Driving/Running and Controlling High Power loads with Microcontrollers

July 8, 2019 By EG Projects

Some times we want to drive heavy loads with microcontrollers. By heavy loads i mean motors, fans, AC's, bulbs and other high voltage and current sources. Since we all know that microcontrollers can output/source +3.3 volts to +5 volts and 25 mA to 40 mA through their input/output pins. This voltage and current is not enough to drive high power loads motors, fans and bulbs etc. Their are few methods and electronic components which can handle much greater loads(currents/voltages). We can interface these components with microcontrollers and can drive and handle high power loads. In this tutorial i am going to explain these methods and about electronic components that can be interfaced with microcontrollers in order to handle heavy (current-voltage) loads.

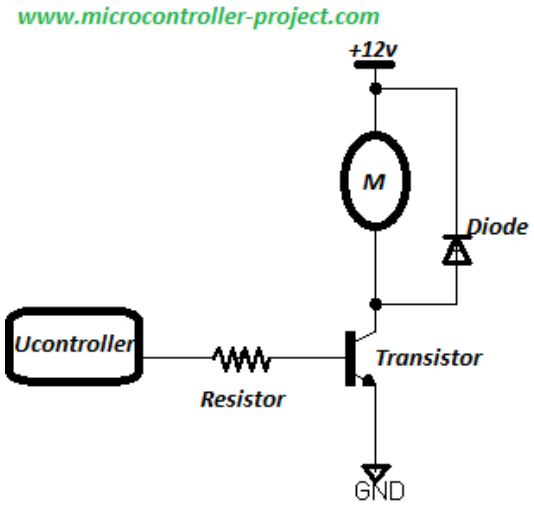
Methods/Techniques to drive heavy loads with Microcontrollers

We can use following electronic components to drive high power loads with microcontrollers.

- Transistors
- optocoupler
- Relays
- Mosfets
- SSR(Solid State Relay)

The upper list starts from low power control electronic component(Transistor) to high power control(SSR-Solid State relay). These electronic components can be interfaced with any vendor of microcontrollers Altera, Atmel, Cypress Semiconductor, Maxim Integrated, EPSON Semiconductor, Freescale Semiconductor, Infineon, Intel, Microchip Technology, National Semiconductor, NXP Semiconductors, Panasonic, Parallax, Silicon Laboratories, Silicon Motion, Sony, STMicroelectronics, Texas Instruments, Toshiba. I interfaced the above components in many circuits with different microcontrollers e.g Arduino, Pic, Stm32, 8051, Picaxe, Avr, Atmega, Arm and LPC series etc to control high power loads. The above components can be used with mini computers or development boards such as BeagleBone, Raspberry Pi, Olimex and Xilinx FPGA boards.

base makes the current to flow from collector to emitter(npn) or from emitter to collector(pnp). Their are two common types of transistors PNP and NPN. This tutorial does not go in depth of electronic components rather it only shows the method through which we can control heavy loads.



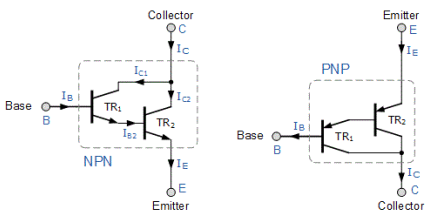
Transistor driving heavy load with microcontroller

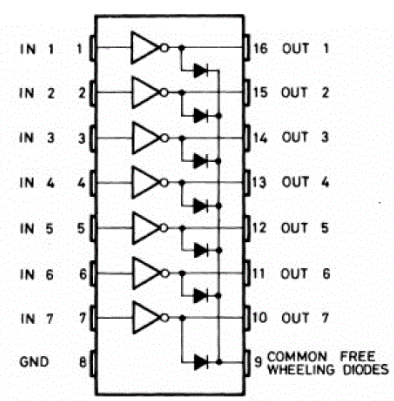
Generally transistor can handle currents up to 600 mills Amperes and voltage up to 20 volts. The ratings can be little bit high or low. The maximum power that a transistor can handle is 12 watts to 18 watts. This power is enough to control loads that falls below 18 watt power such as dc toy motors and dc bulbs etc. But still this power is not enough to control the loads that consumes continuous current of 1 amperes.

A typical connection between transistor and microcontroller is shown on the left side. A small dc toy motor is controlled through microcontroller. NPN transistor is used in the circuit. Diode against the motor is fly back diode to protect circuit from any back emf by the motor.

Transistor can be arranged together for high current gain. Most popular configuration is darlington configuration in which a high current gain is achieved by small voltage switch. Many commercial ic's are available in market that contain the transistors build in side them. Such as ULN2003 and ULN2803 contains darlington transistor array in side them.

Darlington circuit configuration and ULN2003 ic pin out is shown on the right hand side. ULN2003 contains 7 darlington configuration in side it. Its easy to use the ic instead of making the darlington configuration by our own. Ic





Many more configurations can be made using transistors for current gain. But for this tutorial the darlington is best suited. ULN2003 can control 500 mA at 50 volts. Thus a darlington configuration increases power control to 25 watts.

Some projects that i created using transistors and microcontrollers to control loads etc. Projects contains free source code and circuit diagrams.

Door Look with 89c51 microcontroller and Transistor

Transistor with pic microcontroller

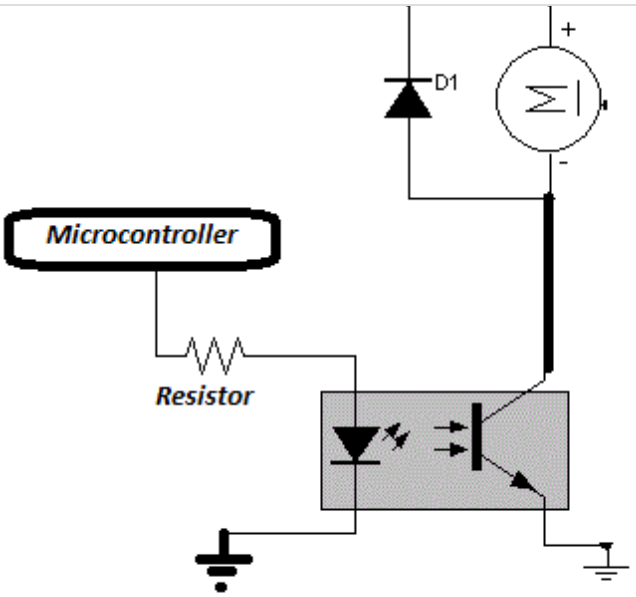
Pickit2 clone build at Home

Driving heavy loads with Microcontrollers and Optocoupler.

An Optocoupler/optoisolator or photocoupler is an electronic component that separates two circuits from each other using a light as medium. The two circuits are independent but can be controlled by light source. A small voltage applied a one side activates the other circuit. Optocoupler is composed of a led diode and a photo cell. When voltage is applied across the led diode it illuminates and showers light on photo cell. Photo cell resistance decreases upon receiving light so it starts conducting.

A general optocoupler circuit with connections to microcontroller is shown on the left hand side. A motor is driven by the microcontroller. Optocuplers are used in many circuits to isolate the circuit from the other. This way danger of high spikes is eliminated. If their is a high spike it will only blow off the optocoupler at the remain circuit will remain safe. It is generally used in high valuable circuit cores. To isolate them with high current regulation circuits.

Optocouplers can handle more power than transistors. Such as FOD3180 optocoupler that can handle continuous 2 Amperes of



Optocoupler driving heavy loads with microcontroller

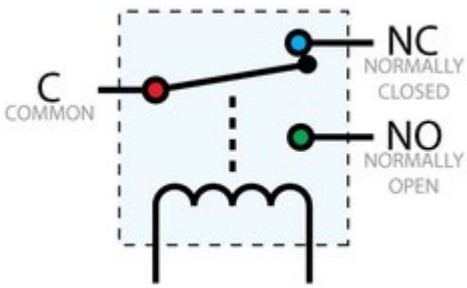
Unlike transistors which are not useful in switching AC loads. Optocouplers can be used to control heavy AC loads. This will be discussed in SSR(Solid State relays) topic.

Some projects that i created using optocouplers and microcontrollers to control loads etc. Projects contains free source code and circuit diagrams.

PLC with Pic Microcontroller

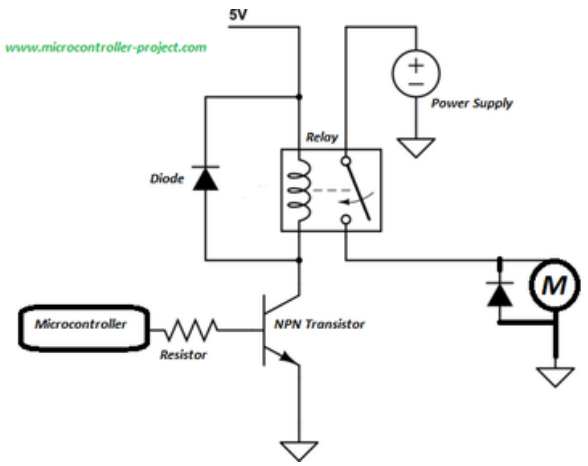
Driving heavy loads with Microcontrollers and Relays.

Relays are mechanical switches that open and close when voltage is applied across its specified pins. Relays consists of a coil and a NC(Normally Close), NO(Normally Open) and Common line. During ideal state(No Power) the common pin is shorted with the NC(Normally Close) pin. Making a path of current flow between common and normally close line. But when a sufficient voltage is applied across the coil of relay the common pin shorts with the NO(Normally Open) pin. Making a path of current flow between common and normally open pin. The path is a straight mechanical connection between wires. A 5 pin relay is shown on left hand side. Relay's comes in many packages such as single pole single through, double pole and double through(DBDT), Single pole double trough(SPST) etc.

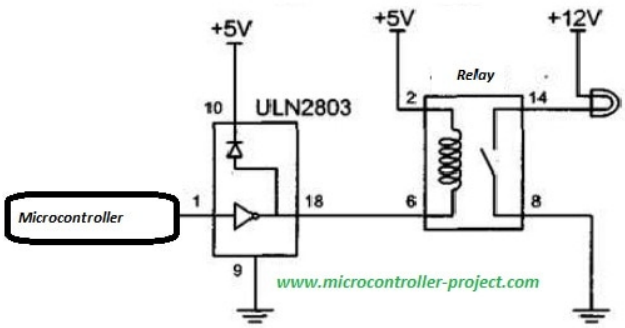


Relay Pinout

sufficient voltage they are derived through transistors. Relays can handle 10-15 Amperes of current and 110-220 volts. We can easily control a 500 watt load with standard relays.



Relay driving heavy loads with microcontroller and transistor



Relay driving heavy loads with microcontroller and uln2003

In the above pictures a relay is controlled with a single transistor and uln2003 ic containing darlington transistor array circuit. Relays can control Dc as well as Ac loads. Relay is the oldest mechanical method to switch heavy loads e.g bulbs and fans.

Some projects that i created using relays and microcontrollers to control heavy current loads etc. Projects contains free source code and circuit diagrams.

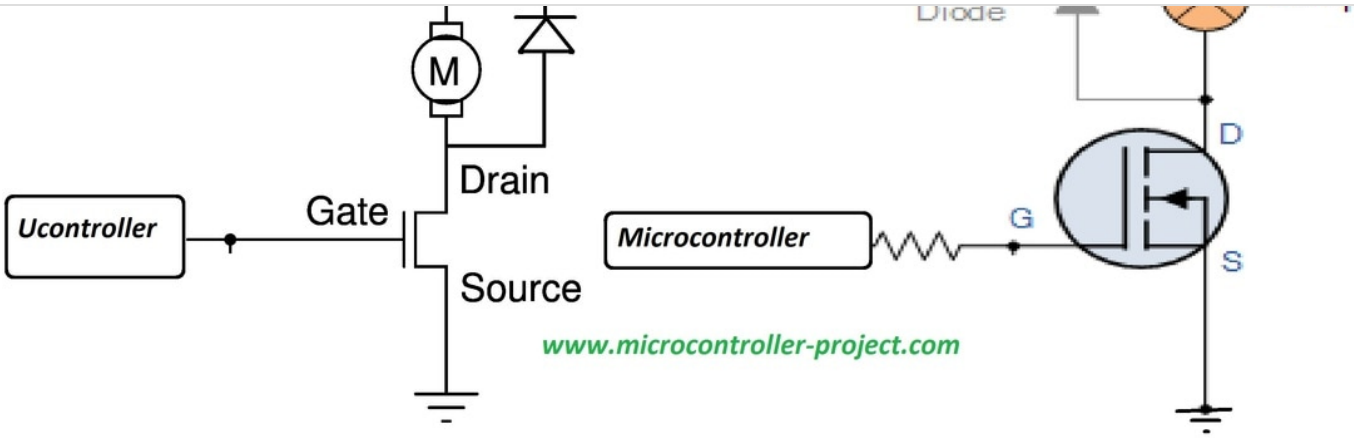
Solenoid/Dc motor/ Fan with Nodemcu WiFi – Controller

Car Headlight Control with Arduino

Plc with pic microcontroller

Driving heavy loads with Microcontrollers and Mosfets.

The term MOSFET stands for Metal Oxide Semiconductor Field Effect Transistor. To understand mosfets we first need to understand FET(Field Effect Transistor). A field-effect transistor (FET) is a type of transistor commonly used for signal amplification. Field effect transistor can amplify analog or digital signals. It can also be used to switch DC loads. In the FET's, current flows along a semiconductor path called the *channel*. Field-effect transistors exist in two major classifications. These are known as the junction *FET (JFET)* and the metal oxide semiconductor *FET (MOSFET)*. Mosfet has three pins gate, drain and source. Fet and Mosfet is a big topic can't explain it in this post. A resource is available here FET and MOSFET

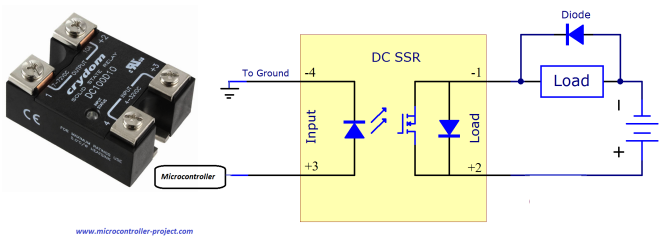


FEt and mosfet driving heavy loads with microcontroller

Mosfet become very popular now a days. They are used in switch mode power supplies, buck and boost converters. Mosfets have great potential in controlling heavy currents with PWM(Pulse width modulation) signal. They are used in solar battery chargers Pwm or MPPT(Maximum power point tracking). Mosfet can control loads of greater than +1000 watts. So if you require to drive a 1000 watt load with microcontroller than mosfets are a good choice.

Driving heavy loads with Microcontrollers and SSR(Solid State Relay)

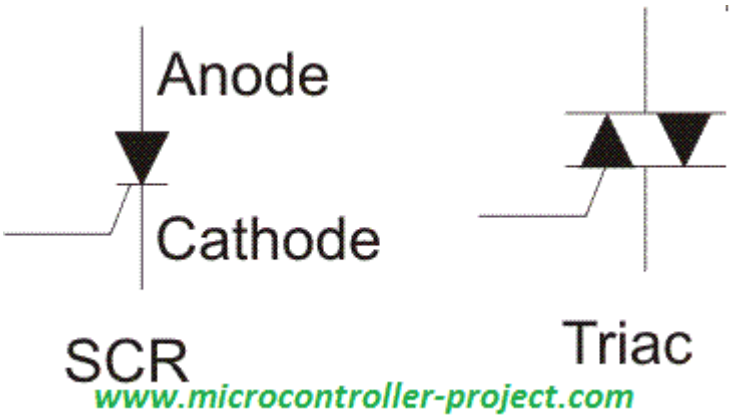
SSR stands for solid sate relay. It can handle several 1000 of watts load. It can handle around 300 Amperes to 500 Amperes of current. SSR is not a normal relay which are just like mechanical switches. A small voltage at input can trigger a heavy load(current) to flow from the circuit.



SSR with microcontroller controling heavy loads

In order to fully understand the ssr working we must first understand two electronic components. These components are building block of SSR. The components them self are evolved from transistors working concept.

- SCR(Silicon Controlled Rectifier)
- TRIAC



SCR vs TRIAC

current from flowing. If terminal A is taken positive with respect to K, the SCR is forward biased, and will block current flow until terminal G (the gate) receives a positive pulse with respect to K. This trigger pulse will trigger the SCR into conduction and current will pass from A to K. The SCR will conduct with an almost constant voltage drop across it – typically 1.2 Vdc. The SCR will continue to conduct after the trigger pulse has ceased, until current through the SCR ceases, at which point it returns to a blocking state.

The name Triac stands for triode (three electrode) AC switch. It is a thyristor device similar to an SCR, but differs in that it can be triggered into conduction in both directions, in response to a positive or negative gate signal. TRIAC ans SCR symbols are shown on the left hand side. SCR can work like TRIAC if we attach one more SCR in opposite direction to it and gate are combined.

SCR and TRAIC are used to control AC loads. They are used to control mains electricity phases etc. They can also work on PWM input. They are widely used in AC circuits to dim lights. Standard dimmers available in market are all comprised of SCR or TRIAC. A SSR for AC use usually consists of an opto isolator driving a Triac. A SSR for DC use usually consists of an opto isolator driving a power MOSFET.

Some projects which i created using relays and microcontrollers to control heavy current loads etc. Projects contains free source code and circuit diagrams.

SSR with Arduino: Auto AC ON/OFF

Driving heavy loads with Stm32 microcontroller

Heavy loads controlled over WiFi using Nodemcu