Handout, page 50 – Amplifier Circuit Description

Look at schematic. Obvious feature is a playback head. It is ferrite particles in a ceramic (could be other metals too). Shielded cable comes off the playback head; the shield is grounded. Playback head is a magnetic transducer, transforming magnetic energy to electrical energy. Couple signal into Q301 through C311; C311 passes audio and blocks DC. Where would the DC come from that needs to be blocked? There is DC on the transistor base, but the voltages out of the playback head is very low. The playback coil is a very low resistance coil (1 2 or 3 ohms); if the transistor's DC hits it it may burn it out from IR losses.

What configuration is Q301 in? Common emitter. Signal out collector, goes to base of Q303 without a coupling capacitor. Why no coupling capacitor? Even if the collector were only sitting at 6 volts, that's a bit much to be putting on a transistor base, so how to deal with it? It is a two-stage **direct-coupled** amplifier. We don't lose the DC level, and we don't have any low-frequency roll off. How to maintain a 0.7 V difference between base and emitter? Bring up the emitter voltage. This configuration sacrifices gain; the dynamic level suffers because we don't have as much voltage range (swing) to use in faithfully reproducing an amplified wave. End up sharing the voltage between the two transistors.

Coupling capacitor at the collector of Q303. This leads to the play line amplifier.

EQ (low speed) signal at the bottom right of the schematic. Recall what happens when play back tape at varying speeds and various frequencies. If increase from 1 kHz from 5 kHz, what would be the effect on the amplitude of the signal? High frequencies tend to be lossier, but with magnetics, as sped up the tape, the faster the magnetics change direction, the higher the resulting amplitude. So, the amplitude will increase as frequency is increased. This is about the only place in electronics that this happens. So, we have to equalize the higher frequencies to make their amplitude like the original signal that was recorded. Response cuts off when the frequency wavelength approaches the width of the head gap. Need to boost the low frequencies and attenuate the high frequencies to give us the response curve that we want.

Break

We have a guest.

Continued

What does low speed refer to? The tape speed. 3 ¾ or 7 ½ inches per second. Must know how fast tape is traveling in order to set a baseline. Q305 is in common collector; it acts like a switch. When current flows, R333 and C323 are coupled into the circuit, modifying the response (mostly these affect the high end). R327 sets one of the frequencies, and the other one follows along based on the RC combination. Q301 and Q303 are common emitter; two inverted outputs make the eventual output non-inverted. Combination of R325 and C319 determine the frequency which will be filtered out; C319 is zero impedance at high frequencies, and high impedance at low frequencies. Go through C315 and back to the emitter of Q301.

Read 8-1 to 8-2, the explanation of how it works. The NAB characteristic is a standard curve for audio response.

Amplification and Feedback

In amplifiers, we have positive feedback and negative feedback.

If take transistor in common emitter, get phase inversion at the output (collector). If feed this output signal back to the base through a resistor, the input signal should get canceled somewhat. This is a method of stabilizing a transistor. If fed the output of the emitter, would get oscillation from the positive feedback. Most amplifiers are stabilized using negative feedback. Also reduces bandwidth and reduces gain. But, collector of Q303 is fed back to the emitter of Q301; this is positive feedback. Controlling it to avoid oscillation through the RC combination. If feed back a limited amount, we can selectively amplify according to frequency.

Signal flows between Q303 emitter and Q301 base through R317. This would provide negative feedback to Q301. This is frequency-independent negative feedback providing overall circuit stabilization.

The components between the collector of Q303 and the emitter of Q301 is the frequency-dependent equalizing feedback.

This circuit amplifies the signal coming off the playback head, and it equalizes the signal.

Mute Circuit

Stop the sound. Mutes the signal by sending it to ground (grounding the play line amplifier line). Q307 acts like a switch. R337 then limits current from the output of the amplifier.

IEC Equalizing Response

Can support another response curve (IEC) by switching on Q333. Grounds the signal through R345 and C325, giving the response that time constant.

Playback Line Amplifier

What will R541 and C541 on the input to the line amplifier do to the frequency response? They are just coupling components and should not have an effect. C541 must be a fairly large value one.

Q541 is in common emitter. Q543 is in common emitter as well (with emitter tied to the positive line).

Output comes out of Q543 collector, out C545, out connector.

R547 (and R549) provide the feedback path to stabilize the circuit.

Notice that Q543 is PNP.

Monitor Amplifiers (page 52)

What's the triangle with the exclamation point inside? This is a warning, but we don't see anything in the text about them.

Triangle in the middle is an amplifier (an IC). U301 has 6 amplifiers in it.

Q313 and Q314 – what do they do? This is a voltage regulator. Q313 is a pass transistor. Q314

participates in feedback. D309 is a Zener diode. These are dead giveaways of a regulator circuit.

Why regulate the voltage going into a power output stage? Not to provide a standardized amplification. What about the bias points? Not really.

The manual says "reduces the impedance of the power line and crosstalk between circuits since the single chip contains six circuits" This would involve the 24 volt line bouncing up and down based on load that draws current (this is a high-current device), which could allow one circuit to modify the voltage supply of the other circuits. So, the voltage regulation circuit providing isolation is important to avoid the crosstalk resulting from the modulation of the voltage supply. The regulator is really just a capacitor amplifier; it makes the capacitor seem larger in capacitance with respect to the effect on isolation. Must be capable of enough current since this looks like a high output amplifier.

Play Line Amplifier Input

What is R537? A control on the front of the unit, called output level (volume control). Signal goes to pin 1 of U301 (pin 15 on the other channel). Output is pin 3 (pin 13 for the other channel). Goes through C389. Signal can go up through filtering circuit to the output jack. C395 and L301 probably filter out any bias frequency that remains (remember this is for a tape player); maybe there is PB/PB in confidence mode, or EE/PB. What is k301? A relay. K is always a relay. R421 is a load resistor, then the output.

Or, through C391, go through another op amp (the phone amplifier) to the headphones. R397 is for protection of your eardrums (current-limiting).

On bottom of schematic, S306 labeled as monitor; switches tape and source, and can look at it on the meter. R371 for adjusting the level of the signal being mixed in from the mixing amplifier. C397, R405 to the op amp, then to Q331 in common collector aka emitter follower. Benefit is high current; we will be driving a meter that is just a coil in a magnetic field. Then, out through C399, passes around R399. What does we do to the signal from there? Rectifies the signal since not a centered meter, so just want DC to the meter. This is a voltage doubler also.

Homework

Handed out circuit boards to each student. Assignment is to draw the schematic implemented on the circuit board. Draw the circuit first, and then make it flow. The big connector (J1) should be on the left (it is the input), the small connector (J2) should be on the right. This is due Tuesday March 20. Make assumption that every hole goes through to the other side.

Oscillator Load Circuit

Bias oscillator. On an erase head, we expect to find a few hundred volts. Bias oscillators rely a lot on resonance (resonant rise of voltage). If record on one channel, must take the bias off of the other channel, and then must load down the bias oscillator so that it stays in resonance and the other channel works as expected. Have the erase and record heads on. If turn off one of the channels, must go through the load (dummy load). Takes place of erase head and record head inductively, so that the oscillation remains and we don't change the circuit. The record and erase heads depend on resonant rise in voltage, so if we disconnect one channel, this changes the resonant frequency, so we must hook the unused channel to the dummy load.

What are C301 and C302? Variable capacitors. A T shape on the schematic symbol because it is a trimmer capacitor. S41 and S42 are switches, each has multiple switches ganged together (***mechanically*** connected).

In video, erase head is full width.

Have a erase, record, and playback heads. Playing back what just is recorded is called **confidence**.

Exploded View

Usually comes with a legend (Steve didn't include the one that came with this view).

What are the Dashed Lines around some Transistors?

They appear on pages 38 and 39. They represent heat sinks.

For Q67, Q74 on page 38 and Q72 on page 39, these transistors are acting as pass transistors. They carry current; they are power supply regulators. They carry a lot of heat.

On page 38, Q71 and Q70 also handle high current since they are used to switch the current to the reel motors.

DC motors have brushes. Brushless DC motors are really AC motors that convert the DC to AC for the motors. Brushes transfer current to the coils which are on the rotor. Brushes are carbon blocks riding on a commutator. The brush rides on two copper lands on the rotor. Universal AC motors have brushes.