Assignment – Plan of 24-hour to 12-hour BCD Converter

Add 15 to the most significant BCD nibble, add 14 to the least significant BCD nibble. For example BCD 13 ends up being BCD 01. This is for values 13-23.

Use 8-input gate to detect zero as special case. Add 12 or set 12 as answer.

Take 1-12 as-is.

Common Emitter Configuration

Diagram 1.

Input into base, output from collector.

Emitter terminal common to both input and output.

The arrangement is the same for a PNP transistor; just the polarity changes.

Advantage of medium input impedance, medium output impedance, high voltage gain, high current gain.

Usually seen labeled as Q in schematics. The slide shows T, but T is usually a transformer.

Common Base Configuration

Diagram 2.

Often on high frequency (RF) applications. Great isolation between input and output.

Low input impedance, high output impedance. Like a transformer or a resistor pad in function. Resistor pad loses power of course, and transformer is not an active device.

Unity (or less) current gain, high voltage gain.

Common Collector Configuration

Diagram 3.

Also known as **emitter follower**.

If use a FET, where input into gate, output from source. Would be called common drain or **source follower**.

For vacuum tube, called a **cathode follower**.

Called that because input signal applied to base/gate/grid followed quite closely at the emitter, with a voltage gain close to 1/unity (or less).

High current gain. Advantage is circuit used extensively as a buffer (Steve says better term is driver) converting impedances or for feeding/driving long cables or low impedance loads. For us, we use 75 ohm coax, so this is a good configuration for feeding coax. High current allows us to have enough to overcome losses so we have enough at the other end of the coax.

Also, impedance of loudspeaker is 8 or 4 ohms, so need a lot of current to drive a speaker. Lower priced amps use an emitter follower to drive the speakers.

Comparison Among Configurations

Amplifier Type	Common Base	Common Emitter	Common Collector
I/O phase relationship	0	180	0
Voltage gain	High	Medium	Low
Current gain	Low	Medium	High
Power gain	Low	High	Medium
Input resistance	Low	Medium	High
Output resistance	High	Medium	Low

The collector will be tied to positive voltage supply and won't have signal on a common collector. Mostly the collector will have a signal, so if off one transistor collector there is no signal, then look at schematic to see if configuration is common collector.

What if have a circuit where take signals off both emitter and collector? Have an undefined situation. Diagram 4. Called a **phase splitter**, since the emitter signal in phase with base input signal, but the collector signal is 180 degrees out of phase.

Amplifiers

Two conditions: DC and AC/RF. These are two totally different sets of conditions.

Ft is transient frequency (point at which the unity gain line is transited). We'll call it the total frequency. It is the highest frequency where the gain is unity or more.

Most transistors in the 100 MHz range.

DC Conditions

Transistor has to be turned on or have the base opened. To do this, the base has to have a voltage applied to it about 0.65V higher than the voltage level at the emitter. It really is 0.7V but the slides in class all have 0.65V. This is true for NPN transistors.

Examples here are mostly common emitter.

This property allows transistor to be used as simple switch.

Diagram 5 shows DC and AC model vs. equivalent AC-only model. These circuits are referred to a lot in this section of notes.

Why are the two circuits so different?

Why is there a resistor and capacitor on the emitter on the AC/DC circuit and nothing on the AC-only circuit? Capacitor blocks DC. AC doesn't see the resistor since the capacitor passes AC with low resistance.

With class A amplifiers, this is done by biasing the transistor for DC configurations. Operates during the entire part of the signal cycle and uses DC at all times (keeps circuit working in anticipation of an AC signal). Lower efficiency, higher fidelity.

Start with 12VDC power supply. This is a fairly common power supply for analog circuits.

Resistor from supply to base and resistor from base to ground. Resistor from supply to collector as well as resistor from emitter to ground. The resistors form voltage divider networks, for example, R1 and R2 at the base of the transistor.

Calculate Base DC Voltage and Current

The ratio of [R2/(R1 + R2)] * 12V = base DC voltage.

If use 82K for R1 and 39K for R2, get base voltage of 3.9V.

Also, the current flowing through these base resistors (ignoring current into the base) is from ohms law 99 microamps (0.1 mA).

Calculate Emitter DC Voltage, Current, and Resistance

The current through the emitter should be between 5 and 10 times the base current. Since the circuit is an amplifier, would want more power going through emitter to collector than coming into the base. This lets us as technicians know what to expect from an amplifier circuit Picking a midpoint, 0.7 mA for emitter.

Recall the base must be 0.7V higher than emitter. If base voltage of 3.9V, and is 0.7V higher than emitter, the emitter must be at 3.9 – 0.7 = 3.2V.

If we also said that emitter current is 0.7 mA then the emitter resistor R3 must be 3.2V / 0.7 mA = 4.6K ohms. We would use the standard value of 4.7K ohms. This may also be notated as 4K7.

Calculate R4 Value

R4 is the load resistor. It could (at RF) easily be a choke (inductor), a transformer, or a resonant circuit (tank).

If 0.7 mA flowing through emitter, must be also flowing through the collector. Negligible current flow from emitter to base. If supply voltage is 12V and emitter voltage is 3.2V, collector voltage must be Vcc – (Ic * R_L) where R_L is R4. 12V – (0.0007A * R4).

Collector voltage called Vcc because of convention going back to radio when had batteries for the plate and called it Vbb. When went to transistors, promoted the letters to cc. Vee is voltage at emitter. Vbe is voltage from base to emitter. Vce is voltage from collector to emitter.

Choose 6800 ohms (6K8) for R4, what happens? So far, we have discussed just DC conditions.

AC Conditions

First, need **coupling capacitor** from previous stage and **coupling capacitor** at the output. These are C1 and C3, respectively. Their sole purpose is to block DC so that DC voltages do not transfer between stages. Usually look for very low reactance Xc at the frequency of interest so that frequency isn't impeded in the transfer.

In our example, our frequency is 2400 Hz (the time code reader). For C = 0.001 mF at 2.4KHz, what is the Xc? 66 K ohms. That seems like too much. Try 0.1 mF, get 663 ohms capacitive reactance. Let's say we can live with that resistance at this frequency.

Well, calculate using 0.82 mF capacitor at 2400 Hz. Xc is 650 ohms at 300 Hz and 65 ohms at 3000 Hz (the limits of audio frequencies for communications purposes). These reactances are low enough to use this value of capacitor as a coupling capacitor here. If this were a high fidelity amp then higher values of capacitance would be better.

Emitter

For AC or RF purposes the emitter should be grounded. If at AC there is a resistor to ground then the gain suffers due to **emitter degeneration**. Later we take advantage of this in another circuit employing feedback. Keeping the emitter at ground allows the collector voltage to vary significantly more. This capacitor on the emitter (C2) is called the bypass capacitor since it allows AC to bypass the resistor.

At the emitter, the capacitor in parallel with the resistor presents zero ohms resistance to AC since all the AC flows through the capacitor.

How do we get a grounded emitter for AC? Bypass the emitter resistor with a capacitor (C2) of the same or similar value to C1 and C3. This capacitor makes emitter resistor R3 invisible for AC/RF.

Last capacitor (C4) (again same or higher value) is from 12VDC to ground. This has effect of **decoupling the supply**. It's called a **power supply bypass capacitor**. The resistor would have a small value like 33 ohms. This means any AC/RF in amp section gets shunted (shorted – a really low resistance) to ground and doesn't pass along the DC power bus line to contaminate other stages. Similarly no contamination from other stages should ever get into our stage.

So what happens now that we've surrounded our transistor with resistors and capacitors?

We are looking at the circuit of a single-stage amplifier. Same circuit can be used for RF, AF, video signals.

How Parts Fail

We won't see a shorted resistor ever (Steve's seen only one in his 30-year career). Resistors open and capacitors short. Capacitors dry out and short out. Diodes short, transistors short (will rarely open). Usually an emitter-to-base short on transistors.

What's the best way to determine if a part is defective? Replace it. In our business this is not bad form. A lot of variables exist. Can be a fast way to fix. Of course, you will be checking voltages to determine the bad stage. Most of the time it's the active component that is the problem.

If R3 opens, there would be no current flow, so at the collector there would be 12VDC because the IR drop from resistors R4 and R5 would be zero since the current flow is zero.