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Prediction of Distribution Transformer Premature Failures

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Abstract**: *This paper deals with two types of Distribution Transformer failure analysis tests which can help in monitoring the Distribution Transformers condition. The three methods are Conventional oil test, Furan derivatives test. Conventional oil testing procedures determine the gas concentrations in the Distribution Transformers oil sample and analysing the defect by considering the ratio of two suitable gasses. Furan derivative analysis includes determination of Furan derivatives present in the Distribution Transformers oil sample and helps in deciding the Distribution Transformers insulation condition. A computer program was developed for which that can help in finding out the fault probability of the Distribution Transformer. Here, we demonstrate the application of these three methods on a 132/33kV, 15MVA Distribution Transformer from CSEB substation, Korba Bilaspur, India, under three different conditions namely healthy, moderately deteriorated and extensively deteriorated conditions and results obtained.***
Keyword: Furan derivatives, Harmonics, Transformers insulation, Moderately deteriorated, Extensively deteriorated.

I. INTRODUCTION

Distribution Transformers are crucial in deciding the power flow in large power systems. Their better Performance implies high power system efficiency and enhanced power transfer capability. However, various Distribution Transformer failures in the recent past lead to power supply disturbance and have acquired much attention from the electrical intellectuals. Different preventive, predictive and spontaneous repair techniques have been designed to eliminate or at least minimize the failures. Utilities deliver power to their customer through a network of generation, transmission lines, substation, and distribution system. A distribution system carries power from substation transformer through feeder circuit to distribution transformer located near the customer. Distribution spending is one of the largest costs for most power system utilities also cause of concerns as power distribution network increases day by day along with the increasing power demand. Utilities are constantly looking forward to increasing productivity in the distribution system. So to improve the Productivity of the distribution system and managing financial assets properly we have decided to work on the Distribution Transformer Future Failure Prediction using statistical data obtain from the CSEB. In this paper, we try to illustrate three methods of testing the given Distribution Transformer`s performance. Where in the Distribution Transformer oil is tested for its gas composition and the ratio of appropriate dissolved gasses is considered and thus the Distribution Transformer condition can be analysed. Furan derivatives test, which uses software application once the oil is eligible for Furan test. The software gives the corresponding reading about the present health of Distribution Transformer and thus the performance can be known, the output of which gives failure probability of the given Distribution Transformer.

A. Cause Of Failures

There can be variety of reasons for failure of Distribution Transformers some of the important ones are listed below:-

TABLE I CAUSE OF FAILURES

Descr	**Failure Rate**
Electrical disturbances, Overloading	29.43%
Lightings Strike	17.32%
Loose Electrical Connections, High Resistance	7.3%
Maintenance Issues, Oil Contamination	5.91%
Moisture Ingress	4.03%
Line Surge, Other Issues	3.25%

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II. METHODOLOGY

While there is no specific sequence specified in the standards for perform the tests of Distribution Transformers, but the following sequence is considered healthy for the Distribution Transformers tests. Measurement of voltage ratio and check of Voltage vector relationship. Measurement of winding resistance. Applied high voltage tests and induced over-potential tests. Measurement of no-load loss, Magnetizing currents, Analysing of impedance voltage, Short circuit impedance and Load loss. Measurement of insulation resistance (also called the Mugger test).

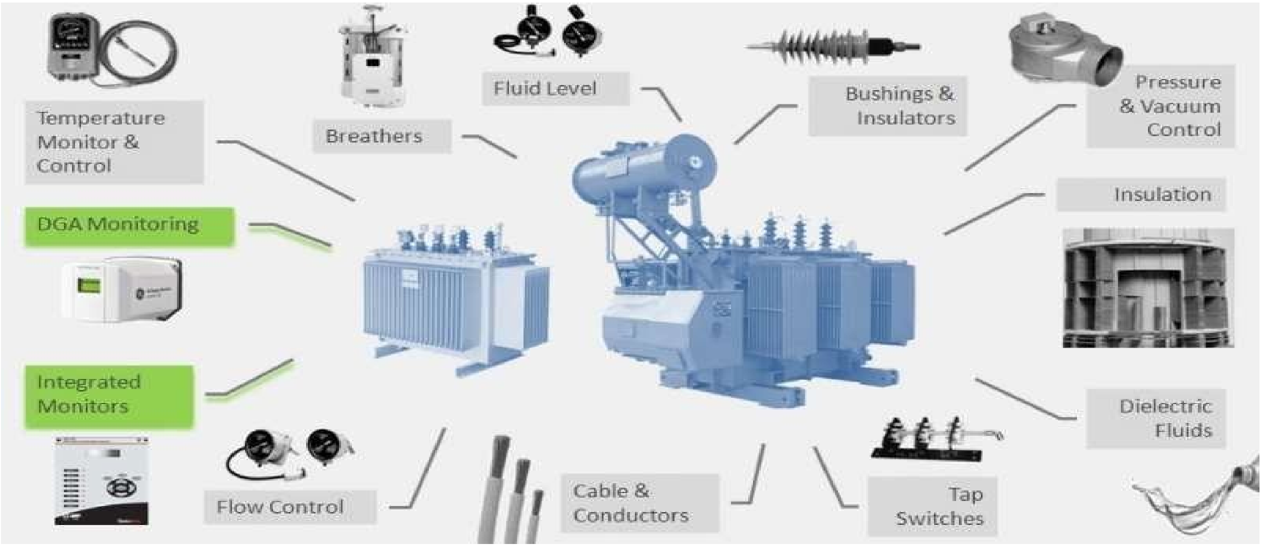

Fig. 1 Distribution Transformer tests sections

A. *Conventional Oil Testing Process*

This is the most commonly undertaken method of testing Distribution Transformer efficiency. Oil sample are taken from the Distribution Transformer and subjected to various tests and the results are analysed before declaring the equipment fit or unfit.

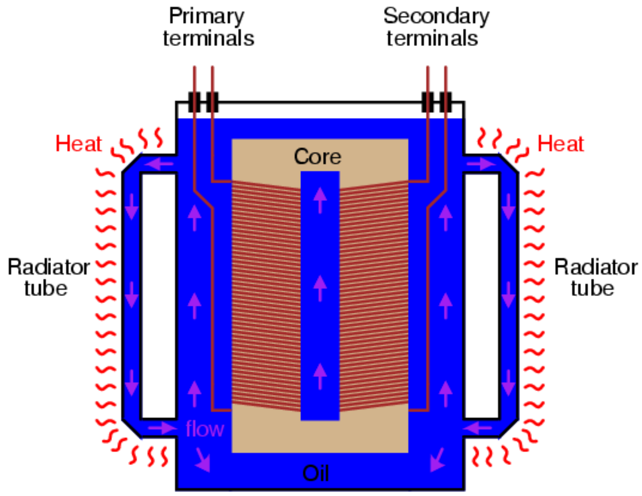

Fig. 2 Oil (Dielectric Fluids) behaviour inside Distribution Transformer

1) *Colour and Visual:* This test checks the turbidity, cloudiness, suspended particles, and colour. New oil is bright and clear without visual contaminants and pale yellow in colour. Hence, while testing the oil, the colour and brightness should be checked, indicating that turbidity, cloudiness and suspended particles are within limits.
2) *Moisture Content:* The fresh oil sample should not exceed moisture content more than 40ppm. This is a very necessary to test the moisture affects the dielectric properties of the oil. Therefore, when testing the Distribution Transformer oil for moisture content, the test reading should not exceed 40ppm. A moisture content of more than 40ppm recommends that the

oil has to be immediately changed.

3) *Dielectric Strength (Breakdown Voltage):* An oil sample is placed between two electrodes with a 2.5mm gap. A continuously increasing voltage is attached until the oil discharges at a certain kV. Sample of used oil, on an average, should not break down before 40kV. If the oil sample breakdowns below 40kV, then the Distribution Transformer oil needs to be replaced.
4) *Neutralization (acid) number I:* This test measures the neutralization number. When oil oxidizes in a Distribution Transformer, acids and sledges are produced along with water. A severe increase in neutralization number can be detrimental to the insulation system. The neutralization number of any used oil is 0.3 or less. Hence, if the oil sample neutralization number is more than 0.3, it indicates that Distribution Transformer oil has to be changed.
5) *Neutralization (acid) number II:* It is very sensitive in analysing oil-soluble polar contaminants such as acids and sledges formed from the oxidation of Distribution Transformer oil. The more contaminants in the oil, the lower are the interfacial tension. Used oil specification is 0.04N/m (minimum). Hence, the tested oil sample shall have an interfacial tension value of 0.04N/m or more, otherwise, the oil needs replacement.
6) *Power Factor:* This test measures the leakage current that passes through oil. This is a very sensitive indicator as far as deterioration is concerned, it has become one of the important tests in the industry. The greater the power factor, the more polar the contamination is in the oil. However, it can be easily measure from the dissipation factor evaluation.
7) *Dielectric dissipation factor (tan delta) test:* This test is also known as the loss tangent or dielectric dissipation factor measurement. Tan delta may be defined as the measurement of the cosine of the phase angle or the sin of the loss angle. It is basically the measurement of the leakage current through the oil, which in turn is a measure of the contamination or deterioration of the oil. The oil is non-polar and most other contaminants are polar, enabling a dipole action, which this test depends upon. A normal degree of refining will result in a low value for the power factor. The presence of contaminant such as other oil can easily be detected with this parameter. An oil sample should not have tan delta value more than 1.0. Therefore, if the value is above 1.0, the oil has to be changed.
8) *Dissolved GAS Analysis:* The oil sample is composed of various gasses which are significant in deciding the Distribution Transformer behaviour and life. These gasses are to be isolated from the sample and analysed quantitatively using gas chromatography process. This technique enables proper diagnosis of the Distribution Transformer condition in service and can also suggest preventive measures. The quantities of gasses generated from the Distribution Transformer oil and their types help in identifying the various fault conditions. The main gasses that are collected include:

a) Hydrogen
b) Methane
c) Ethane
d) Acetylene
e) Ethylene

Now, the relative quantities of all these gasses give the oil decomposition energy during a particular fault. Each fault has its own characteristic amount of energy. Elevated concentrations of gasses may signal corona, discharge, overheating and arcing or cellulose insulation pyrolysis. A comfortable way to the fault diagnosis is the calculation of the ratio of suitable gasses. Like, in one scheme, ratios used are acetylene/ethylene, methane/hydrogen, and ethylene/ethane. In the process, the ratio of any two significant gasses is taken into account and is analysed. Ratio denoting abnormal condition as per the reference standard implies the power Distribution Transformer is to be taken off from service and given for rectification.

B. Furan Derivatives Test

This is another method undertaken to prevent Distribution Transformer failures. A number of Furan derivatives denote the degree of degradation of the cellulose paper used in the insulation. However, other procedures for determining the healthiness of the Distribution Transformer based on the cellulose paper used in the Distribution Transformer insulation are very difficult, time -consuming and tedious. Here comes the need of Furan derivatives test wherein a number of furans in the oil can be computed using High-Performance Liquid.

Chromatography (HPLC) apparatus and thus the aging of paper insulation can be analysed Furan(C_4H_4O) is obtained from the compound Furfural, which is also called Furan-2-carboxaldehyde, Furfural, Furfuraldehyde, 2-Furaldehyde, Pyromucic aldehyde, with chemical formula OC_4H_3CHO. The furans are reported in ppm (parts per million).

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The results can be used to calculate the average degree of polymerization (DP) thereby measures the percentage of residual life of the insulation. As the paper ages, the polymer chains break down slowly, and the mechanical strength of the paper reduces. The degree of polymerization (DP) decreases by the age of Distribution Transformer, till it reaches 200 units, the insulation paper gets so weak that any further stress will disrupt the paper and lead to failure. Electrical insulating oil analysis can play a vital role in preventing unscheduled outages in electrical transmission and distribution equipment by determining the condition of the equipment itself and other factors like paper insulation.

1) Loss of Furan values: Restoration (regeneration or purification) or replacement of Distribution Transformer oil destroys furan compounds, which are used to measure the degree of polymerization (insulation condition and lifetime). Furan analysis should be done before the process. If Distribution Transformer oil is allowed to degrade beyond salvaging without regeneration or purification, Distribution Transformer lifetime decreases significantly. After purification, a new baseline for furan compounds control is established. Future furan test must be referenced against this new baseline.

TABLE II REFERENCE STANDARDS FOR FURAN DERIVATIVE TEST

Furaldehyde content (ppm)	DP value	Significance
<0.1	700-1200	Healthy
0.1-1	450-700	Moderate deterioration
1-10	250-450	Extensive deterioration
>10	<250	End of life

III.RESULT AND ANALYSIS

In order to predict the probability of failure of a transformer, we need to be able to model common problems with transformers. Our initial focus was on transformer insulation paper degradation. A first order model of paper degradation in transformers in presented in works by Emsley and Lundgard . This model served as the basis for our analysis.

$$\frac{dDP(t)}{dt} = -k(t)[DP(t)]^2,$$

$$DP(t) = \frac{DP(t_0)}{1 + DP(t_0)\int_{t_0}^{t} k(\tau)\, d\tau},$$

$$k(t) = A\exp\left(-\frac{E_a}{R_g\, T(t)}\right),$$

A. Set the parameters for the transformer

1) SHAPE PARAMETER : sp0 = -3, sig0 = 0.05, mu0 = 0
2) Original DP value (Degree of Polymerization): DP0 = 1000;
3) Threshold DP value below where transformer ceases to function : DPc = 250;
4) The activation energy: Ea = 111*10^3; J/mol
5) Process Constant : A = 2*10^+8; %h-1
6) Gas Constant: Rg = 8.314;
7) Temperature (As a function of time. Assumed constant): T = 370; %K, 98 deg C
8) Reaction rate: k = A*exp(-Ea/(Rg*T)), h-1, k = 24*k, d-1

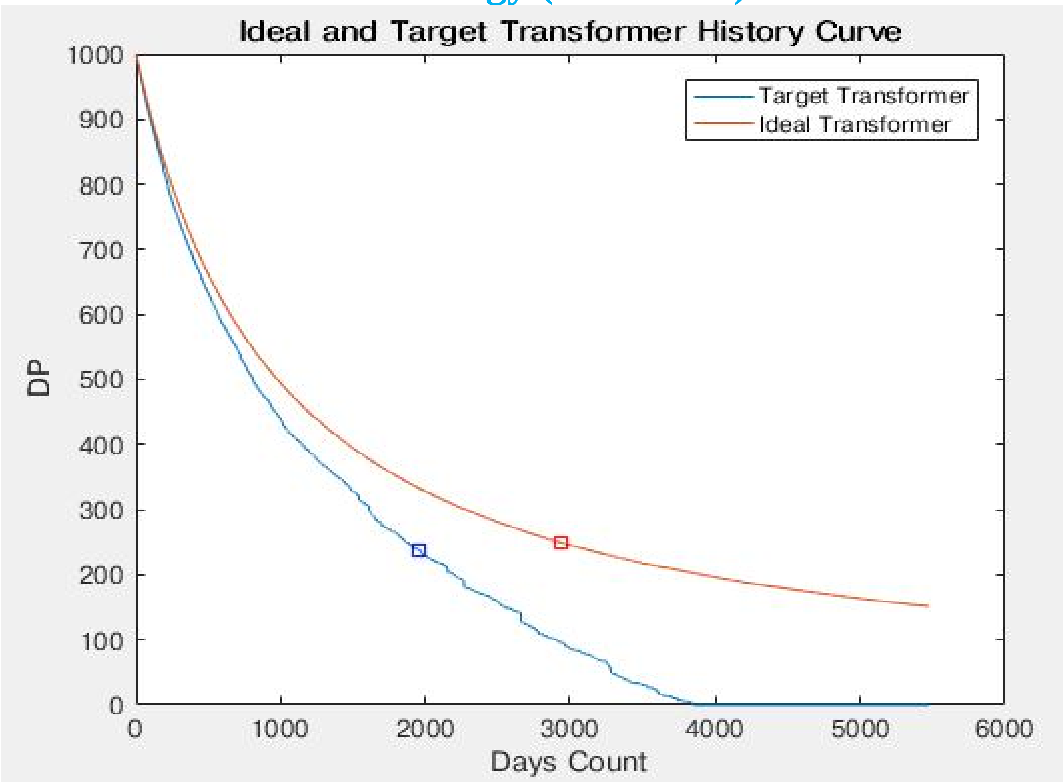

Fig. 3 The prediction of sampled transformer with furan and DGA test

Ideal transformer would last for 2931 days or 8.030137e+00 years
Non-ideal transformer would last for 1974 days or 5.408219e+00 years

IV. CONCLUSIONS

This paper discusses, in short, some of the important reasons for the Distribution Transformer failure along with methodology to classify Distribution Transformer failures depending on various factors. Based on the data it can be said that many times Distribution Transformers interfacing distribution network experience number of faults for longer duration further resulting into the failure of Distribution Transformer. This paper also discussed some of the preventive methods in brief to minimize the rate of Distribution Transformer failure. Entire practical basis required to carry out performance tests on Distribution Transformers in -service (along a Street or Road) for electricity consumers; however, proper inspection/testing of transformers whether power or distribution should be undertaken on routine maintenance or preventive maintenance to avert the causes of transformer failure due to

A. Poor earthing system
B. Absent of lightening Arresters.
C. Overloading of a transformer.
D. Lightning Surges.
E. Line Surges/External Short Circuit.
F. Thief on apparatus
G. Consumers wrong connection
H. Poor Workmanship-Manufacturer
I. Deterioration of Insulation
J. Moisture.
K. Inadequate Maintenance
L. Sabotage, Malicious Mischief.
M. Loose Connection

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V. ACKNOWLEDGMENT

She authors acknowledge that this study will help to test all the Distribution Transformer located in Korba(C.G.) and the data are collected from CSEB of Korba (C.G.) can be used in SCADA control program. Computer application to estimate the transformer end-of-life.

REFERENCES

[1] Wenyuan, "Evaluating Mean Life of Power System Equipment with Limited End-of-Life Failure Data," Power Systems, IEEE Transactions on, vol. 19, pp.236-242, 2004.

[2] E. M. Gulachenski and P. M. Besuner, "Transformer Failure Prediction Using Bayesian Analysis," Power Systems, IEEE Transactions on, vol. 5, pp. 13551363,1990.

[3] Mirzai, A. Gholami, and F. Aminifar, "Failures Analysis and Reliability Calculation for Power Transformers," Journal of Electrical Systems, vol. 1-12, 2006.

[4] "Weibull Analysis," in MathPages. vol. 2010, http://www.mathpages.com/home/kmath122/kmath122.htm.

[5] G. F. Chris Kurts, Mark Vainberg, Mike Lebow, and B. Ward, "Managing Aged Transformers, Utility develops repair/refurbish/replace strategy using innovative risk-based methodologies," in Transmission & Distribution World www.tdworld.com/July 2005, 2005, pp. 36-42.

[6] Richard E. Barlow and F. Proschan, Mathematical Theory of Reliability. New York: John Wiley & Sons, 1965.

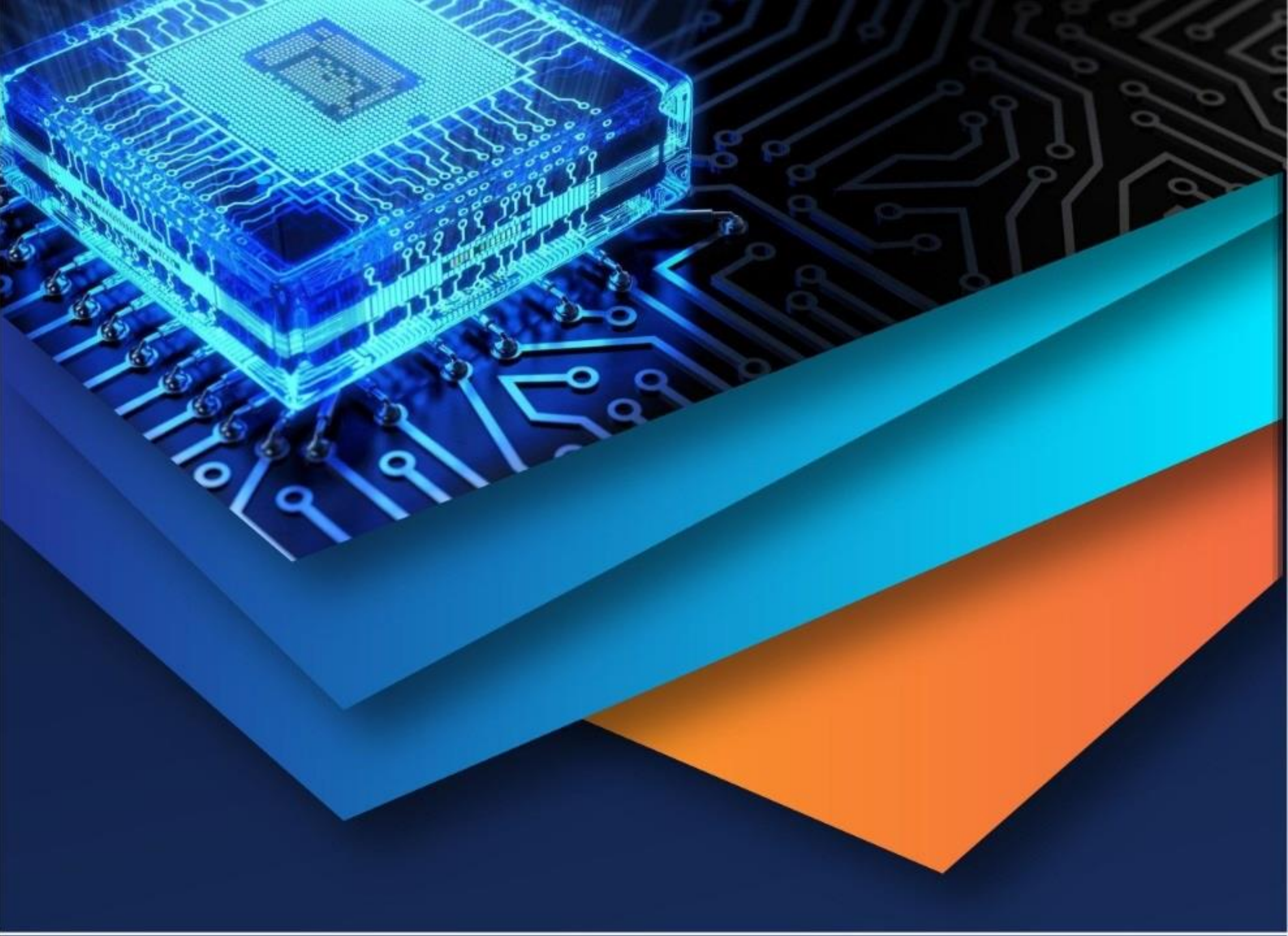
[7] K. A. Lindsay, "Probability with Applications, http://www.maths.gla.ac.uk/~kal/PROB.pdf.

[8] "Least Square Fitting," in Probability and Statistics. vol. 2010: WolframMathWorld, 2010, http://mathworld.wolfram.com/LeastSquaresFitting.html.

[9] NIST/SEMATECH, "e-Handbook of Statistical Methods,"http://www.itl.nist.gov/div898/handbook/, 2010.

[10] "Least-Square Estimator and Linear Regression." vol. 2010, pp.http://www.docin.com/p-4798008.html.

[11] D. Feng, "National Grid Power Transformer Analysis on End-of-Life Modelling," The University of Manchester, PhD First Year Transfer Report 2010.



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