

Micro-Controller Power Circuitry

Application Notes

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Abstract:

MOSFET control circuits are used to power a multitude of out board devices from a micro-controller. Using Pulse Width Modulation (PWM) signals, the output of the control circuit can vary vastly to fit the application with out changing the physical circuit components.

Intro of topic:

Micro-controllers do not output enough current to power many of the devices that they are designed to control. These devices require varying supply voltages and have different electrical characteristics. A circuit that can power a multitude of devices is needed.

Key Words:

PWM inverter, MOSFET, Protection Diode, Relay, Micro-Controller power circuitry

Objective:

The objective of this note is for the reader to get a basic understanding of the options available for powering a multitude of devices with a micro-controller and a supplemental power circuit.

Control Circuitry:

Control circuits have many varieties and largely vary based upon the demands of the system and the capabilities of the microcontroller. First, the most elemental control circuit needs to be understood. The most simple system uses a basic N-type MOSFET to provide current to the load. MOSFET only consume power when switching and therefore this configuration has a high efficiency.

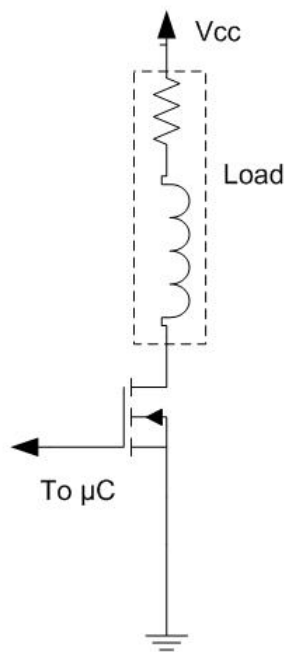


Figure 1. Basic MOSFET Control

This configuration cannot control the current or voltage applied to the load. The voltage V_{CC} is applied and the current is solely based upon V_{CC} and the resistance of the load. It is important to note that there is a voltage drop across the P-N junction that varies based on doping levels and material from about .2 to 1V. It is common for Silicon to produce a .7V voltage drop. A graphic of the physical structure of an N-Channel MOSFET can be seen below. The voltage

(diode) drops occur across the junctions from the negatively doped channels (labeled N) and the metallic plates that are connected to the circuit.

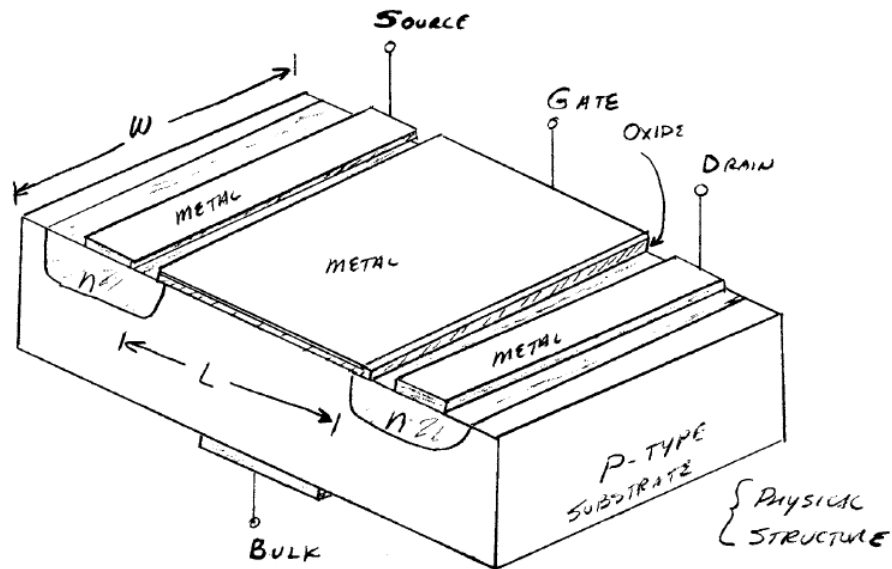


Figure 2. N-Channel MOSFET Physical Structure

The majority of loads that are driven by Micro-Controller are highly inductive. Solenoids and motors are common examples. In this case the inductors emit force on the electrons to continue to flow even when the MOSFET has shutoff. This force can be very strong and possibly overcome the breakdown voltage of the MOSFET and pull current out of the Micro-Controller. It is very common for MOSFETs to have a breakdown voltage in the range of 200mV. If the solenoid pulls current directly from the Micro-Controller in excess of 25mA it will burn up. To prevent this, the most common version of the schematic, shown in figure 1, is modified to provide a path for this force and therefore current to discharge. Basically the voltage across the load cannot be forced to exceed the supply voltage or the current will flow the wrong way. The revised schematic is shown in Figure 3.

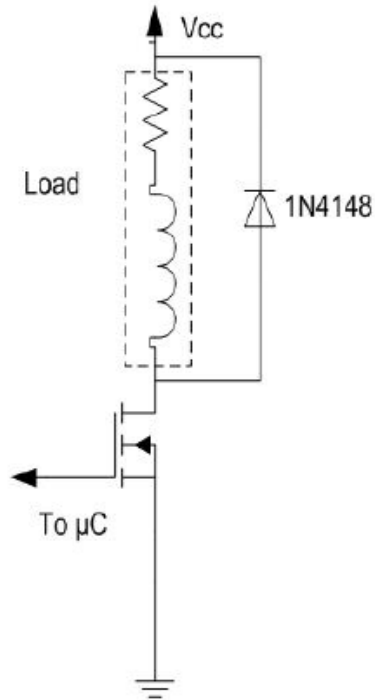


Figure 3. Revised N-Channel MOSFET Control Circuit

In many applications it is required to have complete voltage and therefore current control without the ability to vary the input voltage. In many instances a system will require a multitude of output voltages for varying devices with only one input voltage. For this case a technique called Pulse Width Modulation (PWM) is used to provide these varying voltages. PWM takes advantage of the fact that the system is driving an inductive load by pulsing the load on and off to achieve the correct voltage. Recall that the inductor will hold the current and voltage to a mean value of the respective inputs of each. Both current and voltage decay with respect to time based on the size of the inductor. To moderate this decay the switching takes place at a very high frequency, approximately 10,000Hz. This causes the load to have an applied voltage approximately equal to the percent time the power is applied (Duty Cycle) multiplied by the supply voltage. Through this scheme any voltage below the

supply voltage can be applied with minimal losses and without changing hardware configurations. Varying duty cycles give varying average voltages and varying voltage produce varying currents. Thus, through duty cycling the input to the MOSFET differing devices can be powered through the same scheme. These varying duty cycles can be seen in Figure 4.

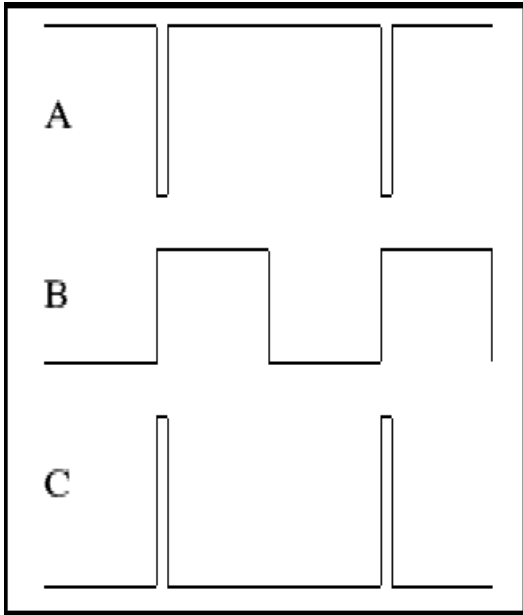


Figure 4. PWM Input Signals

Some situations do not cater to PWM schemes, generally because of the electromagnetic radiation produced. Pulsing a powered inductor provides significant amounts of EMI very close to the, digital, low current Micro-Controller. For these instances an analog version of the same pulsing scheme can be implemented. The schematic shown in figure 5. shows a solenoid control circuit that pulses the voltage to twice the input voltage to open the solenoid and then holds the solenoid open with the input voltage. Many variations of the PWM scheme exist to promote efficiency and EMI rejection but all work on the same concepts.

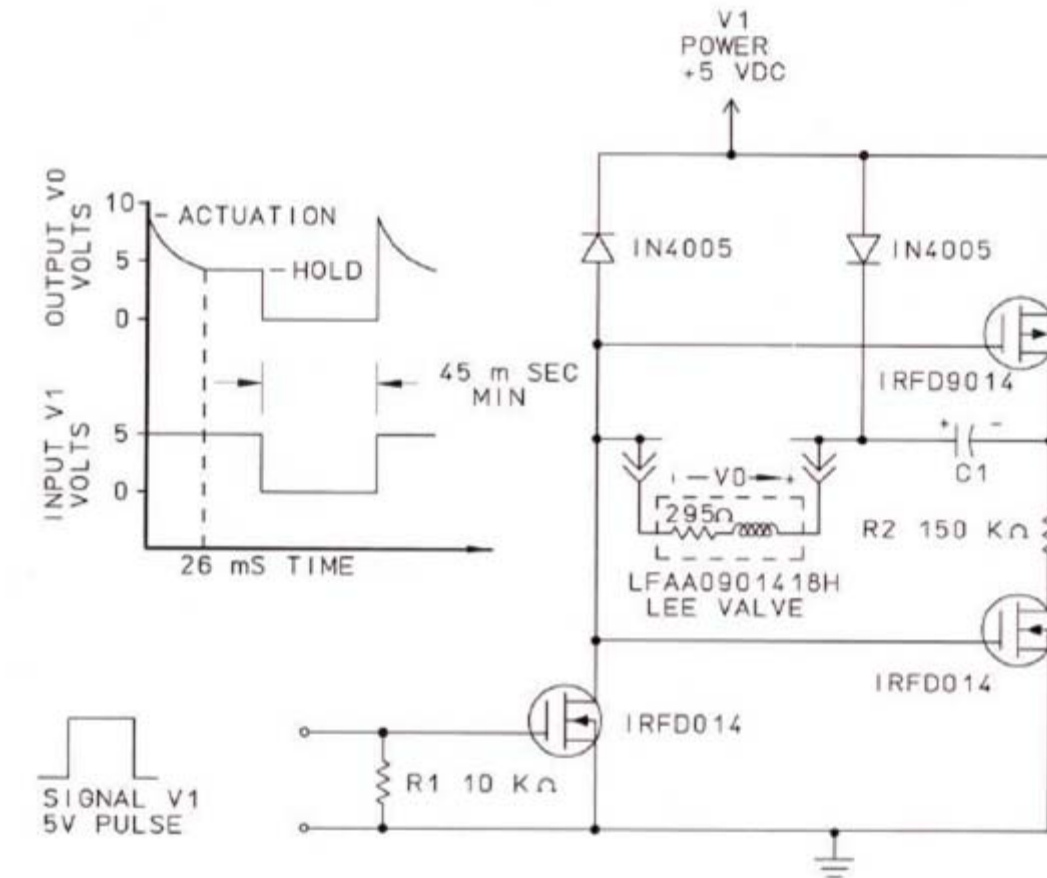


Figure 5. Advanced Analog Pulsing Circuit

Conclusion:

PWM schemes provide a range of power options when controlled by Micro-Controller. From a design standpoint it is wise to start with a PWM power scheme and modify the analog circuit and the micro-processor code to accommodate any system.

References

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