DEVELOPMENT OF ELECTRICAL DISCHARGE MACHINING POWER GENERATOR

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This project report is dedicated to my family for their endless support and encouragement.

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ABSTRACT

Electrical Discharge Machining process has been widely used for manufacturing micro components due to its contactless process. The power generator design and configuration requirements for producing the desired spark have always been a challenge to the researchers. The aim of this project is to design and implement the power generator using Switch Mode Power Supply (SMPS) with 100W output power for the EDM system. The power generator is designed based on the SMPS push-pull topology. The hardware of the push-pull converter has been successful built its characteristic almost similar to the designed specification. The SMPS power generator for EDM machine is working properly according to the supply current needed by the load. The SMPS is based on the push-pull topology that utilize IGBT transistor. The project describes both simulation and experimental work carried out on the developed circuit. Simulation results show that this push-pull converter capable to produce DC voltage up to 100V. The experimental results show that the 100W EDM power generator with up to 1A gap currant is stable and reliable.

ABSTRAK

Proses *'Electrical Discharge Machining'* (EDM) telah digunakan secara meluas untuk pembuatan komponen mikro kerana kebaikan kaedah tanpa sentuhnya. Reka bentuk dan konfigurasi keperluan penjana kuasa untuk menghasilkan bunga api yang dikehendaki sememangnya merupakan cabaran kepada penyelidik. Tujuan projek ini adalah untuk mereka bentuk dan melaksanakan penjana kuasa menggunakan Switch Mode Power Supply (SMPS) dengan 100W kuasa output untuk sistem EDM ini. Penjana kuasa direka berdasarkan konfigurasi SMPS push-pull. Perkakasan penukar push-pull telah berjaya dibina dan sifatnya hampir sama dengan spesifikasi yang direka. Penjana kuasa SMPS untuk mesin EDM berfungsi dengan betul mengikut arus bekalan yang diperlukan oleh beban. Penjana kuasa ini direka adalah berdasarkan topologi tolak-tarik yang menggunakan IGBT transistor. Projek ini menggambarkan kedua-dua simulasi dan ujikaji dijalankan ke atas litar maju. Keputusan simulasi menunjukkan bahawa ini penjana kuasa mampu menghasilkan DC voltan sehingga 100V. Keputusan eksperimen menunjukkan bahawa penjana kuasa 100W EDM dengan arus sehingga 1A adalah stabil dan boleh dipercayai.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
C	-	Capacitor
DC	-	Direct Current
F	-	Farad
f	-	Frequency
GND	-	Ground
H	-	Henry
Hz	-	Hertz
I	-	Current
kΩ	-	Kilo Ohm
L	-	Inductor
m	-	Mili
P	-	Power
Q	-	MOSFET
R	-	Resistor
V	-	Voltage
Ω	-	Ohm

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Electrical Discharge Machining (EDM) is the process of machining electrically conductive materials by using precisely controlled sparks that occur between an electrode and a workpiece in the presence of a dielectric fluid. Electrical Discharge Machining process has been widely used for manufacturing micro components due to its contactless process.

In EDM system, there are several subsystems, i.e. generator, (also known as power supply), electrode, dielectric and servo mechanism. Generator provides a series of DC current discharges between the electrode and the workpiece. Dielectric is electrically non-conducting liquid which is used to fill the gap between electrode and workpiece. It is used for removing EDM’s debris in the sparking gap. Electrode is usually made of high strength material with high melting point and easy to machine such as Brass, Copper and Graphite. Servo system feeds the electrode into the work piece maintaining a constant gap as well as cooling system.

The first development of EDM machine was investigated by Dr. Boris Lazarenko, Moscow University Professors and Dr. Natalya Lazarenko in 1943 at the All Union Electro Technical Institute. The Lazarenkos developed a spark-machining process with an electrical circuit that used many of the same components as the automobile ignition system. This process became one of the standard EDM systems in use throughout the world.

One of the key elements of EDM is a power generator unit that controls the amount of energy consumed. This power generator helps to maintain the machining gap (known as spark gap) in order to generate succession of uniform electrical discharge in the form of sparks. It has a time-control function, which called on time that control the length of time that current flows each pulse. It also controls the amount of current allowed to flow during each pulse. In conventional EDM, the voltage and current level are high, thus the electrode gets locally melted and welded work-piece and electrode. Moreover, a present of stray arching should be minimized or eliminated. Until now, a number of power supply units have been developed ranging from basic resistance-capacitance (RC) power supply to the complex resonant power supply unit.

A Relaxation-type RC pulse power supply is the earliest pulse power for EDM, with simple structure and reliable capability, is able to generate a small pulse width of narrow pulse. However, the pulse in the discharge process is uncontrollable. The machined parts would suffer from micro crack; melted electrode and left over debris. Furthermore, some energy-saving EDM pulse power supplies have replaced the existing linear power supplies. Thus, in this project pulse power generator will be designed by implementing Switch Mode Power Supplies which is push-pull converter.

Figure 1.1 illustrates the application of the power generator in EDM system. The RC power generator will be applied between the electrode and workpiece.

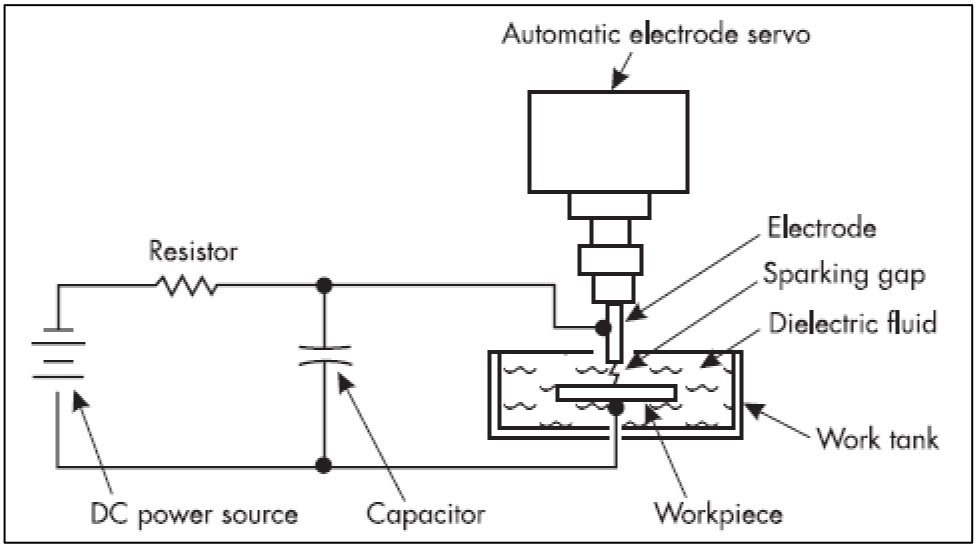

Figure 1.1 EDM resistor-capacitor (R-C) circuit [1]

Two basic types of EDM generator are RC and pulse. Both types are requiring DC supply as a source. The power supply is a very unique role in this system. In many respects, it is the mother of the system. It gives the system life by providing consistent and repeatable power to its circuits. The two major DC source technologies are linear power supply (LPS) and Switched Mode Power Supply (SMPS).

1.2 Problem Statement

Most conventional EDM power generator uses linear power supply as their main topology. Main issue of linear power supply is a raw DC input voltage is usually derived from the rectified secondary of a 50Hz transformer whose weight and volume was often a serious system constrain. Besides, the Linear Power Supply is constrained to produce only a lower regulated voltage from a higher non-regulated input. The regulation efficiency is low, resulting in a considerable power loss needing large heat sinks in relatively large and heavy power units.

1.2 Project Objectives

The objectives of the project are;

- To design a 100W EDM power generator system with maximum 1A gap current.
- To develop EDM power generator according to push-pull topology.
- To experiment and analyze EDM power generator.

1.4 Project Scope

In order to achieve the objective of this project, there are some guidelines need to be refered in this project. The theory involved in constructing the device is investigated before constructing the device. First of all, the operation of EDM power generator has been study. The behavior of the power generator is analyzed and it is consist of power supply module and switching module. Push pull converter was chosen as the DC to DC converter because the core size of the transformer is small due to the excitation of transformer in both directions.

Push pull converter is the main focused of the circuit because of the complexity of the circuit. The control circuit of the push pull converter is design using integrated circuit to minimize the number of component. The design of the circuit is simulated using PSpice. The hardware is built on breadboard first before it is printed on the circuit board permanently.

Besides, the operation and topology of the MOSFET, transformer and PWM circuit need to be study too. Their behaviour need to be analyzed so that any problems can be avoided when it is being used in the circuit. The transformer is used to step down or step up the voltage and at the same time it is also used to isolate the input voltage from the output voltage. In the same time, it will transfer the energy from primary winding to the secondary winding. Therefore, any considerations regarding on the transformer must be acknowledged.

Next, after studying and reviewing all the information, the transformer and the Push-Pull Converter need to be designed. All the parameters will be calculated by using the related formulas in the analysis. The data is collected from the hardware and it is compared to the theoretical and simulation data.

1.5 Report Organization

This project is organized in five chapters. Their contents are summarized as follows:

(i) An overview of the project, problem statements, project objectives, project scopes and project significance are all arranged under Chapter 1.

(ii) While in Chapter 2, the literature review of EDM system and push-pull topology has been discussed in detail where the push-pull converter and the basic operation of push-pull converter are being discussed as well.

(iii) As in Chapter 3, the overall discussion of research methodology is detailed out in flow chart that will give a clear view of the project flow. It discusses the designed circuit of push-pull converter circuit, the process to build the hardware of designed circuit and the steps to produce the printed circuit board. Apart from that, all the activities and deliverables that need to be done are also listed in this chapter.

(iv) Chapter 4 presents an experimental works and discussion of the project. Experimental results also being presented in this chapter. The push-pull converter circuit has been tested in order to determine the characteristic and the reliability of isolation power supply.

(v) Chapter 5 accomplishes the work undertaken and will conclude the overall study on this project. Several recommendations are given for future research possibility.

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