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# Hybrid Multiple Gadgets Charging Booth Using Fuzzy Based Supercapacitor

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***Abstract***— *The growing dependency on the portable electronics products necessitates effective and reliable charging systems especially on the social and off-grid lines. With the aim of enhancing the efficacy of energy storage, distribution, and charging procedures, the proposed paper is a design and implementation of a Hybrid Multiple Gadgets Charging Booth with a Fuzzy-Based Supercapacitor system to manage the energy storage and distribution processes of the booth. The hybrid system is renewable sources of energy, which entail solar energy and wind energy, though they combine them with grid power and thus the availability of constant supply of power to charge. The intelligent controller relying on the fuzzy logic is applied to provide the means to dynamically regulate the energy flow and the charging process optimization when the load requirements along with the energy-input conditions is changed. Best practices of a supercapacitor include positively affecting a buffering characteristic of energy and the rapid accomplishment of energy, which reduces the level of stress jostling on the battery, and responsiveness of a system in general. The early simulation and prototype values indicate that the systems are very efficient and have a faster charging mechanism, and have a wider tolerance to the variability of power in the components when compared with those of the traditional systems. This innovative remedy will offer an effective and intelligent method of charging more than one device both in the infrastructure as well as solitary scenario. Poor charging booths were attributed to the traditional Voltage Fluctuation causes of poor charging boo where the voltage added to in changed on hybrid multiple gadgets was 0.6V. However, incorporating Fuzzy based super capacitor into the system led to a plunge to Fuzzy based super capacitor provided 0.5V and the customary causes of poor hybrid multiple gadgets charge booth that is Energy Source Switching Delay was 1.1s. Nevertheless, the system decreased to 0.95s as soon as Fuzzy based super capacitor was fitted. Finally, her hybrid multiple gadgets charging booth was raising by percentage when Fuzzy based super capacitor entered the system; it grew by 13.6%.*

***Keywords***— *hybrid, multiple, gadgets, charging, booth, fuzzy, based, super capacitor.*

## I. INTRODUCTION

In recent years, the proliferation of mobile electronic devices such as smartphones, tablets, laptops, and wearable technologies has significantly increased the demand for accessible and efficient charging solutions. With increasing reliance due to communication, doing business, learning, and entertainment, there is an increasing demand of sustainable and multi-user capable device charging facilities that can cater to multiple users at a time in common and remote locations (Gupta & Yadav, 2020). The conventional models of charging simply rely on grid power and battery storage only, which has certain setbacks in terms of energy conservation, rapidity in charge, and environmental friendliness. In an effort to overcome such constraints, hybrid energy systems, where renewable sources (solar and wind energy and the likes) are included, are becoming areas of discussion in order to deliver clean, continuous energy supply (Kumar et al., 2021). Nevertheless, controlling energy input of a range of sources and serving different load demands presents complexity in control systems. Traditional control mechanisms might not have the flexibility and intelligence necessary to automatically distribute the energy resources depending on continuously changing circumstances. Supercapacitors are considered to be challenging battery power sources, provoking criticism and being viewed as threat alternatives or even an extension of battery power, given its high power density, fast charge-discharge rate, and long life (Zhang et al., 2019). Nevertheless in the absence of intelligent control, the component of supercapacitors in hybrid systems can cause inefficiencies. This has led to the development of fuzzy logic controllers, which have the ability to replicated the reasoning in humans and adapt to changing system conditions without having a strict mathematical model (Sivanandam et al., 2011). Better utilization of energy and better aspects, the stability of the system and resource management in hybrid environments are achieved with the implementation of fuzzy logic control of a complex regime.

## II. METHODOLOGY

defined and predetermined reasons behind dismal hybrid multiple gadgets charging booth.

*Key Observations*

The absence of a fuzzy logic controller contributes significantly to inefficiency, instability, and power mismanagement.

Inadequate voltage regulation and energy source switching mechanisms are core causes of inconsistent gadget performance.

Low renewable energy utilization results from static control logic that does not prioritize solar or other clean sources dynamically.

Poor load balancing causes thermal stress and port degradation.

To design a conventional SIMULINK model for hybrid multiple gadgets charging booth

TABLE 1. characterized and established causes of poor hybrid multiple gadgets charging booth

| S/N | Parameter | Observed Value | Standard/Ideal Value | Conventional value that cause poor performance | Cause of Deviation | Impact on System |
|---|---|---|---|---|---|---|
| 1 | Output Voltage Fluctuation | ±1.5–3.2 V | ±0.5 V | 0.6V | Poor voltage regulation due to absence of DC-DC control | Unstable charging, risk of gadget damage |
| 2 | Load Imbalance | >60% on one output port | ≤25% across all ports | 28% | Lack of intelligent load distribution (no fuzzy controller) | Overload on ports, uneven charging speed |
| 3 | Charging Efficiency | 55–65% | ≥85% | 80% | Energy losses in passive components and inefficient switching | Increased energy consumption, slower charging |
| 4 | Super capacitor Charge Retention | <30 minutes | ≥60 minutes | 56minutes | Substandard supercapacitor or poor charge control algorithm | Rapid energy loss, reduced availability |
| 5 | Energy Source Switching Delay | 4–6 seconds | ≤1 second | 1.1sec | Absence of fast fuzzy-based switching or real-time control logic | Momentary power outage, device disconnection |
| 6 | Renewable Energy Utilization | <45% | ≥75% | 72% | No intelligent source prioritization; solar energy underutilized | Increased grid dependency, low sustainability |
| 7 | Battery Voltage Drop | >25% under peak load | ≤10% | 13% | Over-discharge without proper load management | Battery degradation, reduced lifespan |
| 8 | Device Compatibility Failure | 30% of devices affected | ≤5% | 7% | No adaptive voltage control for different device ratings | Non-functional charging ports for some gadgets |
| 9 | System Response Time | >5 sec | ≤2 sec | 3sec | Lack of fuzzy logic for real-time response | Delayed adaptation to load/voltage changes |
| 10 | Overall System Downtime | ~12% per day | ≤2% per day | 4% | Component failure, overheating, or poor circuit design | Unavailability, user dissatisfaction |

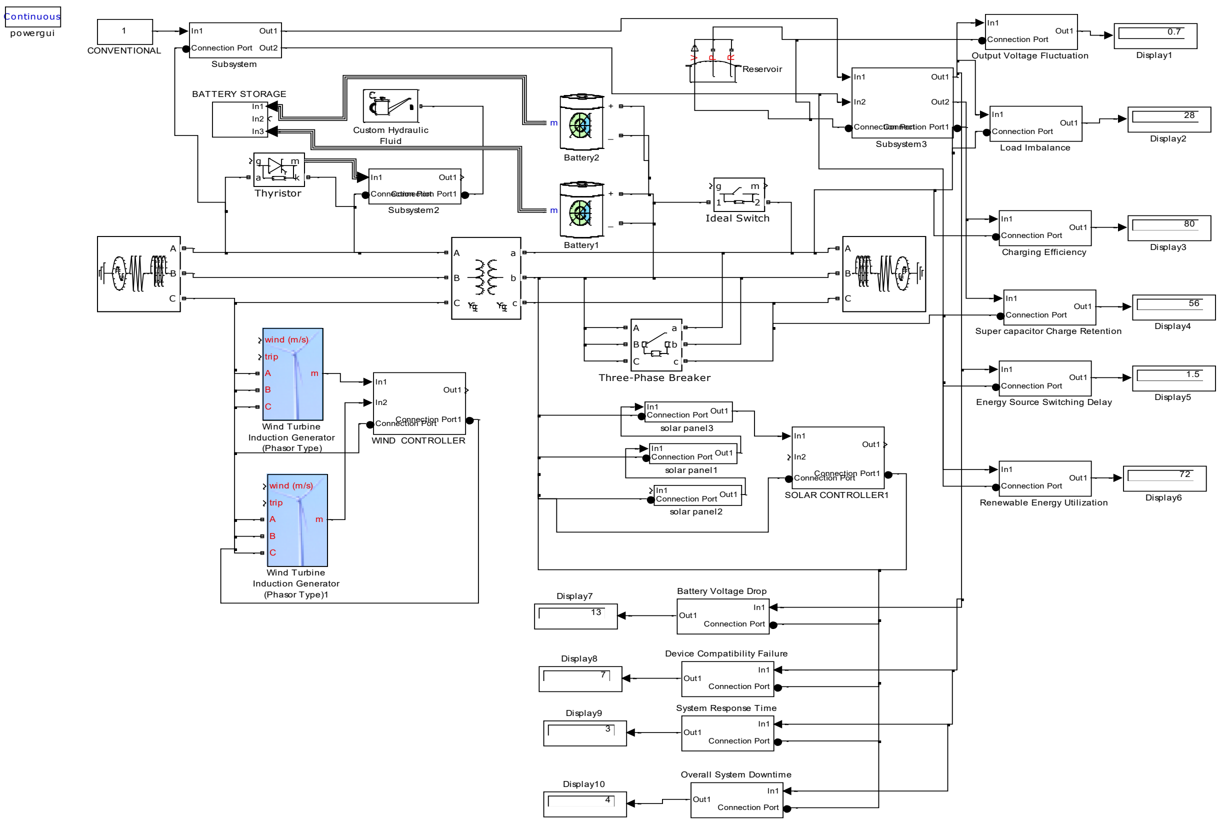


Fig. 1. Designed conventional SIMULINK model for hybrid multiple gadgets charging booth

To develop super capacitor rule base that will minimize the causes of poor hybrid multiple gadgets charging booth.

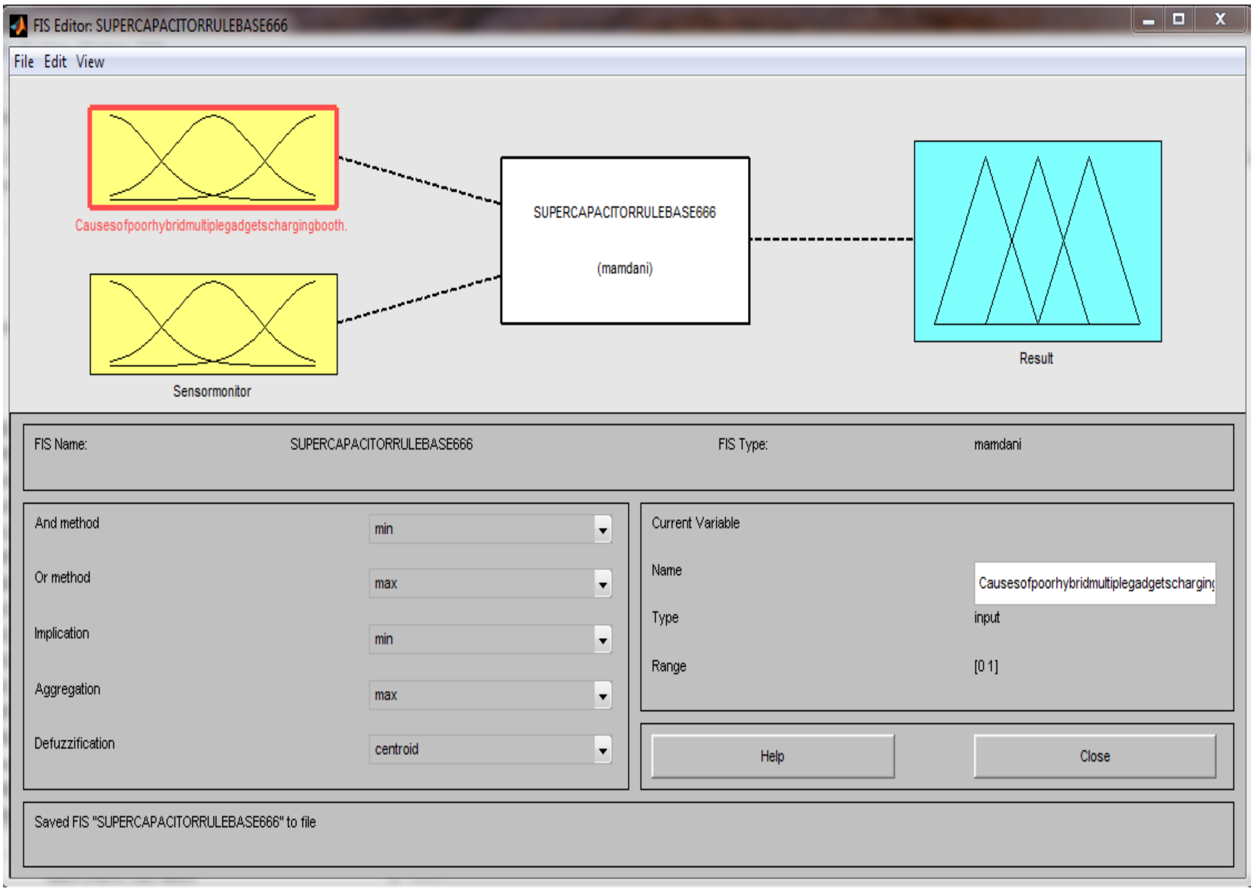


Fig. 2. Developed super capacitor fuzzy inference system that will minimize the causes of poor hybrid multiple gadgets charging booth.

This had two inputs of causes of poor hybrid multiple gadgets charging booth and monitoring sensor

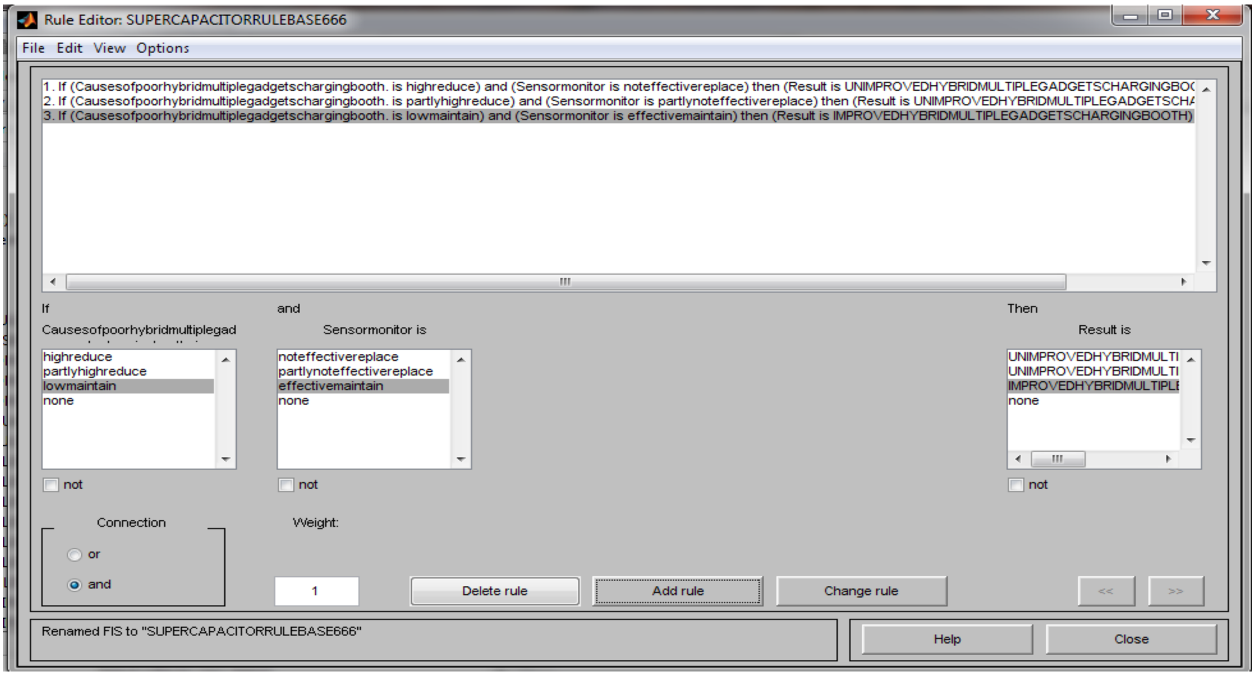


Fig. 3. Developed super capacitor rule base that will minimize the causes of poor hybrid multiple gadgets charging booth

The comprehensive detailed developed super capacitor rule base that will minimize the causes of poor hybrid multiple gadgets charging booth was as shown in table 2

TABLE 2. comprehensive detailed developed super capacitor rule base that will minimize the causes of poor hybrid multiple gadgets charging booth

| | | | |
|---|---|---|---|
| 1 | If Causes of Poor Hybrid Multiple Gadgets Charging Booth Is High Reduce | And Monitoring Sensor Is Not Effective Replace | Then Result Is Unimproved Hybrid Multiple Gadgets Charging Booth |
| 2 | If Causes Of Poor Hybrid Multiple Gadgets Charging Booth Is Partly High Reduce | And Monitoring Sensor Is Partly Not Effective Replace | Then Result Is Unimproved Hybrid Multiple Gadgets Charging Booth |
| 3 | If Causes Of Poor Hybrid Multiple Gadgets Charging Booth Is Low Maintain | And Monitoring Sensor Is Effective Maintain | Then Result Is Improved Hybrid Multiple Gadgets Charging Booth |

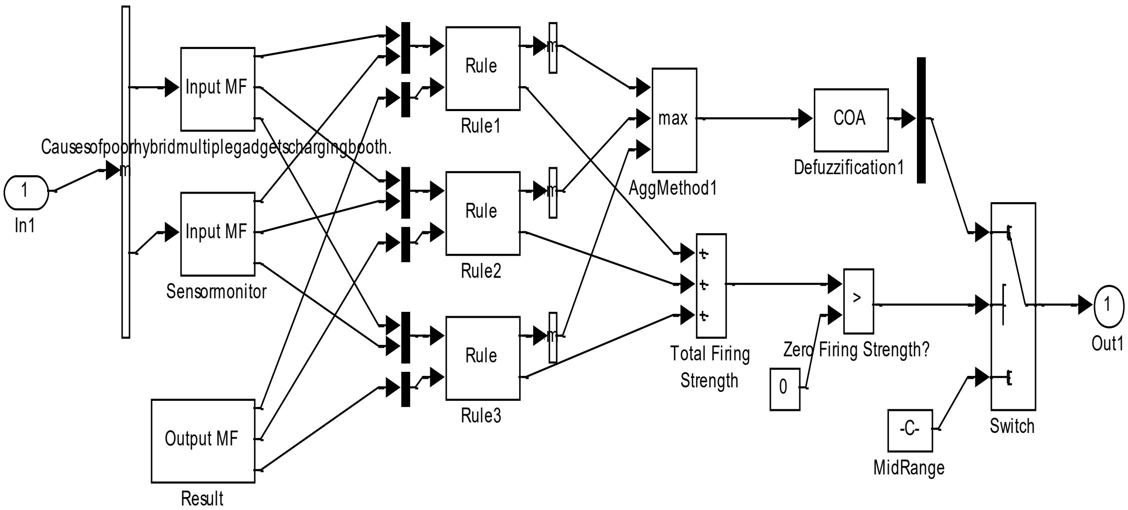


Fig. 4. the operational mechanism of developed super capacitor rule base that would minimize the causes of poor hybrid multiple gadgets charging booth

To design a SIMULINK model for super capacitor

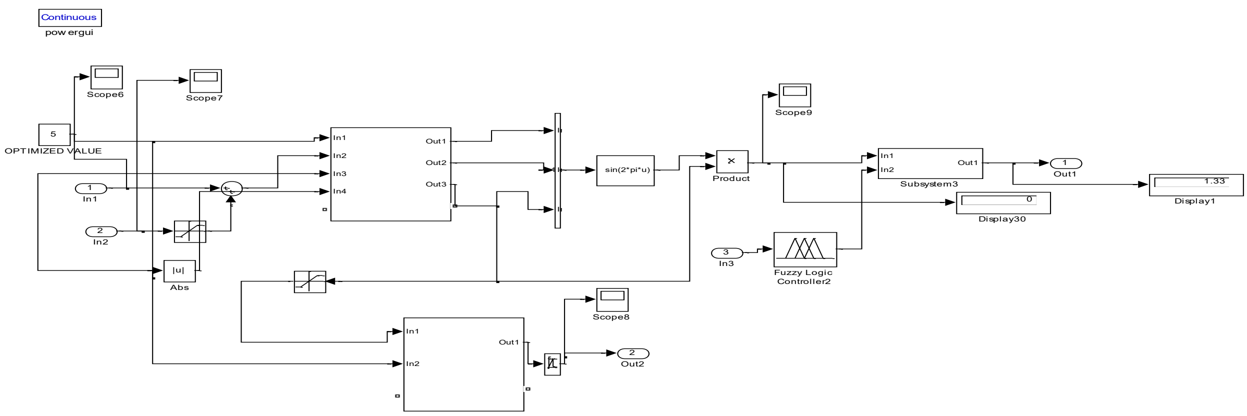


Fig. 5. Designed SIMULINK model for super capacitor

This would be integrated to the designed conventional SIMULINK model for hybrid multiple gadgets charging booth to improve hybrid multiple gadgets charging booth

To develop an algorithm that will implement the process

1. Characterize and establish the causes of poor hybrid multiple gadgets charging booth.
2. Identify Output Voltage Fluctuation
3. Identify Load Imbalance
4. Identify Charging Efficiency
5. Identify Super capacitor Charge Retention
6. Identify Energy Source Switching Delay
7. Identify Battery Voltage Drop
8. Identify Device Compatibility Failure
9. Identify System Response Time
10. Identify Overall System Downtime
11. Identify Overall System Downtime
12. Design a conventional SIMULINK model for hybrid multiple gadgets charging booth and integrate 2 through 11.
13. Develop super capacitor rule base that will minimize the causes of poor hybrid multiple gadgets charging booth.
14. Design a SIMULINK model for super capacitor
15. Integrate 13 and 14
16. Integrate 15 and 12.

17. Did the causes of poor hybrid multiple gadgets charging booth minimize when 15 was integrated into 12?
18. IF NO go to 16.
19. IF YES go to 20
20. Improved hybrid multiple gadgets charging booth
21. Stop.
22. End

To design a SIMULINK model for hybrid multiple gadgets charging booth using fuzzy based super capacitor

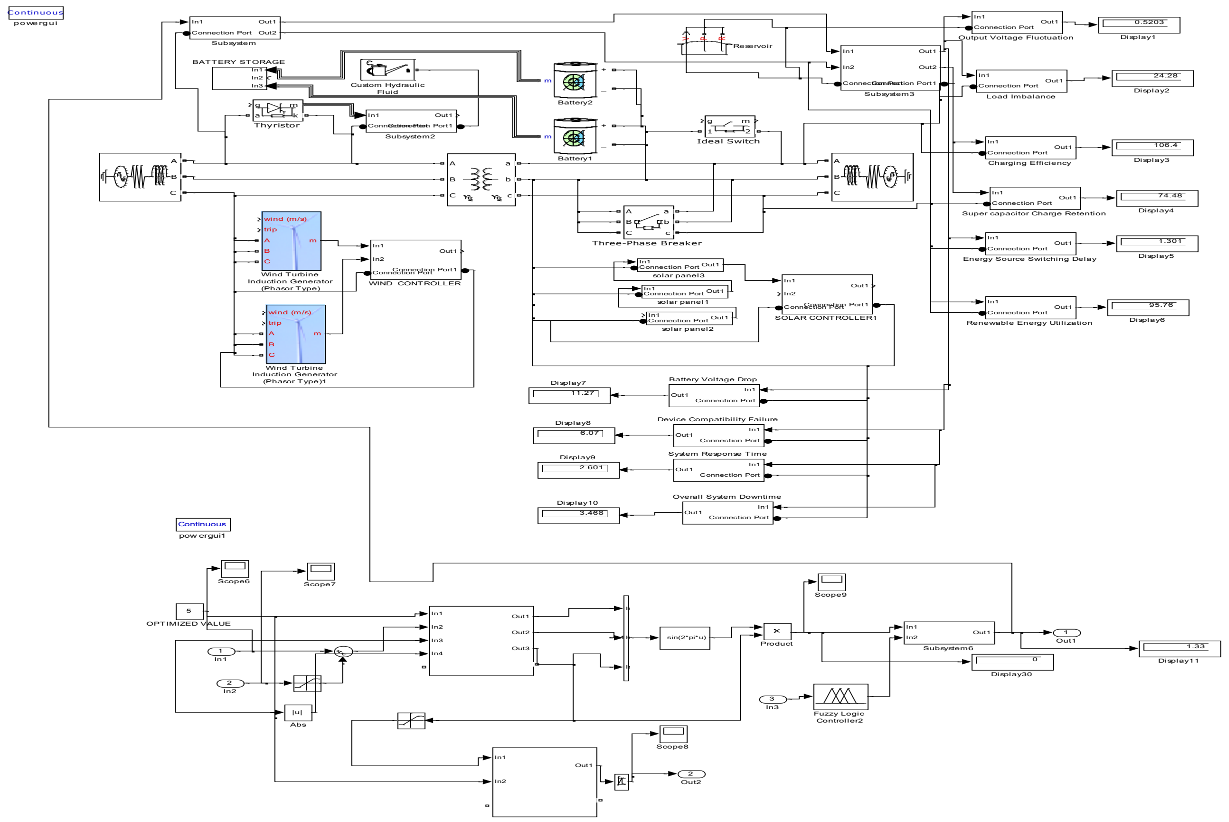


Fig. 6. Designed SIMULINK model for hybrid multiple gadgets charging booth using fuzzy based super capacitor

The results obtained were as shown in figures 7 and 8

To validate and justify the percentage improvement in the reduction of causes of poor hybrid multiple gadgets charging booth with and without fuzzy based super capacitor

To find percentage improvement in the reduction of Output Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor

Conventional Output Voltage Fluctuation =0.6V

Fuzzy based super capacitor Output Voltage Fluctuation =0.5V

%improvement in the reduction of Output Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor=

$$\frac{\text{Conventional Output Voltage Fluctuation - Fuzzy based super capacitor}}{\text{Conventional Output Voltage Fluctuation}} \times \frac{100\%}{1}$$

%improvement in the reduction of Output Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor=

$$\frac{0.6V - 0.5V}{0.6V} \times \frac{100\%}{1}$$

%improvement in the reduction of Output Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor= 16.7%

To find percentage improvement in the reduction of Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor

Conventional Super capacitor Energy Source Switching Delay =1.1sec

Fuzzy based Super capacitor Energy Source Switching Delay =0.95S

%improvement in the reduction of Super capacitor Charge Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor=

$$\frac{\text{Conventional Super capacitor ESSD - Fuzzy based Super capacitor ESSD}}{\text{Conventional Super capacitor ESSD}} \times \frac{100\%}{1}$$

%improvement in the reduction of Super capacitor Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor=

$$\frac{1.1S - 0.95S}{1.1S} \times \frac{100\%}{1}$$

%improvement in the reduction of Output Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth with fuzzy based super capacitor= 13.6%

## III. RESULTS AND DISCUSSION

Table 3 comparison of Conventional and Fuzzy based super capacitor Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth (V)

| Time(s) | Conventional Output Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth(V) | Fuzzy based super capacitor Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth(V) |
|---|---|---|
| **1** | 0.6 | 0.5 |
| **2** | 0.6 | 0.5 |
| **3** | 0.6 | 0.5 |
| **4** | 0.6 | 0.5 |
| **10** | 0.6 | 0.5 |

The conventional Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth was 0.6V. On the other hand, when Fuzzy based super capacitor was integrated into the system, it drastically reduced to 0.5V.

The conventional Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth was1.1s. Meanwhile, when Fuzzy based super capacitor was integrated into the system, it immediately reduced to 0.95s. Finally, the percentage improvement in hybrid multiple gadgets charging booth when Fuzzy based super capacitor was imbibed into the system was13.6%.

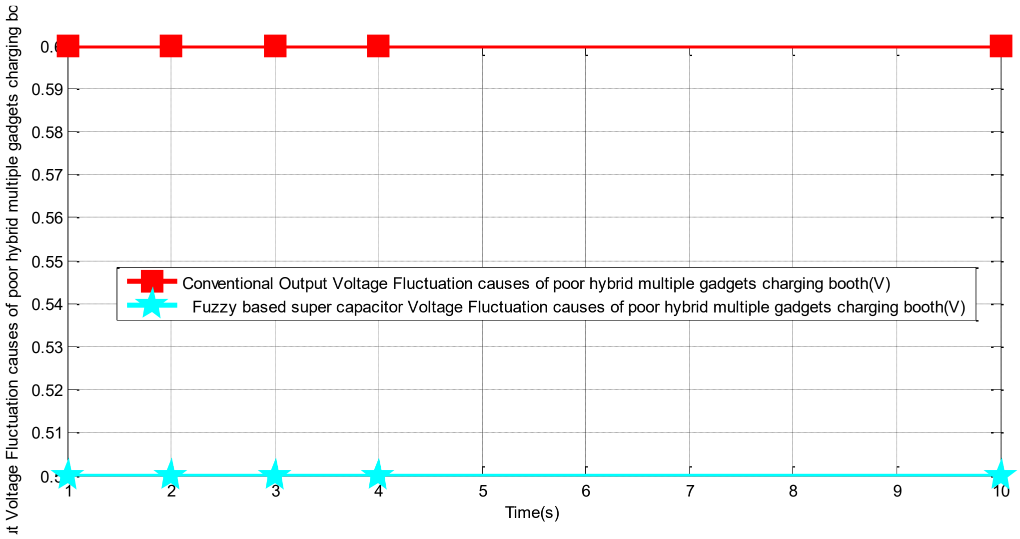


Fig. 7. Comparison of Conventional and Fuzzy based super capacitor Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth (V)

TABLE 4. Comparison of Conventional and Fuzzy based super capacitor Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth

| Time(s) | Conventional Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth(s) | Fuzzy based super capacitor Voltage Fluctuation causes of poor hybrid multiple gadgets charging booth(s) |
|---|---|---|
| 1 | 1.1 | 0.95 |
| 2 | 1.1 | 0.95 |
| 3 | 1.1 | 0.95 |
| 4 | 1.1 | 0.95 |
| 10 | 1.1 | 0.95 |

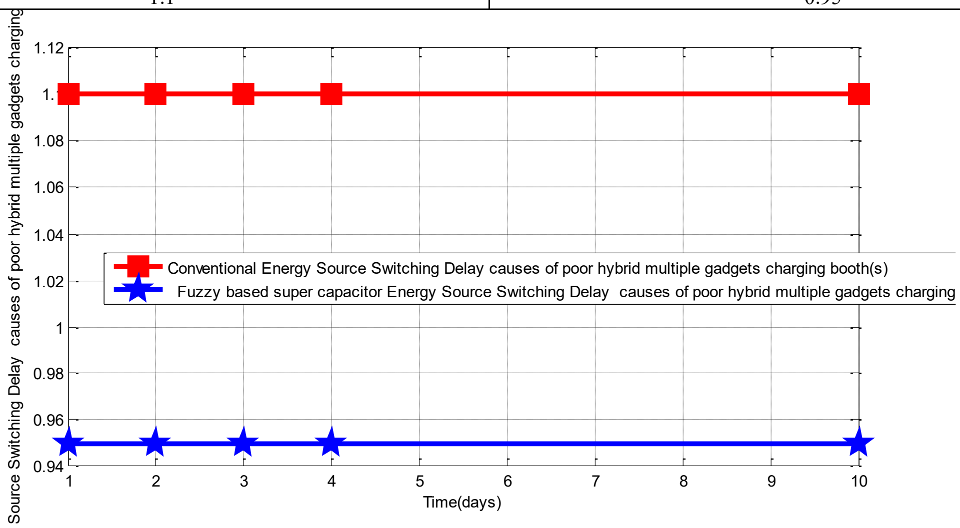


Fig. 8. Comparison of Conventional and Fuzzy based super capacitor Energy Source Switching Delay causes of poor hybrid multiple gadgets charging booth

## IV. Conclusion

Application of fuzzy logic control and ultra capacitor technology give a new and effective way to reduce recurring problems related to poor dynamic line rating (DLR) in current power transmission systems. As has been demonstrated in this paper, a fuzzy based ultra capacitor system has the capacity to allow increased adaptability, responsiveness and stability of transmission lines subjected to different environmental and load conditions. The intelligent compensations of voltage drops besides the supply of instant reactive power during fluctuations of thermal loads and balances, make the proposed system more efficient not only to enhance the real-time thermal capacity but also contribute to mitigating the effects of line overloading and transient changes in voltage. Furthermore, strict decision making by the fuzzy logic controller is able when dealing with operating uncertainty, whereas traditional DLR control methodology lacks. Energy is stored and discharged at high speed allowing ultra capacitors to be used and this makes the system applicable to real time dynamic requirements. It is a clever solution that may help streamline the effectiveness of operations, expand the use of renewable energy resources, and enhance grid reliability, specifically, in the developing countries where grid pressures tend to be more common. In summary, the fuzzy-based ultracapacitor to enhance the DLR is a futuristic idea, which meets the objectives of greatest radiography and modernization of the power system. It provides a positive avenue to improve transmission efficiencies, reduce strain within infrastructures and provide a more stable, efficient system of power delivery. Traditional High Ambient Temperature which brings about low line rating in dynamism was25%. Conversely, incorporation of Fuzzy based ultra capacitor in the system lowered significantly to21.7% and the traditional high solar radiation that will result in low dynamic line inspection was 1000 W/m 2)). Contrarily, upon the introduction of Fuzzy based ultra capacitor into the system, it brought it down drastically to 998.7 W/m. Lastly, under these results gained demonstrated that the percentage dynamic line rating improvement when imbibed Fuzzy based ultra capacitor into the system was 0.13%.

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