ISSN Application No. 21779

Journal of Wireless Communication and Simulation

Volume No. 13

Issue No. 3

September - December 2025

ENRICHED PUBLICATIONS PVT. LTD

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MANISH ABHINAV PLAZA-II, ABOVE FEDERAL BANK,
PLOT NO-5, SECTOR-5, DWARKA, NEW DELHI, INDIA-110075,
PHONE: - + (91)-(11)-47026006

Journal of Wireless Communication and Simulation

Aims and Scope

Journal of Wireless Communication and Simulation has become very important with the ever increasing demands of the software development to serve the millions of applications across various disciplines. For large software projects, innovative software development approaches are of vital importance. In order to gain higher software standards and efficiency, software process adaptation must be derived from social behavior, planning, strategy, intelligent computing, etc., based on various factors. This Journal addresses the state of the art of all aspects of software engineering, highlighting the all tools and techniques for the software development process.

Journal of Wireless Communication and Simulation

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(Volume No. 13, Issue No. 3, September - December 2025)

Contents

Contingency Assessment of Electric Power System by Calculation of Unequal Priority Factors for Static Severity Indices using Analytic Hierarchy Process

Samrat Malakar[1], M. K. Maharana [2]

[1]M. Tech, Power & Energy Systems, School of Electrical Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

[2]Associate Professor, School of Electrical Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

1. INTRODUCTION

Contingencies are expressed as a specified set of events occurring within a short duration of time, which actually indicates loss or failure of one or more components on power system [1]. In the experience of an unintended (or spontaneous) apparatus outage, contingency analysis gives the operators a clue, of what might ensue to the power system [2]. It is basically a computational software continuously run in an energy management system, simulating a hypothetical test on a list of conjectural cases, which would generate line flow, voltage or reactive power violations. These cases are recognized and graded according to their level of severity using contingency ranking algorithm [3].

Usually the procedure of contingency analysis can be classified as, contingency definition, selection and evaluation [4], but in present days the selection and the evaluation both steps are done in same segment. For more than three decades many work has been done on contingency selection, aiming at reducing the primary extensive list of contingencies, by choosing the cases with severe limit violations only [5]–[8]. This selection is accomplished by mainly two methods, i.e., contingency ranking and contingency screening. The screening methods are local solution based analysis, which basically gives top priority to the most severe cases for detailed ac analysis, at the same time the m would

In the present work, the effort has been made towards contingency ranking incorporating Analytic Hierarchy Process, for calculating the unequal weights for the weighted severity index. At first the contingency list is processed, which contains the cases whose chance of arising is estimated amply high. Then the large list is routinely rendered into electrical network transformations: usually generator and/or line outages. Detailed AC power flow is then carried out on the consecutive distinctive cases in declining order of severity for contingency evaluation. Then up to the spot where no post-contingency infringement are met, or until a precise time has been elapsed, the process is continued. The proposed technique has been verified on IEEE 14 bus system and the network graphical overlays are depicted in order to express its effectiveness for contingency ranking.

2. ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) is a multi-criterion decision making approach which was introduced by Saaty (1977 and 1994) [14]. Due to its simplified mathematical properties and the fact that the required input data are somewhat effortless to achieve it has engrossed the concern of many researchers. The AHP is applicable as a decision support tool, as it is used for selecting one alternative from a set of alternatives and for determining the relative merit of a set of alternatives. It provides a way of decomposing the problem into a pecking order of sub problems which can more easily be realized and intuitively evaluated. These individual assessments are then transformed into numerical values and processed to rank each alternative on a numerical scale.

During power system operation, the assignment of priority factors to individual buses and transmission lines is influenced by the significance of the particular bus and transmission line respectively. Therefore, power system operation has noteworthy impact on the judgment of experts for suitable priority factor assortment to be imposed on severity index. The application of AHP for priority factor selection is based on inquiries requested from experts.

The inquiries can be just categorized as:

(a) What is the priority of i^{th} bus compared to j^{th} bus?

(b) What is the priority of i^{th} line compared to j^{th} line?

The exact predilection values based on the above two inquiries given in Table 1, should be selected by each expert, based on their previous experience or may be from the results of conventional contingency ranking scenario. A numerical value is allocated to each answer from Table 1. Then, the priority factors are calculated in accordance with numerical average value for the solutions contributed by experts, from decision matrix (DM) by AHP [15], [16].

Table1: Range of prefference values

Numerical Values of priority	Definition
1	Two options have equal priority
3	One has week priority over another
5	One of the options have strong priority
7	One of the options have significant priority
9	Supreme priority of one option over another
2, 4, 6, 8	Intermediate values between two adjacent judgments
Reciprocals of above nonzero	If option *i* has one of the above nonzero numbers allotted to it when compared with option *j*, then j has the reciprocal value when compared with *i*

iAssume the decision matrix of a four bus power system shown in Figure 1, based on proficient views associated to voltage security (i.e. $|V_i|-|V_i^{SP}|$) for all buses of this sample (i.e. system is:

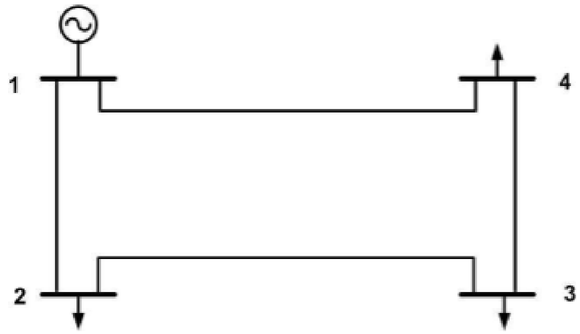


Figure 1: Four bus power system

$$W_{DM}=\begin{bmatrix} & \text{Bus 1} & \text{Bus 2} & \text{Bus 3} & \text{Bus 4} \\ \text{Bus 1} & 1 & 2 & 4 & 2 \\ \text{Bus 2} & \frac{1}{2} & 1 & 2 & 3 \\ \text{Bus 3} & \frac{1}{4} & \frac{1}{2} & 1 & 2 \\ \text{Bus 4} & \frac{1}{2} & \frac{1}{3} & \frac{1}{2} & 1 \end{bmatrix} \quad (1)$$

In WDM it is clear that, from the experts' point of view the priority of voltage security in bus 1 is twice compared to voltage security in bus 2. Likewise, the priority (importance) of voltage security in bus 2 is half of the priority of voltage security in bus 1. Also, it can be understood that the diagonal elements of decision matrix (WDM) is equal to unity all the times. Now for the formulation of the AHP technique, we will go after these steps:

• **Step 1:** The columns of WDM are added, thus:

$$W_{DM}^{1}=\begin{bmatrix} & \text{Bus 1} & \text{Bus 2} & \text{Bus 3} & \text{Bus 4} \\ \text{Bus 1} & 1 & 2 & 4 & 2 \\ \text{Bus 2} & \frac{1}{2} & 1 & 2 & 3 \\ \text{Bus 3} & \frac{1}{4} & \frac{1}{2} & 1 & 2 \\ \text{Bus 4} & \frac{1}{2} & \frac{1}{3} & \frac{1}{2} & 1 \\ \text{Sum} & \frac{9}{4} & \frac{23}{6} & \frac{15}{2} & 8 \end{bmatrix} \quad (2)$$

• **Step 2:** Each elements of the decision matrix W_{DM}) are divided in specific columns to sum of its own column given in W_{DM}^{1} , thus:

$$W_{DM}^{2}=\begin{bmatrix} & \text{Bus 1} & \text{Bus 2} & \text{Bus 3} & \text{Bus 4} \\ \text{Bus 1} & \frac{4}{9} & \frac{12}{23} & \frac{8}{15} & \frac{1}{4} \\ \text{Bus 2} & \frac{2}{9} & \frac{6}{23} & \frac{4}{15} & \frac{3}{8} \\ \text{Bus 3} & \frac{1}{9} & \frac{3}{23} & \frac{2}{15} & \frac{1}{4} \\ \text{Bus 4} & \frac{2}{9} & \frac{2}{23} & \frac{1}{15} & \frac{1}{8} \end{bmatrix} \quad (3)$$

- ***Step 3:*** *The mean value of each row in* W_{DM}^{2} *are calculated, thus:*

$$W_{DM}^{3}=\begin{bmatrix} & Bus\ 1 & Bus\ 2 & Bus\ 3 & Bus\ 4 & mean \\ Bus\ 1 & 0.444 & 0.522 & 0.533 & 0.25 & 0.437 \\ Bus\ 2 & 0.222 & 0.261 & 0.267 & 0.375 & 0.281 \\ Bus\ 3 & 0.111 & 0.130 & 0.133 & 0.25 & 0.156 \\ Bus\ 4 & 0.222 & 0.087 & 0.067 & 0.125 & 0.125 \\ sum & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \quad (4)$$

This column matrix expressing the mean values is called the right eigenvector of the comparison matrix. These elements of the normalized eigenvectors are termed importance or priorities with respect to the criteria and ratings with respect to the alternatives, are also used to derive the principal eigenvalue. This principle eigenvalue is used to evaluate the consistency ratio (CR) of the previously calculated decision matrix, which according to Saaty (1994) should be less than 0.1 [16]–[19]. In our case we have the CR of 0.0872 for the four bus system. Therefore for the specified power system the calculated priority factors are:

W1 = 0.437, W2 = 0.281, W3 = 0.156, W4 = 0.125

These results indicate that bus 1 is the most important bus from the AHP method based on hypothesis experts' viewpoint, on the topic of voltage security importance in the power system shown in Fig. 1. It can be made obvious that the same procedure could be implemented in order to calculate priority factors for line flow security $\frac{P_1}{P_1^{lim}}$).

3. SYSTEM SEVERITY INDEX

The deviation of system variables such as line flows, bus voltages, from its rated value is measured by the system severity index. It is also used to evaluate the relative stability of a contingency [2], [20].

3.1 Voltage Severity Index "SIV"

The system deficiency due to out-of limit bus voltages is defined by the voltage severity index [2], [20].

$$SI_V=\sum_{i=1}^{NB}\left(\frac{W_{vi}}{2n}\right)\left(\frac{|V_i|-|V_i^{SP}|}{\Delta V_i^{lim}}\right)^{2n} \quad (5)$$

Where $|V_i|$ is the voltage magnitude at bus i, | | the specified (rated) voltage magnitude at bus i, | | is the voltage deviation limit, | | is the average of and V_{imin} which are the maximum and minimum voltage limits of the i^{th} bus respectively, higher than which voltage variations are intolerable. n is the exponent of penalty factor (n= 1), NB is the total number of buses in the system, W_{vi} the real non- negative weighting factor (W_{vi}=1). The voltage variation ΔV_i^{lim} symbolize the verge, higher than which the voltage level difference are outside their restrictions. The harshness of the voltage profile on buses with out-of limit voltages and the relative severity of the contingencies for different outages are measured by this severity index.

3.2 Real Power Severity Index "SIP"

A manifestation for measuring the degree of overloads of lines can be expressed in terms of real power severity index [2], [20].

$$SI_P = \sum_{i=1}^{NL} \left(\frac{W_{li}}{2n}\right)\left(\frac{P_l}{P_l^{lim}}\right)^{2n} \qquad (6)$$

Where, P_l the real power flow of line l, P_l^{lim} the maximum endurance of active power flow e of line l, NL the number of lines of the system, W_{il} real nonnegative weighting factor (W_{il}=1), n is the exponent of penalty factor (n=1). The severity index SIP contains all normalized line flows, elevated to an even power setting (by selecting n = 1, 2...n), thus the use of absolute magnitude of flows is avoided. The value of maximum power flow in each line is calculated using the formula:

$$P_l^{lim} = \frac{V_i * V_j}{x_l} \qquad (7)$$

Where, V_i = Voltage at bus i obtained from NRPF solution, V_j= Voltage at bus j obtained from NRPF solution, X_l= Reactance of the line linking bus i and bus j. For calculation of SIV it is required to know the maximum and minimum voltage limits, generally a margin of 5 percent is kept for assigning the limits. The boundary is normally 1.05 P.U. for maximum and 0.95 P.U. for minimum limits respectively . To obtain the value of SI for each contingency the lines in the bus system are being numbered as per convenience, then a particular transmission line and/or a generator at a time is simulated for outage condition and the individual power flows and the bus voltages are being calculated with the help of Newton-Raphson power flow solution.

Apparently, there is no clear suggestion on how to choose the weighting factors and hence, are usually considered to be equal. In the present paper we use the mentioned severity index widely for contingency ranking in static security appraisal. So we apply the Analytic Hierarchy Process (AHP) to correct the proper unequal weighting factor values in the given equations, to offer more precise and practical contingency ranking. These factors are termed as the priority factors. This approach corrects the errors in ranking due to the assumption of the weighting factors as unity in the conventional methods.

4. CONTINGENCY ASSESSMENT

The priority factors for the respective lines and buses are first calculated using AHP in MATLAB coding environment following by a consistency check of its calculated weights, from the decision matrix. Then the data are fed into the contingency ranking algorithm while calculating severity index for the bus voltages and line flows. Further the power system analysis toolbox (PSAT) is used to develop the Network Graphical Overlays, which is a MATLAB-based Open Source software (OSS), certified by IEEE for electric power system simulation and analysis [20]. In the present work the active power flows and magnitude of bus voltages are obtained from Newton Raphson power flow, which is achieved using MATLAB coding and followed by a detailed comparison via Network Graphical Overlays, for pre-contingency and post-contingency state of the system using PSAT (ver.2.2). The Figure 2 shows the flow chart for the simplified severity index based power system contingency ranking, incorporating AHP for calculation of priority factors.

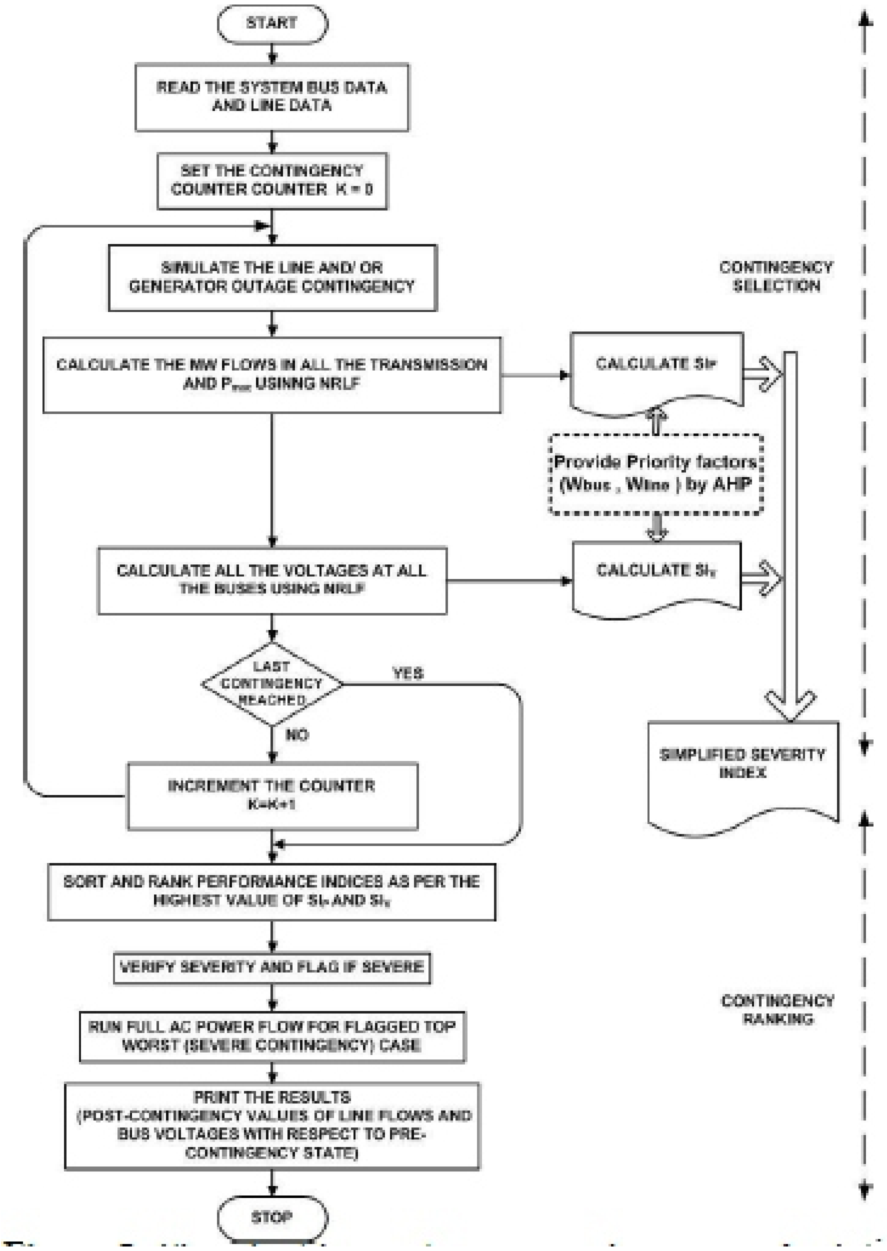


Figure 2: Flowchart for contingency ranking using Analytic Hierarchy Process

5. RESULTS AND DISCUSSION

To demonstrate the effectiveness of the proposed analytic hierarchy approach, contingency ranking is performed on IEEE 14 bus system which is shown in Figure 3. The system consists of 5 synchronous generators including 3 synchronous condensers, 14 buses, 20 lines and 1 shunt capacitor.

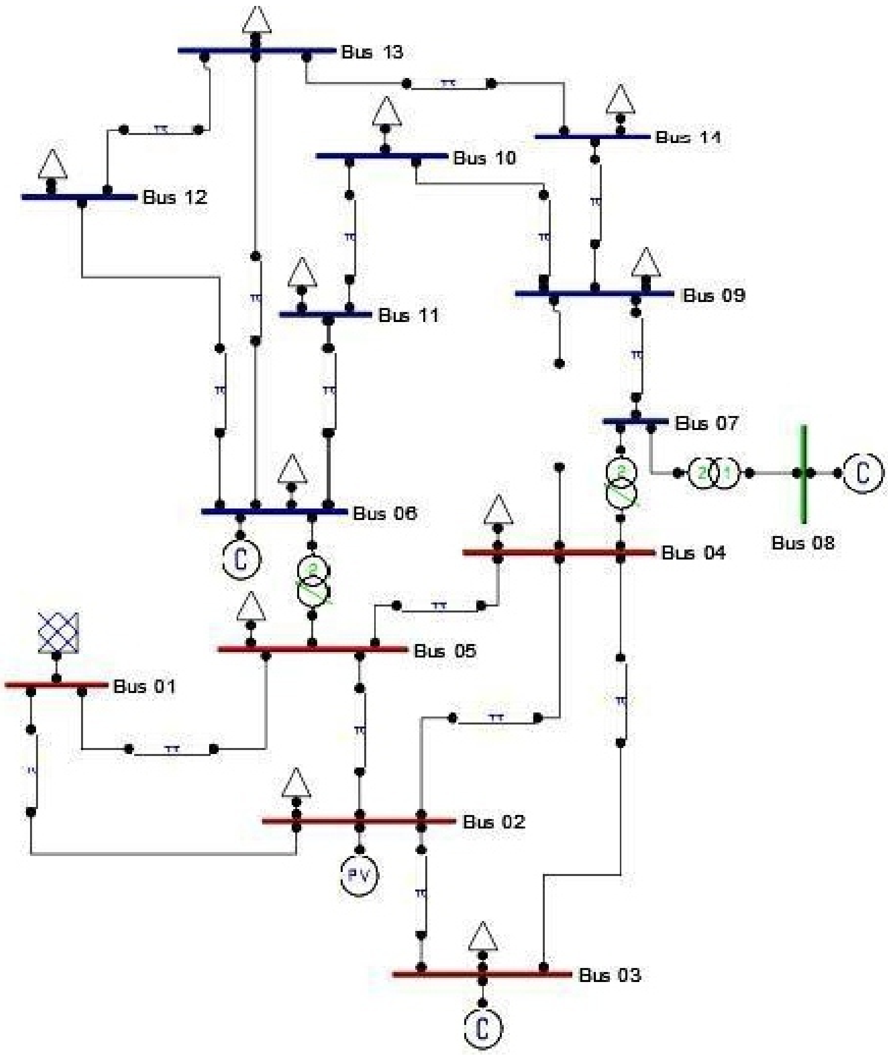


Figure 3: Equivalent simulation diagram of IEEE 14 bus system

The priority factors of the 14 buses are evaluated before demonstrating the simulation result, which is tabulated in Table 2.

Table 2: Priority factors for buses obtained by AHP

Bus	Priority Factor
1	0.13320000
2	0.10910000
3	0.11620000
4	0.11110000
5	0.08400000
6	0.07700000
7	0.07550000
8	0.06900000
9	0.05670000
10	0.04720000
11	0.03550000
12	0.02690000
13	0.03570000
14	0.02290000

Similarly the priority factors of 20 lines of the test power system are presented are presented in Table 3.

Table 3: Priority factors for lines obtained by AHP

Line Number	From Bus	To Bus	Priority Factor
1	1	2	0.06644446
2	2	3	0.05125154
3	2	4	0.03943731
4	1	5	0.04740199
5	2	5	0.06037220
6	3	4	0.06139875
7	4	5	0.05985670
8	5	6	0.04410364
9	4	7	0.05211741
10	7	8	0.04625939
11	4	9	0.05620352
12	7	9	0.05171349
13	9	10	0.00428919
14	6	11	0.05919837
15	6	12	0.05608748
16	6	13	0.00417537
17	9	14	0.05671457
18	10	11	0.06199013
19	12	13	0.05628163
20	13	14	0.05557197

The consistency ratios of the decision matrices are 0.0994 and 0.091 respectively. The pre-contingency state and base case power flow of the IEEE 14 bus system is shown in Figure 4.

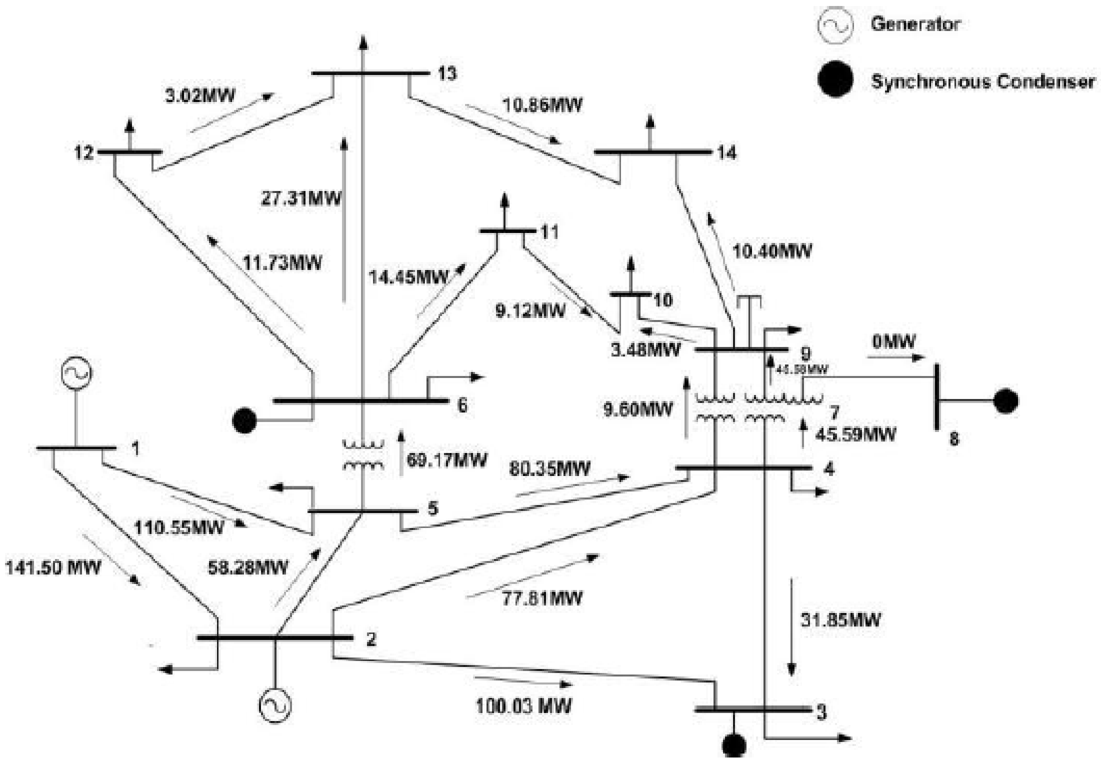


Figure 4: Pre-contingency state of IEEE 14 system

The ranking of the contingency cases incorporating line and/or generator outage has been detailed in Table 4.

Table 4: AHP based contingency ranking of IEEE 14 bus system

Contingency No.	Type Of Outage	From Bus	To Bus	SI_P	SI_V	SSI	Rank
1	Line	1	2	71.8200	2.7520	74.570	1
2	Line	2	3	1.2940	2.0870	3.3812	9
3	Line	2	4	0.4901	1.9646	2.4546	12
4	Line	1	5	0.6026	1.0923	1.6949	21
5	Line	2	5	0.5339	1.1699	1.7038	20
6	Line	3	4	0.8024	1.2368	2.0390	17
7	Line	4	5	0.5496	6.1611	6.7108	5
8	Line	5	6	2.9795	5.7691	8.7486	4
9	Line	4	7	0.4043	5.1387	5.5430	7
10	Line	7	8	35.371	3.3923	38.763	2
11	Line	4	9	0.5664	2.6689	3.2350	10
12	Line	7	9	0.8570	5.7732	6.6300	6
13	Line	9	10	0.6849	0.5243	1.2092	23
14	Line	6	11	0.6158	3.1795	3.7953	8
15	Line	6	12	0.6470	0.9152	1.5622	22
16	Line	6	13	0.7676	0.0280	0.7956	24
17	Line	9	14	0.8649	10.344	11.208	3
18	Line	10	11	0.6739	2.2230	2.8969	11
19	Line	12	13	0.6769	1.2923	1.9692	19
20	Line	13	14	0.6941	0.0074	0.7015	25
21	Generator	G1	G1	0.6712	1.3972	2.0684	16
22	Generator	G2	G2	0.5701	1.4467	2.0168	18
23	Generator	G3	G3	0.6712	1.3972	2.0685	13
24	Generator	G6	G6	0.6712	1.3972	2.0685	14
25	Generator	G8	G8	0.6712	1.3972	2.0685	15

From the contingency ranking list it can be seen that, the first contingency case was identified as most severe as it forces the power systems to make its transition into the emergency state, upon its occurrence. So this contingency due to the outage of the line between bus 1 and bus 2 is elaborated and parameters of the post contingent states are also explained. The post-contingency state of the system after the occurrence of the outage is shown in Figure 5.

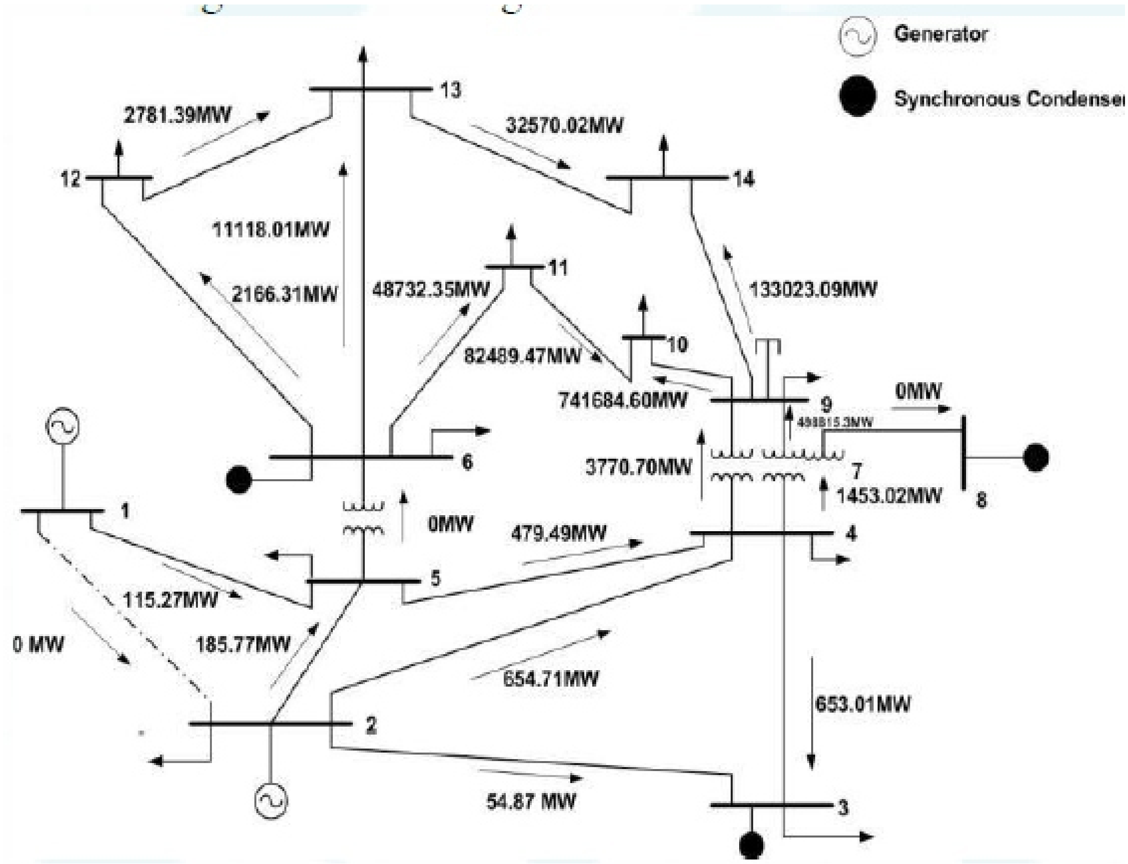


Figure 5: Post-contingency state of the IEEE 14 bus system after the outage of the line between bus 1 and bus 2

The pre and post-contingency values of the bus voltage magnitudes are presented in Table 5 along with the limit violations.

Table 5: Bus voltage magnitudes of pre-contingency and post-contingency state

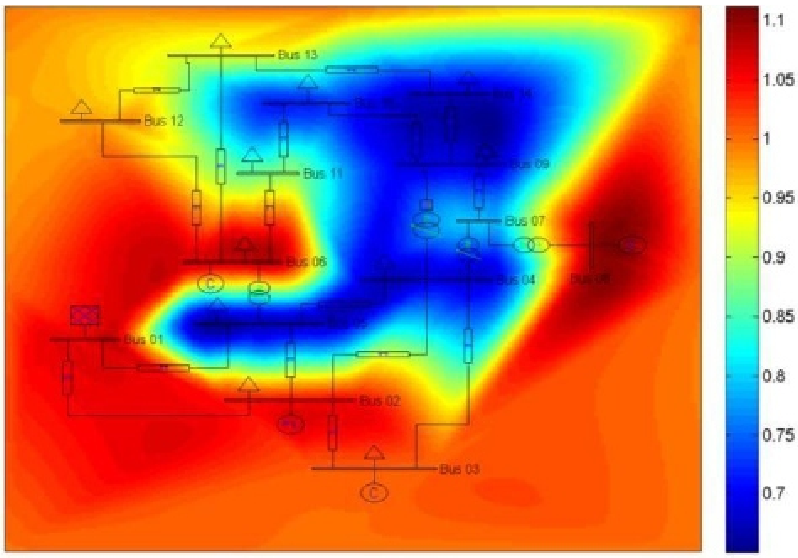
Bus No.	Pre-contingency Voltage (p.u)	Post-contingency Voltage (p.u)	Limit Violation
1	1.06	1.06	No
2	1.045	1.045	No
3	1.01	1.01	No
4	0.99772	0.83721	Yes
5	1.0024	0	Yes
6	1.07	1.07	No
7	1.0347	2.35873	Yes
8	1.09	1.09	No
9	1.0111	2.99623	Yes
10	1.0105	2.65655	Yes
11	1.0346	1.45976	Yes
12	1.0461	3.517	Yes
13	1.0362	6.1084	Yes
14	0.99568	2.18274	Yes

Similarly, the pre and post-contingency values of the line flows are detailed in Table 6 along with the limit violations.

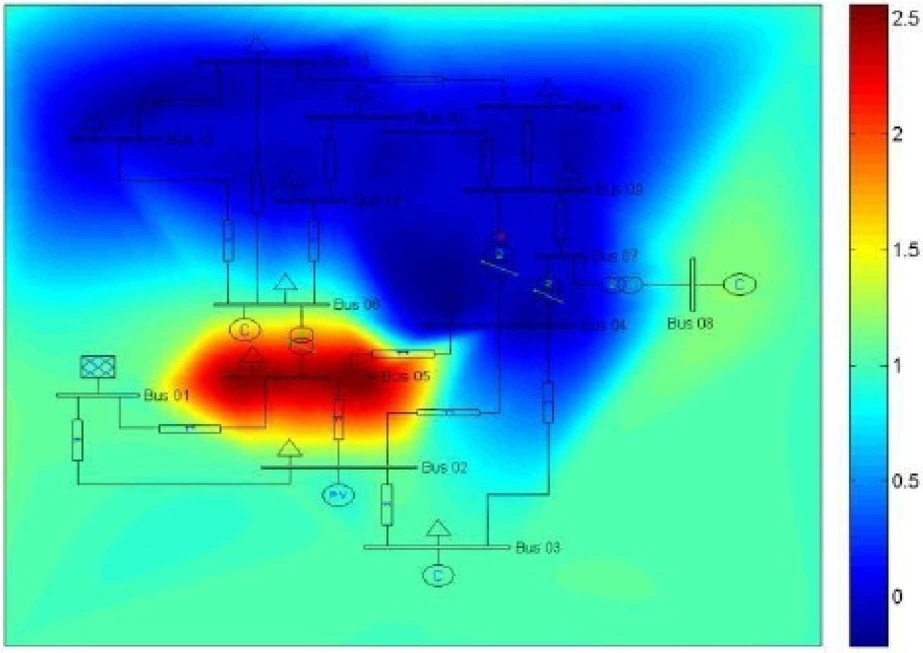
Table 6: Line flows for pre-contingency and post- contingency state

From Bus	To Bus	Pre-contingency MW Flow	Post-contingency MW Flow	Limit Violation
1	2	141.4974	0	Outage
2	3	100.0314	54.8678	No
2	4	77.8081	654.7052	Yes
1	5	110.5549	115.27	No
2	5	58.2781	185.7687	Yes
3	4	31.8486	653.0107	Yes
4	5	80.3531	479.4949	Yes
5	6	69.1681	0.0003	No
4	7	45.5864	1453.0238	Yes
7	8	0	0	No
4	9	9.5983	3770.2954	Yes
7	9	45.5864	498815.3077	Yes
9	10	3.4796	741684.6092	Yes
6	11	14.4494	48732.353	Yes
6	12	11.7258	2166.3097	Yes
6	13	27.3128	11118.0123	Yes
9	14	10.4001	133023.0877	Yes
10	11	9.1243	82489.4662	Yes
12	13	3.0168	2781.3947	Yes
13	14	10.8573	32570.0206	Yes

From the comparisons of Table 5 and 6 it is evident that the specified contingency has made severe limit violations, thus it cannot be taken care of and it will result in complete loss of load or voltage collapse. The scenario is better understood with the network graphical overlays of the bus voltages comparison, for the pre-contingency and post-contingency state of the power system given in Figure 6.



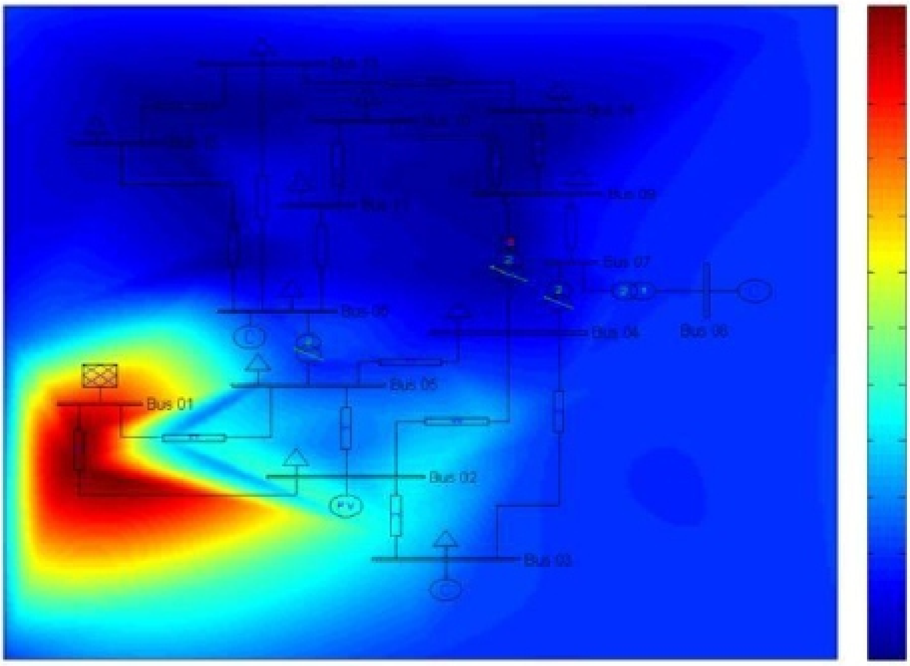
(a) Pre-contingency bus voltage magnitudes



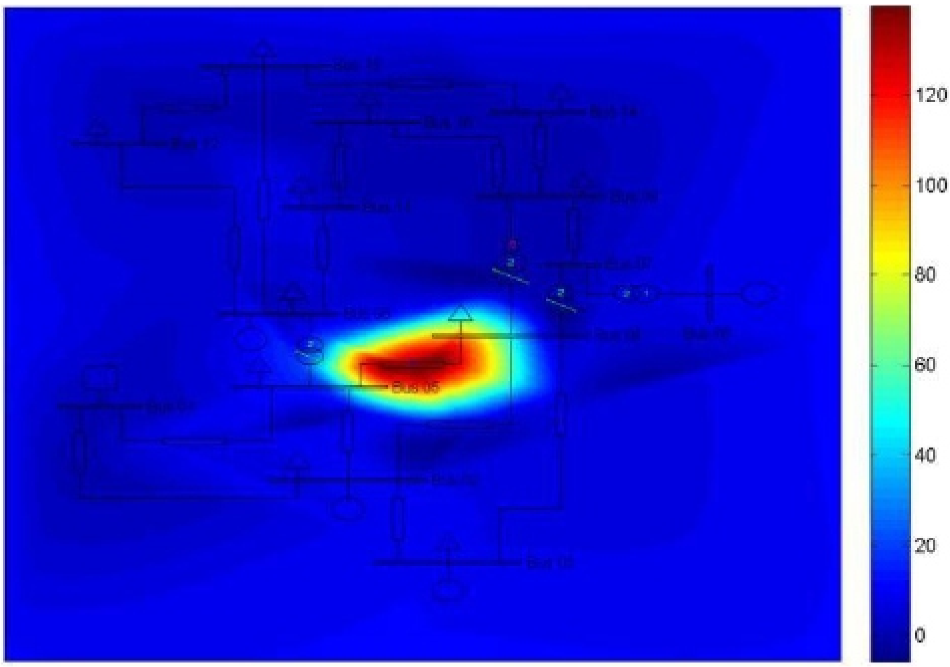
(b) Post-contingency bus voltage magnitudes

Figure 6: Network graphical overlays of the bus voltage for IEEE 14 bussystem

Similarly the network graphical overlays for the line flows for the pre-contingency and post-contingency state of the power system are given in Figure 7.



(a) Pre-contingency line flows



(b) Post-contingency line flows

Figure 7: Network graphical overlays of the line flows for IEEE 14 bus system

6. CONCLUSION

In this paper, an Analytic Hierarchy Process based approach has been developed for contingency ranking. The present approach incorporates severity index, related to the priority factors adjustment of the bus bars and transmission lines. The usefulness of the proposed approach has been demonstrated on IEEE 14 bus power system and detailed comparison is portrayed with the help of network graphical overlays. A more accurate and realistic ranking can be obtained by the proposed method. Thus, it is expected that the proposed approach can serve as an on-line operational aid to operators.

REFERENCES

[1] L. H. Fink and K. Carlsen, "Operating under stress and strain.", IEEE spectrum, vol. 15, pp. 48-53, Mar. 1978.

[2] K. S. Swarup and G. Sudhakar, "Neural network approach to contingency screening and ranking in power system." Neurocomputing 70, vol. 1, pp. 105- 118, June 2006.

[3] G. C. Ejebe, and B. F. Wollenberg "Automatic contingency selection.", IEEE Transactions on Power Apparatus and Systems, vol. 1, pp. 97-109, Feb. 1979.

[4] Brian Stott O. Alsac, and A. J. Monticelli, "Security analysis and optimization.", Proceedings of the IEEE 75, vol. 12, pp. 1623-1644, 1987.

[5] A. J. Wood and B. F. Wollenberg, "Power generation, operation, and control.", John Wiley & Sons, 2012.

[6] J Zaborszky, K. Whang and K. Prasad, "Fast contingency evaluation using concentric relaxation.", IEEE Transactions on Power Apparatus and Systems, vol. 1, pp. 28-36, 1980.

[7] V. Brandwajn and M. G. Lauby, "Complete bounding method for AC contingency screening.", IEEE Transactions on Power Systems, vol. 4, pp. 724-729, 1989.

[8] N. M. Peterson, W. F. Tinney and D. W. Bree, "Iterative linear AC power flow solution for fast approximate outage studies.", IEEE Transactions on Power Apparatus and Systems, vol. 5, pp. 2048-2056, 1972.

[9] C. Y. Lee,, and N. Chen, "Distribution factors of reactive power flow in transmission line and transformer outage studies.", IEEE Transactions on Power Systems, vol. 1, pp. 194-200, 1992.

[10] S. N. Singh and S. C. Srivastava, "Improved voltage and reactive power distribution factors for outage studies.", IEEE Transactions on Power Systems, vol. 3, pp. 1085-1093, 1993.

[11] F. Albuyeh, A. Bose, and B. Heath, "Reactive power considerations in automatic contingency selection.", IEEE Transactions on Power Apparatus and Systems, vol. 1, pp. 107-112, 1982.

[12] M. K. Maharana, and K. Shanti Swarup. "Identification of Operating States of Power System Using Transient Stability Analysis.", In Power System Technology and IEEE Power India Conference, 2008. POWERCON 2008. Joint International Conference on, pp. 1-6. IEEE, 2008.
[13] M. K. Maharana, and K. Shanti Swarup. "A corrective strategy to alleviate overloading in transmission lines based on particle swarm optimization method.", The Journal of Engineering Research, Vol. 7, No. 1, pp. 31-41, 2010.
[14] Thomas L. Saaty, What is the analytic hierarchy process?. Springer Berlin Heidelberg, 1988.
[15] N. Bhushan and Kanwal Rai, "Strategic decision making: applying the analytic hierarchy process", Springer Science & Business Media, 2004.
[16] H. R. Baghaee. and M. Abedi. "Calculation of weighting factors of static security indices used in contingency ranking of power systems based on fuzzy logic and analytical hierarchy process.", International Journal of Electrical Power & Energy Systems, vol. 33, no. 4 pp. 855-860, 2011.
[17] E. Triantaphyllou, and Stuart H. Mann. "Using the analytic hierarchy process for decision making in engineering applications: some challenges.", International Journal of Industrial Engineering: Applications and Practice, Vol. 2, no. 1, pp. 35-44, 1995.
[18] Saaty, Thomas L. "How to make a decision: the analytic hierarchy process.", European journal of operational research, vol. 48, no. 1, pp. 9-26, 1990.
[19] M. K. Maharana and Samrat Malakar, "Sensitivity Based Network Contingency Ranking Using Newton Raphson Power Flow Method", International Journal of Scientific Engineering and Technology, Volume No.4, Issue No.2, pp. 45•49, 2015.
[20] L. Vanfretti, F. Milano, "Application of the PSAT, an Open Source Software for Educational and Research Purposes", pp. 7803-6672, IEEE 2001.
[21] V. Terzija, G. Valverde, D. Cai, P. Regulski, V. Madani, J. Fitch, S. Skok, M. M. Begovic, and A. Phadke. "Wide-area monitoring, protection, and control of future electric power networks.", Proceedings of the IEEE, vol. 99, no. 1, pp. 80-93, 2011

AUTHOR PROFILE

Samrat Malakar completed B. Tech in Electrical Engineering first class in 2013 and pursuing M. Tech in Power Engineering & Energy Systems, from KIIT University, Bhubaneswar, India. His Research interested on Power System Contingency analysis, Power System Voltage Security. He is at KIIT University, Bhubaneswar, India

Dr. M. K. Maharana received M. Tech from NIT- Warangal and PhD from IIT Madras. He is currently working as Associate professor and working in many areas in KIIT University, his area of interest is Power System Security, Power System Operation and Control, contingency analysis, smart grid etc. He presented many research papers in National and International conferences.

Analysis the Performance of Multi- Carrier CDMA System with Fading and Interference

Bobby Barua*

*Assistant Professor, Department of EEE, Ahsanullah University of Science and Technology, Dhaka, Bangladesh

A B S T R A C T

Users moving at vehicular speed communicate over a wireless channel that exhibits time- variant frequency-selective characteristics due to multipath propagation and doppler effects. Multi Carrier Code Division Multiple Access (MC-CDMA) is a relatively new concept to improve the performance over multipath links. MC-CDMA is a modulation method that uses multi carrier transmission of DS-CDMA type signals and an MC-CDMA transmitter spreads the original data stream in the frequency domain over different sub carriers using a given spreading code. The MC-CDMA offers better frequency diversity to combat frequency selective fading. In this paper we evaluate the performance results of MC-CDMA in terms of bit error rate, power, length, code length and no. of subscriber.

Keywords: Bit Error Rate (BER), Code Division Multiple Access (CDMA), Multi Carrier Code Division Multiple Access (MC-CDMA), Multipath propagation.

1. INTRODUCTION

Mobile communications are rapidly becoming more and more necessary for everyday activities. With so many more users to accommodate, more efficient use of bandwidth is a priority among cellular phone system operators [1]. Again the security and reliability of these calls are equally important. One solution that has been offered to mitigate the situation is a Code Division Multiple Access system [2]. Multiple Access is a technique where many subscribers or local stations can share the use of a communication channel at the same time or nearly so despite the fact originate from widely different locations [3].

A multicarrier system is a system where several subcarriers are used for parallel transmission of data packets. A new multicarrier mechanism is applied to a Code Division Multiple Access (CDMA) network [4]. In a CDMA network each data symbol is spread over a larger bandwidth, larger than the bandwidth needed for transmission. This allows to transmit with a spectral energy that is lower than in a non spread spectrum system, a fact that allows the use of parallel transmission channels, at the same time in the same frequency band. Each symbol of the data stream of one user is multiplied by each element of the same spreading code and is thus placed in several narrow band subcarriers. Multiple chips are not sequential, but transmitted in parallel on different subcarriers [5].

In the field of wireless communications, the combinations of Multi-Carrier (MC) modulation [6] and Code Division Multiple Access (CDMA) [7] have gained considerable interest due to their excellent performance. According to the spreading approach used, these techniques can be classified into two different schemes [8]. In the former, referred to as Multi-Carrier Direct Sequence CDMA (MC-DS-CDMA), spreading is performed in the time-domain, whereas in the latter, named Multi- Carrier CDMA (MC-CDMA), spreading is performed in the frequency-domain [9-10].

Again MC-CDMA based communication system has some limitation. Bandwidth, Noise and Fading are some major limitation of the system.

Bandwidth is the measurement of a particular frequency range. When we fixed a bandwidth for a channel then we transmit that amount of data in one second of time. So if the frequency range is very high then we can transmit or receive more data for a period of time. In a communications system lack of bandwidth means lack of throughput of intelligible data. So that Bandwidth limitation means restricting the quantity of information transmitted from sender to receiver per second. This either means the information arrives slower, or the information contains less detail.Noise will also affect intelligibility. The noise is additive, i.e., the received signal equals the transmit signal plus some noise, where the noise is statistically independent of the signal.

Fading is a fluctuation in the received signal strength at the receiver or a random variation in the received signal is known as fading. Fading of radio waves is the undesired variation in the intensity or loudness f the waves received at the receiver. There are two types of fading limitations. Frequency-selective fading & Time selective fading.

In this paper we try to investigate the performance of MC CDMA system with fading and interference. Here different schemes of MC-CDMA are considered to evaluate the performance results in terms of bit error rate code length, no. of subscriber etc.

2. SYSTEM MODEL FOR MULTI CARRIER CODE DIVISION MULTIPLE ACCESS

MC-CDMA is a modulation method that uses multi carrier transmission of DS-CDMA type signals. An MC-CDMA transmitter spreads the original data stream in the frequency domain over different sub carriers using a given spreading code. In this system the sub carriers convey the same information at one time. The MC-CDMA offers better frequency diversity to combat frequency selective fading.

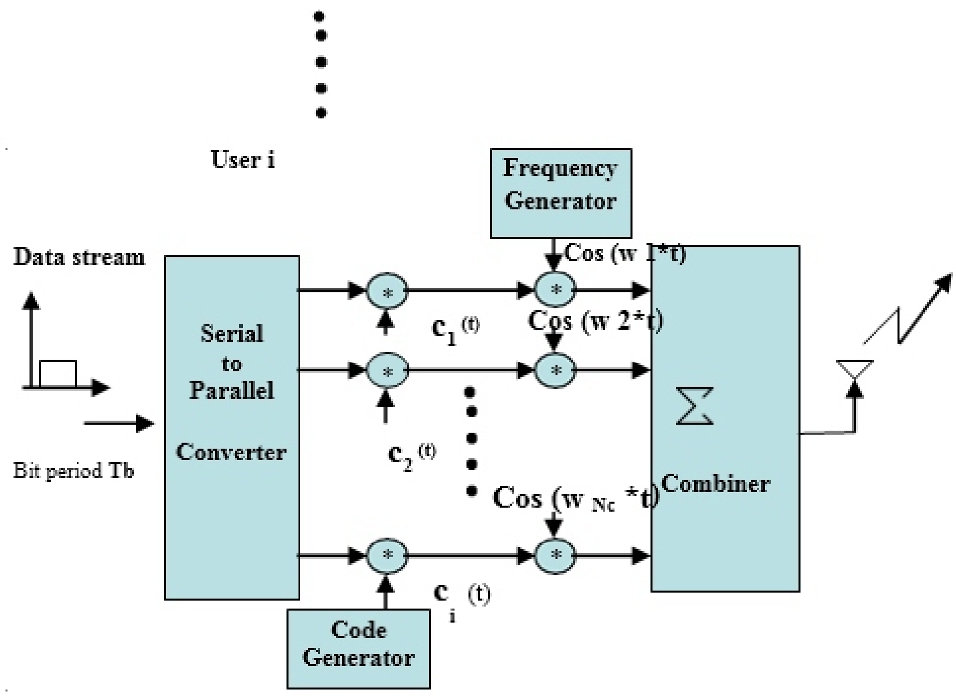


Figure 1 MC-CDMA transmitters

In figure 1 we see the transmitter MC-CDMA system for i number of user. The MC-CDMA transmitter spreads the original data stream using a given spreading code in the frequency domain. The code generator creates different unique codes for each different user and then combines together. Then the frequency generator combines different carrier frequency to the data signal and then combines the entire signal together by a combiner. After combining all the signals the CDMA antenna transmits the signals over the wireless media.

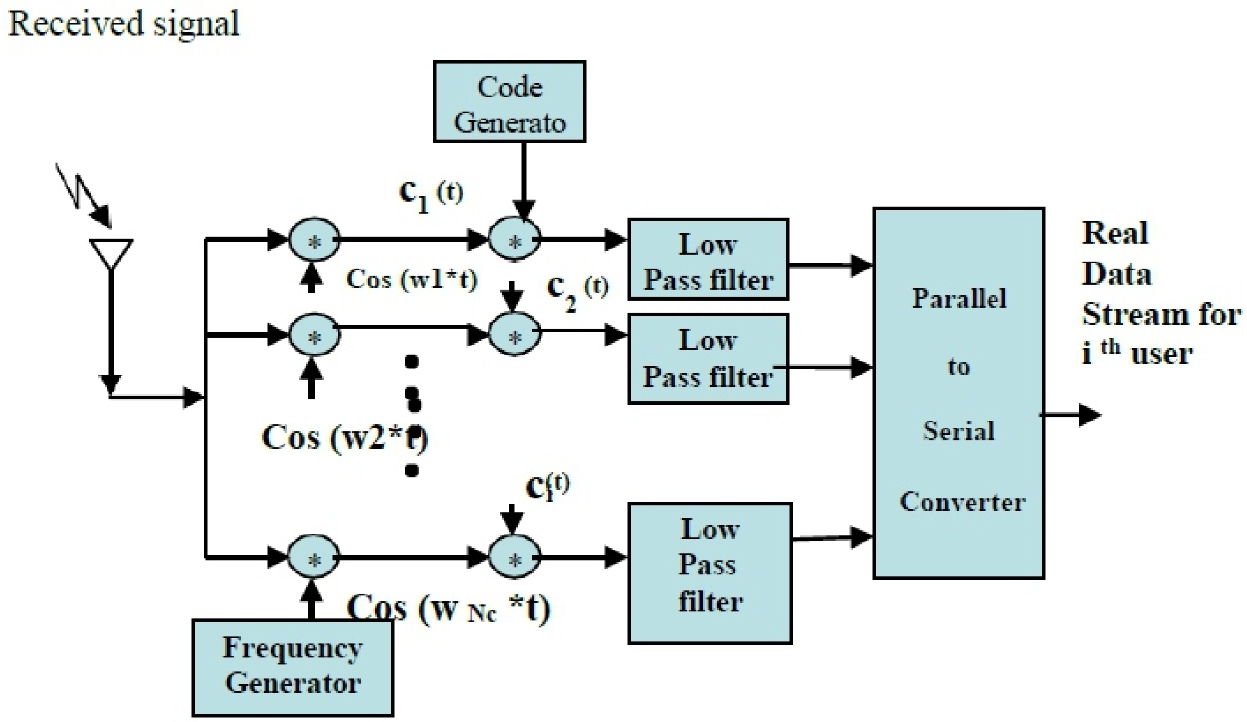


Figure 2 MC-CDMA receiver

In figure 2 the MC-CDMA receiver is designed by the capacity of i number of user. MC- CDMA receiver also receives the transmitted signal as a summation of i number of users. At first demodulates the received signal by the same career frequency of each signal and then the signals multiply with the specific codes given by the receiver code generator. Then we get the signal of ith user which is same for transmitter and receiver. After that low pass filter remove the high frequencies portion of the signal. Finally, the P/S converter presents the actual digital data signal.

In receiver side we get the all combing signal with some unexpected signal which are MUI, ICI and Noise signal. So in the receiver side after combining all sub-carrier signals we get the received signal is

$$x = x_0 + x_{MUI} + x_{ICI} + x_{noise} \qquad [1]$$

Where,

x_0 = wanted signal;

x_{MUI} = multi-user interference (due to imperfect restoration of the sub-carrier amplitudes);
x_{ICI} = inter-carrier interference (due to crosstalk $\beta_{m,n}$ between a_n and y_m);
x_{noise} = noise;

We can write the wanted signal as,

$$x_0 = b_0 \frac{T_s}{N}\left[\sum_{n=0}^{N-1} \beta_{n,n}\omega_{n,n} + \sum_{m\neq 0}\sum_{n=0}^{N-1} \beta_{m,n}\omega_{n,n} c_0[n]c_0[n-m]\right] \qquad [2]$$

Where,

N = number of subscriber,
n = subscriber number,
$\beta_{n,n}$ = crosstalk between the user.
T_s = Sampling time.
$\omega_{n,n}$ = weight factors which is constant.
$c_0[n]c_0[n-m]$ = orthogonal spreading codes

The variance of x_0 became zero for large number of N , i.e., the system working like non fading channel.

3. THEORETICAL ANALYSIS OF MC-CDMA

The multi-user interference signal is

$$x_{MUI} = T_s \sum_{k=1}^{N-1} b_k \left[\sum_{n=0}^{N-1} \beta_{n,n}\omega_{n,n}\, c_0[n]c_k[n]\right] \qquad [3]$$

We can write the x_{MUI} as,

$$x_{MUI} = T_s \sum_{k=1}^{N-1} b_k \left[\sum_{n\in A_+} \beta_{n,n}\omega_{n,n} - \sum_{n\in A_-} \beta_{n,n}\omega_{n,n}\right] \qquad [4]$$

Where,

$A_- = \{n : c_j[n]c_k[n] = -1/N\}$ is the sets of orthogonal code of the sub career index n

$A_+ = \{n : c_j[n]c_k[n] = 1/N\}$ is the sets of orthogonal code of the sub career index n

And $A_+ \cup A_- = A$ is the value of $\sum_{A_+ \cup A_-} c_j[n]c_k[n] = 0$.

So the variance of MUI,

$$\sigma^2_{MUI} = E_{ch}\, E x_{MUI} x^*_{MUI}$$

$$= \frac{(N-1)T_s}{N}\left[E_{ch}\left(\sum_{n\in A_+} \beta_{n,n}\omega_n\right)^2 + E_{ch}\left(\sum_{n\in A_-} \beta_{n,n}\omega_n\right)^2 - 2E_{ch}\left(\sum_{n\in A_+} \beta_{n,n}\omega_n\right)\times\left(\sum_{n\in A_-} \beta_{n,n}\omega_n\right)\right] \qquad [5]$$

If we may assume that fading of the sub-carriers is independent, we can write

$$E_{ch}\left(\sum_{n\in A_+}\beta_{n,n}\omega_n\right)^2 = \frac{N}{2}M_{22} + \frac{N}{2}\left(\frac{N}{2}-1\right)M_{11}^2 \qquad [6]$$

and,

$$E_{ch}\left(\sum_{n\in A_+}\beta_{n,n}\omega_n\right)\times\left(\sum_{n\in A_-}\beta_{n,n}\omega_n\right) = \left(\frac{N}{2}\right)^2 M_{11}^2 \qquad [7]$$

Where

$$M_{11} = E\beta_{n,n}^2 / N_0 = P_0 / N_0$$
$$M_{22} = E\beta_{n,n}^4 / N_0^2 = 2P_0^2 / N_0^2$$

P_0 = power of the signal.

N_0 = power of the noise signal.

After simplify all the equation we get the variance,

$$\sigma_{MUI}^2 = \frac{(N-1)T_s^2}{N}\left(M_{22} + \square^2 M_{11}\right) \qquad [8]$$

The ICI comes from the crosstalk between sub carriers. Inter-carrier interference signal is,

$$x_{ICI} = T_s\sum_{n=0}^{N-1}a_n\sum_{\Delta\neq 0}\beta_{n+\Delta,n}\omega_{n+\Delta,n+\Delta}c_0[n+\Delta] \qquad [9]$$

Here,

Δ = distance of signal between two subscriber,

Now afterputting $a_n = \sum_k c_k[n]b_k$ in the equation,

$$x_{ICI} = \sum_{\Delta\neq 0}\sum_{n=0}^{N-1}\sum_{k=0}^{N-1} b_k c_k[n]\beta_{n+\Delta,n}\times\omega_{n+\Delta,n+\Delta}c_0[n+\Delta] \qquad [10]$$

So the variance of ICI,

$$\sigma_{ICI}^2 = E_{ch}Ex_{ICI}x_{ICI}^*$$

$$= T_s^2 E_{ch} E\left[\sum_{m=1}^{N-1}\sum_{k=1}^{N-1} b_k \sum_{n=0}^{N-1}\beta_{mn}\omega_n c_0(n)c_k(n-m)\right]^2 \qquad [11]$$

After simplify the equation we get the variance

$$\sigma^2_{ICI} = \sum_{\Delta \neq 0} p_{\Delta} M_{02} T_s^2 \qquad [12]$$

Where $M_{02} = E\beta^2_{n,n} / N_0^2 = P_0 / N_0^2$

p_{Δ} = variation of the signal power between of any two subscriber.

The variance of the noise collected over all sub-carriers weighted by $\omega_{n,n}$ becomes,

$$\sigma^2_{noise} = NM_{02} N_0 T_s \qquad [13]$$

Now

$$\frac{E_N}{N_0} = \frac{M_{11}^2 T_s^2}{\sigma^2_{ICI} + \sigma^2_{MUI} + \sigma^2_{noise}}$$

$$= \frac{M_{11}^2}{(M_{22} + M_{11}^2) + M_{02}\left[\sum_{\Delta \neq 0} p_{\Delta} + \frac{N_0}{T_s}\right]} \qquad [14]$$

Since we consider many different channels, x_{MUI}, x_{ICI} and x_{noise} are zero-mean complex Gaussian. So BER is,

$$B = \frac{1}{2} erfc \sqrt{\frac{E_N}{N_0}} \qquad [15]$$

4. RESULTS AND DISCUSSION

The system described above is simulated using Matlab. For the convenience of the readers the parameters used for computation in this paper are shown in table 1.

TABLE 1

Parameter	Value
Max. TxPower	10dBm
Spreading Factor	4
CWmin	4 slots
Cwmax	255 slots
Code Length	8, 16 and 32
Number of Subcarriers	12
Channel Bandwidth	20 MHz
Carrier Frequency	5.25 GHz
Noise Level	-93dBm
Path loss Factor	3.5
TxRate Data	12Mbps
TxRate Control	12 Mbps
Data Packet Length	1024 Byte

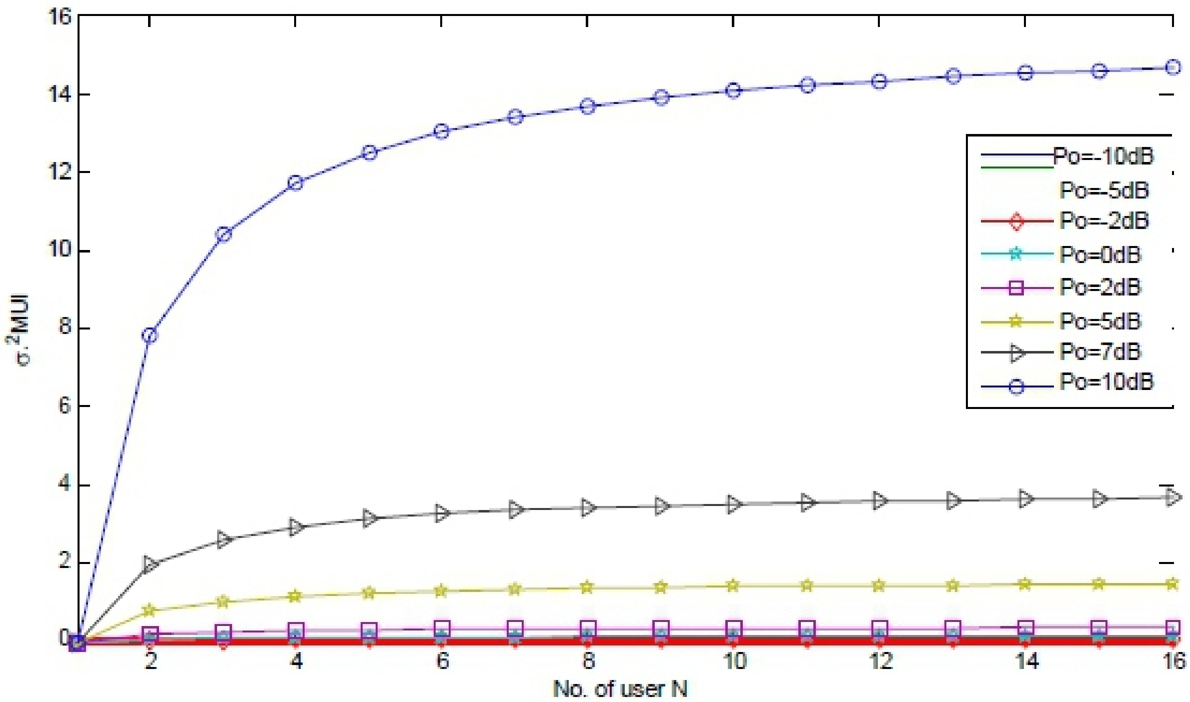


Figure 3: Plots of σ^2_{MUI} versus number of user in MC-CDMA system

Figure 3 shows the plots of σ^2_{MUI} versus number of user in MC-CDMA system. This figure comes from equation 8. We see that if we increase the number of user then the interference between different user increases. The variance of the multi user interference depends on signal power. If we increase the power then the interference increases gradually. For example, in this graph variance of MUI for 10dB power is very high and it is more than 14. Whereas for low power like 5dB variance of MUI is less than 2. and it is close to zero for very low power like -10dB.

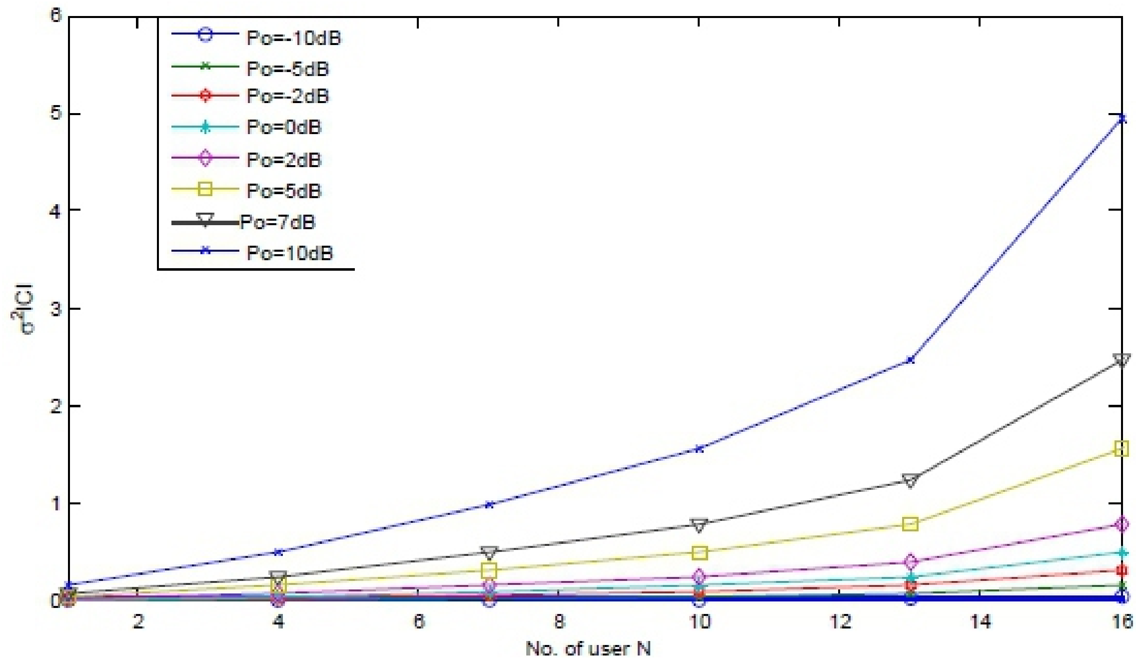


Figure 4: Plots of σ^2_{ICI} versus number of user in MC-CDMA system

Figure 4 shows the plots of σ^2_{ICI} versus number of user in MC-CDMA system. This figure comes from equation 12. We see that if we increase the number of user then the variance of ICI increase. The variance of the ICI also depends on the signal power. If power is low then the interference between the carrier is very low but when we increase the power then the inter carrier interference also increase and that case the crosstalk between the sub carrier occurs very rapidly.

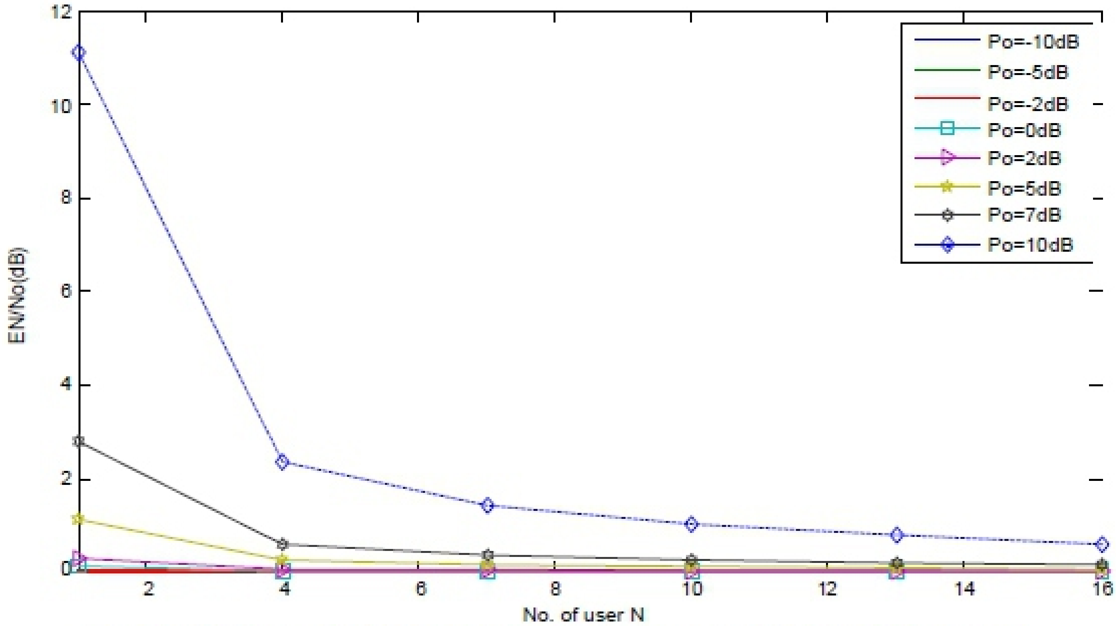


Figure 5: Plots of E_N/N_0 versus number of user in MC-CDMA system

Figure 5 shows the plots of E_N/N_0 versus number of user in MC-CDMA system. This figure comes from equation 14. E_N/N_0 have an inverse relationship with no of subscriber. If we increase number of user then E_N/N_0 decreases.

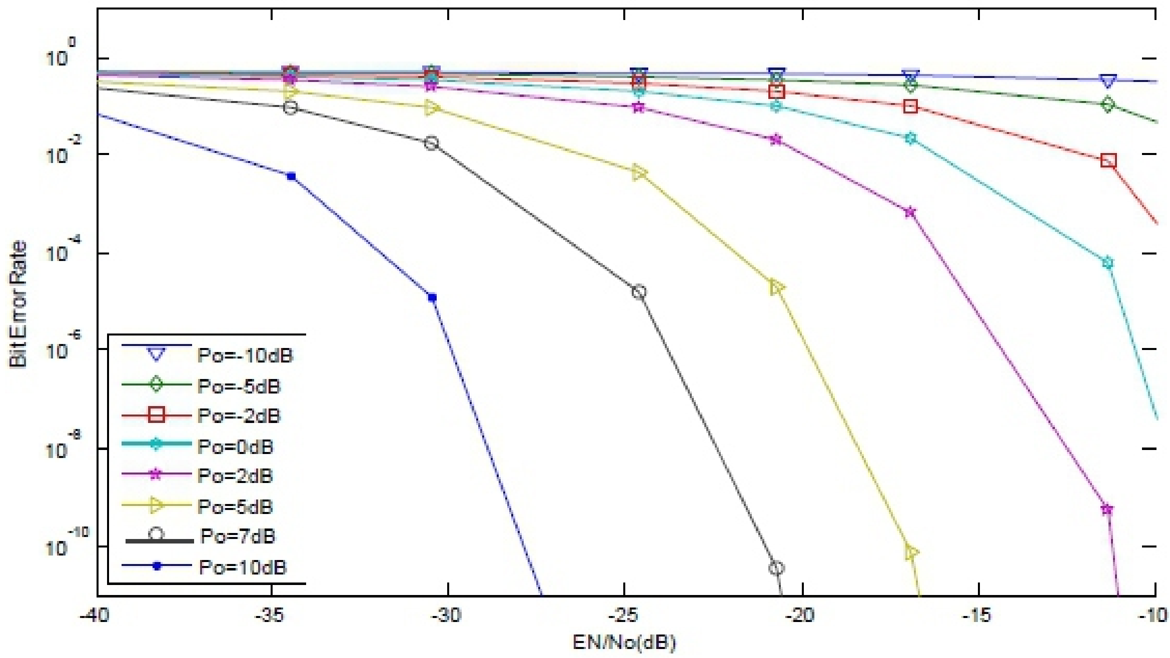


Figure 6: Plots of Bit Error Rate versus E_N/N_0 in MC-CDMA system

Figure 6 shows the Plots of Bit Error Rate versus E_N / N_0 in MC-CDMA system. This figure comes from equation 15. It is found that BER decreases with respect to E_N/ N_0 for a particular signal power. I signal power is very high than BER decrease rapidly with respect to E_N /N_0 . But if signal power is very low then BER decreases very slowly with respect to E_N/ N_0. We prefer lower BER in Wireless communication system and that's why we should use high signal power.

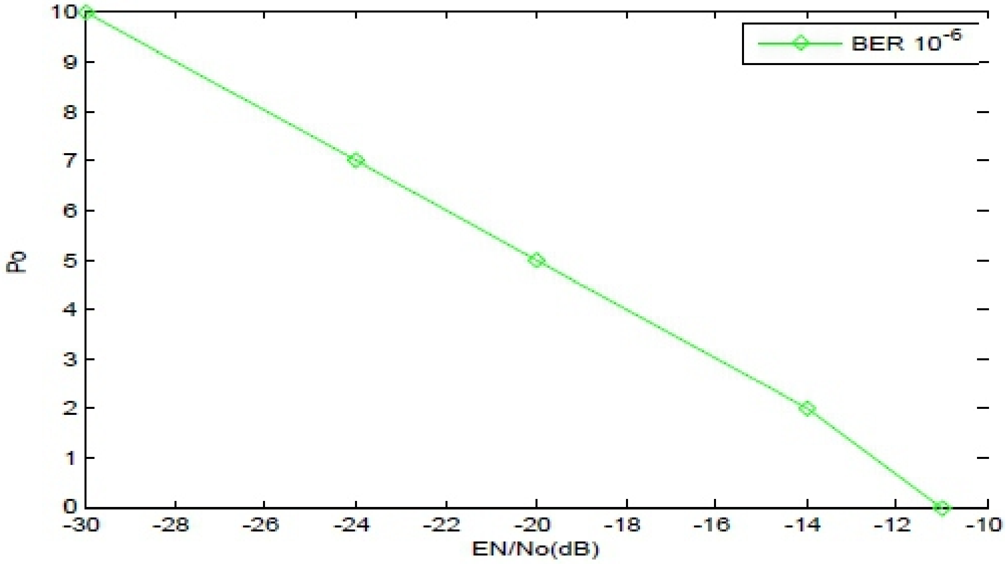


Figure 7: Plots of Signal Power versus E_N/ N_0 in MC-CDMA system

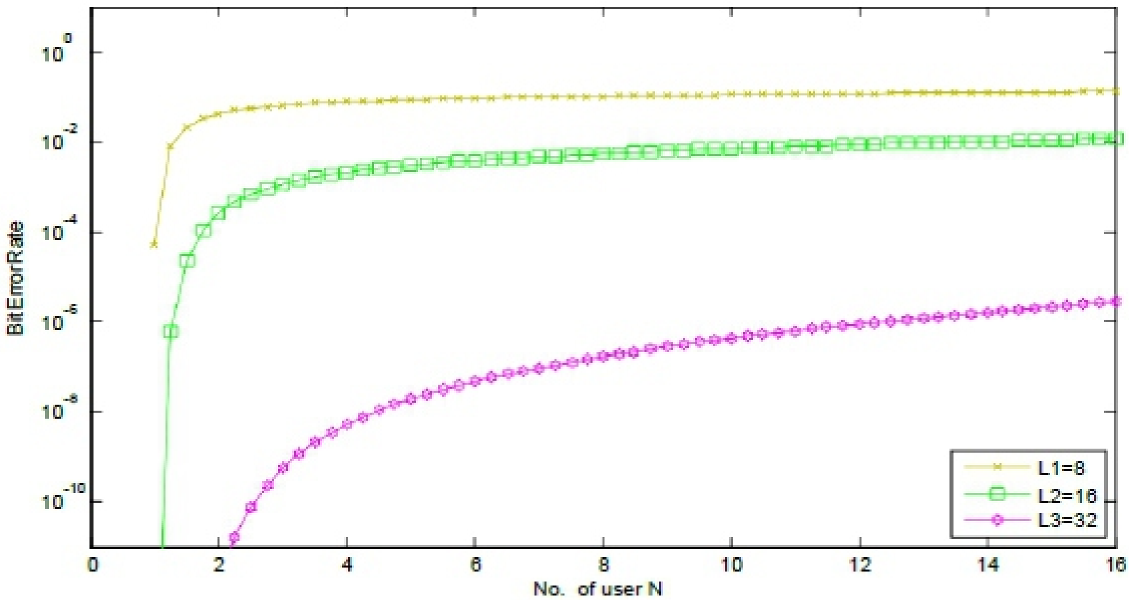


Figure 8: Plots of bit error rate versus number of user in MC-CDMA system

Figure 8 shows the plots Bit Error Rate versus number of user in MC-CDMA system. Here we three different code length which is 8bit , 16bit and 32 bit. It is show that the number of user increases and at the same time BER also increases. Since grater BER is not accepted in wireless communication system and it is essential to reduce higher BER. We can easily do that by increasing the number of chips per bit. When we increase the code length the BER decreases and at the same time we can easily give service more number of user.

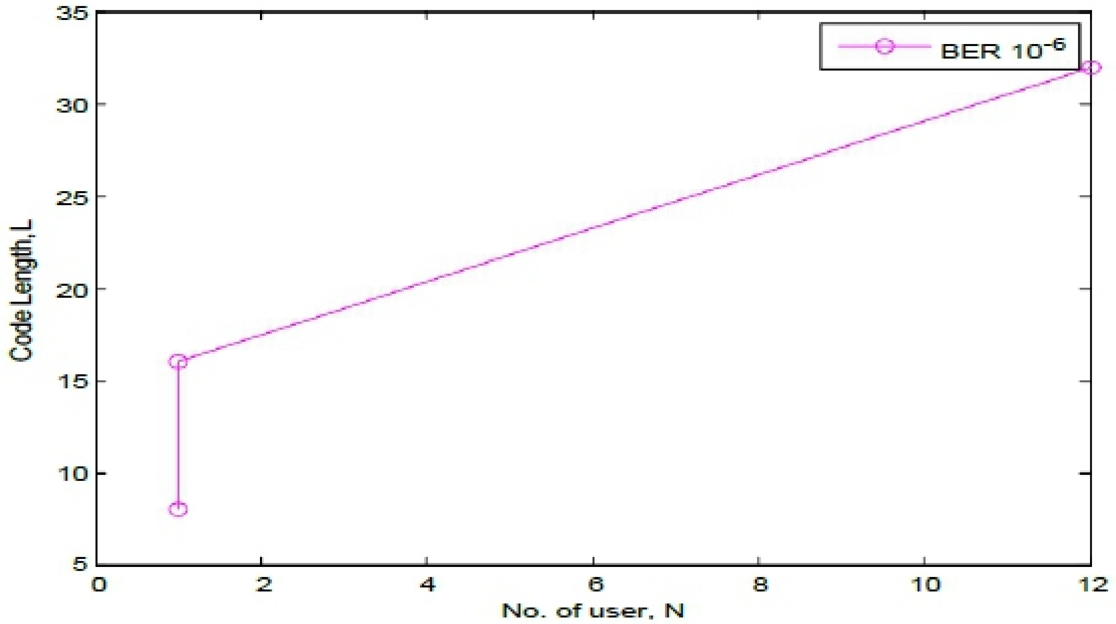


Figure 9: Plots of Code Length versus number of user in MC-CDMA system

The graph for Code length versus Number of user for related BER 10^{-6} which we see in Figure 9. Here we see that for a particular BER if we increase the Code length then we can easily give support to the more number of users. For more number of users that particular BER may be low and that is acceptable in our system. But if user is less and this reason that particular BER became high for system and that is not acceptable.

5. CONCLUSION

In this paper we used some basic equation to find out our expected results. From the overall analysis we found that the performance result for Multi-user interference and Inter carrier interference for certain number of user. If we increase the user then the MUI and ICI occurs more and more. By BER versus ratio of Energy of bit and Noise density analysis we saw that if we increase the value of E_N/N_0 then the BER became low. In communication system we can not prefer high BER. If BER is low then the channel can transfer the signal more perfectly .We also saw that how can the Code length effect the user capacity in the system. For a particular accepted BER we can easily serve more number of users if the code length is high. The major problem of MC-CDMA is Multi carrier interference and inter carrier interference occur. Near far problem and Multi-path fading also another disadvantage of this system. We saw that in CDMA system due to code difference between the users they can easily share the same frequency.

REFERENCES

1. Jean-Paul M. G. Linnartz – "Performance Analysis of Synchronous MC-CDMA in Mobile Rayleigh Channel with Both Delay and Doppler Spreads", IEEE transactions on vehicular technology, vol. 50, no. 6, November 2001

2. L. B. Milstein. Wideband code division multiple access. IEEE J. Select. Areas Commun., 18(8):1344–1354, Aug. 2000.

3. T. Bianchi and F. Argenti. Analysis of filterbank and wavelet tranceivers in the presence of carrier frequency offset. In Proc. ICC 2004, pages 2852–2856, Paris,France, June 2004.

4. S. Hara and R. Prasad, "Overview of multicarrier CDMA," IEEE. Communication Magazine., vol. 35, no. 12, pp. 126–133, Dec. 1997

5. Linnartz, J., "Performance Analysis of Synchronous MC-CDMA in Mobile Rayleigh Channel With Both Delay and Doppler Spreads", in IEEE Trans. On Vehicular Technology, vol. 50, issue 6, Nov. 2001.

6. J. A. C. Bingham. Multicarrier modulation for data transmission: An idea whose time has come. IEEE Commun. Mag., 28(5):5–14, May 1990.
7. Saimoon Ara Amin and Md.Mahbubul Alam – "Performance analyses of Multi-Carrier DS-CDMA wireless communication systems."
8. H. Steendam and M. Moeneclaey. The effect of synchronization errors on MC-CDMA performance. In Proc. ICC '99, pages 1510–1514, Vancouver, BC,Canada, June 1999.
9. Yi, S. and Tsimenidis, C. and Hinton, O. and Sharif, B., "Adaptive Minimum Bit Error Rate Multi-user Detection for Asynchronous MC-CDMA Systems in Frequency Selective Rayleigh Fading Channels", in Proc. IEEE PIMRC 2003, Sept. 7-10, 2003.
10. L. Tomba and W. A. Krzymien. Sensitivity of the MC-CDMA access scheme to carrier phase noise and frequency offset. IEEE Trans. Veh. Technol., 48(5):1657–1665, Sept. 1999.

Proposing Solutions for EVM Application for Construction Management in Vietnam

[1] **Wei Tong Chen, [2] Ductuan Nguyen, [3] Hew Cameron Merrett**

[1]Graduate School of Engineering Science and Technology / Department of Civil and Construction Engineering National Yunlin University of Science and Technology, Douliu, Taiwan

[2]Graduate School of Engineering Science and Technology, National Yunlin University of Science and Technology, Douliu, Taiwan

3Graduate School of Engineering Science and Technology, National Yunlin University of Science and Technology, Douliu, Taiwan

E-mail: [1]chenwt@yuntech.edu.tw, [2]tuannguyentlu@gmail.com, [3]hew.merrett@gmail.com

A B S T R A C T

Vietnam's economy is dramatically growing by sake of the investment from foreign and young labor work force leading to the needs for infrastructure development. Construction project managements should be improved according the rapid expansion of economy. Construction project management is known as a complicated work because of the volatility of planned to manage unexpected changes during process. Earned Value Management can be considered as a powerful method to monitor and control project in Vietnam because some achievements in construction management in developed countries like: USA, Belgium can prove the efficiency and useful of this method. Research specified the benefits of EVM and its shortcomings then based on the previous researches to propose the solutions for better application of EVM in Vietnam. All factors derived from previous researches that might affect to the successful application of EVM in Vietnam construction would be analyzed. There are still a lot of problems involving user, culture, system, implementation aspects because of the unique characteristic of Vietnam. Each aspect has been analyzed carefully to find more detailed problems to find relevant solutions. Educational, legislation and operational strategies have been proposed to handle some limitations of Vietnam situation. This direction of research should be extended and analyze in quantitative method so that it can open a chance for successfully applying EVM in developing countries like Vietnam

Keywords - Earned Value Management, Construction Project Management, EVM Application

I. INTRODUCTION

Most of construction projects face with large potential possibility of time and cost overrun. Saudi Arabia experienced 70% of schedule delay in construction works, and most of them lasted longer 10% to 30% of the planned schedule (Assaf & Al- Hejji, 2006). Furthermore, the average of final cost in seven huge projects in Korea increased 122.4% compared to the planned budgeted (Heon, 2009).

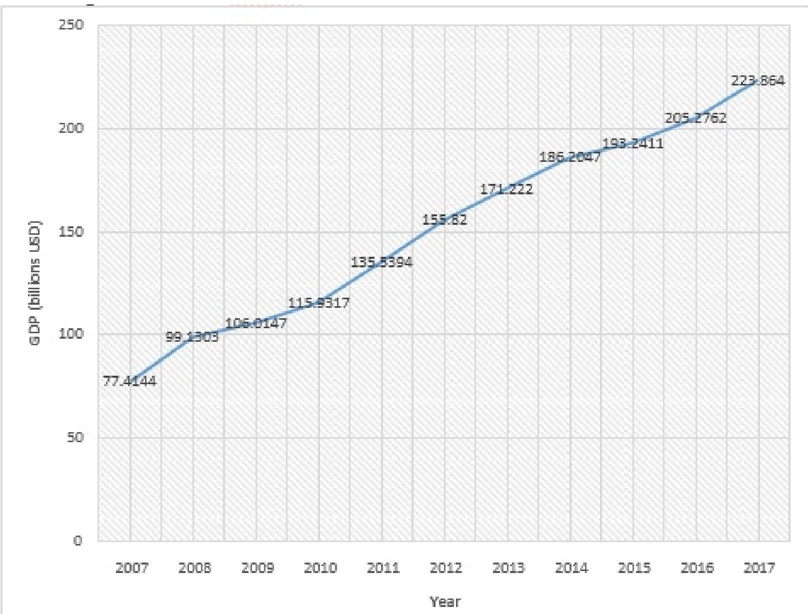
Because construction industry is a dynamic sector and has a lot of tasks to finish under a selected plan, hence it is complicated to be fixed in term of the relationships between works. Time and cost overrun has become a global phenomenon; in particular, this happens often in developing countries especially in Vietnam. This issue starts from the poor project management (PM), inappropriate estimate (overestimate or under estimate), incorrect forecast,budget flow for project and complex payment procedures (Muhwezi and Joseph, 2014).

Traditional PM methods focus on variance between the planned value and actual cost to assess the level of project success. Earned Value Management (EVM) was invented to solve the question that how the health of project is in any point of time? What are internal and external factors and how do positive and negative factors impact to project execution? How to protect project by potential risk? Moreover, the needs rose to help contractors easily finish financial problems when contract request the payment based on the “earned work”. EVM paves the way to monitor the progress of work and manage project by collecting completed data via project execution.

Three key parameters play a vital role on EVM: Budget cost of work scheduled (BCWS) referred as planned value (PV), budgeted cost of work performance (BCWP) referred as Earned Value (EV) and actual cost of work performed (ACWP) referred as actual cost (AC). PV is the value of the estimation-completed work before doing the work bas on schedule in the give point of time. EV is the value of work actually archive based on the budget at completion in particular point of time. Finally, AC is the total cost covered the actual work to date. The phrase budget at completion (BAC) refers to the sum of budget to accomplish all activities, which are listed in work breakdown structure. Budget at completion also can be referred to as the total planned value of the project. In the project plan, there are a list of activity, each activity can be planned for a value to complete and each of these activity is planned can be summed to determine a final value of budget at completion. By searching the Vietnamese document relating to EVM in construction management, it experienced that there are limited researches and EVM guides in construction project management. Finding problems and proposing solutions based on the previous studies in all over the world are necessary.

II. ECONOMY STATUS OF VIETNAM

According to the 2017 Macroeconomics Report, Vietnam's national economy was increasing significantly in the year of 2017. This was a motivation for development of Viet Nam, which is open-relationship with other countries. In 2017, the pace of development of economy and FDI attraction has gotten new record for a decade. Economic Grow Rate at 6.81% can be seen as a high rate comparing with some countries in Southeast Asia, for example: Philippine at 5.9%, Indonesia at 4.8%, Thailand at 2.8%, etc. GDP per citizen has reach at 53.5 million/year (2.385 USD) and higher 170 USD comparing with the year of 2016. Infrastructure has been promoted and invested to warrant the suitability in operation and overtake the development of population and economy. Figure I shows the accelerated growth in Vietnam GDPfrom 2007 to 2017. GDP in 2007 only stood at 77.41 billion USD. After a decade of development, GDP tripled accounted for 223.86 billion USD. During 10 years period, it experienced a steady increase in GDP proof that Vietnam economy always archives positive accomplishments. According to the reports from Ministry of Planning and Investment of the Socialist Republic of Viet Nam, the status of delay and over budget happened usually in construction project of private sectors and government sectors by sake of budget and management method, etc. In Viet Nam there are 1600 delay projects, 22 violated quality management, 284 projects have to stop executing from January to December 2017. The actual situation is alarming and the Government is perplexed to solve those problems. Applying EVM to construction management should be considered as a good idea to control the situation.



Source: World Bank)

Figure I.Vietnam GDP within a decade

III. THE STATUS OF EVM APPLICATION

EVM has experienced a long process of foundation and development since 1960. This technique can apply widely for variety of field in the world such as: Information Technology (IT), Construction, Professional Service, Government or Public Works, Energy and Power, Design or Procurement, Military, Engineering, Aerospace, Manufacturing, Telecom, Healthcare, Software Development, and Utility or Infrastructure (Song, 2010). The high level of flexibility is important to cope with the large variance in the nature of project involved in the rapid development of infrastructure in Vietnam.

EVM can be seen as a highly accepted by most of PMs in USA at 82% (Kim, et al., 2003). Not only can public sectors implement EVM, private sectors also have been increasing the popularity. Most project managers believe EVM only need for huge and long- term projects but it is proved that EVM method on the short and small scale has been found extremely useful. As a result, EVM is now compulsory when executing many USA government programs and projects. It is very vital to encourage engineers, designers, and project managers to understand about EVM and apply into the real project to archive the success in project management as USA does.

Tan and Najihah (2015) have pointed out that in Malaysia the awareness of EVM experienced very low point at 60.61%. A similar situation also occurs in developed countries, in spite of a vast methodological literature; European area witnessed a low level of acceptance of EVM in construction industry (Timur and Alberto, 2013). Undoubtedly, the potential application of EVM has not been discovered totally and indeed practical researches still are necessary for widely applying EVM.

Recorded applications in European construction projects and best practical reports were shortage in Europe (Marshall 2008). Certain well respected organizations such as PMI, the International Project Management Association and the Association for Project Management have been establishing some programs to populate the knowledge and applications of EVM. However, there are shortages in lack of established standards proposed by Government or practice guidelines in most European countries.

EVM are highly accepted in USA-a developed country, but experienced a low awareness in some countries as Malaysia, Vietnam, Nigeria which are developing countries. Researching solutions to widely spread out this method plays important role on adapting to the booming development of economic.

IV. EVM BENEFITS

EVM in construction industry has proven the importance in integrating management of project scope, schedule, and cost. The great benefit of EVM gives to project managers the ability to evaluate the status of project. Whereas, analyzing schedule and cost performance indices can remind managers to have an early decision before project might be put at critical risk. As a result, they can consider that whether budget or schedule was used effectively or not. Based on that assessment, EVM enables project managers to forecasting the budget and schedule at completion.

EVM requires a carefully tracking progress reports, this helps it become an effective control system for collecting data and providing data for the next project. Supporting to the EVM requirements, the data need to be collected from cost, progress reports to analyze the project performance and forecasting the final cost accurately. Nowadays, PM requires managers closely monitor the progress of the work with reports, but there is not yet an effective system to ensure classified information and meet the needs of each specific item. The high level of accuracy of the information will help EVM to make accurate estimates and predictions that minimize risk and damage to customers.

V. THE BARRIERS OF EVM APPLICATIONS

Ibrahim et al. (2018) have concluded that as a result of limited experience in managing construction project, the fixed price contracts, cost incurred in applying new method during construction execution are the main difficulties for successful utilization of EVM. Consequently, the requirement for add-in using EVM in construction contract would directly bring this kind of method to organization and managers. Nowadays, in order to minimize pressures for clients, they often offer fixed contract to aim transferring cost risk to contractor hence, EVM does not regard in the regulation between contract sides (Christensen-Day, 2010).

In US, the EVM method is believed that it might not be universally accepted by sake of too many rules in the industry standard called ANSI EIA. Despite EVM's justification, it expressed that tasks in Earned Value Analysis (EVA) do not have any connection whereas practically, some task would be combined dependently. Moreover, high-cost and many reports really becomes the biggest obstacle to EVM implements as a consequence of traditional management methods as well as constructor's habits. In Vietnam, detailed reports often are neglected result from forced schedule progress from clients and owners.

Each country should have own standards for EVM implementation. However, most of countries have no standards based on their geographical, economy, cultural characteristics as a result EVM has no regulations from government and would be sensitive method in some nations. Finally, the requirement for information is greater because of the sensitive changes in EVM calculations.

According to Kim et al. (2003), the difficulties in implement EVM widely in construction management (CM) has been resulting from user, culture, system and implementation. They listed forty detailed variables derived from previous studies that are categorized by four factors group: EVM user, EVM

Methodology, Implementation process, and Project environment. Table 1 shows generally some researches in relation to the barriers in application of EVM in construction domain and proposed solutions to solve problems.

Author	Barrier	Proposed solution
Ibrahim et al. (2018), Kim et al. (2003)	Lack of understanding of EVM	Training Program, Conference
Kim et al. (2003)	High-Cost and many reports	Computerizing system, Software
Kim et al. (2003), Christensen-Day (2010)	Conflict between groups	Third party, Consultant Institution
Christensen-Day (2010)	Operational machine	Contract Operation
Christensen-Day (2010), Ibrahim et al. (2018)	Lack of Government's Concern and participants	Legislation Discussion, Particular Standards

Table I. The barriers in application of EVM in CM

VI. EVM APPLICATION IN VIETNAM

Vietnam is a developing country so proven effective PM methods should be applied and delivered from scientific researches. This section focuses on presenting the solution and creating a process for EVM application in Vietnam in general.

Solutions proposed to manage to limitations in application of EVM based on the characteristics of territory, people, economy, social needs, etc. Firstly, The Government and authorities need to discuss and provide a specific standard for EVM. Thereby, project managers can flexibly use in construction management as well as other professions. By searching the information of concept "Earned Value Management", there were few results showing the guidelines for applying EVM in Vietnamese version. This explains the lack of interest for this method in Vietnam.

Secondly, it is necessary to diversify types of contracts and choose contract management according to the quality of works instead of basing on prices offer by bidders. This opens up opportunities to apply new effective management methods like EVM. However, managers need to balance costs to apply the method and benefits to achieve the highest investment efficiency. EVM requires a huge volume of detailed reports so it is necessary to combine technology (software, GPS, UAV, etc.) to create reports that bring convenience to managers.

Thirdly, the role of EVM needs more visibility with industry practitioners and need for this skill set in the industry. Universities or education institutions should encourage the positive attitude about applying new method such EVM. In the educational environment, it is easier to train participants during workshops, conferences, researches. According to the survey, the EVM documents in Vietnam is shortage so should encourage them to expand the scope of reference or Government need invest to translated EVM books, journal to spread the knowledge about EVM.

Finally, the conflict of interest in reporting the progress of project is the big barrier for applying EVM. EVM needs a big volume of detailed and accurate reports so requires project managers collecting data and analyze them consecutively. Moreover, they tend to display the good news to the client and try to hide deviations in PM. We need to enhance professional ethics as well as, we should establish an intermediary party to control the quality of report and handling problems of contractors with clients, investors.

VII. CONCLUSION

The economy is increasingly growing so that construction management techniques need to be researched and evolved to suit the requirements of infrastructure and architectural. EVM with over 60 year's developments should be considered as an effective tool to apply in construction management. By reviewing previous articles in EVM, the authors have analyzed in depth the benefits and barriers in application of EVM. As of result, combining with the characteristics of Vietnam's people, geography, tradition, the authors proposed the solution to disseminate the efficiency as well as overcome the difficulties to implement EVM efficiently.

Some solutions proposed to solve the studied problems in previous researches that are referred from professional experts and specialists in EVM. However, this cannot cover all the aspect of EVM, consequently the quantitative researches should be considered to give more accurate remarks about the effectiveness of the solutions.

The gap between research and practice still has a significant distance. The literature reviews is a great method to bring the theoretical information to practitioners because it can convey the concise and explicit knowledge to readers. This research is initial literature review research about the application of EVM in Vietnam. Hence, farther studies about applying new method in Vietnam as well as in developing countries to solve the problems that prevent the success of construction project are expected to extend in scale and comprehensiveness.

REFERENCE

[1] E. Kim, W. G. Wells Jr. and M. R. Duffey, "A Model for Effective Implementation of Earned Value Management Methodology," International Journal of Project Management, vol. 21, pp. 375-382, 2003.

[2] L. Song, Earned Value Management: A Global and Cross- Industry Perspective on Current EVM Practice, Newtown Suqare, Pennsylvania, USA: Project Management Institute, Inc., 2010.

[3] R. A. Marshall, "Top Ten Secrets of Earned Value Management," Public CIO, 2008.

[4] C. J. Christensen-Day, "Earned Value on Fixed-Price Projects," AACE International Transactions, EVM.S2, 2010.

[5] M. Ibrahim, A.-E. Ibrahim, S. E. Ahmed and R. Lamisse, "Difficulties of Implementing Earned Value Management in Construction Sector in Egypt," International Journal of Engineering Researches and Management Studies, vol. 5, no. 2, pp. 49-63, 2018.

[6] C. K. Tan and S. Najihah, "The Application of Earned Value Management in Constrcutin Project Management," Journal of Technology Management and Business, vol. 2, no. 2, pp. 1- 11, 2015.

[7] D. M. Alberto and N. Timur and, "Earned Value-Based Performance Monitoring of Facility Construction Projects," Journal of Facilities Management, vol. 11, no. 1,pp. 69-80, 2013.

[8] L. Muhwezi and A. Joseph, "An Assessment of the Factors Causing Delays on Building Construction," International Journal of Construction Engineering and Management, vol. 3, no. 1, pp. 13-23, 2014.

[9] S. A. Assaf and S. Al-Hejji, "Causes of Delay in Large Construction Projects," International Journal of Project Management, vol. 24, pp. 349-357, 2006.

[10] H. S. Heon, "Analyzing Schedule Delay of Mega Project: Lessons Learned from Korea Train Express," IEEE Transactions on Engineering Management, vol. 56, no. 2, pp. 243-256, 2009.

The Implementation of Taguchi Approach on ECM Process Parameters for Mild Steel and Aluminum

R. Goswami*, R. Chouhan*, V.Chaturvedi**

*Lakshmi Narain College of Technology, Bhopal

**Madhav Institute of Technology & Science, Gwalior

A B S T R A C T

In this paper, the cutting of Mild Steel and Aluminum using electrochemical machining (ECM) with a electrode by using Taguchi approach has been reported. The Taguchi orthogonal array design is used to formulate the experimental layout, to analyze the effect of each parameter on the machining characteristics, and to predict the optimal choice for each ECM parameter such voltage, tool feed and current. It is found that these parameters have a significant influence on machining characteristic such as metal removal rate (MRR) and surface roughness (SR). The analysis of the Taguchi method show that, in general the current significantly affects the SR and voltage affects the MRR. Verification of taguchi approach is done by confirmation test.

Keywords: ECM, Taguchi method, Aluminum, Mild steel, metal removal rate, Surface roughness, ANOVA.

1. INTRODUCTION:

Electrochemical machining (ECM) is a method of removing metal by an electrochemical process. It is normally used for mass production and is used for working extremely hard materials or materials that are difficult to machine using conventional methods.[1] Its use is limited to electrically conductive materials. ECM can cut small or odd-shaped angles, intricate contours or cavities in hard and exotic metals, such as titanium aluminates, Inconel, Wispily, and high nickel, cobalt, and . ECM is often characterized as "reverse electroplating," in that it removes material instead of adding it. Through an electrolytic material removal process having a negatively charged electrode (cathode), a conductive fluid (electrolyte), and a conductive work piece (anode); however, in ECM there is no tool wear. The ECM cutting tool is guided along the desired path close to the work but without touching the piece. High metal removal rates are possible with ECM, with no thermal or mechanical stresses being transferred to the part, and mirror surface finishes can be achieved.

In the ECM process, a cathode (tool) is advanced into an anode (work piece). The pressurized electrolyte is injected at a set temperature to the area being cut. The feed rate is the same as the rate of "liquefaction" of the material. The gap between the tool and the work piece varies within 80-800 micrometers (.003 in. and .030 in.) As electrons cross the gap, material from the work piece is dissolved, as the tool forms the desired shape in the work piece. The electrolytic fluid carries away the metal hydroxide formed in the process.

The Implementation of Taguchi Method on ECM Process of Mild Steel and Aluminum study of these parameters has been performed by many researchers; most of the studies do not much consider both engineering philosophy (DOE) and mathematical formulation (ANOVA) particularly in machining very hard materials such as Aluminum and mild steel. Therefore, the Taguchi method, which is a powerful tool for parametric design of performance characteristics, is used to determine the optimal machining parameters for maximum material removal rate and minimum surface roughness in the ECM operations. The experimental details when using the Taguchi method are described.

2. EXPERIMENTAL PROCESS

Aluminum and mild steel alloy was the target material used in this investigation. Table 1 shows the material related properties. Experiments were performed using a Electrical Chemical Machine. Figure 1 show schematically the experimental set-up. A tool with a diameter of 9 mm was used as an electrode to erode a work piece of Aluminum and mild steel.

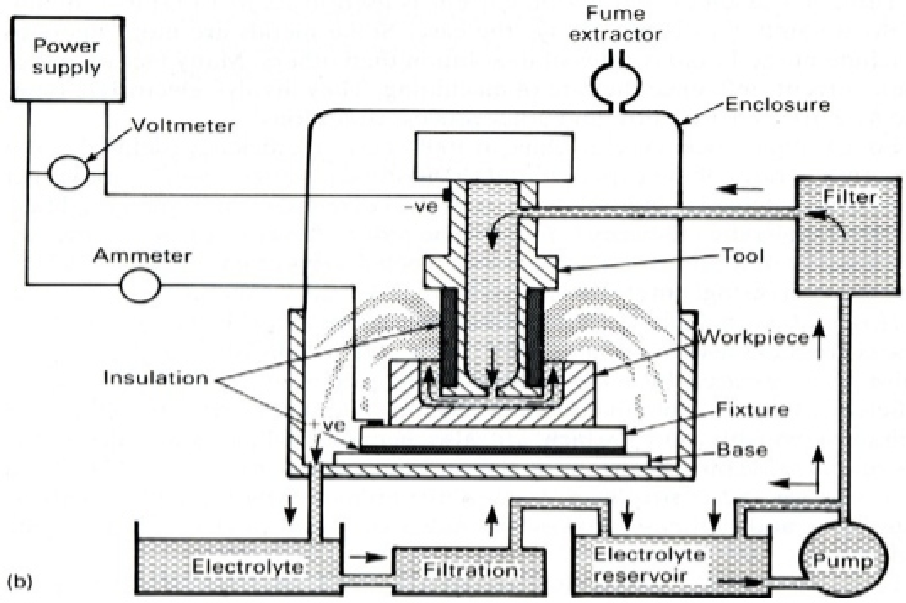


Figure 1: schematically the experimental set-up ECM

Table1 : Properties of Mild Steel

Property	Value
Young's modulus	210,000M
Density	7.85gm/cm^3
Carbon with rage	0.16%to 0.19%

Table2: Properties of Aluminum

Property	Value
Modulus of Elasticity (GPa)	68.3
Poissons Ratio	0.34
Thermal Conductivity (0-100°C) (cal/cms. °C)	0.57
Co-Efficient of Linear Expansion (0-100°C) (x10-6/°C)	23.5
Electrical Resistivity at 20°C (Ω.cm)	2.69
Density (g/cm^3)	2.6898
Melting Point (°C)	660.2
Boiling Point (°C)	2480

3. DESIGN OF EXPERIMENTS AND DATA ANALYSIS

3.1. Design of Experiments

The experimental plan for the machining parameters using the L9 orthogonal array was used in this study. This array consists of three control parameters and three levels, as shown in table 3. In the Taguchi method, most all of the observed values are calculated based on 'the higher the better' and 'the smaller the better'. Thus in this paper, the observed values of MRR and SR were set to maximum and minimum respectively. Each experimental trial was performed with three simple replications at each set value.

Next, the optimization of the observed values was determined by comparing the standard analysis and analysis of variance (ANOVA) which was based on the Taguchi method.

3.2. Selection of the machining parameters and their levels

The experimental plan has three variables, namely, tool feed, current and applied voltage. On the basis of preliminary experiments conducted by using one variable at a time approach, the feasible range for the machining parameters was defined by varying the voltage (05-15 V) , tool rate (0.10 – 0.30 mm/min) and current (0 – 100 A). In the machining parameter design, three levels of the cutting parameters

Table 3: Design scheme of experiment of Parameters and levels

	Process parameter	Level 1	Level 2	Level 3
A	Voltage(V)	5	10	15
B	Tool feed (mm/min)	0.1	0.2	0.3
C	Current(A)	20	60	100

Table 4: Experimental layout using L9 orthogonal array

Experiment No.	A Voltage(V)	B Tool feed (mm/min)	C Current(A)
1	1	1	1
2	1	2	2
3	1	3	3
4	2	2	3
5	2	3	1
6	2	1	2
7	3	3	2
8	3	1	3
9	3	2	1

3.3 Analysis of Variance (ANOVA)

Analysis of variance (ANOVA) and the F test (standard analysis) are used to analyze the experimental data as follows [2, 3, 4]:

$$CF = T^2/n \tag{1}$$

$$S_T = \sum_{i=1\,to\,27} Y_i^2 - CF \tag{2}$$

$$Sz = (Y_{z1}{}^2/N_{z1} + Y_{z2}{}^2/N_{z2} + Y_{z3}{}^2/N_{z3}) - CF \tag{3}$$

$$f_z = (\text{number of levels of parameter z}) - 1 \tag{4}$$

$$f_T = (\text{total number of results}) - 1 \tag{5}$$

$$f_e = f_T - \Sigma f_z \tag{6}$$

$$V_z = S_z/f_z \tag{7}$$

$$S_e = S_T - \Sigma S_z \tag{8}$$

$$V_e = S_e/f_e \tag{9}$$

$$F_z = V_z/V_e \tag{10}$$

$$S_z' = S_z - (V_e * f_z) \tag{11}$$

$$P_z = S_z'/ S_T * 100\% \tag{12}$$

$$P_e = (1 - \Sigma P_z) * 100\% \tag{13}$$

Where;

CF correction factor
T total of all results
n total number of experiments
ST total sum of squares to total variation
Y_i value of results of each experiment (i= 1 to 27)
S_z sum of squares due to parameter z(z= A, B and C)
N_{z1}, N_z, N_{z3} repeating number of each level(1, 2, 3) of parameter z
Y_{z1}, Y_z, Y_{z3} value of results of each level(1, 2, 3) of parameter z
f_z degree of freedom(DOF) of parameter z
f_T total degree of freedom
f_e degree of freedom(DOF) of error term
V_z variance of parameter z
S_e sum of squares of error term
V_e variance of error term
$F_{z, F}$ ratios of parameter z
S'_z pure sum of square
P_z percentage contribution of parameter z
P_e percentage contribution of error term

3.4. Data Analysis

In this paper, all the analysis based on the Taguchi method is done by Taguchi to determine the main effects of the process parameters, to perform the analysis of variance (ANOVA) and to establish the optimum parameter conditions. The main effects analysis is used to study the trend of the effects of each of the factors, as shown in figures 2. The machining performance (ANOVA-significant factor) for each experiment of the L9 can be calculated by taking the observed values of the as an example from table 5 and 8.

Table 5 : Result /observed value for Aluminum

Result /observed value for Aluminum						
No. of Trial	MRR (g/min)			SR (Ra)		
	1	2	3	1	2	3
1	1.12	1.11	1.41	2.14	2.18	2.17
2	0.99	0.97	1.2	3.12	3.16	2.16
3	0.98	0.97	0.96	2.15	2.19	2.18
4	0.91	0.89	0.91	3.18	3.16	3.19
5	0.95	0.96	0.97	2.15	2.2	2.22
6	0.91	0.89	0.88	2.56	2.5	2.2
7	0.85	0.89	0.84	3.19	3.21	3.19
8	0.9	0.89	0.88	2.16	2.21	2.25
9	0.94	0.93	0.93	2.18	2.19	2.2

Table 6: Analysis of variance (ANOVA) and F-test for MRR

Factor	DF	SS	Varience	F-ratio	s'z	%
A	2	0.181	0.090	12.857	0.177	46.286
B	2	0.005	0.003	0.428	0.001	0.262
C	2	0.070	0.035	5.000	0.066	17.272
e	18	0.126	0.007		0.121	31.675

Table 7: Analysis of variance (ANOVA) and F-test for SR

Factor	DF	SS	Varience	F-ratio	s'z	%
A	2	0.213	0.107	1.138	0.129	2.407
B	2	1.672	0.836	8.893	1.588	29.613
C	2	1.783	0.892	9.489	1.699	31.682
e	18	1.695	0.094		1.611	30.039

Table 8: Result observed valau for Mild steel

Result /observed value for Mild steel						
No. of Trial	MRR (g/min.)			SR (Ra)		
	1	2	3	1	2	3
1	0.73	0.76	0.77	3.14	3.12	3.16
2	0.67	0.66	0.65	3.28	3.3	3.32
3	0.76	0.73	0.73	3.69	3.7	3.71
4	0.97	0.88	0.89	3.63	2.99	2.36
5	0.89	0.91	0.9	2.64	2.66	2.68
6	1.02	1.09	1.11	3.69	3.71	3.73
7	0.9	0.9	0.91	3.5	3.51	3.53
8	1.03	1.04	1.02	3.69	3.7	3.72
9	0.88	0.89	0.87	2.69	2.72	2.7

Table 9: Analysis of variance (ANOVA) and F-test for MRR

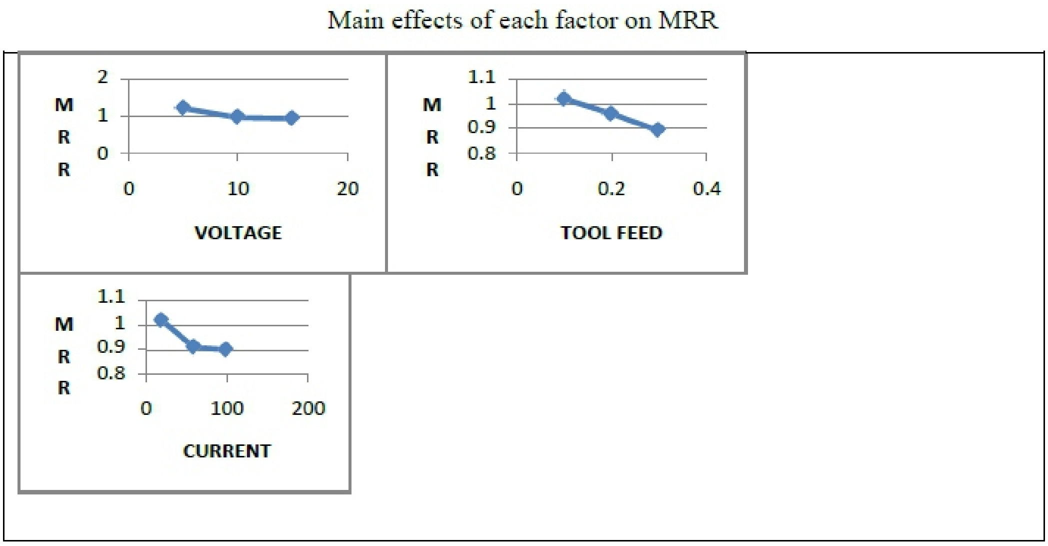
Factor	DF	SS	Varience	F-ratio	s'z	%
A	2	0.326	0.163	32.600	0.322	71.912
B	2	0.010	0.005	1.000	0.006	1.339
C	2	0.012	0.006	1.200	0.008	1.737
e	18	0.100	0.005		0.096	21.428

Table 10: Analysis of variance (ANOVA) F-test for SR

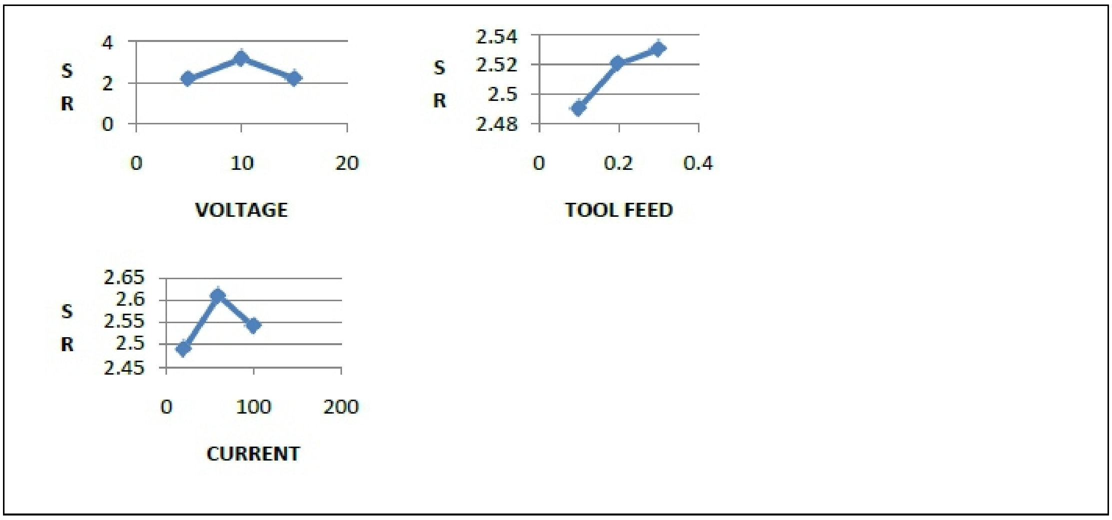
Factor	DF	SS	Varience	F-ratio	s'z	%
A	2	0.320	0.160	1.428	0.236	4.683
B	2	0.140	0.070	.625	0.056	1.112
C	2	2.560	1.280	11.428	2.476	49.034
e	18	2.03	0.112		1.946	38.534

Figure 2: Influence of process parameters performances for Aluminum and Mild Steel

For Aluminum

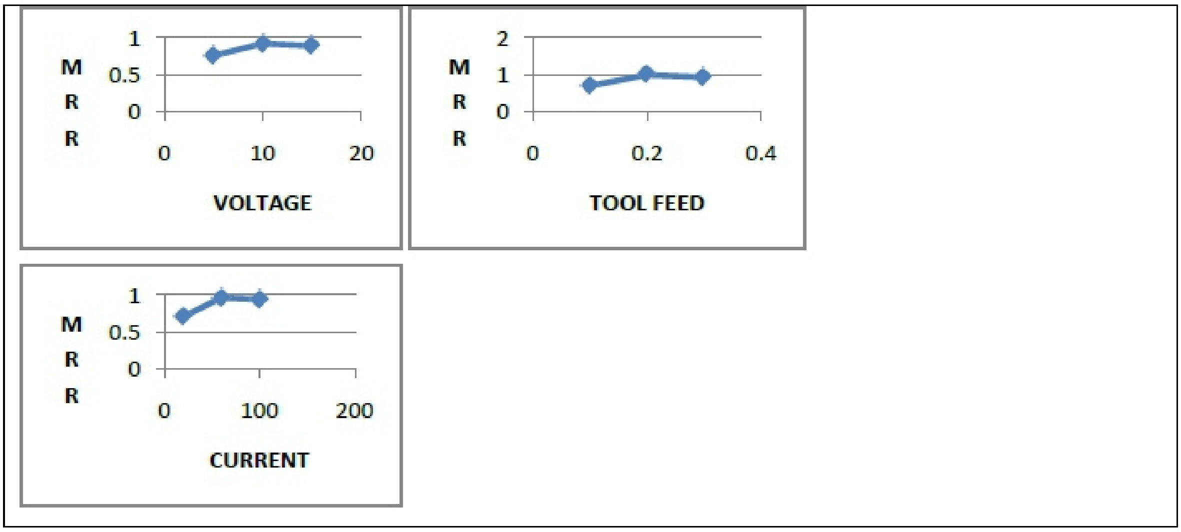


Main effects of each factor on SR

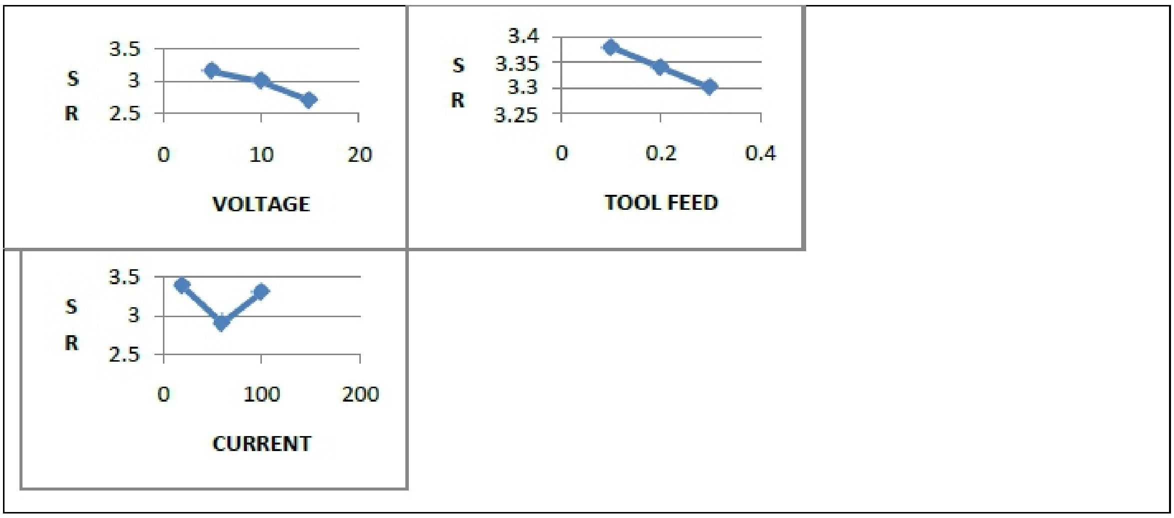


For Mild Steel

Main effects of each factor on MRR



Main effects of each factor on SR



CONCLUSION

This research paper is used to optimize the machining condition of Aluminum and Mild Steel by ECM with an electrode. Taguchi approach has been used to determine the main effects, significant factors and optimum machining condition to the performance of ECM Based on the results presented herein, we can conclude that, the voltage is the most significant parameter for MRR in both material, and the current most significant parameter for SR in both material and according to graph predicted optimal parameter setting for MRR of Aluminum is (A1,B1,C1) and SR of Aluminum is (A1,B1.C1). In case of Mild Steel predicted optimal parameter setting for MRR is (A2,B2,C2) and SR of Mild Steel is (A3,B3,C2).

CONFIRMATION TEST

According graph to predicted optimal parameter setting for MRR of Aluminum (A1,B1,C1) used have been consider the experiment found is MRR 1.08 (g/min.) and SR of Aluminum (A1,B1,C1) have been used to consider the experiment for SR and found the value 1.99(Ra).In case of parameter setting for MRR of Mild Steel (A2,B2,C2) have been consider for the experiment and found MRR is 1.02(g/min.) and SR of Mild Steel (A3,B3,C2) have been consider for the experiment for SR and found the value 2.20(Ra). These result those same implementation of Taguchi Method ECM.

REFERENCES

[1] J.A. McGeough, "Advanced Methods of Machining", Chapman and Hall, New York, 1998.

[2] Ranjit K.Roy, "A Premier On The Taguchi Method", Van Nostrand Reinhold, New York, 1996.

[3] Ranjit K.Roy, "Design of Experiments Using the Taguchi Approach", John Wiley & Sons, New York, 2001.

[4] Glen Stuart Peace, "Taguchi Methods", Addison-Wesley Publishing, inc, 1993

[5] Process. Ross PJ. Taguchi techniques for quality engineering. New York: McGraw-Hill; 1988

[6] Sorkhel S K, Bhattacharyya B, "Parametic control for optimal quality of the workpiece surface in ECM," J. Mater. Process. Technol., vol. 40, pp. 271-286, January 1994.

[7] H. Hocheng, Y.H. Sun, S.C. Lin, P.S. Kao, "A material removal analysis of electrochemical machining using flat-end cathode," J. Mater. Process. Technol., vol. 140, pp. 264-268, September 2003.

Development of a Vibration Signal Data Acquisition System for Fault Diagnosis of a Machine

Sanjay K Asati[1], Dr P. M. Bapat [2]
[1]Faculty, Mech. Engg.,MIET Gondia (M.S.)
[2]Principal, VPS College of Engb & tech Lonavala, Pune (M.S)

A B S T R A C T

In operating the machines, occurrence of vibration due to various factors affecting machine operations are very crucial to diagnose and analyse as it has adverse effect on its performance and effectiveness. In turning operations, the variation in cutting parameters and failure in any one of its machine parts or elements of driving mechanism of a lathe machine results in vibrations. This results in deteriorated machined surface and defectives being produced for not meeting the specifications. In order to prevent the losses due to this, it is imperative to keep the machine in well healthy condition by minimizing the vibration of the machine while turning on lathe. The analysis revealed that for the specified range of speed, feed and depth of cut, any change in the depth of cut causes a large change in the tool vibration while change in the cutting speed causes comparatively lowest change in tool vibration. It is long observed that the maintenance of machine is a very critical activity and is a major cost burden activity for any organization. It is therefore demanded to develop a system which assist in condition monitoring of operative members/machine so that the machine may be restore to its initial condition before any failure occur. For this an effort is made to develop a vibration signal measurement system which shall acquire the relevant data for further study and analysis. In this regard a series of such systems are studied and a simple cost effective vibration signal acquisition/measurement system suitable for use for small industries is developed and tested for its successful performance.

Keywords: Vibration Sensor, Data Acquisition system,vibration, amplitude, frequency.

1. INTRODUCTION:

In a typical machining process, in the cutting region there are several cutting variables, such as cutting forces, vibrations, acoustic emission, temperature, surface finish, etc. that are influenced by the cutting tool condition and the material removal process conditions. These variables which are prospectively effective for machining process monitoring can be measured by the use of suitable sensors. Signals detected by these sensors are subjected to analogue and digital signal conditioning and processing with the objective to generate functional signal features w.r.t. the cutting tool and cutting parameters. The acquired signals/features are then used to analyse and evaluate by appropriate decision making techniques for the ultimate diagnosis.

In turning operation checking the tool vibration is very important for the machined part. Occurrence of vibration exceeding the permissible limit may have adverse effect on the cutting tool and surface finish and the part being manufactured may not meet the desired specification limits. Vibration in machine tool and cutting tool is one of the most important factors limiting its performance. Lot of research work and investigations have been carried out across the world to help industries in sorting out the problem. Many researchers have succeeded on some fronts but limitations in data acquisition and insufficient knowledge and inappropriate technology in signal analysis could not permit them to reach a stage from where a dedicated flawless system may be developed to minimize remove the problem and industries are working with improved efficiency and effectiveness. However, it has also been found that, limiting conditions minimizes the production rate [1]. A large number of analytical and experimental study has been carried out for vibration control [2,3,4]. An effort is made in this direction through this research work to develop a vibration signal measurement system which shall not only include a sophisticated signal acquiring sensor but a supportive system that shall record and collect the data that can be retrieved for further analysis.

Vibration in a turning operation can be classified as [3] free, forced and self- excited vibration. Free vibration has short transient response than forced & self excited vibrations little practical significance. Self excited vibration is the result of a dynamic instability of the turning process. Forced vibration emerges due to periodic cutting forces acting on the cutting tool. Tool vibration analysis [2,5] has revealed that cutting parameters not only have an effect on the amplitude of vibration, but also on the variation of the natural frequency of the tool. [6] predicts surface roughness based on the cutting parameters and tool vibrations in turning operations. [7] also predicts surface roughness and dimensional deviation by measuring cutting forces and vibrations in turning process. [8], According to [9], the cutting forces depend primarily on the feed rate and the depth of cut. It is also learnt that the optimum parameters for reducing vibration are achieved by observing a judicious combination of each.It is observed that despite all efforts taken to prevent maintenance of machine through various maintenance activities it has been a tedious job for the maintenance crew to keep the machine in good operating condition. Still machines are unreliable and demand for ways to anticipate the failure likely to occur in future. It may go out of action or may run in faulty condition that can lead to a catastrophic fault with time. In faulty running condition the quality of product also suffer. Such an erroneous situation motivates to monitor the parameter of machine condition i.e. condition monitoring [10] [11]. Condition monitoring is one of the ways to address such problem. In support of condition monitoring techniques, there must be dedicated fault detection techniques available for use. The machine health can be well diagnosed based on the variation in vibration signals recorded. Hence there is a need to design and develop a system which can record those signals and store for its further use by retrieval for diagnosis and analysis.

Machine performance is based on various parameters that vary with change in machine condition and such observed variation in any of the observed parameter can be used for monitoring the condition of machine. Machine vibration is one of the parameters for monitoring purposes to directly monitor machine health condition. During operation each machine vibrates with its natural frequency and the coupled sections transmit these vibrations. The machine has its own unique vibration signature that indicates normal machine behavior. In the event of any failure/defect come to fore, the frequency components in the spectrum changes and give an exclusive vibration pattern. It means that variation in the machine vibration is the indication of emerging problem/defect in machine to call it a faulty one. Vibration monitoring methods are capable of detecting and identifying such more other faults than other fault detection methods as vibration acquisition has no effect on the operation of machine [12] [13] [14].

Vibration signal acquisition and interfacing of acquisition system with PC have been discussed in few papers. In [15] accelerometers is used to sense Vibration signals, vertically measured signal for analysis and the horizontally one for verification. Data acquisition board having inbuilt anti aliasing filter, is used for signal collection. In [16] Vibration acquisition is done by Dytran 3035AG accelerometer. The signal is amplified by the Dytran 4105C and low pass filtered. In [17] Vibration signal is amplified and converted into digital by ADC 0808. The processing is done for interfacing to PC data acquisition. In [18] ADXL330, a tri axial, MEMS type piezoelectric accelerometer is preferred because of their high frequency response. Vibration data acquired and saved in the computer using Shielded Collector Block, DAQ card and LABVIEW 8.6. In [19] simple and low cost instrument system for online structural vibration monitoring is developed using MEMS accelerometer MMA7260QT based on RS-485 network topology consisting of a master and four slave units. Master is interfaced with PC through RS-485 while Slave is a vibration sensor coupled with microcontroller based data acquisition system.

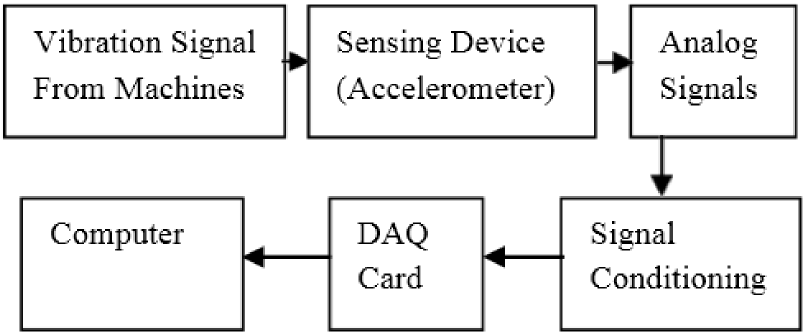


Fig. 1. Block diagram of general Data Acquisition System

The past researches who worked on machine vibration used technically old accelerometers interfacing with pc through USB port as shown in fig. 1. The shortcomings of these vibration acquisition systems are costly; bulky, complicated and its interfacing method. With this paper an attempt is made to develop an economical and useful vibration data acquisition system for small machines using latest, low cost, small size, capacitive micro machined accelerometer MMA7260QT of new technology like MEMS (Micromachined Electromechanical system) and interfacing with PC through line in port of sound card. This sensor features signal conditioning, a 1-pole low pass filter, temperature compensation and g-select to select among 4 sensitivities. The salient feature surface mount Micromachined capacitive accelerometer is its small size, compactness, sensitive, lightweight, and relatively cheap, on board signal conditioning [20].

In this system preconditioned analog output signal is amplified, conditioned, and filtered by circuit components mounted inside the same IC package. Thus the need for signal conditioning is eliminated [21]. Sensor with 5v circuit is mounted on PCB board. The acquisition system is interfaced with computer through line in port of sound card. The block diagram of presently used data acquisition system is shown in figure 2. The experimental set up is established on a centre lathe for turning operation with the specifications: Motor 1 Hp, 1400 rpm, 4 feet, 4-speed cone pulley headstock with backgears.

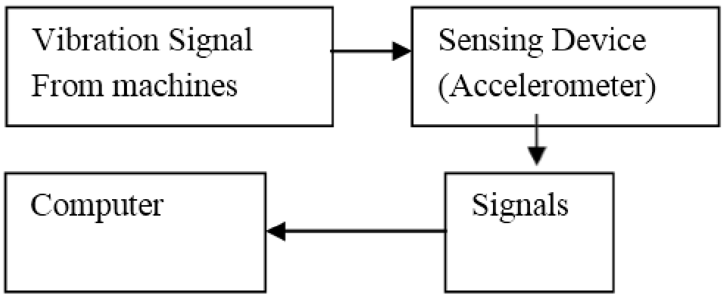


Fig 2. Block diagram of Newer Data acquisition system

2. Introduction to lathe machine and its vibration signals:

The purpose of lathe machine is to remove extra material from the cylindrical surface penetrating a single point cutting tool against the workpiece material at given cutting parameters. In this, material is normally held in the chuck and power is transmitted from motor through cone- pulley headstock via spindle. A cutting tool is mounted on the tool post and the depth of cut is adjusted with the movement of cross slide. The feed is given using the carriage mounted on feed red or lead screw. The size of machine varies from 4 feet to 10 feet. The head stock accommodates the cone-pulley drives with backgears for obtaining number of speeds. Normally the machine capacity is rated with the motor being used and it ranges from 1 Hp, 1440 rpm onwards as per the requirement. The expected frequencies of induction motor will be 1440/60 = 24 Hz and integer or fractional multiple of it and frequency of gear box also depends on (gear shaft rpm × no of teeth of gear) and its harmonics. Typically frequency range of machines is 10 Hz to 10 KHz [12] [14].

3. DEVELOPMENT OF A SIGNAL ACQUISITION SYSTEM:

3.1. Selection of sensor, mounting and interfacing method: The selection of an appropriate vibration sensing device depends on specification of the machine under monitoring in terms of its motor power, rpm, driving mechanism, output capacity desired accuracy and precision of the data to be collected. Normally available devices with high frequency sensors have low sensitivity and vice- versa. Thus selecting a suitable device is based on making judicious selection between sensitivity and frequency range to suit the requirement. The ranges of sensors available are Piezo-resistive, piezo-electric and MEMS type. Piezo-electric sensors are the widely used accelerometers offering a very wide frequency range (upto 20 kHz or so) with range of sensitivities, weights, sizes and shapes. These accelerometers are available with a charge or voltage output. These sensors can be expensive and require additional signal conditioning circuits. Piezo-resistive accelerometers generally have low sensitivity making them desirable for shock measurements [22] [23] [24].

The latest in sensors available are MEMS, (technology based on very small mechanical devices driven by electricity). With surface Micromachined Capacitive approach prices of sensor have gone down dramatically and cost/Performance ratio is also improving. The salient feature of surface mount Micromachined capacitive accelerometer is its low cost and on board signal conditioning.

In the present signal acquisition work accelerometer MMA7260QT is used as vibration sensor with its 5V regulated power supply circuit mounted on PCB board. There are a number of ways to mount an accelerometer to the target. Mounting of sensor on machine for signal acquisition plays an important role in the overall performance therefore the best sensing location must be identified and a suitable place for sensor positioning is decided. The sensor must be mounted using fasteners to achieve better signal transmissibility. Adhesive mounting may be recommended especially on small surfaces and PCB boards [25] [26]. For PCB mounted accelerometer MMA7260QT adhesive mounting being is most suitable is used for the purpose. In the present data acquisition system line in port of sound card is used for interfacing the sensor with computer. The analog to digital conversion or vice versa takes place in the sound card itself.

3.2. Hardware: A 5v regulated power supply circuit is designed using 9v transformer, 1N4007 diode, 2.2mF, 100uF and 220uF capacitors and IC-7805 is given to the sensor circuit. The sensor circuit is integrated signal conditioning with low pass filter and high sensitivity 800mV/g at maximum acceleration1.5g avoiding the need of further pre-amplification and filtering. The output of sensor circuit is in the range of input of line in port of sound card. The developed signal acquisition system is shown in fig. 3.

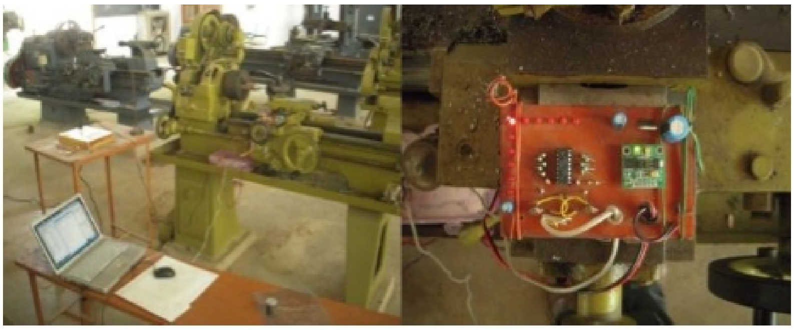


Fig 3. Developed acquisition system

3.3 Software: The vibration data signals are acquired using Matlab Simulink block and stored in the computer. Simulink is a multi domain simulation and Model-Based Design which provides an interactive graphical environment and a customisable set of block libraries to allow design, simulate, implement, and test a variety of time-varying systems, including communications, controls, signal processing. The details of used blocks are given below. 5V Regulated Supply configures an analog data acquisition device. The opening, initialization, and configuration of the device occur once at the start of the execution. During the model's run time, the block acquires data either synchronously or asynchronously. In synchronous acquisition mode the acquisition occur at each time step. The simulation will not continue until all data is acquired. In asynchronous mode the acquisition initiates when simulation starts. The block has no input ports. It has one or more output ports. In the used system data is acquired asynchronously. The scope block lies in sink library and display signals generated during simulation with respect to simulation time. The Scope block have multiple axes and all axes have a common time. For the continuous signal, the Scope generates point-to-point plot. In discrete signals, the plot is stair step. The Scope provides toolbar buttons to allow modification of signal to meet the requirement.

The To Wave File block streams audio data to a Microsoft Wave (.wav) file in the uncompressed pulse code modulation (PCM) format. For compatibility reasons, the sample rate of the discrete-time input signal should typically be one of the standard Windows audio device rates (i.e. 8000, 11025, 22050, or 44100 Hz), although the block supports arbitrary rates. While acquiring the signal using the sensor the audio device rate used is 8000 Hz.

4. Experimental results of developed acquisition system:

The signal data acquisition started with the set up of a lathe machine (turning operation) for the ideal running condition for one of the known cutting parameter and known specified condition .The machine is verified for its performance for the given condition and the signal data are acquired to ascertain that the data acquisition system is working in tune with the machine. For the known operating condition the signal are collected and the developed system indicated the waveform. To meet the objective of vibration data collection the cutting and machine condition are classified in terms of Normal/Healthy and Abnormal/Faulty condition.

The numbers of setup are run to test the data acquisition system on real time basis. The data acquisition began with the conditions for Normal being verified by the machine operator as well that the machine is running in healthy condition and there is no unfamiliar symptoms observed as part of the condition monitoring system. The monitor of computer indicated the relevant waveform to indicate the amplitude against time scale. The acquired waveform and its spectrum is indicated in fig 4 and fig 5.

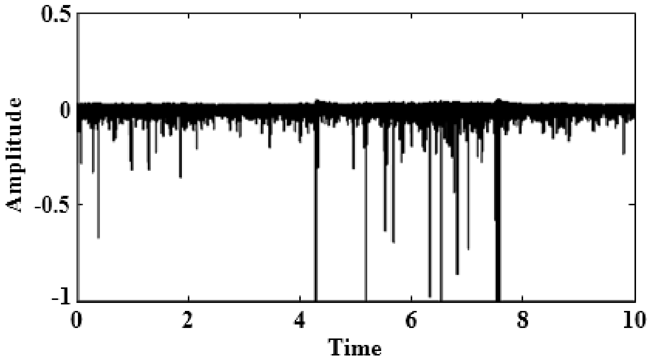


Fig 4. Vibration signal in normal condition

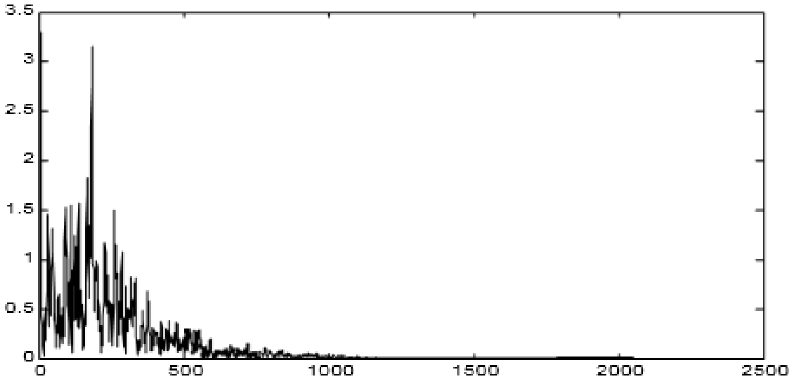


Fig 5. Spectrum of Normal Signal

To further analyse test data for Abnormal/Faulty condition one of the factors under consideration is varied to introduce Abnormal/Faulty behavior in the machine. The machine behavior is different than normal and the operator confirmed this as faulty condition. Signals are collected and the waveform and its spectrum obtain are as shown in fig 6 and Fig 7.

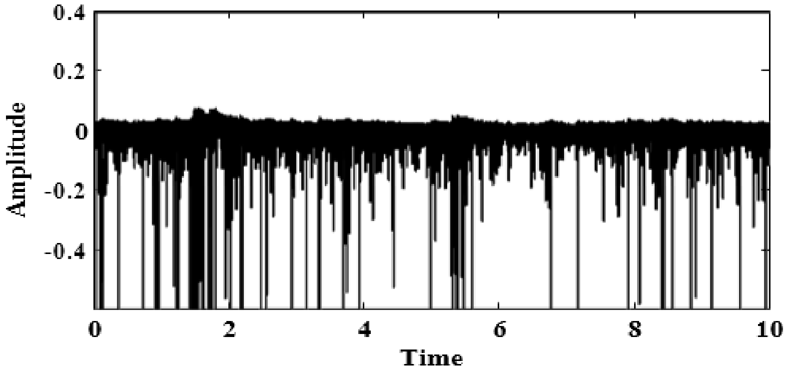


Fig 6. Vibration signal in normal condition

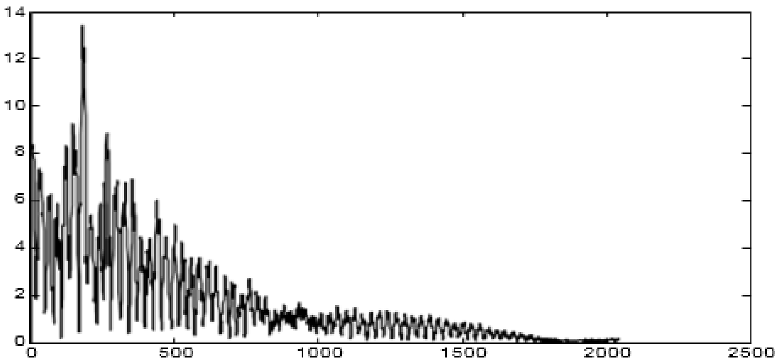


Fig 7. Spectrum of Abnormal Signal

Many signals from machine are acquired in normal condition and this is confirmed with the help of working machine operator. One normal signal and its spectrum are shown in fig 4 and fig 5. An abnormal condition is created by losing the four base screws of foot of motor connected to the hard base. Then abnormal signals are acquired from motor at the same place. The abnormal signal and its spectrum are shown in fig 6 and fig 7.

The comparison of the signals being displayed in the waveforms and spectrums are sufficient to draw some conclusion. In faulty state, high amplitude and frequency components are present and hence spectrum ranges are high to state that as the machine starts behaving Abnormally there are rise in the amplitude and frequencies. On this basis it can be broadly concluded that the machine behavior in terms of Normal and Abnormal condition can be conveniently detected by comparing the real time vibration signals using the developed data acquisition system.

5. CONCLUSION

The vibration\data acquisition system is developed to acquire the vibration signal. On data collection and comparing the results with the actual condition of machine in real time ensures that the developed data acquisition system is functionally correct and giving satisfactory results. The developed system has indicated better characteristics in signal acquisition which prompted it to use for many other data collection processes for many other machine parameters and cutting conditions.

The faulty condition is detected by analyzing vibration signals. Generally the amplitude of vibration and the range of frequency in spectrum are the indicator of the machine condition and this data acquisition system succeeded in classifying the data correctly. In the present data acquisition and testing procedure it is observed that the amplitude and the frequency had increased in the faulty conditions. The developed data acquisition system is very useful for small and medium sized machines because it can acquire the vibrations of moderate frequency range. For early prediction of faults the very high frequency vibration should be acquired.

REFERENCES:

[1] On-line control of machine tool vibration during turning operation,S.K. Choudhurya, M.S. Sharathb, Mechanical Engineering Department, I.I.T. Kanpur,

[2] Effect of tool vibrations on surface roughness during lathe dry turning process, Thomas M., Beauchamp Y., Youssef A.Y., Masounave J. Professor, Mechanical Engineering Department École de technologie supérieure Montréal, Canada.

[3] Design of dynamic vibration absorber against vibrations in turning operations, E.C. Leea, C.Y. Nianb, Y.S. Tarnga,, Department of Mechanical Engineering, National Taiwan University of Science & Technology, Taipei, Taiwan.

[4] On-Line Control of Machine Tool Vibration in Turning, S.K. Choudhury, N.N. Goudimenko and V.A. Kudinov,

[5] Tool vibration and its influence on surface roughness in turning, M. S. Selvam, Department of Mechanical Engineering, College of Engineering, Guindy, Madras

[6] Surface roughness prediction based on cutting parameters and tool vibrations in turning operations, O.B. Abouelatta, J. Mádl,, Mechanical Technology Department, Praha,
Czech Republic

[7] Prediction of surface roughness and dimensional deviation by measuring cutting forces and vibrations in turning process, K.A. Risbood, U.S. Dixit, A.D. Sahasrabudhe, Dept of Mechanical Engineering, Indian Institute of Technology, Guwahati

[8] Design optimization of cutting parameters for turning operations based on the Taguchi method, W.H. Yang, Y.S. Tarng, Department of Mechanical Engineering, National Taiwan University of Science and Technology, Taipei , Taiwan,

[9] *Statistical investigation of modal parameters of cutting tools in dry turning, M. Thomas, Y. Beauchamp, Department of Mechanical Engineering, E´ cole de technologie supe´rieure, Notre Dame West, Montreal, Canada.*
[10] *"Extrasensory inspection", C.Sell,, Engineer, Vol.293, Issue25, 23 July 2004, pp. 31-34.*
[11] *M. Laszkiewicz,"Using maintenance as a strategic business asset", Plant Engineering, Vol. 58, Issue 10, 2004, pp 31-35.*
[12] *Design of Vibration Signal Acquisition System for Condition Monitoring of Plastic Extrusion Machine", S Rastogi, A Mitra, IJERT, Vol. 1 Issue 6, August- 2012*
[13] *"P.J. Tavner, "Review of condition monitoring of rotating electrical machines", IET Electrical Power Applications, Vol. 2, No. 4, 2008, pp. 215*
[14] *V. Alexej, and Barkov, "The Capabilities of the new generation of the monitoring and diagnostic systems", Metallurg, No.11, 1998.*
[15] *A. R. Fairclough, and A. Wienese, "Practical experiences of VibrationCondition Monitoring", Proceedings of The SAST Association, June 1988.*
[16] *Jie Liu, "An Intelligent System for Bearing Condition Monitoring", a thesis presented to the University of Waterloo, for the degree of Doctor of Philosophy in Mechanical Engineering, Waterloo, Ontario, Canada,2008*
[17] *Shahab Hasan Ghafari, "A Fault Diagnosis System for Rotary Machinery Supported by Rolling Element Bearings", A thesis presented to the University of Waterloo, for the degree of Doctor of Philosophy in Mechanical Engineering, Waterloo, Ontario, Canada, 2007*
[18] *Dilip Das, S. Sheetal, "Data Acquisition Using AT89c51 and PCL-207" A project submitted at, NIT, Rourkela*
[19] *Himanshu Jain, "Detection and severity classification of rotor imbalance faults in induction machines", A thesis submitted to the University of Texas at Arlington for the Degree of M.S. in electrical engineering, August 2010.*
[20] *D. R. Santoso, "A Simple Instrumentation System for Large Structure Vibration Monitoring", TELKOMNIKA, Indonesian Journal of Elect. Engineering.*
[21] *R. Joel, L. William, Cleghorn, & K. M. James, "Design and analysis of a low frequency MEMS vibration sensor for automotive fault detection", International Journal of Vehicle Design, 54(2), 2010, pp. 93-110*
[22] *Freescale Semiconductor, MMA7260Q XYZ 3-Axis Low g Acceleration Sensor, available on http://www.fre escale.com/files/senso rs/doc/factsheet_MMA 7260QFS.pdf.*
[23] *Bob Judd, "Using Accelerometers in a Data Acquisition System" UEI App Notes, United Electronics Industries, Inc.*
[24] *Patrick L. Walter, "How High in Frequency Are Accelerometer Measurements Meaningful?" PCB Piezotronics, Inc. and Texas Christian University.*
[25] *Petr Kadaník, PC-Based Data Acquisition Systems", Gerstner Laboratory for Intelligent Decision Making and Control Czech Technical University in Prague.*
[26] *Kaveh Mollazade, Hojat Ahmadi, Mahmud Omid, Reza Alimardani, "An Intelligent Combined Method Based on Power Spectral Density, Decision Trees and Fuzzy Logic for Hydraulic Pumps Fault Diagnosis", International Journal of Electrical and Computer Engineering, vol. 3, Aug. 2008*
[27] *Asan Gani and Mje Salami, "Vibration Faults Simulation System: A Lab Equipment to aid Teaching of Mechatronics Courses", International J. Engg Ed. Vol. 20, No. 1, 2004, pp. 61-69.*

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