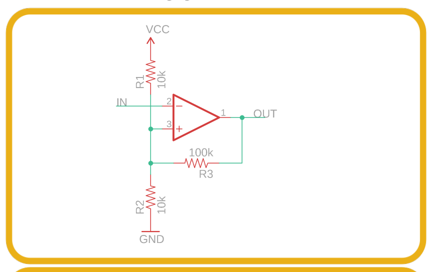
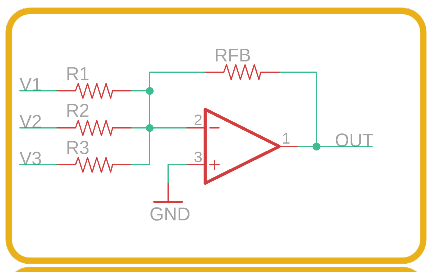
Schmitt Trigger



A schmitt trigger is a circuit that provides hysteresis: its threshold voltage depends on the current state. This is useful in preventing noisy sources from generating many spurious transitions in digital logic or when using a comparator. R1 and R2 form a voltage divider, setting the comparator's threshold at VCC / 2. R3 sources or sinks a small current from the output into the positive terminal. When the output is high, this increases the threshold voltage slightly, and when the output is low it decreases it. This positive feedback provides a range of voltages for which the output will not change from the state it's currently in.

31 35

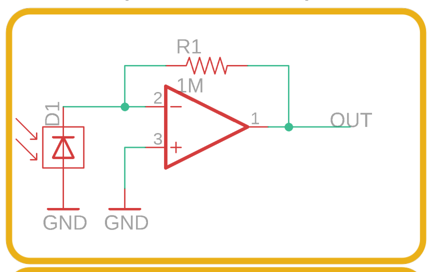
Summing Amplifier



A summing amplifier sums several (weighted) voltages: Vout=-Vref*(V1/R1+V2/R2)

32 35

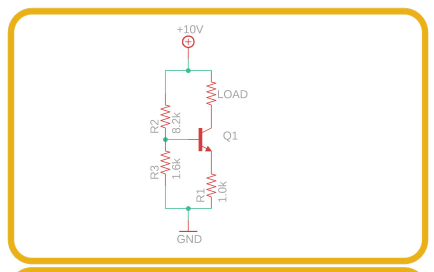
Transimpedance Amplifier



A transimpedance amplifier converts a current to a voltage. They're particularly useful for sensors that output currents, like the photodiode depicted above. The inverting input of the opamp forms a virtual ground. This requires the current through R1 to be equal to the current being sunk by the photodiode, which results in an increase in the output voltage equal to the product of the input current and the feedback resistor. Because a transimpedance amplifier has an input measured in amps and an output measured in volts, its gain is measured in ohms.

33 35

Transistor Current Source

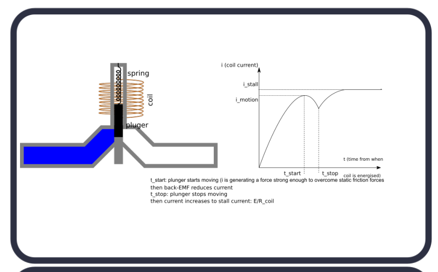


Current sources are useful in a variety of situations and applications. The diagram above shows a simple current source constructed using an NPN transistor. A voltage is applied to the base of the transistor, in this case provided by a voltage divider. In the example schematic, the voltage is 1.6 volts. The current across the load is determined by ; in the example above this will be 1 milliamp. Note that the current does not depend on the Hfe of the transistor, but only on the base voltage and the emitter resistor.

$$I_c = \frac{V_b - 0.6}{R1}$$

34 35

Solenoid Valve

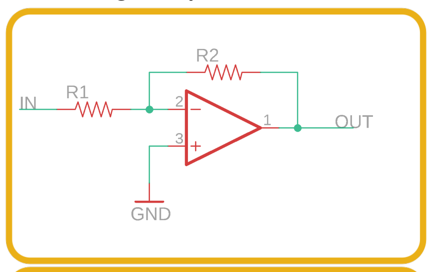


Solenoid valve is used to control electrically the flow of fluids. The plunger (the moving part) is held back by a spring and will be activated by the EMF force generated when the coil is energised either by a current or by a voltage. F the force-stroke of the plunger is determined by electro mechanical build (alpha and beta) and by the current (i) The plunger will start moving once F overcomes static friction and stops moving when hitting the damper.

$$F = \frac{i_0^2}{2} * \frac{-\beta}{(\alpha + \beta * x)^2}$$

35 35

Inverting Amplifier

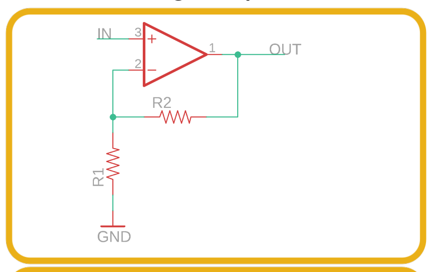


Along with the noninverting amplifier, the inverting amplifier is one of the simplest opamp configurations. It amplifies the signal by a fixed gain, while inverting it relative to the supply rails. This is accomplished with negative feedback from the output to the inverting input of the opamp via R2. Combined with R1, this forms a voltage divider that attenuates the output; the opamp then acts to ensure this attenuated version of the output signal is equal to the input signal. The gain of this circuit is thus .

$$G = -\frac{R2}{R1}$$

25 35

Noninverting Amplifier

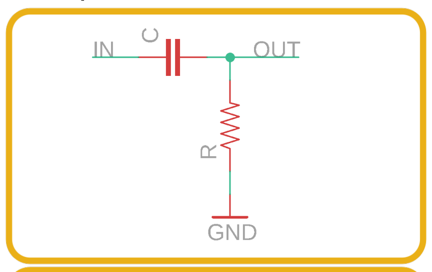


Along with the inverting amplifier, the noninverting amplifier is one of the simplest opamp configurations. It amplifies the signal by a fixed gain. This is accomplished with negative feedback from the output to the inverting input of the opamp via R2. Combined with R1, this forms a voltage divider that attenuates the output; the opamp then acts to ensure this attenuated version of the output signal is equal to the input signal. The gain of this circuit is thus .

$$G = 1 + \frac{R2}{R1}$$

26 35

Rc Hpf

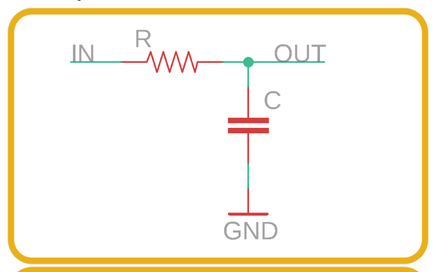


A Resistor-Capacitor Highpass Filter is a simple analog filter that allows high frequencies to pass but attenuates lower frequencies. The cutoff frequency of the filter is determined by .. An RC highpass filter effectively forms a frequency dependent voltage divider. At low frequencies, the capacitor acts as a very high resistance, so the signal is attenuated a lot. At higher frequencies, the capacitor has less resistance, so the signal is attenuated less.

$$F_c = \frac{1}{2\pi RC}$$

27 35

Rc Lpf

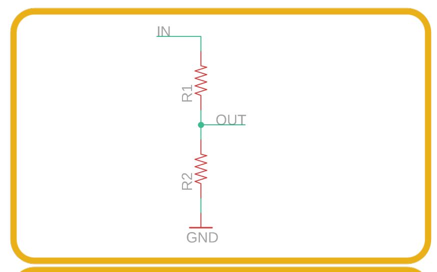


A Resistor-Capacitor Lowpass Filter is a simple analog filter that allows low frequencies to pass but attenuates higher frequencies. The cutoff frequency of the filter is determined by . An RC lowpass filter effectively forms a frequency dependent voltage divider. At low frequencies, the capacitor acts as a very high resistance, so the signal is attenuated very little. At higher frequencies, the capacitor has less resistance, so the signal is attenuated more.

$$F_c = \frac{1}{2\pi RC}$$

28 35

Resistor Divider

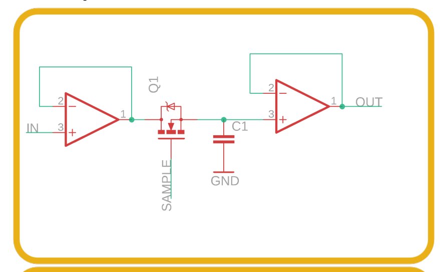


A voltage divider produces an output voltage that's a fraction of its input voltage, determined by the two resistors R1 and R2. The output voltage is determined by . Resistor dividers are often used to generate reference voltages or as level shifters; their high impedance means that attempting to draw significant current from them will cause the voltage to vary.

$$V_o = V_i \frac{R2}{R1 + R2}$$

29 35

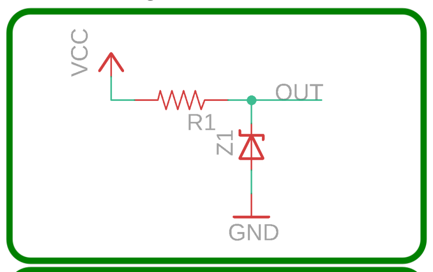
Sample And Hold



A sample and hold circuit is used to sample a voltage, and retain it for some period of time. This is particularly useful in digital applications where a stable voltage is required in order to take accurate measurements. An Opamp follower on the input ensures that the circuit provides a low impedance copy of the input signal. The FET Q1 enables sampling; when the gate is high, current can flow to charge or discharge the capacitor C1, which serves to maintain the voltage while Q1 is off. Another opamp follower allows measurement of the voltage without discharging the capacitor in the process.

30 35

Shunt Regulator

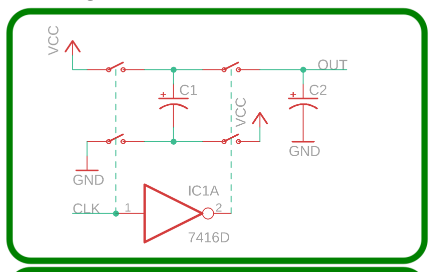


The simplest form of voltage regulator is a shunt regulator. This relies on the reverse breakdown voltage of a zener diode to provide a regulated voltage on the output. The resistor R1 limits current through the zener and to the load. Because current must flow through the zener to maintain regulation, this is a particularly inefficient regulator, particularly with a variable input voltage, and the zener must be able to dissipate at least watts.

$$P_{zener} = (\frac{V_{in} - V_{out}}{R} - I$$

19 35

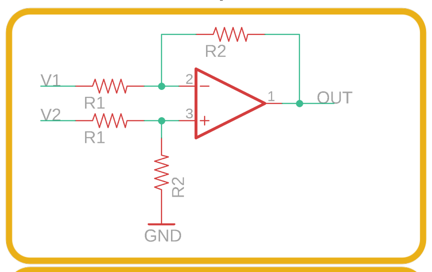
Voltage Doubler



A capacitative voltage doubler uses transistors and a 'flying' capacitor to double or invert an input voltage. A clock signal and an inverter drive the switches. First, the input switches are closed, charging C1 to VCC. Then the input switches are opened, and the output switches are closed, putting the positive terminal of C1 at VCC × 2, and charging the output capacitor C2. Voltage doublers are only capable of supplying a small current, but they are particularly useful in situations where a voltage outside the range of the supply terminals is required.

20 35

Differential Amplifier

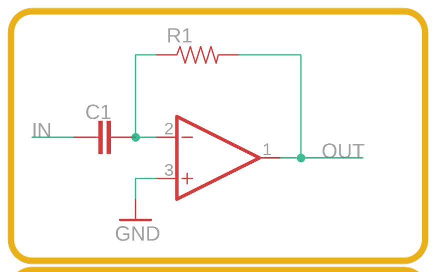


A differential amplifier amplifies the difference between its two input signals. The voltage at the noninverting terminal is determined by the input signal and the resistor divider formed by the lower two resistors. This is matched at the inverting terminal by opamp action. The output of the amplifier is . A differential amplifier requires very close matching of resistor values R1 and R2 to achieve high common-mode rejection ratios.

$$V_{out} = \frac{R2}{R1}(V2 - V1)$$

21 35

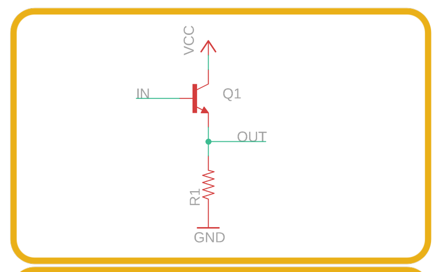
Differentiator



An opamp differentiator performs the opposite action of an integrator: it outputs a voltage proportional to the rate of change of its input. The input capacitor sources a current proportional to the difference between its terminals into the opamp's inverting input. The noninverting input is a virtual ground, and the opamp acts to maintain this by asserting a voltage across R1. This voltage is proportional to the input current, and thus proportional to the rate of change of the input signal. Current flowing through R1 charges C1, ensuring that a DC signal will result in the output returning to ground.

22 35

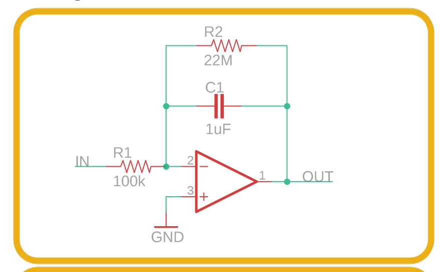
Emitter Follower



An emitter follower is a transistor configuration where the output voltage follows the input voltage, less one diode drop (0.6 volts). This is useful because the output impedance is much lower than the input impedance, meaning the output signal can be used to drive higher power loads than the input. Due to its configuration, an emitter follower is not symmetric - it can source current through the transistor, but cannot sink current.

23 35

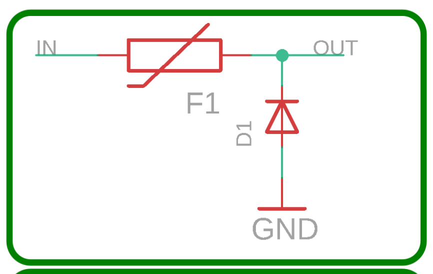
Integrator



An Opamp Integrator performs the mathematical operation of integration on its input signal - that is, its output voltage is proportional to the input voltage over time. The resistor R1 converts the input voltage to a current, which charges capacitor C1 at a rate determined by the values of R1 and C1. The negative input is a virtual ground, and the opamp acts to maintain that by linearly increasing the voltage on the output while an input signal is present - performing the integration operation. R2 ensures the output voltage doesn't drift over time.

24 35

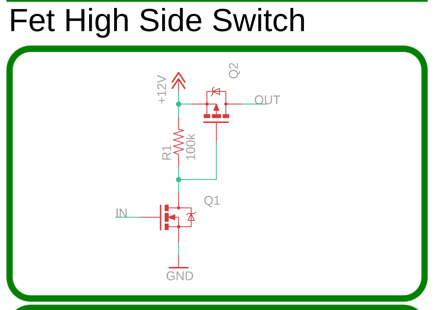
Crowbar Circuit



A crowbar circuit provides reverse polarity protection by creating a short circuit if the polarity is reversed. In normal operation, the resettable fuse F1 protects the attached circuit from overcurrent conditions, and the diode D1 is inactive. If the supply is connected in reverse, the diode D1 shorts power to ground, causing a large amount of current to flow, and tripping the resettable fuse. A more sophisticated crowbar design is possible using an SCR and a Zener diode that also protects against overvoltage in a similar fashion.

13 35

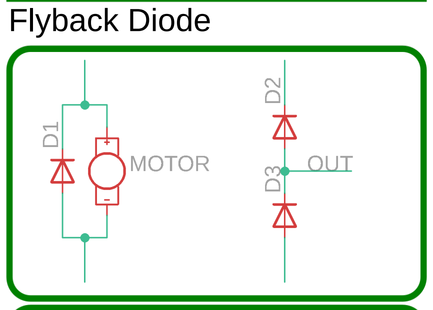
Fet High Side Switch



When doing high-side power switching, it's often necessary to switch a higher voltage (eg, 12v) from a lower logic voltage (eg, 5v). It's not possible to do this using just a P-channel FET, as the logic voltage cannot go high enough to turn the PFET off. The circuit above solves this issue with the use of a second, N-Channel FET. When the input is low, Q1 does not conduct, and the gate on Q2 is held at VCC via the pullup resistor R1. When the input goes high, Q1 turns on, grounding the gate of Q2 and turning it on, allowing it to conduct.

14 35

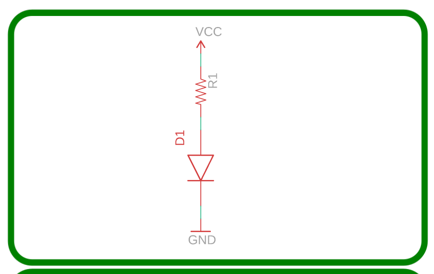
Flyback Diode



A flyback diode is used to protect electronics from the voltage spikes generated when an inductive load such as a motor, is disconnected. Cutting power to a motor generates a voltage spike of the opposite polarity, and a flyback diode absorbs this, protecting the driving electronics. When a motor or other inductive load is driven unidirectionally, connecting a diode in reverse across the load, as shown on the left, is sufficient. When a load needs to be driven in either direction, a diode bridge can be formed for each pole of the load, as shown on the right.

15 35

Led Current Limit

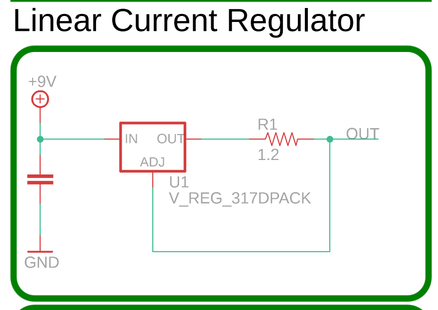


When powering an LED from a voltage source, it's necessary to limit the current that flows through it to prevent it burning out. As the voltage across an LED exceeds its forward voltage, the current the LED consumes rises rapidly. The simplest and most common way to handle this is with a simple series resistor. Calculating the necessary value of the resistor is easy. If Vth is the LED's forward voltage, Vin is the input voltage, and I is the desired current, the resistor value is calculated by:.

$$R_1 = \frac{V_{CC} - V_{th-D1}}{I}$$

16 35

Linear Current Regulator

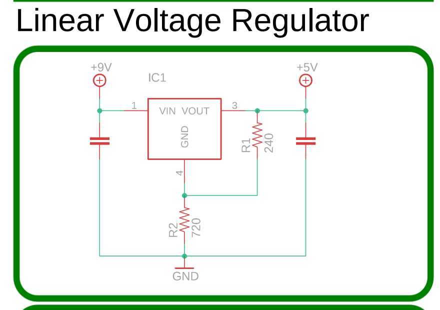


This design uses a commonly available linear regulator to produce a constant current source. R1 is chosen such that the voltage drop across it will be equal to the linear regulator's reference voltage of 1.25 volts when the desired current is reached. Thus, the resistor value is determined by . One downside to this configuration is the high voltage drop required across the shunt resistor. This results in a high-power dissipation, requiring larger components, and also reduces the compliance voltage range for the current source.

$$I_{out} = \frac{1.25}{R1}$$

17 35

Linear Voltage Regulator

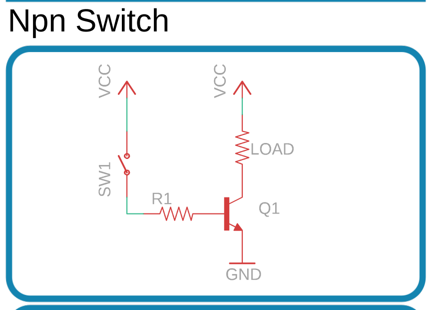


The adjustable linear voltage regulator is one of the most widely used ICs. It provides a simple way to generate a regulated voltage at practically any level, with a minimum of complexity and external components. The regulator's output voltage is set by the resistor divider R1 and R2. The output voltage follows the relation - or intuitively, that the voltage produced by the divider should be 1.25 volts when the output is at the desired voltage.

$$V_{out} = 1.25(1 + \frac{R2}{R1})$$

18 35

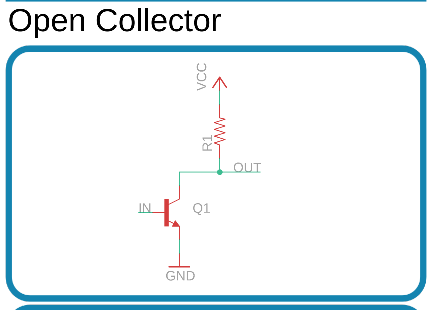
Npn Switch



One of the simplest uses for an NPN transistor is as a switch. In this configuration, when the physical switch - which could also be an output from a microcontroller or other digital line - is closed, current flows through the current limiting resistor R1 into the base of Q1, turning on the transistor, and allowing power to flow through it and R1, turning the load on. Bipolar transistors are current controlled devices, and the resistor R1 on the base of the transistor limits the current flow from base to ground. The transistor will conduct a maximum current from collector emitter equal to the base current multiplied by the transistor's gain, notated Hfe.

7 35

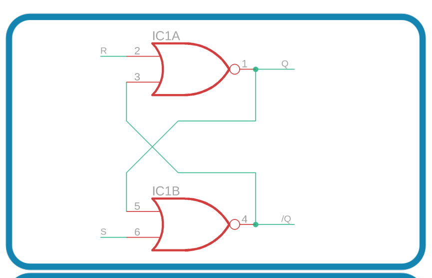
Open Collector



Open-collector logic is a common configuration wherein the output of a digital logic circuit can drive a signal line low, but is high-impedance when the output is high. A pull-up resistor is required on the signal line to pull the line high. This has several advantages. It makes it possible for an IC operating at one voltage level to drive a line at another voltage level. It can also be used with multiple drivers for 'wired AND', since the output signal is implicitly the AND of all the input signals. This is taken advantage of by protocols like I2C to support multiple devices on a bus.

8 35

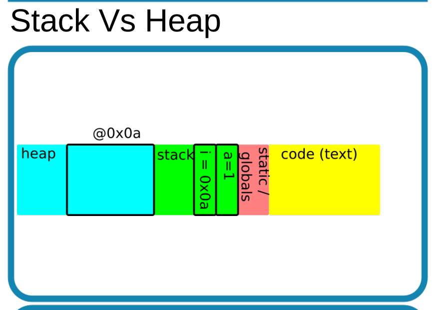
Sr Latch



An SR latch is a simple digital logic circuit with memory - once set or reset, it remains in that state until it receives a pulse on the opposite input. Assume that Q is high and both inputs are low; the latch will remain in this state. If the R input is brought high, however, the top NOR gate will change its output to low; the bottom NOR gate now has low on both its inputs, and sets its output to high. This ensures that the new state persists even after the R input ends. Since the circuit is symmetrical, the same applies when asserting the S input.

9 35

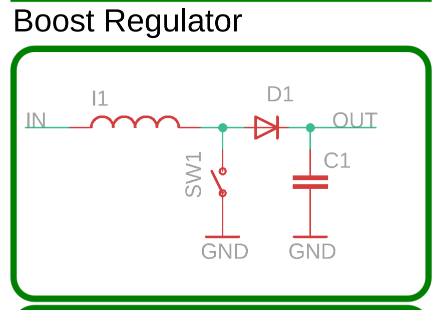
Stack Vs Heap



```c include include int main() { int a; a=1; //value of a in stack int i; i = (int)malloc(sizeof(int)); i=10; //value of i stored in heap free(i); i = (int)malloc(20*sizeof(int)); } ```

10 35

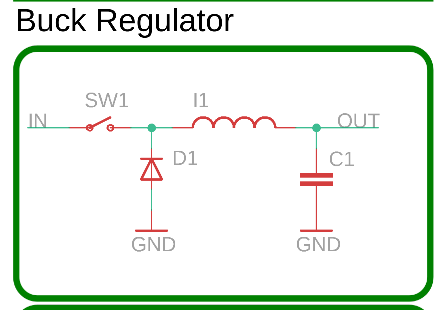
Boost Regulator



A boost regulator is a type of switching regulator, a highly efficient means of producing a regulated DC voltage or current from a lower input voltage. With switch SW1 on, current flows through the inductor I1, charging it. When SW1 turns off, the voltage on that end of the inductor rises rapidly until the diode D1 conducts, charging the output capacitor. The output voltage can be much greater than the input voltage. A feedback loop adjusts the duty cycle or frequency of the switch's on periods in order to regulate the output voltage at the desired level.

11 35

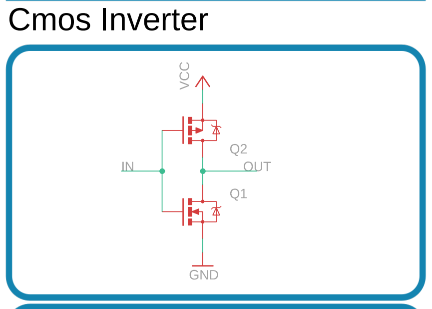
Buck Regulator



A buck regulator is a type of switching regulator, a highly efficient means of producing a regulated DC voltage or current from a higher input voltage. With the switch on, current flows through the inductor I1, charging the output capacitor C1. When the switch turns off, the diode D1 completes the circuit with the inductor, applying a voltage of the opposite polarity to the inductor, and causing the current to linearly decrease. A feedback loop adjusts the duty cycle or frequency of the switch SW1 in order to maintain a constant output voltage on the output capacitor.

12 35

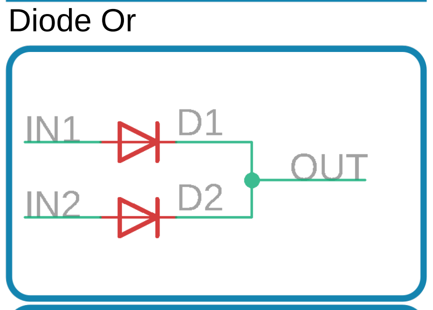
Cmos Inverter



The CMOS inverter is the simplest CMOS gate, and also forms the basic structure for all CMOS logic. Two complementary MOSFETs, a P-channel and an N-channel, are connected in series as shown above. When the input signal is HIGH, the bottom FET is on and the top FET is off, bringing the output LOW. When the input signal is LOW, the top FET is on and the bottom FET is off, bringing the output HIGH.

1 35

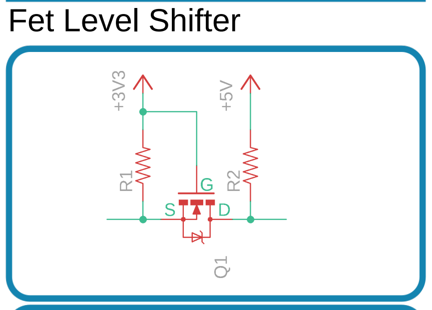
Diode Or



A diode OR is used to isolate two or more potential power sources. The circuit behind the diode OR draws power from the highest voltage input source. This is commonly used for selecting between multiple power sources. For instance, a device with a 9v battery pack and a 12v power brick will be powered by the battery unless the power brick is plugged in. It can also be used to draw power from multiple independent batteries in a balanced fashion, while still allowing independent balance charging of the cells.

2 35

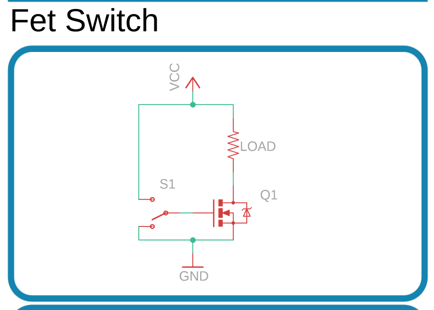
Fet Level Shifter



A single FET in the configuration shown can be used as a bidirectional level shifter, useful for I2C or other bidirectional buses. With neither side being driven, the pullups ensure both lines are high. If the low voltage side is driven low, the FET gate is now at a higher voltage than the source, and the FET conducts, driving the high voltage side low. If the high voltage side is driven low, the FET's body diode conducts, bringing the low voltage side low and turning the FET on.

3 35

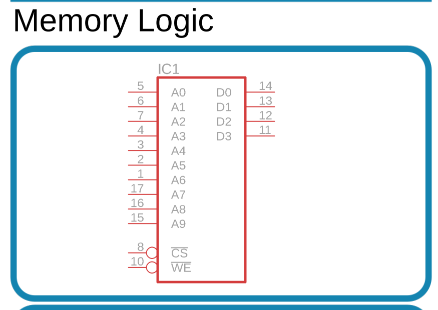
Fet Switch



One of the simplest uses for a FET is as a switch. In this configuration, when the physical switch - which could also be a digital output - is connected to VCC, the gate voltage on the n-channel FET is high, and the FET acts like a short circuit. When the switch is connected to GND, the gate is low, and no current flows. Unlike bipolar transistors, FETs are voltage controlled, and are thus even simpler to control. Since the gate consumes no current, though, it's necessary to drive the gate both low and high, or connect a resistor between the gate and ground, to ensure it isn't left "floating" when turned off.

4 35

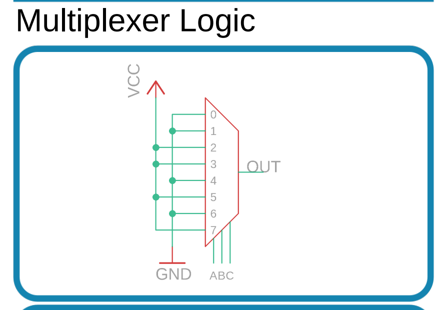
Memory Logic



An asynchronous memory module - either temporary like SRAM, or permanent like EEPROM or flash - can be used to implement arbitrary digital logic functions. By programming the truth table into the memory, the address lines can be treated as inputs to the binary function, and the data lines can be treated as the result of several independent binary functions. The image depicts a 1024×4 memory module, which can implement any four binary functions on 10 inputs.

5 35

Multiplexer Logic



A logical multiplexer can be used to implement an arbitrary truth table, by connecting each input to the appropriate logic level. In the diagram above, a 3-to-8 multiplexer implements a function that determines if its input is prime.

6 35
```