Quiz

Switches, diodes, schematic symbols.

Previous Quiz

On Ohm's Law.

Question 1

What is the value of the resistor with 3 bands blue, blue, blue? 66 megohms.

Question 2

What do I need to know to calculate the direct current through the above resistor? Voltage across the resistor.

Question 3

How much current would flow through the above resistor that dissipates ¼ watt? $P = I^2R$. I = square root of (P/R). About 62 microamps.

Question 4

What is the voltage applied across the above resistor? E = IR. 4100 volts.

Question 5

What is the RMS value of the 120 volt AC line? 120 volts.

Question 6

Passing 120VAC through a diode and then a capacitor whose open lead returns to the other side of the line, the voltage across the cap is what? Convert RMS volts to peak volts by multiplying by 1.414 (170 volts), less the diode voltage drop of 0.6.

Question 7

Using the same scenario as above, what is the voltage across the cap when using full wave rectification? Same as question 6, since only one diode conducts at any one time.

Question 8

What circuit can I use to obtain full wave rectification using the power line without a transformer? Using

a bridge rectifier.

Question 9

What is the benefit of full wave rectification over half wave rectification? Smoother output, rectifies more energy since full wave uses both halves of the cycle. Recharging the capacitor 120 times a second instead of 60 times a second.

Question 10

The more common name for a "capacitor amplifier" is what? (think power supply) Voltage regulator. At one time these were called capacitor amplifiers, maybe not so much any more.

If have 18 volts going into a capacitor that results in a ripple going from 16 to 18 volts. If use a voltage regulator at 12 volts, eliminates the ripple and makes the capacitor seem like it is much bigger than it is.

Transistors

For Ralph.

Introduced June 30, 1948. John Pierce, Bell Labs, trans-resistor.

The fastest acting fuse known to mankind. The component exists to protect the fuse.

Mostly bipolar. NPN more common than PNP. Why? Noise higher in PNP. Also we are more accustomed to seeing the positive voltage on top of the circuit (analogous to the plate of a vacuum tube), and the PNP has the negative side on top of the circuit.

FET field effect transistor. High impedance behaving more like vacuum tubes. Includes JFET (junction FET) and MOSFET (metal oxide silicon FET).

How do transistors work?

Today made of silicon. Used to be made out of germanium. Called solid state devices. Materials conductive proportional to number of free electrons. Silicon crystals have few free electrons, but if add impurities in a controlled manner (called doping), then free electrons or conductivity increased. By adding other impurities like gallium, an electron deficiency or hole is created. Holes encourage conductivity, and material called semiconductor. N-type material conducts by free electrons, P-type material conducts by virtue of electron deficiency (holes). Discouraged from thinking of N as negative and P as positive.

If take piece of p-type material and connect it to piece of n-type material and apply voltage, current will flow. Electrons will be attracted across junction of p and n materials. Current flows by means of electrons going one way and holes going the other way. If battery polarity reversed, conduction ceases.

A junction of p and n types constitutes a rectifier diode. With zero spacing between p and n junctions we have a relatively high value capacitor. This type of construction places an upper frequency limit at which the device will operate. This was a severe early limitation on transistors at radio frequencies. The capacitance at the junction of a diode is often taken advantage of in the form of varactor diodes. See

diagram 1 of a varactor-tuned resonant circuit.

Transistor is a sandwich of these devices. There are capacitances between base and emitter and base and collector.

Amplification

Because collector current (where voltage relatively high) is pretty much same as emitter current and also controlled by the emitter current (where voltage usually much lower) it can be shown by Ohm's law $P = I^2 * R$ that amplification occurs.

Diagram 2. Can think of (simulate) a transistor as three resistors, where the base is a variable resistor and the others are fixed resistors. Voltage will be higher at the collector than at the emitter.

Common emitter inverts the signal. 30 volts at top, 1 amp flows through from emitter to collector. Attempting to use the resistor network in diagram 2 to model how signal inversion occurs. If have base at 10 ohms, collector voltage is 20 and emitter voltage is 10. If reduce base resistance to 5 ohms, collector voltage at 18 and emitter voltage at 12, so as the emitter voltage goes up the collector voltage goes down. If have base at 20 ohms, emitter drops to 7.5 and collector goes up to 22.5 volts, so as the emitter voltage goes down the collector voltage goes up. A transistor is a resistor that controls current. Maybe that's where the term trans-resistor comes from. The current changes as the base resistance varies.

The NPN Transistor

Differences between NPN and PNP are important in biasing.

A silicon NPN transistor needs to be forward biased by about 0.7V for it to turn on. Germanium transistors only need about 0.3 volts forward biasing to conduct. In crystal radio originally used crystal and cat's whisker; poke wire around a rock until it acted like a diode.

FET

J-FET transistor and dial gate MOSFET transistors. MOSFET transistors very sensitive to static discharge and are thus hard to handle. Diagram 3. Arrow points in or out depending on if enhancement or depletion material.

Extremely high input impedance; key feature for use in video clamping. Bipolar transistor has moderate input impedance while some FETs can and do have input impedances measured in megohms.

Bipolar transistors are essentially current amplifiers while FETs could be considered voltage amplifiers.

How Semiconductors are Made

Create 8 to 20 patterned layers on and into the substrate to create an integrated circuit.

Small Signal Amplifiers

What most of our work involves. Run all the time; class A. Greatest fidelity, least distortion, least efficient. Power delivered to load is only small percentage of DC power used in the amplification

process. May or may not use negative feedback.

Feedback

Part of output signal fed back to input 180 degrees out of phase. Why? Stop oscillations. Improve fidelity.

Fidelity

Output must be exact replica of input except only magnified or amplified.

Efficiency

Theoretical limit of efficiency for this amplifier is 50%. Can improve this by using Class B push-pull so that no current drawn when no signal present at the input. On small signals this is not so much of a problem. Class A losses through inefficiency are not significant at low levels of signal and amplification, and are far outweighed by the goal of fidelity or linearity.

Class A amplifier definition is to bias right in the middle of the signal. For example if the signal goes from 0 to 20 volts, the class A amplifier runs at 10 volts when no signal.

Transistor Basics with the 2N2222A

ID – it is a silicon NPN general purpose type

Pd – 0.5W – capable of dissipating 500 mW.

Vce – 40V – maximum voltage from collector to emitter, meaning don't use with anything higher than a 20V DC supply.

Ic – 0.8A – maximum collector current

What is the power? 40V * 0.8A = 32 watts, but capable of dissipating only 0.5 watts. So, can't put both voltage and current up high at same time.

Hfe – 100 at Ic of 150 mA. This means it has an **amplification factor** of 100. Beta. Unitless.

Ft – 300 MHz. Total/maximum frequency to have amplification (amplification factor is 1 at this frequency).

Case – TO-18 type package.

Do not always believe all the specs. Do not under any circumstances exceed specs, or get close. The particular run of transistor you are using may not meet spec, and maybe different from different manufacturers, or different environmental conditions. Most specs are conservative, but important items like Hfe can vary widely. Always use transistor well under published specifications.

What would a fourth lead on a transistor be called? For the shield of the case to provide RF isolation, to ground the case.

Small amount of base current leads to much larger current flowing between emitter and collector.

Do not take the EBC connections or leads on transistors for granted. The order may be different among transistor types or among manufacturers.

Projects

On report, tell what percentage done, what are waiting for, percentage of possible completion before semester end.