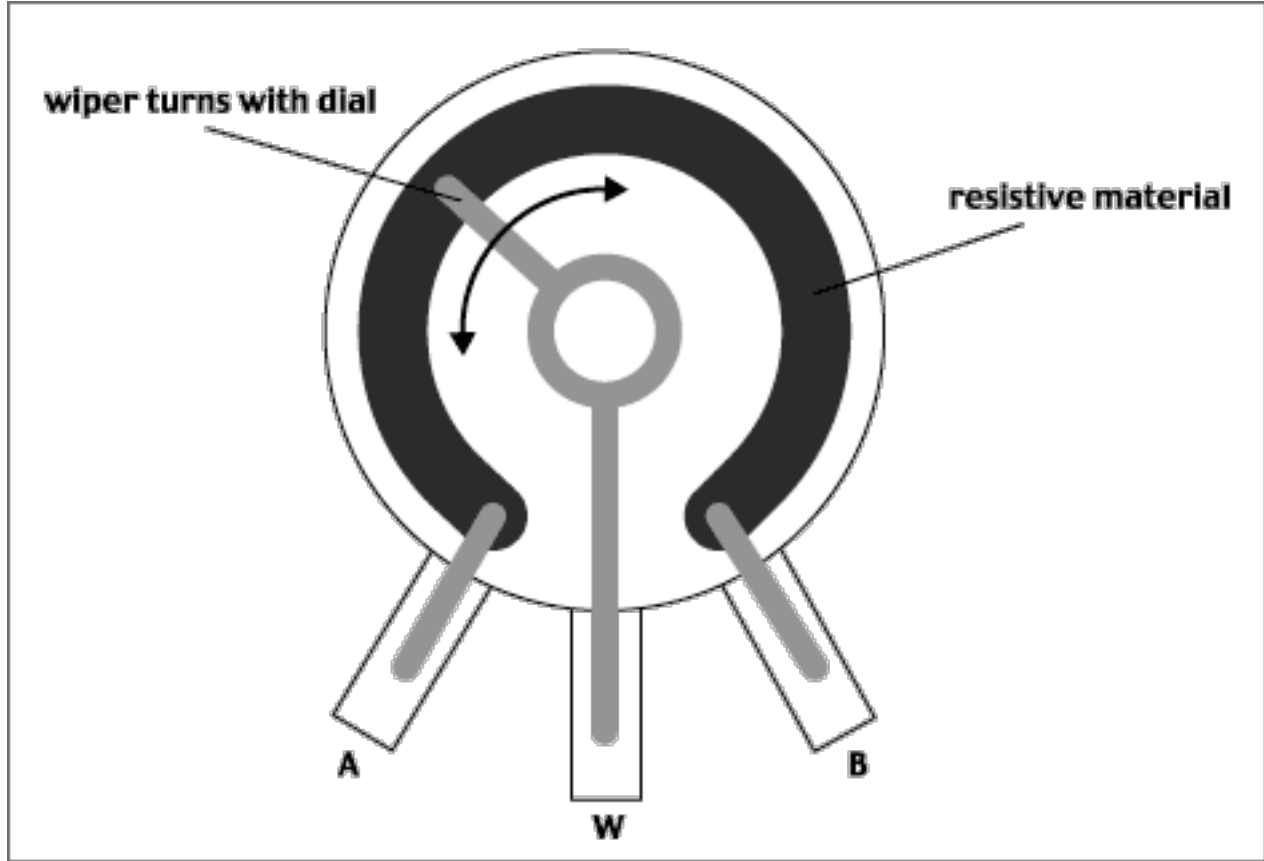


Lesson 3

potentiometers, transistors, soldering

Potentiometer

- 1) Variable resistor
- 2) Wiper moves between two leads. Resistance between wiper and lead determines resistance
- 3) Resistance between leads is maximum resistance of potentiometer.
- 4) Comes in dial, slider, and trimpot form



5) With linear pots resistance varies directly with the rotation of the knob.

6) With logarithmic pots resistance varies exponentially with the rotation of the knob.

6) Some other variable resistors include heat sensors, photoresistors and bend sensors.

soldering

- secure what you are working on
- tin your tip and keep it clean
- solder is not glue

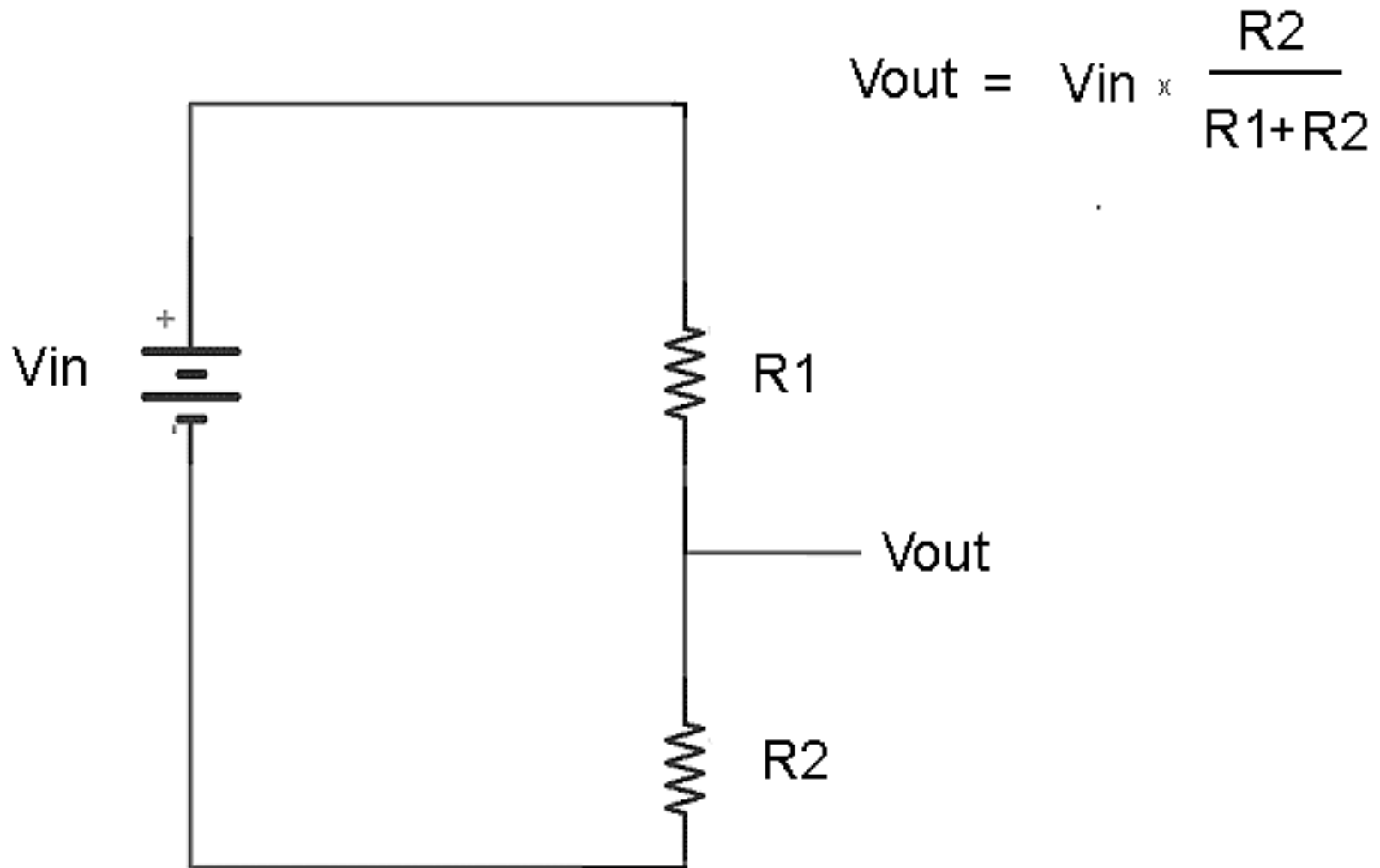
solder steps

- turn on soldering iron
- wait
- achieve a good mechanical connection
- clean tip in golden fleece
- tin tip
- apply soldering iron to area to be joined
- wait briefly then feed solder to area without removing iron
- remove solder then remove iron

Voltage Divider

- 1) With two resistors in series, the sum of the voltage drop across each equals the total voltage drop across both.
- 2) To determine the voltage between the two resistors, we use the voltage divider formula.
- 3) The voltage divider formula says $V_{out} = V_{in} * (R_2 / (R_1 + R_2))$
- 4) This turns out to be very useful

voltage divider



Transistor basics

3) Transistors have three leads - the base, collector and emitter.

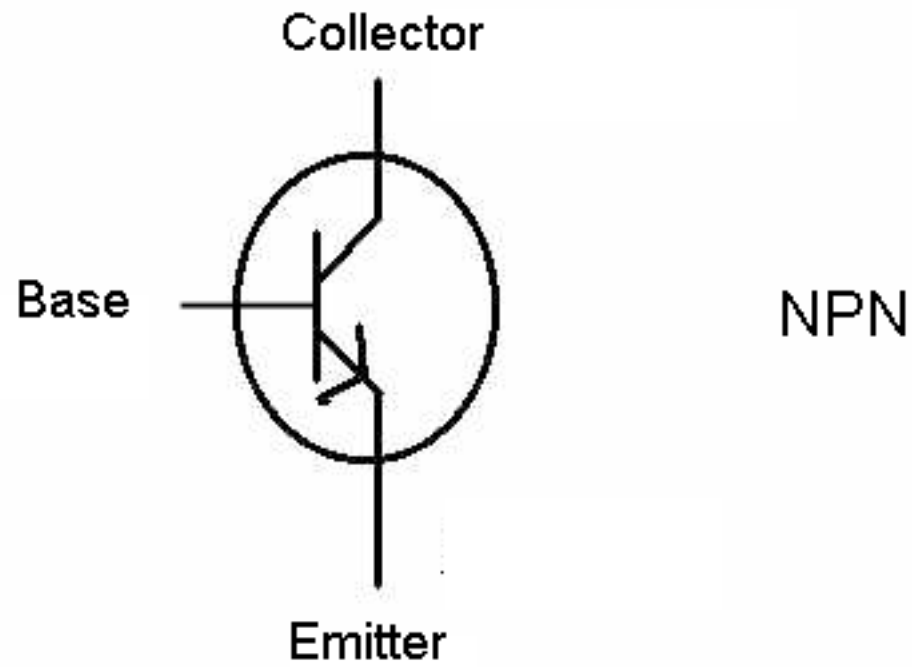
1) Small voltage on the base controls current flow through collector and emitter

2) Can be used as a switch or an amplifier.

3) Processor chips are lots and lots of transistors in one package.

NPN

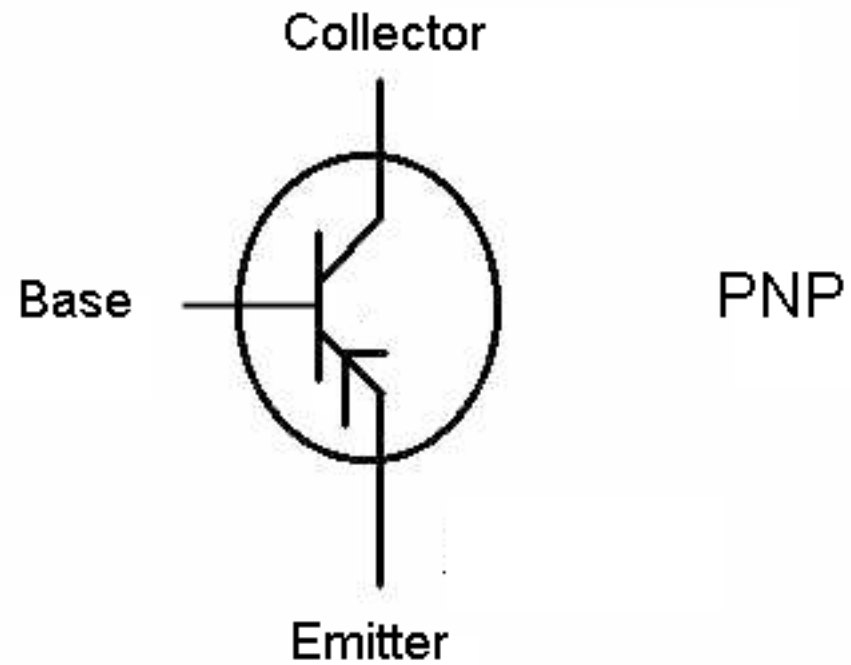
- 1) NPN. If the base is at a **higher** voltage than the emitter, current flows from collector to emitter.
- 2) NPN. Small amount of current also flows from base to emitter.
- 3) NPN. Voltage at base controls amount of current flow through transistor (collector to emitter).



follow arrow to see direction of current flow

PNP

- 1) PNP. If the base is at a **lower** voltage than the emitter, current flows from emitter to collector.
- 2) PNP. Small amount of current also flows from emitter to base.
- 3) PNP. Voltage at base controls amount of current flow through transistor (emitter to collector).



follow arrow to see direction of current flow

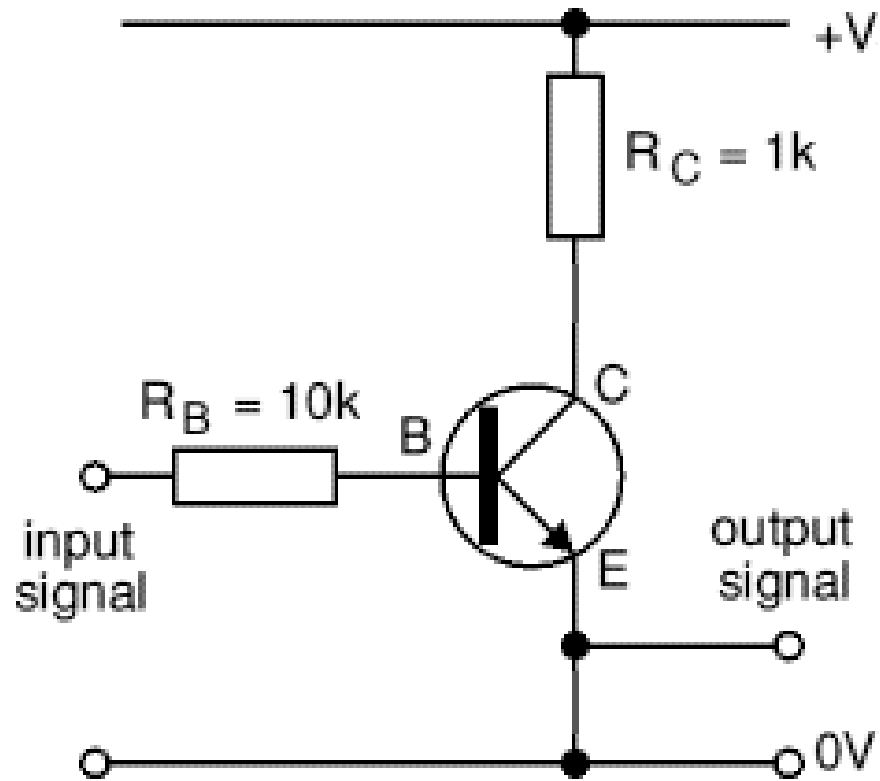
bipolar vs mosfet

- 1) There are two main families of transistors, Bipolar and FET.
- 2) FETs are more popular, waste less power (therefore run cooler), and are cheaper than bipolar.
- 3) FETs can be easily damaged by static electricity, so we will be using bipolar.
- 4) The basic operation of bipolar and fets are the same.

transistor as switch

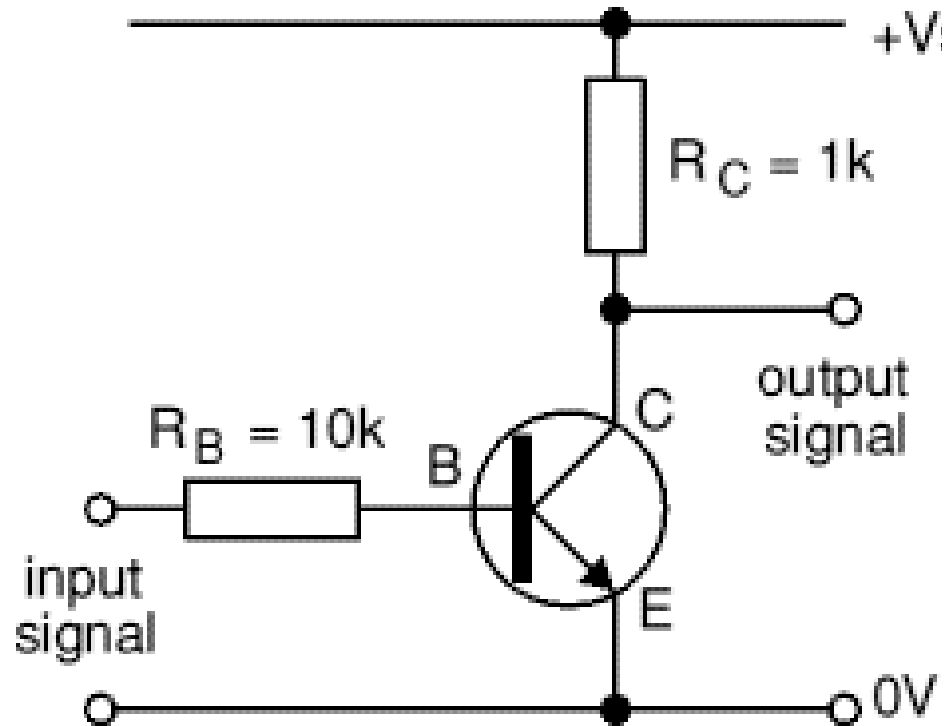
- 1) Most sensors, processors, microcontrollers can't source enough power to make things happen in the real world.
- 2) Transistors allow a large amount of current to be controlled by a small change in voltage.
- 3) Grounds between control circuit and transistor must be common.

transistor switch

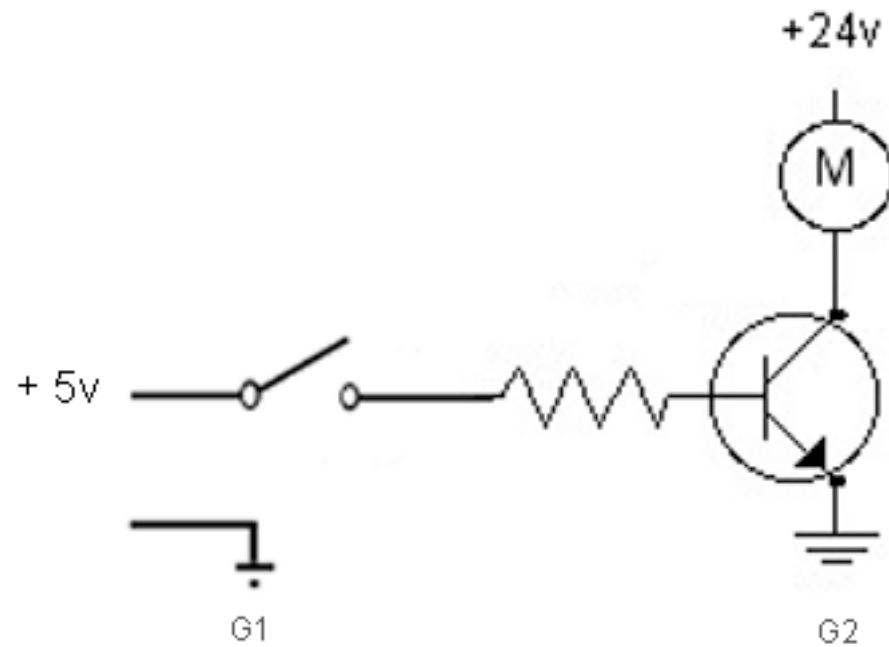


When base is high, output is high

transistor inverter



When base is low, output is high



transistor voltage and load voltage can be different,
but they must share a common ground

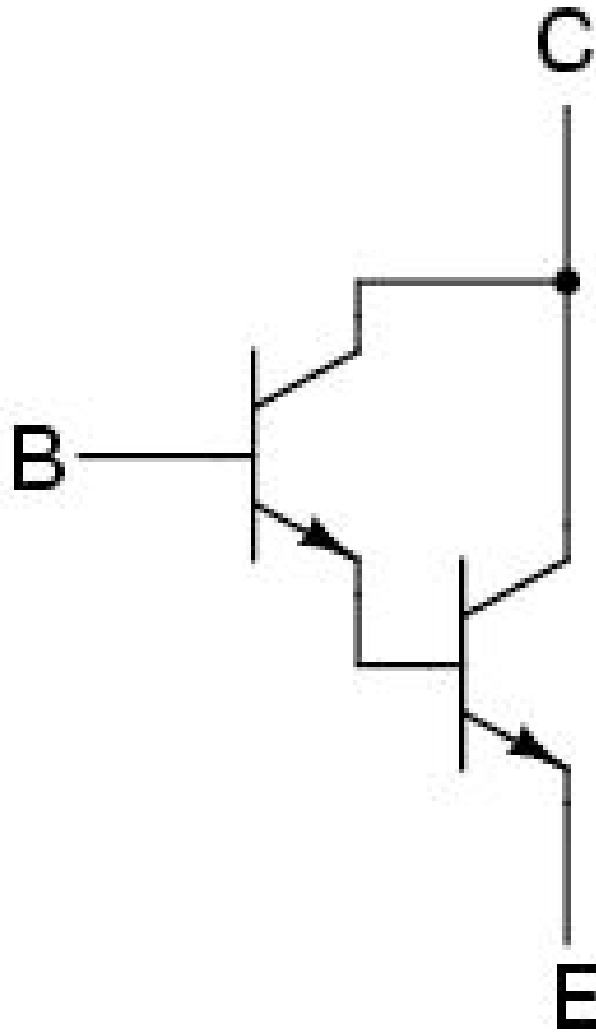
Amplification

- 1) Transistors have a fixed degree of amplification. (H_{fe})
- 2) When a transistor is at maximum amplification it is saturated. Saturation works when we want to pass the maximum amount of current through the transistor.
- 3) By limiting the voltage at the base, we can limit the current through the circuit.
- 4) Somewhat against intuition, when we limit current with a transistor, it's called amplification, because the small amount of voltage at the base is controlling the large current flow.

packages

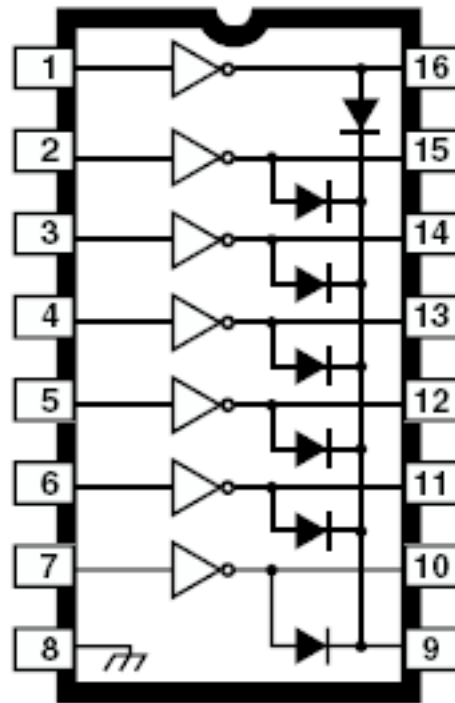
- depending on package, transistors can deal with different levels of current.
- power transistors have heat sinks on them
- arrays of transistors can be packaged together as ICs.

Darlington Pair

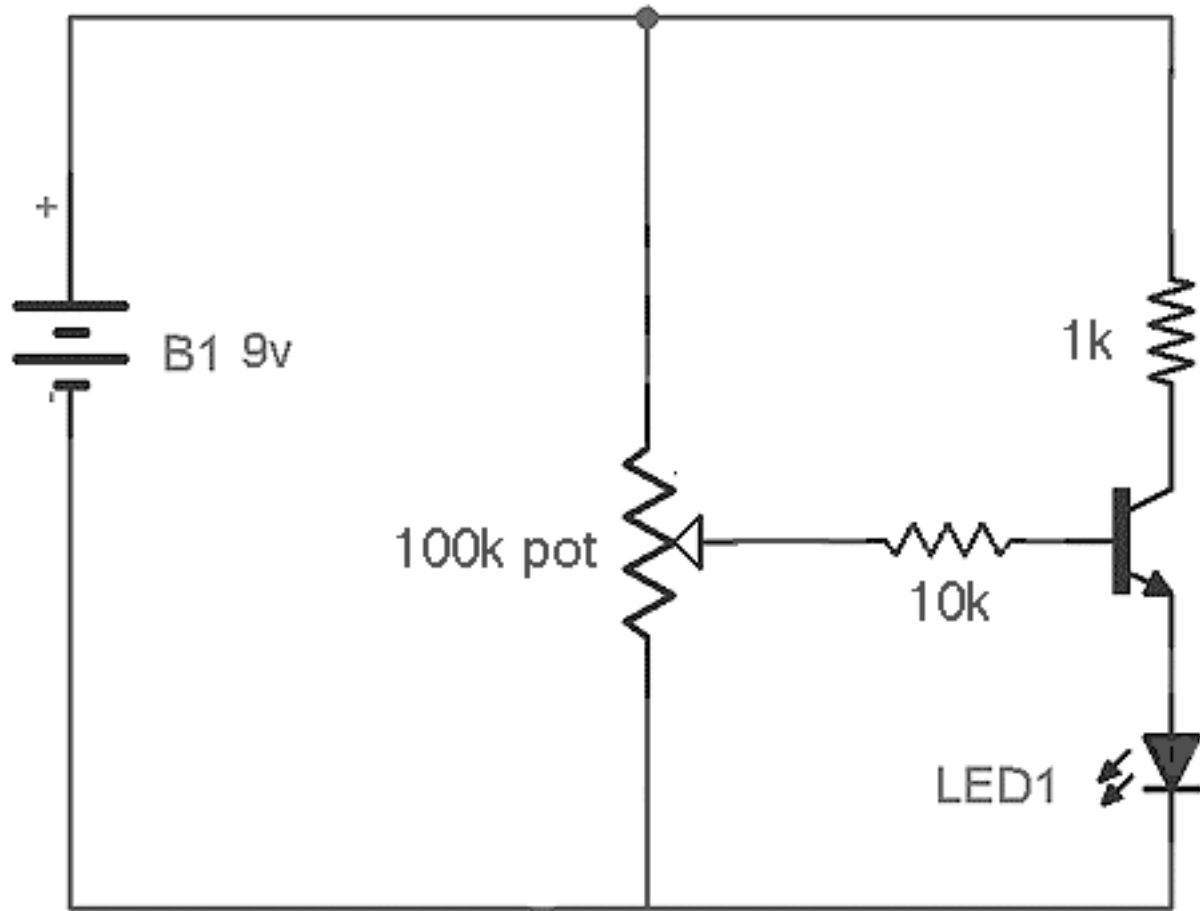


transistors can be cascaded for more amplification

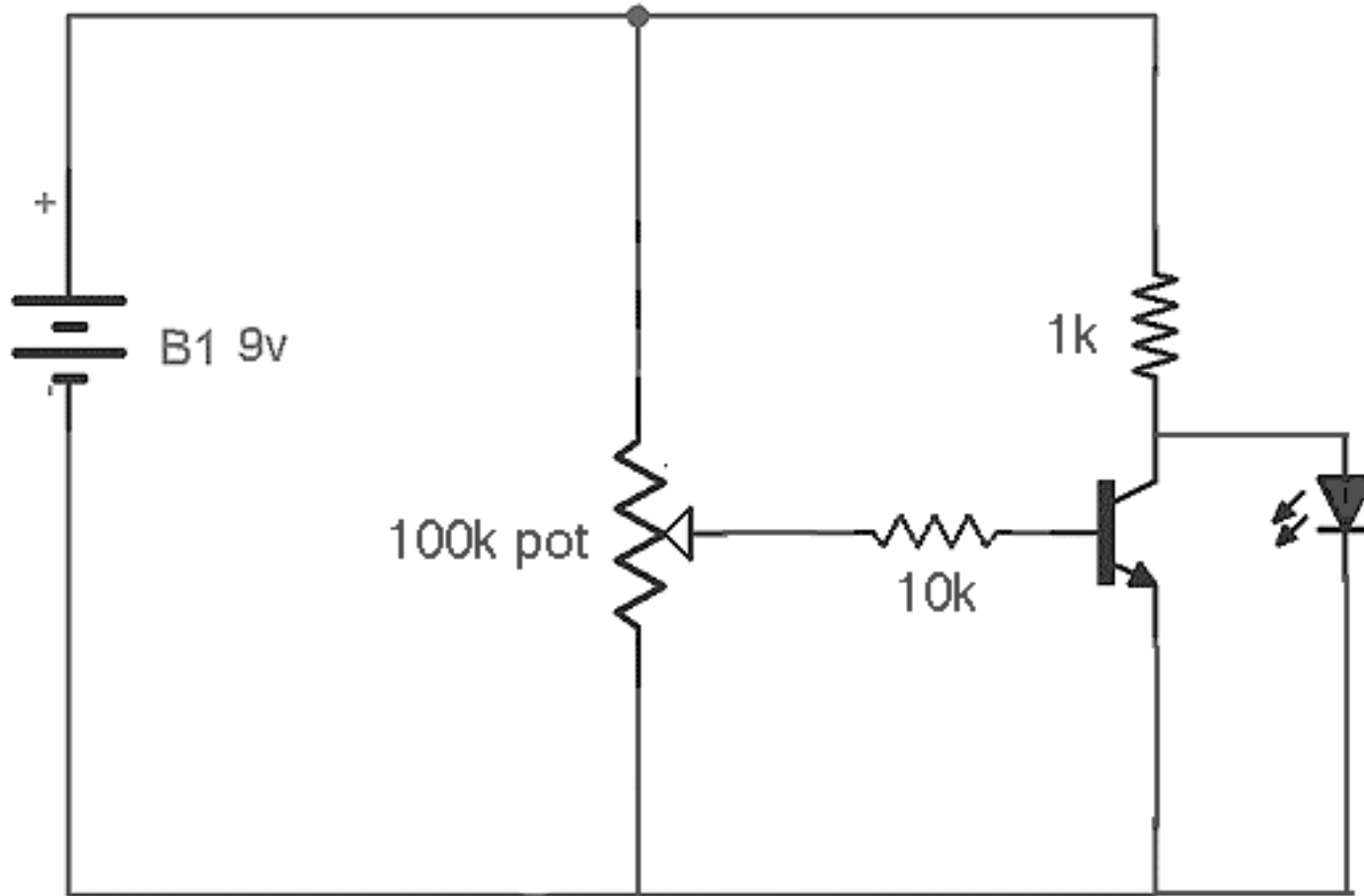
ULN2803



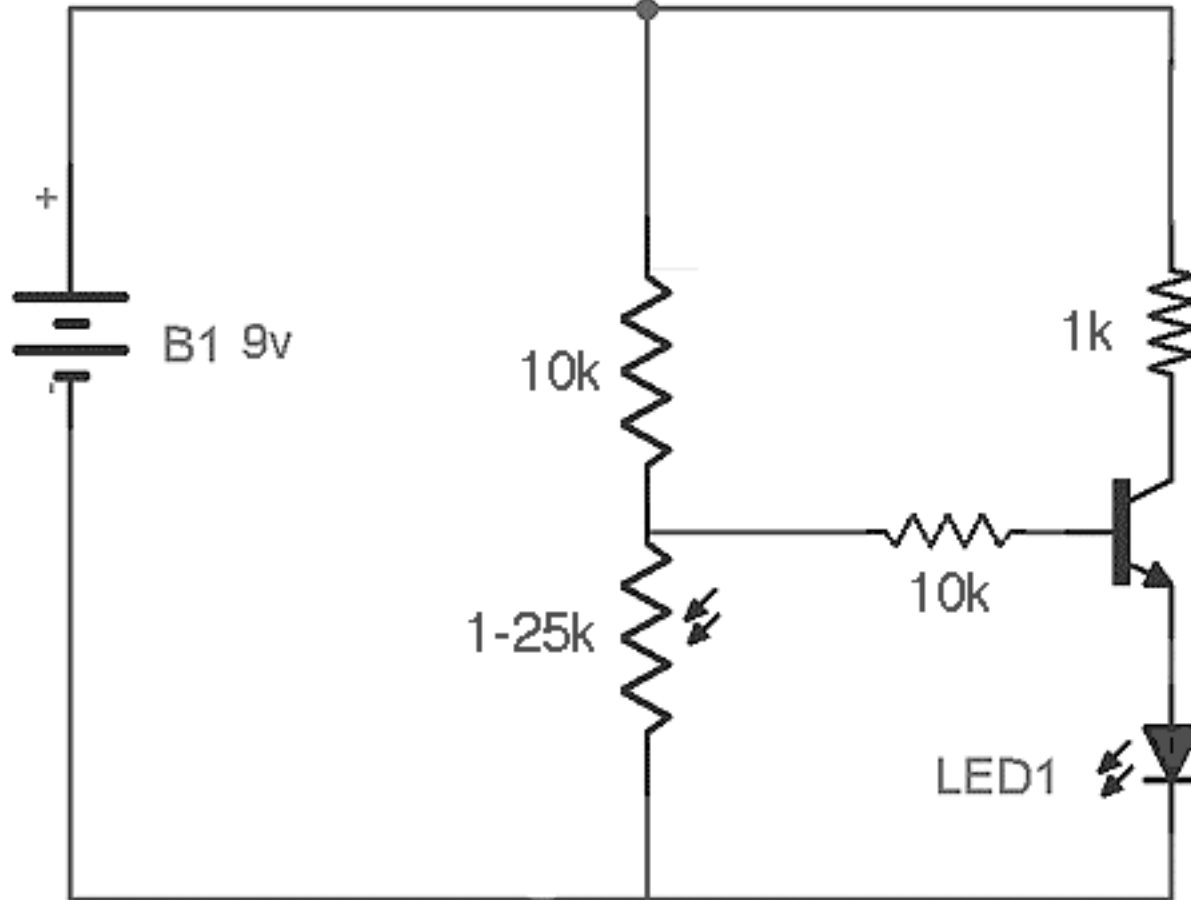
multiple darlington pairs packed in one IC



input voltage is created with potentiometer
when input voltage is high, led should turn on

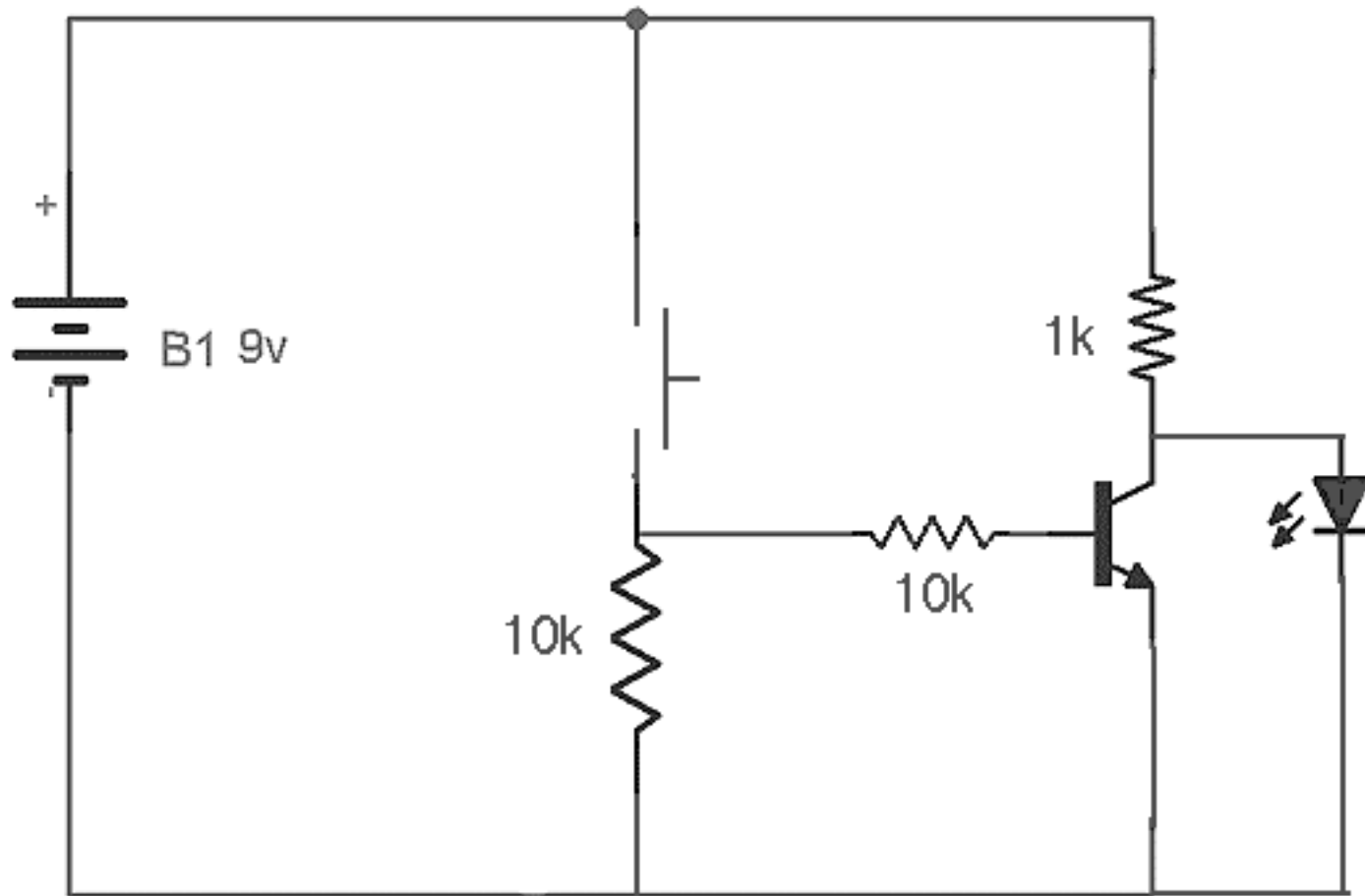


input voltage is created with potentiometer
when input voltage is low, led should turn on



Photosensor controls voltage at base

LED should light in darkness



switch is soil probe
led goes on in dry soil

Homework

- bring in computer speakers

