

Electronics

Controlling Power to Output Transducers

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Basic Rule of Control

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These will be arranged in a voltage divider.

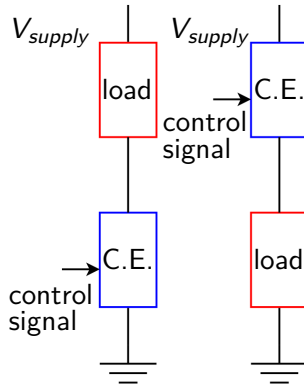
Basic Rule of Control

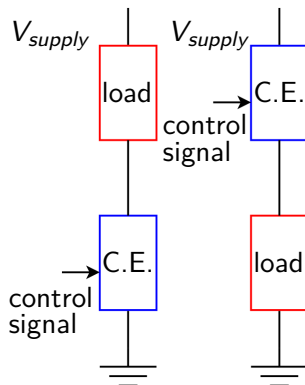
Types of output transducers

Types of control

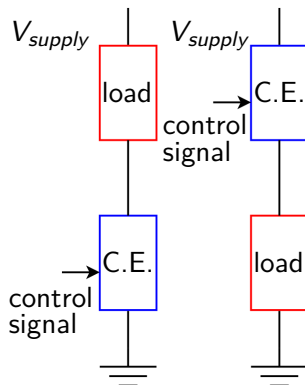
Devices for control

Other considerations





“C.E.” is the control element.



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“Load” could be a motor, solenoid, relay coil, etc.

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Produce "information"
Produce "action"

Low power devices

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An operational amplifier is a *voltage* device; it can't produce more than a few mW of power.

Types of control

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- on/off

Types of control

- on/off
like a switch

Types of control

- on/off
like a switch
- proportional

Types of control

- on/off
like a switch
- proportional
like a rheostat or potentiometer

Control trade-offs

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There is a trade-off between efficiency and noise.

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 - the supply voltage,
 - the control device,
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- The order of the control element and the load in the voltage divider has some effects on the circuit operation.

Relay

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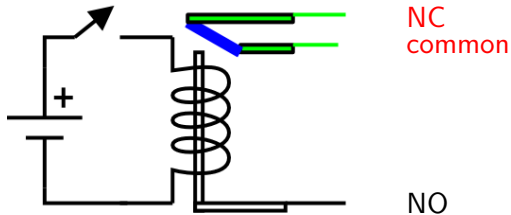
- coil
- common
- **NO**; normally open (possibly)

Relay

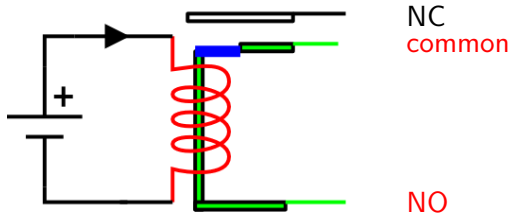
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- **NO**; normally open (possibly)
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Relay **OFF**



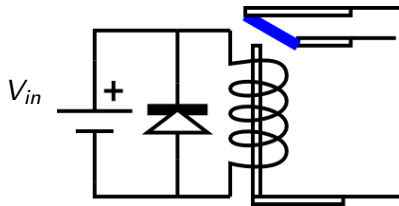
Relay ON



An internal spring returns the solenoid to its original position when power is removed from the coil.

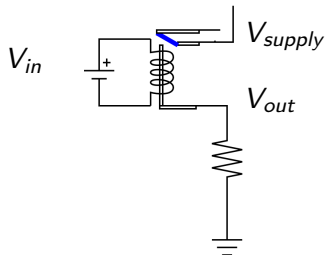
Since a relay is inductive, all of the precautions for an inductive device must be taken.

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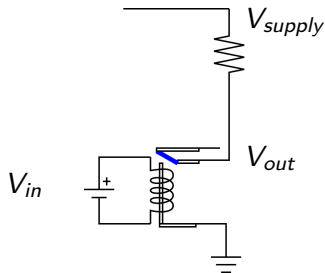


The relay can be inserted on either side of the load in a voltage divider.

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Transistors

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- Transistors are often used in voltage dividers to act as variable resistors.

Metal Oxide Semiconductor Field Effect Transistors

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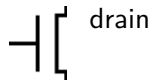
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- drain
- source
- gate

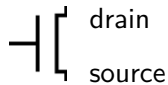
FET symbol



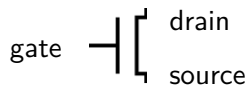
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Actually it's the voltage between the gate and the source which matters.

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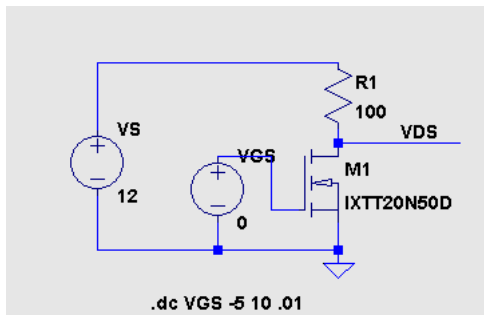
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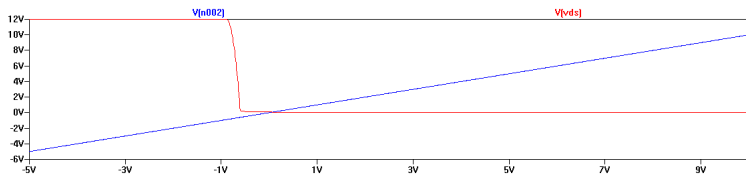
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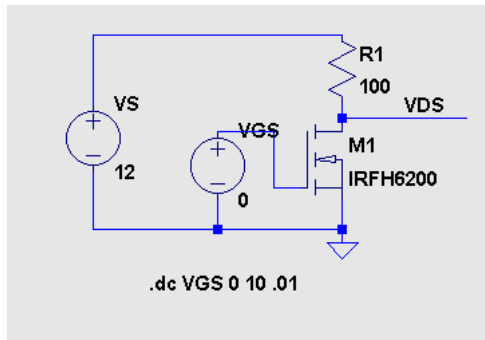
Actually, all MOSFETs operate in *enhancement* mode. It's just that some *only* operate in that mode. Which kind you want depends on whether or not you want *some* current to flow with no applied gate-source voltage.



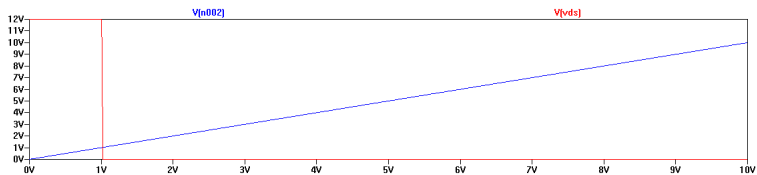
D (depletion mode) MOSFET



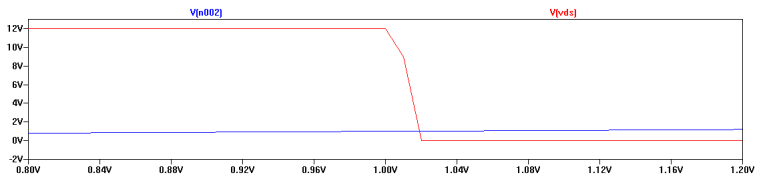
D (depletion mode) MOSFET output



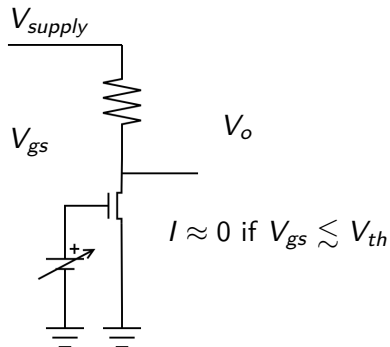
E (enhancement mode) MOSFET



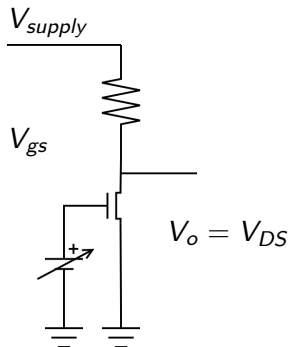
E (enhancement mode) MOSFET output



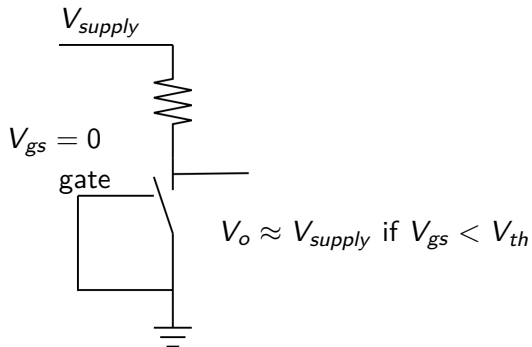
E (enhancement mode) MOSFET output zoomed in



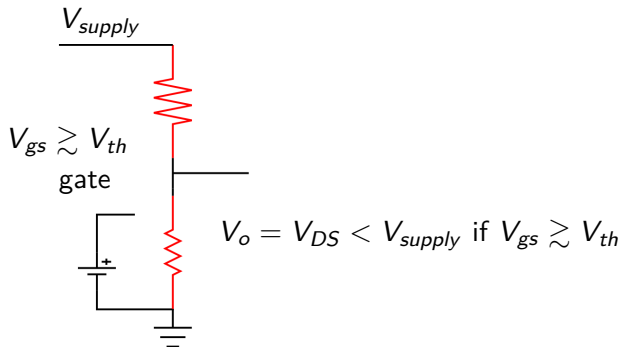
E (enhancement mode) FET



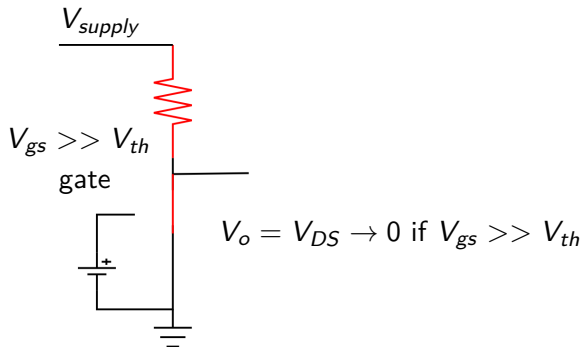
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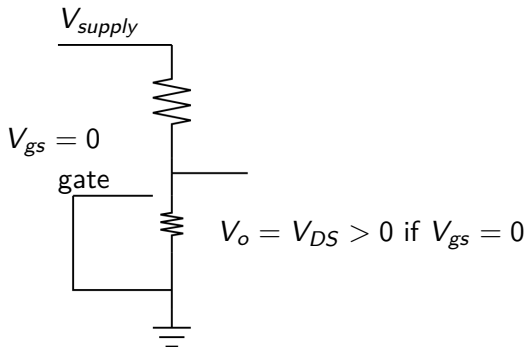


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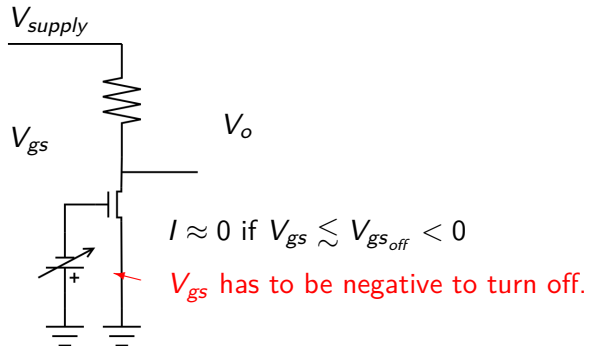
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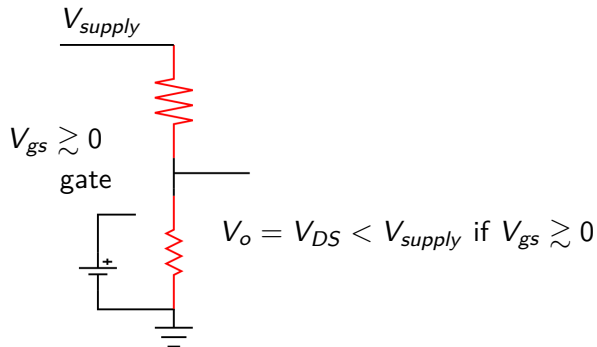
- FETS are *voltage* amplifiers; a small **gate-source** voltage controls a much larger **drain/source** current.
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- All FETs work in *enhancement* mode; some also work in *depletion* mode.



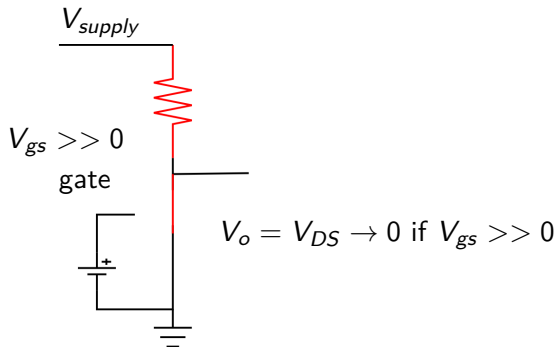
D (depletion mode) FET



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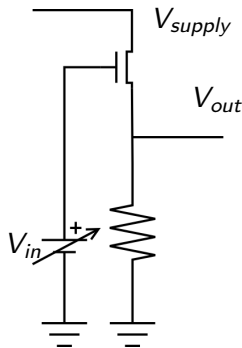


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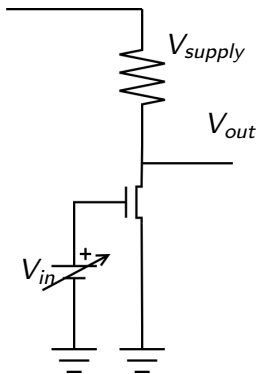
The MOSFET, like the relay, can be placed in either position of a voltage divider.

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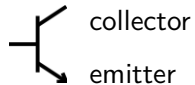
- collector
- emitter
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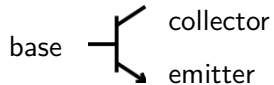
The current from the collector to the emitter is controlled by the *current* into the base.





collector





BJT operation

BJT operation

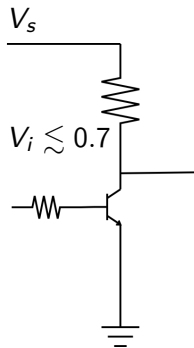
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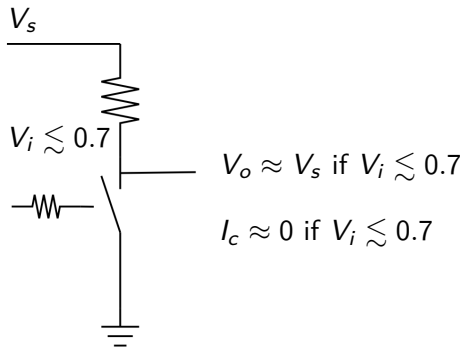
BJT operation

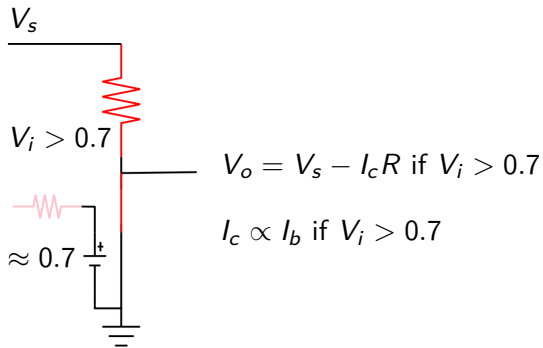
- BJTS are *current* amplifiers; a small **base** current controls a much larger **collector/emitter** current.
- *You should always have a base resistor with a BJT!*



$$V_o \approx V_s \text{ if } V_i \lesssim 0.7$$

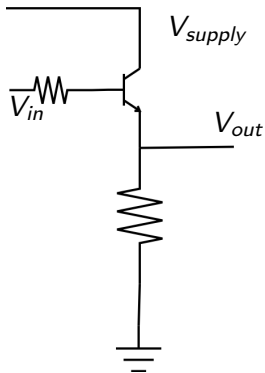
$$I_c \approx 0 \text{ if } V_i \lesssim 0.7$$





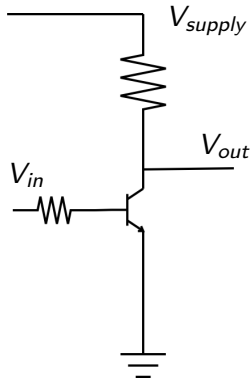
Like the previous devices, either position in a voltage divider can be used.

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TRIAC

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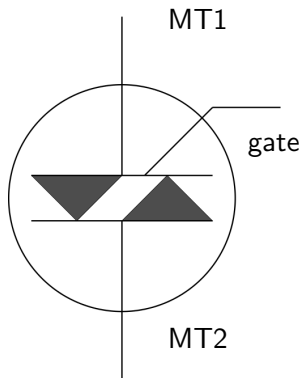
A triac will begin to conduct when it receives a voltage pulse on the *gate*.

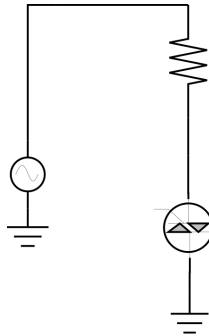
TRIAC

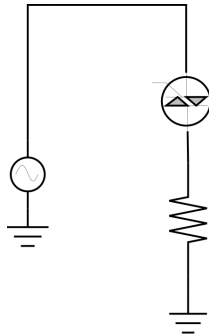
A TRIAC is a three terminal *ac voltage* device. The terminals are

- main terminal 1
- main terminal 2
- gate

A triac will begin to conduct when it receives a voltage pulse on the *gate*. It will continue to conduct until the *current* is zero.







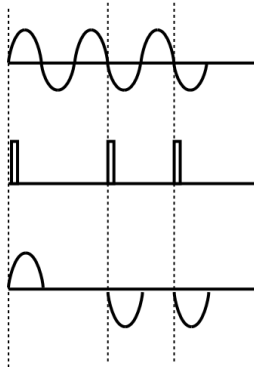
It can operate in two modes.

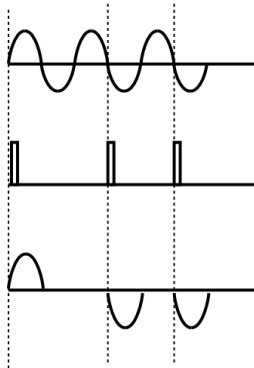
It can operate in two modes.

- burst

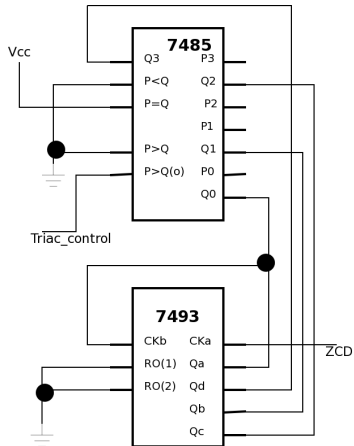
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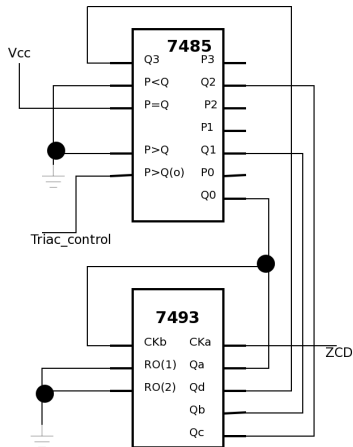
- burst
- delayed trigger



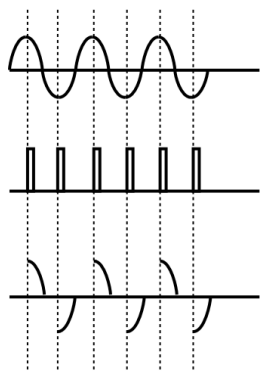


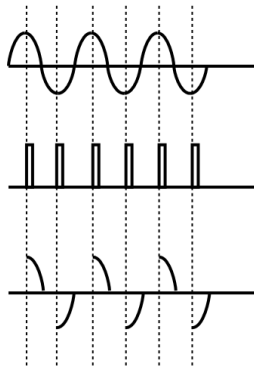
In *burst* mode, trigger pulses are only given at the beginning of half-cycles.



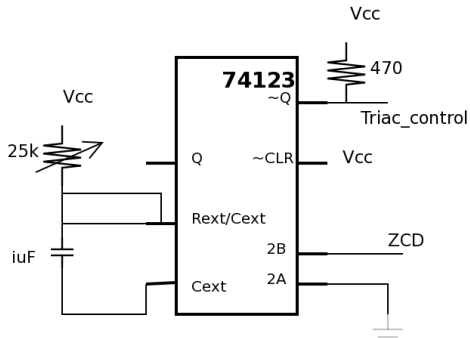


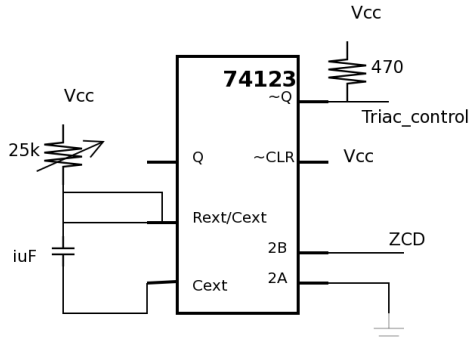
This is a typical circuit to control a triac in burst mode.





In *delayed trigger* mode, trigger pulses are delayed after the beginning of half-cycles to produce power for only a part of each half cycle.





This is a typical circuit to control a triac in delayed trigger mode.

Using TTL gates for control

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- “Extra” current from TTL

Using TTL gates for control

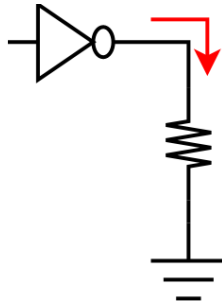
- “Extra” current from TTL
- sink instead of source

Using TTL gates for control

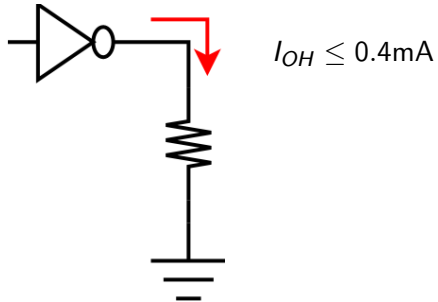
- “Extra” current from TTL
- sink instead of source
- 0.4mA vs. 8 mA (LS)

Current sourcing

Current sourcing

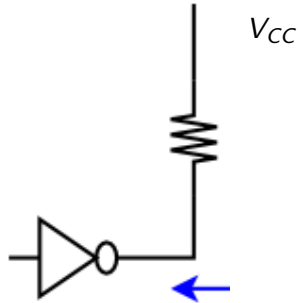


Current sourcing

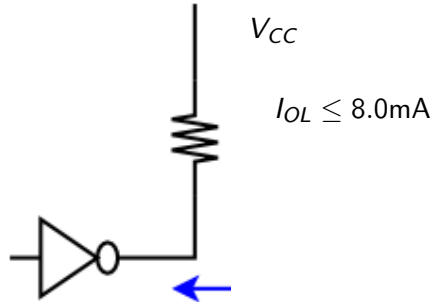


Current sinking

Current sinking



Current sinking



Using a TTL gate to sink instead of source allows 20x the current!