

Rapid Comparative Analysis of Switched Mode Converter using Conventional and Intelligent Controllers

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Abstract— The comparative performance analysis of conventional PI controller and Fuzzy Logic Controller for a switched mode converter application. Switched mode converters need to regulate its output voltage to lower voltage and must quickly respond to fast load and line variations or transients to keep the output voltage within a limited range. The design of high performance linear proportional integral controller for switched mode converter presents series of challenges due to nonlinear nature of the plant process. Fuzzy logic controller is mostly used in variety of industrial applications including use in domestic appliances and main tool of operation of fuzzy logic controller is membership function. By using the MATLAB and Simulation we compare the characteristics of the linear proportional integral controller and nonlinear fuzzy logic controller with switched mode converter and also which gives the desired results. The main comparison for Proportional Integral controller (PI) and Fuzzy logic controller (FLC) is to get the pure Direct current (DC) without any fluctuations for sensitive applications. The Switched Mode Converter with both the PI controller and Fuzzy logic controller is implemented and output characteristics are analyzed and compared.

The switched mode converters are efficient in power conversion, taking a main voltage AC input and converting it down to a low voltage DC output. AC-DC switched-mode converters are better used. It is used for the external desktop power supply laptop, set-top box, and the wall plug-in charger for smartphones and computers.

Index Terms— Switched mode converter (SMC), Pulse Width Modulation (PWM), Direct current (DC), Alternating current (AC), Fuzzy Logic Controller (FLC).

I. INTRODUCTION

For supplying DC loads with a regulated output voltage and safety against over currents and short circuits, switched-mode converters are AC/DC converters. Switched-mode converters are AC/DC converters that provide short-circuit and over current safety as well as a regulated output voltage for DC loads. Typically, these converters are powered by an AC network through a transformer and a typical diode rectifier. Non-reversible switched-mode converters in the first quadrant enable feeding a DC load with uni-polar voltage and current. Two categories are used to categorize the switched-mode converters. The first part will be given to the fundamental AC/DC converters, which are usually used in low- to mid-power applications.

As a result, only hard commutation procedures are made possible. The overview of this evolution enables reduction in these losses. It can be concluded from this direct DC/DC converter that the buck and buck-boost structures include a transformer. This makes it possible for an unusual voltage adaption to be built into the converter. These

topologies, which frequently involve the insertion of LC components, include middle-frequency transformers like those previously described, and they provide lower commutation losses as a result of typical soft commutation conditions. High switching frequencies are made possible as well as size reduction. We compare the traditional controller performance characteristics with those of the intelligent controller characteristics.

II. METHODOLOGY

Switched mode converters (SMC) are a common component across a wide range of products because they have benefits over linear voltage regulators. For a variety of electronic devices that need varying DC voltage levels without any transients, switched mode electronic converters are employed. Switched mode converters must reduce their resultant voltage to some lower voltage and maintain the output voltage without any ripples and transients to get pure DC voltage.

A. Switched Mode Converter:

Switched Mode Converters (SMC) are AC to DC converters that supply DC loads with a direct voltage, and security against over-currents. These converters are for the sinusoidal AC source by means of transformer and a diode rectifier. The control circuit of SMC is outlined for 50 Volt DC, 20A yield from single phase AC input. In simulation, we set a sub system which contains controllers and PWM generators.

The benefits of Switched mode power supply include:

- Its high efficiency (up to 80% to 90%).
- Less power is wasted.
- Less heat is produced.
- Less harmonic feedback affecting the power supply mains.
- The SMC is small and portable.
- The price of production is decreased.
- A mechanism for supplying a sufficient quantity of voltages.

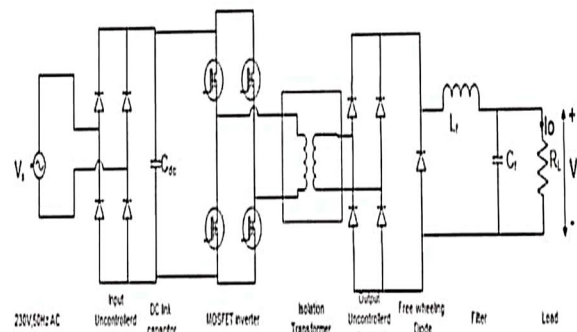


Fig-1: Circuit diagram of switched mode converter

B. Rectifier with Capacitor Design:

An electronic device is called as rectifier which transforms alternating current into direct current. Diode function as a single way switches that only let current flow in one direction. This action is referred to as rectification. When a constant DC voltage is required, these rectifiers are utilised. An input filter capacitor, power electronics switches like MOSFETs, IGBTs, and BJTs, inductors, diodes, high-frequency transformers (in isolated configuration only, for isolation), The typical parts of an uncontrolled rectifier are isolation devices and control circuits to deliver regulated DC output. Various applications, counting low-power ITE, shopping gadgets, IoT, broadcast, restorative, mechanical, and communication.

C. Inverter Circuit Design:

The inverter circuit based on Metal Oxide Semiconductor Field Effect Transistor (MOSFET) and the inverter output are provided to a single 1:1 transformer with resistance and inductance. The inverter's MOSFETs are designed to operate at switching frequencies greater than 20 kHz. A chopped DC output is produced by this inverter. The working frequency of the MOSFETs is 20 kHz, and their current rating is 20 Amp. The inverter generates a AC output whose output is the same as the DC bus voltage and whose ON period is determined by the

MOSFETs' conduction time. For inverter applications with a switching frequency higher than 20 kHz, MOSFETs are used in some low-capacity inverter applications. In the relatively low current conditions, MOSFETs offer benefits such as fast switching and less conduction loss.

D. High Frequency Isolation Transformer Design:

Transformers increase or decrease voltage by delivering electricity from a single alternating-current circuit to a few other circuits. The source side is isolated by the 1:1 isolation transformer, improving its safety.

E. Output Rectifier Circuit Design:

It is a device that changes AC voltage into DC current. The rectifier transforms the transformer's bipolar pulse wave into a DC pulse. High frequency diodes having a frequency rating of at least 40 kHz have been used. A rectifier is a component of semiconductors that converts alternating current to direct current. Diodes act as one-way switches that only permit one direction of current passage is known as rectification. When a constant DC voltage is required, these rectifiers are utilized.

F. Selecting the Load Resistance:

For a pure resistive circuit with a continuous output of 50 volts DC and a 1 KW application. As a result of load resistance has been selected across the 50 V output terminals and the output voltage is obtained across the load.

G. Output Filter Design:

Inductor and capacitor filters are circuits that combine inductors (L) and capacitors (C) to filter an electric signal's specific frequency ranges. Capacitors facilitate higher frequency AC transmission while obstructing DC currents. Inductors efficiently pass DC currents, while at higher frequencies they pass AC current less effectively. The output of the open loop simulation is observed to be around 50 Volt. This is sent into an LC filter, which provides a steady, uniform DC waveform across the load by smoothing out the pulsed DC waveform.

H. PI Controller Designing for SMC

The most often used controller for many different types of applications is the traditional PI controller. In the suggested arrangement, the PI controller created and provided P and I parameters to the SMC. An alternative name for an integral controller is a proportional plus integral (PI) controller. It is a type of controller that utilises proportional and integral control functions. It is referred to be a PI controller as a result. The proportional-integral controller employs both proportional and integral controller actions. Combining these two separate controllers results in a more robust controller.

The advantages of SMC include,

- The efficiency is between 80 and 90%.
- Less power is wasted and less heat is produced.
- Less harmonic feedback entering the power supply mains.
- A provision for supplying the necessary quantity of voltages.

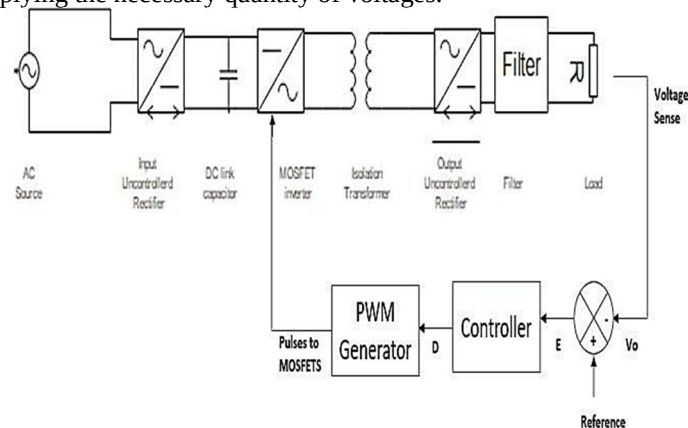


Fig 2-Circuit diagram of SMC with PI controller

I. Fuzzy Logic Controller Designing for SMC

A fuzzy logic controller is a specific kind of intelligent system that is both distinct and distinctive. The knowledge base for the knowledge base systems to support estimated reasoning, fuzzy knowledge bases, based on fuzzy set

theory, represent the facts of the rules and linguistic variables which contains membership functions. For converters, an FLC based on the Mamdani fuzzy inference system technique is proposed. The controller requires in the inputs "Error" and "Change in Error," processes them, and then produces "Change in Duty Ratio."

Fuzzification:

The error and change in error is fuzzified by the use of triangular membership functions is used for the input which his (i) Error and (ii) Change in error.

Fuzzy Rule Base and Inference:

This method has exact requirements, such as how the rule must be created for each given error magnitude and error change in value. The rule base denotes exact requirements, such as how the rule must be determined for any given error magnitude and error change value.

Defuzzification:

Defuzzification is required for the fuzzy set combined output. The fuzzy sets are used to produce output using the defuzzification approach.

Scaling of Output:

The final duty cycle value is calculated by scaling and accumulating the duty cycle changes.

Characteristics with input Step Response:

By properly scaling the inputs and outputs, the desired outcome is produced. These scaling factor values are chosen by a procedure of trial and error. It is found that a good response with less overshoot is provided having a scaling factor of 0.01 and the scaling factor of output is 0.0015.

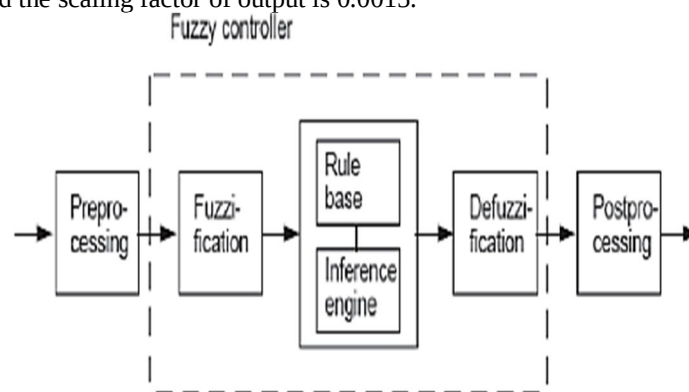


Fig.3- Schematic block diagram of Fuzzy Logic Controller

III. SIMULTION AND MODELLING

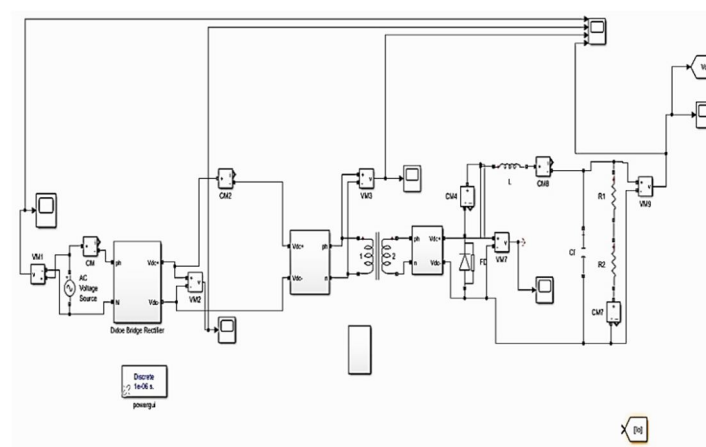


Fig 4- Simulation circuit diagram of switched mode converter.

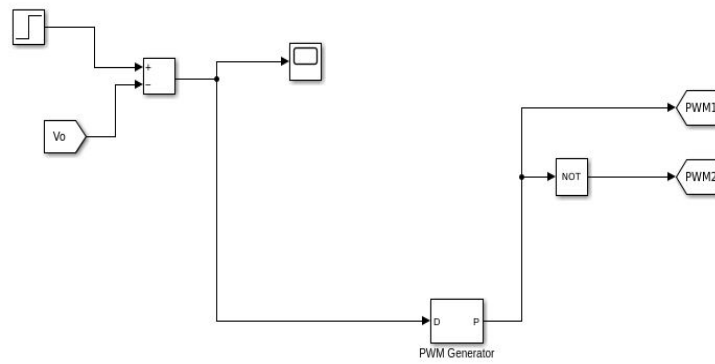


Fig 5- Simulation circuit diagram of subsystem without controller

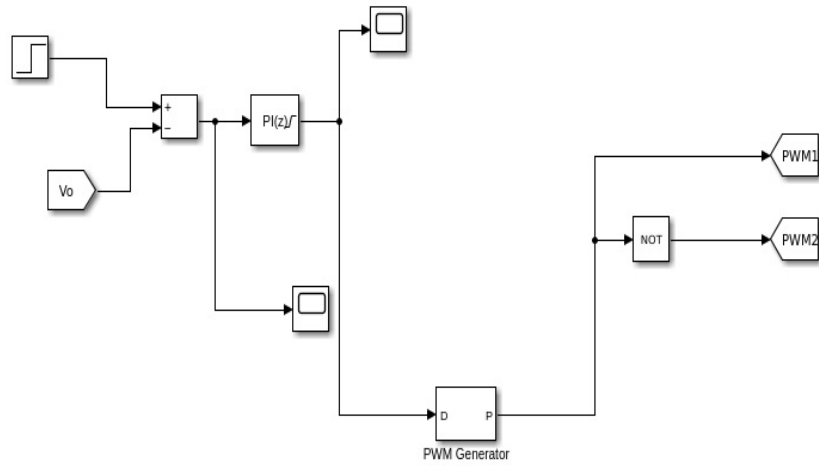


Fig 6- Simulation circuit diagram of Subsystem with PI controller

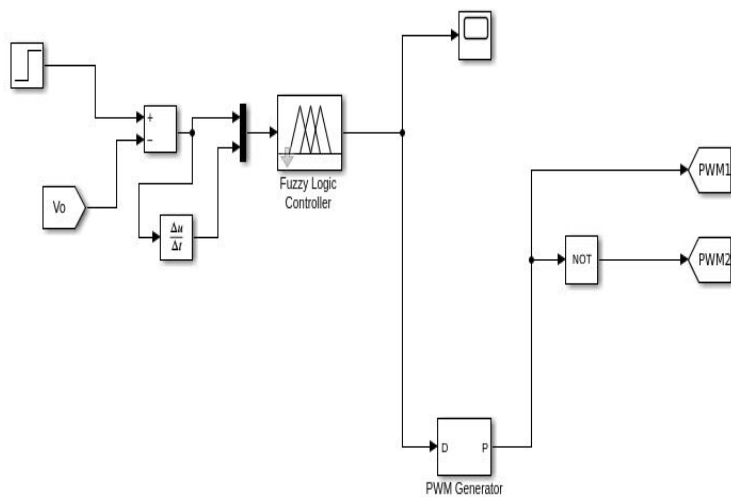


Fig 7- Simulation circuit diagram of subsystem with fuzzy controller.

IV. RESULTS AND CONCLUSION

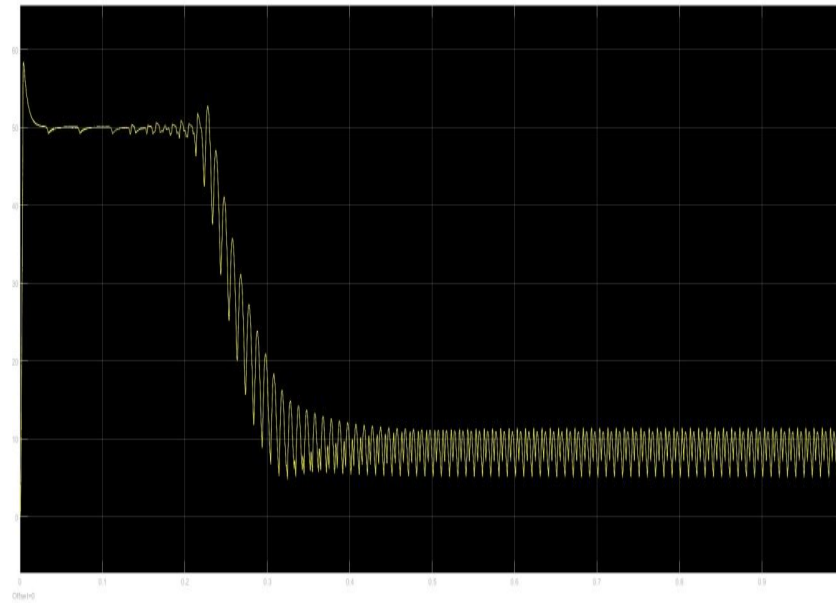


Fig 8- Output response of the switched mode converter without controller

The Output response of this switched Mode Converter without controller is observed that there is no pure DC voltage and it is having full of transients as well as ripples which is undesired. So we use the conventional controller which is PI controller and Intelligent Controller which is Fuzzy Logic controller.

A. Comparision of the Output of the Switched Mode Converter With PI Controller And Fuzzy Logic Controller.

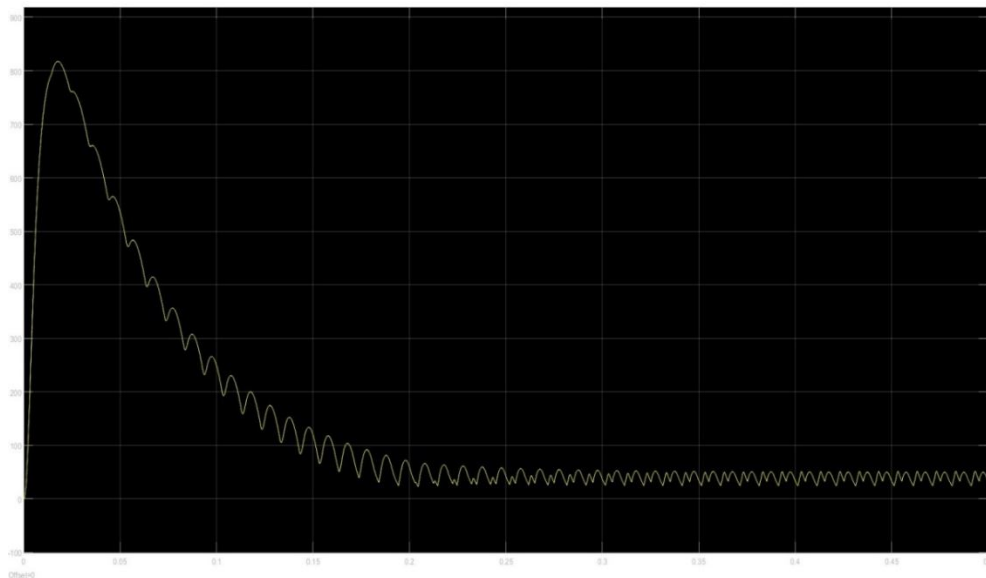


Fig 9- Output response of the Switched mode converter with PI controller.

The result has led to the PI controller being adjusted with the gains $K_p=0.0469$ and $K_I=9.28$. After the gains are given the output result to be shown when the step response is applied.

- The PI controller response indicates the following:
 - i) Slower response.
 - ii) When compared to an SMPC without a controller, the output voltage with a PI controller has the lowest ripples.
 - iii) The output response settling time is after 0.25 seconds.

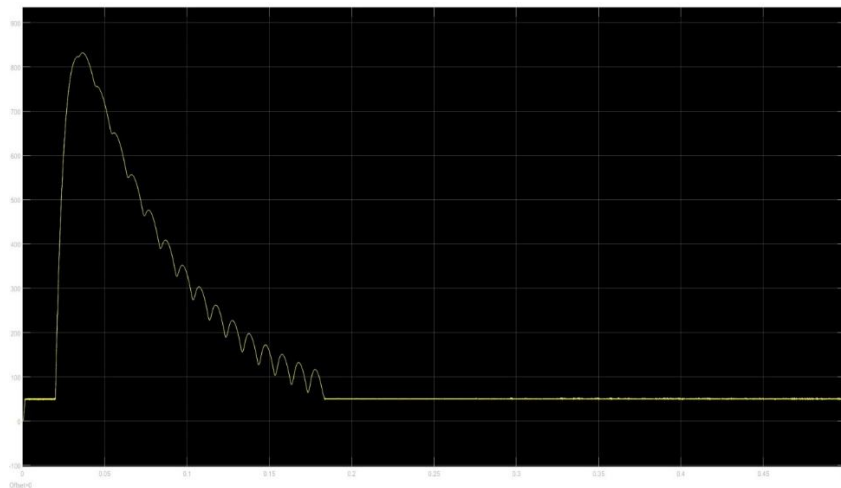


Fig 10- Output response of the Switched mode converter with Fuzzy logic controller.

- The step response plot demonstrates the following characteristics of the fuzzy logic controller:

i) Faster response.

ii) It can be observed that the output response is absolutely free from ripples in comparison to PI controller.

iii) The settling time of the output response is 0.18 seconds.

From the output responses therefore, the fuzzy logic controller can be said as the intelligent controller which can be used for better applications having high efficiency and also having pure DC voltage without any ripples. With reference to the outputs of the system without controller, with PI controller and fuzzy controller, we conclude that the feature of Switched mode converter to convert AC current to DC current without any transients/ripples has been verified and better utilised with Fuzzy Logic Controller.

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