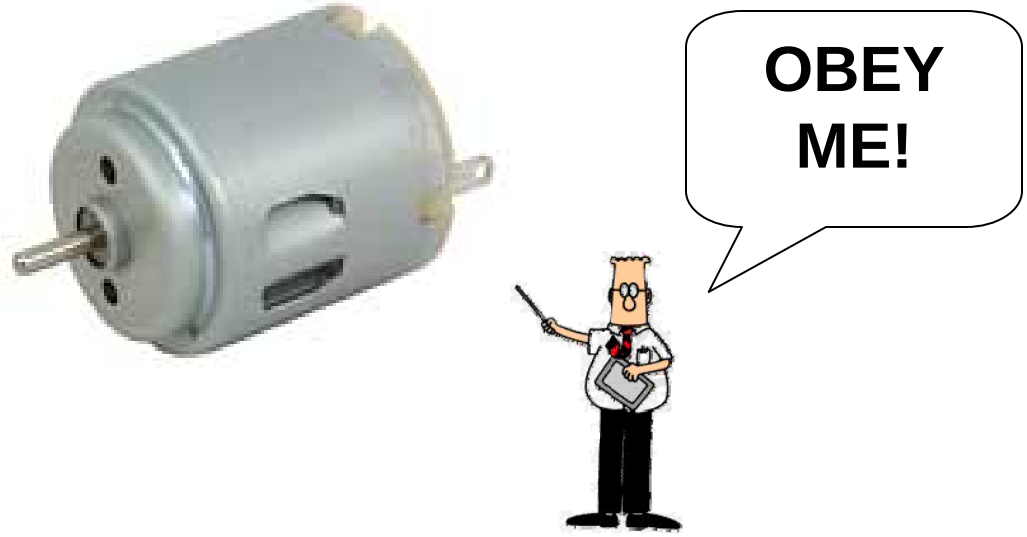
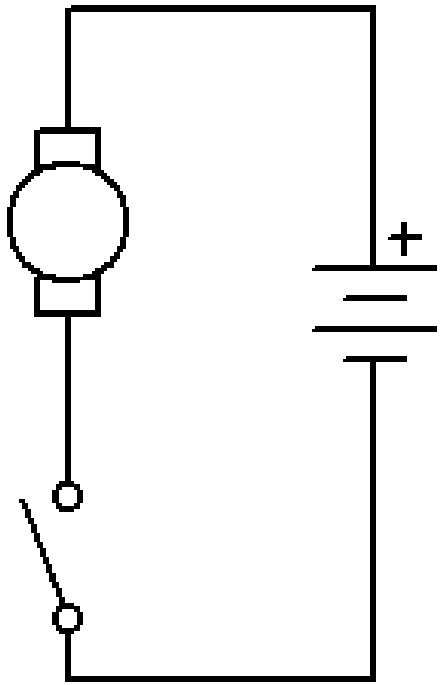
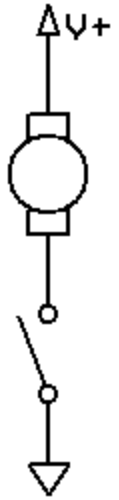
Controlling Motors



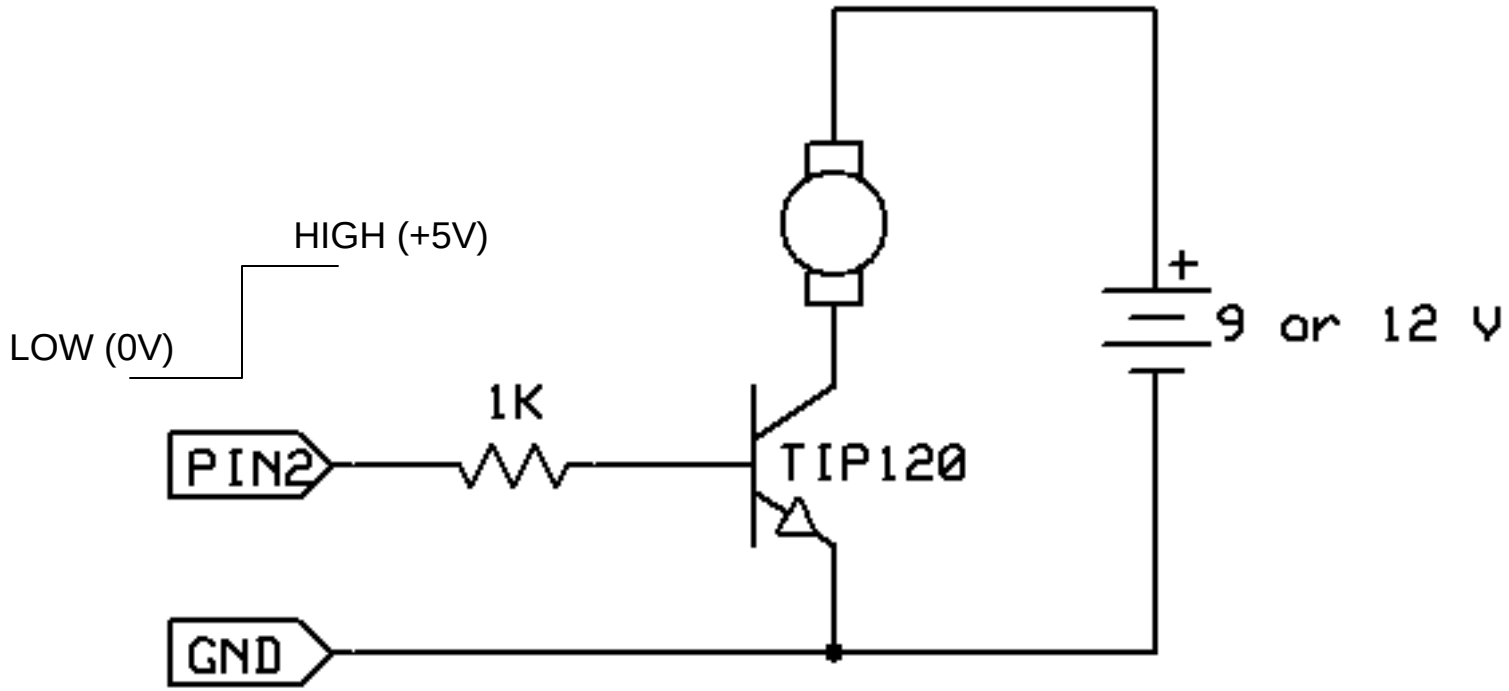
On-Off Control

1. Switch control

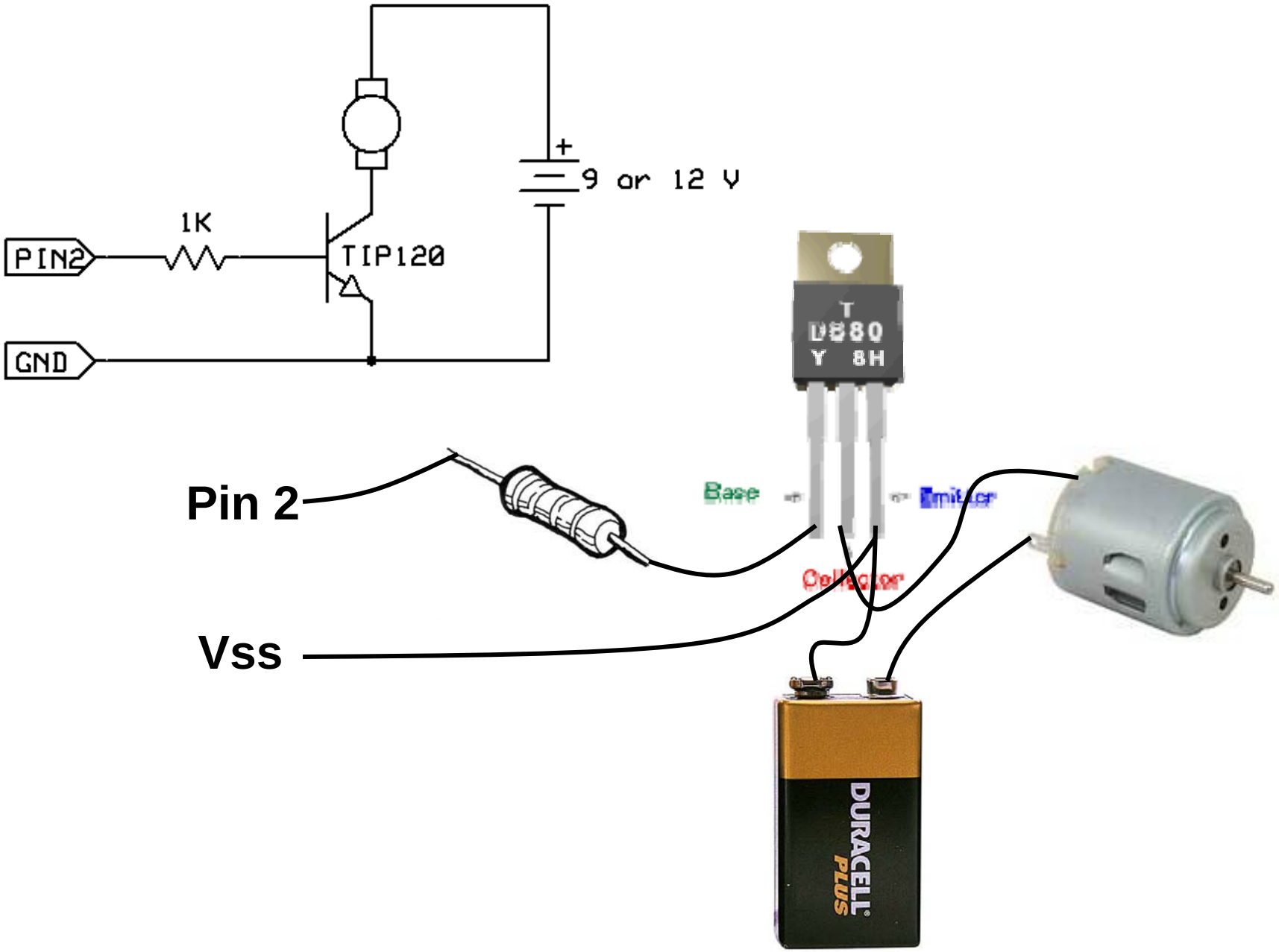




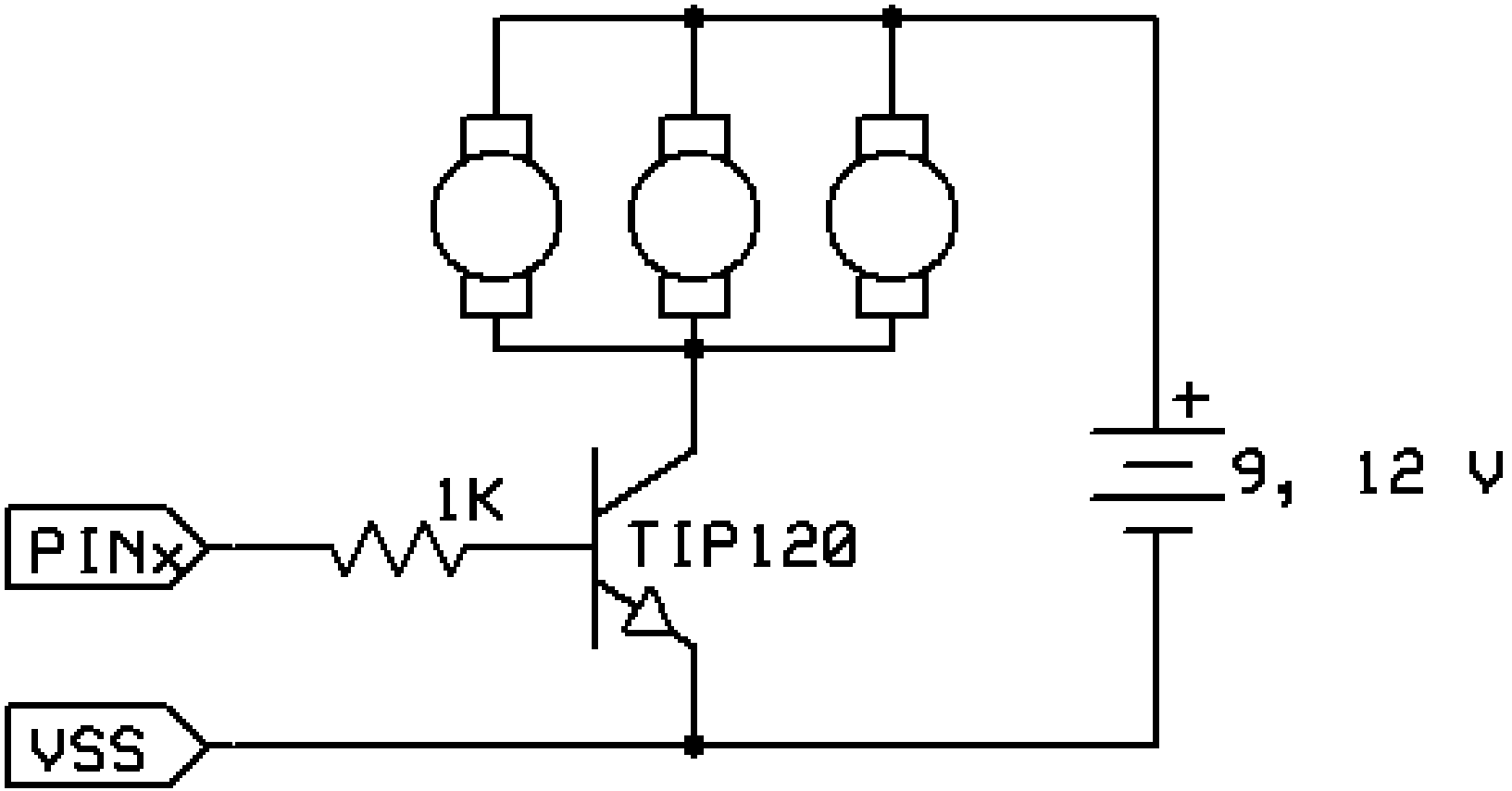
2. Transistor control



Type	Imax (mA)	Vce (V)
2N3904	100	0.2
TIP120	1500	1.5

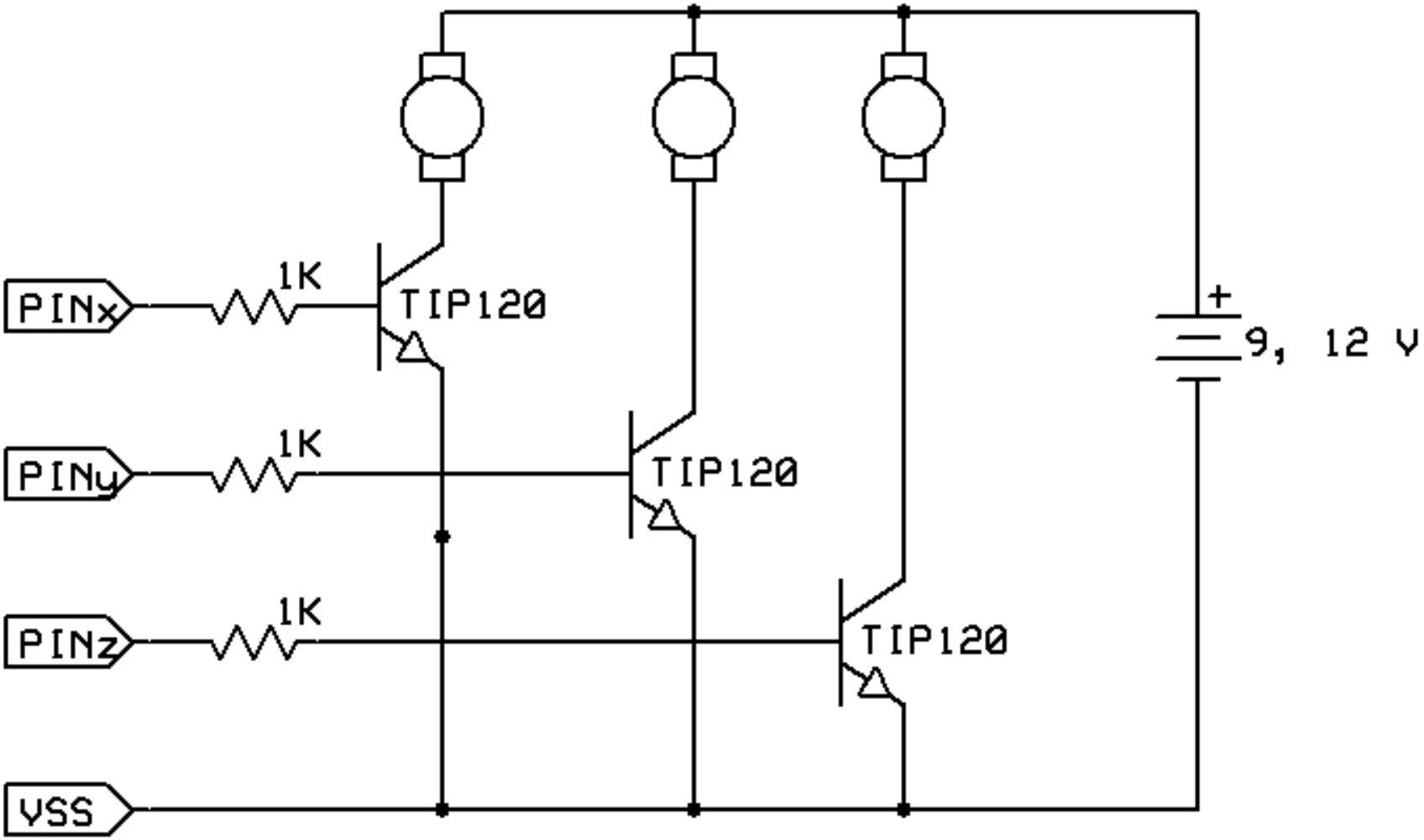

+
9 or 12 V
1K
PIN2
TIP120
GND
Pin 2
Vss
Base
Emitter
Collector
DURACELL
PLUS

Several motors

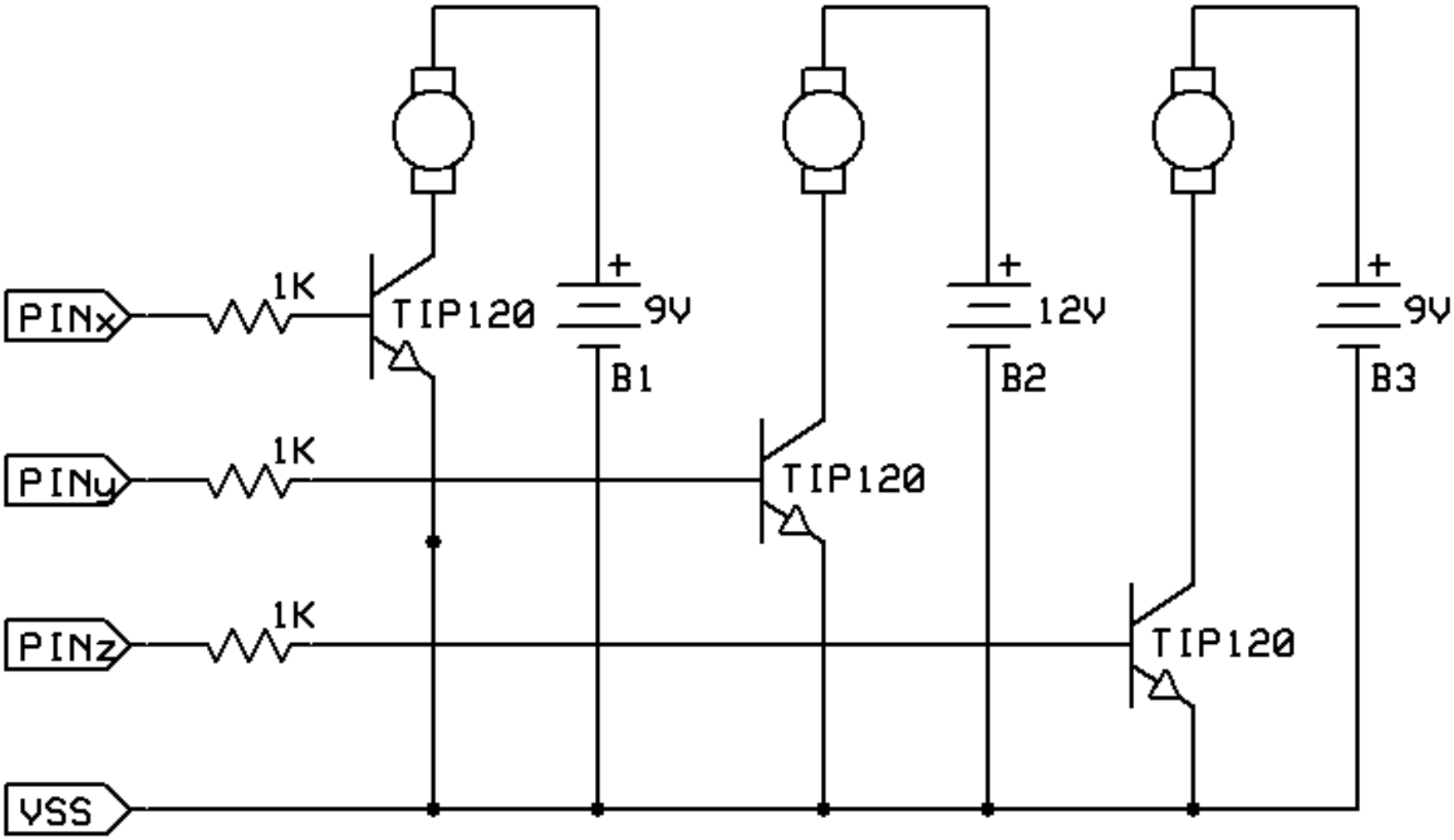


Watch out for TIP120 overheating

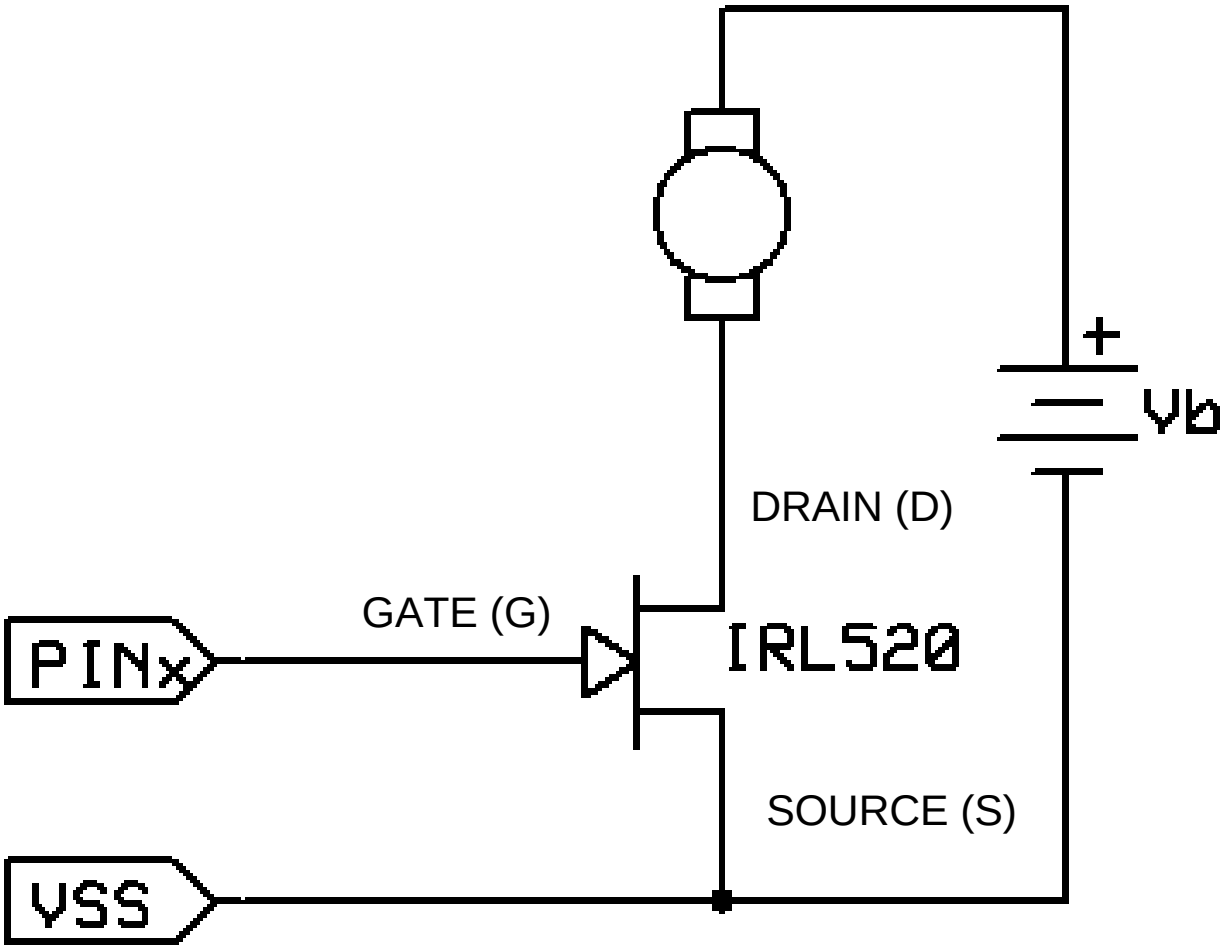
Several motors, each controlled



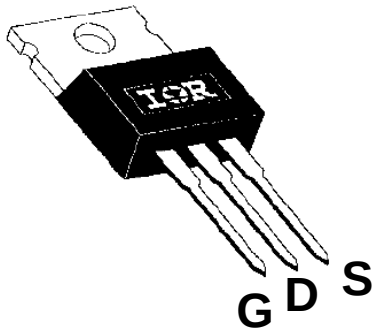
Several batteries



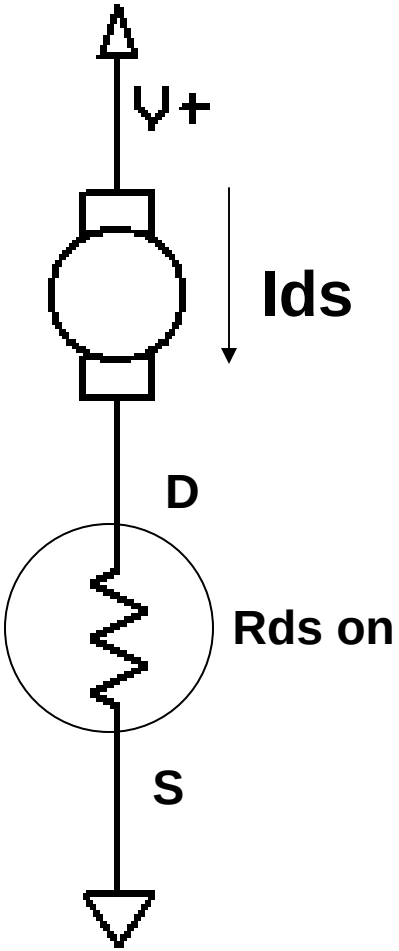
MOSFET Control



MOSFET



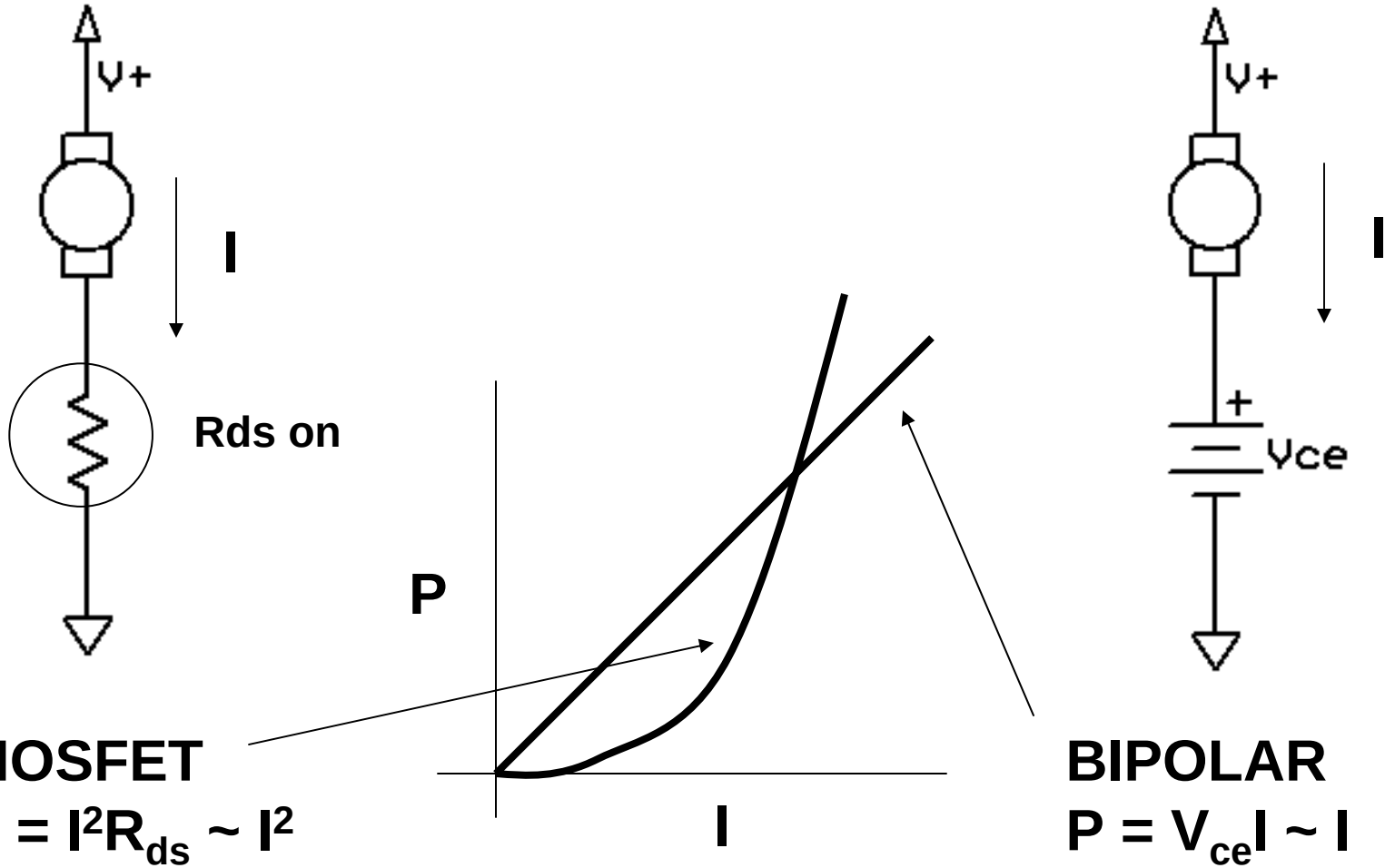
IRL520
Ids = 10A
Rds on = 0.18 ohm



If Ids = 2.0 A
Vds = I*R = 2.0*.18 = .36V
P = IV = 2*.36 = .72W

For TIP120, Vce = 1.5V
P = 2*1.5 = 3W !

For high currents, bipolar wins



MOSFET

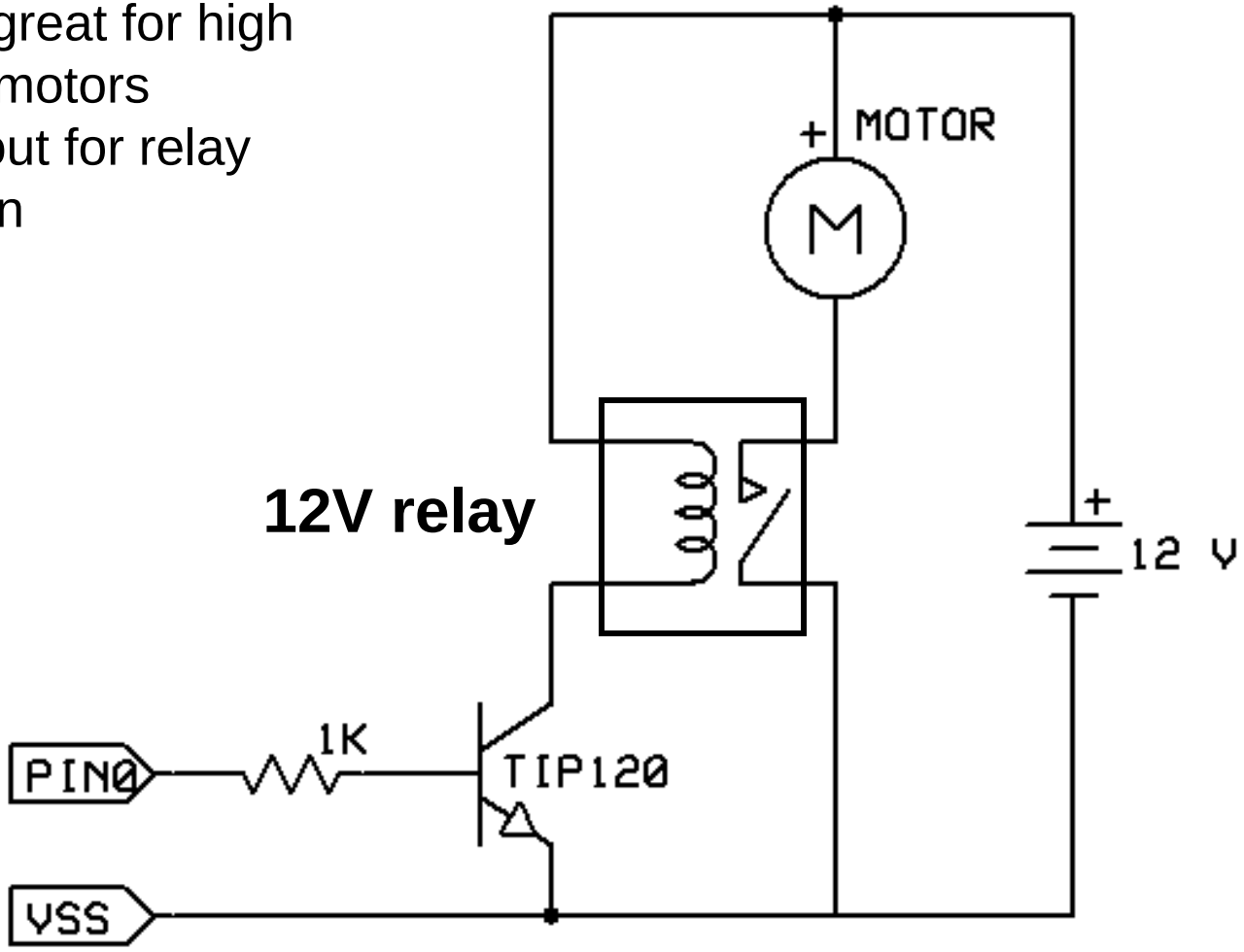
$P = I^2R_{ds} \sim I^2$

BIPOLAR

$P = V_{ce}I \sim I$

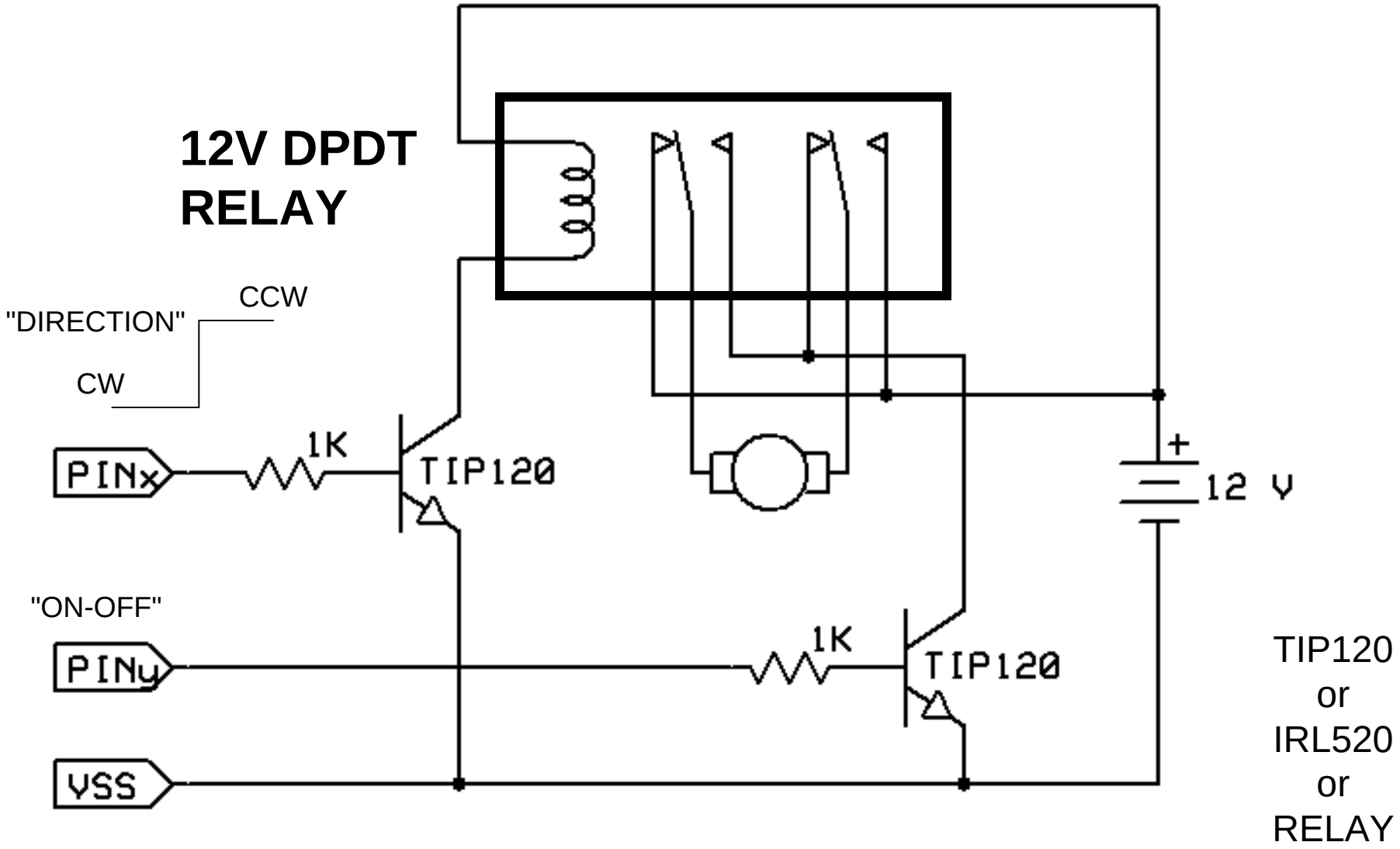
3. Relay control

- Relays great for high current motors
- Watch out for relay coil drain

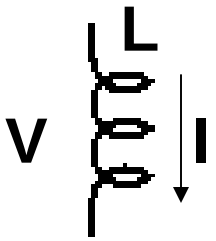


TIP120 or 2N3904

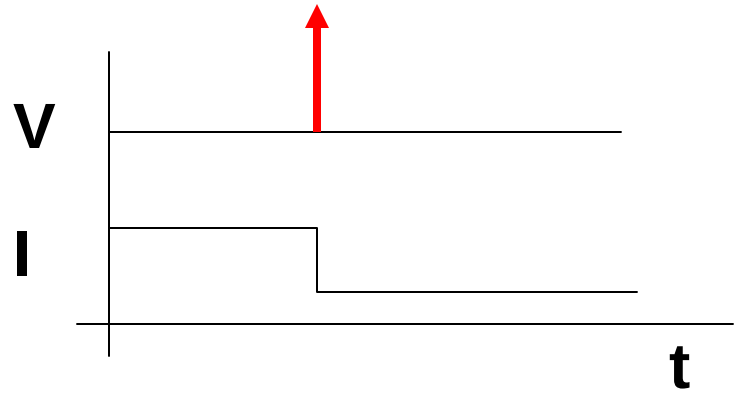
Bi-directional motor control

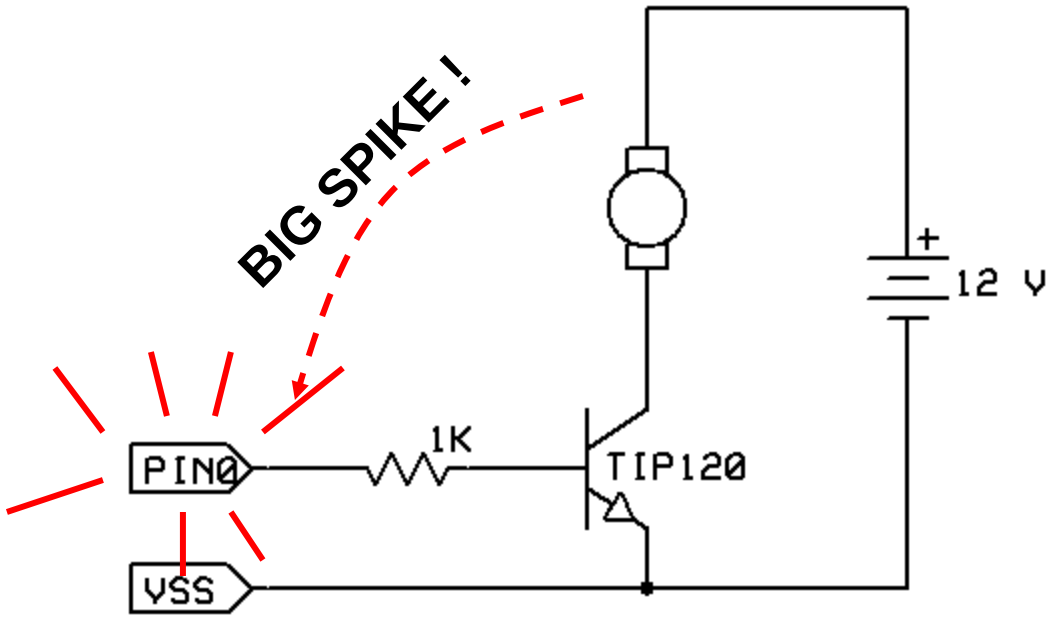


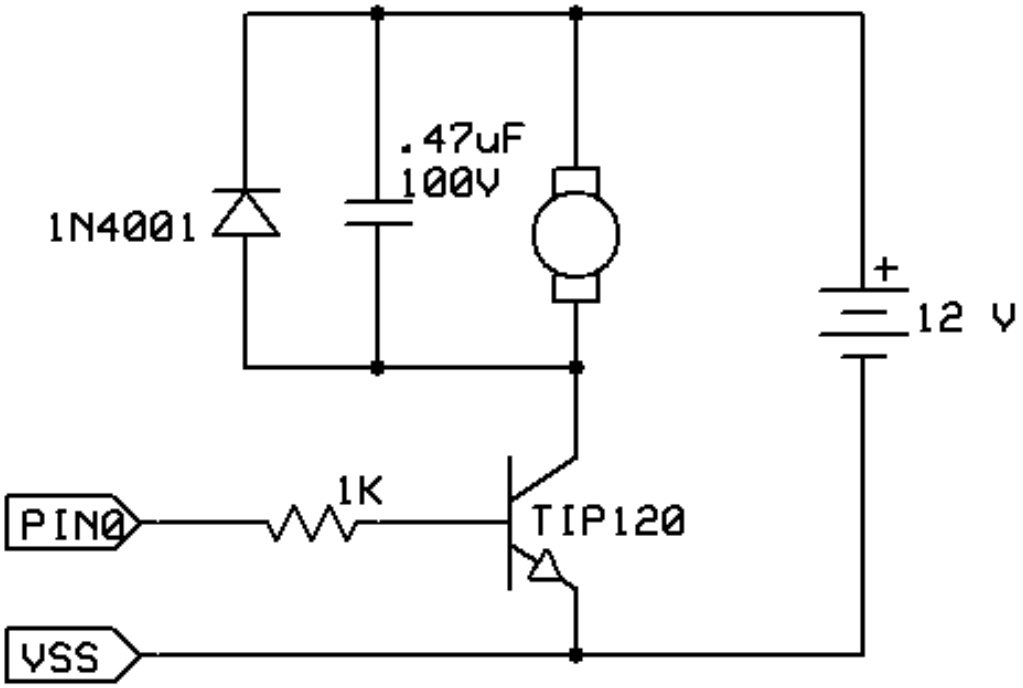
Inductive loads cause switching spikes



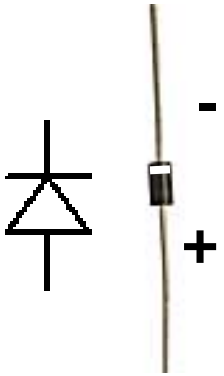
$$V = L\frac{dI}{dt}$$





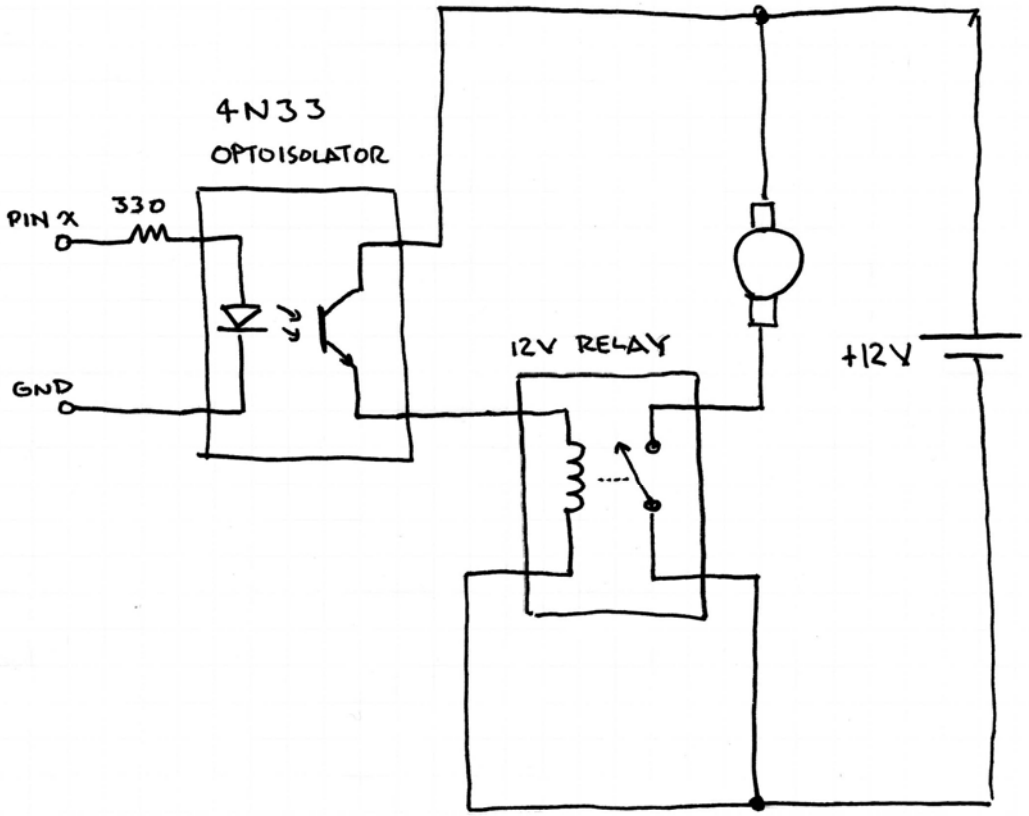


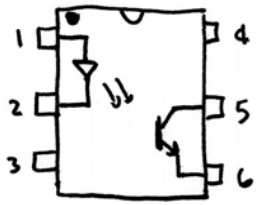
.47, 100V mylar



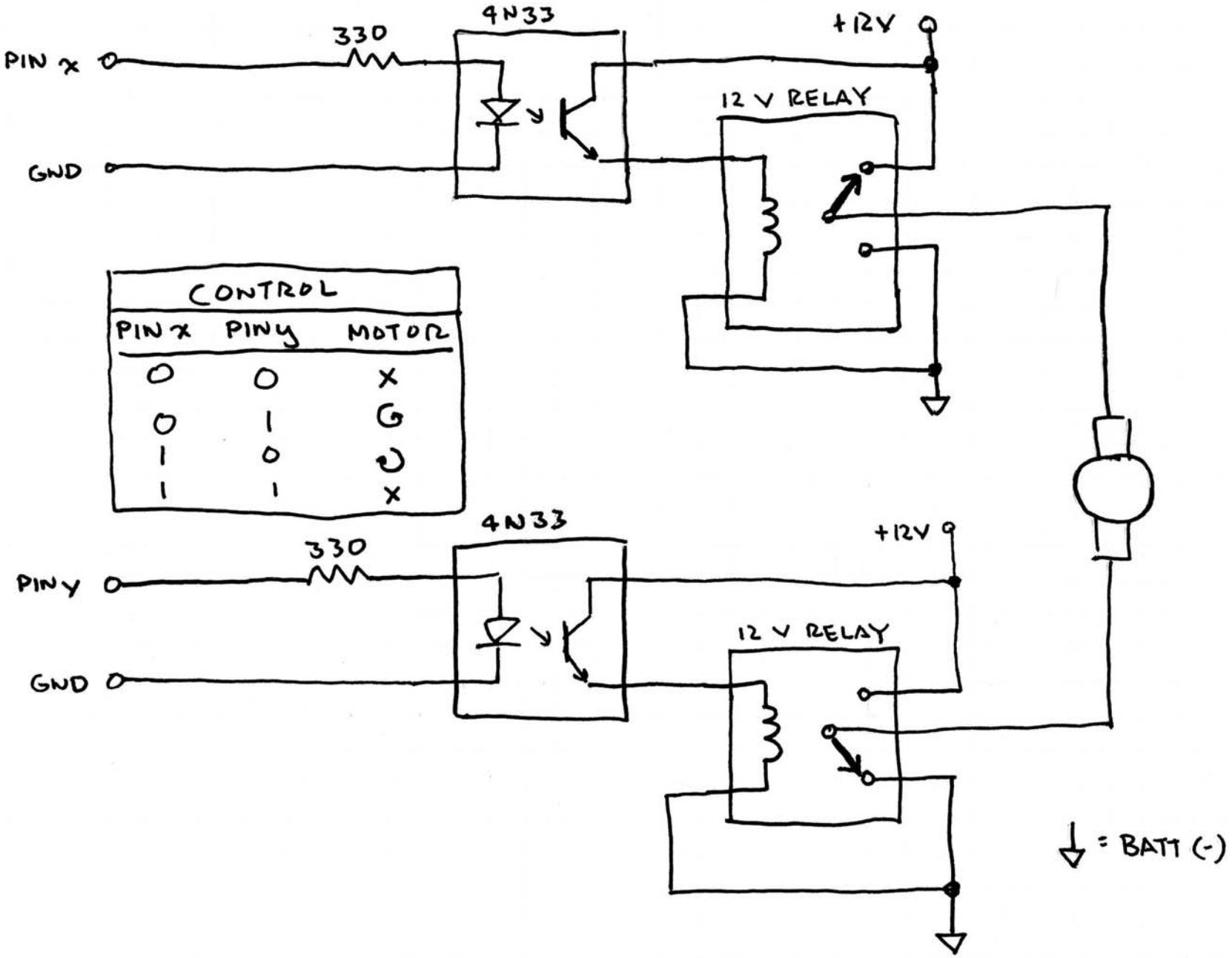
diode

ISOLATE COMPUTER FROM MOTOR



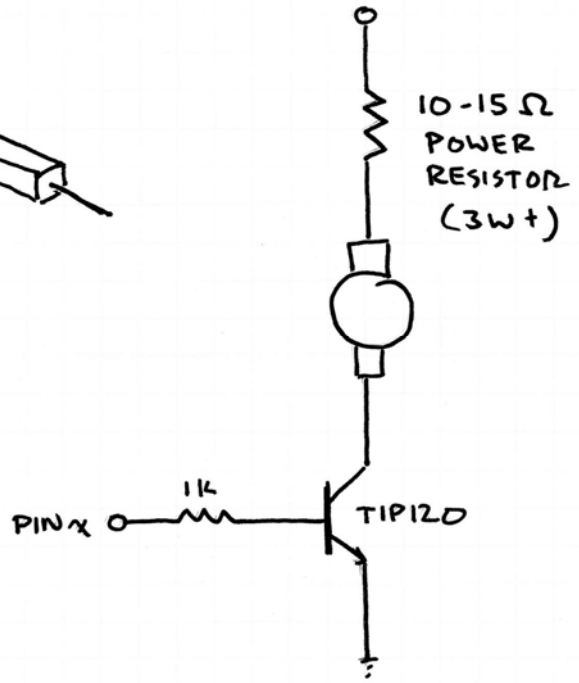


ISOLATED BI-DIRECTIONAL MOTOR CONTROL



CONTROL		
PIN x	PIN y	MOTOR
0	0	X
0	1	G
1	0	↻
1	1	X

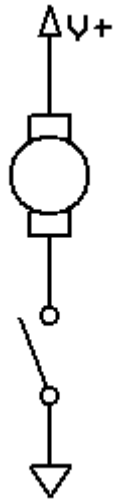
SLOWING MOTOR



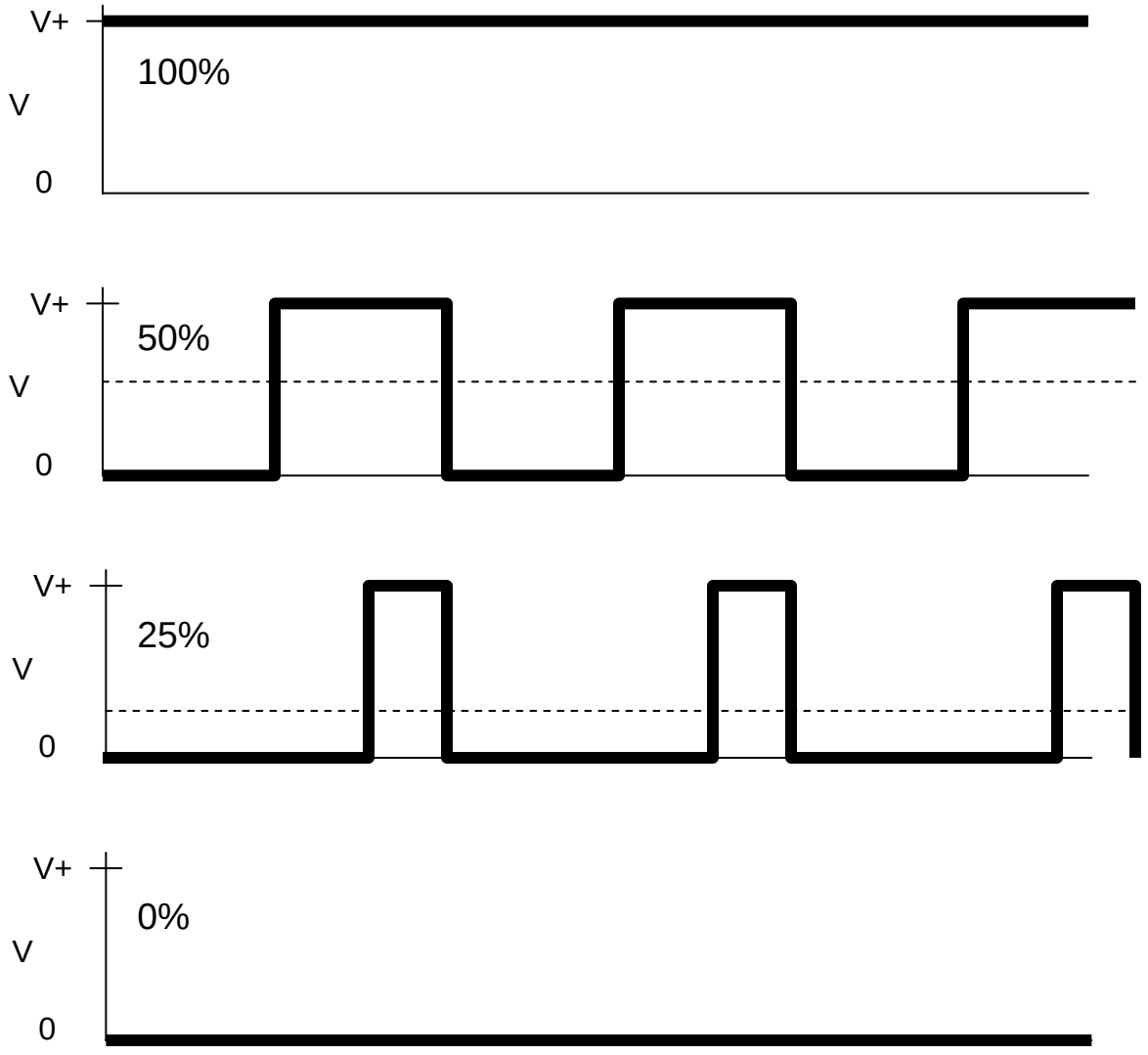
NEED A LOAD RESISTOR?

TRY A 2-CELL FLASHLIGHT BULB
...OR 2 IN SERIES OR PARALLEL

Speed Control by Pulse Width Modulation (PWM)

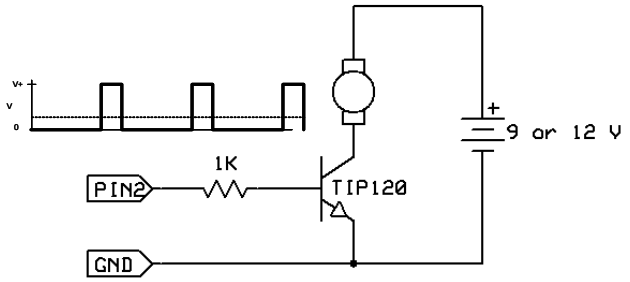


Open and close switch rapidly



PWM for Variable Speed

```
...
while(digitalRead(6)==HIGH) {
  digitalWrite(2,HIGH);
  delay(5);
  digitalWrite(2,LOW);
  delay(35);
}
...
```



Duty cycle = 5/35 = 14%

Watch out for voltage spikes!

```
...
//run at 3 speeds
analogWrite(2,64);  //slow
delay(2000);
analogWrite(2,128); //medium
delay(2000);
analogWrite(2,255); //fast
delay(2000);
...
```