Electronics 2

- Transformers
- Diodes
- Speakers
- Op Amps
- Timers

Review

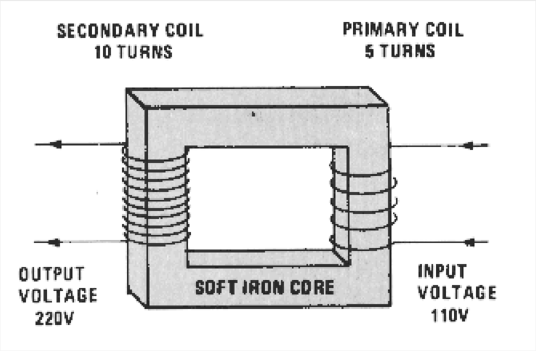
- Ohms law says how much current flows for a particular voltage and resistance
- Capacitors store energy in an electric field, pass AC (depending on freq), block DC
- Inductors store energy in a magnetic field, pass DC, block AC (depending on freq)
- Bipolar transistors switch a current using a smaller current
- FETs switch a current using a voltage

Transformers

- As we talked about last time current flowing in a coil causes a magnetic field to be created
- When the current changes the magnetic field changes but tends to resist the change as it tries to find a place to dump the energy in the magnetic field
- If two coils physically share the same the same magnetic field (are wound on the same core) the energy from the current changing in one coil can be extracted in the other

Transformers 2

- http://www.falstad.com/circuit/e-index.html
- Click on Other Passive Circuits->Transformers->Transformer



Transformers 3

- The output voltage is proportional to the ratio number of windings on the secondary and the primary
- Try the ”Step-up transformer” example and the ”step-down transformer example”
- The current is inversely proportional to the same ratio
- The amount of power out remains the same as the voltage current change
- You can't get free energy by being smart with this stuff

Transformers 4

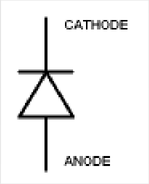
- Power is important – inefficiencies are due to core heating – heating changes the inductance
- Voltage isolation can be important – safe isolation from the mains
- Impedance can be important (to match a speaker coil for example)

Transformers 5

- Why do we ship power around at high voltages?
- Power loss in wires is proportional to the square of the current $P=I^2R$ – halving the current reduces the transmission losses by 4
- Look at the ”Long Distance Power Transmission” example

Diodes

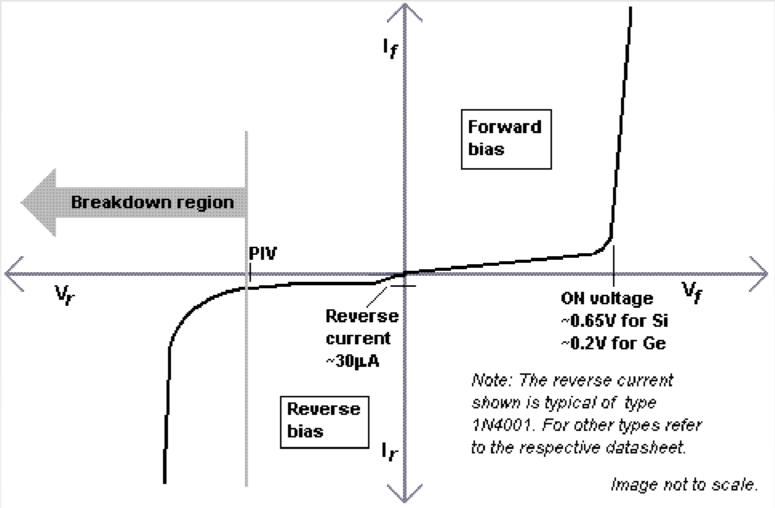
- A diode is a device that passes current in one direction but not the other



- Current flows when the anode is more positive than the cathode

Diodes 2

- There is a small voltage drop required before the diode starts to conduct

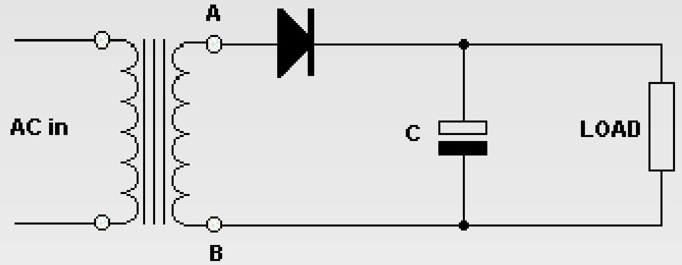


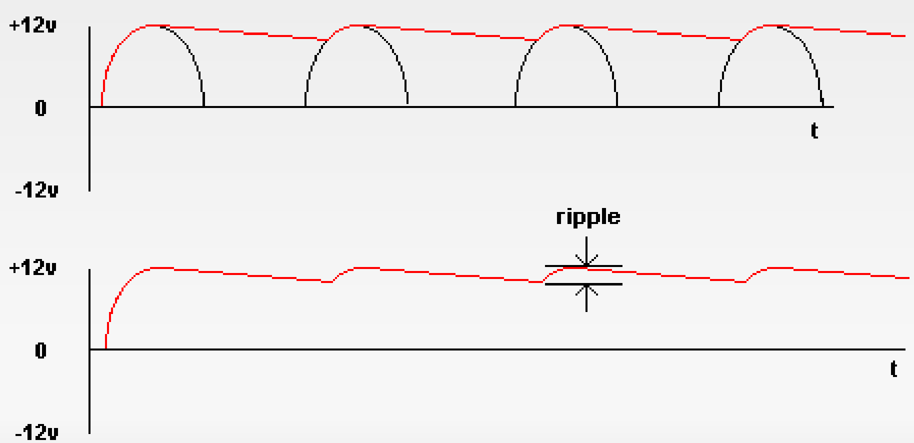
(not to scale)

- After that the resistance is relatively small
- Your diode must be rated for the power from the voltage drop and the marginal resistance

Diodes 3

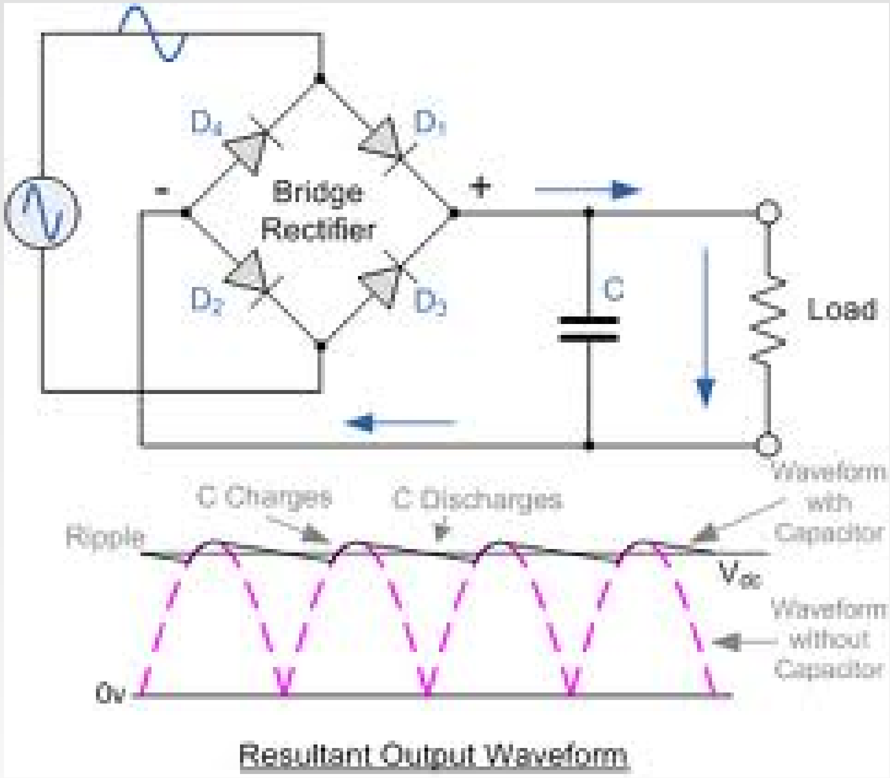
- A half wave regulator – when the diode conducts it tops up the charge in the capacitor





Diodes 4

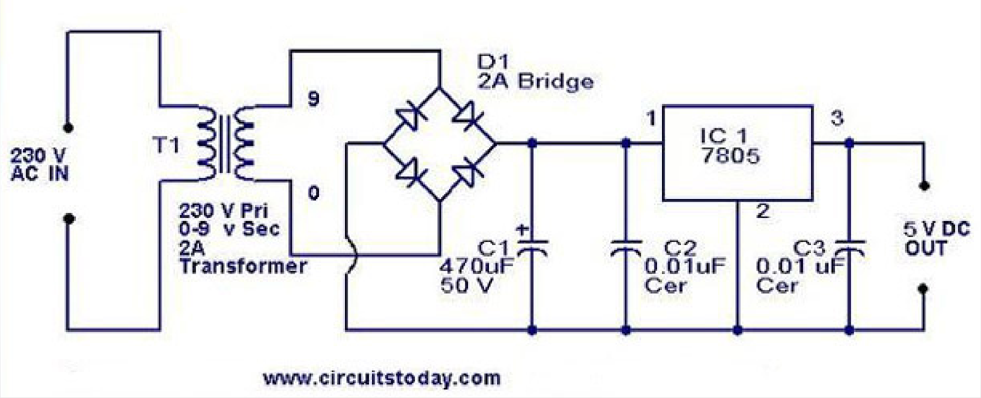
- A full wave rectifier lets you use more of the energy available from the transformer



- Check out the ”full wave rectifier with load” example – try making the load a smalled value

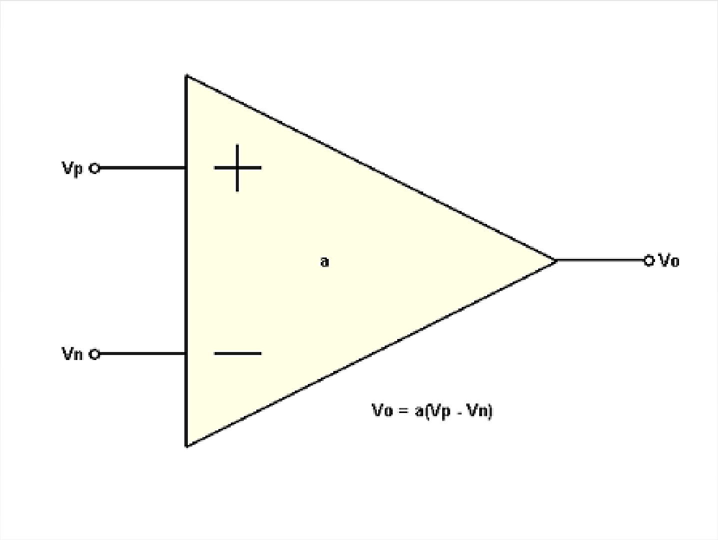
Power Supplies

- We've seen that we can make a power supply with a rectifier and a filter capacitor – we still have some ”ripple” that increases with load
- To solve this we can use an active voltage regulator – you need to aim for a voltage that's at least a couple of volts less than the lowest ripple – the commonly used 78xx regulators are used:



Op Amps

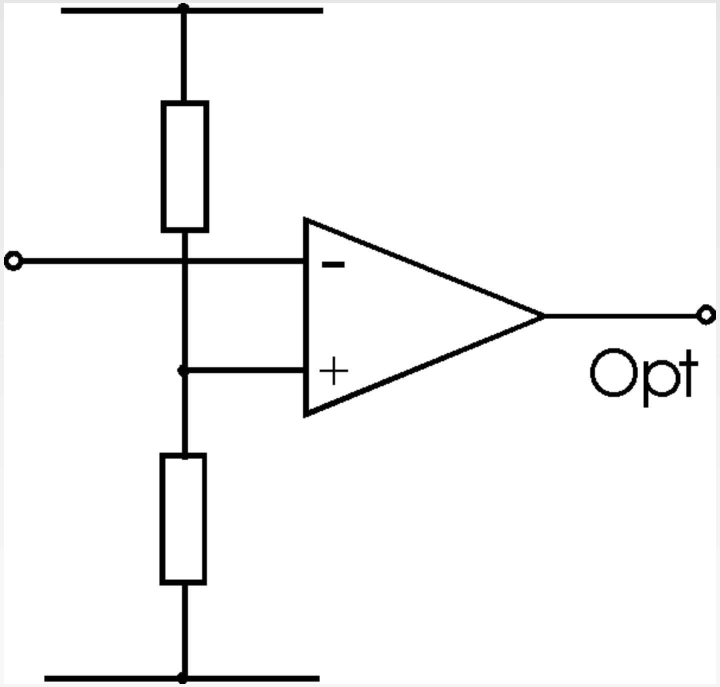
- An ”Operational Amplifier” is an integrated linear amplifier with a nominaly infinite gain



- The output is negative when the + input is more positive than the - input

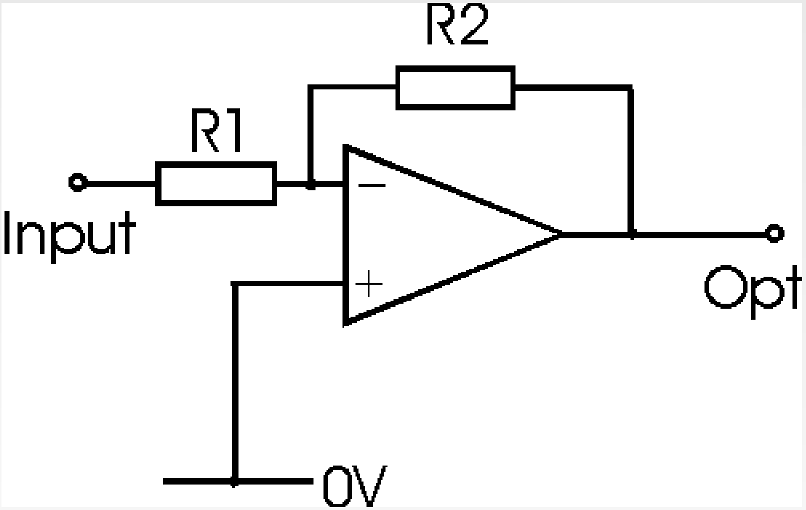
Op Amps 2

- With no feedback we have a ”comparator” the output depends on whether or not the – input is above or below the voltage programmed at the + input



Op Amps 3

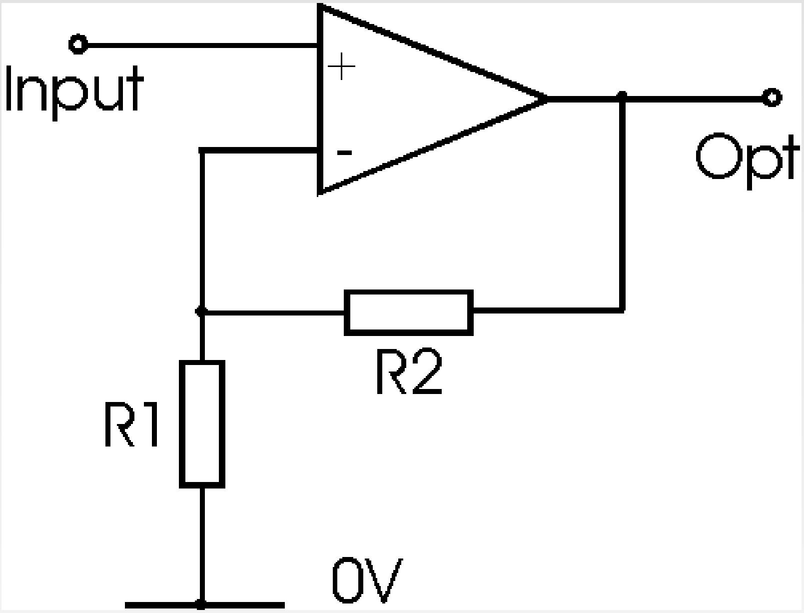
- With feedback we can set the gain – in this inverting case it is -R2/R1- in essence the op amp works to try and make the – and + inputs the same voltage



- Look at the Op Amps Inverting Amplifier example

Op Amps 4

- Here's the non-inverting equivalent – the gain is 1 + R2 / R1



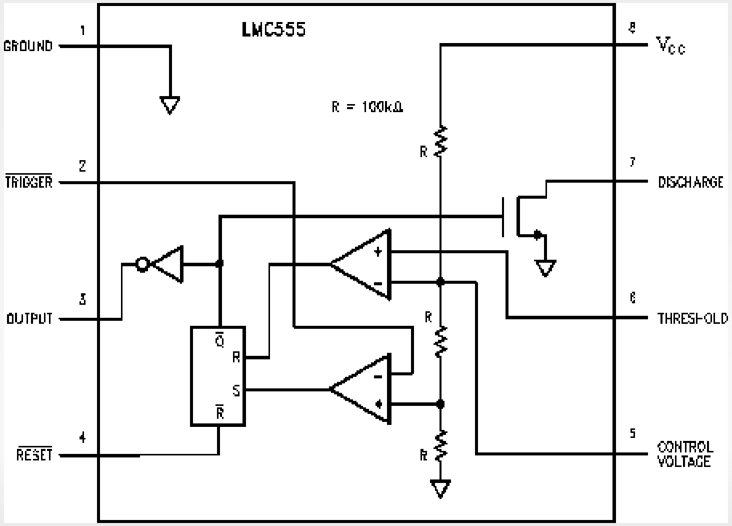
- Look at the Op Amps Noninverting Amplifier example

Op Amps 5

- Op amps are infinitely flexible building blocks – look at the examples:
- Amplifiers
- Oscillators
- Peak detector
- Integrators/differentiators
- Voltage regulator (what's in that 7805)

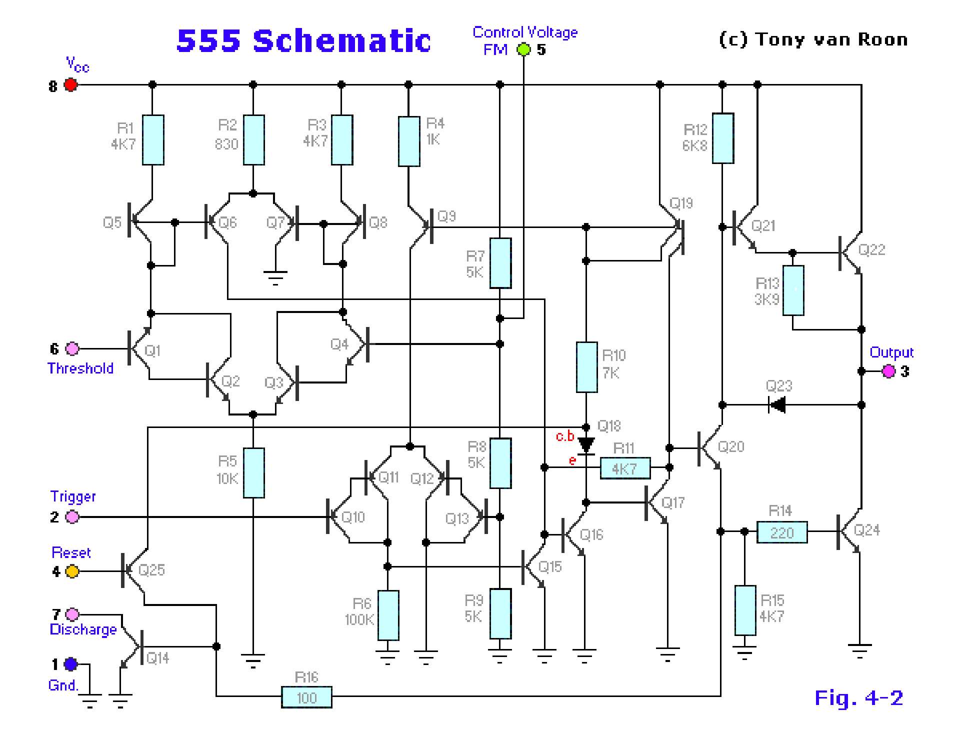
Timers

- Mostly here I'm going to talk about the 555 timer – an analog workhorse
- Inside we have a pair of comparators connected to a 1/3, 2/3 voltage divider driving an SR flip flop



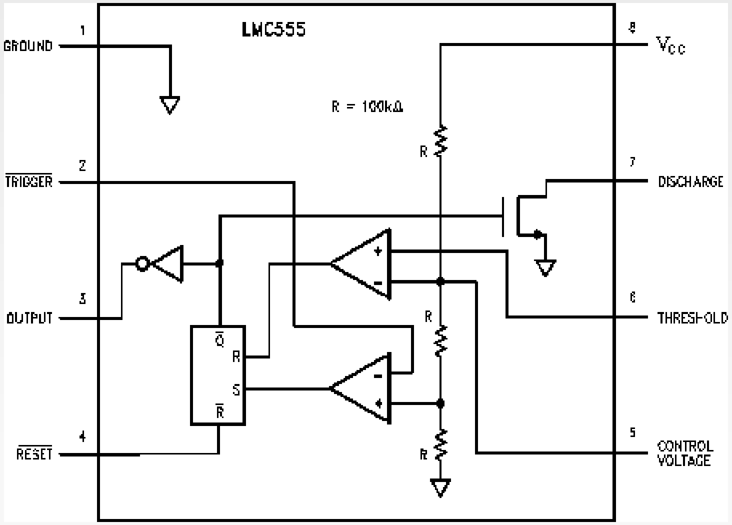
Timers 2

- It really looks like this:



Timers 3

- There are two comparators in there – driven from a 1/3, 2/3 voltage divider
- They drive a set/reset flipflop – triggering one comparator makes it go on, triggering the other makes it go off
- Q is the output it also drives a FET that can be used to discharge a cap
- There's an extra reset



Timers 4

- There are lots of timer circuits, most involve charging a cap, then dischrging it again when the timer's output changes
- Look at the ”555 Square Wave Generator” example for the generic oscillator circuit
- The cap is charged through the 2x10k resistors until the voltage at TH hits 2/3 then it discharges through 1x10k and the DIR output until the voltage at TR hits 1/3
- Now look at the ”555 Internals” example to see how it works inside

Timers 5

- Check out the rest of the examples, and the many 555 fanboi web sites for designs you can copy and bend
- 555 variants are made by many different manufacturers – there are dual and even quad 555s available

Next Time

- Digital logic