JSS MAHAVIDYAPEETHA

JSS SCIENCE AND TECHNOLOGY UNIVERSITY

SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING
CONSTITUENT COLLEGE OF JSS SCIENCE AND TECHNOLOGY UNIVERSITY
JSS TECHNICAL INSTITUTIONS CAMPUS
MYSURU - 570 006

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Subject: *Control Systems (20EC530)*

Event 4: Report on “SMPS MODEL ON SIMULINK”

Submitted by

Name	Roll no.	USN
ASHWIN VIJAYAKUMAR BHANDARI	4	01JST20EC013
B P RASHMI	5	01JST20EC014
B R MANOJ	6	01JST20EC015

Submitted to

Dr. U. B. Mahadevaswamy,

Professor and Head

Department of Electronics & Communication Engineering
SJCE, JSS S&TU, Mysuru.

2022-2023

Table of contents

ABSTRACT

Switched-mode power supplies (SMPS) are confidently replacing outdated linear power supplies. They are distinguished by high performance, improved stabilization indicators and compactness. The SMPS are widely used in power supply of control systems for small energy facilities. The article is devoted to the research of forward converter parameters. The task of research is to establish quantitative interrelations between the parameters of the converter elements and the energy loss in them. An analytical model of forward converter has been developed, which allowed revealing the main regularities of the processes occurring in the converter. A simulation model of the power source made based on forward converter has been developed. Using the dependences obtained on the simulation model, rational parameters of the converter elements have been determined, ensuring the maximum level of electromagnetic compatibility and the minimum level of power losses. The optimum values of the forward converter parameters have been used in the design of a power source prototype.

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power, see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. The switched-mode power supply's higher electrical efficiency is an important advantage. Switched-mode power supplies can also be substantially smaller and lighter than a linear supply because the transformer can be much smaller. This is because it operates at a high switching frequency which ranges from several hundred kHz to several MHz in contrast tothe50 or 60 Hz mains frequency. Despite the reduced transformer size, the power supply topology and the requirement for electromagnetic interference (EMI) suppression in commercial designs result in a usually much greater component count and corresponding circuit complexity. Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight is required. They are, however, more complicated; switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor. A linear power supply (non-SMPS) uses a linear regulator to provide the desired output voltage by dissipating power in ohmic losses (e.g., in a resistor or in the collector–emitter region of a pass transistor in its active mode). A linear regulator regulates either output voltage or current by dissipating the electric power in the form of heat, and hence its maximum power efficiency is voltage-out/voltage-in since the volt difference is wasted. In contrast, a SMPS changes output voltage and current by switching ideally lossless storage elements, such as inductors and capacitors, between different electrical configurations. Ideal switching elements (approximated by transistors operated outside of their active mode) have no resistance when "on" and carry no current when "off", and so converters with ideal components would operate with 100% efficiency (i.e., all input power is delivered to the load; no power is wasted as dissipated heat). In reality, these ideal components do not exist, so a switching power supply cannot be 100% efficient, but it is still a significant improvement in efficiency over a linear regulator. For example, if a DC source, an inductor, a switch, and the corresponding electrical ground are placed in series and the switch is driven by a square wave, the peak-to-peak voltage of the waveform measured across the switch can exceed the input voltage from the DC source. This is because the inductor responds to changes in current by inducing its own voltage to counter the change in current, and this voltage adds to the source voltage while the switch is open. If a diode-and-capacitor combination is placed in parallel to the switch, the peak voltage can be stored in the capacitor, and the capacitor can be used as a DC source with an output voltage greater than the DC voltage driving the circuit. This boost converter acts like a step-up transformer for DC signals. A buck–boost converter works in a similar manner but yields an output voltage which is opposite in polarity to the input voltage. Other buck circuits exist to boost the average output current with a reduction of voltage. In a SMPS, the output current flow depends on the input power signal, the storage elements and circuit topologies used, and also on the pattern used (e.g., pulse-width modulation with an adjustable duty cycle) to drive the switching elements. The spectral density of these switching waveforms has energy concentrated at relatively high frequencies. As such, switching transients and ripple introduced onto the output waveforms can be filtered with a small LC filter.

LITERATURE SURVEY

Various techniques can be found in literature to obtain a linear continuous time invariant (LTI)model of a DC-DC converter. The most well-known methods are: Current injected approach, circuit averaging and state space averaging (Middlebrook and Cuk, 1976; Sokal et al., 1991; Mohanet al.,2007; Vernerian, 1990) [4]. Mahery et al., (2012) proposed a new method based on Laplace and Z transforms for mathematical modelling of buck-boost in CCM. Ghadimi et al. (2007) presented a detailed small signal and transient analysis of a full bridge pulse width modulator (PWM) converter based on average model [5].

PROBLEM STATEMENT

Linear power supplies include size, high heat loss, and lower efficiency levels when compared to a switch-mode power supply. The problem with linear power supply units, when used in a high-power application, is that it requires a large transformer and other large components to handle the power. Using larger components increases the overall size and weight of the power supply and can pose a challenge for weight distribution within a given application. For that we will be implementing a SMPS type power supply which has better efficiency, and the weight is very less compared to linear power supply.

OBJECTIVE

I. To understand closed loop system and its fundamentals.
II. Develop the Model for the system.
III. Develop the feedback system.
IV. Compare the proposed methods with existing works.

METHODOLOGY

All switching converter output voltage is a function of the input voltage, duty cycle and load current, as well as converter circuit component values. The output voltage should be constant regardless of variation in input voltage, load current and converter circuit parameter values. The input voltage may vary from 90 VAC to 264 VAC, and input frequency from 47 Hz to 63 Hz for an off-line power supply, and -25% to +50% from the nominal value for the DC input supply. The load current may vary from no load to full load. In addition, the load may vary from no load to 50%loadinstep, and vice versa. The converter circuit components will have some tolerance. Despite variation, it is desired that the output voltage be within a certain limit. This is not practical to achieve without negative feedback and setting the duty cycle to a single value. There are two basic methods to control the duty cycle to keep the output voltage within the specified limit: voltage mode control and current mode control, we are using voltage Mode control.

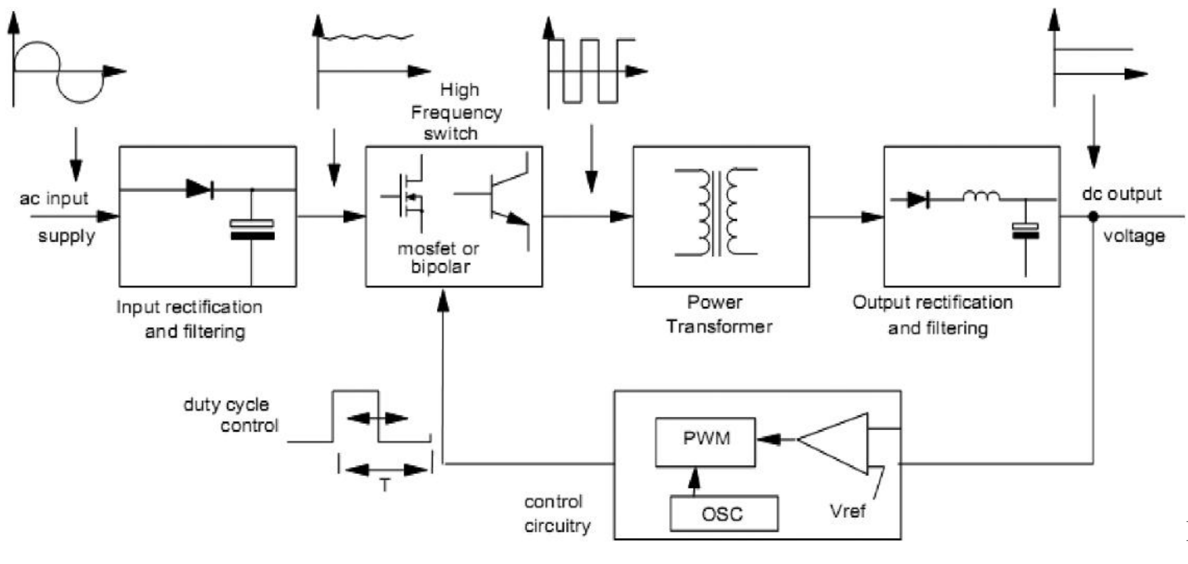
Voltage Mode Control

In voltage mode control, the output voltage is measured and then compared with the reference value (desired output voltage). The error is then processed by the compensation block to generate the next duty cycle value, as shown in Figure. This mode has only one control loop, so it is easy to design and analyse. However, in this control method, any change in the line or the load must be first sensed as an output voltage change and then corrected by the feedback loop. Therefore, the response is slow, and the transient response (step load change) is not favourable. Adding input voltage feed-forward to this control scheme will reduce the effect of input voltage variation in the output.

SIMULINK

SIMULINK is a computer program developed by Math Works [1] for the analysis of dynamic systems. There are two important steps in running SIMULINK: model definition and model analysis. In the definition phase a graphical editor is used to set-up hierarchical block diagram models of control systems. Blocks can be selected form the SIMULINK library and blocks can be nested within other blocks. Then the blocks can be wired together to establish the model of a system. In the analysis phase, the defined model can be simulated from the SIMULINK menu. SIMULINK can use any function of MATLAB or its related toolboxes. These toolboxes include control systems, nonlinear control, robust control, optimization, system identification, neural networks, fuzzy logic, quantitative feedback theory, partial differential equations, signal processing, symbolic mathematics, and many more. MATLAB and its toolboxes are well known and widely used by control engineers. The simulation process in SIMULINK consists of numerical integration of ordinary differential equations. The available algorithms include Euler's method, Runge-Kuta third and fourth order methods, Gear's predictor-corrector method for stiff systems and Adams predictor corrector methods. For more detailed information, the user guide of SIMULINK should be consulted [1]. SIMULINK and MATLAB are well known and widely used by control engineers, and it is believed that its application can be extended to power electronics, to the dynamic modelling of DC-DC converters. In the next section, SIMULINK is employed to model a resonant switched mode circuit. Sub-models for the converter and control circuit are derived, and the converter is tested in an open loop and closed-loop system.

BLOCK DIAGRAM



F

ig 1: Block Diagram of SMPS

FLOW CHART

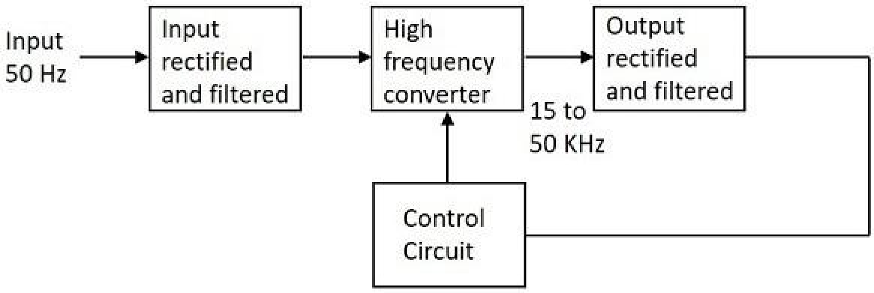


Fig 2: Flow Chart of SMPS

CIRCUIT DIAGRAM

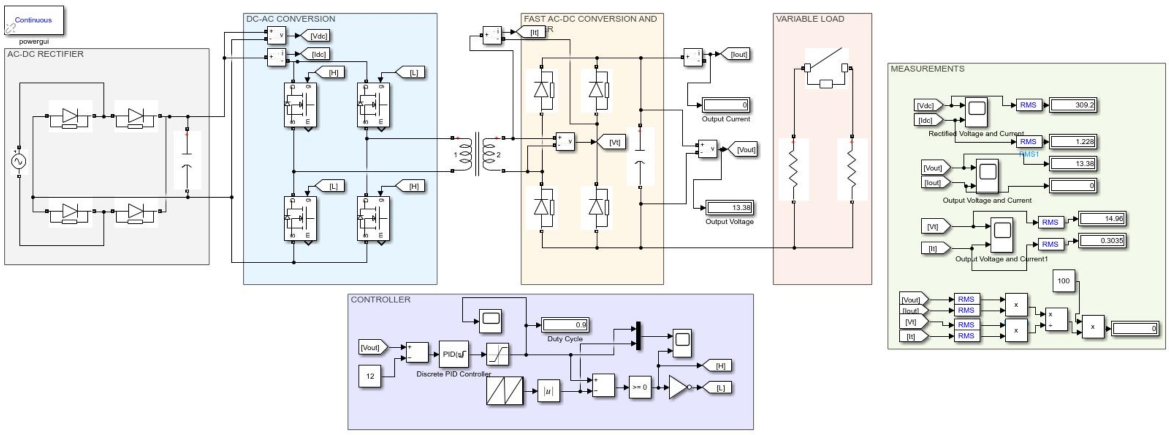


Fig 3: Circuit Diagram of SMPS

RESULTS

	Input Voltage in V_{rms}	Input Current in I_{rms}	Output Voltage in V_{DC}	Output Current I_{DC}	Efficiency
Without LOAD	14.96V	0.30A	13.3V	0A	--
With LOAD	14.59V	51.22A	12.68V	44.02A	76.08%

Table 1. Comparision of Input Voltage and output and their Efficiency

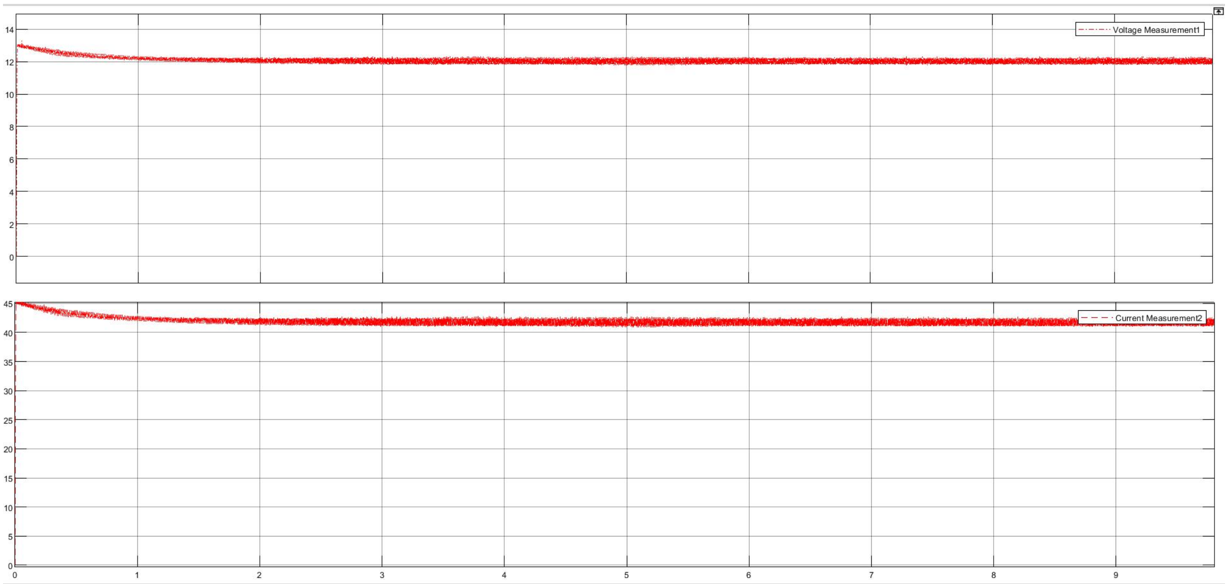


Fig 4: Plot of Voltage and Current with respect to Time

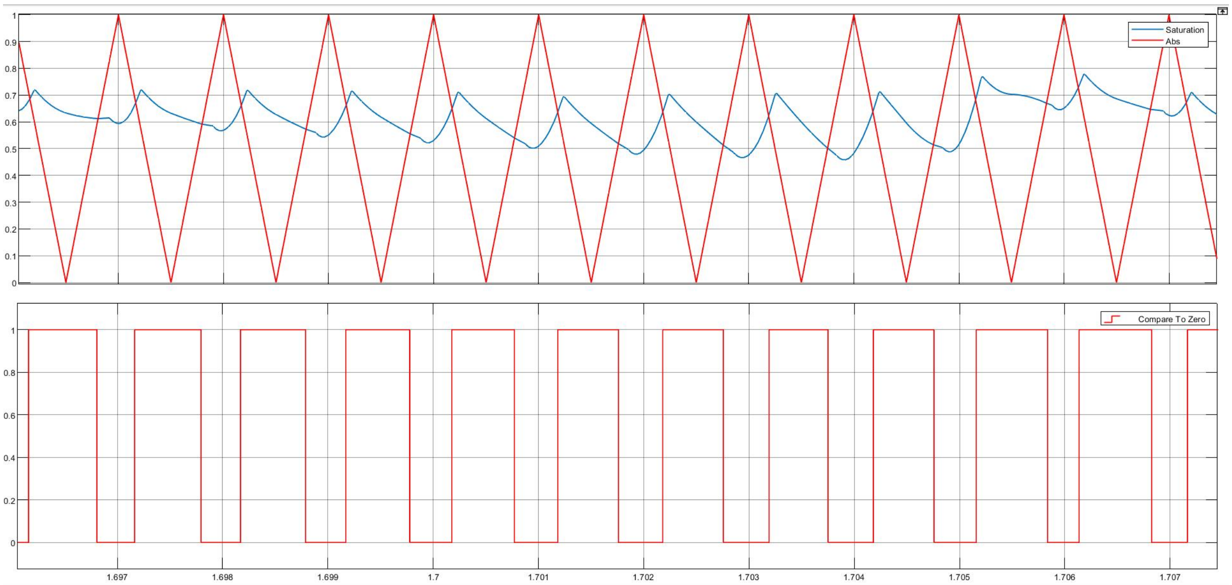


Fig 5: Plot of Triangular Wave and PWM with respect to Time

CONCLUSION AND FUTURE SCOPE

The Output Voltage is Controlled and maintained constant, and it is independent of whether load is there or not. The loss is less than that of linear power supply. Whenever the Load increases in SMPS it sends the signal to controller which in Turn increases PWM Duty Cycle, hence there is a relation between Output Voltage and Controller, as the Load current increases PWM increases and as load Current Decreases PWM decreases.

The efficiency of our Implementation is 78-80% Which is better than linear Power Supply 30-50%, We can further increase the Efficiency up to 90-95% by using better controller and better MOSFET Drivers which reduces power loss.

REFERENCE

[1] Liao Wang 2012. MATLAB/SIMULINK. IEEE TRANSACTIONS ON EDUCATION, 55(1)

[2] The Math Works Inc., "SIMULINK, Dynamic System Simulation Software," 1994.

[3] The Math Works Inc., "SIMULINK 1.3 Release Notes," 1994.

[4] Middlebrook and Cuk (1976). A general unified approach to modelling switching converter power stages. In the IEEE Power Electronics Specialists Conference, IEEE: 19-34. https://doi.org/10.1109/PESC.1976.7072895

[5] Emadi A (2004). Modelling and analysis of multi converter DC power electronic systems using the generalized state-space averaging method. IEEE Transactions on Industrial Electronics, 51(3): 661-668.

CONTRIBUTION OF GROUP MEMBERS

Each member of the group did literature survey on switched mode power supply. All of them read about working principle of how a SMPS works. We tried to build a simulation model, then analysed the result and concluded with a report.