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Contents

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Dynamic Investigations of Grid Connected Fixed Speed Wind Turbine During Grid Faults

Ferchichi Noureddine, Ben Aribia Houssem, Abid Slim

ABSTRACT

Especially during grid faults, grid code requirements for wind power integration have become a key element in improving grid efficiency and reliability. Under severe problems for network operation, wind turbines are expected to continue operating and supporting the grid during frequency restoration. This paper presents simulation results of a fixed-speed grid connected wind turbine under various short-circuit current contributions. Fault analysis is carried out by studying the grid side line to ground fault, double line fault, double line to ground fault, and three phase fault involving ground and without ground. The obtained current waveforms are analyzed to explain the behavior, such as the rate of decay and peak values. Variations of active and reactive power during post-fault conditions and faulty conditions are investigated. Moreover, recommendations for switchgear and protection equipment are performed.

Keywords: Grid Fault, Voltage Support, Short-Circuit Current, Active and Reactive Power Strategies, Stability Improvement.

I. INTRODUCTION

The evolution of electrical networks has been marked, in recent years, by new design, operation and control strategies. Indeed, the solution adopted by most countries to deal with the problem of rapid growth in the demand for electrical energy can be essentially summed up in the following points: The commissioning of new, more powerful power plants, the mesh of more and more transmission and distribution networks, the exchange of energy between countries through international and even intercontinental interconnections and mainly the integration of renewable energies [1].

This structural complexity is essentially the basis of current problems encountered in online behavior especially the weakening ability of networks to maintain stability following a disturbance likely to alter the smooth running of equipment and industrial processes [2]. Among these disturbances, there are those of short duration such as voltage sags, short cuts and over voltages, which are generally caused by the presence of short circuits [3].

They are characterized by important variations in voltage amplitude and can have costly and harmful issues on electrical equipment. The most extreme grid code requirements, taking into account the voltage range level at which the frequency range is required were combined to dress a frequency-voltage profile as well as an active reactive power profile [4].

In modern grids, wind installations must be able to participate in the full dynamic support of the grid in case of failure [5,6]: remain connected to the grid and provide voltage support by injecting a reactive current. Dynamic grid support allows power plants to be able to stay connected in case of fault, support voltage by supplying reactive power during the fault, and consume the same reactive power or less after the fault is cleared.

Essentially, short circuit and open circuit faults represent the majority of electrical faults in three-phase networks. Also, these faults can be symmetrical or asymmetrical. They are due to the break of one or more conductors [7][21][22], or open circuit faults where an unbalanced current flows through the system, thus heating the rotating machines [8]. We can define a short circuit fault as being an abnormal very low impedance connection, whether it is established accidentally or intentionally between at least two points of different potential. It is the most severe and common type of fault, leading to abnormally high currents flowing through transmission lines or equipment. Even for a short time, if these faults are allowed to persist, this leads to important damage to the grid or equipment [9]. The different possible short circuit conditions are: three-phase to ground (L-L-L-G), three phase above ground (L-L-L), phase to phase (L-L), single phase to ground (L-G) and two-phase to ground (L-L-G) [10]. However, the study of these faults is necessary to select the circuit breakers breaking capacity, to choose the phase relay setting and other protective devices and finally to manage the transit of reactive and active powers [11].

In few past years, numerous research works have investigated fault classification schemes and estimation for power systems based on signal measurement, decomposition and analysis, feature extraction and classification, fault classification and location [12, 13, 14, 18, 19, 20]. Fault location is another important aspect to consider when designing a protection scheme because it gives an indicative sign of where the fault has occurred along the power distribution line, resulting in a much quicker restoration time. Also, it gives the effect of AC voltages, AC currents and especially the flow and waveforms at the grid side of AC active and reactive powers [15].

II. PROPOSED POWER SYSTEM CONFIGURATION

The proposed and simulated wind energy conversion system architecture is presented in Figure 1. The device consists of a wind rotor connected to a rotor shaft of a squirrel cage induction generator (SCIG) through a gearbox converting kinetic energy captured by the wind turbine blades to mechanical energy. For this fixed-speed turbine, the highest efficiency is obtained at a particular speed only. Regardless of the wind speed, the rotor speed is fixed and is determined by the ratio of the gearbox, grid supply frequency and induction generator design. The SCIG is connected directly to the grid through a step-up transformer. According to grid code requirements, wind turbines must have the ability to absorb or generate reactive power to adjust the voltage level at the point of common coupling (PCC). A fixed power factor is maintained, so that the generator is not allowed to take reactive power from the grid and capacitors are sized to provide the suitable reactive power for improving the power factor and for induction generator magnetization needs. This wind turbine is equipped with a pitch angle controller to regulate the active power output to a defined level and also to increase the ability to control transient stability during faults.

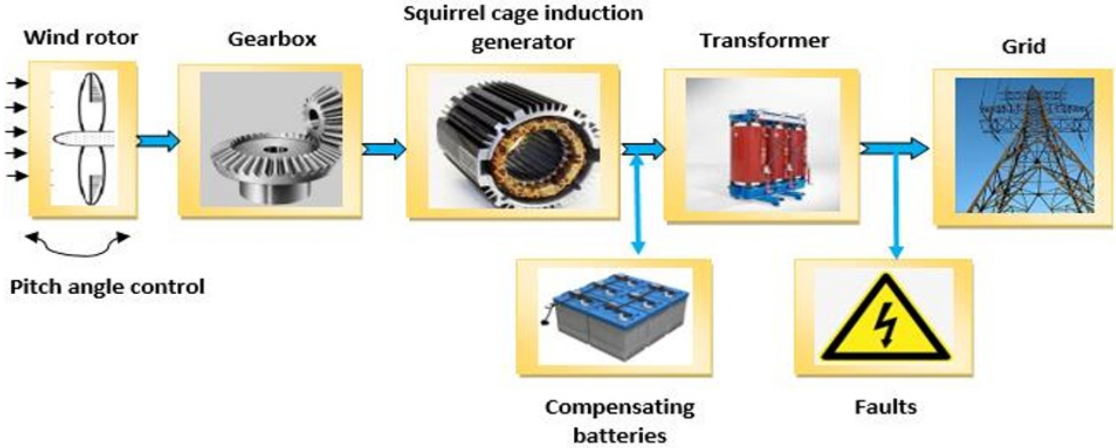

Figure 1. Fixed-Speed Wind Turbine Configuration

The mechanical power extracted from the wind is given by [12]:

$$P_m = C_p(\lambda, \beta)\frac{\rho A}{2}V_w^3 \quad (1)$$

With:

C_p- Power coefficient

ρ- Air density (kg/m^3)

A- Turbine swept area (m^2)

V_w- Wind speed (m/s)

λ- Tip speed ratio

β- Blade pitch angle

For the studied SCIG, all parameters are referred to the stator side, and all stator and rotor quantities are in the arbitrary twoaxis reference frame (d.q) [16]. The mathematical model of the SCIG is as presented in equation (2):

$$\begin{cases} V_{qs} = R_s i_{qs} + \frac{d\varphi_{qs}}{dt} + \omega\varphi_{ds} \\ V_{ds} = R_s i_{ds} + \frac{d\varphi_{ds}}{dt} - \omega\varphi_{qs} \\ V'_{qr} = R'_r i'_{qr} + \frac{d\varphi'_{qr}}{dt} + (\omega - \omega_r)\varphi'_{dr} \\ V'_{dr} = R'_r i'_{dr} + \frac{d\varphi'_{dr}}{dt} + (\omega - \omega_r)\varphi'_{qr} \\ T_e = 3/2p\left(\varphi_{ds} i_{qs} - \varphi_{qs} i_{ds}\right) \end{cases} \quad (2)$$

with

$\varphi_{qs} = L_s i_{qs} + L_m i'_{qr}$

$\varphi_{ds} = L_s i_{ds} + L_m i'_{dr}$

$\varphi'_{qr} = L'_r i'_{qr} + L_m i_{qs}$

$\varphi'_{dr} = L'_r i'_{dr} + L_m i_{ds}$

$L_s = L_{ls} + L_m$

$L'_r = L'_{lr} + L_m$

The mechanical mathematical model is given by the equation (3):

$$\begin{cases} \frac{dw_m}{dt} = \frac{1}{2h}(T_e - Fw_m - T_m) \\ \frac{d\theta_m}{dt} = w_m \end{cases} \quad (3)$$

with:

w: Reference frame angular velocity
w_r: Electrical angular velocity
w_m: Rotor angular velocity
R_s, L_{ls}: Stator resistance and leakage inductance
R'_r, L'_{lr}: Rotor resistance and leakage inductance
V_{qs}, i_{qs}: q axis stator voltage and current
V_{ds}, i_{ds}: d axis stator voltage and current
V'_{qr}, i'_{qr}: q axis rotor voltage and current
V'_{dr}, i'_{dr}: d axis rotor voltage and current
$\varphi_{qs}, \varphi_{ds}$: Stator q and d axis fluxes
$\varphi'_{qr}, \varphi'_{dr}$: Rotor q and d axis fluxes
L_m: Magnetizing inductance
L_s: Stator inductance
L'_r: Rotor inductance
Θ_m: Rotor angular position
p: Number of pole pairs
T_e: Electromagnetic torque
T_m: Shaft torque
h: Inertia constant
F: Viscous friction coefficient

The simplified grid model is a three-phase system containing three single-phase star-connected sources. The internal resistance Rg and inductance Lg are defined as [17]:

$$R_g = \frac{X}{(X/R)} \cdot \frac{2\pi f L_g}{(X/R)} \quad (4)$$

$$L_g = \frac{\vartheta_{base}^2}{P_{sc}} \cdot \frac{1}{2\pi f} \quad (5)$$

with:

ϑ_{base} : Base voltage
P_{sc} : Inductive three-phase short circuit power (VA).
f : Frequency (Hz).

Unsymmetrical sets of voltages and currents under grid faults are represented using their symmetric sequence sets. If Z denotes the impedance matrix, voltages and currents in abc system may be converted to the 012 system to obtain

$$V_{012} = Z_{012} I_{012} \quad (6)$$

This makes it possible to analyze the unbalanced 3phase current system by separately analyzing the symmetric sequence systems and then adding the results.

III. SIMULATION RESULTS AND DISCUSSION

A detailed model of the SCIG-based wind turbine system was performed in Matlab/Simulink to explore its dynamic performances in case of short circuit faults. For a wind speed of 9 m/s, different fault conditions are applied at the grid-side of the transformer at time t = 6 s and cleared after 83 ms based on 60 Hz frequency. SCIG generates power when supplied by a negative torque on its shaft, this power is positive when consumed by the SCIG and negative when generated by the SCIG. A snapshot of simulation results is shown in Figures 2 and 3. From these figures, it can be seen that after approximately 4s, the turbine model parameters reach an optimum operating point. The transients of grid current, active and reactive power are plotted respectively in Figures (4) to (13) for each of the short-circuit faults.

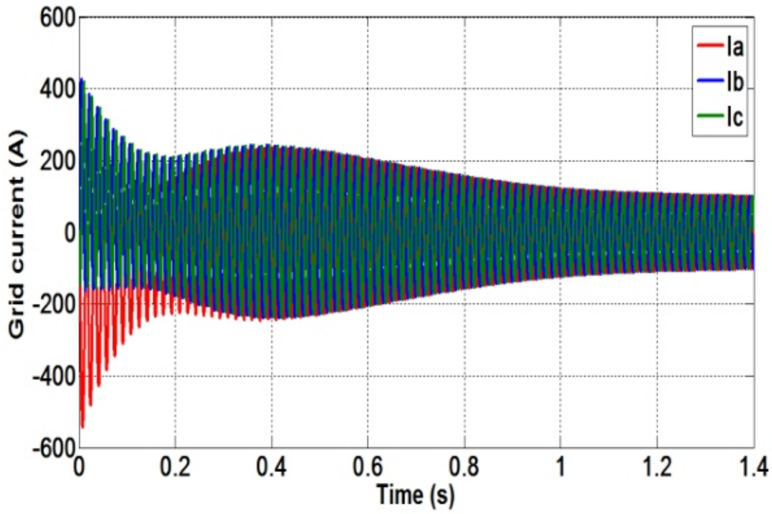

Figure 2. Grid Current

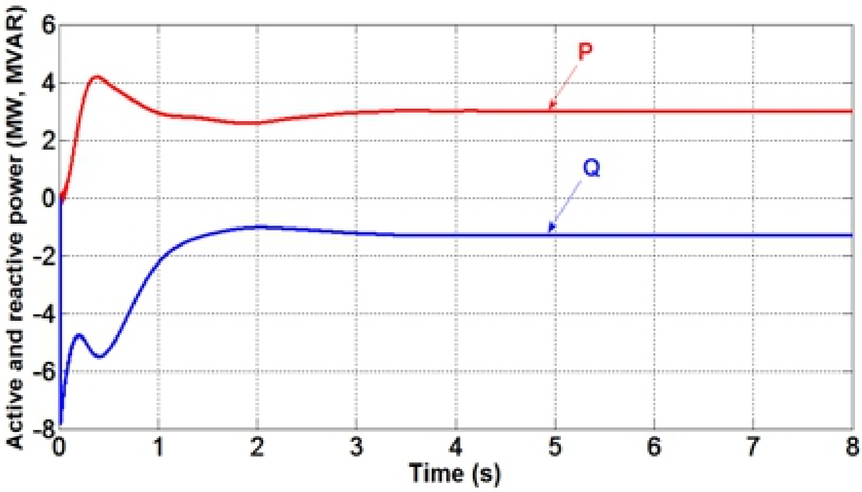

Figure 3. Injected Active and Reactive Power to the Grid

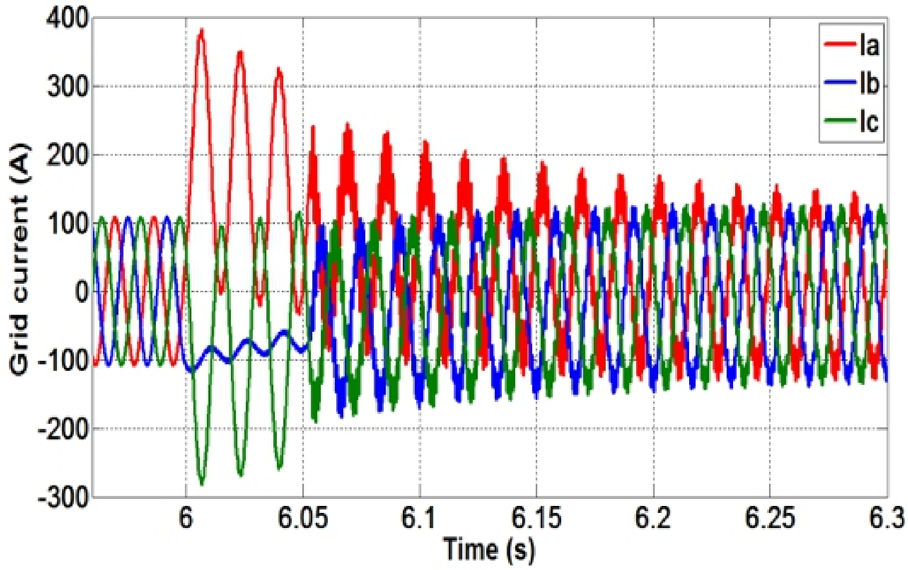

Figure 4. Grid Current with LG Fault

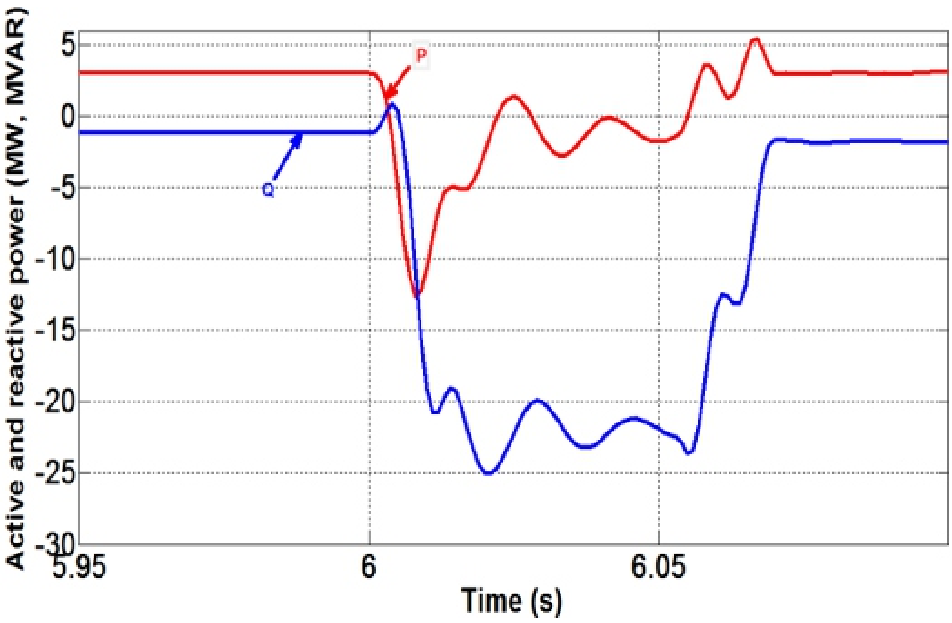

Figure 5. Active and Reactive Power with LG Fault

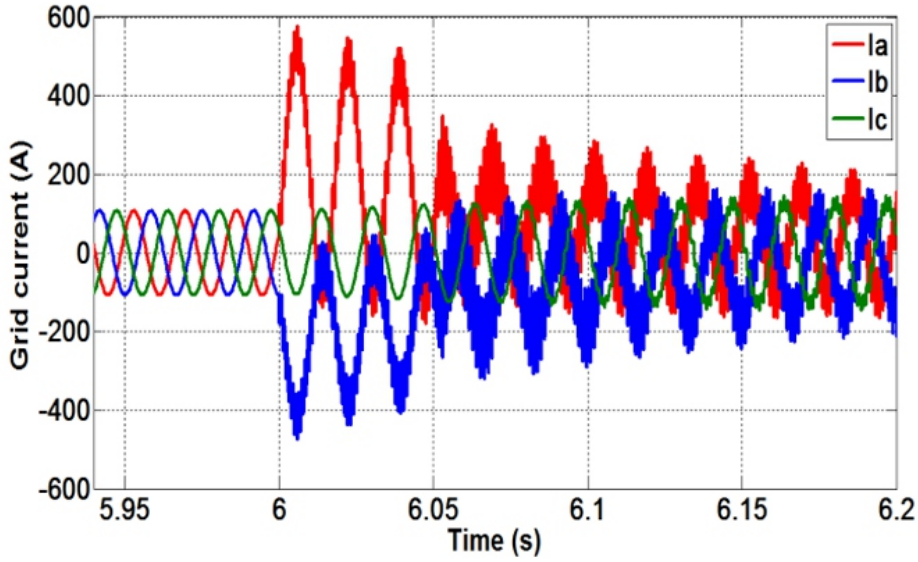

Figure 6. Grid Current with LL Fault

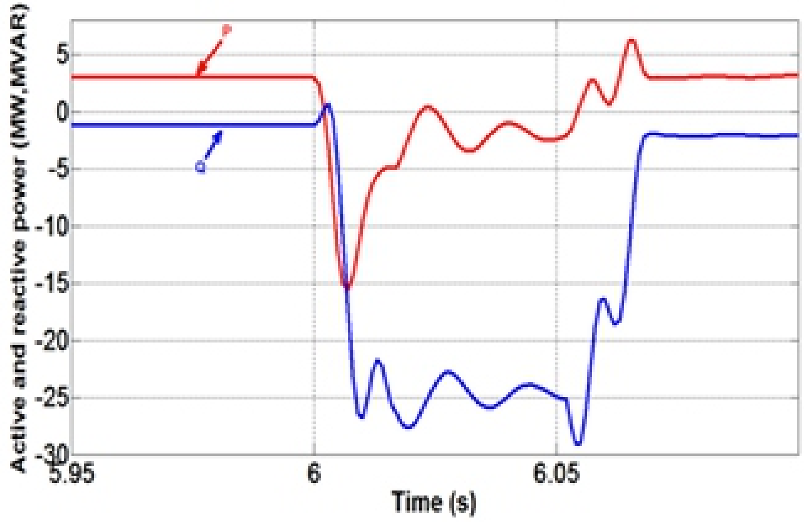

Figure 7. Active and Reactive Power with LL Fault

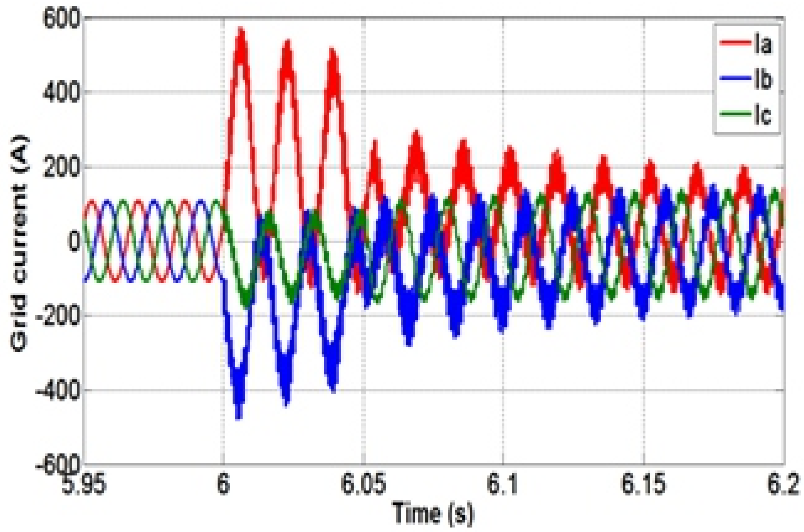

Figure 8. Grid Current with LLG Fault

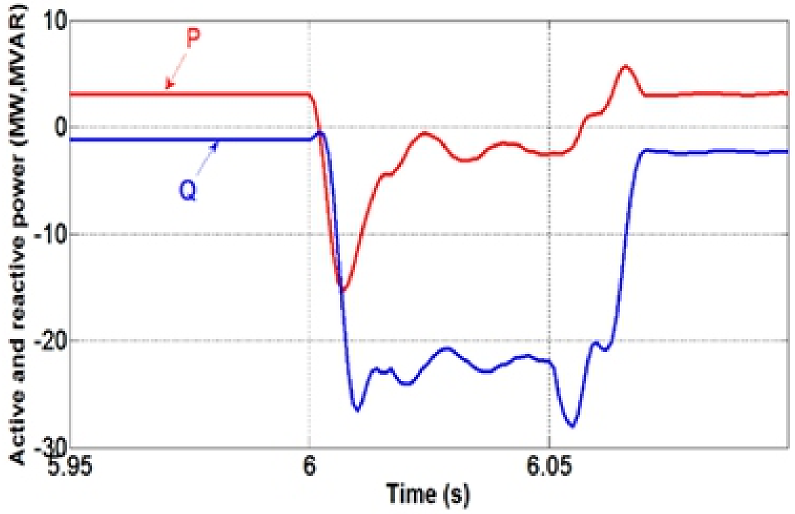

Figure 9. Active and Reactive Power with LLG Fault

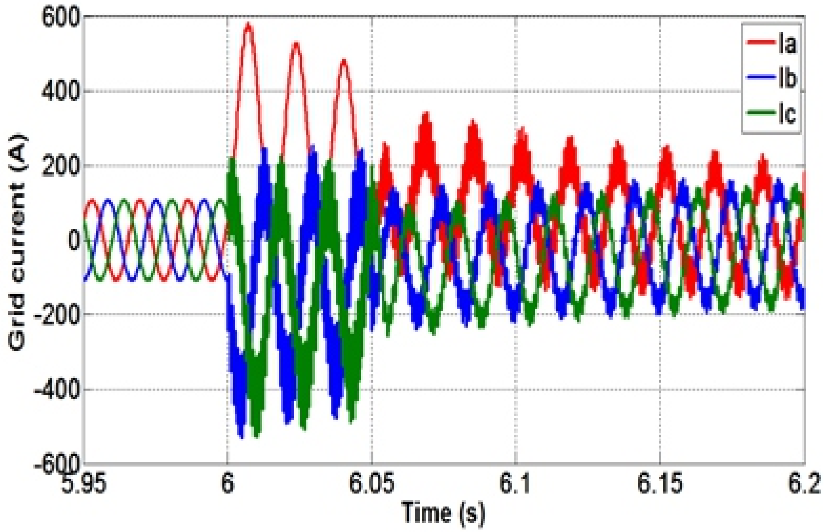

Figure 10. Grid Current with LLL Fault

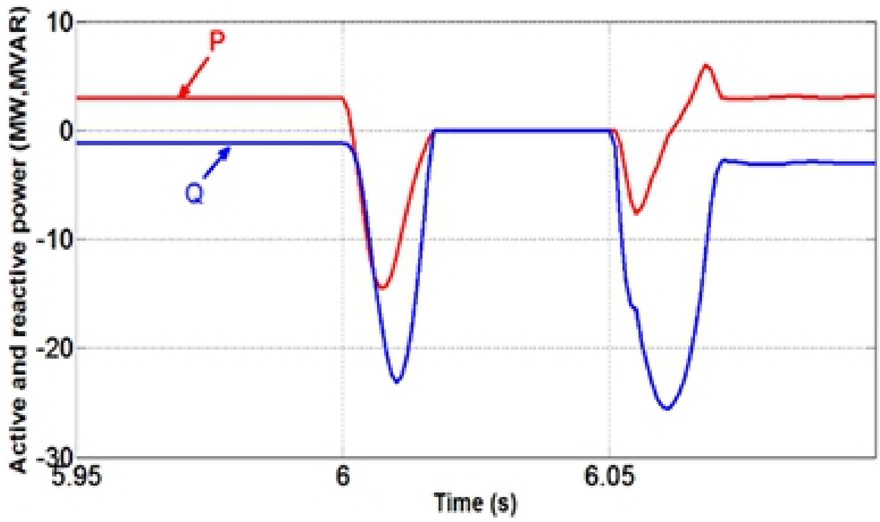

Figure 11. Active and Reactive Power with LLL Fault

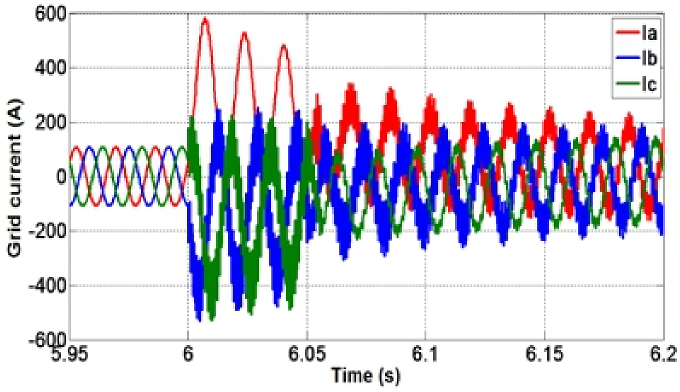

Figure 12. Grid Current with LLLG Fault

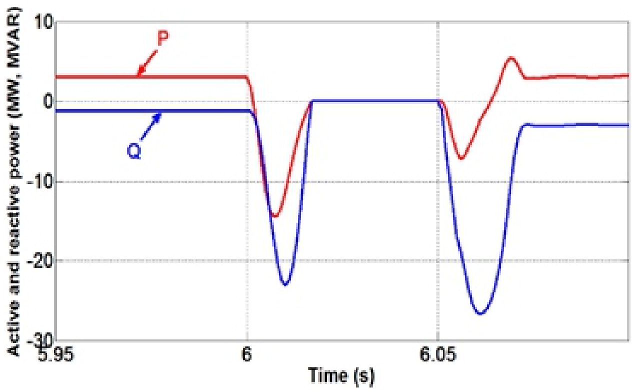

Figure 13. Active and Reactive Power with LLLG Fault

Phase currents, active and reactive powers variations during different faults are presented in the Table 1.

Table 1. Phase Currents, Active and Reactive Power Decays During Different Fault Conditions

FAULT	Rated current peak value for phase a	Rated current peak value for phase b	Rated current peak value for phase c	Rated active power peak value	Rated reactive power peak value
LG	355.88 %	53.87 %	262.35 %	137%	90.98%
LL	537.27 %	440.1 %	103.143 %	139.76 %	151.6 %
LLG	535.08 %	442.06 %	80.5 %	131.9 %	159.27 %
LLL	542.27 %	229.38 %	205.14 %	117.42 %	153 %
LLLG	542.27 %	235.03 %	211.02 %	117.42 %	153 %

The modeling and simulation results show the net current surge with a magnitude higher than the normal rated current. Notice that type 1 wind turbine generators can generate significant fault currents. Depending on the time of short-circuit, and including the dc component, the contribution during the initial cycle of the fault (asymmetrical current) can be as high as six times the rated current or more as given in Table 1. These high transient currents shown in Figures 4, 6, 8, 10 and 12 create an imbalance between system phases. We clearly distinguish as presented in Table 1 that LLLG, LLL, LLG and LL faults are respectively the most severe and present the largest short-circuit current. The threephase fault is the least likely to occur, however, the duration of this type of fault must be the shortest because the air-gap flux of the induction generator collapses without sufficient line voltage support. The single line to ground fault is the most likely to occur. The terminal voltage and currents are sustained longer because the line voltages, except from one phase, can sustain air-gap flux. Although the short-circuit current contribution from this type of fault is the lowest among other different faults, that's why when sizing the relay setting and breaker capacity, this data must be very useful to overcome by safety equipment. If the fault remains, the magnitude of the contribution decreases. When the shortcircuit is cleared, the supply voltage returns to its normal waveform but the system will still draw an unbalanced and higher-than-normal rated current. Wind turbines must have the ability to control their active/reactive power for transient stability, this is done by limitations on the rate of change of active/reactive power to suppress large frequency fluctuations, remagnetize the generator and solve the problem of generation/consumption imbalance of power. As presented in Figures 5, 7, 9, 11 and 13, a wind turbine can regulate its active power output to a defined ramp and level directly after fault clearance. A fast return to the normal active power supply is recorded. This is of a great importance for power system operation. The subject of these requirements is to ensure a stable system frequency, to minimize the dynamic operation effect on the grid, to prevent overloading of transmission lines and for transient stability during faults.

Within a very narrow interval, the voltage level in the grid is maintained constant. Wind turbines can supply or absorb reactive power to maintain the voltage level at the PCC. To help the reestablishment of grid voltage, the reactive power as presented in figures 5, 7, 9, 11 and 13 needed for remagnetization of the induction generator is less after the fault is cleared.

IV. CONCLUSION

Fixed-speed wind turbine generators can contribute significant fault currents, this contribution can be as high as six times the rated current or more. These high transient currents create an imbalance between system phases. LLLG, LLL, LLG and LL faults are respectively the most severe and present the largest short-circuit current. The single line to ground fault is the most likely to occur. The terminal voltage and currents are sustained longer because the line voltages, except from one phase, can sustain air-gap flux. Although the short-circuit current contribution from this type of fault is the lowest among other different faults.

As the fault remains, the contribution decreases in magnitude. When the short-circuit is cleared, the supply voltage returns to its normal waveform but the system will still draw an unbalanced and higher-than-normal rated current.

A wind turbine can regulate its active power output to a defined ramp and level directly after fault clearance. A fast return to the normal active power supply is recorded. This is of great importance for power system operation because it ensures a stable system frequency, minimizes the dynamic operation effect on the grid, prevents overloading of transmission lines and allows transient stability during faults. Within a very narrow interval, the voltage level in the grid is maintained constant. Wind turbines can supply or absorb reactive power to maintain the voltage level at the PCC. To help the reestablishment of grid voltage, the reactive power needed for the remagnetization of the induction generator is less after the fault is cleared.

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Authors Contributions	All authors have equal participation in this article.

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Emerging Trends of web Mining Through Cloud Mining (Bitcoin) in Business Companies

Nirmla Sharma, Sameera Iqbal Muhmmad Iqbal

ABSTRACT

In this paper we show research about how to mine valuable knowledge on the web mining through cloud mining in business companies and comparison about web mine. This paper illustrates the recent, previous, and upcoming web mining by cloud mining. Now we initiate real-time data set for recovery facts on the network i.e., web content mining, and the detection of client approach relationships from cloud servers, i.e., web management mining that enhance the web mining problems. Moreover, we similarly illustrated web mining through cloud mining in business companies. Cloud mining is an upcoming Web Mining. That is the main benefit of the company looking after all the usual mining problems. Cloud mining decreases the costs correlated with running a mining rig. Cloud mining is a procedure to mine cryptocurrency like bitcoin, by leased cloud computing operate without connecting or promptly governing the hardware and associated software. The initial processor that has observed a result to the problem catches the succeeding Bitcoin block, and the procedure remains. Bitcoin mining needs advanced hardware to explain difficult calculations and arithmetic challenges. In this paper we have discussed to work and is beneficial for business companies. We have proposed a structure for a cloud mining service. These services are supported by business model and strategy, hardware procurement and setup, user interface and dashboard and customer support and education etc. Cloud mining service deals are often tricks, or rip-offs. Cloud mining suppliers and companies benefit by leasing away their hardware in replace for funds. Trading mining hardware seems like a prospect's agreement for saving ruses.

Keywords: Cryptocurrency Mining, Business Companies, Cloud Mining, Cloud Mining Models, And Web Mining.

I. INTRODUCTION

A. Web Mining

It broadly be observed like the application of modified data mining techniques to the web, although data mining is denoted like the application of the algorithm to search designs on typically organized statistics fixed into a knowledge discovery process [1][20]. Web mining has a unique property to help a group of numerous data types. The web has numerous features that produce numerous methods for the mining procedure, like web pages containing text etc.

Web pages are associated through hyperlinks, and consumer action be observed through web server logs represents in Figure 1 below.

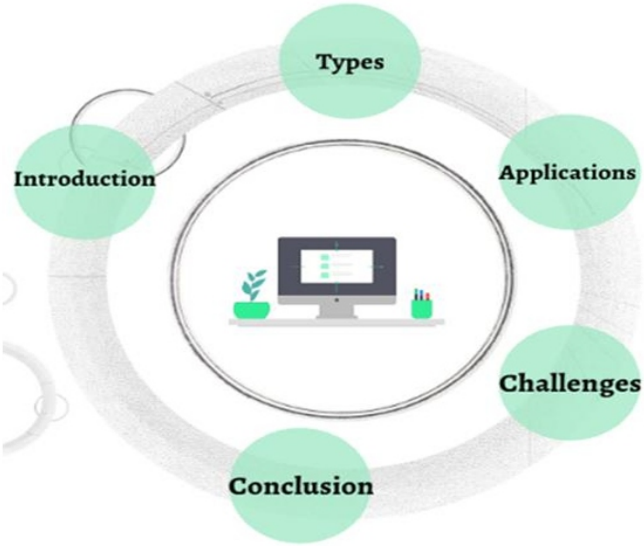

Fig. 1. Web Mining Process

It is created on the behind comments, the Web similarly positions unlimited challenges for actual source and knowledge discovery [2,3].

1. Web appears to be also huge for well-organized data warehousing and data mining. The dimension of the web is in the instruction of hundreds of terabytes and is still developing quickly.
2. Complexity of Web pages is far greater than any traditional text document group. Web pages are more deficiency a joining organization. It holds in future other authoring style and content variations than any group of books or other traditional text-based documents.
3. Web is an extremely dynamic statistic source. It does not individual prepare the web produce quickly, and then its data is similarly frequently updated. Broadcast, trading, climate, sports, shopping, company advertisements, and several extra web pages are restructured frequently on the web.
4. Web serves a broad diversity of consumer groups. The Internet presently links more than 100 million terminals, and its consumer community is static quickly increasing. Consumers have numerous circumstances, benefits, and tradition goals [4].

B. Cloud Mining

It is a process to mine cryptocurrency like bitcoin, by hiring out cloud computing run without connecting or immediately passing the hardware and linked software [5]. The mining set up is boarded, and it is provided in a resource admitted by a mining company, and the client perfectly requirement to require enrolling and acquisition mining agreements or stakes [6,7][21][22].

It is a substitute for the usual cryptocurrency mining technique. Mining keeps the safety of the evidence of production blockchain by confirming operation confirmations are distributed. Consumers are granted prevent returns as customers authenticate operations. In the prior Bitcoin cloud mining eras, miners worked modern mining tools [8,9][23][24]. When the number of miners expands, prevent returns are reduced, and prevent returns are divided at periods shown in Figure 2 below.

Fig. 2. Connected Miners

Bitcoin Cloud mining business companies support us to initiate an account and remotely contribute to cryptocurrency mining for a fundamental expense, creating mining available to numerous societies around the earth. So, this procedure of mining is executed via the cloud, it cuts down tools' protection or immediate resources efforts [10,11].

II. PROBLEM STATEMENT

How does cloud mining work for web mining to get started with cloud mining, and the process involve in cloud mining is easier than conventional cryptocurrency mining. It will benefit emerging trends of web mining through cloud mining in business companies [9].

III. RELATED STUDIES

Web mining is an area of data mining associated to the facts presented on the internet. It is an idea of obtaining instructive information accessible on web pages over the internet [12]. Web Mining: Today and Tomorrow Kavita Sharma al.et. Numerous academics have stared for discipline of denote the web mining and expectations of web mining. Certain of these are stated that cloud mining is the upcoming of web mining. As we realize, Etzioni is the initially person who invented the name Web Mining. This paper defines the web mining subtask and procedure [13].[14] termed the web mining category as Content mining, Structure mining & Usage mining. Here also they explain the process of web usage mining. Other one also signifies the web mining and upcoming of web mining in Cloud Computing. This paper expresses the web usage mining in Cloud Computing technology [8]. Web usage mining model is a thoughtful of mining to server logs. Web Usage Mining performs a main character in recognizing developing the serviceability of the web site model, the amendment of clients' associations and recovering the condition of technique presentation and so on.

Web usage mining gives the help for the web site strategy, presenting personalization server and other commercial making decision, etc. [15]. Web usage mining in Cloud Computing is plainly one of recent most expertise topic in research topic due to its effort productivity and elasticity [16]. Though, although expanded action and awareness, there are major, determined relates about cloud computing that are blocking thrust and will ultimately concession the sight of cloud computing as an innovative IT finding pattern [17,18].

The phrase cloud is an icon for the Internet, and perception of the Internet 's causal setup, treated to symbol the statement at which concern suggests from the client to an exterior source. Ultimately, Cloud Mining is the latest method to accepted explore user interface [19].

The Bitcoin Timeline Bitcoin white paper was published on 2008, October 31, through Satoshi Nakamoto, whose devoted character is even unidentified. On January 3, 2009, Bitcoin operated quick with digging its creation block that recognized the initial operation to begin the blockchain. In 2009, the Bitcoin value was hardly over null. Bitcoin achieved $1, parallel to the US dollar, in February 2011. All through the historical, Bitcoin produced from $1 to $30 In 2013 Bitcoin ended 6,600% improvements and showed charges corresponding between $13 and $1100 In January 2017, Bitcoin value affected the $1100 spot, and amazingly, it exited entirely the method to $20,000 by December 2017 in November first week of 2020, Bitcoin has touched $62500, an entirely top below Figure 3 shown average values result of BTC 2009 to 2020 every 4 years difference [9].

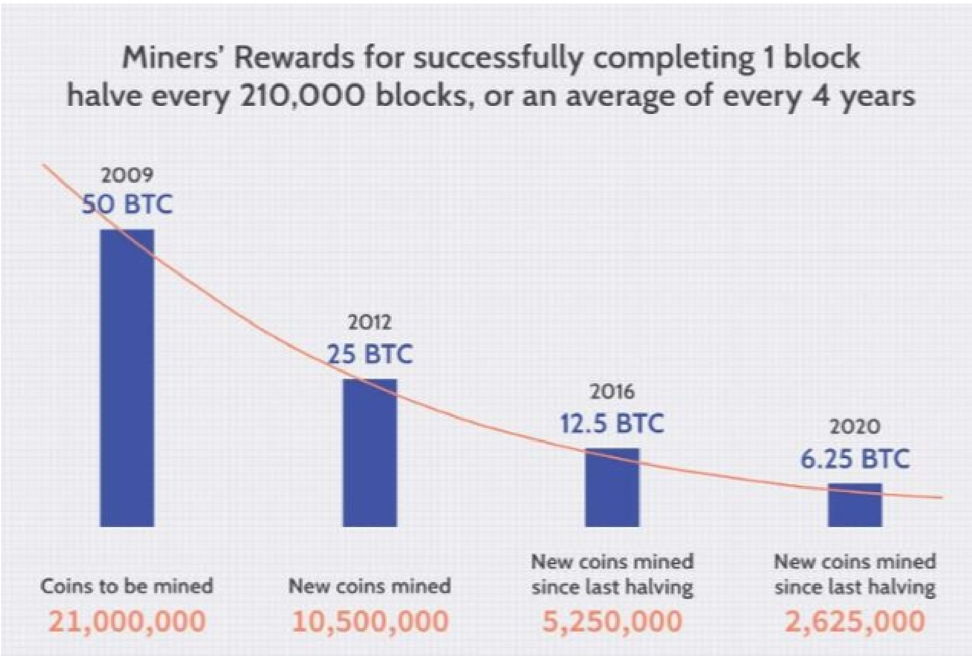

Fig. 3. Miners Rewards for Successfully an Average Value of BTC [9].

Only 1 megabyte of operation statistics has measured into a one bitcoin block. The 1MB edge was established by Satoshi Nakamoto, and this takes develop a substance of argument since approximately mineworkers trust the block dimension should growth to adapt further statistics, which would successfully mean that the Bitcoin system could procedure and confirm transactions further rapidly.

IV. PROPOSED STRUCTURE OF CLOUD MINING

Cloud mining is a service that allows individuals to participate in cryptocurrency mining without the need for acquiring and maintaining their own hardware. It involves renting computing power from a cloud mining provider who operates and manages the mining hardware on behalf of the user. Here's a proposed structure for a cloud mining service:

1. Business Model and Strategy: Define the business model, target audience, and strategic goals. Determine the cryptocurrencies to be mined and the duration of mining contracts.
2. Hardware Procurement and Setup: Acquire and set up mining hardware, such as ASIC (Application-Specific Integrated Circuit) miners, GPUs (Graphics Processing Units), or other specialized mining equipment. Ensure that the hardware is efficient and up to date with the latest mining algorithms.
3. Data Centre Infrastructure: Establish a reliable and secure data centre facility to house mining hardware. Consider factors such as power supply, cooling systems, security, and redundancy to ensure continuous and optimal mining operations.
4. Mining Pool Integration: Connect the mining hardware to established mining pools to increase the chances of successfully mining cryptocurrency blocks. Mining
pools allow for the efficient distribution of rewards based on the contributed hashing power.
5. User Interface and Dashboard: Develop a user-friendly web-based platform or application that allows users to create accounts, purchase mining contracts, and monitor their mining activity. Provide a dashboard that displays real-time statistics, earnings, and contract details.
6. Pricing and Contract Options: Offer various mining contract options based on the desired cryptocurrency, contract duration, and hashing power. Implement flexible pricing structures to accommodate different user preferences and budgets.
7. Payment Systems and Wallet Integration: Integrate secure payment systems that accept various payment methods, including cryptocurrencies and fiat currencies. Implement wallet integration for users to receive their mining rewards.
8. Customer Support and Education: Provide responsive customer support to assist users with inquiries, technical issues, and concerns. Educate users about cryptocurrency mining, the cloud mining service, and best practices for optimizing mining performance. 9. Security Measures: Implement robust security measures to protect user data, funds, and the mining infrastructure. Utilize encryption, multi-factor authentication, and regular security audits to ensure a high level of security.
10. Legal and Regulatory Compliance: Adhere to legal and regulatory requirements in the jurisdictions where the cloud mining service operates. Comply with relevant laws, licensing, and taxation regulations.
11. Monitoring and Maintenance: Establish a monitoring system to continuously track the performance and health of the mining hardware. Conduct regular maintenance to optimize efficiency and address any hardware issues promptly.
12. Transparency and Reporting: Ensure transparency by providing users with regular reports on their mining performance, earnings, and operational updates. Maintain open communication to build trust and confidence with users.

By following this proposed structure, a cloud mining service can effectively operate and provide users with a reliable and hassle-free cryptocurrency mining experience.

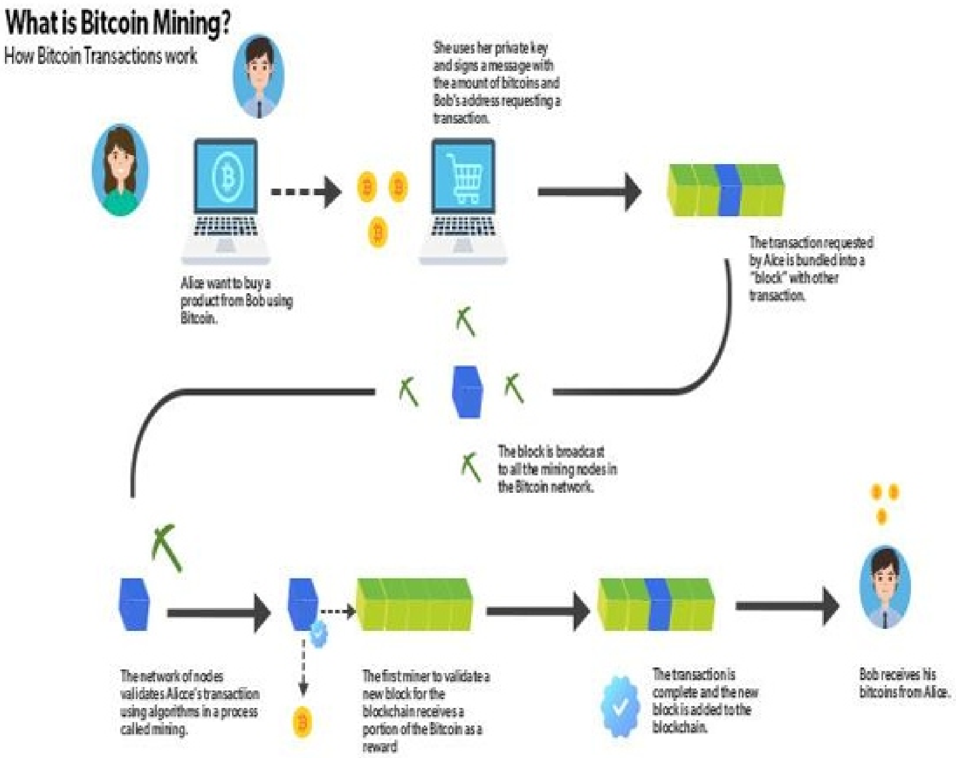

Fig. 4. Bitcoin Mining and Bitcoin Transaction Working

Above Figure 4 shows Bitcoin transaction work. As profitable Bitcoin mining needs a lot of financing in limited tools, and requirements low power, numerous are cut off. In the above services, however, it is required for the company to perform, in a written agreement, to settle the full amount of the loan containing the undertaken interest. For those who finance in this way conversely, it is only contributing funds to a mining company, and not really mining.

V. RESULT DISCUSSION

Bitcoin mining is a usual development with which modern Bitcoins reach movement. The initial processor that has observed a result to the problem catches the succeeding Bitcoin block, and the procedure remains. Bitcoin mining needs advanced hardware to explain difficult calculations and arithmetic challenges. The systems that mine Bitcoins have gathered again produced money like a return. Bitcoin is a digital property, the single of its type, and it extends with a limited reserve of 21 million. It cannot be established so fresh paper money is officially produced by Authorities and associations. Someone indicated to Bitcoin so "Digital Gold," indicating that Bitcoin has burrowed as gold. In November first week of 2021, Bitcoin touched $68,000, an entirely top. Bitcoin is the first and best dominant cryptocurrency internationally, with the greatest worth of its sort. Meant for single Bitcoin, the rate is $37,228 so of the first week of February 2022. Corresponding to the current statistics from Coinbase, there are now 18.9 million Bitcoins in exchange, presented for mining.

It will stare extremely into the latest Bitcoin mining measurements 2023. Bitcoin mining affects the figure of Bitcoins mined per day. The Bitcoin holders were enthusiastic to observe the entire great value of Bitcoin with $68,000 for single Bitcoin throughout the first week of November 2021. Still, the price collapsed in the succeeding months by 40 percent and stopped to $41,000 throughout the first week of January 2022. The value more reduced and happen to $37,228 by January 31, 2022. Corresponding to commercial stock experts, the international Cryptocurrency will touch $4.9 billion in 2023 with a Compound annual growth rate (CAGR) of 12.8 percent below Table1, Table 2 and Figure 5, Figure 6 show histogram, all statistic from 2009 to till 2023 below-.

Table 1. Tolal Circulating Bitcoin Values from 2009 to 2023

BTC	YEAER	Values
0M	2009	50 BTC
5M	2010	N/A
10M	2011	N/A
15M	2012	25 BTC
20M	2013	N/A
25M	2014	N/A
30M	2015	N/A
35M	2016	12.5 BTC
40M	2017	N/A
45M	2018	N/A
50M	2019	N/A
55M	2020	6.25 BTC
60M	2021	6.8 BTC
65M	2022	37.22 BTC
70M	2023	70 BTC

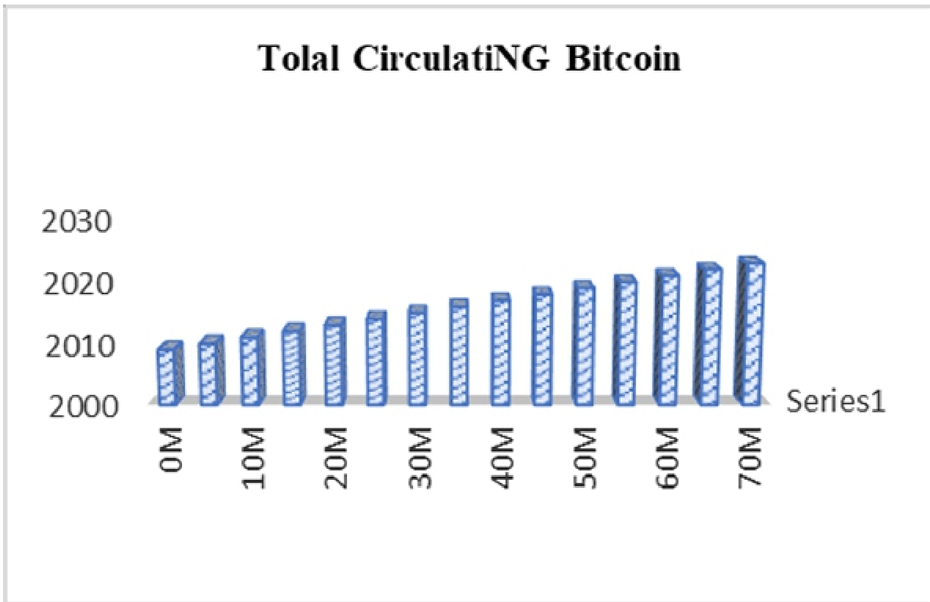

Fig. 5. Tolal Circulating Bitcoin Values from 2009 to 2023

Table 2. Difference 4 Years Tolal Circulating Bitcoin Values from 2009 to 2023 Statistics

BTC

N	Valid	7
	Missing	0
Mean		17.5929
Std. Deviation		1.62E+01
Variance		261.815
Minimum		3.7
Maximum		50

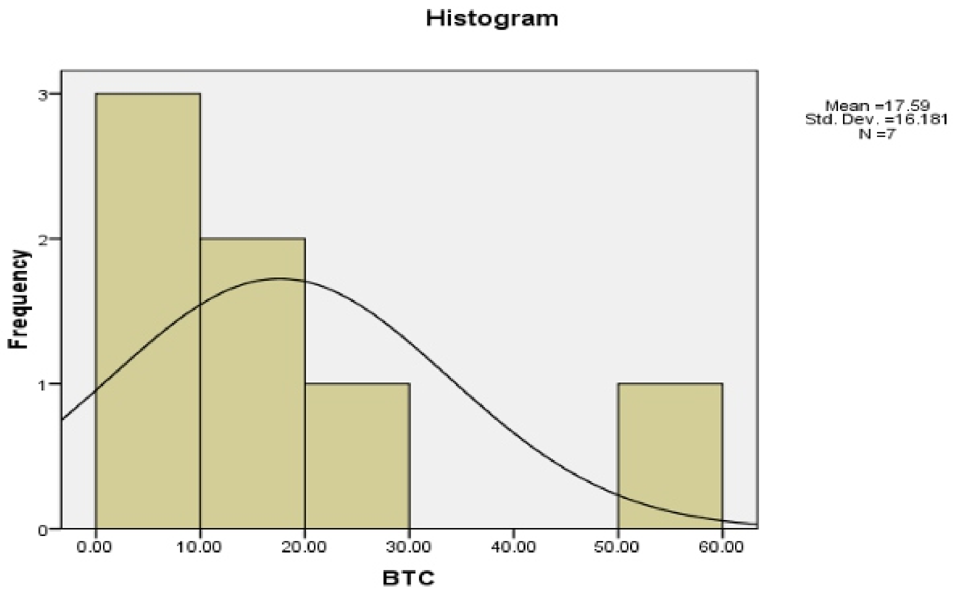

Fig. 6. Histogram 4 Years Difference Tolal Circulating Bitcoin Values from 2009 to 2023

A various topic is when cloud mining services are proposed to increase funds as a finance in sequence to business the commercial. We used to select a good mining corporation, hire tools from them, and wait for them to begin earning money. These are below statements of research contribution:

How does cloud mining work for web mining: as an activity anywhere, people share in the mining of cryptocurrencies, such as Bitcoin, without taking to accept or control the mining hardware themselves. It gets started with Cloud Mining in web mining. Afterwards starting our account, we will take to payment money to start our cloud mining behaviors. Cloud mining suppliers naturally take payment in cryptocurrencies like Bitcoin or Ethereum.

The process involve in cloud mining is easier than conventional cryptocurrency mining as cloud mining is a convenient and cost-economical substitute to conventional cryptocurrency mining. With cloud mining, miners join in the production of cryptocurrencies without the necessary to specific and state costly mining tools and software.

Cloud mining suppliers and companies benefit by leasing away their hardware in replace for funds. Trading mining hardware seems like a prospect's agreement. If we appreciate that we have discussion in result discussion section supply loads of Bitcoin at different companies and years price, it is great business to previously trade at one and other companies. where other companies are sufficient to contain what think beneficial for us. Cloud mining companies mostly produce more than other companies, which is a great turn a profit.

VI. CONCLUSION

In assumption it can be stated that sorry to say cloud mining service deals are often tricks, or rip-offs. There is only a rare sincere service in this area, and they are markedly those that have been conducting appropriately for numerous years currently. Earlier ordering such a result it is importance comparing it with simply accepting BTC on trades, since regularly this solution is better than it is much less unsafe, even while it is.

At last, when bitcoin was first extracted in 2009, mining one block would gain 50 BTC. In 2012, this was cut to 25 BTC. By 2016, this was reduced again to 12.5 BTC. On May 11, 2020, the return cut again to 6.25 BTC. So, March 2022, the value of Bitcoin was going on $39,000 per bitcoin, which means have gained $243,750 (6.25 x 39,000) for completing a block, Cryptocurrency will touch $4.9 billion in 2023. Our proposed structure for a cloud mining service supports business model and strategy, hardware procurement and setup, data center infrastructure, transparency and reporting etc.

FUTURE WORK

Furthermore, they expect that Bitcoin's value will improve by 1500% by the succeeding 10 years. This will affect how many bitcoins are extracted per day.

DECLARATION STATEMENT

Authors are required to include a declaration of accountability in the article, counting review-type articles, that stipulates the involvement of each author. The level of detail differs; Some subjects yield articles that consist of isolated efforts that are easily voiced in detail, while other areas function as group efforts at all stages. It should be after the conclusion and before the references.

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Intelligent Traffic Management System to Improve Mobility at Ayigya, a Commuter City in Ghana

John Nyamekye Ansah, Loretta Owusu-Ansah, Selikem Asare-Brown

ABSTRACT

The issue of vehicular traffic congestion is faced by most road users all over the world, including Ghana. The complications intensify day in and day out, especially in most urban areas, due to development and urbanization. The exponential increase in road users awakens concern for an effective road transportation system to convey people and goods from one place to another. In an attempt to mitigate the effect of the problem, a system based on a statistically programmed lighting sequence was introduced. This technique served its purpose for some time and was realized to be inefficient because it controlled traffic flow by assigning a fixed amount of green light time to each phase of traffic, which meant that green light time was sometimes given to lanes even when there was no conflicting traffic. The persistent nature of the problem requires the need for an intelligent traffic management system to effectively coordinate the flow of vehicles through the available road network. The proposed system works based on priority queuing, where green and red phases are dynamically assigned to lanes depending on the present traffic volume. The proposed system uses two methods of counting to determine the highest lane count. They are the Digital Vehicle Counting (DVC) and the Manuel Vehicle Counting (MVC) methods. An effective detection zone of sixty meters is declared away from the traffic intersection. The values produced by both counting methods are fed to the Traffic Phase Router (TPR) for comparison. The lane with the highest vehicle counts from both counters is given the chance to leave The proposed system was designed using Simulation of Urban Mobility (SUMO) software. Results obtained after the simulation showed that the proposed system performed better than the existing system based on the Key Performance Indicators (KPIs) used.

Keywords: Digital Vehicle Counting (DVC), Intelligent Traffic Management System (ITMS), Manual Vehicle Counting (MVC), Traffic Phase Router (TPR).

I. INTRODUCTION

A. Overview

The current traffic management system deployed in Ghana is based on fixed time allocation which is unable to acclimatize to changes in traffic demands, as a result creating unnecessary delays at the intersection [1][15][16]. The inability of the existing traffic management system to cope with large volumes of traffic on inadequate road infrastructures results in huge congestion and prolonged waiting times [1] [5][17][18][19]. This suggests that one of the effective ways to manage traffic flow is to introduce automation or intelligence to roadside infrastructure [3] [4].

The main objective of this project was to design an Intelligent Traffic Management System (ITMS) that effectively manages traffic at an isolated intersection by dynamically assigning priority to lanes depending on the immediate traffic demand. The proposed system comprises two techniques that aid in counting vehicles within a declared effective detection area which is sixty meters away from the traffic intersection. The vehicle counts from both technologies for each lane are fed into the Traffic Phase Router for comparison so that the lane with the highest vehicle counts from both counters is given priority to leave the traffic intersection. The proposed system is limited to coordinating traffic flow at an isolated intersection with its efficiency being tested in a virtual simulating environment.

B. Literature Review

Transportation by road undoubtedly is one of the regular and widely used means of throughout the country. The need to transport people, goods, and other items is on the rise, leaving massive congestion on many urban roads, creating discomfort for commuters, increasing fuel consumption and emissions, contributing to air pollution and climate change [1], as well as decreasing economic productivity, among others [2] [6]. Various methods, designs, and projects in that regard have been developed to reduce the effect of this problem. In [7] infra-red sensors were used to collect traffic data and fed to a microcontroller. The system was easy to implement, with priority given to emergency vehicles, however, the sensors were unable to differentiate between pedestrians and other objects from vehicles, hence they may not be entirely reliable.

[8] Combined ultrasonic sensors and GSM technology to control traffic flow at an isolated intersection. The system consumes less power but periodic checking of accuracy and precision is required for effective operation.

[9] This paper proposes a system that combines a Wireless Sensor Network (WSN) and fuzzy logic for real-time traffic monitoring. The system is, however, not flexible and has lots of complex computations.

[10] Propose the use of pneumatic tube sensors. Inaccuracy in axle count when truck and bus volumes are high causes a great defect in the system.

[14] Proposed the use of piezo-electric sensors which obtain data by converting mechanical energy into electrical energy. The system is quite simple to install, and piezo-electric sensors are highly compatible with the pavement, however operation over long cables may introduce noise into the system. The system in [13] adapt to sudden changes in traffic demand thereby enhancing high throughput at intersections; nevertheless, it consumes much power and has high operational cost. The systems proposed in [11] gives a much more accurate count as compared to the other commonly used techniques but it is very expensive to implement.

[12] Assures fast and reliable communication between vehicles but it cannot be installed in rural areas with no internet connection.

C. Data Collection

Data were collected at the Ayigya traffic intersection in three sections during specific working hours of the day. These included the morning, afternoon, and evening sections. During data collection, so much importance was attached to the morning and evening rush sections, where roads were usually busy due to office activities commencing and ending, respectively, in and around those times. Data collection in the morning section started from 6 a.m. to 8 a.m., in the afternoon section from 12 p.m. to 1 p.m., and in the evening section from 5 p.m. to 7 p.m. The selected intersection for data collection was considered at various random intervals, with the necessary deductions made to give a meaningful traffic pattern. Table 1 below shows the data collected at the Ayigya traffic intersection.

Table 1. Data Collection

Location	Session	Arrival (Average No. of Vehicles per hour)	Departure (Average No. of Vehicles per hour)
Tech Junction-to-Top High	MORNING	45	60
Bomso-to-Ayigya	MORNING	20	30
Tech Junction-to-Top High	AFTERNOON	35	50
Bomso-to-Ayigya	AFTERNOON	24	29
Tech Junction-to-Top High	EVENING	40	55
Bomso-to-Ayigya	EVENING	25	32

II. PROPOSED SYSTEM

The proposed system comprises two techniques that aid in counting vehicles within the effective detection area. They are the Digital Vehicle Counting (DVC) technique and the Manual Vehicle Counting (MVC) technique. The effective detection zone serves as a focal area where system operations are based, so vehicles outside this area are ignored. The idea is to consider a particular area close to the intersection and extend it to the entire lane. Of course, if the detection area is less congested or free of traffic, the entire lane can also be assumed to be so. The detection area is defined as being sixty meters away from the traffic intersection. The Digital Vehicle Counter serves as the primary mode for counting vehicles and consists of four cameras, one for each lane. Each camera is responsible for monitoring and capturing vehicles within the detection zone. The camera captures the traffic scene in frames, which are used to generate a vehicle count. The values obtained from each lane are compared, and the highest vehicle count is passed to the traffic phase router. The traffic phase router, after taking the highest count, waits to compare it with the highest value obtained from the manual vehicle counting process to decide the next line of action. The manual vehicle counter serves as the secondary counting method. It consists of a road tube sensor that is laid in a groove cut into the road surface at both the entry and exit points of the detection zone. It maintains a constant burst of air pressure along the tube. When a vehicle drives over the tube, the pressure exerted closes an air switch, which produces an electrical signal. This enables the sensor to detect the entry and exit of vehicles. A count is obtained by dividing the number of axles that pass over the sensors by two. The final vehicle count is determined by subtracting the number of vehicles that left the detection area from those that entered. The final count is then compared with the result attained from the digital vehicle counting process. The next step after the vehicle counting process is assigning priority based on the count. This step is achieved with the help of the traffic-phase router. The highest lane count for both counters (i.e., the DVC and MVC) is placed in variables MAX 1 and MAX 2, respectively, and serves as input to the TPR. The TPR, upon receiving the counts, compares the values. If the value in MAX 1 is greater or equal to that in MAX 2, MAX 1 is considered the highest value, and green phase time is assigned to that lane. However, if MAX 2 is greater than MAX 1, the opposite occurs, and priority is given to the desired lane for vehicles to exit the intersection. Fig 1 below explains the algorithm used by the TPR to assign green phase time.

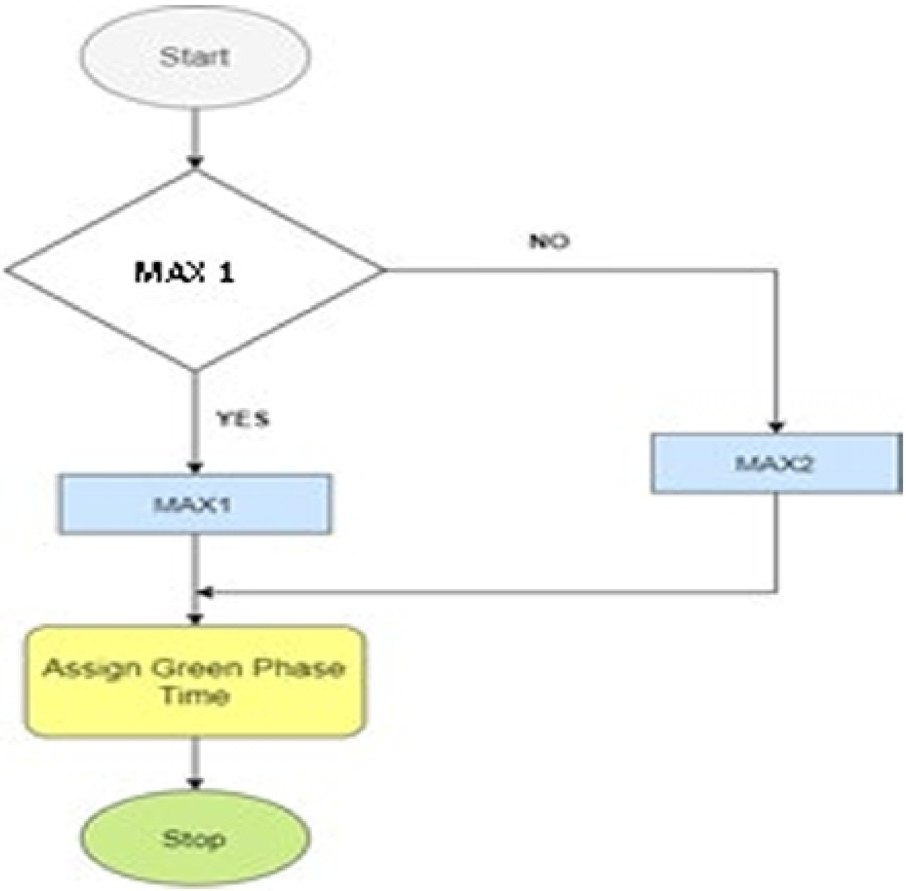

Fig. 1: Algorithm used by the TPR to Assign Green Phase Time

Below is a flow chart that explains the entire operation of the proposed system.

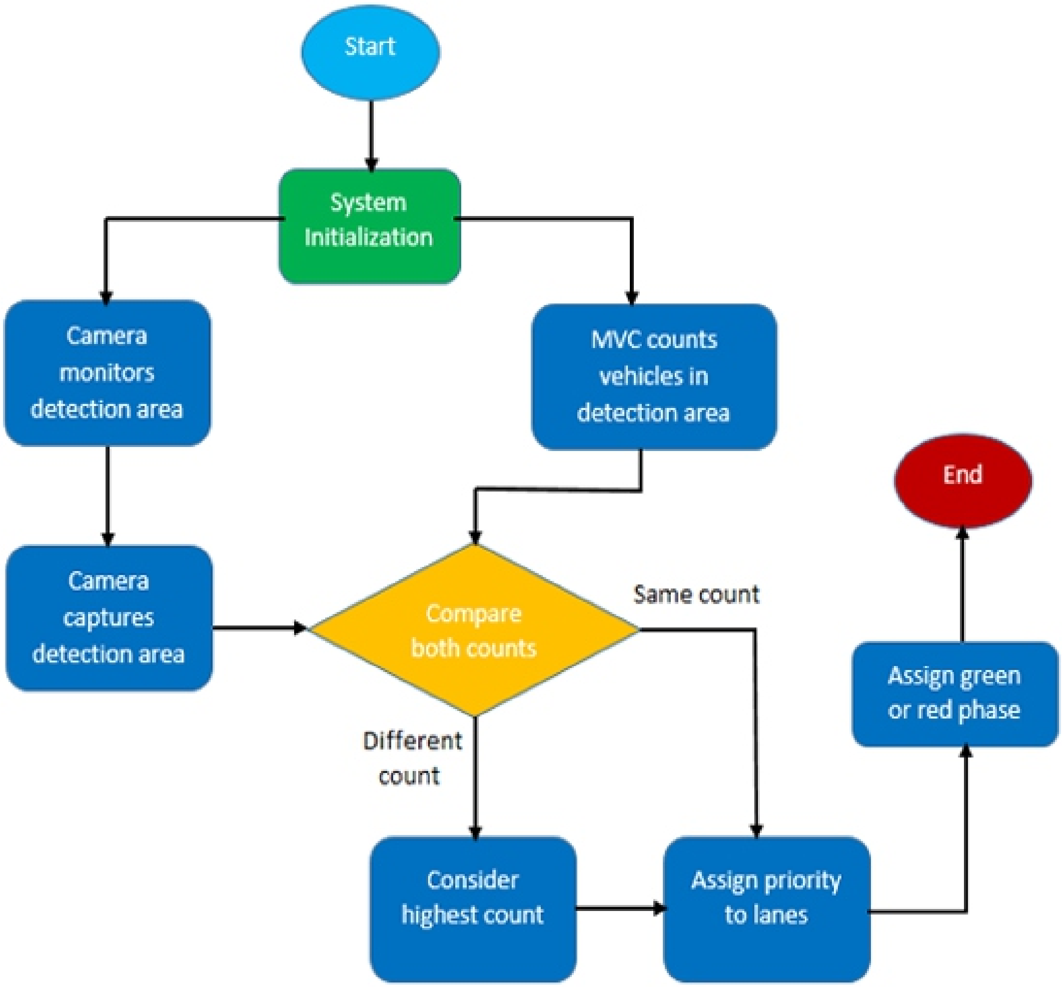

Fig. 2: A Flow Chart of the Proposed System

III. SIMULATION RESULTS

In an attempt to measure the efficiency of both systems, some key performance indicators were considered. They are average vehicular speed, average trip queuing times, and average trip duration. These KPIs serve as the determinants for performance measurements of the systems. Since the goal of this project is to reduce vehicle congestion at an isolated intersection, the KPIs chosen were used to measure traffic congestion and their influence on congestion. Table 2 indicates the chosen KPIs used to outline the performance of both systems.

Table 2. System Key Performance Indicators

Key Performance Indicators	Unit
Average Vehicular Speed	[m/s]
Average Trip Queuing Time	[s]
Average Trip Duration	[s]

A. Average Vehicular Speed

The average vehicle speed is the measure of the speed at which a vehicle moves throughout the network from one point to the next in the simulation. It is expressed in meters per simulation second. This KPI has a significant influence on traffic congestion. Thus, the lower the average vehicle speed throughout the road network, the higher the probability of the occurrence of vehicular traffic congestion, and vice versa. Figure 3 below assesses the performance of both the current and proposed systems in terms of their average vehicular speeds. The blue graph pattern represents the proposed system, with the orange graph pattern representing the current system. The graph below shows that the average vehicle speed for the proposed system is 11.21 meters per second, as opposed to 4.58 meters per second for the current system. This explains that for the same number of vehicles introduced into the network, on average, vehicles in the proposed system drive 6.63 m/s faster as compared to vehicles in the current system. The result obtained primarily means that vehicles in the simulation, on average, would drive at a speed of almost 6 m/s quicker than in the current system. Such a difference is huge and significant for traffic management and analysis.

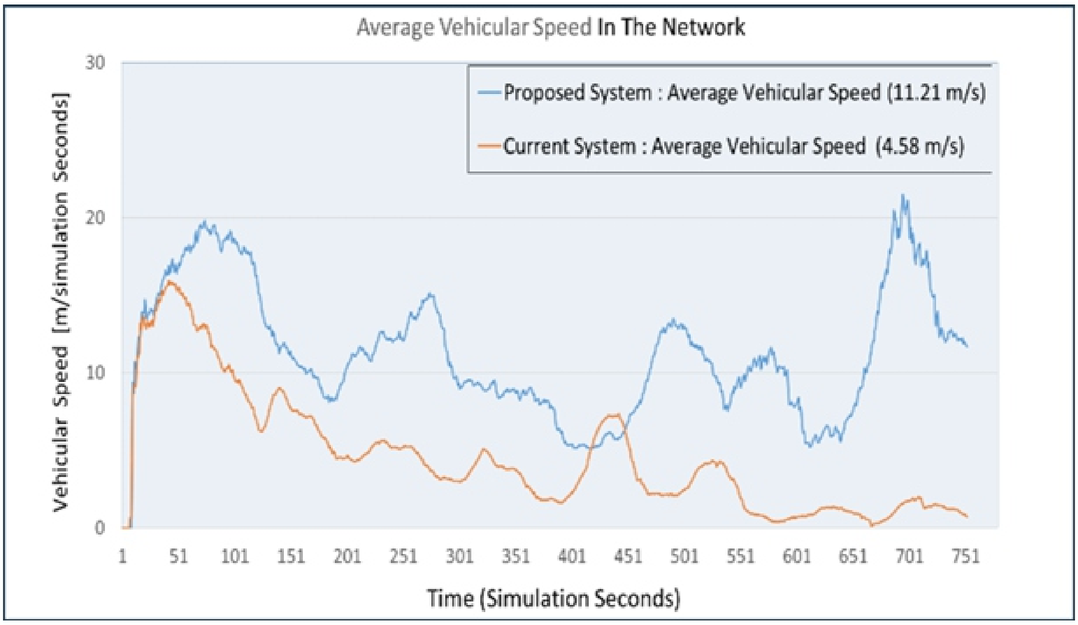

Fig. 3: Average Vehicular Speed

B. Average Trip Queuing Time

The second KPI used for the performance analysis is the average trip queuing time, which actually characterizes the measure of vehicular congestion in the system. It basically represents the time in which a vehicle has to stop and wait on the road network, excluding scheduled or planned stops. In that case, the higher the average trip queuing time, the longer the existence of traffic congestion in the road network, leading to an increase in time loss for a trip, and vice versa. This shows that the average trip queuing time is directly proportional to the trip time loss. The trip queuing time is measured in simulation seconds. Figure 4 below displays the performance of the current and proposed systems in terms of average trip queuing times. The blue graph pattern represents the proposed system, while the orange graph pattern represents the current system. It is realized that the proposed system has an average queuing time of 52.15 seconds as opposed to 68.69 seconds for the current system. This indicates that for the same number of vehicles introduced into the network on average, the proposed system outperforms the current system by 16.54 seconds. This means vehicles in the simulation, on average, would spend at least 16 seconds less queuing on the roads.

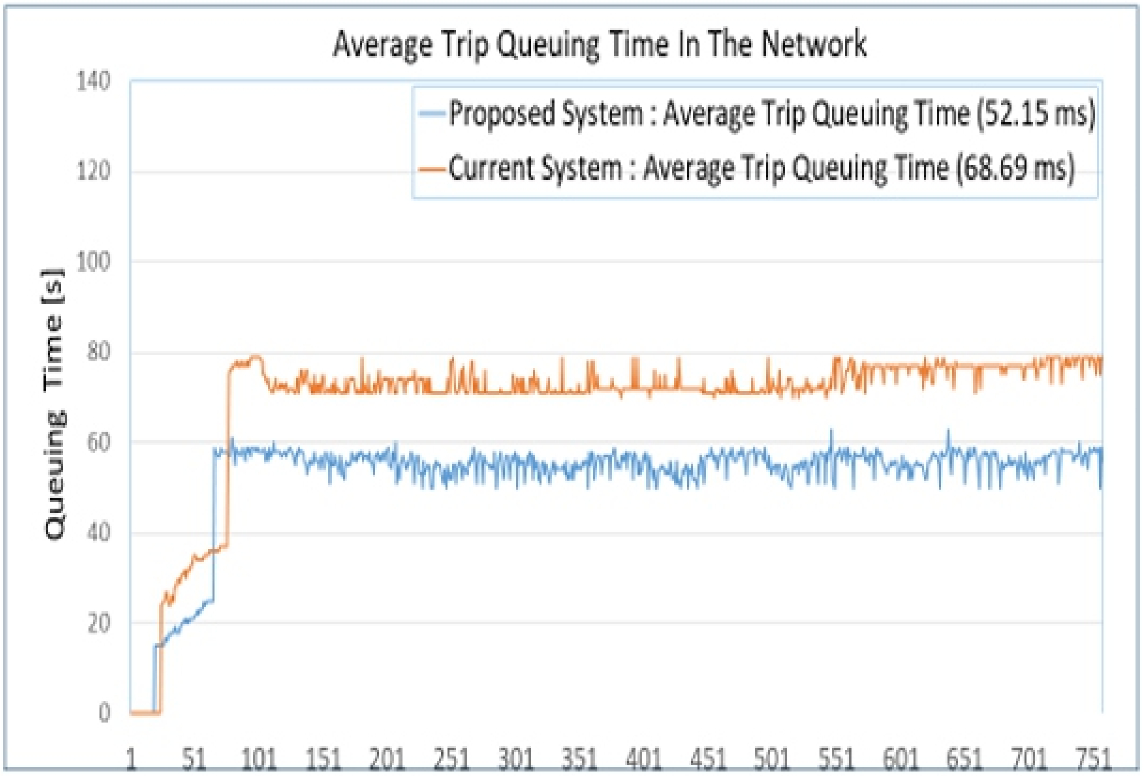

Fig. 4: Average Trip Queuing Time

C. Average Trip Duration

The average trip duration represents the time taken by a vehicle to move from one point to another in the network. The trip duration is also measured in simulation seconds.

This KPI actually has a direct impact on the average trip queuing time and traffic congestion for both systems. It is seen from t below that the proposed system has an average trip duration of 188.88 seconds as opposed to 249.32 seconds for the current system. This explains that for the same number of vehicles introduced into the network on average, the proposed system performs better than the current system by 60.44 seconds. It further indicates that vehicles in the simulation, on average, would leave the simulation at least 60 seconds faster or earlier than in the current system. The blue graph pattern represents the proposed system, while the orange graph pattern represents the current system.

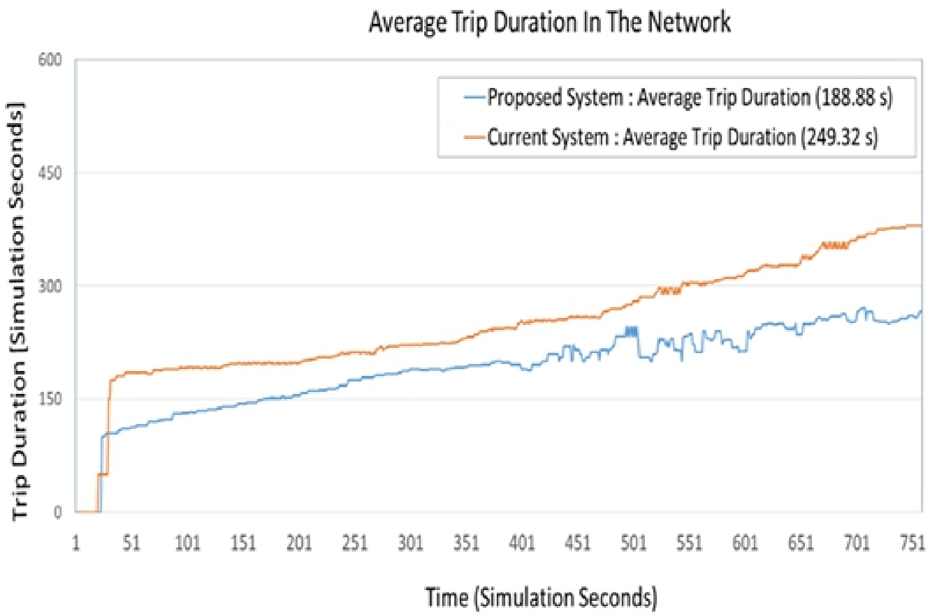

Fig. 5: Average Trip Duration

IV. CONCLUSION

In this project, an intelligent traffic management system that operates based on priority queuing was successfully designed. The system is able to cope with the random nature of traffic. It effectively manages traffic flow at an isolated intersection (bottleneck) by dynamically assigning priority to lanes depending on the present traffic demand. The system was designed in the Simulation of Urban Mobility (SUMO) environment. The simulation results clearly suggested that the proposed system performed better than the existing one with regards to the Key Performance Indicators (KPI's) used.

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Authors Contributions	All authors have equal participation in this article.

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A Comprehensive Study on Failure Modes and Mechanisms of Thin Film Chip Resistors

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A B S T R A C T

Usually, resistors and capacitors populate majority portion of a common electrical circuit, hence miniaturization drive of any package or subsystem starts with miniaturized resistor and capacitors. In this context, thin film chip resistors are the most sought-after components for any electronic/electrical circuit due to their small size, wide range of values, military temperature range, stringent tolerance, low TCR value (recognised with PPM). Increased use of thin-film surface mount chip resistors in military and space application has led to an increased awareness of its potential failure modes in harsh environments. Thin film resistor with lower TCR (5PPM, 10PPM and 25PPM) are most preferable and widely used because of very low temperature coefficient of resistance (TCR) and high resistivity, which suits for high precision measurement application. Low temperature coefficients characteristics of thin film resistors also makes them stable and reliable. Because of their high-volume usage in recent times, failure in thin film resistor with lower TCR/PPM (Parts per Million) are also being seen more predominantly. In general, there are two types of thin film chip resistors, one is discrete type and the other is die type or wire bondable type. Discrete type chip resistor are used directly on cards, whereas, die type/wire bondable type chip resistors used in hermetically sealed HMC packages. Standard failure mode of a resistor is open mode or high resistance mode, whereas short mode failure has a very low probability. Hence in this paper, failure modes and mechanisms of both types of thin film chip resistors, with respect to common failure causes such as EOS, ESD are discussed, which is in continuation to Fabrication/Workmanship related failures discussed in our earlier technical paper. With this, all possible failure modes and mechanism related thin film chip resistors are explained. Discussion in totality always provide in depth analysis on a subject of concern, which in turn facilitate reliability assessment of the component and corrective action, if any.

Key Words: Electrical Overstress (EOS); Electrostatic Discharge (ESD); Temperature Co-efficient of Resistance (TCR); Parts Per Million (PPM); Moisture Ingression; Corrosion, Hybrid Micro Circuit (HMC)

I. INTRODUCTION

Chip resistors are a type of resistor among passivecomponents and are mainly used to lower the circuit voltage and limit the current in electronic products. They are essential components of the majority of high-tech electronic products. Chip resistors have many advantages such as small size, light weight and no inductance, and they are widely used in electronic equipment and populated PCBs for adapting to high density surface mount. The chip resistors can be divided into thin-film chip resistors and thick-film chip resistors. The former offers better precision and lower temperature coefficients, which means more stable and reliable resistance. With the development of high precision electronic devices, thick film chip resistors are unable to meet higher performance requirements because of high temperature coefficient of resistance. Therefore, thin film chip resistors are most preferable because they have low temperature coefficients, which makes them stable and reliable. The predominant films systems used in the manufacture of thinfilm resistors today are nickel-chrome and tantalum nitride [1]. The vast majority of these, however, are derivatives of Nickel-Chrome (Ni-Cr) or Tantalum Nitride (TaN). Ni-Cr thin film has a low temperature coefficient of resistance (TCR) and high resistivity, which increase its importance and technical applications as a resistor in the electronic industry field [2-4][7][8]. However, in the case of thin film chip resistors or other miniature products, it is necessary to encapsulate the film and prevent corrosion in humid environments [5][9]. Increased use of thin-film surface mount chip resistors in military and space application has led to an increased awareness of potential failure modes in harsh environments.

In order to understand the failure mode and mechanism of thin film chip resistor, it is necessary to know about their physical construction. Construction of thin film resistor (discrete type) was already explained in earlier publication [6], however, for the sake of completeness construction of both types of film resistors (discrete type and wire bondable/die type) are shown in figure-1 and figure-2 respectively. Usually, thin film resistors are fabricated by vacuum evaporation or sputtering of thin films of resistive materials (mostly Nichrome) directly on top of the ceramic substrate or silicon wafer. These materials exhibit good adhesion on the oxide as thin films, and are usually built with a film thickness of about 100-1000Å. The value of a thin film resistor can be set precisely to its final value by laser trimming. For discrete type thin film resistor, both side of the chip there are solder coated nickel end-cap for electrical contact of the chip resistor. The resistor film (Nichrome) is protected by a passivation layer of thickness ≤10µm and covered by hard epoxy coating. The role of passivation layer is very critical in chip resistor as it protect the resistor film from moisture and contaminants. By virtue of their construction, passivation layers and end cap are very sensitive for temperature excursion, which the chip resistor usually encounter during manual soldering or post-reflow solder touch-up.

Improper fabrication process of thin film chip resistors usually ends up in moisture induced open mode failure as a result of corrosion of internal resistive material [6]. For wire bondable/die type thin film resistor, aluminium bond pads are provided along with resistive thin film track for wire bond connection. Thin film materials are same as that of discrete type thin film chip resistor (Nichrome), but there is no passivation layer in case of wire bondable/die type thin film resistor. Therefore, these types of resistors are supposed to be used inside hermetically sealed packages.

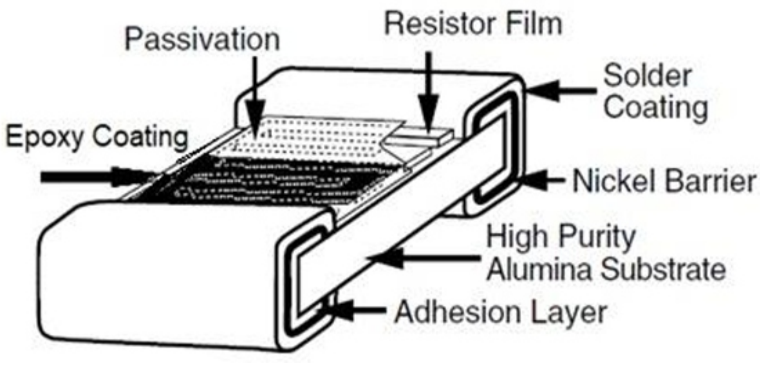

Figure-1: Internal Construction of Discrete Thin Film Chip Resistor

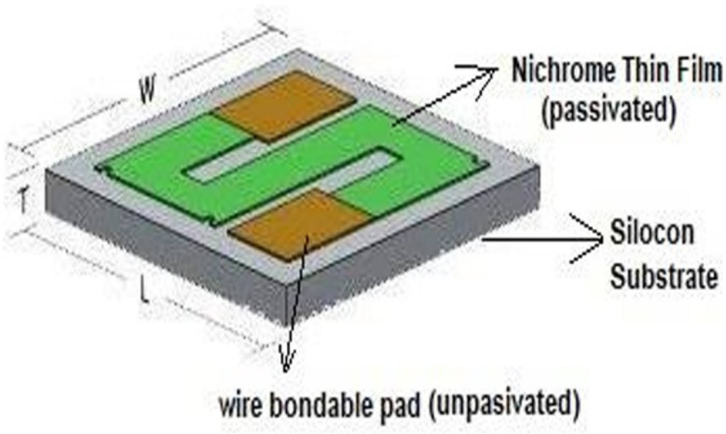

Figure-2: Internal Construction of Wire-Bondable (Die Type) Thin Film Chip Resistor

Electrical Overstress (EOS), Electrostatic Discharge (ESD) and Fabrication/Workmanship Induced failures are the major failure causes of EEE components, which were source screened and qualified as per respective MIL/ESA/NASA standards. Manufacturing related defect or component design related defect, if any, usually wedded out as a part of screening. Thin film chip resistors, used in onboard application of ISRO projects, being source screened and high reliability part, hence it is prudent to understand various failure modes and mechanism, which in turn helps in finding out the root cause of failure and subsequent corrective actions.

II. REFERENCE TO EARLIER SIMULATION STUDY ON THIN FILM CHIP RESISTORS

In an earlier study, fabrication/workmanship induced failure simulation experiments were carried out on discrete type thin film chip resistors RM1206, 0.1%, 25PPM, 1/8W (many values) in order to understand the root cause of failure of large number of thin film resistors in may satellite project during various ground level tests [6]. Simulation study was conducted on Nichrome based thin film resistors, as these types of chip resistors are used in ISRO projects and following conclusions were made.

➢ Thin film resistors soldered using proper soldering method (either manual/re-flow) did not showed any time dependent failure even with biased with higher voltage. However, open mode failure of one 100kΩ resistor, which was reflow soldered, showed the reliability concern in Nichrome based thin film resistor. In this case, there can be two possibilities for open mode failures, i.e., either there is multiple solder touch-up for this particular resistor after reflow soldering for what so ever reason or the passivation layer for this particular piece has a manufacturing defect. The first reason is slightly unlikely as reflow soldering process was carried out on the resistors under strict Quality Control (QC) guidance. There is a possibility for the second reason as thin film resistor do not have any screening test that could weed out defects such as crack and porosity in the passivation layer. Therefore, Nichrome based thin film resistor are not environment friendly.

➢ In order to establish the exact failure mechanism for open mode failure in Nichrome based thin film resistor, biased humidity test was conducted on the chip resistor. As per the test results, when the solder time is more than 15sec, those resistors, even though do not show any anomalies immediately after soldering, subsequently failed in open mode after different time of testing. There are two interesting facts observed from that simulation study; (I) as the soldering time increases, time for open mode failure in the resistors decreases, (ii) the time taken for higher value resistor is lesser than those of lower value resistors. From above two observations, failure mechanisms for open mode failure in chip resistor can be explained as follow. As the soldering time increases, damage probability to the passivation layer increases so also the probability of moisture ingression, which resulted in oxide formation of the Nichrome metal and finally the metal film failed in open mode. Hence, the failure mechanism in this case can be related to corrosion.

➢ From the above discussion, it is inferred that open mode failure in Nichrome based thin film chip resistor is time dependant and related to moisture induced corrosion.

III.FURTHER SIMULATION STUDIES ON THIN FILM CHIP RESISTORS

In order to understand few other failure mechanisms in both discrete type thin film chip resistors and wire bondable/die type thin film resistors few more simulation studies were conducted and they are as follows

(a) Electrical Overstress (EOS) Simulation Study on discrete type thin film chip resistors RM1206, 0.1%, 25PPM, 1/8W (few values).

(b) Electrostatic Discharge (ESD) Simulation Study on discrete type thin film chip resistors RM1206, 0.1%, 25PPM, 1/8W (few values).

(c) Electrostatic Discharge (ESD) simulation study on die/wire bondable type thin film chip resistors RM1206, 0.1%, 25PPM, 1/8W (few values).

The details of the studies are explained in the subsequent sub- sections.

A. Electrical Overstress (EOS) Simulation Study on Discrete Type Thin Film Chip Resistors RM1206, 0.1%, 25PPM, 1/8W (Few Values)

Electrical Overstress (EOS) is one of the very common failure cause in EEE components, happened due to improper testing/test procedures or handling. In order to find out the susceptibility of discrete thin film chip resistors towards electrical overstress few chip resistors RM1206, 0.1%, 25PPM, 1/8W (different values) were subjected to EOS through step stress method. Following steps were adopted in the course of aforesaid simulation study.

a. Initial Visual Examination and Electrical Measurement of Chosen Components:

RM1206, 0.1%, 25PPM, 1/8W (five values, 2nos. each) were chosen for the study. Details about the components are shown in table-1.

TABLE-1: Components Details Taken for Simulation Study

Resistor Type	Resistance Value	Sample Nos.	Sample Marking
RM1206EB, ±0.1%, 25PPM, 1/8W	10.0kΩ	2nos.	R1 to R2
	27.10kΩ	2nos.	R3 to R4
	100.00kΩ	2nos.	R5 to R6
	150.00kΩ	2nos.	R7 to R8
	301.00kΩ	2nos.	R9 to R10

Chip resistors were visually inspected using optical microscope at 100X. No visual anomalies were observed. Optical photographs of few chip resistors are shown in figure3. Values of the chip resistors were chosen based on the feedback from field failure data. Initial electrical test results of each resistor are shown in table-2.

TABLE-2: Initial Electrical Measurement Result of Chip Resistors

Sample No.	Measured value in kΩ	Specified Limit in kΩ	Sample No.	Measured value in kΩ	Specified Limit in kΩ
R1	9.992	9.90 to 10.01	R7	150.075	149.85 to 150.15
R2	10.009		R8	150.098	
R3	27.102	27.073 to 27.127	R9	300.947	300.699 to 301.301
R4	27.098		R10	301.078	
R5	99.927	99.9 to 100.1			
R6	99.981				

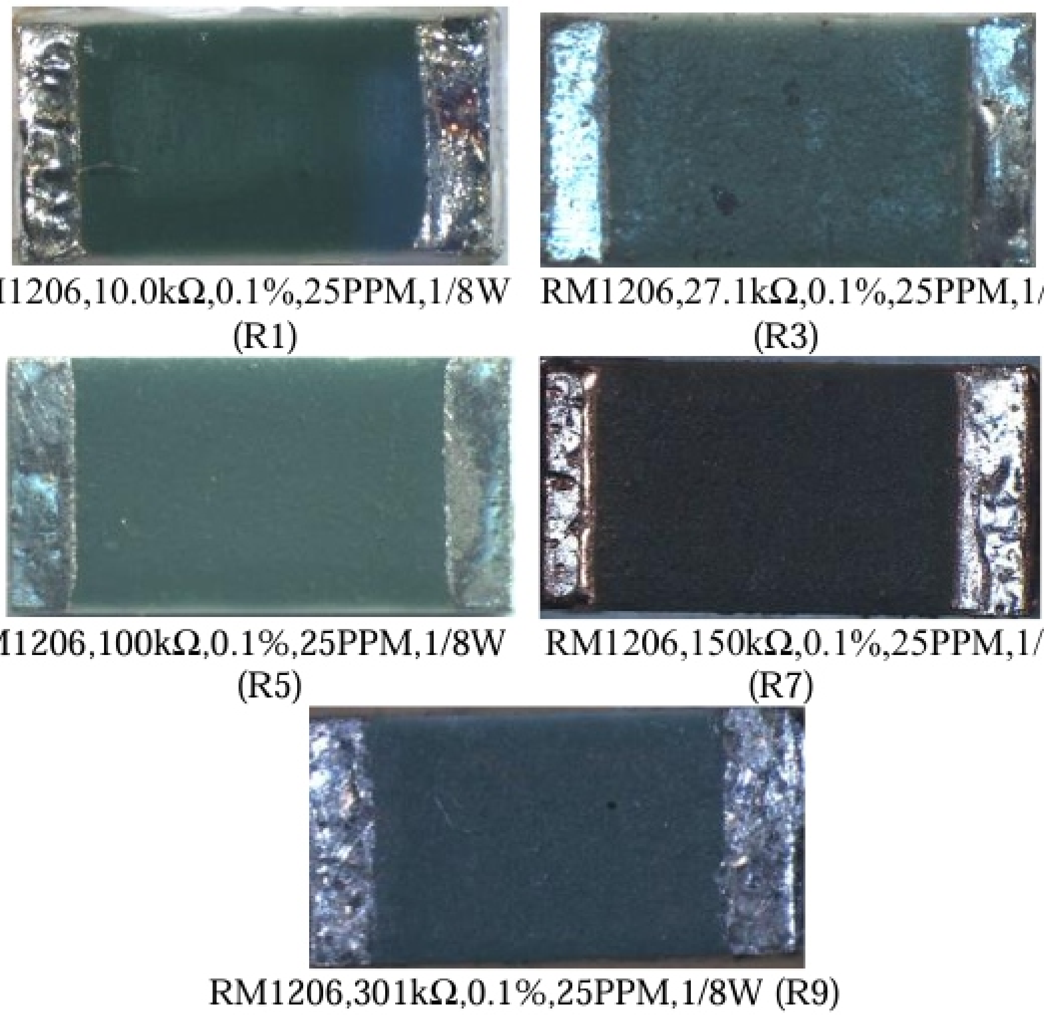

Figure-3: Optical Image of One Resistor from Each Value Shows no Visual Anomalies

b. EOS simulation study by Step Stress Method:

As per the data sheet voltage rating of thin film chip resistors RM1206, 0.1%, 25PPM, 1/8W is 100V. EOS simulation study was conducted on the chip resistors by applying voltage started from 100V up to 220V (>double the rating) in a step of 20V initially and then in a step of 10V after 180V. For lower values resistors, power dissipation limit, exceeded the specified limit from beginning of test, whereas for higher value resistors power dissipation limit exceeded with application of higher voltages. A Lambda make power supply (300V, 5A) was used for voltage application and a sixdigit multi-meter (make: Keysight, model: 34401A) was used for current measurement. The resistors were mounted on a card using reflow soldering and the terminations were connected with 26AWG wires (~5cm length) as a provision for voltage application. The results are shown in Table-3.

TABLE-3: EOS Simulation Test Result

Initial Values of Resistors in kΩ	**Applied Voltage in Volt (v), Voltage Applied for ~30sec and Gap between Voltage Application ~2 min**									**Remarks**
	100	120	140	160	180	190	200	210	220	
	Measure Current Across Each Resistor in mA									
9.992 (R1)	10.09	12.008	14.010	16.011	18.014	19.013	6.608	--	--	At application of 200V, resistance value changed to 28.750kΩ and current decreases appropriately.
10.009(R2)	9.911	11.891	13.874	15.856	17.838	18.830	4.197	--	--	At application of 200V, resistance value changed to 45.270kΩ and current decreases appropriately.
27.102(R3)	3.688	4.427	5.165	5.902	6.641	7.010	7.37	4.830	--	At application of 210V, resistance value changed to 41.4kΩ and current decreases appropriately.
27.098(R4)	3.69	4.428	5.166	5.904	6.642	7.011	7.38	5.025	--	At application of 210V, resistance value changed to 39.8kΩ and current decreases appropriately.
99.927(R5)	1.00	1.2	1.4	1.6	1.8	1.9	2.0	2.1	1.349	At application of 220V, resistance value changed to 155.6kΩ and current decreases appropriately.
99.981(R6)	1.00	1.2	1.4	1.6	1.8	1.9	2.0	2.1	2.2	The resistor did not degrade even after application of 220V.
150.075(R7)	0.666	0.799	0.932	1.066	1.199	1.266	1.332	1.399	1.465	The resistors did not degrade even after application of 220V.
150.098(R8)	0.666	0.799	0.932	1.066	1.199	1.266	1.332	1.399	1.465	
300.947(R9)	0.332	0.398	0.465	0.531	0.598	0.631	0.664	0.697	0.731	The resistors did not degrade even after application of 220V.
301.078(R10)	0.332	0.398	0.464	0.531	0.597	0.631	0.664	0.697	0.730	

NOTE: Resistor R3 and R4 were de-capped after simulation study and optical photograph revealed internal resistive patterns are melted and partially discontinued at certain location due to electrical overstress (refer figures-4 &5). However, this signature is not similar to moisture induced corrosion related failure.

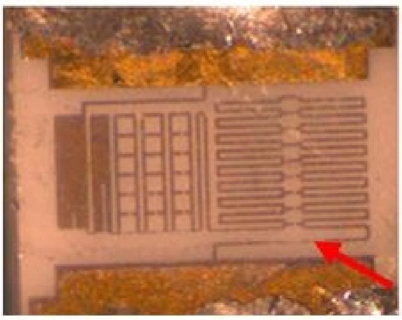

Figure-4: Localized Melting of Resistive Tracks of the Degraded Resistor R3

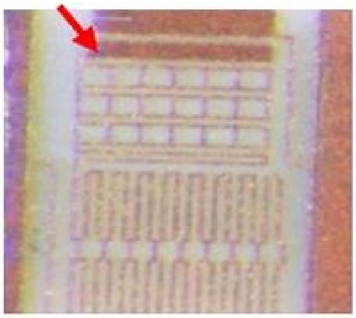

Figure-5: Localized Melting of Resistive Tracks of The Degraded Resistor R4

B. ESD Simulation Study on Discrete type Thin Film Chip Resistors RM1206, 0.1%, 25PPM, 1/8W (Few Values)

Electrostatic Discharge (ESD) is one of the very common failure causes in EEE components, happened due to improper testing/test procedures or handling. In order to find out the susceptibility of discrete thin film chip resistors towards electrostatic discharge, few chip resistors RM1206, 0.1%, 25PPM, 1/8W (different values) were subjected to ESD through step stress method. Following steps were adopted in the course of aforesaid simulation study.

a. Initial Visual Examination and Electrical Measurement of Chosen Components:

RM1206, 0.1%, 25PPM, 1/8W (four values, 5nos. each) were chosen for the study. Details about the components are shown in table-4.

TABLE-4: Components Details Taken for Simulation Study

Resistor Type	Resistance Value	Sample Nos.	Sample Marking
RM1206EB, ±0.1%, 25PPM, 1/8W	10.0kΩ	5nos.	R1 to R5
	20.0kΩ	5nos.	R6 to R10
	33.2kΩ	5nos.	R11 to R15
	301.00kΩ	5nos.	R16 to R20

Chip resistors were visually inspected using optical microscope at 100X. No visual anomalies were observed. Optical photographs of few chip resistors are shown in figure6. Values of the chip resistors were chosen based on the feedback from field failure data. Initial electrical test results of each resistor are shown in table-5.

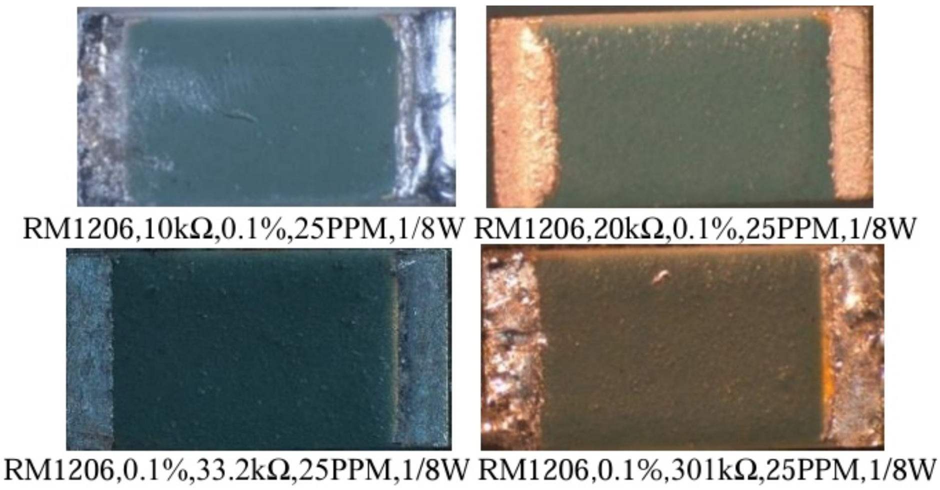

Figure-6: Optical Image of One Resistor from Each Value Shows no Visual Anomalies

TABLE-5: Initial Electrical Measurement Result of Chip Resistors

TABLE-5: Initial Electrical Measurement Result of Chip Resistors

Sample No.		Measured value in kΩ	Specified Limit in kΩ	Sample No.	Measured value in kΩ	Specified Limit in kΩ
R1		9.994	9.90 to 10.01	R11	33.178	33.166 to 33.233
R2		10.009		R12	33.182	
R3		10.008		R13	33.201	
R4		9.996		R14	33.198	
R5		10.005		R15	33.216	
R6		20.012	19.98 to 20.02	R16	300.947	300.699 to 301.301
R7		20.009		R17	301.078	
R8		20.010		R18	301.291	
R9		19.989		R19	301.105	
R10		19.995		R20	300.867	

b. ESD simulation Study by Step Stress Method:

To understand the effect of ESD on thin film chip resistors above resistors were subjected for ESD simulation study. Resistors above 10kΩ were chosen based on the feedback from reported failure. Almost 95% of chip resistor failed in open mode are having value ≥10kΩ. All the above resistors were hand soldered and mounted on the card with proper precautions. Wire termination (~5cm) was provided with each resistor for proper application of ESD stress. ESD pulses were applied with Human Body Model ESD simulator as per MIL-STD-883K method 3015.7. ESD pulses were applied by step stress method in a step of ±1000V starting from ±1000V. However, a final applied ESD pulse is shown for the sake of brevity. Pre and post-ESD resistance measurement was carried out on the chip resistors and the obtained test results are shown in table-6.

Table-6: ESD Simulation Test Results on RM1206 Chip Resistors

Resistor Type	Sl. No.	Measured Resistance (Initial)	Applied ESD Pulses (5 pulses)	Measured Resistance (Final)
RM1206 10.0kΩ 0.1% 1/8W-R	R1	9.998 kΩ	±6000V	9.998 kΩ
RM1206 10.0kΩ 0.1% 1/8W-R	R2	9.997 kΩ	±6000V	9.997 kΩ
RM1206 10.0kΩ 0.1% 1/8W-R	R3	10.003 kΩ	±6000V	10.003 kΩ
RM1206 10.0kΩ 0.1% 1/8W-R	R4	10.002 kΩ	±6000V	28.5 kΩ
RM1206 10.0kΩ 0.1% 1/8W-R	R5	9.996 kΩ	±6000V	9.996 kΩ
RM0505 20.0kΩ 0.1% 1/40W-S	R6	20.002 kΩ	±7000V	20.002 kΩ
RM0505 20.0kΩ 0.1% 1/40W-S	R7	20.005 kΩ	±7000V	48.7 kΩ
RM0505 20.0kΩ 0.1% 1/40W-S	R8	19.996 kΩ	±7000V	19.996 kΩ
RM0505 20.0kΩ 0.1% 1/40W-S	R9	19.997 kΩ	±7000V	19.997 kΩ
RM0505 20.0kΩ 0.1% 1/40W-S	R10	20.005 kΩ	±7000V	20.005 kΩ
RM1206 33.2kΩ 0.1% 1/8W-R	R11	33.202 kΩ	±8000V	33.202 kΩ
RM1206 33.2kΩ 0.1% 1/8W-R	R12	33.198kΩ	±8000V	33.198kΩ
RM1206 33.2kΩ 0.1% 1/8W-R	R13	33.197 kΩ	±8000V	33.197 kΩ

RM1206 33.2kΩ 0.1% 1/8W-R	R14	33.203 kΩ	±8000V	33.203 kΩ
RM1206 33.2kΩ 0.1% 1/8W-R	R15	33.202 kΩ	±8000V	33.202 kΩ
RM1206 301.0kΩ 0.1% 1/8W-S	R16	301.03kΩ	±8000V	301.03kΩ
RM1206 301.0kΩ 0.1% 1/8W-S	R17	300.99kΩ	±8000V	300.99kΩ
RM1206 301.0kΩ 0.1% 1/8W-S	R18	30.995kΩ	±8000V	30.995kΩ
RM1206 301.0kΩ 0.1% 1/8W-S	R19	301.06kΩ	±8000V	301.06kΩ
RM1206 301.0kΩ 0.1% 1/8W-S	R20	301.05kΩ	±8000V	301.05kΩ

NOTE: Resistor R4 was de-capped after simulation study and optical photograph revealed internal resistive pattern are melted and partially discontinued at certain location due to electrical overstress (refer figure-7). However, this signature is not similar to moisture induced corrosion related failure.

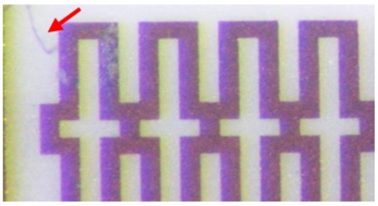

Figure-7: Localized Melting of Resistive Tracks of the Degraded Resistor R4

C. Electrostatic Discharge (ESD) Simulation Study on Die/Wire Bondable Type Thin Film Chip Resistors RM1206, 0.1%, 25PPM, 1/8W (Few Values)

Die/wire bondable type thin film resistors are being used in HMCs [10][11], wherein few resistors failed in open mode during screening/qualification test. Construction of die type thin film chip resistors is different from that discrete type thin film chip resistors. Die type chip resistors are silicon base, whereas, discrete type thin film chip resistors are ceramic (Al2O3) based. However, in both cases, the resistive element is same i.e., Nichrome thin film. After studying the ESD induced failure mechanism in discrete type thin film chip resistors, it was intended to understand the failure mechanism in die type thin film resistors w.r.t. ESD.

a. Initial Visual Examination and Electrical Measurement of Chosen Components:

Few die type thin film resistors of different values were chosen for the study. Details about the components are shown in table-7.

TABLE-7: Components Details Taken for Simulation Study

Resistance Value	Sample Nos.	Sample Marking
100Ω±0.1%	3nos.	R1 to R3
1.5kΩ±0.1%	3nos.	R4 to R6
12.0kΩ±0.1%	3nos.	R7 to R9
22.0kΩ±0.1%	3nos.	R10 to R12
56.0kΩ±0.1%	3nos.	R13 to R15
100.0kΩ±0.1%	3nos.	R16 to R18
240.0kΩ±0.1%	3nos.	R19 to R21
470.0kΩ±0.1%	3nos.	R22 to R24

NOTE: Chip resistors dice were visually inspected using optical microscope at 100X. No visual anomalies were observed.

b. ESD Simulation Study by Step Stress Method:

To understand the effect of ESD on die type thin film chip resistors, ESD simulation study was carried out by mounting the aforesaid resistor dice in 48 pins metallic HMC package and ESD pulses were applied between the HMC pins, which were connected internally to the pads of chip resistor dice. ESD pulses were applied with Human Body Model ESD simulator as per MIL-STD-883K method 3015.7. ESD pulses were applied with Human Body Model ESD simulator as per MIL-STD-883K method 3015.7. ESD pulses were applied by step stress method in a step of ±250V starting from ±500V. However, a final applied ESD pulse is shown in the table for the sake of brevity. Pre and post-ESD resistance measurement was carried out on the chip resistors and the obtained test results are shown in table-8.

Table-8: ESD Simulation Study Result

Resistor Sl. No.	Initial Value of Resistors	Applied ESD Pulses	Final Value of Resistors	Remarks
R1	99.98Ω	±500V,5pulses	99.98Ω	Failed in Open mode (Figure-8)
R2	99.97Ω	±750V,5pulses	99.97Ω	
R3	100.03Ω	±1000V,5pulses	Open	
R4	1.498kΩ	±500V, 5pulses	1.498kΩ	Failed in Open mode (Figure-9)
R5	1.501kΩ	±750V, 5pulses	1.501kΩ	
R6	1.499kΩ	±1000V,5pulses	Open	
R7	11.998kΩ	±500V, 5pulses	11.998kΩ	Failed in Open mode (Figure-10)
R8	11.999kΩ	±750V, 5pulses	11.999kΩ	
R9	11.997kΩ	±1000V,5pulses	Open	
R10	21.998kΩ	±500V, 5pulses	21.998kΩ	Failed in Open mode (Figure-11)
R11	22.002kΩ	±750V, 5pulses	22.002kΩ	
R12	21.997kΩ	±1000V, 5pulses	Open	
R13	55.998kΩ	±500V, 5pulses	55.998kΩ	
R14	55.999kΩ	±750V, 5pulses	55.999kΩ	Failed in Open mode (Figure-12)
R15	55.999kΩ	±1000V,5pulses	Open	
R16	99.999kΩ	±1000V,5pulses	301.003kΩ	Failed in Open mode (Figure-13)
R17	99.998kΩ	±1250V,5pulses	300.997kΩ	
R18	99.999kΩ	±1500V,5pulses	Open	
R19	239.999kΩ	±1000V,5pulses	239.999kΩ	Failed in Open mode (Figure-14)
R20	240.002kΩ	±1250V,5pulses	240.002kΩ	
R21	239.998kΩ	±1500V,5pulses	Open	
R22	999.998kΩ	±1500V,5pulses	999.998kΩ	Failed in Open mode (Figure-15)
R23	999.999kΩ	±1750V,5pulses	999.999kΩ	
R24	999.999kΩ	±2000V,5pulses	Open	

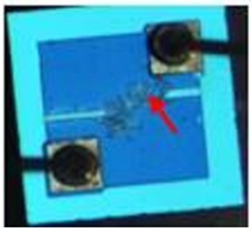

Figure-8: Discontinuity of thin Film track of resistor R3

Figure-9: Discontinuity of thin Film track of resistor R6

Figure-10: Discontinuity of thin film track of resistor R9

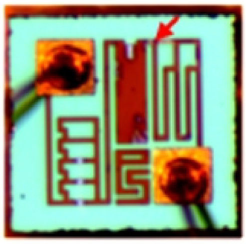

Figure-11: Discontinuity of thin film track of resistor R12

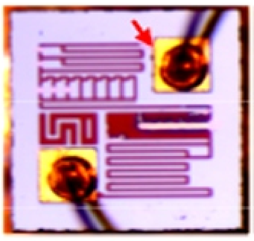

Figure-12: Discontinuity of thin film track of resistor R15

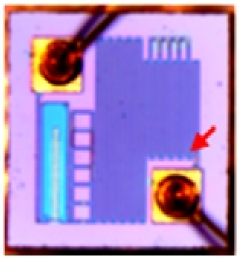

Figure-13: Discontinuity of thin film track of resistor R18

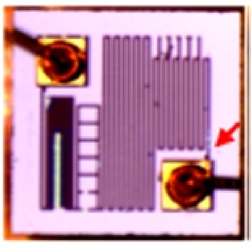

Figure-14: Discontinuity of Thin Film Track of Resistor R21

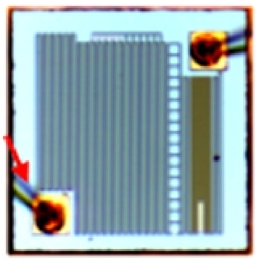

Figure-15: Discontinuity of Thin Film Track of Resistor R24

IV. RESULTS AND DISCUSSION

As discussed in section-A, Electrical Overstress (EOS) simulation study was conducted on discrete type thin film chip resistors Rm1206, 0.1%, 25PPM, 1/8W.

From EOS simulation study, it was inferred that the simulated resistors failed in open mode with application of voltage >twice the rated voltage (100V). Before open mode failure, resistance of the resistors appreciably increased. In this case, resistor pattern got distorted at certain location due to high dissipation, which resulted in increase in resistance value, but complete open mode failure was not observed. Failure mechanism in this case can be described as joules heating effect. This failure mechanism is not similar to that of manual soldering simulation explained in section-2, wherein resistor pattern near end cap region of chip resistor got completely eroded as a result of moisture/contaminant induced corrosion. Therefore, failure signature in chip resistor RM1206 as a result of manual soldering simulation did not match with that of EOS simulation.

As discussed in section-B, ESD simulation study was conducted on discrete type thin film resistor RM1206, 0.1%, 25PPM, 1/8W. From ESD simulation study, it is inferred that these types of resistors are not very sensitive to ESD. Only lower value resistors (10KΩ and 20KΩ) are susceptible at 6000V to 7000V ESD pulses, whereas higher value resistors (>20kΩ) did not show any susceptibility to ESD. Internal visual signature of ESD stressed chip resistor indicated localized distortion of resistive tracks at few locations, which is similar to that of EOS induced failure with same failure mechanism i.e., joules heating effect. Also, ESD induced resistors are failing in higher resistance mode not in complete open mode, which is also similar to that of EOS induced failures. As discussed in section-C, ESD simulation study was conducted on die type thin film resistor. From ESD simulation study, it is inferred that these types of resistors are very sensitive to ESD, wherein, the resistive thin film track got opened/discounted. Resistors values ≤55kΩ failed in open mode with ESD stress ≥1000V. Whereas higher value resistors failed with higher ESD stress such as 1500V and 2000V. Therefore, die type thin film resistors can be classified as class-1 ESD sensitive devices. Even though the resistive elements for both discrete type and die type thin film resistors are same i.e. Nichrome, the difference between them is their substrate. Discrete type thin film resistors have ceramic (alumina) substrate, whereas die type thin film resistor have silicon substrate. This indicates that ESD sensitivity of silicon based thin firm resistor is more than that of alumina based thin firm resistor. The reason behind the above observation could be probably due to higher electrical conductivity of silicon (~1.67x10-2 mho/cm), in comparison to that of ceramic (Alumina) (~10-14mho/cm). Because of higher electrical conductivity of Silicon, ESD pulse discharges un-disruptively thorough Silicon die by damaging the thin film resistive element. The same mechanism does not applicable to ceramic based thin film resistor because the ESD pulses disrupted and dissipated on the lesser conductive surface. However, more study is needed to understand the ESD sensitiveness of die type thin film resistors.

V. CONCLUSION

Controlled experiments were conducted to demonstrate effect of EOS and ESD on discrete type thin film resistor (RM1206 chip resistor, 0.1%, 25PPM, 1/8watt). From the study, it was understood that EOS simulated resistors failed in open mode with application of voltage >twice the rated voltage (100V), wherein, resistor pattern got distorted at certain location due to high dissipation, which resulted in increase in resistance value, but complete open mode failure was not observed. Similarly, from ESD simulation study, it is inferred that these types of resistors are not very sensitive to ESD. Only lower value resistors (10KΩ and 20KΩ) are susceptible at 6000V to 7000V ESD pulses. Internal visual signature of ESD stressed chip resistor indicated localized distortion of resistive tracks at few locations, which is similar to that of EOS induced failure. Also, ESD induced resistors are failing in higher resistance mode not in complete open mode, which is also similar to that of EOS induced failures. Controlled ESD simulation study on die type chip resistors has a different type of observation. From

ESD simulation study, it is inferred that these types of resistors are very sensitive to ESD, wherein, the resistive thin film track got opened/discounted. Resistors values ≤55kΩ failed in open mode with ESD stress ≥1000V. Whereas higher value resistors failed with higher ESD stress such as 1500V and 2000V. Therefore, die type thin film resistors can be classified as class-1 ESD sensitive devices. Even though the resistive elements for both discrete type and die type thin film resistors are same i.e. Nichrome, ESD sensitivity is different for both. Reason for the above reason could be explained in terms of conductivity of their base substrate, further experiment is under progress for in depth understanding.

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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Smart Artificial Intelligence System for Heart Disease Prediction

K Nagaiah

A B S T R A C T

Heart disease playing a vital role in human life, Early detection of heart-disease we can save humans lives and it remains a leading cause of mortality worldwide, making early and accurate prediction of heart disease a critical task for improving patient outcomes. Machine learning has shown great promise in this area, with various models being developed to predict heart disease based on a range of clinical and demographic features. However, there is a growing need for more efficient machine learning models that can accurately predict heart disease while minimizing computational costs, particularly in resource-constrained settings. This research paper proposes an efficient machine learning model for heart disease prediction that combines feature selection, model optimization, and interpretability techniques to achieve accurate predictions with reduced computational complexity. The proposed model utilizes a dataset of clinical and demographic features, such as age, sex, blood pressure, cholesterol levels, and other relevant risk factors, to train a machine learning model using a large real-world dataset. The proposed efficient machine learning model is evaluated on benchmark datasets and compared with other state-of-the-art models in terms of precision, Accuracy, Recall and F1- Score. The results demonstrate the model achieved by superior prediction performance to existing models. Proposed method accuracy increased by 4.8%

Keywords : Heart Disease, Machine Learning, SVM, Decision Tree, Logistic Regression, Accuracy, Sensitivity.

I. INTRODUCTION

Globally, cardiovascular disease (CVD) stands as the predominant contributor to both morbidity and mortality, constituting over 70% of all reported fatalities. As indicated by the 2017 Global Burden of Disease research findings, cardiovascular disease accounts for approximately 43% of total deaths [1][2][25][26][27]. Notably, high-income nations commonly grapple with heart disease risk factors such as poor dietary habits, smoking, excessive sugar intake, and obesity [3] [4][23][24]. Nevertheless, low- and middle-income countries also witness a surge in the prevalence of chronic illnesses [5]. Over the period from 2010 to 2015, the projected global economic burden attributable to cardiovascular diseases was estimated to approach USD 3.7 trillion [6] [7] (Mozaffarian et al., 2015; Maiga et al., 2019). Moreover, technologies such as electrocardiograms and CT scans, crucial for diagnosing coronary heart disease, are at times prohibitively expensive and impractical for consumers. This factor alone has led to the unfortunate demise of 17 million individuals [5]. A significant portion, ranging from twenty-five to thirty percent, of companies' yearly medical expenditures is attributed to employees suffering from cardiovascular disease [8]. Consequently, early detection of heart disease becomes imperative to mitigate both its physical and financial toll on individuals and institutions. According to the World Health Organization's projection, the global fatalities from cardiovascular diseases (CVDs) are anticipated to escalate to 23.6 million by 2030, with heart disease and stroke standing out as the primary causes [9]. Taking action to save lives and alleviate the economic burden is crucial. In the realm of societal well-being, it is imperative to employ data mining and machine learning techniques for pre-emptively gauging the likelihood of individuals developing heart disease. Cardiovascular disease

(CVD), specifically, stands as a predominant cause of morbidity and mortality on a global scale, constituting over 70% of all reported deaths. The Global Burden of Disease Study in 2017 reveals that CVD alone contributes to more than 43% of the total fatalities. Key factors commonly linked to heart disease encompass detrimental dietary habits, tobacco use, excessive sugar consumption, and the presence of excess body weight or fat, prevalent especially in high-income nations. Nonetheless, there is a notable rise in the incidence of chronic diseases in low- and middle-income countries as well. The economic impact of CVDs worldwide has been appraised at around USD 3.7 trillion during the period from 2010 to 2015.

Moreover, crucial medical devices like electrocardiograms and CT scans, necessary for identifying coronary heart disease, are frequently unaffordable and impractical for numerous low- and middle-income countries. Consequently, early detection of heart disease becomes paramount to alleviate both the physical and financial burdens on individuals and organizations. A World Health Organization (WHO) report predicts that by 2030, the total deaths from cardiovascular diseases (CVDs) will surge to 23.6 million, primarily attributable to heart disease and stroke. Hence, employing data mining and machine learning techniques to anticipate the likelihood of developing heart disease is imperative for saving lives and mitigating the economic strain on society. In the medical realm, a copious amount of data is generated daily through data mining techniques, revealing concealed patterns applicable to clinical diagnosis [10].

Undoubtedly, data mining assumes a pivotal role in the medical field, as evidenced by decades of research and implementation. Numerous factors, including diabetes, high blood pressure, elevated cholesterol, and irregular pulse rate, must be taken into account when forecasting heart disease [11]. Frequently, available medical data require supplementation, impacting the accuracy of heart disease predictions.

Machine learning holds a pivotal role within the realm of medicine, contributing significantly to diagnostic, detection, and predictive capabilities for various diseases. The integration of data mining and machine learning methodologies has garnered increased attention, particularly in forecasting the likelihood of developing specific medical conditions. Previous endeavors have applied data mining techniques to predict diseases, yet the quest for accurate results in forecasting the progression of ailments remains a challenge [12].

This paper focuses on the precise prediction of heart disease occurrence in the human body. Our research delves into evaluating the efficacy of diverse machine learning algorithms for predicting heart disease. To attain this objective, we employed a range of techniques, encompassing random forest [13], decision tree classifier, multilayer perceptron, and XGBoost [14]. The enhancement of model convergence involved the application of k-modes clustering for dataset preprocessing and scaling. The study utilized a publicly available dataset on Kaggle, and all computational, preprocessing, and visualization tasks were executed on Google Colab using Python.

While previous studies have reported accuracy rates of up to 94% in heart disease prediction using machine learning techniques [15], these findings often stem from analyses with limited sample sizes, potentially hindering generalizability to broader populations. Our research seeks to overcome this limitation by employing a larger and more diverse dataset, with the expectation that it will enhance the overall generalizability of the results.

algorithm as a promising option for future research.

Hasan and Bao (2020) [20][21] [22] conducted a study aimed at identifying the most effective feature selection approach for predicting cardiovascular illness by comparing multiple algorithms. The investigation initially considered three well-known feature selection methods—filter, wrapper, and embedding. Subsequently, a feature subset was derived from these algorithms using a Boolean process with a common "True" condition. This technique involved a two-stage process to retrieve feature subsets.

To assess comparative accuracy and determine the optimal predictive analytics, various models such as random forest, support vector classifier, k-nearest neighbors, naive Bayes, and XGBoost were incorporated. The artificial neural network (ANN) served as the standard for comparison with all features. The results revealed that The XGBoost classifier, when combined with the wrapper technique, yielded the most precise prediction results for cardiovascular illness. XGBoost achieved an accuracy rate of 73.74%, surpassing SVC at 73.18% and ANN at 73.20%.

III. PROPOSED METHOD

In this methodology we implemented three machine learning algorithms. SVM, Decision tree and logistic regression.

Logistic regression Binary Classification: Logistic regression is a commonly employed method for addressing binary classification challenges, where the target variable exhibits two categorical classes (e.g., 0 or 1, true or false, yes or no). Its efficacy is particularly notable when dealing with dichotomous dependent variables.

Probability Estimation: Logistic regression not only categorizes observations into one of two classes but also furnishes probabilities for the likelihood of a specific event occurring. This allows for the estimation of the probability of an observation belonging to a particular class. Interpretability: The coefficients within logistic regression lend themselves to interpretation in terms of odds ratios. This facilitates a clearer understanding of how each predictor variable influences the probability of the event taking place.

Linear Decision Boundary: Logistic regression models presuppose a linear relationship between independent variables and the log-odds of the dependent variable. This linear decision boundary proves advantageous in scenarios where the relationship approximates linearity. Efficiency and Simplicity: Logistic regression boasts computational efficiency, demanding fewer computational resources compared to more intricate algorithms. Its implementation is also relatively straightforward and user-friendly.

Feature Importance: Logistic regression aids in discerning crucial features within a dataset. Examining the coefficients assigned to each variable provides insights into their respective contributions to the prediction. Well-Suited for Small Datasets: Even with limited data, logistic regression can exhibit robust performance, making accurate predictions without necessitating an extensive dataset. Wide Range of Applications: Logistic regression finds applications across diverse fields, including medicine (predicting disease presence or absence), marketing (customer churn prediction), finance (credit scoring), and beyond.

Regularization Techniques: Logistic regression can benefit from regularization techniques such as L1 and L2 regularization, mitigating overfitting and enhancing generalization to new data. Building Blocks for Complex Models: Serving as a foundational element, logistic regression often acts as a baseline model and its principles extend into more advanced machine learning techniques.

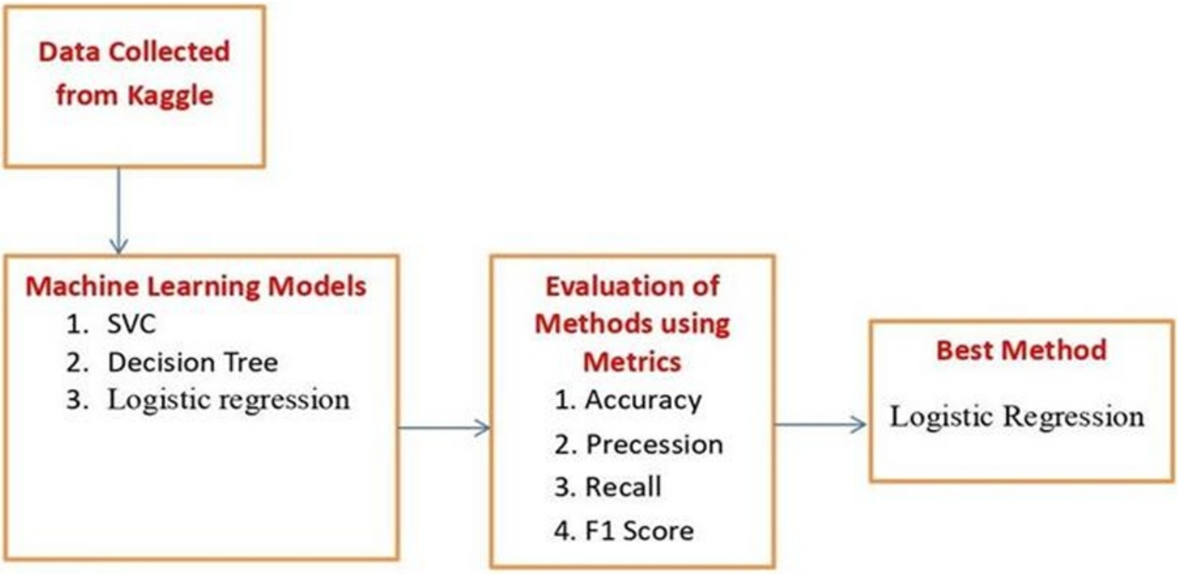

Fig. 1: Proposed Methodology

In this methodology we have collected the data set from kaggle resource.then we identified the machine learning algorithms which is suitable for this dataset with this features. Awe implemented the three powerful algorithms which are svm,logistic regression and decision tree. The evaluation process done based on the matrix like accuracy, sensitivity, specificity, recall and F1_score.

Implementation Process.

1. Importing the libraries
2. Load the dataset
3. Taking care of missing values
4. Taking care of duplicate values
5. Data processing
6. Encoding categorical data
7. Feature Scaling
8. Split the dataset into the training and Testing
9. Applying the models
10. Evaluation based on Metrics
11. We developed GUI also.

A. Dataset Details Used in This Work

DATASET DETAILS
It Consists Of 13 Feature And Two Outputs
1 Normal And
2 Possible To Get Heart Disease 302 PATIENT DATA

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

Fig. 2: Dataset Sample

This work implemented by using Jupiter notebook with only Few libraries and functions. Pandas and sk learn library. Data cleaning, Pre-processing, data splitting training and testing. Model implementation and getting the result and evaluate it.

F1_Score = 2*Recall*Precision /(Recall + Precision)

Precision = TP/(TP+FP) Recall = TP/(TP+FN)

Accuracy = TP+TN/(TP+TN+FP+FN)

These parameters calculated Based on the output confusion matrix.

IV. PERFORMANCE EVALUATION

Classifiers output analysis

Table 1: Comparison of Classifier Output

S no	Classifier	Proposed Model accuracy%	Existing ref 1 Accuracy%	Existing ref 2 Accuracy%
1	Logistic Regression	90.16	78	79.01
2	SVM	86.88	83.2	80.2
3	Decision Tree	75.4	79	75.8

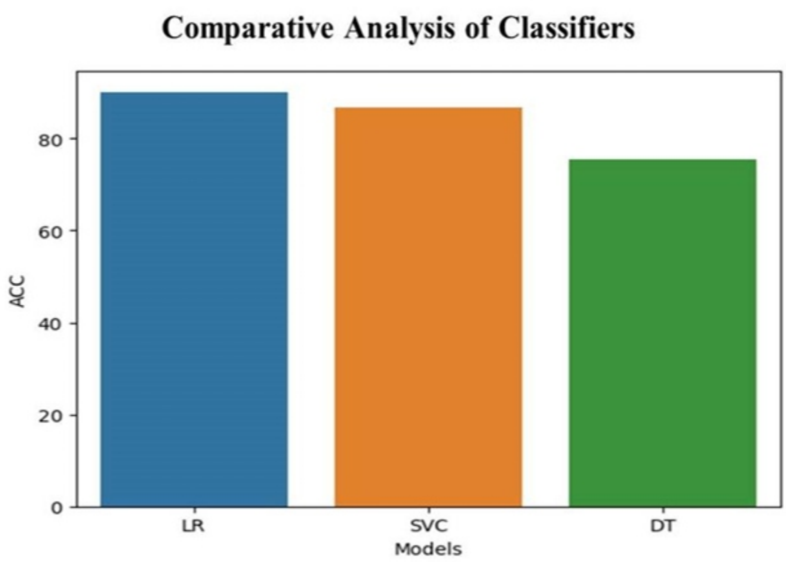

Fig. 3: Comparison of Classifiers Accuracy Web Based GUI System

We can enter the features based on that it.

WE DEVELOPED GUI SYSTEM

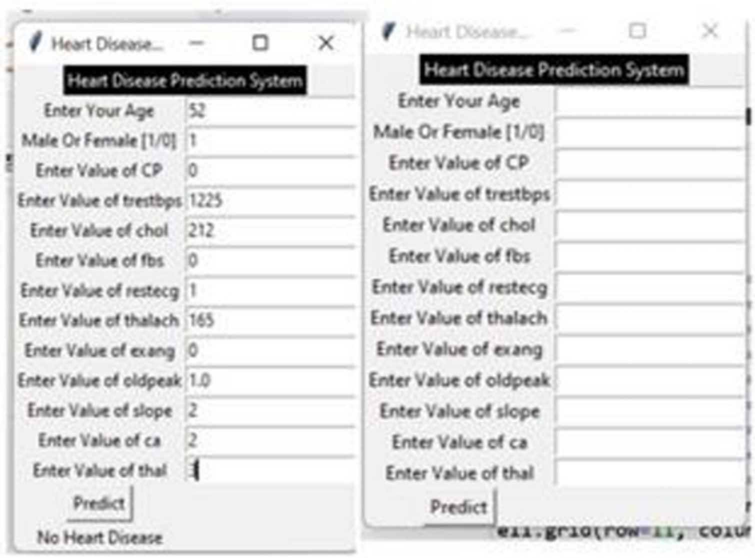

Fig. 4: Sample GUI Output

Table 2: Comparison of Different Authors References and Proposed Method Accuracies

Author	Novel Approach	Accuracy
Shorewall, 2021 [5]	Stacking of KNN, random forest, and SVM outputs with logistic regression as the metaclassifier	75.10% (stacked model)
Maiga et al., 2019 [7] -	Random forest -Naive Bayes -Logistic regression -KNN	70%
Waigi at el., 2020 [12]	Decision tree	72.77%
Our and ElSeddawy, 2021 [21]	random forest	89.01%
Khan and Mondal, 2020 [22]	Holdout cross-validation with the neural network for Kaggle dataset	71.82%
Proposed	**Logistic Regression**	**90.17**

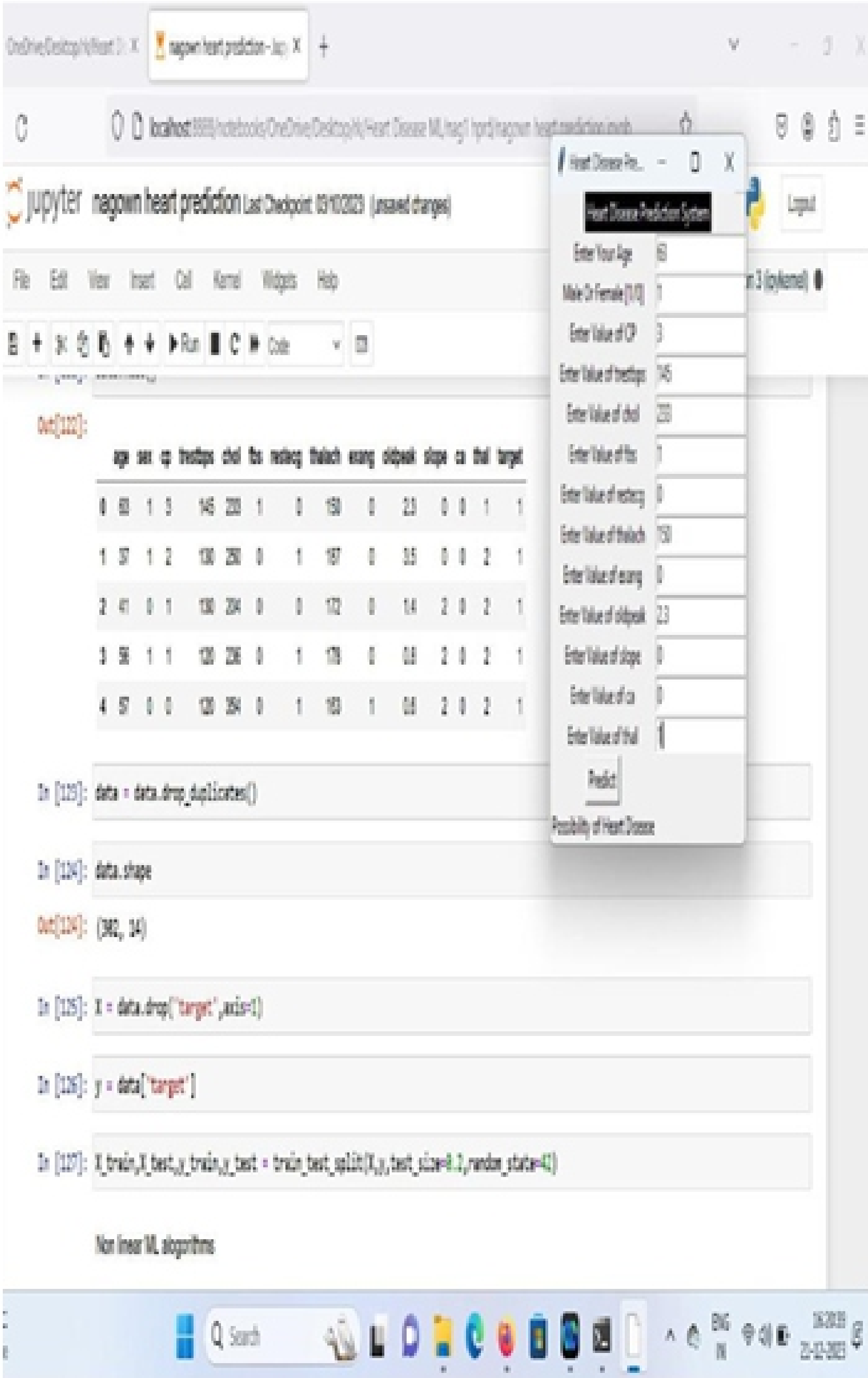

Fig. 5: Webpage Output Prediction

Table 3: Comparison of Existing and Proposed Model Parameters

Model Existing	Accuracy	Precision	Recall	F1-Score	AUC
MLP	87.28	88.7	84.85	86.71	0.95
RF	87.05	89.42	83.43	86.32	0.95
DT	86.37	89.58	81.61	85.42	0.94
XGB	86.57	88.93	83.57	86.16	0.95
Proposed Model	Accuracy	Precision	Recall	F1-Score	AUC
Logistic Regression	**90.17**	93.13	87.9	90.4	0.97

With this we can conclude that these LR algorithm produced best outcome for this dataset. We developed GUI also That is graphical user interface. With this the applicant has the medical report data about the parameters. He can just enter it and he gets the output whether he is the possibility of heart disease or not.

V. CONCLUSSION

We have implemented 3 Machine Learning Models Based on Output Logistic regression has given best results. If we observe the out comes logistic regression accuraqcy incresed by the previous researchers 2.15% to 20 % ,precision incresed by 9%, recall incresed by 4% and F1 Score incresed bt 3.5%. The Best model offers a promising approach to identify individuals at risk of developing heart disease. The dataset contains 13 features and 302 patient data. By using these techniques we can save human lives for early detection. It has potential to improve patient outcomes, reduce healthcare costs, and contribute to better human health management. The proposed method has given best results compared to the existing methods. Future scope further better algorithms with new functions and libraries to be investigated to get better accuracy and area under the curve should be high.

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material	Not relevant.
Authors Contributions	I am only the sole author of the article.

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