}\int_{R_1}^{R_2}\int_{z_1}^{z_2}\frac{(z_Q-z_I)\cos\theta\, dr_I dz d\theta}{r^3} \tag{4}$$

where

$$r=\sqrt{(z_Q-z)^2+r_I^2+R^2-2r_I R\cos\theta}$$

Both configurations are in the air or a non-magnetic and non-conducting environment. We obtain the integral form to calculate these two physical quantities.

III. Calculation Method

After four analytical integration *M* and *F*are respectively:

$$M=\frac{\mu_0 N_1 N_2 R^2}{(z_2-z_1)\ln\frac{R_2}{R_1}}\sum_{n=1}^{n=4}(-1)^{n-1}T_n \tag{5}$$

$$F=\frac{\mu_0 N_1 N_2 I_1 I_2 R}{2(z_2-z_1)\ln\frac{R_2}{R_1}}\sum_{n=1}^{n=4}(-1)^{n-1}S_n \tag{6}$$

where

$$\rho_1=\rho_4=R_2,\ \rho_2=\rho_3=R_1, t_1=t_2=z_Q-z_1, t_3=t_4=z_Q-z_2$$

$$l_n=\frac{\rho_n}{R}, b_n=\frac{t_n}{R}, n=1,2,3,4$$

$$T_n=I_{0n}+\frac{\pi}{8}\text{sign}(b_n)\text{sign}(l_n-1)(l_n^2-3)[1-\Lambda_0(\varepsilon_n,k_n)]-\frac{\pi}{4}\text{sign}(b_n)(b_n^2-1)V_n+$$

$$\frac{3k_n b_n}{8\sqrt{l_n}}[(1+l_n)^2+b_n^2]E(k_n)+\frac{k_n b_n}{8\sqrt{l_n}}[b_n^2-2-4l_n^2+\frac{(l_n-1)(l_n^2-3)}{l_n+1}-\frac{4(b_n^2-1)\sqrt{1+b_n^2}}{\sqrt{1+b_n^2}+1}]K(k_n)$$

$$S_n=\frac{k_n}{\sqrt{l_n}}[2\sqrt{1+b_n^2}-l_n^2-1-b_n^2]K(k_n)+\frac{k_n}{\sqrt{l_n}}[(1+l_n)^2+b_n^2]E(k_n)-\pi|b_n|V_n$$

$$V_n=1-\Lambda_0(\theta_{1n},k_n)+\text{sgn}(\sqrt{R^2+b_n^2}-\rho_n)[1-\Lambda_0(\theta_{2n},k_n)]$$

$$k_n^2 = \frac{4l_n}{(1+l_n)^2+b_n^2}\ ,\ h_n = \frac{4l_n}{(1+l_n)^2}\ ,\ m_n = \frac{2}{\sqrt{1+b_n^2}+1} \le 1$$

$$\theta_{1n} = \arcsin\frac{|b_n|}{\sqrt{1+b_n^2}+1}\ ,\ \theta_{2n} = \arcsin\sqrt{\frac{1-m_n}{1-k_n^2}},\ k_n^2 \le m_n,\quad \varepsilon_n = \arcsin\sqrt{\frac{1-h_n}{1-k_n^2}},\ k_n^2 \le h_n$$

$$I_{0n} = \int_0^{p/2} \sinh^{-1}\frac{b_n}{\sqrt{1+l_n^2+2l_n\cos 2b}}\,db$$

From general cases (5) and (6) it is possible to obtain the special and singular cases.

The expression T_n is in a semi-analytical form where we need to solve the simple integral I_{0n} numerically by using the Gaussian integration for example.

The expression S_n is in the closed form.

Singular Cases

Singular cases are in the analytical form (5) and (6) respectively:

If $b_n = 0$ and $k_n^2 \neq 1$ or $b_n = 0$ and $k_n^2 = 0$.

If $b_n = 0$ and $k_n^2 \neq 1$.

$$S_n = \frac{k_n}{\sqrt{l_n}}[1-l_n^2]K(k_n) + \frac{k_n}{\sqrt{l_n}}(1+l_n)^2 E(k_n) \qquad (7)$$

$$k_n^2 = \frac{4l_n}{(1+l_n)^2} = h_n$$

If $b_n = 0$ and $k_n^2 = 1$.

All expressions in (5), (6), (7), (8) and (9) are the complete elliptical integrals K, EandΛ_0, Heuman's Lambda function [37-38].

IV. Modified Filament Method

In this paper, we give the modified formulas for the mutual inductance and the magnetic force between two Bitter thick coils (See Fig. 2) using the filament method. Applying some modification in the mutual inductance calculation [30], we deduced the mutual inductance and the magnetic force between the Bitter disk and the wall solenoid as follows:

$$M = \frac{N_1N_2(R_2-R_1)\sum_{g=-K}^{g=K}\sum_{l=-n}^{l=n}\frac{M(g,l)}{r_{II}(l)}}{(2K+1)(2n+1)\ln\frac{R_2}{R_1}} \qquad (8)$$

$$F = \frac{N_1N_2I_1I_2(R_2-R_1)\sum_{g=-K}^{g=K}\sum_{l=-n}^{l=n}\frac{F(g,l)}{r_{II}(l)}}{(2K+1)(2n+1)\ln\frac{R_2}{R_1}} \qquad (9)$$

where

$$M(g,l) = \frac{2\mu_0\sqrt{Rr_{II}(l)}}{k(g,l)}\left[\left(1-\frac{k^2(g,l)}{2}\right)K(k(g,l)) - E(k(g,l))\right]$$

$$F(g,l) = -\frac{\mu_0 I_1 I_2 z(g) k(g,l)}{4\sqrt{Rr_{II}(l)}}\left[\frac{2-k^2(g,l)}{1-k^2(g,l)}E(k(g,l)) - 2K(k(g,l))\right]$$

$$r_{II}(l) = R_{II} + \frac{h_{II}}{2n+1}l \quad (l = -n,\ldots,0,\ldots,n) \qquad z(g) = c - \frac{a}{2K+1}g,\quad g = -K,\ldots,0,\ldots,K$$

$$R_{II} = \frac{R_3+R_4}{2},\quad h_{II} = R_4 - R_3 \qquad k^2(g,l) = \frac{4Rr_{II}(l)}{(R+r_{II}(l))^2+z(g)^2}$$

$$R_{11} = R_I = R,\quad h_{II} = R_4 - R_3$$

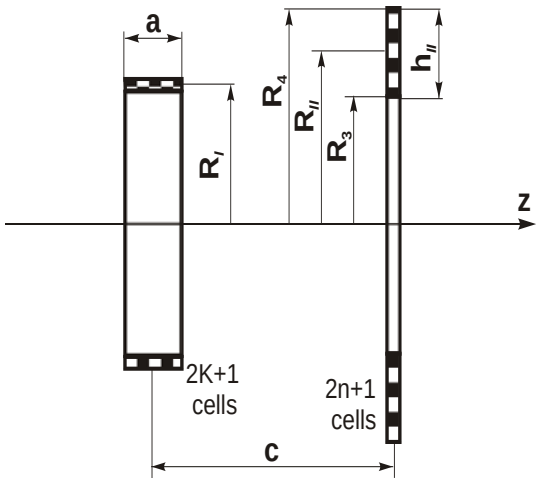

Figure 2: The Bitter disk coil and the thin solenoid (filament method)

Examples

To validate the new approach we present some examples, which cover either the regular or the singular cases. In these examples, all coils are with the unit currents. Also, we define the coil dimensions. For the comparative filament method, the number of subdivisions for each coil is also given. Our goal is to verify the accuracy of this method, so that we will fix the number of subdivisions ($K = n = 3000$) in the following examples without taking into consideration the computational time in the calculations. The number of turn in each coil is 100.

a) Example1.

Wall solenoid: $R = 2$ m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = 2$ m.

From (5) and (6) we obtain:

$M = 17.661179$mH

$F = 7.4710846$mN

From (10) and (11) we obtain:

$M = 17.661179$mH

$F = 7.4710845$mN

b) Example2.

Wall solenoid: $R = 2$ m, m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = 0.5$ m.

From (5) and (6) we obtain:

$M = 26.158014$mH

$F = 0$ N

From (10) and (11) we obtain:

$M = 26.158014$mH

$F = 0$N

c) Example3.

Wall solenoid: $R = 3$ m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = 2$ m.

From (5) and (6) we obtain:

$M = 36.827754$mH

$F = 20.338671$mN

From (10) and (11) we obtain:

$M = 36.827754$mH

$F = 20.338671$mN

d) Example4.

Wall solenoid: $R = 3$ m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = -2$ m.

From (5) and (6) we obtain:

$M = 22.050066$mH

$F = -10.576130$mN

From (10) and (11) we obtain:

$M = 22.050066$mH

$F = -10.576130$mN

e) Example5.

Wall solenoid: $R = 3$ m, m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = 1$ m.

This case is the singular case.

From (5) and (6) we obtain:

$M = 67.6203121$mH

$F = 45.309445$mN

From (10) and (11) we obtain:

$M = 67.620348$mH

$F = 45.309130$mN

f) Example6.

Wall solenoid: $R = 4$ m, m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = 1$ m.

This case is the singular case.

From (5) and (6) we obtain:

$M = 83.323296$mH

$F = 49.855888$mN

From (10) and (11) we obtain:

$M = 83.323370$mH

$F = 49.855568$mN

g) Example7.

Wall solenoid: $R = 4$ m, m, $z_1 = 0$ m, $z_2 = 1$ m.

Disk coil: $R_2 = 3$ m, $R_4 = 4$m, $z_Q = 0$ m.

This case is the singular case.

From (5) and (6) we obtain:

$M = 83.323296$mH

$F = -49.855888$ NmN

From (10) and (11) we obtain:

$M = 83.323370$mH

$F = -49.855568$mN

h) Example8.

Wall solenoid: R= 4 m, m, z_1 = 0 m, z_2= 1 m.

Disk coil: R_2= 3 m, R_4= 5m, z_Q= 1 m.

This case is the singular case.

From (5) and (6) we obtain:

M =91.598922mH

F = 54.254023mN

From (10) and (11) we obtain:

M = 91.598976mH

F = 54.258225mN

i) Example9.

Wall solenoid: R= 3 m, m, z_1 = 0 m, z_2= 1 m, N_1=100.

Disk coil: R_2= 3 m, R_4= 5m, z_Q= 0.6 m, N_2=100.

This case is the singular case.

From (5) and (6) we obtain:

M = 65.436644mH

F = 5.7050033mN

From (10) and (11) we obtain:

M = 65.436923mH

F = 5.7050600 mN

By previous examples, we confirmed that all calculated results by two different methods are in an excellent agreement. The bold digits are significant with the same accuracy in both calculations.

V. Conclusion

The new accurate expressions for calculating two electromagnetic quantities such as the mutual inductance and the magnetic force are presented in this work. All expressions are in the semi-analytical and the closed form. We give the improved filament method as the comparative method. Results obtained by two different methods agree at least in five significant figures.

Nomenclature

I_1: Current imposed in the disk (pancake) in (m)
I_2: Current imposed in the superconducting solenoid in (m)
N_1: number of turns of the pancake
N_2: number of turns of the solenoid
$R_1$and R_2: Inner and outer radius of the pancake in (m)
R: The radius of the solenoid in (m)
z_Q: Axial position to the pancake in (m)
z_1: Axial position to the bottom of the wall solenoid in (m)
z_2: Axial position to the top of the wall solenoid in (m)
M: Mutual inductance in (H)
F: Magnetic force between coils in (N)
J_1 and J_2: Current densities at the pancake and the wall solenoid respectively in A/m
r_i: Radial positions along the pancake
r, θ, z: Cylindrical coordinates
$\mu_0 = 4\pi\times10^{-7}$ H/m: Magnetic permeability of free space

References Références Referencias

1. F. W. Grover, *Inductance Calculations, Chs. 2 and 13*, Dover, New York, 1964.
2. H. B. Dwight, *Electrical Coils and Conductors,* McGraw-Hill Book Company, New York, 1945.
3. C. Snow, *Formulas for Computing Capacitance and Inductance*, 544, National Bureau of Standards Circular Washington DC, December 1954.
4. J. D. Jackson, *Classical Electrodynamics* (second Edition). New York: John Wiley & Sons, 1975, pp.848.
5. L. Urankar, "Vector potential and magnetic field of current-carrying finite arc segment in analytical form, Part III: Exact computation for rectangular cross section," IEEE Trans. Magn., vol. 18, no. 6, pp. 1860– 1867, Nov. 1982.
6. S. Babic, S. Milojkovic, Z. Andjelic, B. Krstajic, J.S.Salon, "Analytical calculation of the 3D magnetostatic field of a toroidal conductor with rectangular cross section," IEEE Trans. Mag., 24, (2), 1988, pp 3162-3164.
7. J. T. Conway, "Exact solutions for the magnetic fields of ax symmetric solenoids and current distributions Vol. 37, Issue 4, 2977-2988, 2001.
8. J. T. Conway,"Trigonometric Integrals for the magnetic field of the coil of rectangular cross section" *IEEE Trans. Magn.*, Vol. 42, No. 5, pp.1538-1548, 2006.
9. E. P. Furlani, "A formula for the levitation force between magnetic disks," IEEE Transactions on Magnetics, vol. 29, no. 6, pp. 4165–4169, Nov. 1993.
10. E. P. Furlani, "Formulas for the force and torque of axial couplings," IEEE Transactions on Magnetics, vol. 29, no. 5, pp. 2295–2301, Sep. 1993.
11. C. Akyel, S. I. Babic, S. Kincic and J. P. Lagacé, "Magnetic Force Calculation of Some Circular Coaxial Coils in Air," *Journal of Electromagnetic Waves and Applications*, Vol. 21, No.9, 1273-1283, 2007.
12. S. Babic and C. Akyel, "New Formulas for Mutual Inductance and Axial Magnetic Force between Magnetically Coupled Coils: Thick Circular Coil of the Rectangular Cross-Section-Thin Disk Coil (Pancake)," *IEEE Trans. Magn.*, Vol. 49, No. 2, pp.860-868, 2013.
13. R. Ravaud, G. Lemarquand, S. Babic , V. Lemarquand, and C. Akyel, "Cylindrical magnets and coils: fields, forces and inductances," *IEEE Trans Magn.*, Vol 46, No. 9, 3585-3590, Sept. 2010.
14. J.T. Conway, "Inductance Calculations for Circular Coils of Rectangular Cross Section and Parallel Axes Using Bessel and Struve Functions," *IEEE Trans. Magn.*,vol 46, n 1 , pp 75-81, 2010.
15. J.L. Coulomb and G. Meunier, "Finite element implementation of virtual work principle for magnetic

and electric force and torque computation," *IEEE Trans. Mag.*, Vol. Mag-20, No. 5, pp.1894-1896, Sept., 1984.
16. A. Demenko and D. Stachowiak, "Electromagnetic torque calculation using magnetic network methods," COMPEL, Vol. 27, No.1, pp. 17-26, 2008.
17. T. Tarnhuvud and K. Reichert, "Accuracy problems of force and torque calculation in FE-systems," IEEE *Trans. Mag.*, Vol. 24, No.1, pp. 443-446, January 1988.
18. J. L. Coulomb,"A methodology for the determination of global quantities from a finite element analysis and its applications to the evaluation of magnetic forces, torques and stiffness," IEEE *Trans. Mag.*, Vol. 19, No.6, pp. 2514-2519, November 1983.
19. S. Mc. Fee, J. Webb and D.A. Loather, "A tunable volume integration formulation for force calculation in finite-element based computational magneto statics," IEEE *Trans. Mag.*, Vol. 24, No.1, pp. 439-442, Jan. 1988.
20. S. Babic, C. Akyel, S. J. Salon, S. Kincic, "New expressions for calculating the magnetic field created by radial current in massive disks, " *IEEE Trans. Mag.*, Vol. 38, No. 2, pp. 497-500, Mars, 2002.
21. Babic, S. and C. Akyel, "Magnetic force between inclined filaments placed in any desired position," *IEEE Trans. Magn.*, Vol. 48, No. 1, pp. 69-80, Jan. 2012.
22. S. I. Babic and C. Akyel, "Magnetic force between inclined circular coils (Lorentz approach)," Progress in Electromagnetic Research B, 2012, Vol. 38, pp. 333–349.
23. B. Azzerboni, G.A. Saraceno and E. Cardelli, "Three-dimensional calculation of the magnetic field created by current-carrying massive disks, " IEEE Trans. on Mag., Vol. 34, No 5, pp.2601 – 2604, Sept. 1998.
24. B. Azzerboni, E. Cardelli, M. Raugi, A. Tellini and G. Tina, "Magnetic field evaluation for thick annular conductors" IEEE Trans. on Mag., Vol. 29, No 3, pp. 2090 – 2094, 1993.
25. Bitter F.: 'The Design of Powerful Electromagnets Part II. The Magnetizing Coil', Rev. Sci. Instrum., 1936, 7, (12), pp.482-489.
26. 'Magnet Lab, National High Magnetic Field Laboratory, Florida State University, Los Alamos National Laboratory, University of Florida', http://www.magnet.fsu.edu.
27. Nakagawa Y.,Noto K., HoshiA., Watanabe K., Miura S.,Kido G., and Muto Y.: 'High field laboratory for superconducting materials, Institute for Materials Research, Tohoku University', Physica B: Condensed Matter, 1989, 155, (1–3), pp. 69-73.
28. Sakai Y., Inoue K., and Maeda H.: 'High-strength and high-conductivity Cu-Ag alloy sheets: new promising conductor for high-field Bitter coils', IEEE Trans. Mag.,1994, 30, (4), pp. 2114-2117.
29. J.T.Conway," Non coaxial force and inductance calculations for bitter coils and coils with uniform radial current distributions," Applied Superconductivity and Electromagnetic Devices (ASEMD), 2011 International Conference on. pp 61-64.
30. Y. Ren, F. Wang, G.Kuang, W. Chen, Y. Tan, J. Zhu and P. He, "Mutual Inductance and Force Calculations between Coaxial Bitter Coils and Superconducting Coils with Rectangular Cross Section,"J. Supercond. Nov. Magn., 2010, DOI 10.1007/s10948-010-1086-0.
31. Babic S. and Akyel C., "Mutual Inductance and Magnetic Force Calculations for Bitter Disk Coils (Pancakes)," IET Science, Measurement & Technology, Vol.10, Issue 8, 2016, pp. 972-976.
32. S. Babic S. and C. Akyel,"Mutual Inductance and Magnetic Force Calculations for Bitter Disk Coil (Pancake) with Nonlinear Radial Current and Filamentary Circular Coil with Azimuthal Current, "Hindawi Publishing Corporation Advances in Electrical Engineering Volume 2016, Article ID 3654021, 6 pages http://dx.doi.org /10.1155 /2016/ 3654021.
33. Babic S. and Akyel C., "Mutual Inductance and Magnetic Force Calculations between two Thick Coaxial Bitter Coils of Rectangular Cross Section," IET Electric Power Applications, Vol. 11, Issue 3, 2017, pp. 441-446.
34. Babic S. and Akyel C.," Mutual Inductance and Magnetic Force Calculations between Thick Coaxial Bitter Coil of Rectangular Cross Section with Inverse Radial Current and Filamentary Circular Coil with Constan Azimuthal Current,"IET Electric Power Applications, Vol. 11, Issue 9, 2017, pp. 1596 – 1600.
35. S Babic S. and Akyel C.,''Calculation of Some Electromagnetic Quantities for Circular Thick Coil of Rectangular Cross Section and Pancake with Inverse Radial Currents,'' IET Electric Power Applications, 2018.
36. Babic S. and Akyel C.,''Mutual Inductance and Magnetic Force Calculations Between Thick Bitter Circular Coil of Rectangular Cross Section with Inverse Radial Current and Thin Wall Superconducting Solenoid with Constant Azimuthal Current,'' WSEAS TRANSACTIONS on POWER SYSTEMS, Volume 13, E-ISSN: 2224-350X ,2018.
37. M. Abramowitz and I. A. Stegun, *Handbook of Mathematical Functions*, National Bureau of Standards Applied Mathematics, Washington DC, December 1972, Series 55, p. 595.
38. I.S. Gradshteyn and I. M. Ryzhik, *Table of Integrals*, Series *and Products,* New York and London, Academic Press Inc., 1965.

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Perovskite Thin-Film Solar Cell: Study of Optical and Electrical Performance Parameters for Nano Textured Surface

By Niajul Karim, Md. Golam Rabbi, Md. Lutful Sadiq Mim & Sakib Ahammad

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*Abstract-*An optical and electrical investigation has been conducted for CH3NH3PbI2Clx based organic-inorganic halide thin-film perovskite solar cells for smooth and pyramid textured surfaces. A reference structure of perovskite solar cell has been reproduced for short-circuit current density and external quantum efficiency and further used in designing pyramid textured solar cell. The actual investigation was done by varying the period and height of the pyramid for better light trapping and enhancing effective thickness of the cell which is quite new for this type of emerging material solar cell. The complete study was carried on theoretically using a commercial Finite Difference Time Domain (FDTD) mathematical simulation tool where Maxwell's curl equations are rigorously solved. An optimized perovskite solar cell has been designed and developed for 600 nm of period and 300 nm of height, exhibiting maximum of 19.15% conversion efficiency and 23.61 mA/cm2short-circuit current density, compared to 18.27% and 22.53 mA/cm2 conversion efficiency and short circuit current, respectively in smooth substrate solar cell.

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GJRE-F Classification: FOR Code: 290901

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Niajul Karim [α], Md. Golam Rabbi [σ], Md. Lutful Sadiq Mim [ρ] & Sakib Ahammad [ω]

Abstract- An optical and electrical investigation has been conducted for CH3NH3PbI2Clx based organic-inorganic halide thin-film perovskite solar cells for smooth and pyramid textured surfaces. A reference structure of perovskite solar cell has been reproduced for short-circuit current density and external quantum efficiency and further used in designing pyramid textured solar cell. The actual investigation was done by varying the period and height of the pyramid for better light trapping and enhancing effective thickness of the cell which is quite new for this type of emerging material solar cell. The complete study was carried on theoretically using a commercial Finite Difference Time Domain (FDTD) mathematical simulation tool where Maxwell's curl equations are rigorously solved. An optimized perovskite solar cell has been designed and developed for 600 nm of period and 300 nm of height, exhibiting maximum of 19.15% conversion efficiency and 23.61 mA/cm2short-circuit current density, compared to 18.27% and 22.53 mA/cm2 conversion efficiency and short circuit current, respectively in smooth substrate solar cell.

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I. Introduction

The energy demand is increasing day by day with ever growing increment of population. Developing countries like Bangladesh still depend on the non-renewable energy such as fuel, diesel and gas to relive the enormous requirement of energy. But those non-renewable sources are confined and not favorable to the environment. On the contrary, the renewable sources of energy are sustainable, abundant and environment friendly such as solar cell. Solar energy is an important form of renewable energy and in the field of solar energy the Perovskite based solar cell has attracted a great attraction due to their high efficiency and low production cost. As we proceed towards the future with more cost efficient solar cells, the absorber layer of thin-film silicon solar cells are inversely getting thinner. Therefore the importance of efficiently absorbing the incident light within very thin absorber layers becomes more crucial. In order to design optically efficient solar cells, it is imperative to understand the interplay between the optical wave propagation within the cell and the surface texture at its interfaces. Within the scope of this thesis, the influence of periodic surface texture was investigated by rigorously solving the Maxwell's equations in two and three-dimensions. By studying the varying parameters in surface textured solar cells,

Their performance in terms of the quantum efficiency and short circuit current was evaluated.

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II. Fundamentals of Nanotextured Perovskite Solar Cell

a) Basic concepts of perovskite solar cell

Solar or photovoltaic cell converts the sun energy into electricity whether they adorning our calculator or orbiting our planet on satellites, they rely on the photoelectric effect. Solar Cell does the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When these free electrons are captured, electric current results that can be used as electricity. When photons are absorbed by matter in the solar cell, their energy excites electrons higher energy states, where, the electrons can move more freely. The perhaps most well-known example of this is the photoelectric effect, where photons give electrons in a metal enough energy to escape the surface. A perovskite solar cell is a type of solar cell which includes a perovskite structured compound, most commonly a hybrid organic-inorganic lead or tin halide-based material, as the light-harvesting active layer.

b) Basic Structure of perovskite solar cell

Perovskite take their name from the mineral, which was first discovered in the Ural Mountains of Russia by Gustav Rose in 1839 and is named after Russian mineralogist L. A. Perovskite. The compound that has similar crystal structure like CaTiO3 are basically known as Perovskite material. A perovskite solar cell is a type of solar cell which includes a perovskite structured compound, most commonly a hybrid organic-inorganic lead or tin halide-based material, as the light-harvesting active layer. Structure of a perovskite with a chemical formulaABX3. The red spheres are X atoms (usually oxygen's), the blue spheres are B-atoms (a smaller metal cation, such as

Ti4+), and the green spheres are the A-atoms (a larger metal cation, such as Ca2+). Pictured is the undistorted cubic structure; the symmetry is lowered to orthorhombic, tetragonal or trigonal in many perovskites [1,2].

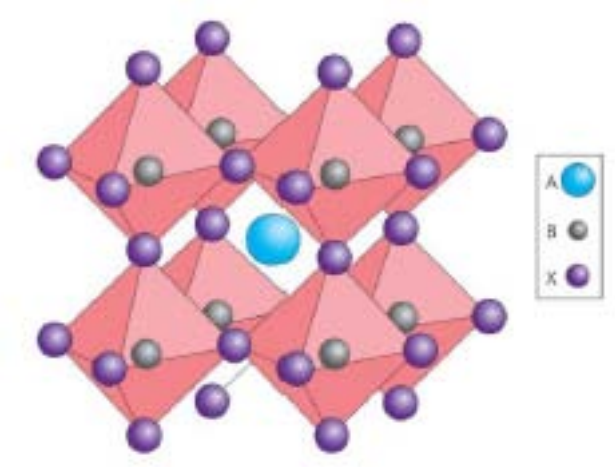

Figure 1: Basic structure of perovskite solar cell [2].

c) Nano textured solar module

Light trapping scheme based on Nano textured sur-faces/interfaces of thin film Perovskite solar cells (amorphous, microcrystalline) deposited on textured transparent conducting oxide(TCO) is modeled with the help of Monte Carlo method taking into account the effects of light coherence. Spectral response and short circuit current density are computed as a function of Nano roughness, angular distribution of scattered light, thickness and optical constants of all layers of single or multifunction solar cells. The spectral response of Nano textured solar cells geometrical optics cannot be used; therefore, usual ray tracing programs cannot be applied. On the other hand, a rigorous treatment using Maxwell electromagnetic theory (being available only for periodically repeating sure-face features) is very complicated and time-consuming. The ultimate performance of Nano textured thin film solar cell in terms of maximum achievable short circuit current, for a given thickness of all layers and the light scattering parameters of layers and interfaces. It enables us to analyze and identify the losses due to each parameter, where an efficient light trapping is absolutely necessary for the efficient thin-film Perovskite solar cells [3-5].

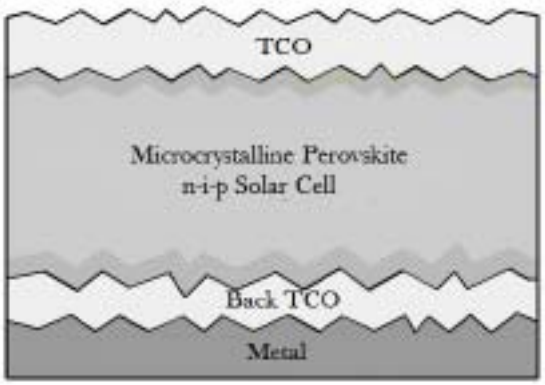

Figure 2: Sketch of n-i-p thin film solar cell [5]

d) Proposed Model

The model as represented above is of smooth surface heterojunction solar cell. With the dependency of technology, solar cell can be deposited in either the superstrate or substrate form. In superstrate configuration the incident light passes.

Through the glass substrate before it enters the ITO and p-i-n layer of the solar cell and the following model states the superstrate configuration as an example. Since the texturing is also happened in this model that's why an efficient light trapping scheme is absolutely worked for the efficient thin film solar cell .moreover, Our optical model of solar cell gives the ultimate performance of Nano textured thin film solar cell in terms of maximum achievable short circuit current, for a given thickness of all layers and the light scattering parameters of layers and interfaces and also It enables us to analyze and identify the losses due to each parameter. Finally the model gives the desired results within few minutes.

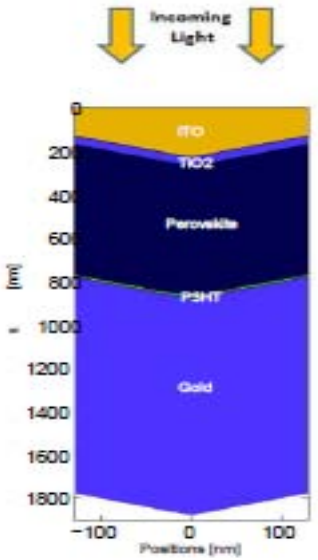

Figure 3: Schematics sketch of unit cell of periodically texture perovskite thin film solar cell with pyramid texture.

III. Properties of Perovskite Solar Cell Material

In our thesis work, we have investigated the efficiency enhancement of a Perovskite solar cell varying thickness of different materials and different contact materials. Then we investigated the efficiency enhancement of same cell after Nano texturing the cell. We also used the optical constants of Perovskite materials, which were extracted, optimized and inserted into the simulation environment to perform the simulation. In our cell the layers consist of Glass as substrate, ITO as Transparent Conducting Oxide (TCO), TiO2 as P-layer, Perovskite (CH3NH3PbI3 xClx) as intrinsic layer, and P3HT as N-layer and Gold as metal reflector. Same material is used for Nano texturing each layer of the Perovskite solar cell.

IV. Designed and Simulation a

a) Short circuit current

Within the scope of this thesis, the optical simulation results were concentrated on periodically textured thin-film Perovskit Solar cells. But in reality, the surface texture in the solar cells are ordered randomly where the period and height of such textures can vary significantly. Which is shown in fig 4 in following. The analysis of such textured surfaces can be done and gives us the height profile and statistics on the surface. Along with the height information, the spatial distribution with regards vto the period is also a necessary quality which determines the light trapping potential of a surface. In order to get a more accurate representation of the surface texture, a tuple of <period-height> information would be desirable. The influence of the perovskite solar cell thickness on the performance of the solar cell is shown in Figure: 4. the overall short circuit current is simulated for perovskite thin film solar cell for different periods and heights. In terms of the simulations performed, the maximum short circuit current is 23.8mA=cm2 and the minimum short circuit current is 22.55mA=cm2.The overall current is gained by 1.25 mA=cm2. The calculated short circuit current for overall perovskite thin film solar cell is shown in Figure: 4 under (wavelength 300 – 800 nm) illumination. The maximum short circuit current is observed for grating period of 600nm and the grating height of 80nm. On the other hand, the minimum short circuit is observed for grating period of 300nm and the grating heights of approximately 25 nm. Since, we have been observed from the simulation the total short circuit current for perovskite thin film solar cell is 22.53 mA=cm2 and the total short circuit current for perovskite thin film solar cell on textured surface is 23.8 mA=cm2. So, compared with the short circuit current of a solar cell on a smooth substrate, the short circuit current is increased by 1.27mA=cm2.

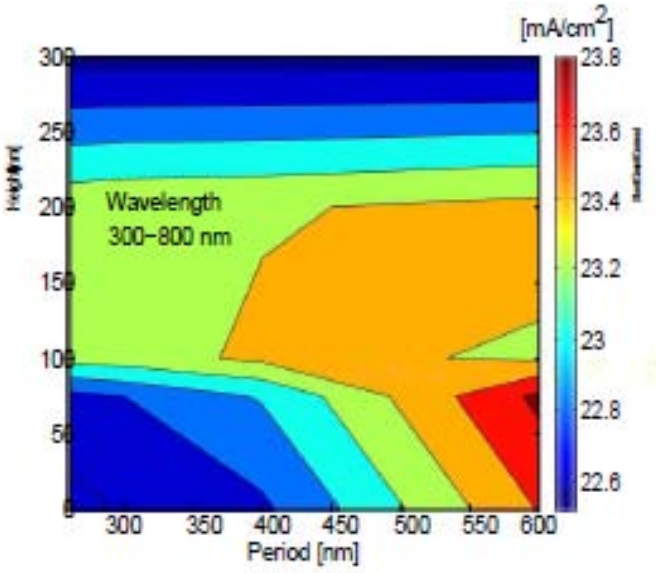

Figure 4: Short circuit current for Perovskite thin film solar cell as function of the grating period and height illuminated under entire sun spectrum (wavelength 300 – 800 nm).

b) Quantum efficiency with varying periods

The quantum efficiency can be viewed as the collection probability due the generation profile of a single wavelength, integrated over the device thickness and normalized to the incident number of photons. It is the ratio of the number of carriers collected by the solar cell to the number of photons of a given energy incident on the solar cell. The curve in Figure: 5 shows the quantum efficiency of perovskite based thin-film solar cell with the variation of periods of (260-600 nm) with a particular height of 75 nm. As Quantum efficiency refers to the ratio of the number of carrier collected by the solar cell due to the incident of photons, it is directly related with the absorption coefficient and mobility of the electron, holes as well as to increase the effective thickness and the diffraction of light. With high absorption we will get higher carrier collection. As we get high short circuit current flows in 600 nm, the quantum efficiency is also high here.

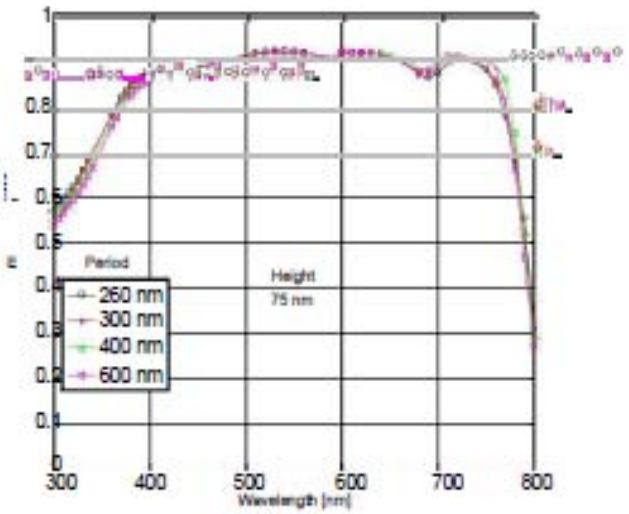

Figure 5: Quantum efficiency for Perovskite thin film solar cell with pyramid structures of height 75 nm and different period.

c) Quantum efficiency with varying heights

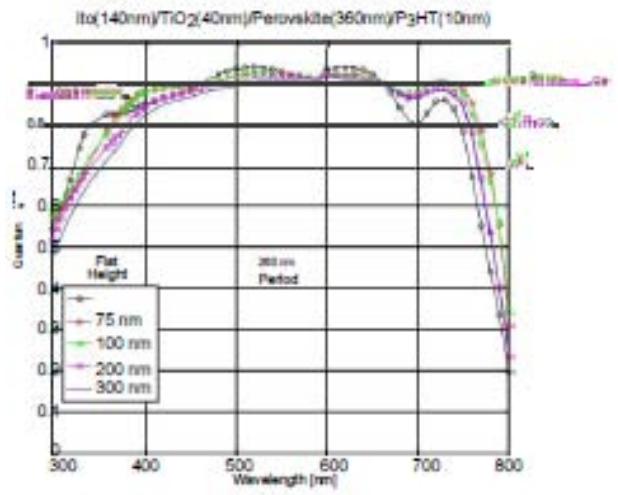

Figure 6: Quantum efficiency for Perovskite thin film solar cell with pyramid structures of period 260 nm and different height

The following curve shows the quantum efficiency of perovskite based thin-film solar cell with the variation of heights of (75-300 nm) with a particular period of 260 nm in Figure:6. As Quantum efficiency refers to the ratio of the number of carrier collected by the solar cell due to the incident of photons, it is directly related with the absorption coefficient and mobility of the electron, holes as well as to increase

The effective thickness and the diffraction of light. With high absorption we will get higher carrier collection. As we get high short circuit current flows in 75 nm, the quantum efficiency is also high here.

Optimized period and height for maximum short circuit current

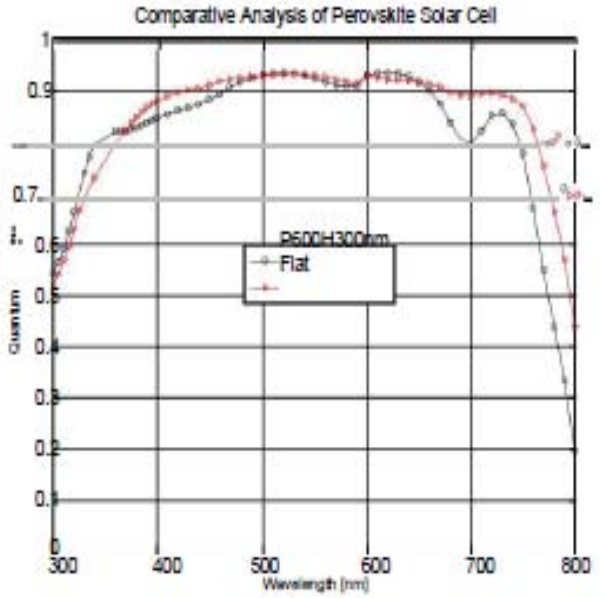

Figure 7: Quantum efficiency for Perovskite thin film solar cell with pyramid structures of period 600 nm and height of 300 nm

The above curve in Figure:7 shows compared with flat solar cell, it has been observed from the curve blue under illumination of (300-500 nm) has a maximum short circuit current and also red which is under illumination (700-800 nm) has a maximum short circuit current. The maximum short circuit current measured as 23.61 mA/cm2. Therefore we got the maximum quantum efficiency and overall efficiency is 19.15 %.

V. Efficiency Calculation and Result

a) Efficiency calculation for varying different periods and heights

The efficiency is the most commonly used parameter to compare the performance of one solar cell to another. Efficiency is defined as the ratio of energy output from the solar cell to input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incident sunlight and the temperature of the solar cell. The efficiency of a solar cell is determined as the fraction of incident power which is converted to electricity and is defined as:

$$h = \frac{V_{oc} I_{SC} FF}{nPi}$$

Table I: Solar Cell Characteristics Analysis for Different Period (260-600 Nm) and Height of 75 Nm for Efficiency

Period (nm)	Short circuit Current, I_{sc} (Ma/cm?)	Open Circuit Voltage, Voc (V)	Fill Factor, FF	Effieiency η(%)
260	23.33	0.9268	0.8751	18.92
300	23.36	0.9268	0.8751	18.92
400	23.36	0.9268	0.8751	18.92
600	23.46	0.9268	0.8751	18.92

Table II: Solar Cell Characteristics Analysis For Different Height (0-1000 Nm) And Period Of 260 Nm For Efficiency

Height (nm)	Short Circuit Current, I_{sc} (ma/cm_2)	Open Circuit Voltage Voc (v)	Fiil Factor, FF	Effieiency η(%)
0	22.53	0.9268	0.8751	18.27
75	23.33	0.9268	0.8751	18.27
100	23.29	0.9268	0.8751	18.27
200	22.72	0.9268	0.8751	18.27
300	22.51	0.9268	0.8751	18.27
600	22.60	0.9268	0.8751	18.27
800	22.75	0.9268	0.8751	18.27
1000	22.82	0.9268	0.8751	18.27

b) Comparatively Characteristic Analysis

Table III: Comparatively Characteristic Analysis for Optimized Perovskite Thin Flim Solar Cell With Textured Surface And Flat Surface

Period (nm)	Height (nm)	Short Circuit Current, I_{sc} (ma/cm_2)	Open Circuit Voltage Voc (v)	Fiil Factor, FF	Efficiency, n (%)
600	300	23.61	0.9268	0.8751	19.15
260	0	22.53	0.9268	0.8751	18.27

From the table we got the maximum quantum efficiency and overall efficiency is 19.15% of perovskite solar cell for texture surface and also it is observed from the table for smooth surface the efficiency is 18.27%.

VI. Conclusion

The results from this study provide a solid foundation in exploring into more intricate issues which are intertwined with the optical response of thin-film silicon solar cells. With optics playing a major role in enhancing the absorption efficiencies of Thin-film Perovskite solar cells, there still awaits exciting areas of research which are yet to be solved. In this research we have analyzed different simulation results and observe Power loss profile of flat solar cell for the wavelength of 630 nm and 730 nm. Also it is analyzed through the research and successfully identified the short circuit current and quantum efficiency of perovskite thin film solar cell for smooth surface as well as for textured surface with the variations of different periods and heights. The efficiency of a perovskite thin film solar cell is determined as the fraction of incident power which is converted to electricity as we investigated from overall result. From the result we have been observed that optimum variation of solar cell for different wavelength spectrum from 300 nm to 800 nm and about 80% light is absorbed at 500- 550 nm of wavelength spectrum as well as the total short circuit current is for textured surface of perovskite solar cell is 23.8mA=cm2.whereas the total short circuit current for smooth surface which we have been observed before is 22.53mA=cm2. These currents are observed with the variation of periods by fixing height or with the variation of heights by fixing period. Finally, the Quantum efficiency of optimized period and height of maximum current for textured surface of perovskite thin film solar cell is analyzed and a delightful maximum efficiency (19.15%) found out which is comparatively higher than the flat Surface of perovskite thin film solar cell.

References Références Referencias

1. 3. Noel, Nakita K.; Stranks, Samuel D.; Abate, Antonio; Wehrenfen-nig, Christian; Guarnera, Simone; Haghighirad, Amir-Abbas; Sadhanala, Aditya; Eperon, Giles E.; Pathak, Sandeep K.; Johnston, Michael B.; Petrozza, Annamaria; Herz, Laura M.; Snaith, Henry J. (1 May 2014). "Lead-free organic–inorganic tin halide perovskites for photovoltaic ap-plications".
2. "Structure of a generic Perovskite crystal" online :http://www.solarchoice.net.au/blog/wp-content/ uploads/Perovskite-crystal.png[Accessed: 28thNovember,2015.
3. Poruba, Z. Remes, J. Springer, M. Vanecek, A. Fejfar, J. Kocka, J. Meier, P. Torres and A. Shah, Proc. 2nd WCPSEC, Vienna 1998, p. 781.

4. B.L. Sopori, J. Madjdpour, W. Chen, Proc. 2nd WCPSEC, Vienna 1998, p. 156.
5. J. Springer, A. Poruba, A. Fejfar and M. Vanecek * Institute of Physics, Academy of Sciences of the Czech Republic, Cukrovarnicka 10, Prague 6, CZ-16253 Czech Republic.

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The IOT-Machine Learning Security Algorithm for Detecting the Intruders Gaining an Unauthorised Access to Government Protected Areas

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Abstract- The essentiality in the protection of the government restricted areas using the technology of IOT (Internet of Things) has been observed in this research, with the sole aim of providing certain measures to curbing the activities of the terrorists creating dirty scenario within the environment.

The neural network employed four input neurons which are the Sensors used as IP address, while the government authorized areas are the clients who receive messages from the IP neurons, there are two separate hidden layers of orders seven each as the processors preceding the output which is the threshold value that has been determined through the sigmoid activation function. The research adopted the deep learning machine language and internet base IP with python socket command lines to address the problem of detecting unauthorized access in the government restricted areas. The unsupervised neural network algorithm used is of configuration 5-7-7-4, which was coded in python functional programming language and trained with the back propagation algorithm with 300 epoch runs to ensure that errors are maintained at about 5% confidence level through the sigmoid activation function.

Keywords: IOT, neural network, algorithm, unsupervised learning.

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The IOT-Machine Learning Security Algorithm for Detecting the Intruders Gaining an Unauthorised Access to Government Protected Areas

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The research concluded that IOT technology if properly annexed is faster and better than conventional security method of narrower view, coverage and limitation to capture intruders invading government protected areas.

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I. Introduction

THE security of our government protected areas within the government offices and environments is the concerns of all the stakeholders. The only way out is full security surveillance which is based on internet of things to watch over the government offices and raise proper alert when there's intruders invading the government areas. The research intends to design an intelligent internet based system, which is capable of detecting the activities of the intruders at the odd hours and make an urgent reports to curb the unauthorized access and monitor the footpaths of the intruders.

In some previous studies, involving the use of internet of things (IOT) and designing of algorithm; Serge Thomas et.al used an unsupervised learning algorithm called K- pattern clustering algorithm of Artificial Neural network and came out with certain evidences that IOT can be used in connection with sensors to provide adequate work place environment [3], [7]. He said that users' daily activities can generate patterns which play an important role in the smart environment. This assisted in receiving prompt alert to detect anomalies in the users' environment [1], [3]. In a similar work by Moeen et.al, IOT was used to monitor the health based on the cloud-based processing. The researchers considered the applications of the remote health monitoring systems for long term recording, management and came up with realizations that this technology can be used as a decision support system by the medical personnel [2], [4].

The IOT technology was used in data analysis which involves the combination of embedded systems, comprising wired, wireless communications, Sensors and actuator devices. The researchers said that IOT requires data to represent better services to users for performance and intelligence [5], [3]. In this manner, the IOT should be able to access raw data from different sources over the network and analyse these information. This research will try to focus on collecting raw data from different Sensors such as; the actuator sensors as a signal generator to map the footprints of the intruders received from the GPS system, and transforming these for prompt reports, Laser Sensor, ground motion Sensor and sound recognition Sensor.

II. Model Conceptionalsation

The system is designed using the coordinates systems of the GPS readings, there's a set boundary for non-inhabitants entering into the government's protected areas of the governor's offices. If an unauthorized access is noticed within these regions, the machine learning system which is also internet connected gives an alert which is viewed through the internet and face recognition cameras within the government's protected regions. The hardware and Engineering requirements is that the system is designed using the pressure or actuator sensor (intruders steps is on the forbidden or authorized regions to actuate the cameras), Laser Sensor, ground motion Sensor, and the sound detection

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Sensor which gives an indication whether there's an abnormalities in the environment. These sensors are used as the input neurons to carry out information on the states of the regions as per forbidden or an access, in this regards the followings sensors are used; Pressure or Actuator: this will sense the various weights of the different people entering into the government's protected areas and detects whether it is within the forbidden or authorised regions and send a message through IP camera attached to the sensor for a prompt action and response from the government's security agent. The second neuron is the ground motion sensor; this is used to detect any un-allowed or strange motion in the forbidden regions of the protected regions in other to issue a response "intruders" for appropriate action. The third sensor used as input neuron is the sound detection/ recognition sensor which detects the unwanted sound like whistling, shouting, and any kind of noise in the environment that is unpleasant for proper action to taken by the security agent. The forth neuron as input is the Laser light sensor, which senses any Locations and coding sheet for the raw data kind of search lights, motor pointer light, touch light for a proper action to be taken. A bias neuron is also attached to all the neurons at all the stages of the processing by the algorithm, the architecture of the system and configuration is an unsupervised neural network of four layers.

III. The Neuron-Computing Approach

The neuron access or forbidden equation can be expressed as; for the IP input neuron 1, for the IP neuron 2, for the IP neuron 3, for the IP neuron 4. The deep learning Algorithm will assign the weights according the predetermined values and initial conditions. The values; are the various divisions in IP neurons as; being high, medium and low to classify the neurons into the deep learning algorithm for proper training and error corrections. The various value supplied into the algorithm can be viewed from the table below which have been converted into appropriate digit for the machine to learn.

Table 1: Code selection process

A		B		C		D		E		F	
21	00001	30	01001	15	00011	35	01001	20	01001	1	01001
22	00001	31	00011	16	00011	36	00101	7	00001	2	01001
23	00001	32	00001	17	10001	38	00001	10	01001	4	01001
24	00001	33	00011	26	01011	39	00001	5	01001	6	00001
25	01001	34	00011	43	01001	40	00011	9	01001	42	00101
27	00011	3	00001	45	00011	41	00001	8	00001	44	01011
28	00001	11	00001	47	00001	48	01001	13	01001	18	00001
29	00001	12	01001	37	01001	19	00001	14	11001	46	01001

IV. The Neural Architecture

The neural Algorithm used assumes an unsupervised configuration of order 5-7-7-4 that is, a neural network that has a memory that influences future predictions, as whether it should raise an alert for intruders' case or not. The four input neurons are the sensors, while the fifth neuron is bias; the algorithm has seven processors in the two separate hidden layers preceding the output which represents the messages sent from each neuron to get an alert from the internet connected sensors with different IP address for message dissemination. The algorithm is coded using python computer language for easier real time data processing and timely information on the security state of the government redistricted areas.

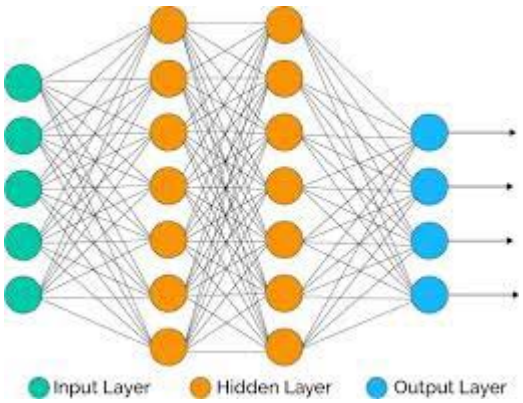

Figure 1: Neural Configuration

The Neural Algorithm of Back propagation Feedback Errors

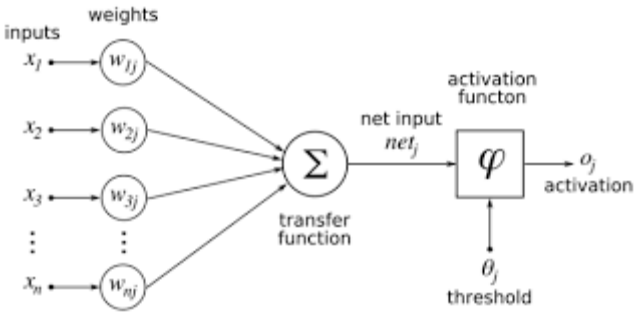

Figure 2: The Error correction Circuit

The Neural network model using the XOR data is repeatedly presented to the neural network, which is the function of the weights. The network maintains the deep learning intelligently enough to carry out the roles as an automatic machine that relates appropriate messages to the IP neurons in charge of the duty. At each presentation, the error between the network inputs, the hidden layers and the desired output were calculated, which is the threshold energy value when it has been activated through the sigmoid function. The computed values are then fed back to the neural network for proper adjustments. These sequences of events were done repeated until an acceptable error has been reached, when the network no longer appears to be learning, and the final output computed. The network ensures that the errors from the IP addresses are adequately feedback for automatic responses.

V. Results and Discussions

The neurons are regarded as the IP addresses while the government restricted areas to be protected is regarded as the clients, the neurons got the signals and immediately transmit the message through the internet protocol address, which is immediately related to the monitoring devices mounted within the closed circuit system. The deep learning algorithm ensures that there's no delay in response to the signals sent by any of the neurons which are the IP addresses. The figure 3 actually showed a particular case which were simulated from different neurons, these are transformed by geodesic software which mapped the forbidden and the authorised regions within the government areas. Those regions mapped by the intelligent neurons with red pigments are forbidden regions where the intruders can likely take and the neurons through the sensors mapped the footpaths of the intruders for a message of insecurity to be alerted. These areas have be given the tolerance values of noise signals in terms of Decibels strength for the sensors that measures noise/sound signals in those areas, also the Laser light sensor has been restricted to certain allowable values on the amount of light intensity that can be absorbed in the environment, any value above the threshold set by neurons means the deep learning algorithm will quickly initiate, the Laser sensor IP to relay a message of insecurity signal for the appropriate measures to be taken. In general any abnormality sensed in the environment by the IP neurons are quickly and timely related by the deep learning algorithm for proper action to be taken. The regions mapped by the intelligent neurons with pink pigments are the save areas where the inhabitants of the government premises are allowed to treed without any information been related by the neurons as long as no messages are being sent by the neurons. As can be shown in the neural architecture in figure2, it is expected that any of the four neurons can send a message through the IP attached to them, but in actual sense, the deep learning algorithm has been coded using an exclusive OR Boolean, to make the neurons more intelligent, which mean if any the IP is active then we can get an insecurity alert for an action to be taken by the security agents which monitor them on internet cameras based on the coordinates in the GPS.

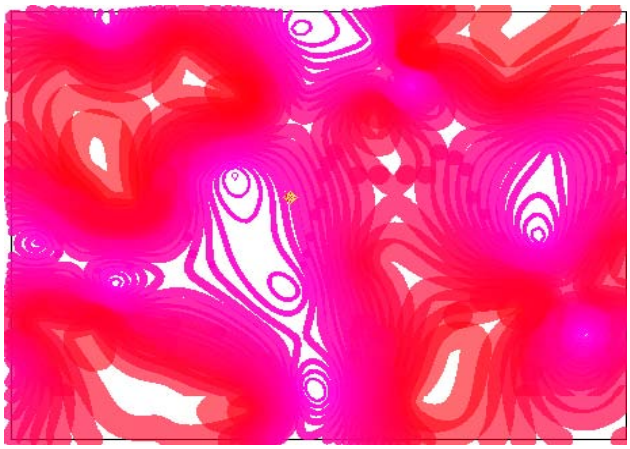

Figure 3: Pattern Recognition Map

VI. Conclusion

The research established that the technology of IOT and pattern recognition gave a better idea of getting vital information in real time and as accurate as possible. The IP Sensors also provides another means of getting a firsthand online message that can assist in reducing the level of crimes involving terrorism in our environments, with a little drawback. The research discovered that it is not only useful to the intending stakeholders, but it can be seen by the public

all over the world who are using the internet as at the time of any crime and a good information to prevent other locations around the globe of being invaded by intruders.

Reference Références Referencias

1. L. Atzori, A. Iera, G. Morabito, The internet of things: a survey, Comput. Netw. 54 (15) (2010) 2787–2805.
2. C. Cecchinel, M. Jimenez, S. Mosser, M. Riveill, An architecture to support the collection of big data in the internet of things, in: 2014 IEEE World Congress on Services, IEEE, 2014, pp. 442–449.
3. Mohammad Saeid, Mahdavinejad, Mohammadreza Rezvan, Mohammadamin Barekatain Peyman Adibi, Payam, Barnaghi and Amit P. Sheth(2013) Machine learning for internet of things data analysis: a Survey, Digital Communications and Networks 4 (2018) 161–175.
4. Moeen Hassanalieragh, Alex Page, Tolga Soyat, Gaurav Sharma, Mehmet Aktas, Gonzalo Mateos Burak Kantarci, Silvana Andreescu (2015)Health Monitoring and Management Using Internet-of-Things (IoT) Sensing with Cloud-based Processing: Opportunities and Challenges, pp.296.
5. N. Bui and M. Zorzi, "Health care applications: A solution based on the internet of things," in Proc. of the 4th Int. Symposium on Applied Sciences in Biomed. and Com. Tech., ser. ISABEL '11. New York, NY, USA: ACM, 2011, pp. 131:1–131:5.
6. W. Zhao, C. Wang, and Y. Nakahira, "Medical application on internet of things," in IET Int. Conf. on Com. Tech. and Application (ICCTA 2011), Oct 2011, pp. 660–665.
7. F. Hu, D. Xie, and S. Shen, "On the application of the internet of things in the field of medical and health care," in IEEE Int. Conf. o and IEEE Cyber, Physical and Social Computing Green Computing and Communications (GreenCom), (iThings/CPSCom), Aug 2013, pp. 2053–2058.

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New Prospects of Science and Technology Development of Energy Industry and Improvement of Conditions for Living on the Planet Earth

By Sapargaliyev Aldan Asanovich

Introduction- The main type of energy used by humanity is the electric energy. Whatever the type of energy source is, the renewable energy or some else, it is, mainly, transferred into the electric energy. This is conditioned by the fact that electricity is easier to store and to transport, and, it is the much more versatile type of energy in terms of application than other types.

For energetic industry and conditions for living on the planet Earth, the things of primary importance are EM and ED. Nowadays there are about 98% of all electric energy used by the humanity is produced by EGs. From all types of energy combined, that a human uses, there are about 60% of it is used by the ED, which, along with other components, includes one or more EM (EM – electric motor), in order to power a machine or a mechanism.

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New Prospects of Science and Technology Development of Energy Industry and Improvement of Conditions for Living on the Planet Earth

Sapargaliyev Aldan Asanovich

Abbreviations used in this document:
EMa – electric machine (EMa is the common name of the EM – electric motor and EG – electric generator)
ED – electric drive

I. Introduction

The main type of energy used by humanity is the electric energy. Whatever the type of energy source is, the renewable energy or some else, it is, mainly, transferred into the electric energy. This is conditioned by the fact that electricity is easier to store and to transport, and, it is the much more versatile type of energy in terms of application than other types.

For energetic industry and conditions for living on the planet Earth, the things of primary importance are EM and ED. Nowadays there are about 98% of all electric energy used by the humanity is produced by EGs. From all types of energy combined, that a human uses, there are about 60% of it is used by the ED, which, along with other components, includes one or more EM (EM – electric motor), in order to power a machine or a mechanism.

Ultimately new concepts, technologies, theoretical and experimental works offered by us, create the basis for the rapid movement through the path of achieving one of the main strategic goals of humanity:

- The development of technologies, effectiveness of electric energy industry by means of more powerful, more compact and more energy efficient EMas and EDs with new functions offered on the market, and the transfer of transport means (land, air, sea and underwater) from ICE (Internal Combustion Engine) to electric drives, while achieving a the high level of technology;
- Creation of favorable conditions for human, flora, and fauna, to exist on the planet Earth by means of reduction of the harmful emissions not only produced by various mechanisms and machines but by electric stations as well, which means the more efficient use of electric energy by it's consumers;

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We should make a notice here, that new technologies would also lead to the reduction of materials consumption ratio, the production cost of mechanisms and machines, as well as to the improvement of their exploitation conditions.

II. Current Problems of Technological Development of the Energy Industry and Improvement of Living Conditions on the Planet Earth

For more than 180 years of development history, the principle of known EMas and EDs was based, in terms of inductive contact in their structure, on two fundamental ideas[5]-[9], which may be referred as single-vector and full-length. (the complete rows of stator and rotor). That's why all known EMa and ED could be called accordingly, the oEMa-FF (single-vector electric machine with complete rows of stator and rotor) and oED-FF (electric drive with complete rows of stator and rotor and single-vector inductive cohesion between them).

Nowadays, the known oEMa-FF and oED-FF systems have reached their maximum capabilities in terms of technical realization. However, oEMa-FF and oED-FF have serious disadvantages: large sizes, limited energy efficiency, functional and structural abilities.

Consider the main factors that constrains the wider use of electric drives in vehicles and the transition from DIC to EM.

Let's cover three main factors, which hold electric drives from the more frequent application in transport and from the ICE (internal combustion engine) to EM transfer. In this relation, the level of technological development of electric cars may be used as an example.

Electric cars that are currently produced (by Tesla and others) use too much electricity for driving, and are also more expensive than cars with ICE, and electric cars are more expensive as well. These oEMa-FF and oED-FF systems, which are mainly expressed by the following factor:

The power P_E of electric current (work per time) is defined by this expression

$$P_E = \mathcal{I}U \quad (1)$$

Where: $\mathcal{I}$ – power of electric current; U – voltage of electric current.

Electric motors of electric vehicles have a value U in the range from 300V to 700V, and the $\mathcal{I}$ value reaches 400A. Such big values of $\mathcal{I}$ and U are necessary for the creation of a significant force of inductive cohesion in a limited volume of electric motors.

The amount of heat, which is emitted during the passage of electric current through the conductor is defined by the law of Joule-Lenz:

$$Q=\mathcal{I}^2\mathcal{R}t, \quad (2)$$

Where: $\mathcal{I}$ – current strength, $\mathcal{R}$ – conductor's impedance, t – time, during which the current was applied.

Because of the big value of $\mathcal{I}$ used in electric motors of e-vehicles, the greater amount of heat is emitted. Such fact leads to the number of issues.

- The efficiency of the electric motor and battery decreases – sufficient portion of electric energy is consumed during the unnecessary and undesired process of heat emission;
- The electric motor has to have a greater amount (up to 700 kg) of expensive electric batteries;
- Tt complicates the structure, increases the weight and production cost of the electric drive – it is necessary to use effective (liquid) cooling system in order to maintain working temperature of electric motor and battery;
- Decreases the lifetime of an electric motor and electric battery – works under extreme conditions;

We also can note the fact that the quantitative ratio of electric vehicles to ICE vehicles is rather low nowadays and equals about 0,1%. At the same time, exhaust gases of ICE vehicles produce about 80% of air pollution in large cities and metropolises. Electric motors are installed only on small aircrafts and even those are experimental models. And the other fact is that ICE offers a 30-35% efficiency rate.

All the above mentioned facts show how undeveloped, in terms of technologies, are energy industry and the idea of provisioning the favorable conditions for living on the planet Earth.

For instance, our up-to-date technologies may help to decrease the level of energy consumption and heat emission in electric vehicles by 3 and 9 times accordingly. However, such indexes of our technologies in this field are not as big as they could possibly be.

III. Our Offer of New Technologies/ Concepts and Their Scientific and Technological Solutions

Our new scientific and technological solutions for the development of energy industry and improvement of living conditions on planet Earth are based, at least, on one of several concepts/ technologies [5]-[9].

- Multi-vector electric machine (mEMa-(FF)) andэelectric drive (mEMD-(FF));
- Multi-section (multi-vector and single-vector) electric machine (EMa-(jk) and electric drive (ED-(jk));
- ED with ZV- draught, under the constant or adjustable directions of it's draught vectors;
- Single plane systems with "self-compensating rotating moments" and/or with "cross-section of maximum energy efficiency" ED;
- Round-multi-vertex-rotating EMa and ED.

The notations used above:

j – The number of sections of active zones on the surface of inductive cohesion (electromagnetic groups) on the stator;

k – The number of sections of active zones on the surface of inductive cohesion on the rotor;

F – Shows that stator or rotor (depending on it's position in sequence F) has a complete row

Notice: All technical solutions are registered and protected by law.

IV. Main Technical and Commercial Advantages of New Technologies/ Concepts and Their Scientific and Technical Solutions

Electric machines mEMa-(jk) and electric drives mED-(jk), which are created based on concepts of multi-vector and multi-section inductive cohesion, would have many advantages in comparison with already known oEMa-FF and oED-FF, which were created based on concepts of single-vector inductive contact and complete row of stator and rotor.

Multi-vector character of EMa and mED (mEMa-FF, mED-FF) has the following advantages before oEMa-FF and oED-FF:

- Specific output power in relation to the volume is 2 to 4 times bigger due to the increased square of inductive contact surface;
- Material consumption rate is twice less;
- Higher efficiency rate, especially for low and medium power, provided by the decrease of ineffective part of the winding, which in it's turn consumes a significant portion of electric energy (to the useless and for useless and harmful resistance of the electrically conductive material).

The multi-section nature of EMa and mED {EMa-(jk) and ED-(jk)}, also provides new capabilities in comparison with svEMa-FF and svED-FF, such as structural diversion due to the spatial scattering of multi-sector inductive contact of EMa-(jk) and ED-(jk), and the improvement of energy efficiency rate due to the increase of quality of inductive cohesion t at EMa-(jk) and ED-(jk) systems.

Multi-vector and multi-section nature of EMa and mED {mEMa-(jk) and mED-(jk)} lead to the addition of abovementioned abilities usually present at multi-vector {mEMa-FF, mED-FF} and multi-section {EMa-(jk) and ED-(jk)} systems – mEMa-(jk) has capabilities of mEMa-FF and EMa-(jk), whereas the mED-(jk) has capabilities of mED-FF and ED-(jk).

The characteristics of mEM-(jk) given above are proven by results of theoretical and experimental works:

- Firstly, based on the mathematical analysis and computer modeling of mEM-FF (mEM-FF – multi-vector electric motor) with complete-row-stator and rotor), described in the report of the international conference[6]—(https://waset.org/Publication/volume-density-of-power-of-multivector-electricmachine /10007686);
- Secondly, based on the experimental test of the mSRM-31 (mSRM-31 – multi-vector switched reluctance motor with three-section-rotor and one-section-stator) laboratory sample created by us https://drive.google.com/file/d/1SIiPcbqDH6DKCsB EcZ CsxwRgE_ Vi6u2n/view?ts=5aa157f1.

Independent testing[9] and examination by commissions, including the field team, (Excerpt from Protocol of official meeting of Administration of "National agency for technological development", or – "NATD", dated September 04, 2017 No. 43/17[9], have shown that the very first laboratory sample of mEMn-(jk) in the world, presented by the mSRM-31 system, has twice more specific output power per given volume than known single-vector analogs.

The concept of ZV-draught with the constant or adjustable direction of it's vectors of draught force, and various structures of systems for it's realization in ED system are based on the purposeful effective use of multidirectional jet forces or pressure differences created by the engine in the given environment. At the same time, this concept may be successfully used for moving objects along the edge of two different environments, whether it is a vacuum, gas or liquid. Energy efficiency of ZV-draught concept is connected with the fact that at least two out of four side vectors of multidirectional jet force or pressure differences in the given environment created by the engine, which usually compensates one another, are changing their direction of force in order to perform the useful work. This idea is realized by means of special structure surfaces with constant or adjustable profile and/or position of, at least, one of the system's components, which create ZV-draughts.

For instance, this concept allows increasing the amount of useful work of engine with horizontal draught, which would increase energy efficiency rate in the horizontal direction and at the same time it would create single-direction vertical draught and/or single-direction side draught. In such case, the useful work is performed in front of the engine and/or behind it.

The technology of achieving the maximum energy efficiency of two interconnected cascades of paddles in single-plane ED with the multi-cascade paddle of single-plane-blade would allow to increase the energy efficiency rate of ED, help to increase all of it's technical and dimensional characteristics.

The technology of achieving the self-compensation effect of the torque in ED with the multi-cascade paddle of the single-plane blade would help in getting rid of various issues connected with the transfer of the torque force to immovable rests of ED and would allow creating a single-plane blade with two or more cascade paddles for the self-movement unit. For instance, technologies of "self-compensating of the torque" and "cross-section of maximum efficiency" would allow creating aircraft with straight vertical take-off by means of a single blade with electric drive, which would be 10 times more energy efficient and would consume 30% less material for production than other known systems.

Particularly, the helicopter with such ED would not require the second co-axial main rotor or the tail wing with the control rotor, which is used for compensation of the torque momentum transferred from the main rotor to the helicopter itself. Known technologies consider using the two co-axial main rotors or the tail control rotor, which significantly decreases the energy efficiency rate, increases the consumption of materials and the overall weight of the aircraft, and these technologies are connected with issues of transferring the torque momentum to the body of the helicopter.

Newly developed technologies of round-multi-vertex rotating EMa and ED allow assigning them any geometrical form or shape.

V. Marketing. the Market of the Annual em and Ed Consumption

Conceptually new EMa and ED offered would have more compact dimensions, greater energy efficiency rate, new functional capabilities and structural diversion in comparison with known oEMa-FF and oED-FF systems. These advantages have such a great importance for energy industry and for the human, flora, and fauna in general, that the technologies offered here are considered as "disruptive innovation" /https://www.publish.ru/articles /201009_15118689/, "which totally changes the values ratio on the market, and essentially

disrupts (substitutes) products and services previously prevailed on the market.

Areas of use of the EMa and ED is rather wide and it's production is highly profitable. EMa and ED are so widely spread and used that any unit of industrial or household appliances has one or more EMa and/or ED component.

With the great degree of probability, one may expect, that new type of mEM and ED offered by us would occupy the multi-billion share of the world market in no time.

a) The market of electric motors (MEM)

Let's review some of the known statistic data (http://en.moment-expo.com/electric-motors), which only cover the export of electric motors. The annual export rate of top-10 exporters of electric motors in 2010 has reached the following indexes (by countries): China – 7 billion dollars with 13% growth per year; Germany – 6 billion dollars with annual growth of 9%. Moreover, besides China and Germany top-10 world exporters of EM also includes Japan (3 billion dollars), USA (3 billion dollars), Mexico (2 billion dollars), France (2 billion dollars), Italy (2 billion dollars), Czech Republic (1 billion dollars), Switzerland (1 billion dollars) and Thailand (1 billion dollars).

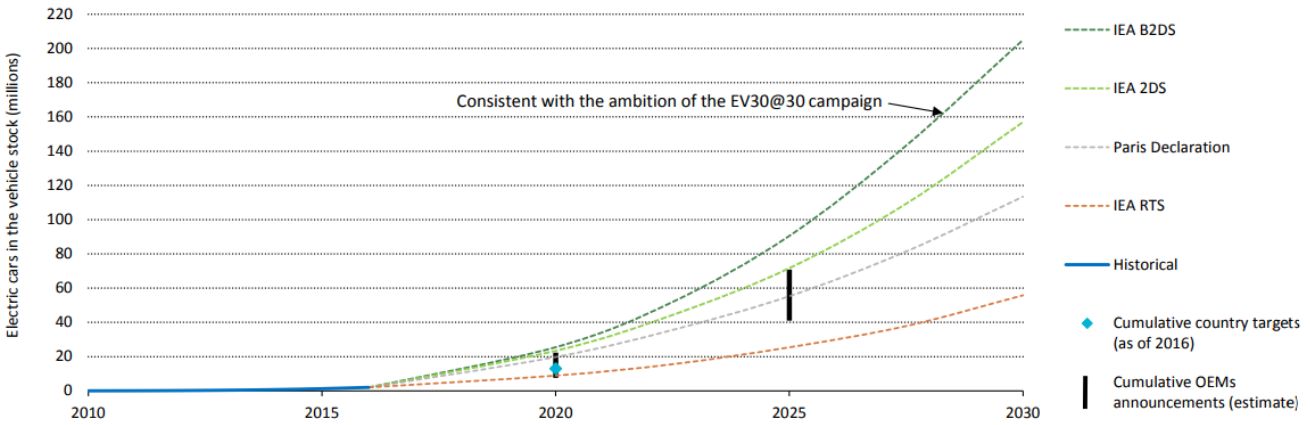
At the same time, one may observe the significant annual increase of EM production rates. For instance, Chinese export in the year 2010 has increased by 13% and German export in the same year has increased by 9%.

b) The market of electric drives (MED) (let's look only at automotive and aerospace industries)

i. *The vehicle market*

In 2010 the German government has accepted the program of production and exploitation of electric vehicles. The goal of this program was to reach 1 million electric vehicles present in the country by 2020, and by the year 2030, the amount of such electric vehicles should reach 6 million. At the same time, this program suggests several methods of stimulation of the demand for such vehicles. The Chinese government plans that by 2020 there would be 5 million electric vehicles on the country (https://hightech.fm/2017/07/03/china_batteries), and by 2030 China would completely shift to electric cars. The Minister for Transport of Russia has announced the schedule and deadlines of shifting to electric vehicles by the year 2027 (http://tass. ru/ekonomika/4475736). Governments of 20 more countries (India, Norway, Ukraine and etc.) have also announced such plans being scheduled to be completed in 2027-2032.

The global vehicle market is equal to 1,6 trillion dollars. According to forecasts the world market of vehicles would reach 121 billion US dollars by the year 2020 http://www. strategyr. com/Market Research/Electric_Motors_Market_Trends.asp, and the growth of sales, according to various forecasts, would be equal to 25-70 million electric vehicles by 2025.



Different scenarios of the growing number of electric vehicles in the world, from 5 up to 14 million units per year. (https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf)

Taking into consideration the fact that the cost of electric drive is about 30% of the cost of the whole vehicle (https://www.quora.com/Can-anyone-provide-a-cost-analysis-of-converting-gasoline-powered-cars-to-a-plug-in-hybrid-cars), the share of electric drives market for electric vehicles in 2020 would be equal to about 40 billion dollars.

c) The market of ASI (ASI – Aero-space industry)

Nowadays the annual income from ASI only in the USA is equal to about 180 billion dollars, which is roughly 0,6% of the total world GDP. Annual turnover in other sectors of the economy, which are immediately connected with the use of aerospace technologies is about 10 times bigger than the turnover of the aerospace industry itself.

Used information sources

1. Ilyinskiy N. F. Basics of electric drive: Study guide for higher education institutions.— 2-nd edition, revised and modified — M.: MEI Publishment, 2003. — C. 220. — ISBN 5-7046-0874-4.
2. Onischenko G.B. Electric drive. — M.: Academy, 2003.
3. Electronic guide “Electric machines”. http://elmech.mpei.ac.ru/em/em/em_cont_0.htm – St.-P. Science, 1968, 487 p.
4. Usoltsev A.A. Electric machines /Study guide. St.-P: ITMO University, 2013, 416 p.
5. WO 2015137790 A3, 12.11.2015, Sapargaliyev A.A.;
6. WO 2016153328 A3, 15.12.2016, Sapargaliyev A.A
7. WO 2016195465 A1, 8.12.2016, Sapargaliyev A.A.
8. “Volume Density of Power of Multivector Electric Machine”, World Academy of Science, Engineering and Technology International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:11, No:6, 2017 (https://waset.org/Publication/volume-density-of-power-of-multivector-electric-machine/10007686)
9. Conclusions of experimental testing of the created laboratory sample of mEM, “Excerpt from Protocol of an official meeting of Administration of JSC “NATD” dated September 04, 2017 No. 43/17 mEM, a video recording that shows the type and operation of the concept-laboratory sample mSRM-31. https://drive.google.com/file/d/1SliPcbqDH6DKCsBEcZ CsxwRgE_Vi6u2n/view?ts=5aa157f1.

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Acknowledgments

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- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
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The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

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b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
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f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

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Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

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Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

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6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

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Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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