Amplifier design - (1)

50 watts, 8 Ω → $P = \frac{V^2}{R} \rightarrow PR = V^2 \rightarrow V = \sqrt{PR}$

20 volts, RMS = 28.3 V peak

$I = \frac{V}{R} \Rightarrow$ 2.5A, RMS, 3.54 A peak

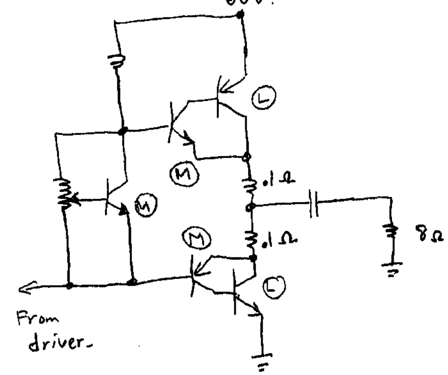
Use 60 volt powersupply.

Voltage gain = $\frac{28.3}{.001}$ = 28,300 (89 dB)

use 4 voltage gain stages 12.97 (13) each

Assume Zin > 10K (not spec'd)

Output stage (2)



Composite/darlington output stage -

$\beta = 2500$

Need base drive current

$\frac{3.54A}{2500} = 1.41$ ma

Power at half output:

$\frac{V^2}{R} = \frac{(30V)^2}{8} = 112.5$ Watts ≈ 120 watt

50% duty cycle → ≈ 60 watts

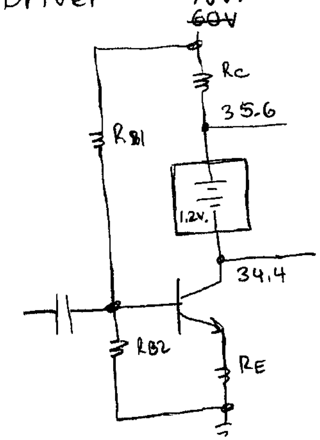
This is above the rating of the "large" transistor.
We could use 2 in parallel,
but often they will use one
because it rarely operates that hot.

Power in driver:

$\frac{(30)^2}{50 \times 8} = 2.25$ watts. 50% duty cycle ⇒ 1.125 watts.

No problem for "medium" transistor.

Driver



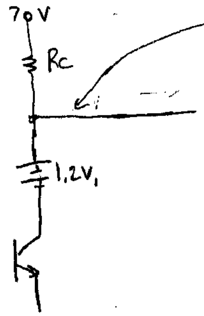
Need higher than 60 volts

Due to voltage drop in Rc and RE.

Increase it to 70.

Set gain = 13.

Determine Rc



$V_Q = 35.6$

$V_{peak} = V_Q + V_{ar\ peak} = 35.6 + 28.3$

$= 63.9$ call it 64

$V_{Rc} = 70 - 64 = 6$

$R_C = \frac{V}{I} = \frac{6}{1.41ma} = 4.25K$ max

use 3.3K

This means $I_{CQ} = \frac{70-35}{3.3K} = \frac{35}{3.3K} = 10.6\ ma$

Power = (35)(10.6 ma) = 371 mw

Rc must be rated at least .37 watt
use 1/2 or 1 watt.

Transistor dissipation OK.

Driver p.2

$r_o = \frac{V_A + V_{CE}}{I_C} = \frac{135}{.0106} = 12.7K$

$\frac{r_\pi}{\beta} = \frac{.026}{I_E} = \frac{.026}{.0108} = 2.4\Omega$

Effective R_{LOAD} = 8 * 2500 = 20K

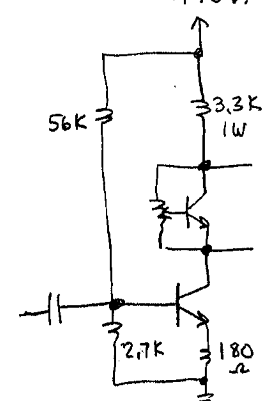
Effective R_C = 20K || 12.7K || 3.3K

= 2316

For gain = 13 $\quad R_{E\ effective} = 178.15$

Actual $R_E = 178.15 - 2.4 = 175.75$

use 180Ω



$V_E = (.0108)(220) = 1.94V.$

$V_B = V_E + .7 = 2.6V.$

$I_B = \frac{10.6ma}{50} = .21\ ma$

Choose bias network current = 2 ma

$R_{B2} = \frac{2.6}{2ma} = 1.3K$ ← Too low.

try 1ma

$R_{B2} = \frac{2.6}{1ma}$. 2.6K (a little better)
use 2.7K

$\frac{R_{B1}}{R_{B2}} = \frac{X}{2.7K} = \frac{67}{3} \quad X = (2.7K)\frac{67}{2.7} = 67K$

Add parallel resistor for I_B ~

$R = \frac{V}{I_B} = \frac{67}{.21ma} = 319K$

R = 67K || 319K = 55.3K use 56K

⑤

Pre-driver

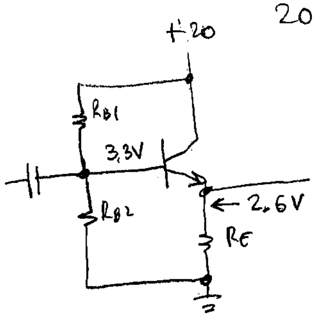
Need : gain = 13

$R_{LOAD} = 2.7K \parallel (180)(50) \parallel 56K = 2K$

Output voltage swing $= \frac{28.3 \times 2}{13} = 4.35$ p-p. (2.2V peak)

Use emitter follower to drive 2K.

20 volt supply



Direct couple to next stage, eliminating its bias resistors.

$V_E = 2.6V$

$V_B = V_E + .7 = 3.3V.$

→ sees 2K $\quad Z_{in} = (2K)(50) = 100K$

I_E – must supply $(3.3 + 2.2)V$ into 2K

$\frac{5.5V}{2K} = 2.75$ ma

Make R_E 2.7K (from the next stage bias network)

$I_E = \frac{2.6V}{2.7K} \approx 1$ ma

$I_B = \frac{1}{50} = .02$ ma

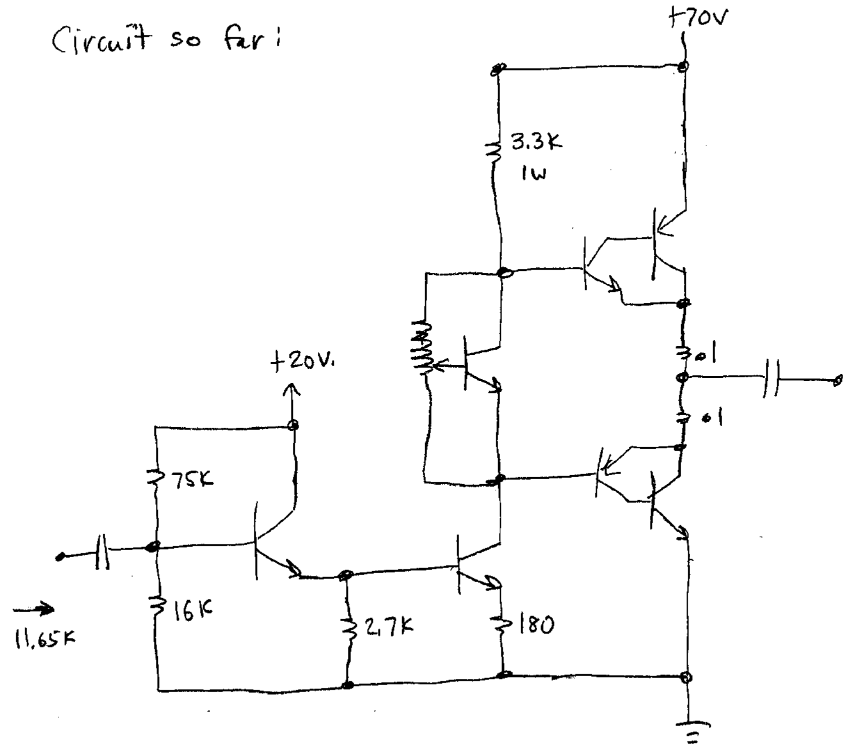
Choose Bias resistor current .2ma

$R_{B2} = \frac{3.3V}{.2ma} = 16.5K$ use 16K

$R_{B1} = \frac{20-3.3}{.22ma} = \frac{16.7}{.22ma} = 75.9K$ use 75K

⑥

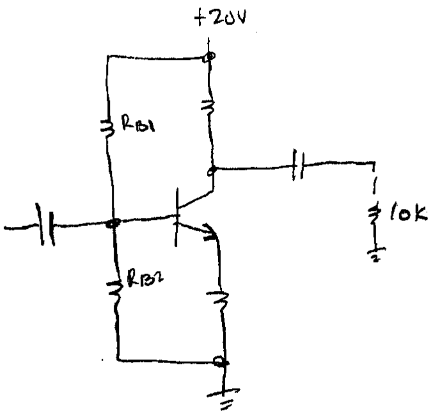
Circuit so far:



Preamp:

Use 3 identical stages, $A_V = 13$ each

$Z_{in} = 10k$ $R_L = 10K$



Choose $R_C = 10K$ $V_C = 11$ V (for $V_{CE} \approx 10$)

So -- $V_{RC} = 9$ $I_C = .9$ ma

$$r_o = \frac{V_A + V_{CE}}{I_C} = \frac{109}{.9ma} = 121K$$

$$\frac{r_\pi}{\beta} = \frac{.026}{I_E} = \frac{.026}{.9ma} = \frac{26mV}{.9ma} = 29\,\Omega$$

Effective collector load = $10k \| 10k \| 121k = 4.8K$

Want effective $R_E = \frac{4.8K}{13} = 369$

Actual $R_E = 369 - 29 = 340\,\Omega$ — use $330\,\Omega$

$Z_{in} = (330)(50) = 16.5K$

Preamp p.2

Bias resistors --

for $Z_{in} = 10K$, want the parallel value to be

$$R_B = \frac{1}{\frac{1}{10K} - \frac{1}{16.5K}} = 25K$$

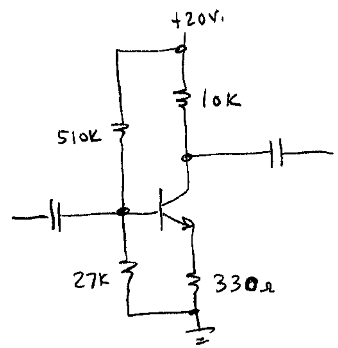
For $V_C = 11V$.

$V_E = (.9ma)(330\Omega) = 297$ mV

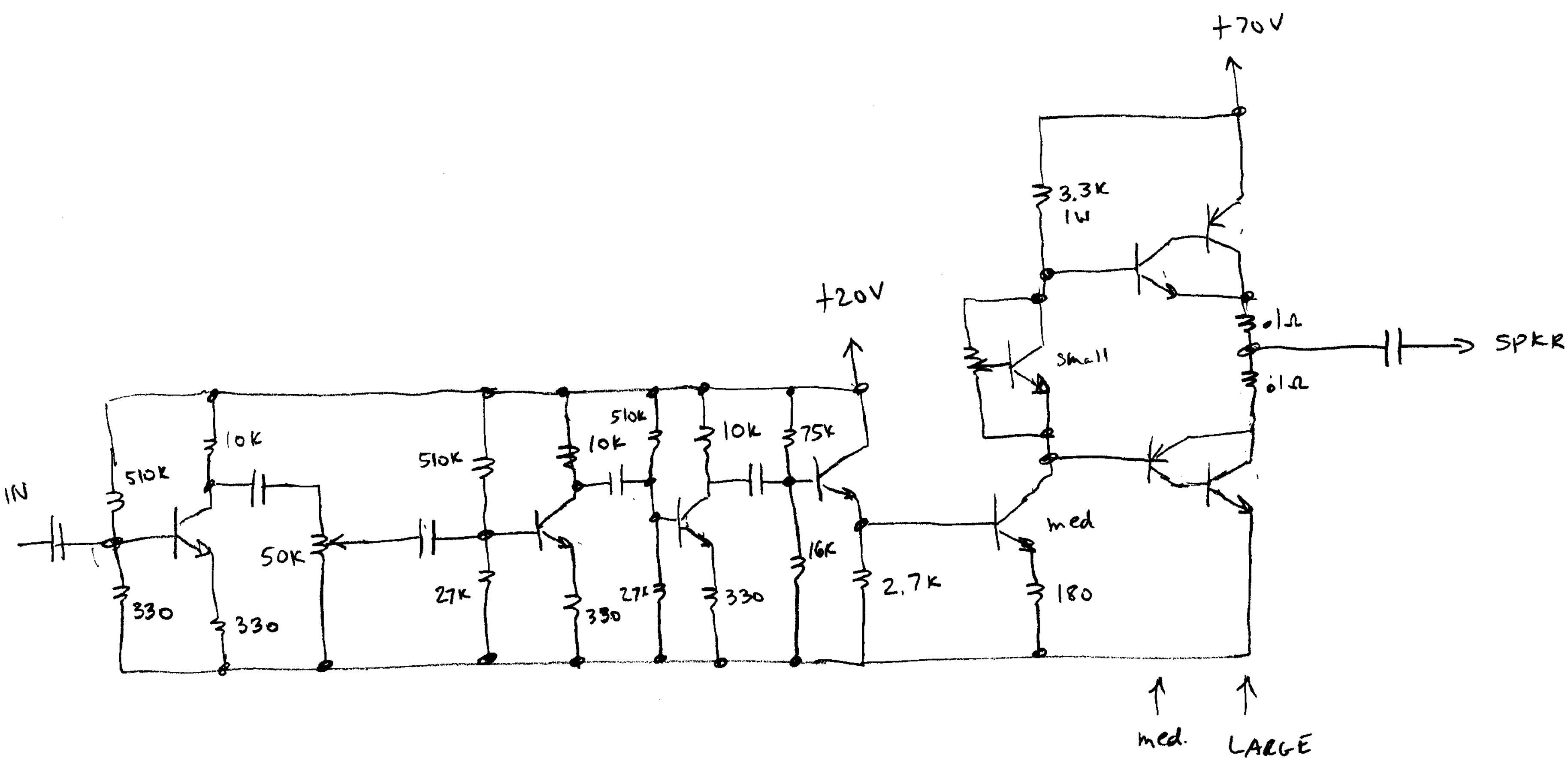
$V_B = 1V$

Make R_{B2} 27K

$R_{B1} = (19)(27K) = 513K$ use 510K



Put volume control between first + second stages.



+70V
3.3K
1W
+20V
.1Ω
SPKR
small
.1Ω
510K
10K
510K
10K
10K
75K
IN
510K
50K
med
27K
27K
330
16K
2.7K
180
330
330
330
330
med.
LARGE