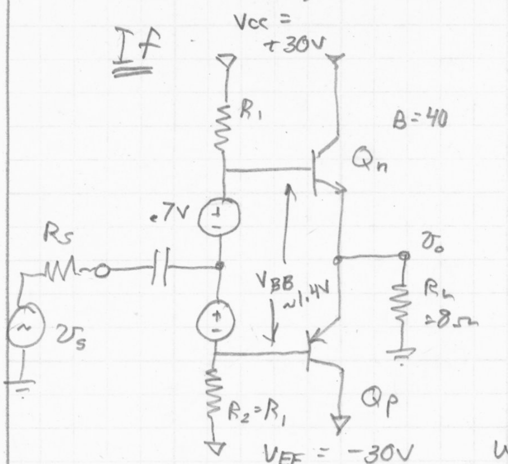
8.28 Supplement – Additional Discussion

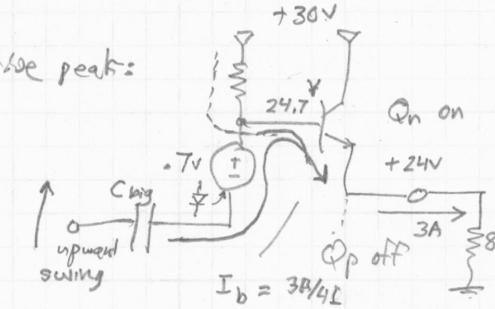
This is a very common problem.

Issue: Diodes act like voltage sources, but only when current is flowing through them

If



At positive peak:



$I_b = 3A/41$

$= 73.2\ mA$

We need 73.2 mA into Q_n base

Most of that can come from C_{big}!

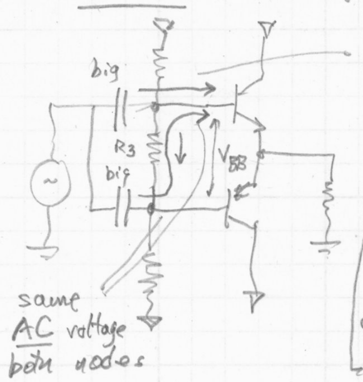
(we need sufficiently big v_s and small R_s)

R_1 (and R_2) can be made arbitrarily small.

(When we swing low, same thing happens on the bottom side.)

Key issue: for this to work, the diodes have to act like .7V sources whichever way current flows! They don't

In Lab 6 we mitigated this issue by
1) Using two capacitors
2) Using a resistor to get the Vdrop: V_{BB}



i_B free to flow from both capacitors into transistor base.

[If you leave out one of capacitors, R_3 affects gain for one or other of transistors.]

(This doesn't quite work with large R_1, R_2 if diodes replace the central resistor R_3, since lower capacitor will accumulate a positive charge and upper C will accumulate neg. charge.)

Reasons for not using this:
1) Unless you are very confident in your Q points, the capacitors may need to be polarized.
2) Since the capacitors may need to be big and nonpolarized, they will be expensive.
3) Diodes are cheap.

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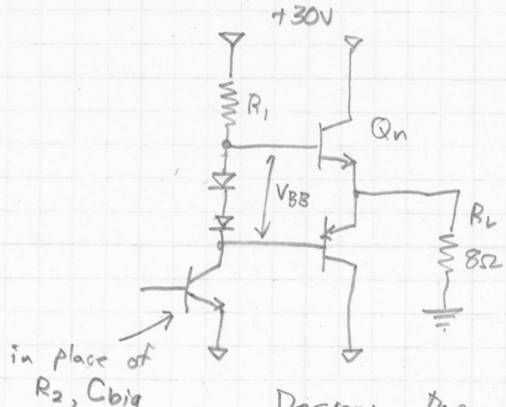
So, what is commonly done is: Get rid of all the capacitors (direct coupling)

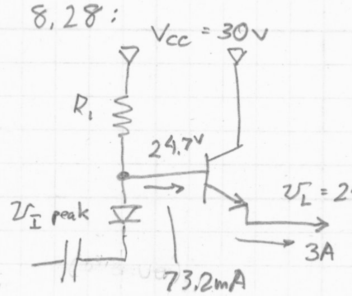


Key point: We need sufficient Q point current through the diode stack that we can steer that current through the base of Q_n at positive peaks.

(With active pull-down, negative peaks won't be a problem.)

Designing the above circuit is similar to problem 8.28. In fact, it's the same problem except for the complications of the driver transistor replacing C and R_2.

8.28:



Look at peak positive situation.

ALL current into the base of Qn Must come through R_1, since it can't get through the diode.

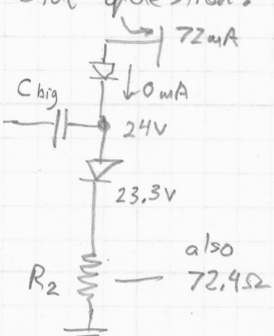
[So where does input current go? $v_I = 24V$ so i_I goes through other diode, R_2 to V_{EE}]

⇒ R_1 must be small enough to pass 73.2mA with 30V − 24.7V across it:

$R_1 = 5.3V/73.2mA = 72.4\Omega$ or smaller

If R_1 is smaller, the extra current goes through the diodes.

Side question: So, how much current at + peak flows through R_2?



$i_{R2} = 23.3V/72.4\Omega = 322mA$ (Current supplied by Cbig)

(Cbig will recharge on the next negative swing.)

Note that the driver stage must provide a peak output current equal to this! So the AC load is $24V/322mA = 75\Omega$ – so this power output stage is giving current gain of just $3A/322mA = 9.3 = A_i$

(We'd like to do better) ⇒

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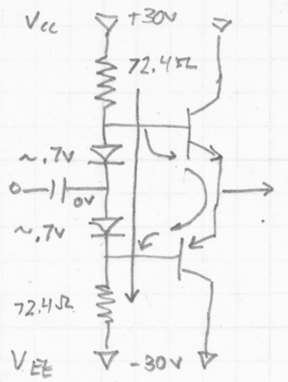
8.28 Commentary: So if we try to use a R-D-D-R stack for bias in this problem, $R_1 = R_2 = 72.4\Omega$ (or less)

Let's look at Q point: $(60V - 1.4V)/(72.4\Omega + 72.4\Omega) = \underline{.405A}$



(Some of this current gets steered through the transistor bases instead of the diodes. - That causes transistor Q point current.

With matched diodes, transistors $I_C = I_D$ ~~≈ ½ (.405A)~~

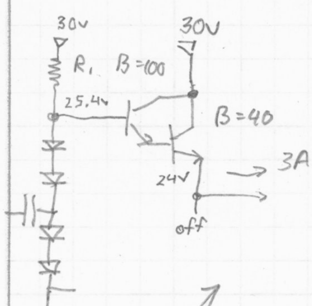
But I_S is not constant with temperature. It goes up with increasing dissipation so danger of thermal runaway

So, What can we do?

1.) Make v_{R_1} larger at peak output, so R_1 can be larger. But that requires a higher V power supply for same v_L pk

2.) Go back to using big capacitors from driver stage (Or, equivalently, put a C_{big} across the diodes) (would need to be very big)

3) Reduce peak base current by using a higher β transistor. (or, more likely, go Darlington so $i_b = i_L / (\beta+1)(\beta+1)$ Qn Q darlington

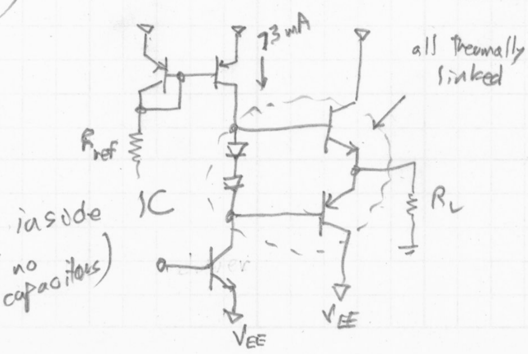


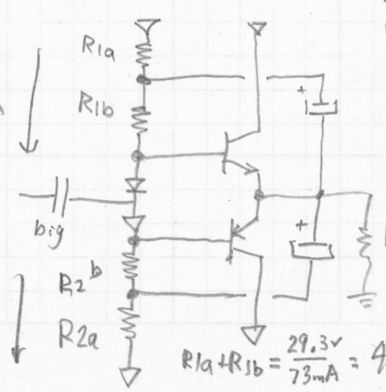
$R_1 = \frac{30V - 25.4V}{.72\,mA} = 6.4K\Omega$ A whole lot better

At Q: $I_{R_1} = 30V - 1.4V / 6.4K\Omega = \underline{4.5\,mA}$

However - now diodes don't match transistor stack and most of current gets steered through the transistors at Q - you get meltdown! Fix by adding emitter resistors.

(or both 3 and 4) 4) Substitute a current source for R_1: (Also reduces load on driver)





R_{1b}, R_{2b} now look like current sources (make I = 73 or more)

$R_{1a} + R_{1b} = \frac{29.3V}{73mA} = 401\Omega$