Detection System of Switch Power Supply Based on DSP

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Abstract. The power supply of electronic equipment is significant and have important function in electronic field. In this paper, a detection system of switch power supply based on DSP is introduced. The system can detect the duty-ratio of capacity value, inductance value, resistance value, output voltage value, diode voltage drop and current pulse-width modulation chip on PCB of switch power supply. Consequently, it finishes the real-time detection on PCB and it is significant to research the fault analysis of switch power supply. The schematic diagram and the outside circuit schematic diagram based on DSP is given in the paper. In the meanwhile, the system accomplishes the data selecting and setting of lower computer by using LabVIEW upper computer. The system has the universality to electrical industry.

Keywords: Switch power supply detection; LC shocking theory; LabVIEW.

1. Introduction

With the development of electronic technique, all kinds of electronic equipments become a necessary part of industry production and daily life. The power supply of electronic equipment is significant and have important function in electronic field. As a result, the supply quality of the power supply can effect the working efficiency and service life of switch power supply. The hardware circuit’s power supplying require of the electronic is different. Some are on single line, others are on multipath lines, the requirement of voltage and current value is also different. Most circuit board use switch power supply. Switch power supply use power electronic technology, use PWM to adjust the on-off of the switch, a power supply is well known with stable voltage, little wave, small bulk and long life in power supply field [1].

This paper provide a switch power supply detecting system, it can accomplish interior detecting on switch power supply, including inductance value, capacity value, resistance value, PWM duty-ratio, voltage drop of diode and outlet voltage, it provide the basis for that if the switch power supply can reach the industry level. In the paper, the DSP chip(as TMS320F28335) of Texas Instruments was selected to be the main chip [2] [3]. It has powerful capability for dealing digital signals, and intergate in ECAP, A/D, ECAN modules, and have a number of GPIO connectors, these factors provide a reliable guarantee for inventing this system. This switch power supply detecting including chip detecting, voltage collecting, voltage drop of diode collecting and duty-ratio.

2. Component Detecting Theory

2.1. Capacity and Inductance Detecting Theory

The capacity and inductance are the basic shaking component, therefore, use LC shaking theory, make capacity or inductance detecting come true , rely on the formula (1) [4]
$f = \frac{1}{2\pi\sqrt{LC}}$  \hspace{1cm} (1)

It is an explain to capacity detecting:
There is another formula according to formula (1)

$$C = \frac{1}{4\pi^2 f^2 L} = \frac{T^2}{4\pi^2 L}$$  \hspace{1cm} (2)

From the formula (2), the capacity value is C we will get, there should be a fixed inductance value as the known value, the C can be calculated from formula (2) if just get LC shaking period T. The capacity detecting schematic diagram is shown as Figure 1.when the detected capacity is linked to the circuit, there is going to be period shaking sinusoidal wave, then use LM393 comparator put the sinusoidal wave into the DSP chip’s high speed catching ECAP, the period of the capacity is not changed. The capacity are the same, the schematic diagram is as Figure 2.

\textbf{Figure 1.} Capacity detecting peripheral circuits. \hspace{1cm} \textbf{Figure 2.} Inductance detecting peripheral circuits.

2.2. Resistance Detecting Theory

This theory is the multivibrator built up with chip NE555, make the wave of output high-level and low-level be the same with the theory of inductance and capacity, the input wave is caught by DSP ECAP, and the detect the oscillation period, get the resistance value $R_x$ by process calculating, period calculating formula\(^5\).

$$T = t_1 + t_2 = (In2)(R + R_x)C + (In2)R_xC = (In2)(R + 2R_x)C$$  \hspace{1cm} (3)

$t_1$ is the time of output wave high-level in a period, $t_2$ is the time of low-level. According to the formula (3), then we can get:

$$R_x = \frac{1}{2} \left( \frac{T}{(In2)C} - R \right)$$  \hspace{1cm} (4)

The schematic diagram of resistance detecting is as Figure3.

\textbf{Figure 3.} Resistance detecting peripheral circuit.
2.3. Isolating Module
Above are the peripheral circuits of capacity, inductance and resistance, because the high-level of output wave is 5V, it can not put in DSP directly, or the DSP will burn, so isolating chips should be added to it, make the wave voltage between 0V to 3.3V. We use TXB0106PW in this isolating system, as Figure 4.

Figure 4. The schematic diagram of 5V to 3V isolating chip.

3. Voltage Collecting and Diode Voltage Drop Collecting Circuits
In this voltage collecting, the voltage should be changed during 0V to 3.3V, then it can be collected by A/D of DSP, we use the amplifier TL082ACD drop the voltage which is going to be collected with the same rate, because collecting voltage is different, the drop rate is different either, we can change the resistance proportion of op-amp[6]. The voltage collecting circuit is as Figure 5.

Figure 5. Voltage collecting circuit.
Switch power supply interior use Sean diode half-wave rectificate, the diode voltage drop is a significant parameter of the switch power supply high frequency transformer’s winding calculating, the collecting circuit of diode voltage drop is as Figure 6.

Figure 6. Diode voltage drop collecting circuit.
4. PWM Duty-ratio Detecting
Duty-ratio detecting is using ECAP of DSP collect current PWM output pulse to switch power supply, get a proportion of sustaining high-level time in a period and the whole period\(^7\):
\[
\text{Duty-ratio} = \frac{\text{high-level sustaining period}}{\text{the whole period}}
\]
The duty-ratio of current PWM, can act the running condition of switch power supply, feedback controlling duty-ratio is the requirement of constant voltage output to switch power supply.

5. Multisim Simulating Wave and Labview Upper Computer Control Interface

5.1. Multisim Simulating Wave
In the detection of capacity, inductance and resistance, accurate grasp to relevant period is the key to detecting accurately, so the stable period wave is needed, then it can satisfy the detecting requirement. In this system, use Multisim simulate the capacity, inductance and resistance detecting circuits, they are as Figure 7, Figure 8 and Figure 9.

![Figure 7. Capacity detecting simulation.](image1)

![Figure 8. Inductancedetecting simulation.](image2)

![Figure 9. Resistancedetecting simulation.](image3)

According to the results of Multisim simulation waveform, we can see that measurement circuit of components can generate stable, neat rectangle wave and can provide input variable for precise calculation of the element parameters.

5.2. LabVIEW Upper Computer Control Interface
LabVIEW as upper computer virtual apparatus, it widely used in modern industry by its powerful function, short exploit period, good transplating, low cost, we use these to control switch power supply in this system. The component detecting, voltage collecting and diode voltage drop detecting are proceeding to multiple target, so we divide it with manual mode and auto mode. It can switch over the two modes optionally. It propose an example with four output switch power supply, the four output are
+5V, -5V, +15V and -15V, detecting components are including decoupling capacity (0.1uF), π style filtering inductance (150uH), current filtering resistance (1K) and half-wave diode BYV26C. It proposes the switch power supply system’s upper computer interface of the collecting result, it is as Figure 10.

Figure 10. Switch power supply detecting system upper computer interface.

6. Conclusion
We use DSP chip(as TMS320F28335) make the detecting in real time to switch power supply. It not only can measure the interior component parameter of switch power supply, but also monitor the diode voltage drop, output voltage and duty-ratio. At the same time, it can analyze the fault timely and conveniently, so it is significant to comploit the switch power supply.

References
[1] Huihui Yan, Min Han. Design of a Switching Power Supply with Single-ended Flyback Type. Information and Communication,2019.10
[2] Lingshun Liu. TMS320F28335 DSP Principle and Development Programming. Beijing University of Aeronautics and Astronautics Press, 2015.12.
[3] Xiao FU, Zhu Hongshun. TMS320F2833x DSP application development and practice. Beijing University of Aeronautics and Astronautics Press (first edition), 2016.7.
[4] Shangshu Guan, Yutong Zhao, Guiying Song. Design and Production of Single-ended Flyback switching power supply. Communication Power Supply Technology,2019.4
[5] Chunkai Chen, etc. Principles, Design and Examples. of Switching Power Supply, Electronics Industry Press, 2014.05.
[6] Robert H. Bishop (US), Ruiping Qiao, Xin. LabVIEW Practical Tutorial. Electronics Industry Press, 2018.4.
[7] Shuping Qi. Design of a New Type of Mine Intrinsically Safe Power Supply. Electronic Devices, 2019.6