Team 57 - Pulsed Power Supply: Applications and Educational Prototype

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Executive Summary

This project presents the design of a low-power pulsed power prototype that simulates high-power system behavior in a safe and testable format. The system generates controlled electrical pulses while minimizing noise, voltage transients, and electromagnetic interference.

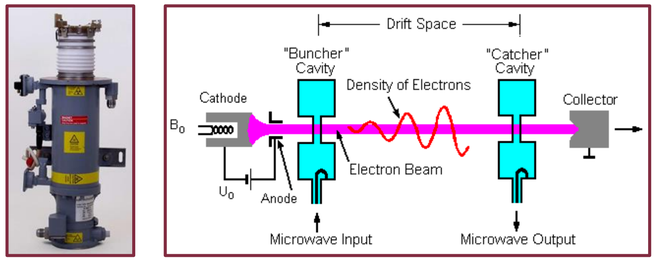

Fig. 1: Klystron Machine and Schematic
Image Credit: OSTRON, Christian Wolff

Background & Inspiration

Pulsed power systems have a wide range of uses in industry from particle accelerators to x-rays to radar, but all systems are created to deliver short, high-intensity bursts to enable large instantaneous power into the load. The design of the pulse topology will change depending on the application. The original inspiration is the klystron modulator at Los Alamos National Laboratory which drives a particle accelerator. Because this is an educational prototype, the team could not model after the exact same topology as the klystron, but instead used a gate driver to create the pulses inspired by the Z pulse power machine from Sandia National Laboratories.

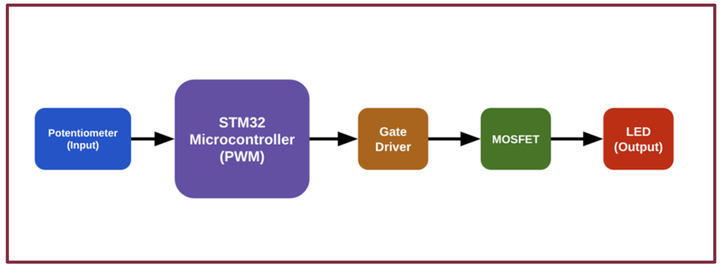

Fig. 2: Simplified block diagram of pulse power topology

System Design

The prototype consists of four main stages. The STM32F407 microcontroller generates a PWM signal with adjustable frequency and duty cycle from user input. The IXDN602PI Gate Driver then amplifies the signal, and controls the switching ability of the IRF540N MOSFET. The MOSFET acts as a high speed switch which reliably delivers controlled burst of power to the load, which in this topology is a resistor and LED for visual aid.

Fig. 3: PWM Switching Waveform from Oscilloscope
Image Credit: Trumpetep, Wikimedia

Results

The team was able to construct the prototype to successfully demonstrate the adjustable PWM in real time via the potentiometer. The system is able to operate in two modes: a continuous dimming mode and a pulse mode where the PWM controls LED brightness and pulse rate respectively. The modes can be toggled with a button. In the lab, the team verified conditions under the minimum rated voltage for components, operating at 12V. The working prototype is available for demonstration.

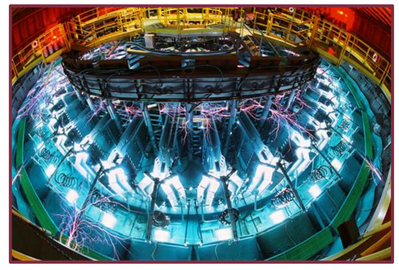

Fig. 4: High Wattage Z Pulse Power Machine
Image Credit: Sandia National Laboratories

Conclusion

This project demonstrated the successful development of a low-power pulsed power prototype capable of generating stable and controlled pulse outputs. Key challenges such as noise and system stability were addressed through iterative design and testing.

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