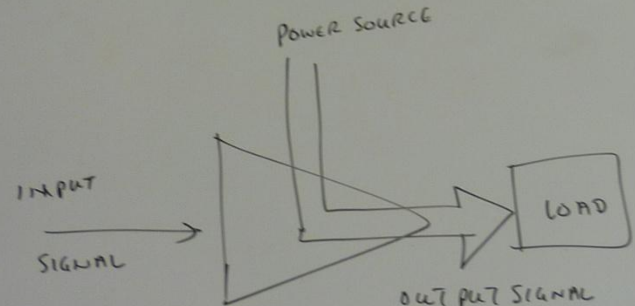
POWER OUTPUT STAGE (PART-1)

FIRST AND INTERMEDIATE STAGE AMPLIFIERS CAN NOT HANDLE THE LARGE POWER.

THE OUTPUT STAGE REQUIRES THE POWER AMPLIFIER. THE OUTPUT STAGE MAY BE SERVO MOTOR (OR) INDICATING DEVICES (OR) SPEAKER.

OUTPUT STAGE USUALLY HAS UNITY VOLTAGE GAIN



THE BASIC REQUIREMENTS FOR ANY POWER OUTPUT STAGE ARE

- HIGH EFFICIENCY
- LOW DISTORTION
- LOW OUTPUT IMPEDANCE

OUTPUT STAGE AMPLIFIERS

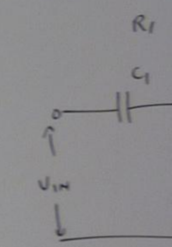
(1) CLASS (A)

(2) CLASS (B)

(3) CLASS (A+B)

CLASS (A)

— OUTPUT DEV



CLASS(A)

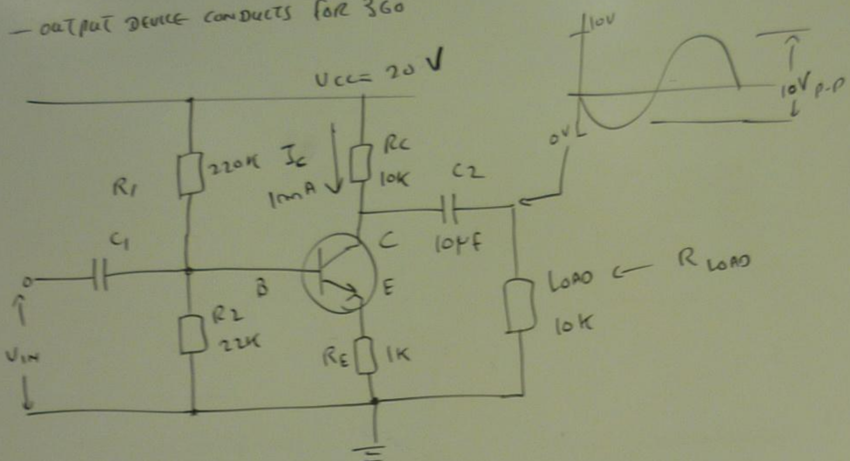
- MAXIM
- MAXIM
- LOW D
- HIGH
- OUT

...ARGE POWER.
...E MAY BE

...AGE AMPLIFIERS
(A)
(B)
(A+B)

CLASS (A) AMPLIFIER

– OUTPUT DEVICE CONDUCTS FOR 360°



COMMON EMITTER RC COUPLED
CLASS (A) AMPLIFIER

CLASS(A) AMPLIFIER CHARACTERISTICS

- MAXIMUM EFFICIENCY 25% FOR RC COUPLED TYPE
- MAXIMUM EFFICIENCY 50% FOR TRANSFORMER COUPLED TYPE
- LOW DISTORTION THAN CLASS(B)
- HIGH QUIESCENT CURRENT
- OUTPUT DEVICE CONDUCTS FOR 360° OF INPUT SIGNAL

$$P_{IN} = V_{CC} \times I_C$$

$$V_{o\,rms} = \frac{V_{o\,p\text{-}p}}{2\sqrt{2}}$$

$$P_{OUT} = \frac{(V_{o\text{-}rms})^2}{R_{LOAD}}$$

$$\%\eta = \frac{P_{OUT}}{P_{IN}} \times 100$$

PB CALCULATE (a) P_{IN} (b) P_{OUT} (c) $V_{o\,rms}$ (d) EFFICIENCY OF ABOVE CLASS(A) AMPLIFIER

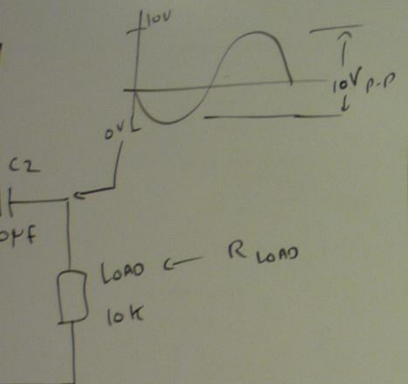
$$P_{IN} = V_{CC} \times I_C = 20 \times 1mA = 20mW$$

$$V_{o\text{-}rms} = \frac{V_{o\,p\text{-}p}}{2\sqrt{2}} = \frac{10}{2 \times 1.4142}$$

$$= 3.53V$$

P...
$\%\eta$...

PB
REQ...
SYS...
20%...
OF...



...UPLED

...TERISTICS

...% FOR RC COUPLED TYPE

...% FOR TRANSFORMER COUPLED TYPE

...ASS(B)

...s FOR 360° OF INPUT SIGNAL

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$$P_{OUT} = \frac{(V_{o\text{-}rms})^2}{R_{LOAD}} = \frac{(3.53)^2}{10k} = 1.25\,mW$$

$$\%\eta = \frac{P_{OUT}}{P_{IN}} \times 100 = \frac{1.25}{20} \times 100 = 6.25\%$$

Pb CALCULATE THE INPUT POWER REQUIRED FOR AN INDUSTRIAL SOUND SYSTEM WITH AN EFFICIENCY OF 20% THAT HAS AN OUTPUT POWER OF 50kW.

$$\%\eta = \frac{P_{OUT}}{P_{IN}} \times 100$$

$$20 = \frac{50}{P_{IN}} \times 100 \rightarrow P_{IN} = \frac{50 \times 100}{20} = 250\,kW$$

$$I = \frac{P_{IN}}{V} =$$

$$=$$

$P_{IN} = V_{CC} \times I_C$

$\text{rms} = \frac{V_O\ p\text{-}p}{2\sqrt{2}}$

$\text{T} = \frac{(V_{O\text{-}rms})^2}{R_{LOAD}}$

$= \frac{P_{OUT}}{P_{IN}} \times 100$

ALCULATE (a) P_{IN} (b) P_{OUT}

$V_{o\,rms}$ (d) EFFICIENCY OF

OVE CLASS(A) AMPLIFIER

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$= \frac{250\times 10^3}{240}$

$= 1041.67\ A$

CLASS(

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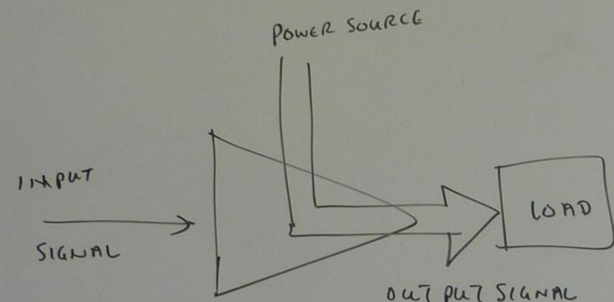

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OUT PUT STAGE AMPLIFIERS

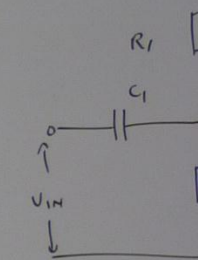
(1) CLASS (A)

(2) CLASS (B)

(3) CLASS (A+B)

CLASS (A) AM

— OUTPUT DEVICE



COM MO
CLASS

CLASS(A)

- MAXIMUM
- MAXIMU
- LOW DIST
- HIGH Q
- OUT PUT

GE POWER.

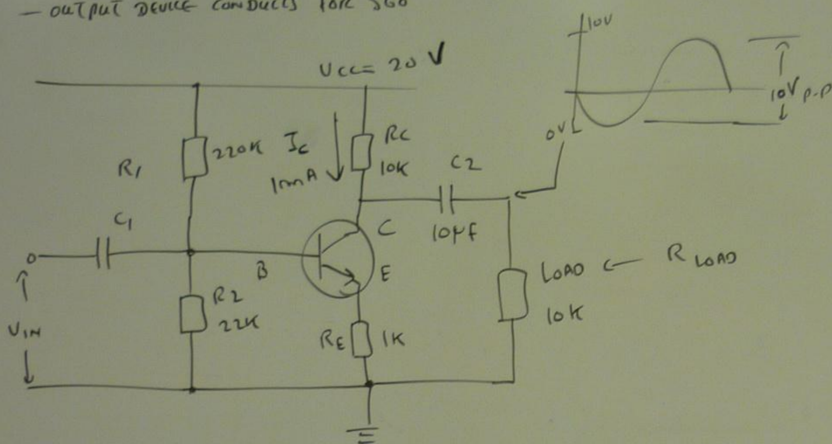
MAY BE

AMPLIFIERS

+B)

CLASS (A) AMPLIFIER

— OUTPUT DEVICE CONDUCTS FOR 360°



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$P_{OUT} = ($

$= ($

$\%\,n = \frac{P_{O}}{P_{IN}}$

Pb CALCULA… REQUIRED F… SYSTEM WIT… 20% THAT… OF 50kW.

$\%\,n =$

$20 = \frac{50}{P_{IN}}$

$V_{cc} \times I_c$

$= \dfrac{V_{o\,p\text{-}p}}{2\sqrt{2}}$

$\dfrac{(V_{o\text{-}rms})^2}{R_{LOAD}}$

$\dfrac{P_{OUT}}{P_{IN}} \times 100$

...LATE (a) P_{IN} (b) P_{OUT}

...rms (d) EFFICIENCY OF

CLASS(A) AMPLIFIER

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$$= \frac{250 \times 10^3}{240}$$

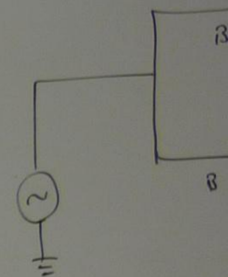
$$= 1041.67\,A$$

GENERAL FEATURES OF CLASS (B) AMPLIFIER

- MAXIMUM EFFICIENCY - 78.5%
- HIGH DISTORTION (COMPARED TO CLASS (A))
- LOWER POWER DISSIPATION BY THE OUTPUT DEVICES
- TWO OUTPUT DEVICES NEEDED BOTH CONDUCT FOR 180°.
- VOLTAGE GAIN (A_V) = UNITY

POWER GAIN (A_P) = CURRENT GAINS OF TRANSISTOR

CLASS (B) POW...



- CLASS (B) AMPL... OF TWO OUTPUT...
- Q_1 CONDUCTS FOR ... THE INPUT SIGN...
- Q_2 CONDUCTS FO...
- THE OUTPUT SIG... BOTH TRANSIS...

Q_1 CONDUC...

Q_1 OFF

1.25 mW

= 6.25%

...PUT POWER
...STRIAL SOUND
...ICIENCY OF
...UTPUT POWER

...N = $\frac{50 \times 100}{20}$ = 250 kW

$$I = \frac{P_{IN}}{V} = \frac{250\,kW}{240} = \frac{250 \times 10^3}{240} = 1041.67\,A$$

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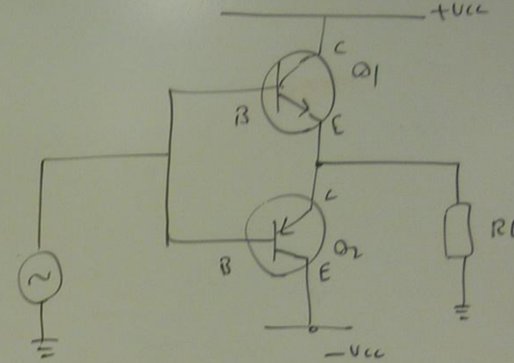
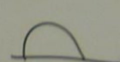
CLASS (B) POWER OUTPUT STAGE

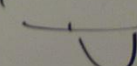


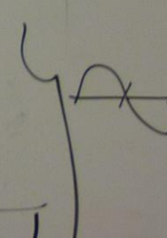
- CLASS (B) AMPLIFIER REQUIRES A MINIMUM OF TWO OUTPUT DEVICES
- Q_1 CONDUCTS FOR THE POSITIVE HALF OF THE INPUT SIGNAL
- Q_2 CONDUCTS FOR THE NEGATIVE HALF.
- THE OUTPUT SIGNAL IS PRODUCED BY BOTH TRANSISTORS.



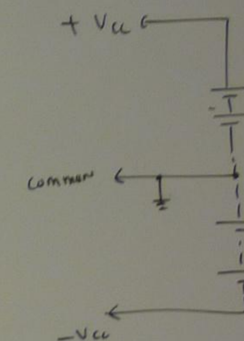
Q_1 CONDUCTS - Q_2 OFF

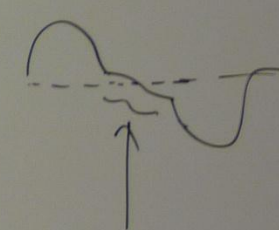
Q_1 OFF - Q_2 CONDUCT





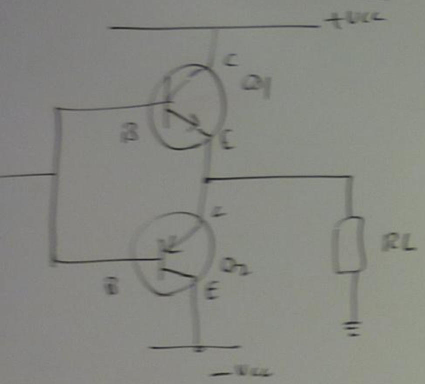
DUAL POLARITY POWER S...





CROSS OVER DIS...

...(B) POWER OUTPUT STAGE



...) AMPLIFIER REQUIRES A MINIMUM
... OUTPUT DEVICES

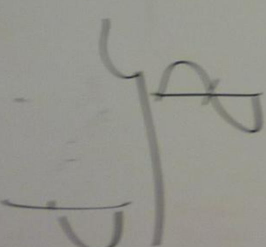
...TS FOR THE POSITIVE HALF OF
...PUT SIGNAL

...DUCTS FOR THE NEGATIVE HALF.

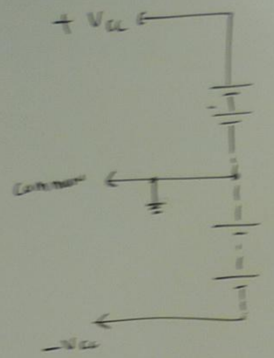
...PUT SIGNAL IS PRODUCED BY
...TRANSISTORS.

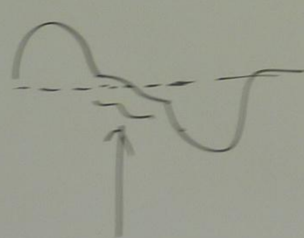
...CONDUCTS - Q_2 OFF

OFF - Q_2 CONDUCT



DUAL POLARITY POWER SUPPLY





CROSS OVER DISTORTION

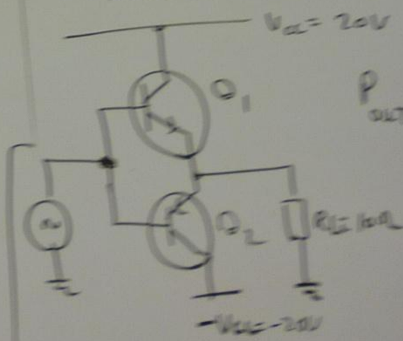
POWER OUTPUT EQUATION

$$P_{OUT} = \frac{(V_{O\text{-}RMS})^2}{R_{LOAD}}$$

$$P_{OUT} = \frac{\left(\frac{V_{O\,P\text{-}P}}{2\sqrt{2}}\right)^2}{R_{LOAD}}$$

$$P_{OUT} = \frac{(V_{O\,P\text{-}P})^2}{8\,R_{LOAD}}$$

P3 CALCULATE THE MAXIMUM OUTPUT POWER FOR THE GIVEN CIRCUIT



$$P_{OUT} = \frac{(V_{O\,P\text{-}P})^2}{8R_L} = \frac{(40)^2}{8 \times 10} = 20W$$

1.25 mW

6.25%

...UT POWER
...STRIAL SOUND
...CIENCY OF
...UTPUT POWER

$P_{IN} = \frac{50 \times 100}{20} = 250$ k...

$$I = \frac{P_{IN}}{V} = \frac{250\,kW}{240}$$

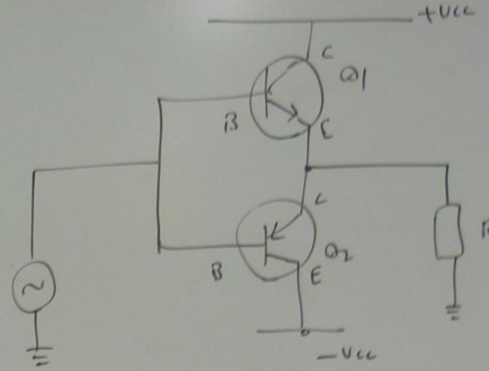
$$= \frac{250 \times 10^3}{240}$$

$$= 1041.67\ A$$

GENERAL FEATURES OF CLASS (B) AMPLIFIER

- MAXIMUM EFFICIENCY – 78.5%
- HIGH DISTORTION (COMPARED TO CLASS (A))
- LOWER POWER DISSIPATION BY THE OUTPUT DEVICES
- TWO OUTPUT DEVICES NEEDED
  BOTH CONDUCT FOR 180°.
- VOLTAGE GAIN (A_V) = UNITY
  POWER GAIN (A_P) = CURRENT GAINS OF TRANSISTOR

CLASS (B) POWER OUTPUT STAGE



- CLASS (B) AMPLIFIER REQUIRES A MINIMUM OF TWO OUTPUT DEVICES
- Q_1 CONDUCTS FOR THE POSITIVE HALF OF THE INPUT SIGNAL
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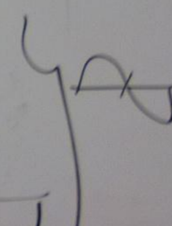
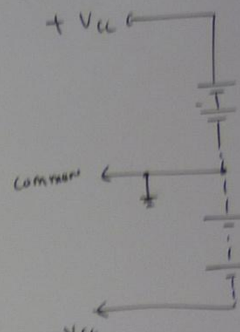
- THE OUTPUT SIGNAL IS PRODUCED BY BOTH TRANSISTORS.

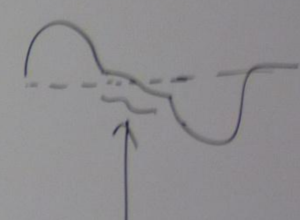
Q_1 CONDUCTS – Q_2 OFF

Q_1 OFF – Q_2 CONDUCT



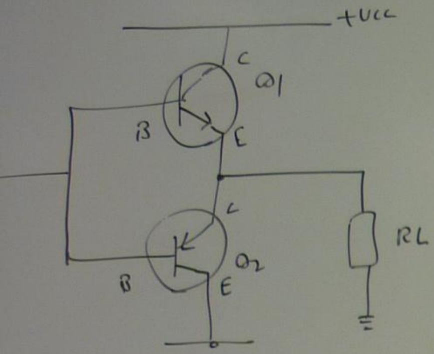
DUAL POLARITY POWER SUPP...





CROSS OVER DISTO...

…S (B) POWER OUTPUT STAGE

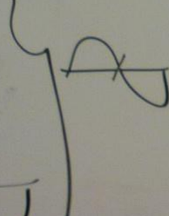


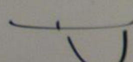
…B) AMPLIFIER REQUIRES A MINIMUM
… OUTPUT DEVICES
…UCTS FOR THE POSITIVE HALF OF
…NPUT SIGNAL
…NDUCTS FOR THE NEGATIVE HALF.

…TPUT SIGNAL IS PRODUCED BY
… TRANSISTORS.

… CONDUCTS - Q_2 OFF

… OFF - Q_2 CONDUCT





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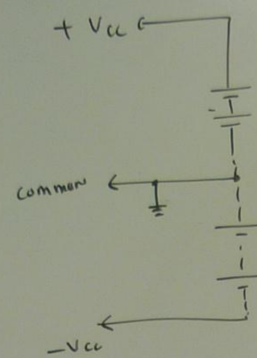

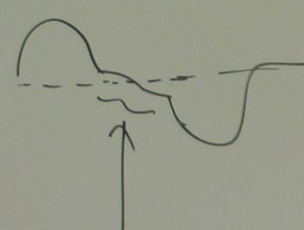

CROSS OVER DISTORTION

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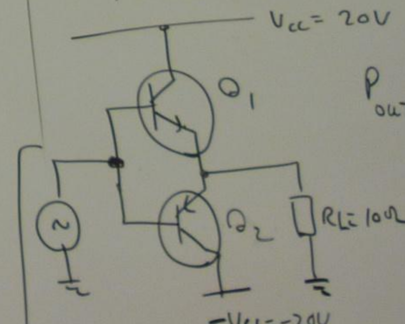
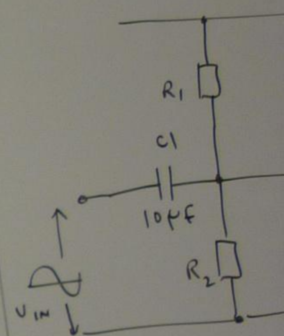
pb CALCULATE THE MAXIMUM OUTPUT POWER FOR THE GIVEN CIRCUIT



$$P_{OUT} = \frac{(V_{o\,p-p})^2}{8R_L} = \frac{(40)^2}{8\times10} = 20W$$

pb FOR THE GIVEN …
(a) STATE THE OPT…
(b) CALCULATE THE …
(c) CALCULATE TH…
(d) STATE THE …



$V_{c(RMS)} = V…$

$V_{c}(MAX) = \sqrt{…}$

$P_{OUT} = \frac{(V_o…}{…}$

$J_c = \frac{V_{CC} - …}{R…}$

...OWER OUTPUT EQUATION

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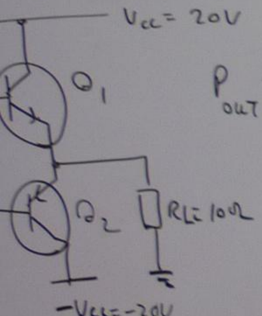
...ALCULATE THE MAXIMUM OUTPUT ...OWER FOR THE GIVEN CIRCUIT



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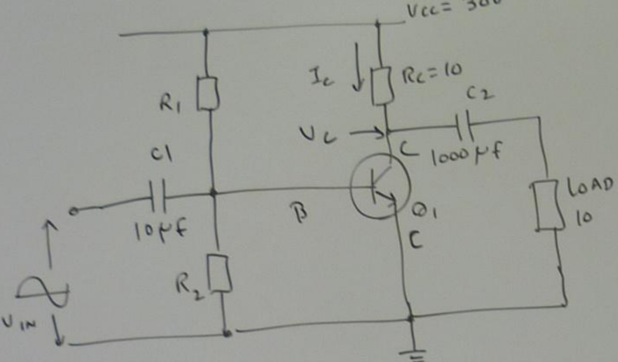
Q) FOR THE GIVEN CIRCUIT

(a) STATE THE OPTIMUM VALUE OF COLLECTOR VOLTAGE

(b) CALCULATE THE MAXIMUM OUTPUT POWER

(c) CALCULATE THE POWER BEING DISSIPATED BY Q_1 WHEN THE INPUT SIGNAL IS ZERO

(d) STATE THE MAXIMUM EFFICIENCY THE CIRCUIT CAN ACHIEVE.



$$U_{c(RMS)} = \frac{V_{CC}}{2} = \frac{30}{2} = 15V$$

$$U_{c(MAX)} = \sqrt{2}\,U_{C\,RMS} = \sqrt{2}\times 15 = 21.2V$$

$$P_{OUT} = \frac{(V_{o\,rms})^2}{R_{(LOAD)}} = \frac{15^2}{10} = 22.5W$$

$$I_C = \frac{V_{CC} - V_C}{R_C} = \frac{30-15}{10} = 1.5A$$

$$P_{IN} = V_{CC}\times I_C = 30\times 1.5 = 45W$$

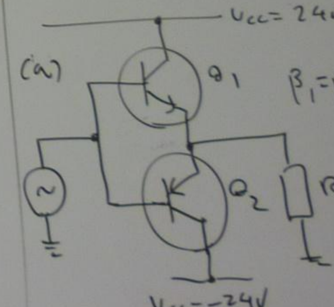
$$\%\eta = \frac{P_{OUT}}{P_{IN}}\times 100 = \frac{22.5}{45} = 50\%$$

Q) FOR THE GIVEN CIRCUIT, CALCULATE

(a) THE THEORETICAL MAXIMUM OUTPUT POWER

(b) THE POWER GAIN OF THE CIRCUIT.

(a)



$\beta_1 = \beta_2 = 80$

$$P_o = \frac{(V_{o\,p\text{-}p})^2}{8R_L} = \frac{(2\times 24)^2}{8\times 5.76} = 50W$$

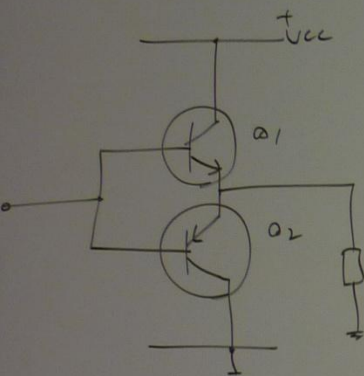
(b)

$A_p = \beta_1 = \beta_2$

$A_p = 80$

POWER OUTPUT STAGE (PART-2)

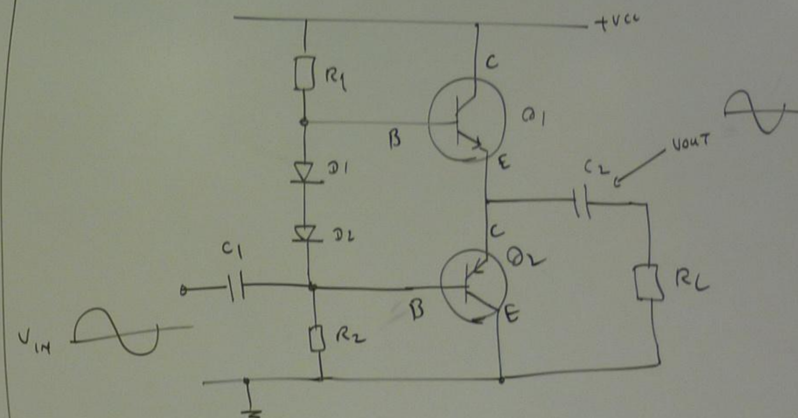
CLASS (AB) AMPLIFIER



TO ELIMINATE THE CROSS OVER DISTORTION, FORWARD BIAS OF 0.6V NEEDS TO BE APPLIED TO BOTH TRANSISTORS.

CLASS (B) + 0.6V FORWARD BIAS TO ELIMINATE CROSS OVER DISTORTION = CLASS AB AMPLIFIER

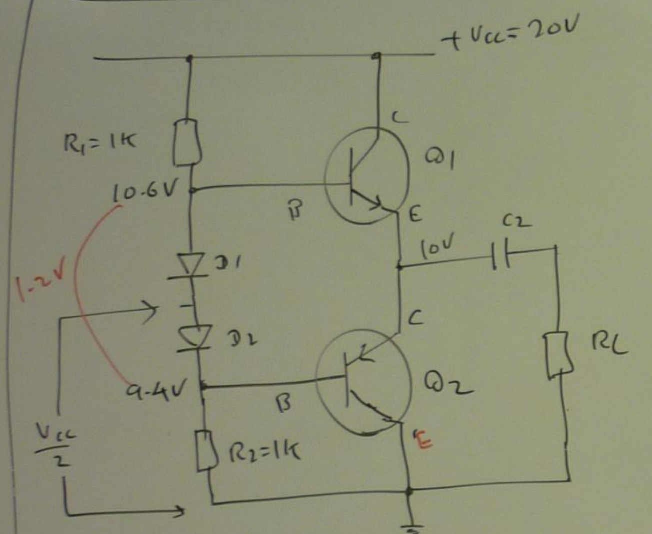
THE BASIC CLASS AB COMPLEMENTARY SYMMETRY AMPLIFIER



CHARACTERISTICS

- MAXIMUM EFFICIENCY = 78.5%.
- EACH TRANSISTOR CONDUCTS FOR EXACTLY 180° OF THE INPUT SIGNAL
- THE CROSS OVER DISTORTION IS ELIMINATED
- THE FORWARD BIAS FOR THE TRANSISTOR IS SUPPLIED BY THE INPUT SIGNAL

DC CONDITION



- R_1 MUST BE EQUAL TO R_2
- THE DIODES ARE USED TO ENSURE THAT THERE IS A DIFFERENCE OF 1.2V BETWEEN THE VOLTAGES AT THE BASES OF Q_1 AND Q_2
- BOTH TRANSISTOR HAVE A FORWARD BIAS OF 0.6V ACROSS THEIR BASE-EMITTER JUNCTION

LIMITATION

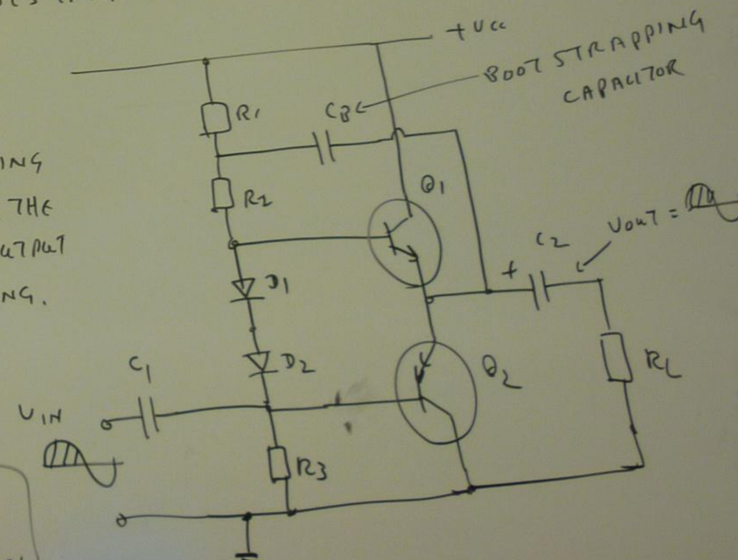
EMITTER VOLTAGE MUST ALWAYS BE LESS 0.6V THAN BASE VOLTAGE.

BOOT STRAPPING

SOME TIME, IT WILL NOT FULFILL $V_E - V_B = 0.6V$ WHEN THE SIGNAL SWING IS HIGHER. THE CROSS OVER DISTORTION CAN HAPPEN AGAIN.

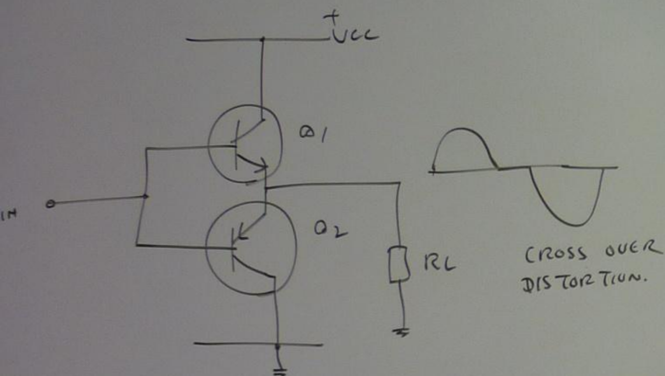
TO ELIMINATE THE CROSS OVER DISTORTION AT HIGH SIGNAL SWING, THE BOOTSTRAPPING CIRCUIT IS APPLIED.

APPLYING BOOTSTRAPPING TO OBTAIN THE GREATER OUTPUT SIGNAL SWING.



POWER OUTPUT STAGE (PART-2)

CLASS (AB) AMPLIFIER



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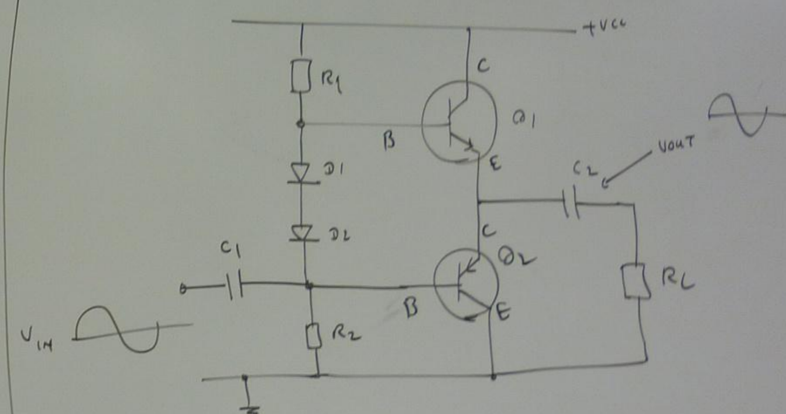
THE BASIC CLASS AB COMPLEMENTARY SYMMETRY AMPLIFIER



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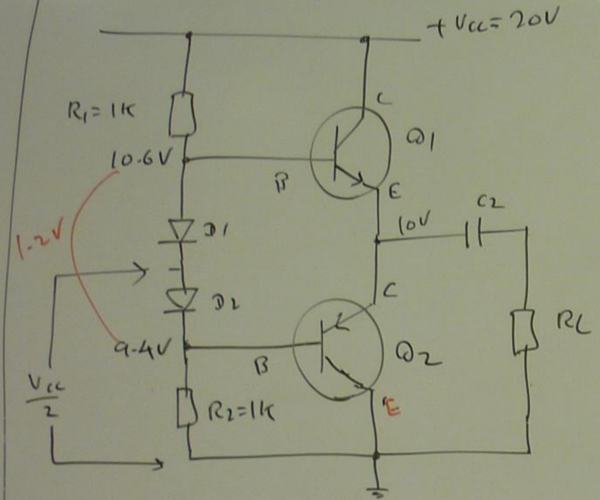
AMPLIFIER

DC CONDITION



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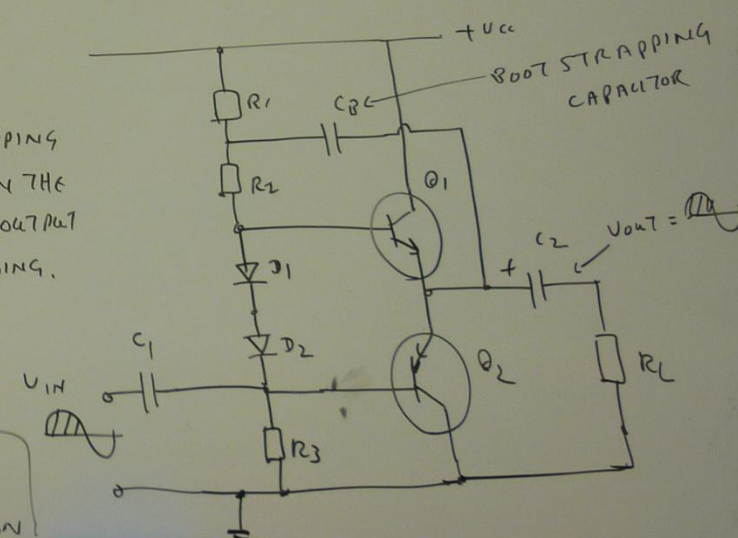
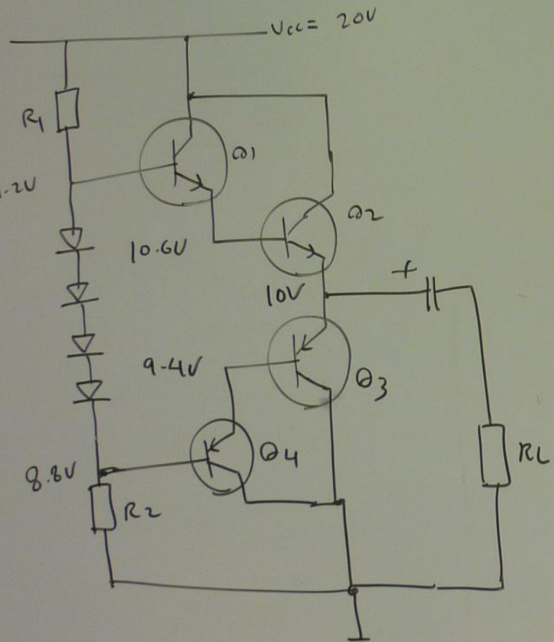


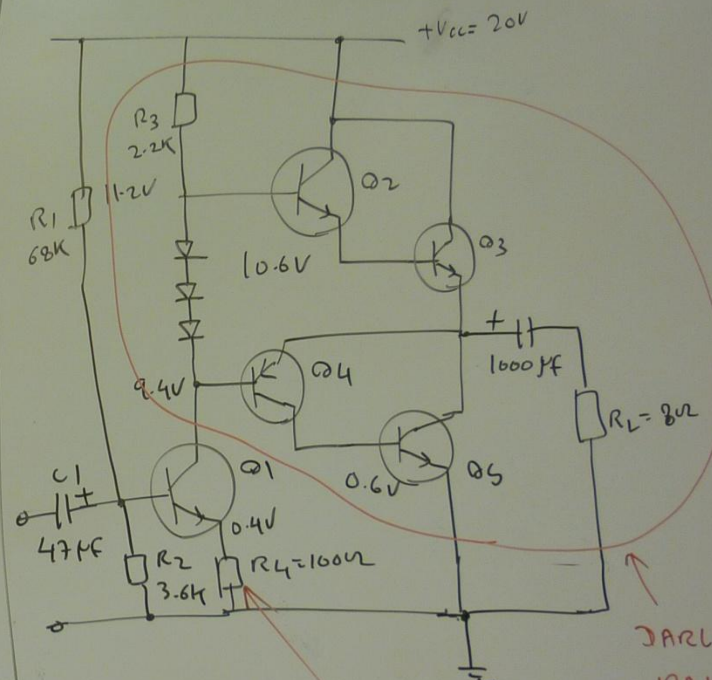
DARLINGTON OUTPUT TRANSISTORS

TO INCREASE THE CURRENT GAIN OF THE OUTPUT TRANSISTORS, IT IS COMMON TO USE THE DARLINGTON PAIRS.



DARLINGTON OUTPUT

QUASI COMPLEMENTARY AMPLIFIER



POWER AMPLIFIER WITH AMPLIFIER DRIVER STAGE

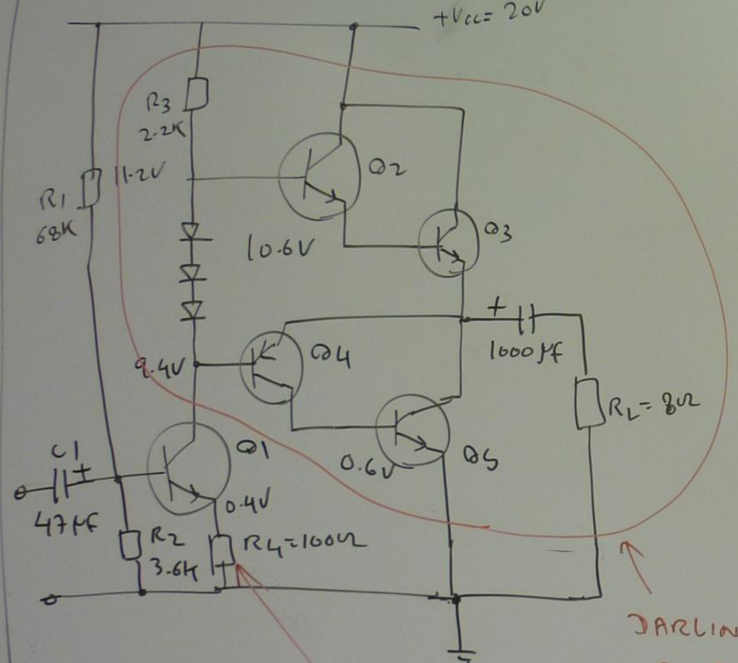
DRIVER STAGE

DARLINGTON PAIR (TO INCREASE CURRENT GAIN

POWER OUT P

NSISTORS,

QUASI COMPLEMENTARY AMPLIFIER



POWER AMPLIFIER WITH AMPLIFIER DRIVER STAGE

DRIVER STAGE

DARLINGTON PAIR (TO INCREASE CURRENT GAIN

POWER OUTPUT CALCULATION = $\dfrac{(V_o\ p\text{-}p)^2}{8R_L}$