Turn In Homework

The homework was to show how to convert a DC voltage (5VDC in this example) into positive and negative DC voltages of various values.

How to Get a Negative Voltage from a Positive DC Voltage

Can't use an op-amp because the device already requires both positive and negative voltages..

Can't use a transformer since DC won't go through a transformer.

Buck/boost transformer won't do it.

Can't use a tank circuit by itself since the DC will go through the inductor to ground.

Need an oscillator: use a tank circuit with a transistor. Diagram 1. Run at 40 kHz: 10 kHz have more expensive/bigger parts, higher frequencies run into other problems. Now have a sine wave coming out, but power in the milliwatt range. Next, amplify the sine wave using the 5VDC power we already have; use a common collector to provide current gain.

Can run amplified sine wave through a transformer. For example, common collector circuit fed with 10 amps at 5 volts (50 watts maximum here). Can run the transistor in Class C through proper bias level; the transformer will regenerate the sine wave. Class C requires a tank at the emitter to ensure the amplifier continues to operate. Can run transistor in Class A but must bias carefully. Class B maybe since the oscillation may not continue if we only run half the cycle.

Output from the transformer, if produces 100 volts, will be at most 0.5 ampere.

Hook on diodes to transformer output to rectify to DC.

How to get +15 volts and –100 volts. Get the -100 volts by reversing the diode. Also, can run the 100 volts through another transformer to get the 15 volts. Or, get a transformer that has another winding for that voltage.

This is how a switching power supply works. This is how inverters work in your car; use square waves. It's a lot easier to use square waves, but some equipment is sensitive and requires sine wave output (if you need AC output). Square wave plus an inductor will result in spiky voltage. Could put in a 60 Hz tuned circuit, but would need a pretty large capacitor.

Calculate X_C of 10 ohms at 60 Hz, what does C have to be? 300 microfarads (265 ignoring significant digits). At what maximum voltage peak-to-peak? Would need a voltage rating of about 6 times the desired output voltage. Polarized capacitor, not so physically big, but non-polarized would be much larger size. Calculate X_L of 10 ohms at 60 Hz, what does L have to be? 30 millihenrys. This is a pretty hefty transformer. This is why the square wave inverters are so much cheaper, so they don't have to use these expensive components.

Boosting DC Voltage without using a Transformer

Stack two capacitors, use complicated switching arrangement, boost the voltage out without a transformer. Diagram 2.

No longer use vibrating inverters (vibrator). Common reed and an inductor tuned to 60 Hz. Diagram 3. Simulated AC (as a square wave). Used this to power tube radios in cars.

Review For Final

Final can cover anything this semester, and also resistor/capacitor and Ohm's law from first year.

Under what conditions does a smoking power transformer not indicate a problem in the transformer?

The enamel insulation in the windings may be melting. The wires in the windings wound very close together. The coils expand as they heat, which causes the wires to touch. Thermal runaway.

Phase Locked Loop

Three parts: phase detector, filter, VCO (voltage controlled oscillator). Maybe a fourth part (divide-by counter on the feedback line). Diagram 4.

Phase Detector

Frequency input generates a ramp over and over within the phase detector. Phase detector outputs DC. Want output to be 0 volts when locked. Say make ramp go from -5V to +5V. When sample happens, hopefully it happens at 0 V.

VCO

If VCO runs slightly fast, sample is a little higher (in the positive voltages). Phase detector outputs 2 volts, goes through filter, fed to VCO to slow down the VCO. Feedback frequency must be same as input frequency.

PLL used in VTR for sync, phase locking position of tape. Cell phones use them for locking position of the carrier. If can see the ramp and sample, might see samples all up and down the ramp if not locked.

Trying to lock to a square wave. Take freeze spray and spray the VCO to change its frequency.

Optimum filter prevents the phase detector from hunting and allows it to lock quickly. If filter is too slow, can prevent the VCO from following the input frequency. If filter is too fast, can make the VCO change too often.

Can generate a sample from a square wave by feeding it through a differentiator (or an edge detector), which will give a positive-going spike and a negative going spike. Can rectify off one of the spikes using a diode. Diagram 5. Can have a J-K flipflop or an XOR gate for an edge detector.

Bias level for controlling VCOs can vary among VCOs; look at the manufacturer's specs.

Bipolar vs FET

FET uses the electric field around the substrate (controlled by the gate) to regulate current flow; if you don't bias the gate, lets all current go through. Bipolar uses voltage at the base to regulate current flow;

if don't bias the base, no current goes through.

Digital

R-S flip flop makes up many of the devices we know: counters, shift registers.

Modulation

AM

Change the amplitude of the carrier. When modulate a carrier, what are the four frequencies: sum, difference, two originals. That's why we have two sidebands.

In a balanced modulator, just output the two sidebands (the sum and difference). Carrier and modulating frequency are balanced out.

FM

Change the frequency of the carrier. What kind of device can be used to do this? What would be the block diagram for the modulator? A VCO. Control the frequency by controlling a voltage (feeding it the output of a microphone, for example).

Stronger signals represented by larger frequency change. Higher frequencies represented by increased rate of frequency change. “The rate of deviation is proportional to the frequency of the modulation”.

VTRs record video by putting it on an FM carrier. Use NBFM (narrow band FM). Set a limit on deviation. Only take up 1 MHz of bandwidth for video. Disadvantage is that it is noisier, since don't have as much of a frequency spectrum to work within.

Transistor Configurations

Diagram 5.

Common Base

Provides voltage gain. Base is grounded to AC typically. Base voltage-divided for DC.

Good for isolation: with an NPN transistor and a grounded base, don't get much interaction between the input and output. At RF, in receiver use oscillator to move input down to an IF. Don't want oscillator frequency to be radiated out the receiving antenna.

Common Collector / Emitter Follower

Provides current gain. Used for drivers (line drivers). Low impedance lines need current. Voltage loss due to the 0.7 volt drop between base and emitter.

Common Emitter

High power gain. Popular configuration.