

Learning Switched Mode Power Supply Design Using MATLAB/SIMULINK

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Abstract—Switched Mode Power Supplies (SMPS) have become an indispensable part of modern electronic systems. In this paper, a generalized MATLAB/SIMULINK modeling technique is presented. The proposed techniques have been successfully integrated into SMPS design courses at Lunghwa University, Taiwan. The main objective of the course is to teach final year undergraduate students and first year Master's students how to design an SMP in real life. Positive response from students indicates that the proposed technique is useful for SMPS design courses.

Keywords—switched mode power supply (SMPS), MATLAB/SIMULINK, pulsewidth modulation (PWM), Power factor correction (PFC)

I. INTRODUCTION

As to today more than 75% of all generated power was processed by power electronics. The extensive usage of switching converter circuits in electronic products and systems makes the fundamental understanding of power electronics a necessity for students and electronic engineers. This trend has resulted in an increasing interest in providing power electronic courses at the senior undergraduate and the graduate levels in various institutions [1-3]. Traditionally, SMPS are taught as part of a typical introductory undergraduate elective course in power electronics. However, the practical design of SMPS calls for design expertise which can only be gained with years of experience. Fig. 1 shows the block diagram of a typical SMPS, the AC input voltage is rectified by a full-wave bridge rectifier. The rectified input voltage is next applied to power factor correction (PFC) pre-regulator followed by output DC-DC converter(s). Downstream DC-DC converter generates a set of DC voltages required for the load, and normally also provides input-to-output isolation. There are a number of topologies utilized in a DC-DC converter, and a large variety of regulator ICs suitable for each of these topologies. The selection of right topology and controller depends on specific requirements for the power supply and personal experience of the designer.

In this paper, a generalized MATLAB/SIMULINK modeling techniques for SMPS is presented. The objective of the proposed technique is to assist the learning of SMPS through simulation. A practical SMPS design consists of several parts: power converter topology selection, controller (compensation circuit) design, magnetic design and

Electromagnetic Compatibility (EMC). Among them, the magnetic and EMC design depend on the real-world design, therefore is often not taken into account in simulation level. In this paper, a description of the modeling techniques for power converter and control ICs along with their use in SMPS courses will be presented. The various types of converters are considered to be examples to clearly show the validity of the proposed technique, and will be described in detail in the following sections.



Fig. 1 Typical SMPS block diagram

II. SIMULINK MODEL OF SWITCHED MODE POWER SUPPLY

In this section, the generalized construction method of SMPS SIMULINK model will be presented. In this paper, the behavior model technique as presented in [4] is adopted. Take the flyback power converter shown in Fig. 2 as an example. In a flyback converter, the switch Q is continuously switching on and off with high frequency in order to provide the transfer of electric power via energy storage components. Assuming the flyback converter operates in continuous conduction mode (CCM), the state equation of the power circuit when Q is on can be written as

$$\frac{dv_1}{dt} = \frac{1}{L} (v_s - i_1 r_1) \quad (1)$$

$$\frac{dv_2}{dt} = -\frac{1}{C} \frac{v_2}{R_o} \quad (2)$$

and the relationship between the transformer voltage on the primary side v_1 and secondary side v_2 can be shown as

$$v_1 = v_2 \quad (3)$$

$$v_2 = -\frac{n_2}{n_1} v_1 = -\frac{n_2}{n_1} v_2 \quad (4)$$

where n_1 is the number of turns of primary side, and n_2 is the number of turns of secondary side.

When the switch Q turned off, the state equation of the power circuit can be written as

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