Embedded Dev Transistor Tips

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Conclusion

Low voltage, under 3V - use BJT

Low current, under 500mA - use a BJT (or FET)

High current - use a FET

High speed, above 10kHz - use FET with driver

VERY HIGH POWER, use an IGBT

Why Use Transistors?

Switch higher current

Switch higher voltage

Invert signal

Translate voltage levels

Buffer outputs (PWM to Linear voltage)

Transistor as Switches

BJT - good for low power

MOSFET - good for high-current

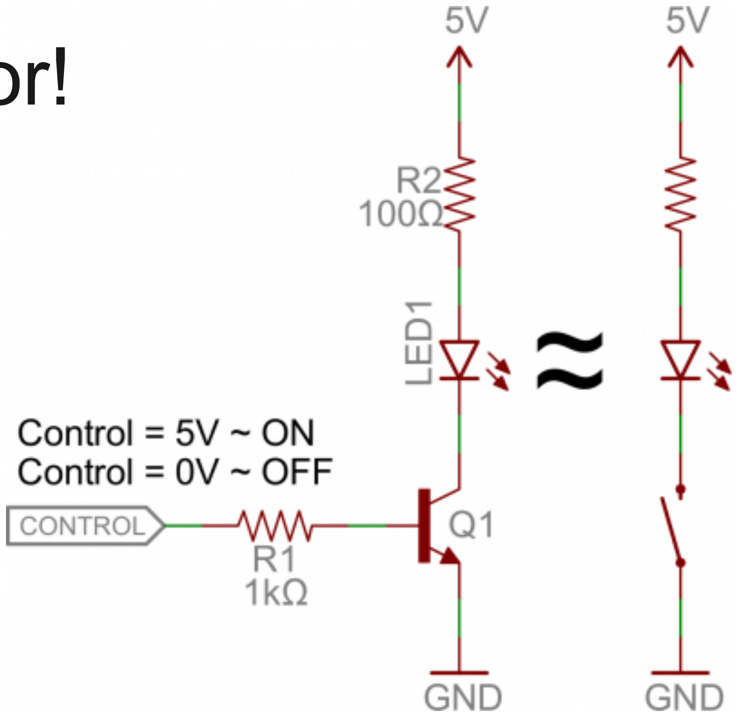
IGBT* - best for high-voltage, high-power

Minimum NPN Switch

Always need base resistor!

Vbe > 0.6V

I(b)=(5V-0.6V)/1k



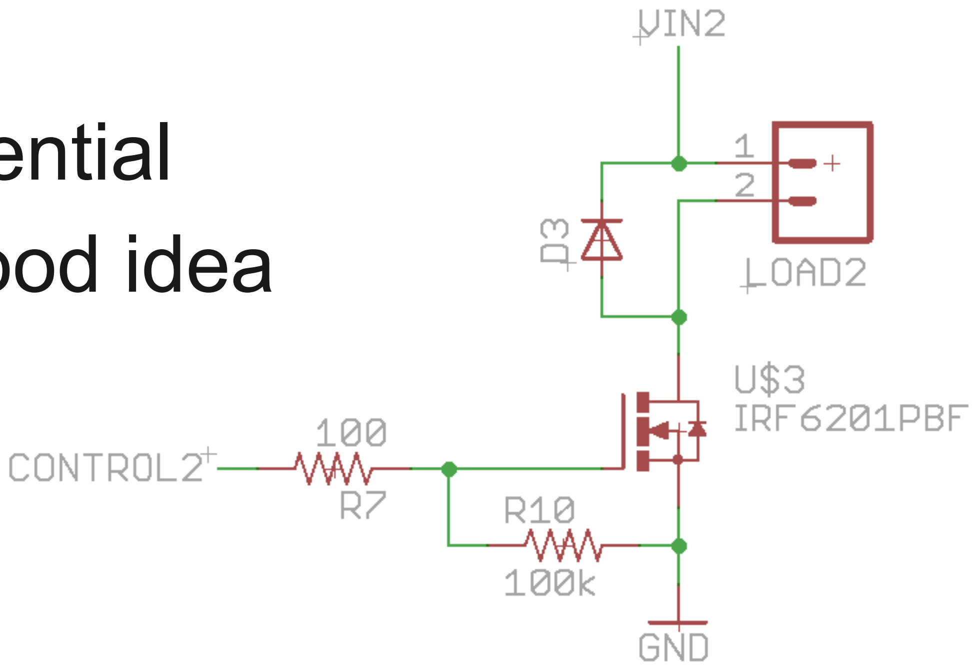
N-FET Inductive Load

Low Rds

Pull-down (100k) essential

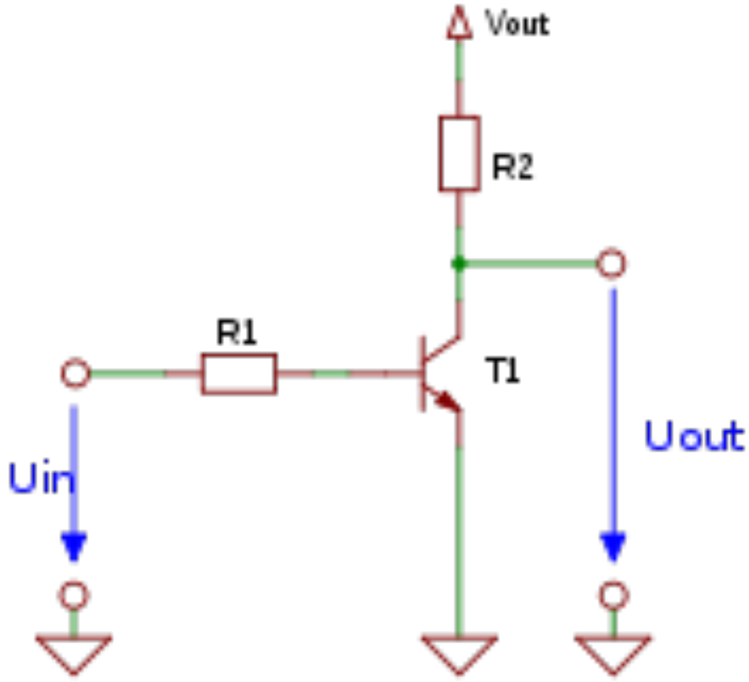
Gate resistor (100) good idea

D3 for inductive kick



BJT Inverter - Shifter

Sensitive FET also



Clever Level Converter

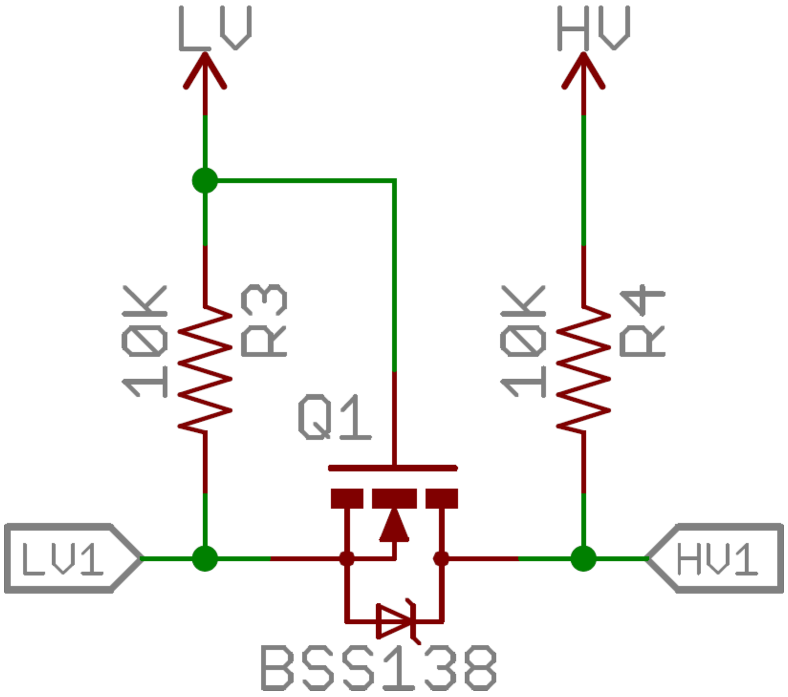
Bi-directional!

Uses body diode

Requires HV-LV > 0.6V

Philips - AN97055

Sparkfun - Level

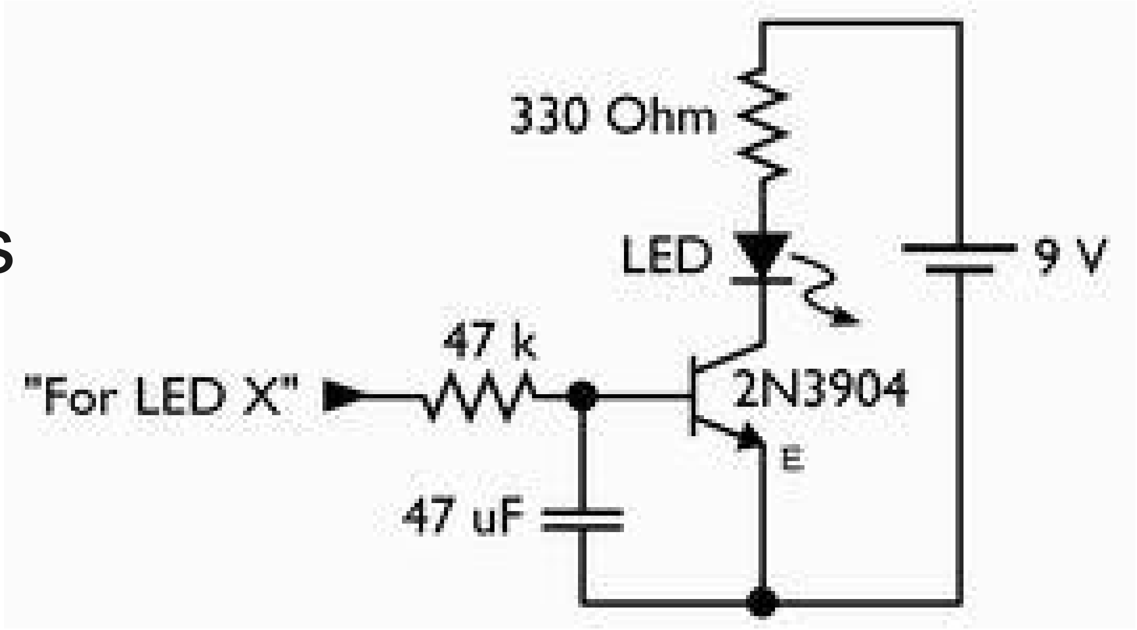


Buffer (with Low-Pass)

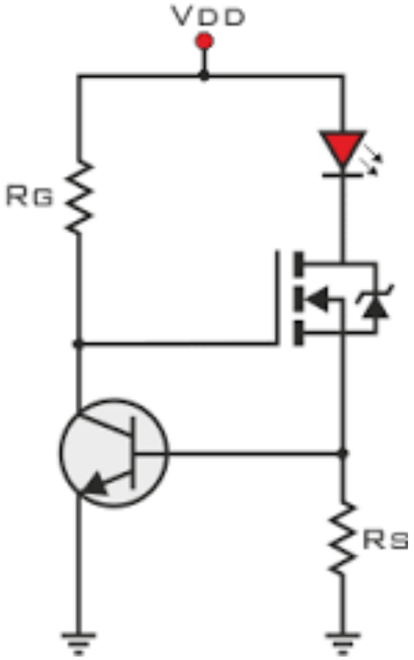
PWM-> Analog

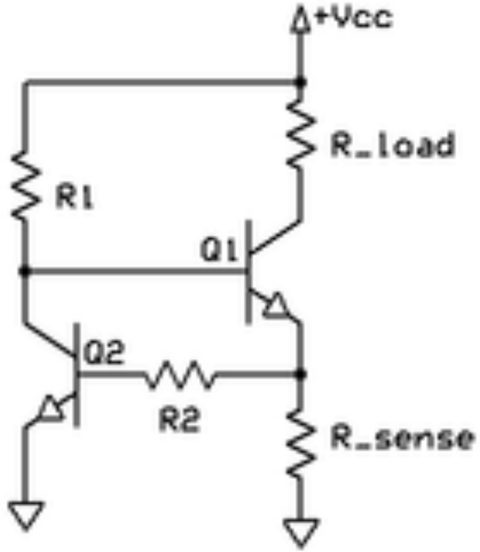
BJT more linear

FET not low Rds



Level Up - Current Limiter





How to Kill a Transistor

Exceed Voltage/Current Rating

Forget to use base resistor on BJT

Underdrive the gate of a FET

Exceed the device power dissipation limits

BJT in a Nutshell

Current driven devices

Vce(sat) < 200mV

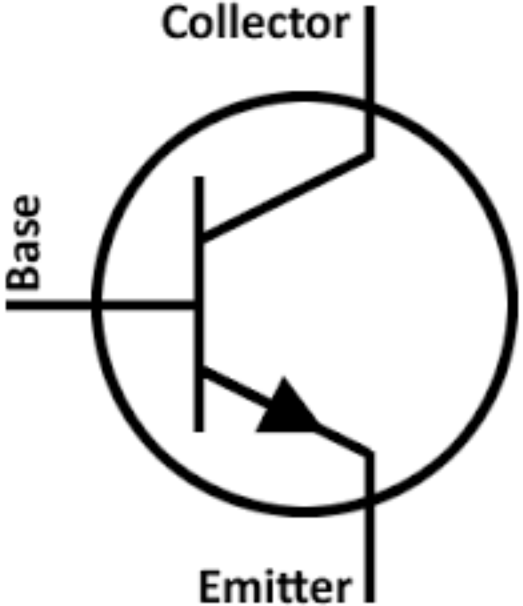
Vbe ~ 0.6V

Base current is multiplied

Susceptible to thermal runaway

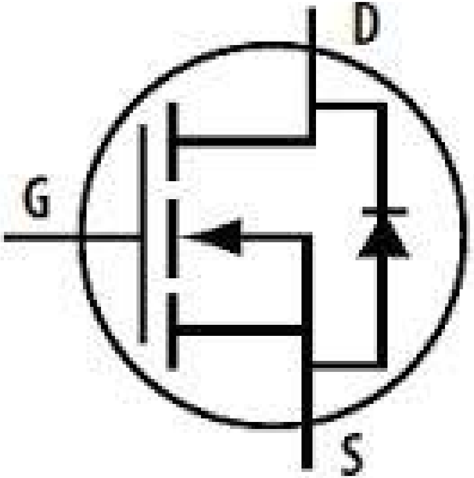
Darlington Vbe ~ 1.4V

Darlington Vce (sat) ~ 0.85V



MOSFET in a Nutshell

Voltage driven devices
On resistance can be < 1 mOhm
Requires min gate voltage
Very fast with proper gate drive
High current at low losses
Resists thermal runaway (can parallel)



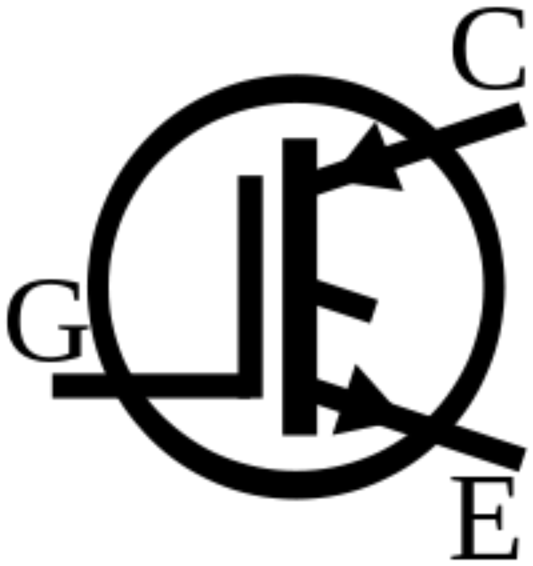
IGBT in a Nutshell

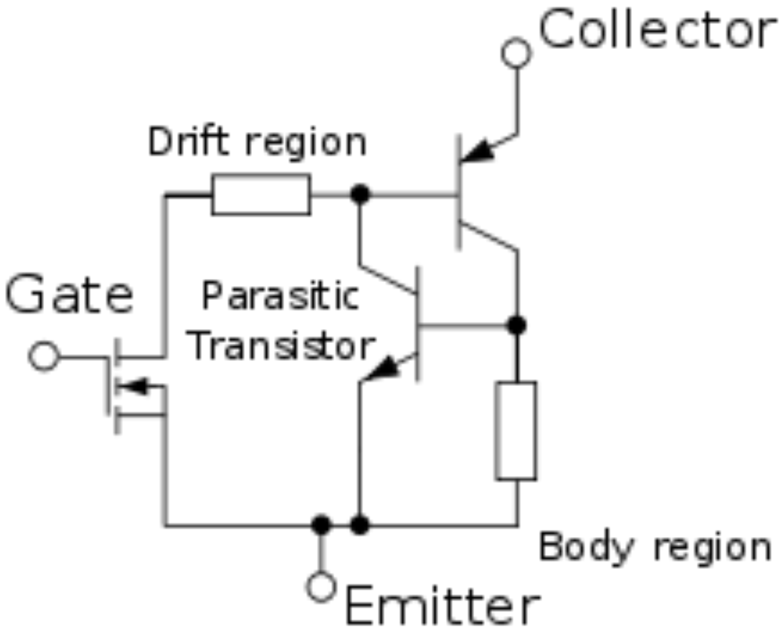
Love child of BJT and MOSFET

Combines low saturation voltage of BJTs with the voltage drive of MOSFETs

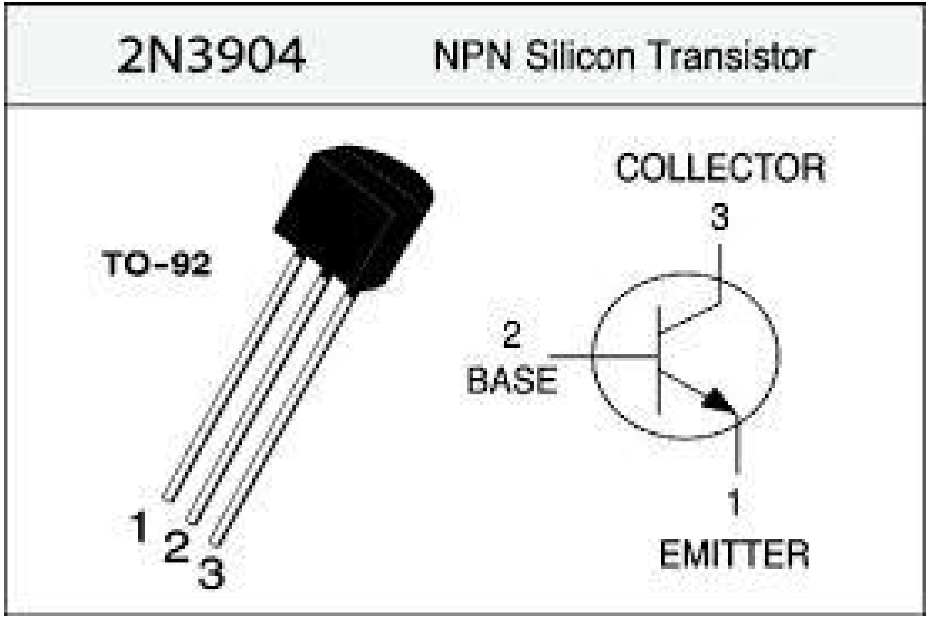
Invented by Dr. Jayant Balaga in 1977 (currently ECE Professor at NCSU)

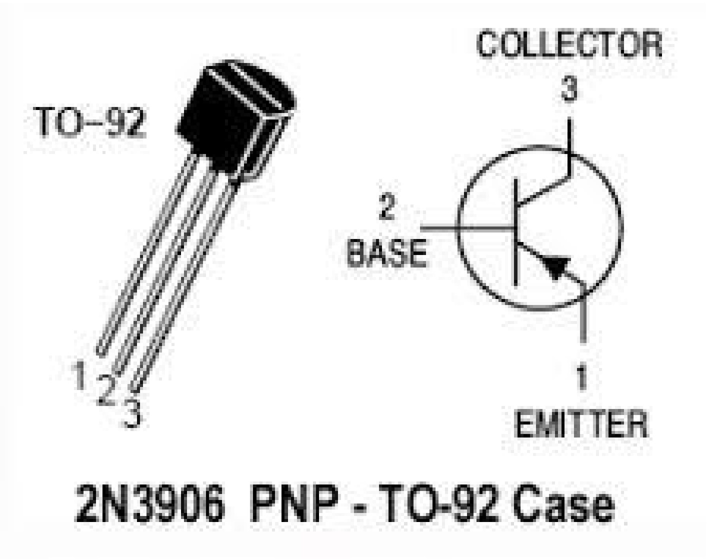
IGBT - Very High Power





BJTs - NPN vs PNP





BJT top Parameters

Voltage (Collector-Emitter)

Collector Current

DC Current gain (hFE) (and Darlington)

Less critical: VBE(sat) and VC(sat)

Similar for many BJTs (0.6V and 0.1-0.2V)

BJTs Easy to Substitute

Same or higher Collector-Emitter voltage

Same or higher current rating

Same type (NPN vs PNP vs Darlington)

limitations are special gain or frequency

MOSFET top Parameters

Vds (drain-source)

Current Rating

Resistance (drain-source) (the “ON” resistance)

Gate sensitivity (logic level?)

Numbers vary from vendor to vendor

Must look at the charts!

MOSFET Substitution

Same or higher Vds and current rating

Same or lower gate drive (logic level?)

Same type (N-FET vs P-FET)

limitations are gate capacitance and speed

Questions?

Resources

The Art of Electronics (any edition, 4th Ed is current)

https://learn.sparkfun.com/tutorials/transistors

https://www.adafruit.com/datasheets/an97055.pdf

https://learn.sparkfun.com/tutorials/bi-directional-logic-level-converter-hookup-guide

http://www.evilmadscientist.com/2006/make-a-cylon-jack-o-lantern/

https://en.wikipedia.org/wiki/Insulated-gate_bipolar_transistor

http://www.ece.ncsu.edu/people/bjbaliga