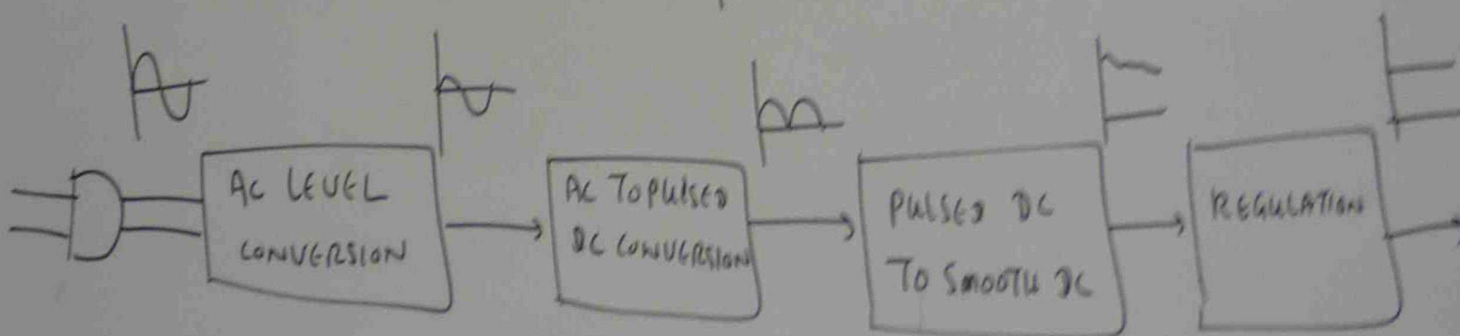
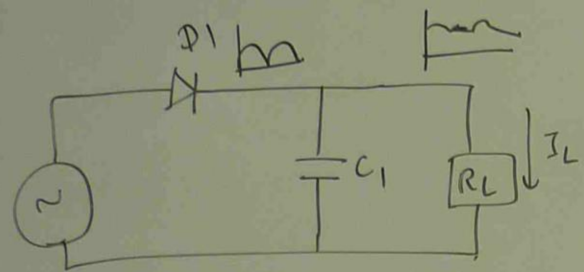
POWER SUPPLIES

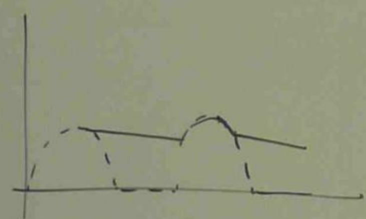
MOST ELECTRONIC EQUIPMENTS REQUIRES SOME FORM OF DC POWER TO OPERATE. IF THIS EQUIPMENT IS TO BE OPERATED FROM A STANDARD AC OUTLET, THEN A DC POWER SUPPLY IS NEEDED. A POWER SUPPLY TAKES ELECTRICAL POWER FROM A DISTRIBUTION SYSTEM AND CONVERTS IT TO THE DESIRED FORM OF POWER.



BLOCK DIAGRAM OF A REGULATED POWER SUPPLY

SINGLE PHASE HALF WAVE RECTIFIER



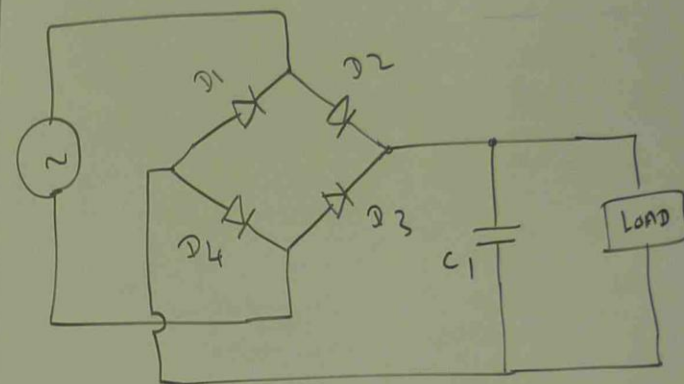


C_1 - FILTER CAPACITOR

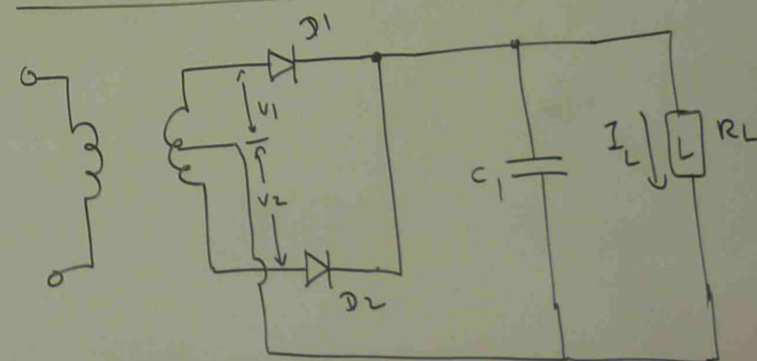
HALF WAVE RECTIFIER WITH FILTER CAPACITOR.

FULL WAVE RECTIFIER

THE BRIDGE RECTIFIER



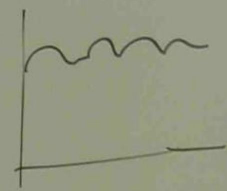
THE CENTRE-TAPPED FULL WAVE RECTIFIER



CENTRE TAPPED TRANSFORMER, FULL WAVE RECTIFIER

CALCULATING THE SIZE OF FILTER CAPACITOR

$$\boxed{V_{dc} = V_r f_r R_L C}$$



V_{dc} = DC OUTPUT VOLTAGE

V_r - P-P RIPPLE VOLTAGE

f_r - RIPPLE FREQUENCY

C - CAPACITANCE

R_L - LOAD SEEN BY CAPACITOR.

Pb CALCULATE THE LOAD RESISTANCE AND CAPACITOR SIZE OF A FULL WAVE RECTIFIER THAT SUPPLIES 40V DC WITH 2% RIPPLE VOLTAGE AT 250mA TO A RESISTIVE LOAD. ASSUME THE RECTIFIER CIRCUIT IS SUPPLIED WITH 50HZ AC.
(RIPPLE FREQ = 100HZ)

$$R_L = \frac{V_L}{I} = \frac{40}{250 \times 10^{-3}} = 160\Omega$$

$$V_r = 40 \times \frac{2}{100} = 0.8V$$

$$V_{dc} = V_r f_r R_L C$$

$$40 = 0.8 \times 100 \times 160 \times C$$

$$C = \frac{40}{0.8 \times 100 \times 160}$$

$$C = 3125 \mu f$$

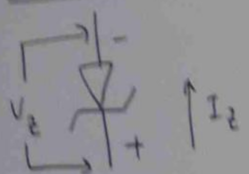
POWER SUPPLIES - PART (2)

VOLTAGE REGULATION

THE PURPOSE OF VOLTAGE REGULATION IS TO MAINTAIN A CONSTANT VOLTAGE ACROSS A LOAD REGARDLESS OF ANY CHANGE IN LOAD CONDITION (OR) SUPPLY VOLTAGE.

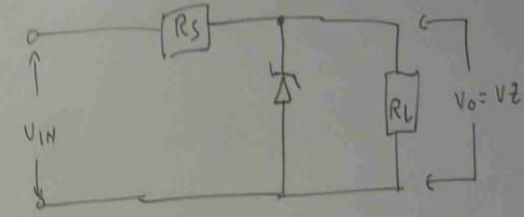
THE MAIN TYPES OF REGULATION ARE SERIES, SHUNT AND SWITCHING.

ZENER DIODE - VOLTAGE REFERENCE DIODE.



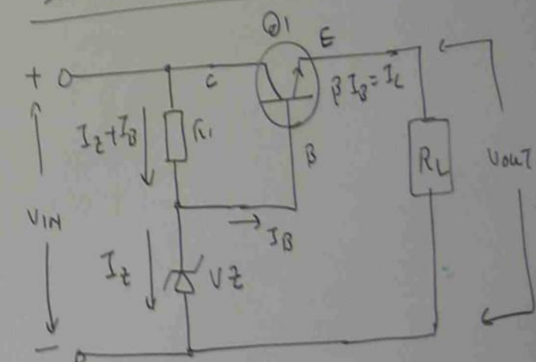
THE OUTPUT VOLTAGE ACROSS THE LOAD R_L EQUALS THE ZENER VOLTAGE V_Z.

THE OUTPUT VOLTAGE IS KEPT CONSTANT DESPITE CHANGES IN V_{IN} AND I_L.



BASIC SERIES ZENER REGULATOR

SERIES TRANSISTOR REGULATOR



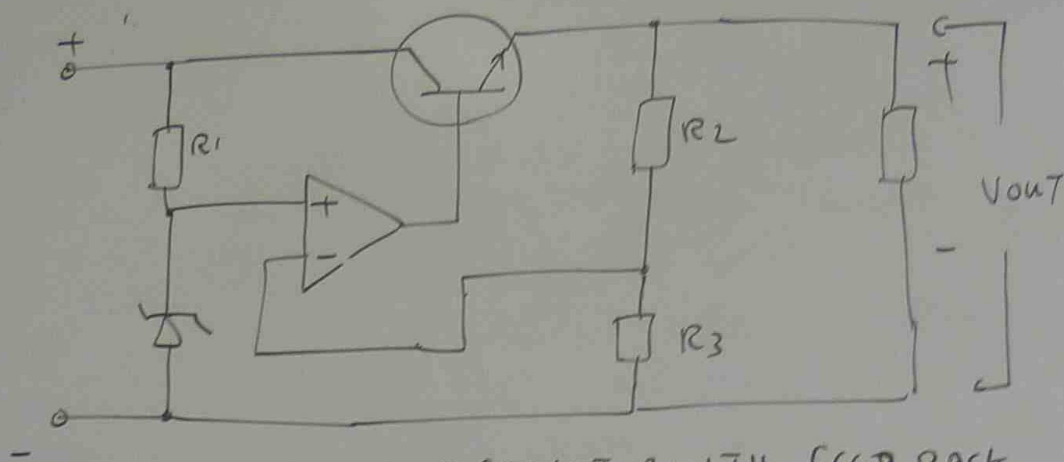
$V_{OUT} = V_Z - 0.6V$

V_{BE}

$V_{BE} = 0.6V$ SILICON TRANSISTOR

$V_{BE} = 0.2V$ - GERMANIUM TRANSISTOR

REGULATORS WITH FEEDBACK



SERIES REGULATOR WITH FEEDBACK

$$V_{OUT} = \left(\frac{R_2}{R_3} + 1 \right) \times V_{REF}$$

WHERE $V_{REF} = V_Z$

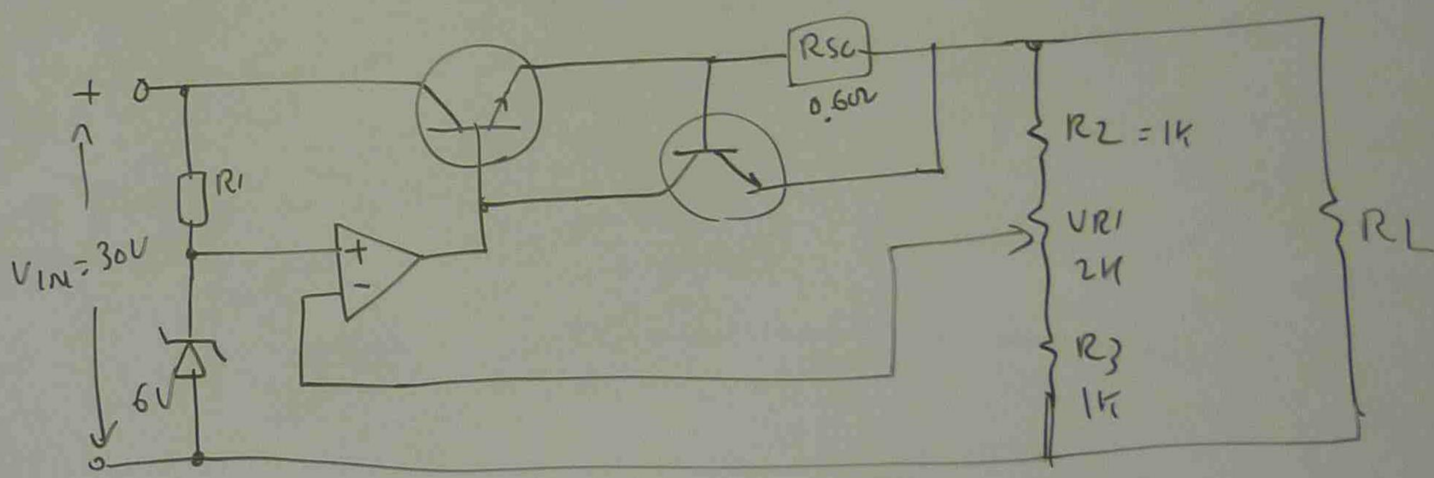
$$P_d = \text{DISSIPATED POWER} = \left(V_{IN} - V_{OUT} \right) \times I_L$$

pb/ FOR THE CIRCUIT IN FIGURE, CALCULATE

(a) THE MAXIMUM AND MINIMUM OUTPUT VOLTAGES

(b) THE CURRENT THAT WILL FLOW IF OUTPUT IS SHORT CIRCUITED.

(c) THE POWER DISSIPATED BY Q1 IF THE OUTPUT IS SHORT CIRCUITED



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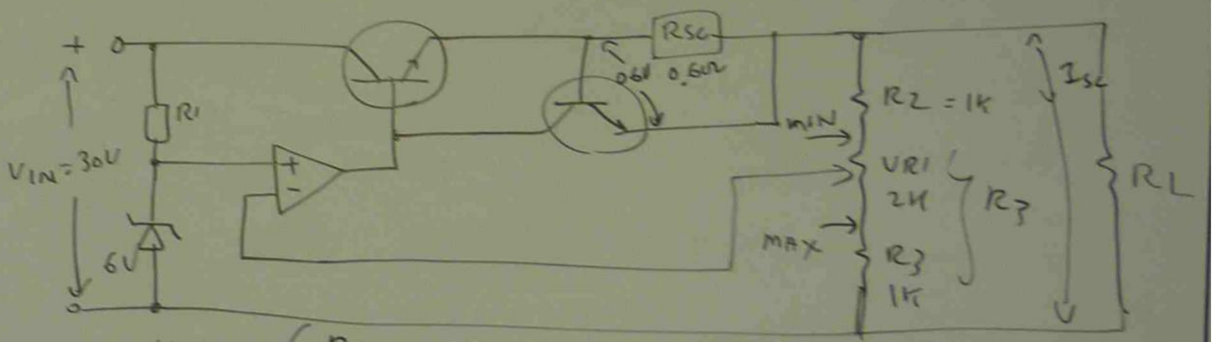


(a) $V_{OUT} = \left(\frac{R_2}{R_3} + 1\right) V_{REF}$

$V_{OUT} = \left(\frac{1}{3} + 1\right) \times 6 = (1.33) \times 6 = 8V$

$V_{OUT} = \left(\frac{3}{1} + 1\right) \times 6 = 4 \times 6 = 24V$

(b) $I_{SC} = \frac{0.6}{R_{SC}} = \frac{0.6}{0.6\Omega} = 1A$

(c) $P_d = (V_{IN} - V_{OUT}) \times I_L$
$= (30 - 0) \times 1 = 30W$

TRANSISTOR CONNECTIONS

The TO-92 dilemma

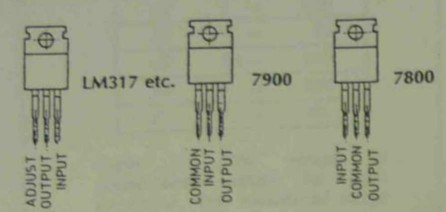
The TO-92 package is very common, but has at least six variations on the lead connections and has numerous lead forms. Transistor data books vary in their method of referring to the particular variation of the package, and some data books even leave out the variation altogether, and just state that the transistor is in a TO-92 package. A little like giving your address as 'Australia'.

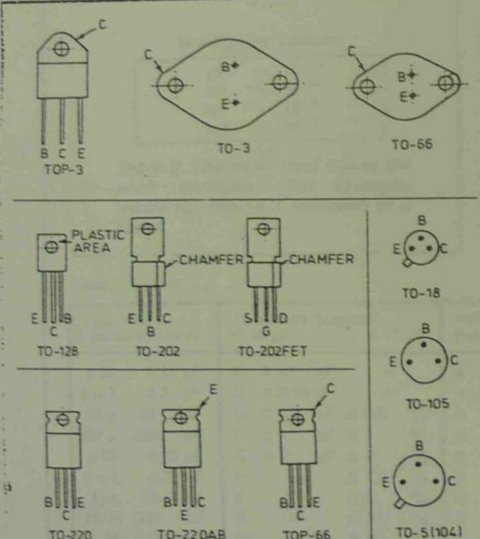
The package is used for transistors, FETs, SCRs and other devices including regulator ICs, PUTs, UJTs etc. Each pinout variation is usually shown with the terminals marked for both transistors and FETs, although not all variations have pinouts for both devices.

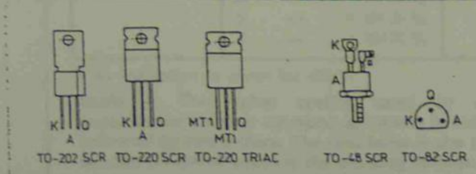
One variation is known as the standard, but it is not the most common variation. Some transistors come in two variations – for example, the BC182B has a totally different lead configuration to the BC182L, even though both are in a TO-92 package. We have even found variations referred to in data manuals that don't exist, that is, no drawing showing the lead connections could be found in the manual.

Obviously there is a slight(?) possibility of confusion – perhaps our summary below will help. Each variation that we could find is shown in two ways; as viewed from the bottom and as seen when mounted on a PCB. Next to each drawing is a listing of some transistor types that apply to that variation. We have not included FET example types, although the FET pinouts are included where applicable.

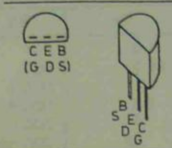
Voltage regulators



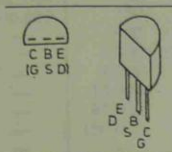




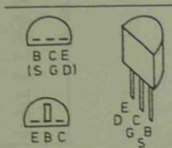
TO-92



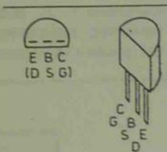
Variation 1
Also called variation 71, 96 etc.
Includes the following transistor types:
MPS6542, '6543, '6546, '6547.
MPSH10, '11, '19, '20, '24, '30.
PE3100, BF233.



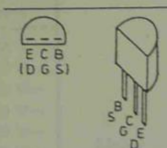
Variation 2
Also called variation 72, 92 etc.
Known as the 'standard'.
2N3641, '3642, '3643, '3903, '3904.
2N3905, '3906, '4400, '4403, '5401.
BC170, '171, '172, '173, '174, '317.



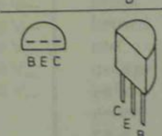
Variation 3
Also called variation 74, 94 etc.
TIPP31, '32, '11O, 117.
BC182L, '183L, '213L, '214L, '257.
BC258, '259, '635, '636, '639, '640.
2N3702, '2926.



Variation 4
Also called variation 77, 97 etc.
The most common type.
BC237B, '307B, '327, '328, '337.
BC338, '415, '485, '546, '547.
BC548, '549, '556, '557, '558.
BC559, '560. BF936, '324.

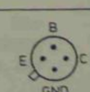


Variation 5
Also called variation 76.
2SC710. Mainly used for FETs.

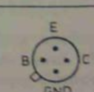


Variation 6
Also called variation 98.
BF194, '195, '196, '197, '198, '199.
BF237, '238, '240, '241, '254, '255.
BF450, '451.

TO-72



BF180
BF200



BF115
BF167
BF173
BF184
BF185

CAPACITOR CODES

This reference sheet is intended to help readers who have problems converting between multipliers for capacitors. It includes the standard we use in the magazine, (conforms to metric standard, by the way), and shows when to use the nanofarad or the millifarad instead of the venerable microfarad.

Although a very difficult area to summarise, due to the number of standards being used, the data sheet also includes information on how to interpret manufacturer's capacitor value codes. The standard used by Philips is reproduced below.

The multiplier

Table 1 shows the range of capacitance values that apply to each multiplier. For example, the value of 1nF is OK, but 100nF is outside the range – instead use the next multiplier and express the value as 0.1uF. Table 2 simply shows the actual value the multiplier represents. For example, the millifarad (mF) is one thousandth of a farad (F).

Table 3 is a conversion table between all the multipliers. For example, a 2.2nF capacitor could also be a 2200pF capacitor or a 0.0022uF capacitor.

Value codes

Capacitor value coding varies, and we include that used by Philips as a guide. Note the use of the multiplier in place of the decimal point. For example, 8.2pF would be written as 8p2.

Another way of expressing a value of a capacitor is to print the first two digits followed by a multiplier digit. This way, 47nF would be expressed as 473, perhaps followed with a letter representing tolerance. To convert the number to a value, write the first two digits, followed by the number of zeros expressed by the third digit. The value obtained is in pF, which can then be converted to nF or uF using Table 3.

Multiplier ranges

pF	1 →	820
nF	1 →	82
uF	0.1→	820
mF	1 →	820
F	1 →	inf.

Table 1. The range of capacitance values for each multiplier. The nanofarad range has the least number of values.

Multiplier values

pF	=	10^{-12}
nF	=	10^{-9}
uF	=	10^{-6}
mF	=	10^{-3}

Table 2. The numerical values for each multiplier. For example, micro (u) means 1 millionth of a farad.

10^{-12} 10^{-9} **Conversions** 10^{-3}

pF	nF	10^{-6} uF	mF	F
100	0.1	0.0001	—	—
820	0.82	0.00082	—	—
1,000	1	0.001	—	—
8,200	8.2	0.0082	—	—
10,000	10	0.01	—	—
82,000	82	0.082	—	—
100,000	100	0.1	0.0001	—
—	820	0.82	0.00082	—
—	1,000	1	0.001	—
—	8,200	8.2	0.0082	—
—	10,000	10	0.01	—
—	82,000	82	0.082	—
—	100,000	100	0.1	0.0001
—	—	820	0.82	0.00082
—	—	1,000	1	0.001
—	—	8,200	8.2	0.0082
—	—	10,000	10	0.01
—	—	82,000	82	0.082
—	—	100,000	100	0.01
—	—	—	820	0.82
—	—	—	1000	1

Table 3. Conversion reference table. This table should allow conversion between multipliers for most given capacitor values. Numerical values for each decade are from 1 to 8.2.

757,1N960				
738,1N961	1N4740	10	14	25

DC Power Dissipation: 400milliwatts @ 50°C Ambient (Derate 3.2mW/°C above 50°C)

1N973

▼DC Power Dissipation: 1Watt @ 50°C Ambient) (Derate 6.67mW/°C above 50°C)

This range will dissipate up to 3W @ 75°C with 10mm lead length as heatsink.

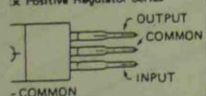
3.0 4.0 5.0 6.0 7.0 8.0 9.0 10 11 12

V_Z, ZENER VOLTAGE @ I_{ZT} (VOLTS)

ree Terminal Regulators

•	Polarity	Case	V_{OUT} min typ max	I_{OUT} (nom)	Dropout Voltage
05	positive	TO-92	4.8 5 5.2	100mA	1.7
62	positive	TO-92	5.95 6.2 6.45	100mA	1.7
09	positive	TO-92	8.64 9 9.36	100mA	1.7
12	positive	TO-92	11.5 12 12.5	100mA	1.7
15	positive	TO-92	14.4 15 15.6	100mA	1.7
5	positive	TO-220	4.8 5 5.2	1A	2
5	positive	TO-220	5.75 6.0 6.25	1A	2
9	positive	TO-220	8.64 9 9.36	1A	2
2	positive	TO-220	11.5 12 12.5	1A	2
5	positive	TO-220	14.4 15 15.6	1A	2
4	positive	TO-220	23 25 25	1A	2
5	negative	TO-220	-4.8 -5 -5.2	1A	1.1
2	negative	TO-220	-11.5 -12 -12.5	1A	1.1
5	negative	TO-220	-14.4 -15 -15.6	1A	1.1
17K	positive	TO-3	adj. 1.2 to 37	1.5Amin	
17T	positive	TO-220	adj. 1.2 to 37	1.5Amin	
50K	positive	TO-3	adj. 1.2 to 33	3A	
50T	positive	TO-220	adj. 1.2 to 33	3A	
05	positive	TO-3	4.85 5 5.25	5A	2.5

nections TO-220 Package
x Positive Regulator Series

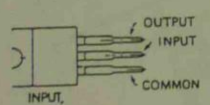


Top View

Connections TO-3 Package
78H05 Positive Regulator

Bottom View

nections TO-220 Package
x Negative Regulator Series

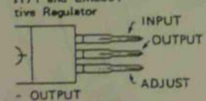


Top View

Connection TO-3 Package
LM317K and LM350K
Positive Regulator

Bottom View

nections TO-220 Package
317T and LM350T
tive Regulator



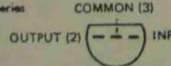
Top View

Note:
Maximum power dissipation for:

TO-220 pack
LM317T 15W
LM350T 25W

TO-3 pack
LM317K 20W
LM350K 30W

nection TO-92 Package
xx Positive Regulator Series



Bottom View

imum Power
ipation for
92 Pack 0.75W

336 Reference Diodes

)	LM336-2.5	LM336-5.0
Fwd Current (mA)	10	10
mmed Ref Voltage	2.44-2.54	4.9-5.1
amic Impedance		

Voltage Regulators

These voltage regulators almost make power supply building unnecessary since they require only a filtered DC voltage input, they are essentially indestructible (if used within manufacturer's specs.) because of internal current limiting and thermal shutdown should a short occur. They are ideally suited to local, on board regulation simplifying power supply distribution systems. Excellent for TTL and project supplies. With the advent of microprocessors and microcomputers, these regulators have been used extensively in power supplies for such systems. This type of use typifies their versatility and reliability. Another area of supply regulation use is with analogue operational amplifiers. These circuits usually call for both + and - complementary rail voltages. These three terminal devices ideally suit such requirements.

The addition of protection diodes, as shown in the 317/350 application circuit, is recommended if there is any possibility of the regulator input or output being shorted to ground. These may also be necessary if significant (>1uF) capacitance is connected between ground and either the common or output terminals of the regulator.

Increase the Output Voltage of a 3 Terminal Voltage Regulator

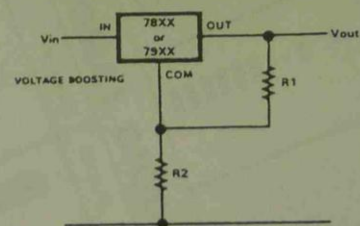
Regulators like the 7805 and the 7905 can give higher output if two additional resistors are configured into the circuit as shown below.

$R1 = V_R/0.02$ $R2 = V_B/0.025$

Where V_R is the normal regulated voltage from the IC and V_B is the amount by which the regulator has to be boosted above V_R.
Some examples are given below:

V_{out}	Regulator	R1	R2
6	5V	220	39
9	5V	220	150
13.8	12V	560	68
18	15V	680	120

To make a variable regulator, use a potentiometer as R2.

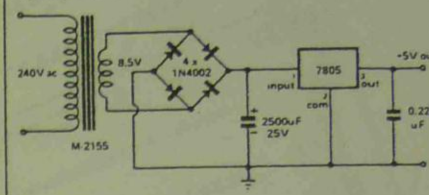


Increasing the Output Current of the Regulator

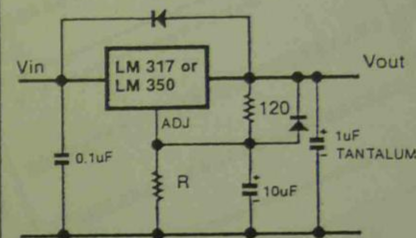
By adding a PNP power transistor to a positive regulator, the output current can be increased above the normal rating of the regulator itself. The circuit shown below can be expected to deliver in excess of 4A with the pass transistor mounted on a heatsink. The same conditions can also be implemented with a negative regulator, the difference being the polarities of components, the pass transistor in this case would be an NPN type such as a 2N3055.

Typical Power Supply Using a 3 Terminal Regulator

Output: 5V @ 1A
The same basic circuit can be used with other regulators of different voltages, only the input ac voltage has to be changed to accommodate the the requirement of that regulator. eg. If an output of 12V was the requirement, a 7812 IC could be used with an ac input voltage of 15V.



LM317 or LM350 Series



1. Choose Resistor R as follows:
   R=(96xVout)-120
   Where R is in ohms and Vout is in volts
2. Vin should be at least 2.5 volts greater than Vout.
3. Capacitor voltage ratings must be chosen appropriately.
4. The protection diodes shown will be necessary if the input or output of the regulator is shorted to ground. 1 amp types should be adequate.

LM334 Adjustable Current Source

Operating Voltage	1-30
Max Power Dissipation	200mW
Voltage Sensitivity	0.1%/V
Temperature Sensitivity	+0.33%/°C

I=68mV/Rset

FETS

FETS	Case	BVGSS V @	IG(uA)	VGS(OFF) Min	Max	@ VDS	ID(nA)	IDss(mA) Min	Max	@ VDS	VGS	Yfs(umhos) Min	Max	@ VDS	Ptot mW	Use/Comments
BF245B	TO-92 Var 1	60	1	0.5	8	15	10	6	15	15	0	3000	6500	15	300	N/CH Junction Audio to H.F.
BF981	SOT-103	>6		2.5		10	20uA	4	25	10	0	14000	typ		225	N/CH Dual Gate MOS. VHF Amp
BFW10	TO-72(25)	30						8	20	15	0		6500		300	N/CH Junction Audio to H.F.
BFW11	TO-72(25)	30						4	10	15	0		6500		300	N/CH Junction Audio to H.F.
BFW61	TO-72(25)	25						2	20	15	0		6500		300	N/CH Junction Audio to H.F.
MEM631	W-25	± 6	± 10		4	15	200uA	5	30	15	0	1600	typ	15	500	N/CH Dual Gate MOS. VHF Amp
MFE131	TO-72(2)	± 6	± 10		4	15	200uA		30	15	0	8000	20000	15	300	N/CH Dual Gate MOS. VHF Amp
MPF102	TO-92(72)	25	10	0.5	8	15	2	2	20	15	0	2000	7500	15	310	N/CH Junction — VHF
MPF103	TO-92(72)	25	1		6	15	1	1	5	15	0	1000	5000	15	310	N/CH Junction — Audio Sw.
MPF104	TO-92(72)	25	1		7	15	1	2	9	15	0	1500	5500	15	310	N/CH Junction — Audio Sw.
MPF105	TO-92(72)	25	1		8	15	10	4	16	15	0	2000	6000	15	310	N/CH Junction — Audio Sw.
MPF106	TO-92(72)	25	1	0.5	4	15	10	4	10	15	0	2500	7000	15	310	N/CH Junction — RF
MPF121	206(B)	± 6	± 10		4	15	200uA	5	30	15	0	10000	20000	15	500	N/CH Dual Gate MOS. VHF Amp
MPF131	262	± 6	± 10		4	15	200uA	3	30	15	0	8000	20000	15	350	N/CH Dual Gate MOS. VHF Amp
2N4342	TO-92(72)	25	10		5	10		12	30	10	0		6000	10	180	P/CH Junction — Audio Sw.
2N4360	TO-92(72)	40	10	0.5	6	15	100	1	5	15	0	1000	5000	15	310	P/CH Junction — Audio Sw.
2N5245	TO-92/77	30	1	1.5	6	10		1	18		0		5800	typ 10	360	N/CH VHF/UHF Mixer
2N5457	TO-92(72)	25	1	0.5	6	15	10	1	5	15	0	1000	5000	15	310	N/CH Junction — Audio Sw.
2N5458	TO-92(72)	25	1	1	7	15	10	2	6	15	0	1500	5500	15	310	N/CH Junction — Audio Sw.
2N5459	TO-92(72)	25	1	2	8	15	10	4	9	15	0	2000	6000	15	310	N/CH Junction — Audio Sw.
2N5484	TO-92(72)	25	1	0.3	3	15	10	1	5	15	0	3000	6000	15	310	N/CH Junction — VHF
2N5485	TO-92(72)	25	1	0.5	4	15	10	4	10	15	0	3500	7000	15	310	N/CH Junction — VHF
2N5486	TO-92(72)	25	1	2	6	15	10	8	20	15	0	4000	8000	15	310	N/CH Junction — VHF
3SK40	TO-72(2)	± 6	± 10		4	15	200uA		25	15	0	8000		15	250	N/CH Dual Gate MOS. VHF Amp
3SK121	2-6F1A	-5		-2.5	4	5	100uA	20	45	5	0	17000	typ	typ 10	200	N/CH UHF GaAs Dual Gate
40673	TO-72(2)	± 6	± 10	-2	typ	15	200uA		35	15	0	12000		15	330	N/CH Dual Gate MOS. VHF Amp

POWER FETS

TYPE	CASE	Ptot (W)	Vds(max) (V)	Id(max) (A)	Vgs(off) min	max	Gfs umhos	Ciss (pF)	Rds (ohms)	Comment
BUZ71	TO220	40	50	14	-	-	-	-	0.1	Nch Power MOSFET
VN10K	TO92	1	60	1	.3	1.5	100K	48	5	Nch DMOS FET
VN46AF	TO202F	12.5	40	2	.8	2			-	Nch VMOS FET
VN66AF	TO202F	12.5	60	2	.8	2	150K	50	-	Nch VMOS FET
VN86AF	TO202F	12.5	80	2	.8	2	-	-	-	Nch VMOS FET
VN88AF	TO202F	12.5	80	2	.8	2	-	-	-	Nch VMOS FET
2SJ48	TO3	100	120	7	.15	1.45	1M	900	-	Pch Power MOSFET
2SJ49	TO3	100	140	7	.15	1.45	1M	900	-	Pch Power MOSFET
2SJ50	TO3	100	160	7	.15	1.45	1M	900	-	Pch Power MOSFET
2SK133	TO3	100	120	7	.15	1.45	1M	600	-	Nch Power MOSFET
2SK134	TO3	100	140	7	.15	1.45	1M	600	-	Nch Power MOSFET
2SK135	TO3	100	160	7	.15	1.45	1M	600	-	Nch Power MOSFET

SMALL SIGNAL DIODES

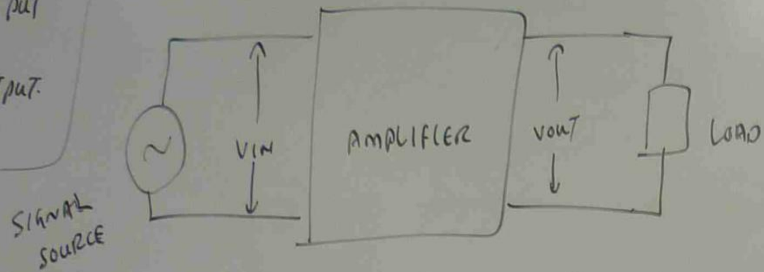
TYPE	CASE	VR	IF (mA)	Cd (pF)	VF @	IF (mA)	IR (uA)	@ VR	Trr (nS)	Use/Comparable Types
Germanium										
AA119	DO-7	30	100	1.2	2.2	10	150	30		AM/FM Detection Point Contact
OA47	DO-7	25	110	3.5	0.45	10	100	25	70	Gold Bonded G.P. Switching
OA90	DO-7	20	45		1.5	10	450	20		G.P. Point Contact OA70, OA80
OA91	DO-7	90	50		1.9	10	180	75		G.P. Point Contact OA71, 79, 81
DSOA91	DO-7	50	30	1	1	5	200	10		G.P. OA91, 1N60
OA95	DO-7	90	50		1.5	10	110	0.75		G.P. Point Contact
Silicon										
BA100	DO-7	60	90	25	0.96	10	10	60		G.P. — Alloyed
BA102	DO-7	20		20-45	Cd Ratio 1.4 @	4/10 V/VV				Variable Capacitance
BA114	DO-7		20		0.7	1				Bias Stabilizer
BA234/4	DO-35	20	100	<2	1	100	0.1	15		UHF Sw.
BAW62	SOD-27	75	200	2	0.75	5	5	75	4	High Speed Silicon Sw.
BB119	DO-35	15		20-25 @ 4V	Cd Ratio >>1.3					Varicap — replaces BA102
BB122	DO-35	30		12 @ 3V	Cd Ratio 5.2		0.05	28		Varicap VHF UHF
BB212	TO-92	12		500-620 @ 0.5V	Cd Ratio > 22.5		0.05	10		AM Dual Varicap
OA200	DO-7	50	160	25	0.96	10	0.1	50		Small Signal — Alloyed
OA202	DO-7	150	160	25	0.96	10	0.1	150		Small Signal — Alloyed
1N914A	DO-35	75	75	4	1	10	5	75	4	Small Signal Sw. 1N4148
1N4148	DO-35	75	200	4	1	10	0.025	20	4	Small Signal Sw. 1N914A
1N4448	DO-35	75	300	4	1	100	0.025	6	4	G.P. Silicon Sw. 1N4148
5082-2800	DO-7	70	15	2	0.41	1	0.2	50	0.1	Schottky (Hot Carrier) UHF Detector, Mixer Switch

RECTIFIERS

TYPE	MAT	VR	IF(A)	VF @	IF(A)	IR(uA) @	VR	USE
BYX21/200/R	S	75	25	1.2	25	1.1mA	75	Automobile H. Duty Press fit.
BYX98/300	S	300	10	1.4	10	200	300	Power Rectifier Stud Mount
DS5404	S	200	3	1.1	3	5	200	G.P. Rectifier
EM4005	S	50	1	1.1	1	5	50	G.P. Rectifier
EM401	S	100	1	1.1	1	5	100	G.P. Rectifier
EM404	S	400	1	1.1	1	5	400	G.P. Rectifier
EM410	S	1000	1	1.1	1	5	1000	G.P. Rectifier
MR110	S	100	10					G.P. Stud Mount
MR410	S	400	10					G.P. Stud Mount
MR5108	S	1000	3	1.1	3	5	1000	G.P. Rectifier
IN3492/R	S	100	25	1.7	18	1mA	100	Heavy Duty Automobile Press fit.
IN3493/R	S	200	25	1.7	18	1mA	200	Heavy Duty Automobile Press fit.
IN4001	S	50	1	1.1	1	5	50	G.P. Rectifier.
IN4002	S	100	1	1.1	1	5	100	G.P. Rectifier.
IN4004	S	400	1	1.1	1	5	400	G.P. Rectifier.
IN4007	S	1000	1	1.1	1	0.2	1000	G.P. Rectifier.
BY229-400	S	400	7	1.85	20	5	400	SMPS trr=450nS
1N4936	S	400	1	1	1			SMPS trr=200nS
IN5059(A14B)	S	200	2.5	1.25	2.5	0.2	200	Transient Protected (Controlled Avalanche).
IN5060(A14D)	S	400	2.5	1.25	2.5	0.2	400	Transient Protected (Controlled Avalanche).
IN5061(A14M)	S	600	2.5	1.25	2.5	0.2	600	Transient Protected (Controlled Avalanche).
IN5062(A14N)	S	800	2.5	1.25	2.5	0.5	800	Transient Protected (Controlled Avalanche).
IN5404	S	400	3	1.1	3	5	400	G.P. Rectifier.
IN5408	S	1000	3	1.1	3	5	1000	G.P. Rectifier.
IN5624	S	200	5	1.1	5	5	200	Transient Protected (Controlled Avalanche).

IN PUT

OUTPUT



INPUT AND OUTPUT CONNECTION TO AMPLIFIER.

GAIN

AN AMPLIFIER CAN PRODUCE A GAIN IN THE SIGNAL VOLTAGE, CURRENT AND POWER

$$\boxed{A_V = \frac{V_{OUT}}{V_{IN}}}$$

A_V = VOLTAGE GAIN

V_{IN} = INPUT VOLTAGE

V_{OUT} = OUTPUT VOLTAGE

$$A_I = \frac{I_{OUT}}{I_{IN}}$$

$$A_P = \frac{P_{OUT}}{P_{IN}}$$

GAIN IN d.B (DECIBEL) UNIT

POWER GAIN IN dB

$$dB = 10 \log \frac{P_{OUT}}{P_{IN}}$$

VOLTAGE GAIN IN dB

$$dB = 20 \log \frac{V_{OUT}}{V_{IN}}$$

CURRENT GAIN IN dB

$$dB = 20 \log \frac{I_{OUT}}{I_{IN}}$$

Pb AN AMPLIFIER DEVELOPS 10W FOR AN INPUT POWER OF 1mW
CALCULATE THE POWER GAIN OF AMPLIFIER IN dB.

$$dB = 10 \log \frac{P_{OUT}}{P_{IN}} = 10 \log \frac{10}{1 \times 10^{-3}} = 10 \log 10 \times 10^{3}$$

$$= 10 \log 10^{4} = 10 \times 4 \log 10 = 40 \ dB$$

Pb AN AMPLIFIER FED WITH 50 mV SIGNAL PRODUCES A 2V
OUTPUT. CALCULATHE THE GAIN.

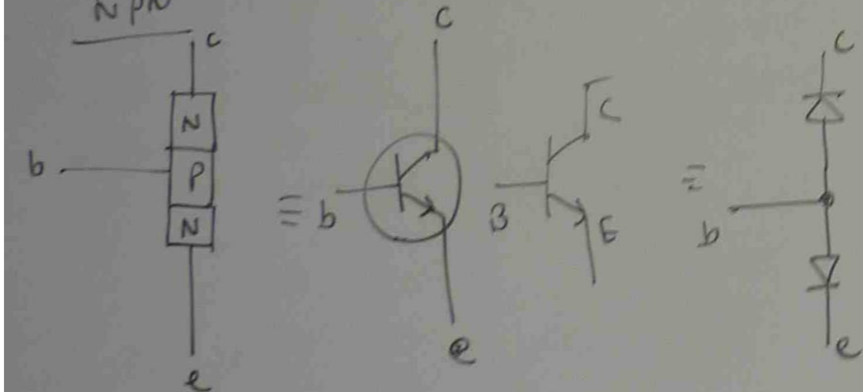
$$A_v = \frac{V_{OUT}}{V_{IN}} = \frac{2}{50 \times 10^{-3}} = \frac{2000}{50} = 40$$

BIPOLAR JUNCTION TRANSISTORS

BJT- BIPLOR JUNCTION TRANSISTOR

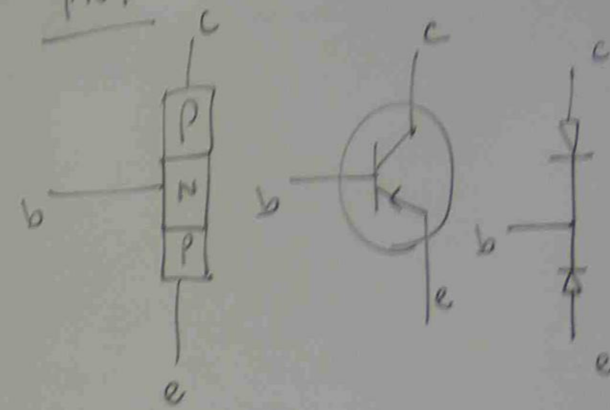
NPN PNP

NPN

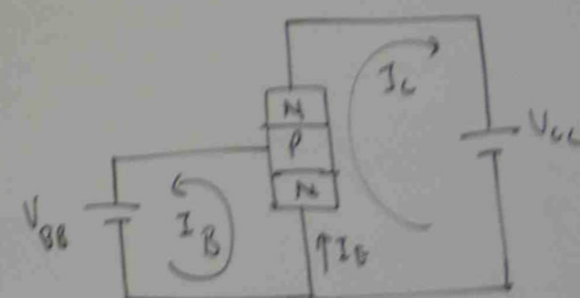


CONSTRUCTION

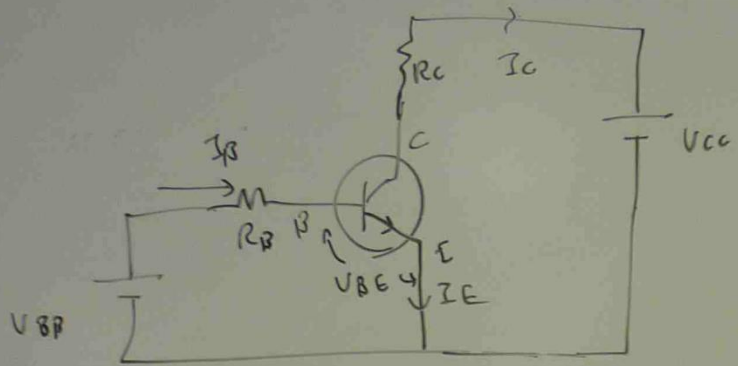
PNP



TRANSISTOR OPERATION



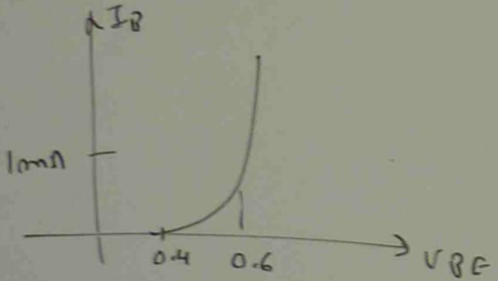
$$I_E = I_C + I_B$$

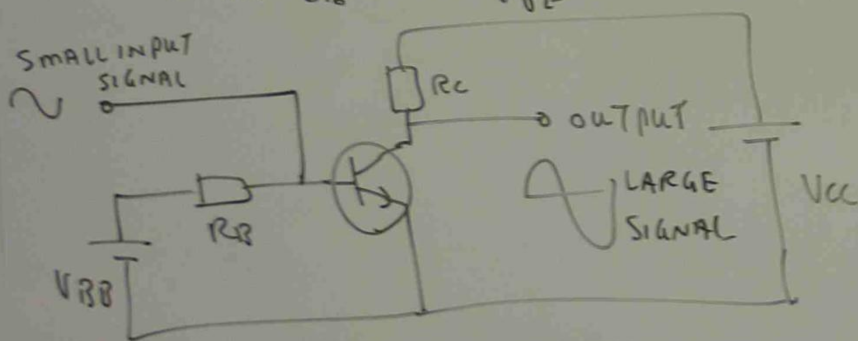


$$\alpha = \frac{I_C}{I_E}$$

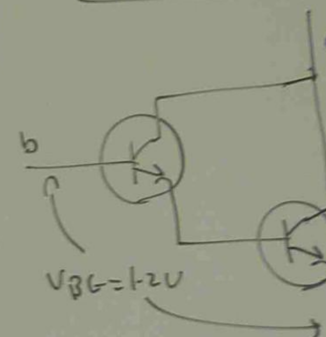
$$\beta = \frac{I_C}{I_B}$$

TRANSISTOR BIASING DIAGRAM

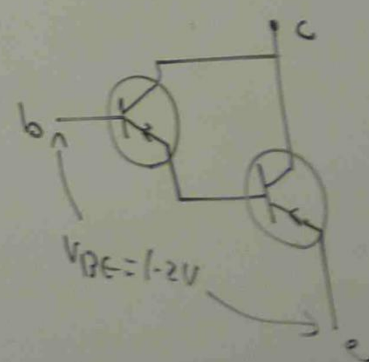




DARLINGTON PAIR



NPN DARLINGTON PAIR



PNP DARLINGTON PAIR

CLASS A

- THIS TYPE OF AMPLIFIER PRODUCES AN OUTPUT OVER THE FULL CYCLE 360° OF INPUT CYCLE

CLASS B

PRODUCE AN OUTPUT FOR ONLY 1/2 OF INPUT CYCLE 180°

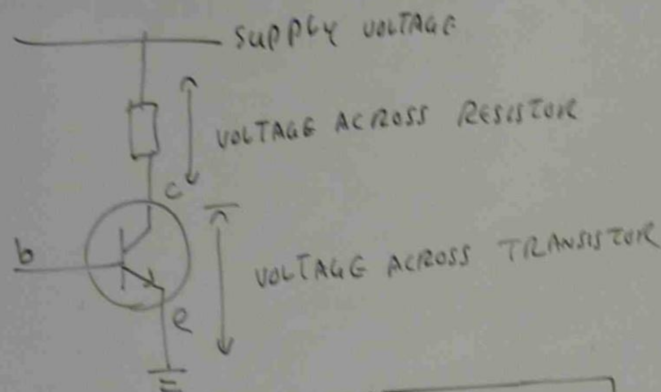
CLASS A B

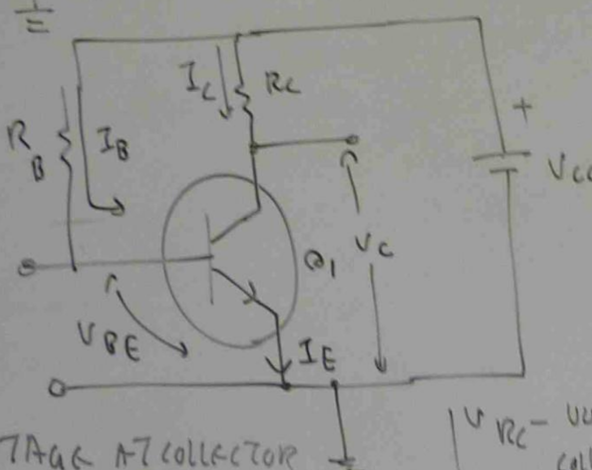
THIS TYPE COMPARISE BETWEEN CLASS A & B

CLASS C

THE TRANSISTOR CONDUCTS FOR LESS THAN 180° OF INPUT WAVE FORM.

TRANSISTOR BIASING CIRCUITS





V_{CB} - VOLTAGE AT COLLECTOR RESPECT TO BASE

V_{BE} - VOLTAGE AT BASE RESPECT TO EMITTER

V_{RE} - VOLTAGE ACROSS EMITTER RESISTOR

V_{RB} - VOLTAGE ACROSS BASE RESISTOR

V_{CC} - SUPPLY VOLTAGE

V_{RC} - VOLTAGE ACROSS COLLECTOR RESISTOR

V_{BE} - VOLTAGE ACROSS BASE RESPECT TO EMITTER

I_C - COLLECTOR CURRENT

I_B - BASE CURRENT

I_E - EMITTER CURRENT.

$$I_B = \frac{V_C - 0.6}{R_B}$$

$$I_C = \beta I_B$$

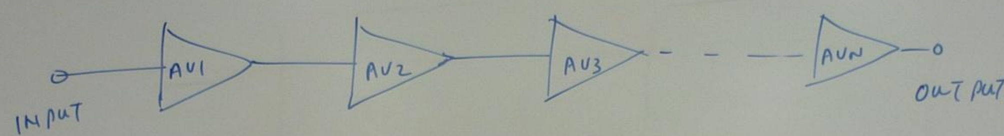
$$I_E = I_C$$

$$V_E = 0\,V$$

$$V_B = 0.6\,V$$

$$V_C = V_{CC} - I_C R_C$$

MULTI STAGE AMPLIFIERS



$$AV_T = AV_1 \times AV_2 \times AV_3 \times - - - AV_N$$

$$AV(dB) = 20 \log AV$$

$$AV_T(dB) = AV_1(dB_1) + AV_2(dB_2) + AV_3(dB_3) + - - - AV_N(dB_m)$$

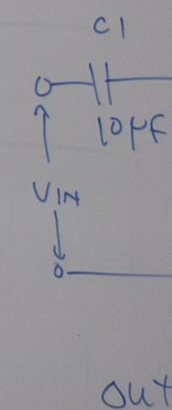
CASADING — HIGHER GAIN

HIGH INPUT RESISTANCE, LOW OUTPUT RESISTANCE

COUPL

- RESIS
- DIREC
- TRANS
- TUNE
- IN

RC COU



-o

OUTPUT

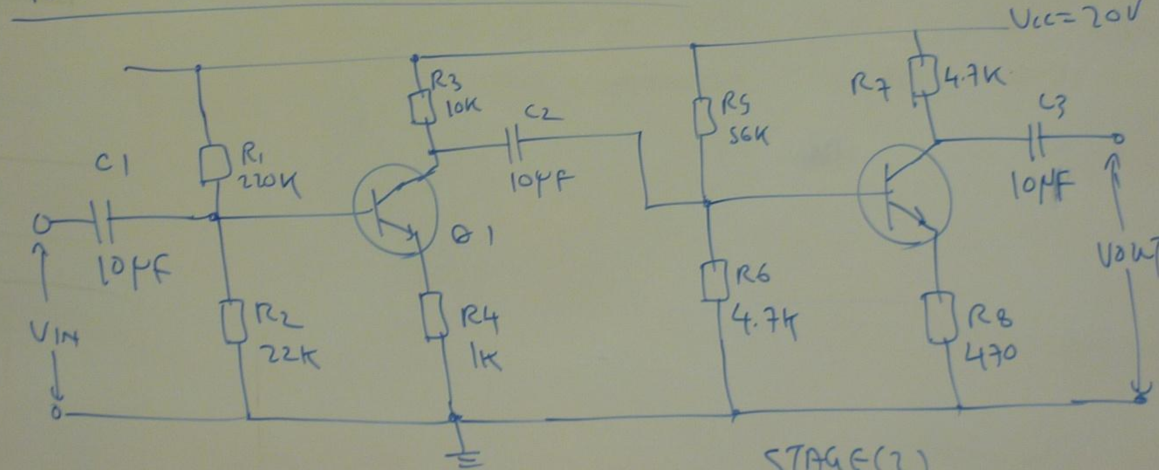
) + - - - AU_N (dB_m)

PUT RESISTANCE

COUPLING METHODS

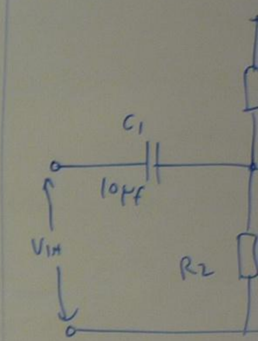
- RESISTANCE - CAPACITANCE (RC) COUPLING
- DIRECT COUPLING - (DC COUPLING)
- TRANSFORMER COUPLING
- TUNED TRANSFORMER COUPLING
- INDUCTANCE - CAPACITANCE COUPLING (LC COUPLING)

RC COUPLING FOR CE AMPLIFIER



OUTPUT WAVEFORM IS INPHASE WITH INPUT.

DIRECT COUPLE



- NO BIASING
- HIGHER INP
- HIGHER GAI

PD FOR ABO

(a) VB_1 (6

(f) VE_2 (

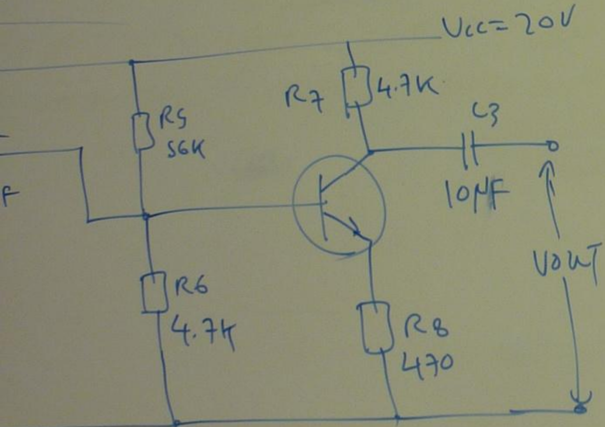
RC) COUPLING

NG)

NG

UPLING (LC COUPLING)

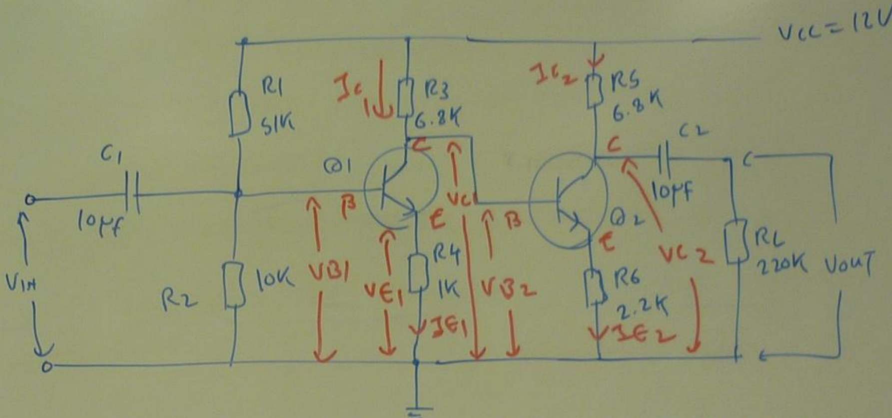
PLIFIER



STAGE(2)

IS INPHASE WITH INPUT.

DIRECT COUPLED AMPLIFIER



- NO BIASING CAPACITOR FOR SECOND STAGE
- HIGHER INPUT IMPEDANCE
- HIGHER GAIN.

Pb FOR ABOVE AMPLIFIER, CALCULATE

(a) V_{B_1} (b) V_{E_1} (c) I_{E_1} (d) I_{C_1} (e) V_{C_1}

(f) V_{E_2} (g) I_{E_2} (h) V_{C_2}

$V_{B_1} = V_{cc} \times$

$= 12 \times \frac{1}{10-}$

$= 1.96$

$V_{E_1} = V_{B_1} - V$

$= 1.96 - 0.$

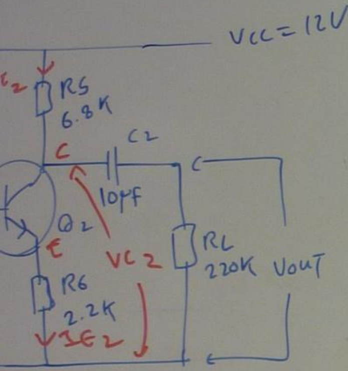
$V_{C_1} = V_{cc} -$

$I_{C_1} = I_{E_1} =$

$V_{C_1} = V_{cc} - I_c$

$= 12 - 1.$

$= 3.84$



SECOND STAGE

...LCULATE

(d) I_{C_1} (e) V_{C_1}

V_{C_2}

$$V_{B_1} = V_{CC} \times \frac{R_2}{R_1 + R_2}$$

$$= 12 \times \frac{10}{10 + 51}$$

$$= 1.96V$$

$$V_{E_1} = V_{B_1} - V_{BE}$$

$$= 1.96 - 0.6 = 1.36V$$

$$V_{C_1} = V_{CC} - I_{C_1} R_3$$

$$I_{C_1} = I_{E_1} = \frac{V_{E_1}}{R_4}$$

$$= \frac{1.36}{1K}$$

$$= 1.36mA$$

$$V_{C_1} = V_{CC} - I_{C_1} R_3$$

$$= 12 - 1.36 \times 10^{-3} \times 6.8 \times 10^{3}$$

$$= 3.84V$$

$$V_{C_1} = V_{B_2}$$

$$V_{E_2} = V_{B_2} - V_{BE}$$

$$= 3.84 - 0.6$$

$$= 3.24V$$

$$I_{E_2} = \frac{V_{E_2}}{R_6}$$

$$= \frac{3.24}{2.2K}$$

$$= 1.6mA$$

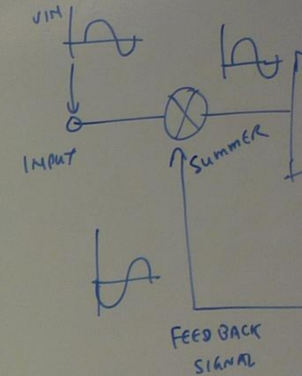
$$I_{E_2} = I_{C_2} = 1.6mA$$

$$V_{C_2} = V_{CC} - I_{C_2} \times R_5$$

$$= 12 - 1.6 \times 10^{-3} \times 6.8 \times 10^{3}$$

$$= 2.4V$$

FEED BACK



ADVANTAGES OF N...

- REDUCED BUT S...
- INCREASED INPUT...
- REDUCED OUTPUT...
- LESS NOISE IN...
- LESS DISTORTIO...
- WIDER FREQUEN...

DC FEEDBACK

- DC VOLTAGE S...

$V_{C_1} = V_{B_2}$

$V_{E_2} = V_{B_2} - V_{BE}$

$= 3.84 - 0.6$

$= 3.24\ V$

$I_{E_2} = \dfrac{V_{E_2}}{R_6}$

$= \dfrac{3.24}{2.2K}$

$= 1.6\ mA$

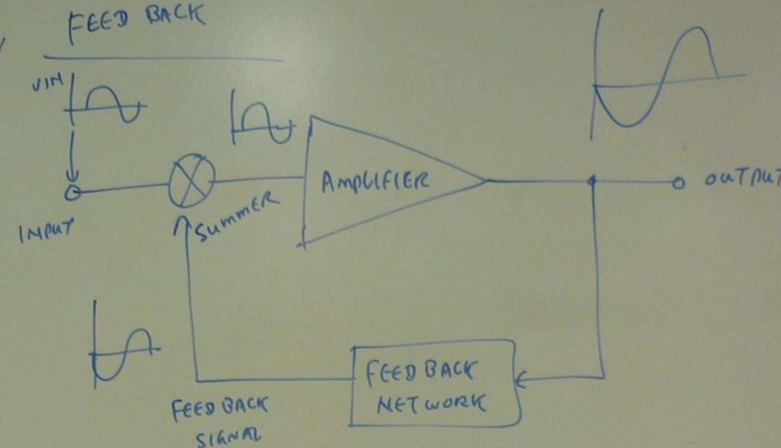
$I_{E_2} = I_{C_2} = 1.6\ mA$

$V_{C_2} = V_{CC} - I_{C_2} \times R_5$

$= 12 - 1.6\times10^{-3} \times 6.8\times10^{3}$

$= 2.4V$

FEED BACK



ADVANTAGES OF NEGATIVE FEED BACK

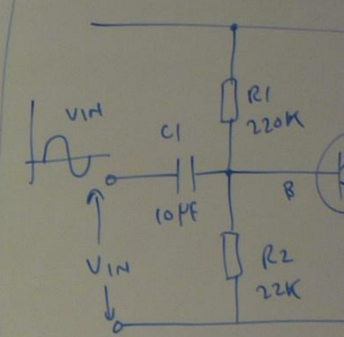
- REDUCED BUT STABILISED GAIN
- INCREASED INPUT RESISTANCE
- REDUCED OUTPUT RESISTANCE
- LESS NOISE IN OUTPUT SIGNAL
- LESS DISTORTION IN OUTPUT SIGNAL
- WIDER FREQUENCY RESPONSE.

AC FEED BACK

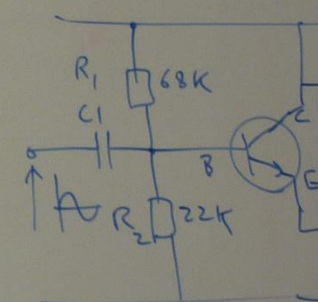
DC FEED BACK

- DC VOLTAGE STABILIZING

EMITTER RESISTOR



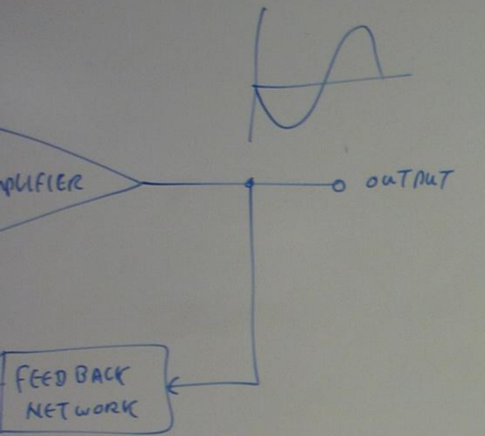
CURRENT DERIVE



DC & AC f

R_5 - LOAD FOR

RESISTANCE fo



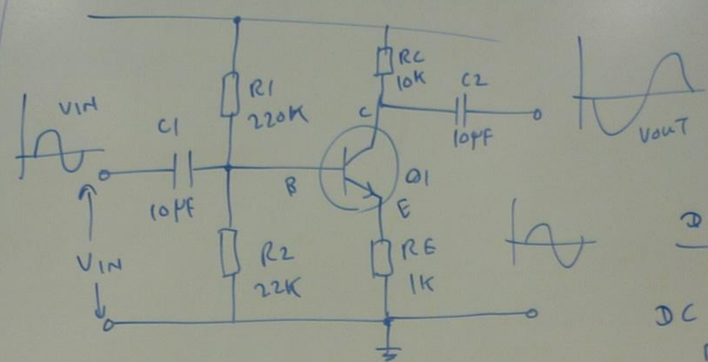
ATIVE FEEDBACK

BILISED GAIN
ESISTANCE
ESISTANCE
T PUT SIGNAL
N OUTPUT SIGNAL
RESPONSE.

BILIZING

AC FEEDBACK

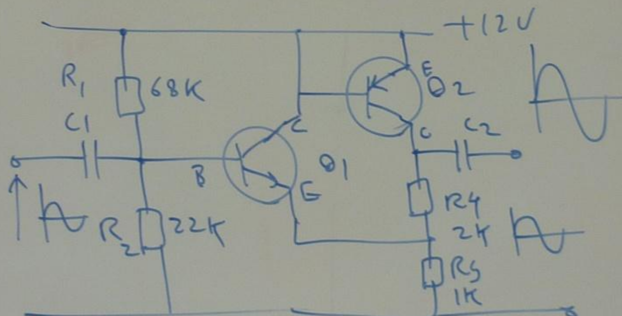
EMITTER RESISTOR AS FEEDBACK



CURRENT DERIVED FEEDBACK.

DC FEEDBACK

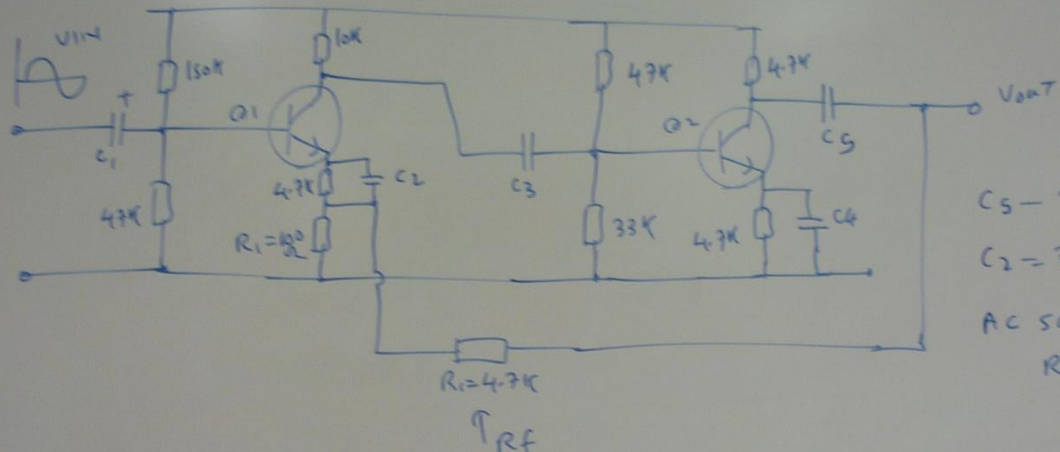
DC STABILITY CAN BE ACHIEVED



DC & AC FEEDBACK.

R_5 - LOAD FOR Q_2, EMITTER FEEDBACK RESISTANCE FOR Q_1.

VOLTAGE DERIVED FEED BACK



C5 — DC ISOLATION

C2 — BY PASS

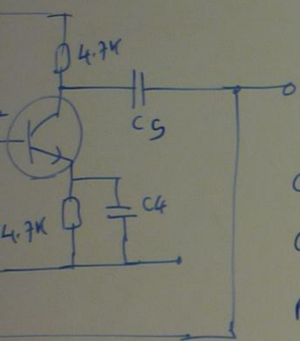
AC SIGNAL ACROSS R1

FEED BACK GAIN $A_{vf} = \frac{R_f}{R_1} + 1$

BENEFIT OF VOLTAGE FEED BACK

- LOWER THE CIRCUIT GAIN AND STABILIZE IT
- INCREASE THE INPUT RESISTANCE
- DECREASE THE OUTPUT RESISTANCE
- PROVIDE ALL BENEFITS OF NEGATIVE FEED BACK.

AC FEED BACK



C_5 — DC ISOLATION

C_2 = BY PASS

AC SIGNAL ACROSS R_1

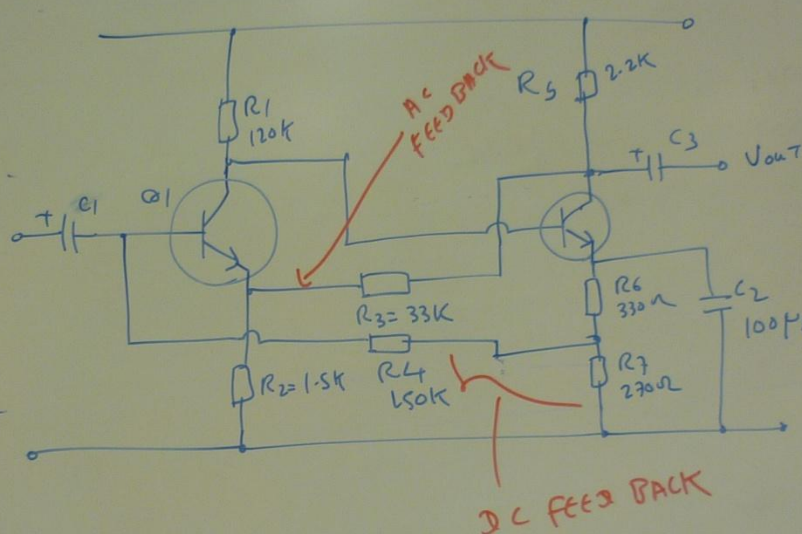
ZE IT

AC FEED BACK

E

VE FEED BACK.

EXAMPLES OF AC & DC FEED BACK



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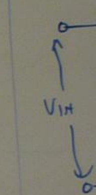
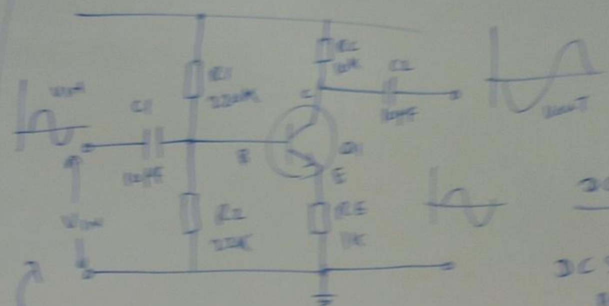


P

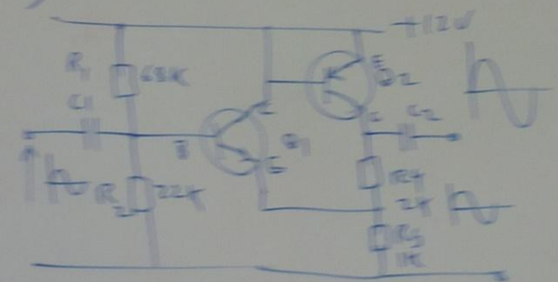
EMITTER RESISTOR AS FEEDBACK



DC FEEDBACK

DC STABILITY CAN BE ACHIEVED

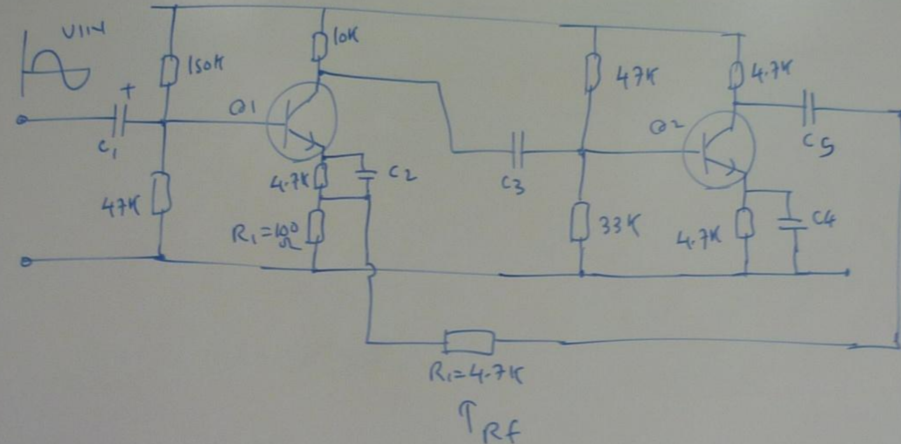
CURRENT DERIVED FEED BACK



DC & AC FEEDBACK.

R_5 – LOAD FOR Q_2, EMITTER FEEDBACK RESISTANCE FOR Q_1.

VOLTAGE DERIVED FEED BACK

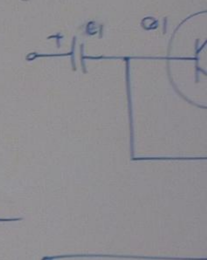


C_5 — DC ISOLATION

C_2 = BY PASS

AC SIGNAL ACROSS R_1

EXAMPL



FEED BACK GAIN $\quad A_{vf} = \frac{R_f}{R_1} + 1$

BENEFIT OF VOLTAGE FEED BACK

- LOWER THE CIRCUIT GAIN AND STABILIZE IT
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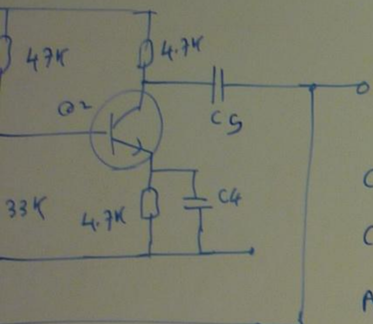
- DECREASE THE OUTPUT RESISTANCE
- PROVIDE ALL BENEFITS OF NEGATIVE FEED BACK.

— AC FEED BACK



C5 — DC ISOLATION

C2 = BY PASS

AC SIGNAL ACROSS R1

+1

ABILIZE IT

ICE

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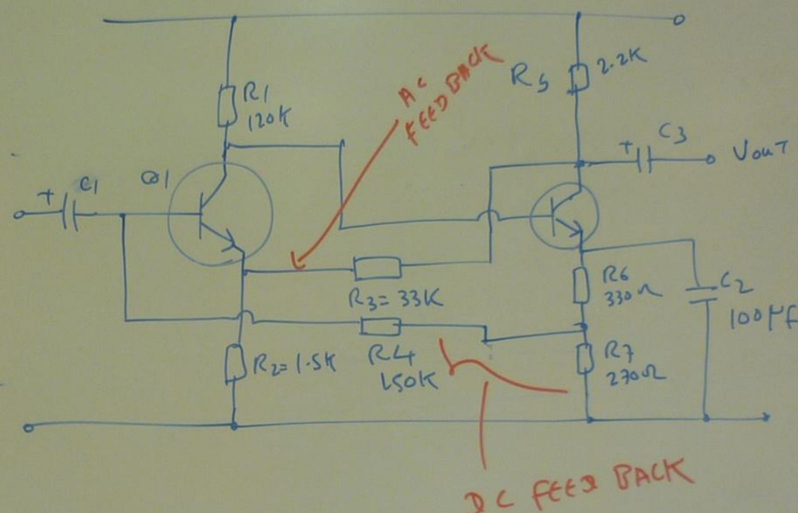
GATIVE FEED BACK.

AC FEED BACK

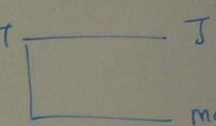
EXAMPLES OF AC & DC FEED BACK



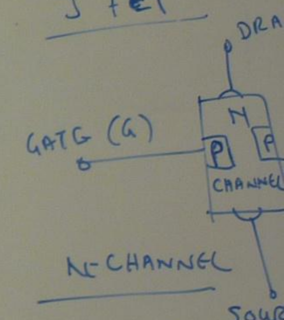
FIELD EFFEC

BJT - TRANSISTOR -

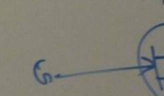
FET - TRANSISTOR -



J FET

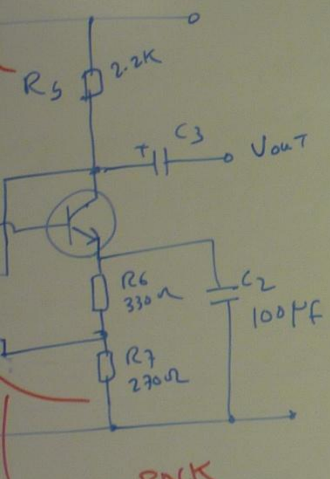


N-CHANNEL



N C

FEED BACK



DC FEED BACK

FIELD EFFECT TRANSISTORS

BJT - TRANSISTOR - THE JUNCTION IS OPERATED WITH REVERSE BIAS

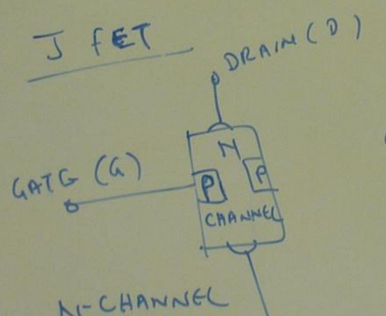
FET - TRANSISTOR - FET IS A VOLTAGE OPERATED DEVICE.

FET — JFET — JUNCTION FIELD EFFECT TRANSISTOR

FET — MOSFET — METAL OXIDE SILICON FIELD EFFECT TRANSISTOR

- DEPLETION TYPE
- ENHANCEMENT TYPE

JFET



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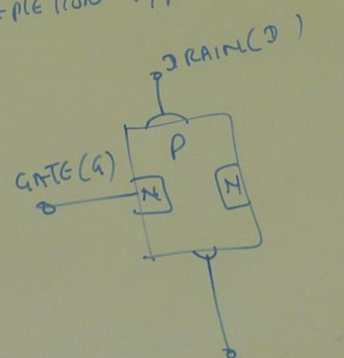
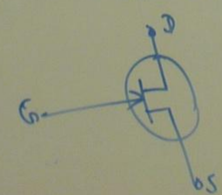
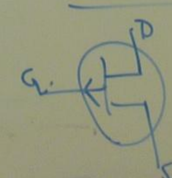


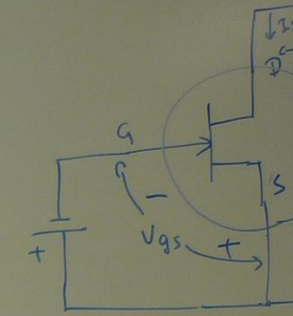
P-CHANNEL



N CHANNEL



P-CHANNEL



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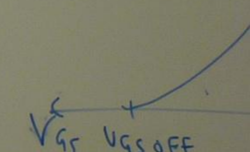
WHEN V_{GS}

I_{DSS} - DR



IS OPERATED WITH REVERSE BIAS

TAGE OPERATED DEVICE.

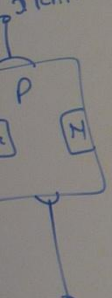
ON FIELD EFFECT TRANSISTOR

OXIDE SILICON FIELD EFFECT TRANSISTOR

ENHANCEMENT TYPE

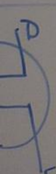
YPE

DRAIN(D)

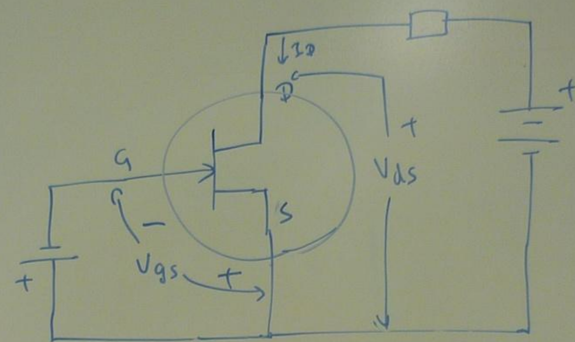


SOURCE(S)

HANNEL



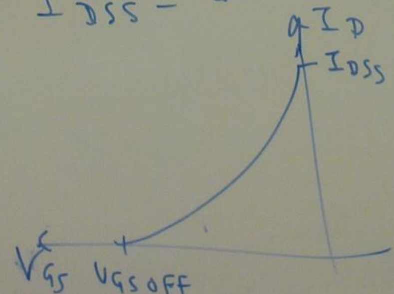
P-CHANNEL



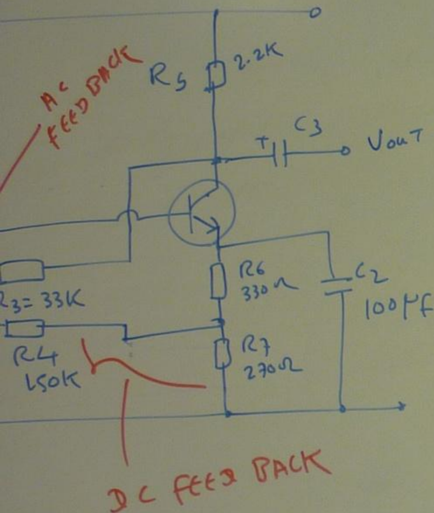
THE HIGHER THE VALUE OF V_{gs}, THE GREATER THE DEPTH OF THE FIELD AND THE HIGHER THE RESISTANCE OFFERED TO THE CURRENT FLOWING FROM DRAIN TO SOURCE TERMINAL.

WHEN V_{GS} IS ZERO $\longrightarrow$ CURRENT FLOWS

I_{DSS} – DRAIN CURRENT FLOWS WHEN $V_{GS} = 0$



& DC FEED BACK



FIELD EFFECT TRANSISTORS

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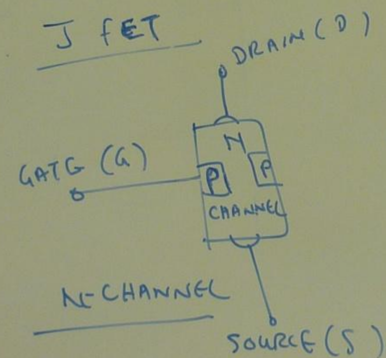
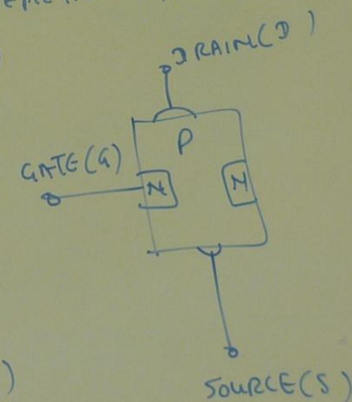
FET - TRANSISTOR - FET IS A VOLTAGE OPERATED DEVICE.

FET
- J FET — JUNCTION FIELD EFFECT TRANSISTOR
- MOS FET — METAL OXIDE SILICON FIELD EFFECT TRANSISTOR
  - DEPLETION TYPE
  - ENHANCEMENT TYPE

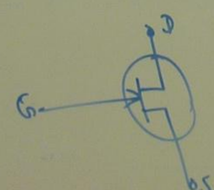
J FET



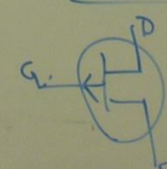
N-CHANNEL



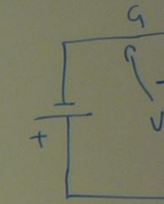
P-CHANNEL



N CHANNEL



P-CHANNEL



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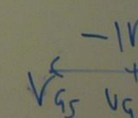


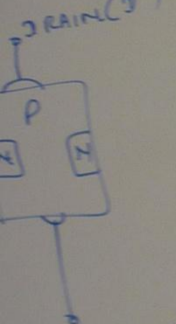
IS OPERATED WITH REVERSE BIAS

OLTAGE OPERATED DEVICE.

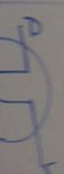
ION FIELD EFFECT TRANSISTOR

OXIDE SILICON FIELD EFFECT TRANSISTOR

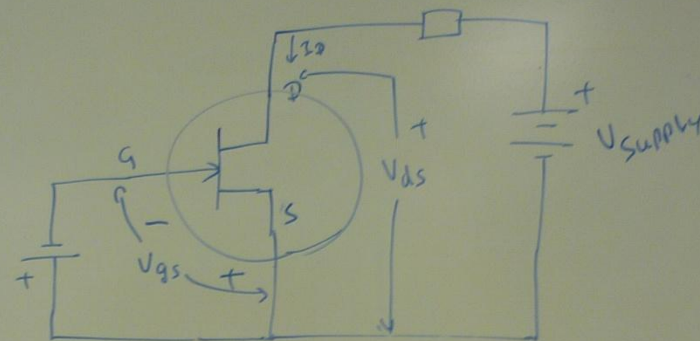
TYPE ENHANCEMENT TYPE



CHANNEL



P-CHANNEL



THE HIGHER THE VALUE OF V_{gs}, THE GREATER THE DEPTH OF THE FIELD AND THE HIGHER THE RESISTANCE OFFERED TO THE CURRENT FLOWING FROM DRAIN TO SOURCE TERMINAL.

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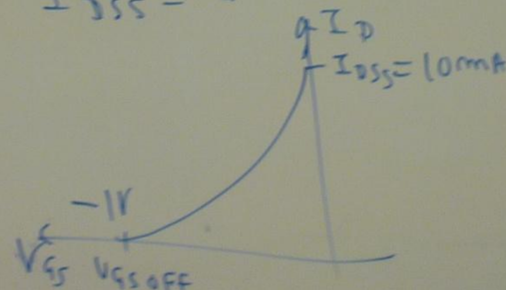
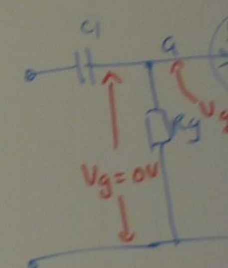


DC CONDITION OF

$V_{ds} = \frac{1}{2} V_{suppl}$

V_{gs} – REVERSED B

I_d



Pb FOR THE A

$V_{gs} = -1V$

(a) THE V

(b) R_d

(c) MUTC

$+$

V_{SUPPLY}

...gs, THE

... AND

...ERED TO

DRAIN

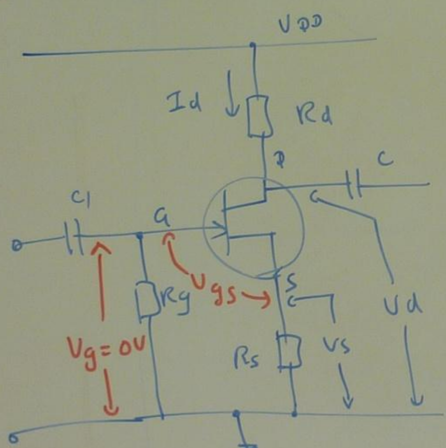
...RRENT FLOWS

...OWS WHEN $V_{gs} = 0$

DC CONDITION OF JFET

$V_{ds} = \frac{1}{2} V_{supply}$

V_{gs} – REVERSED BIAS



$I_D = \frac{I_{DSS}}{2}$

$V_{gs} = - I_d R_s$

$R_s = \frac{V_{gs}}{R_D}$

$g_m = \frac{I_d}{V_{gs}}$

$V_D = V_{DD} - I_d R_d$

$R_g = 1\,m\Omega$ (OR) LESS (FOR JFET)

Pb FOR THE ABOVE CIRCUIT DIAGRAM, $V_{dd} = 10V$, $V_{gs} = -1V$ $I_{DSS} = 10mA$ CALCULATE

(a) THE VALUE OF R_s TO CORRECTLY BIAS THE CIRCUIT

(b) R_d

(c) MUTUAL CONDUCTANCE g_m (amp/volt)

(a) $I_D = \frac{I_{DSS}}{2} =$

$R_s = \frac{V_{gs}}{I_D} =$

(b) $V_D = V_{DD} - I$...

$I_d R_d = V_{DD}$...

$R_d = \frac{V_{DD}}{}$...

$= \frac{10}{}$...

$= 10$...

$=$ ...

(c) $g_m = \frac{I_D}{V_{gs}}$

$I_D = \frac{I_{DSS}}{2}$

$V_{gs} = - I_d R_S$

$R_S = \frac{V_{gs}}{R_D}$ $\qquad g_m = \frac{I_d}{V_{gs}}$

$V_D = V_{DD} - I_d R_d$

$R_g = 1\ m\Omega$ (OR) LESS
(FOR JFET)

T DIAGRAM, $V_{dd} = 10V$,
10mA CALCULATE
TO CORRECTLY BIAS THE CIRCUIT

NCE g_m (amp/volt)

(a) $I_D = \frac{I_{DSS}}{2} = \frac{10\,mA}{2} = 5\,mA$

$R_S = \frac{V_{gs}}{I_D} = \frac{1}{5\,mA} = 0.2 \times 10^{3}\,\Omega = 200\,\Omega$

(b) $V_D = V_{DD} - I_d R_d$

$I_d R_d = V_{DD} - V_D$

$R_d = \frac{V_{DD} - V_D}{I_d}$

$= \frac{10 - \frac{V_{DD}}{2}}{5\,mA}$

$= \frac{10 - \frac{10}{2}}{5 \times 10^{-3}}$

$= \frac{5}{5 \times 10^{-3}} = 1\,k\Omega$

(c) $g_m = \frac{I_D}{V_{gs}} = \frac{5\,mA}{1V} = 5\,mA/V$

(a) $I_D = \frac{I_{DSS}}{2} = \frac{10\,mA}{2} = 5\,mA$

$R_S = \frac{V_{gs}}{I_D} = \frac{1}{5\,mA} = 0.2\times10^{3}\,\Omega = 200\,\Omega$

(b) $V_D = V_{DD} - I_d R_d$

$I_d R_d = V_{DD} - V_D$

$R_d = \frac{V_{DD} - V_D}{I_d}$

$= \frac{10 - \frac{V_{DD}}{2}}{5\,mA}$

$= \frac{10 - \frac{10}{2}}{5\times10^{-3}}$

$= \frac{5}{5\times10^{-3}} = 1\,k\Omega$

(c) $g_m = \frac{I_D}{V_{gs}} = \frac{5\,mA}{1V} = 5\,mA/V$

MOS FET

THE MOSFET IS SIMILAR CONSTRUCTION TO JFET EXCEPT A VERY THIN LAYER OF SILICON OXIDE IS PLACED BETWEEN GATE AND CHANNEL

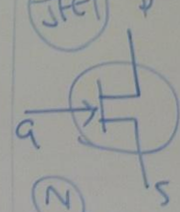
DE-MOSFET - DEPLETION ENHANCEMENT MODE

DESIGNED TO OPERATE WITH GATE-SOURCE VOLTAGE REVERSED BIAS

E-MOFET - ENHANCEMENT MODE MOSFET -

DESIGNED TO OPERATE GATE-SOURCE VOLTAGE FORWARD BIAS.

JFET



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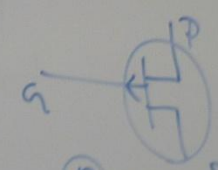

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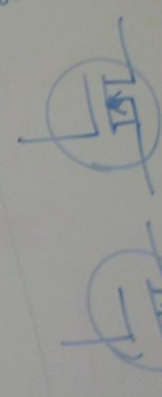
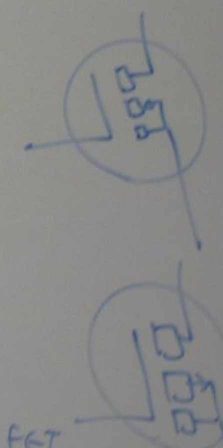


N-CHANNEL

P-CHANNEL

DE-MOSFET



- E-MOSFET

J-FET AMPLIFIER

THE J FET AMPLIFIER IS SIMPLER THAN BJT. IT USES LESS COMPONENT AND VOLTAGE OPERATED.

THE GATE-SOURCE VOLTAGE OF FET CONTROLS IT'S DRAIN CURRENT

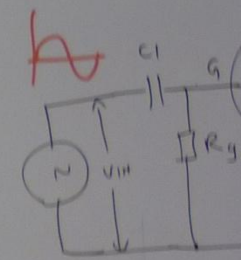
(IN BJT- BASE CURRENT CONTROLS COLLECTOR CURRENT)

- INPUT IMPEDANCE OF FET IS HIGHER THAN BJT

CD - COMMON DRAIN , CS - COMMON SOURCE.

JFET		BJT
CD		CE
CS	—	EMITTER FOLLOWER

J FET - CS



A C CONDITION

V_{IN} ↑

VS CONST

I_d ↑

V_d ↓

∴ OUT P

ER

PLER THAN BJT. IT USES LESS

D.

ET CONTROLS IT'S DRAIN CURRENT

S COLLECTOR CURRENT)

ER THAN BJT

MMON SOURCE.

ET

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MITTER
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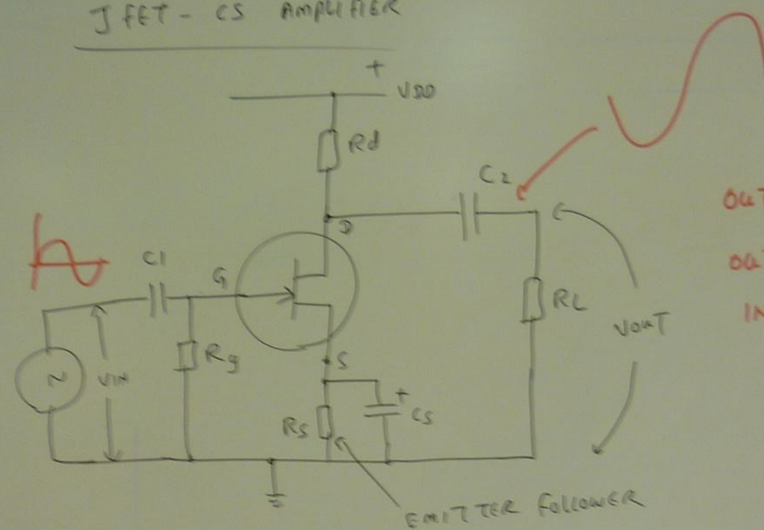
JFET - CS AMPLIFIER



OUT PUT IS 180° OUT OF PHASE WITH INPUT.

AC CONDITION

$V_{in} \uparrow \; \to \; V_g \uparrow$

VS CONSTANT

$I_d \uparrow$

$V_d \downarrow$

∴ OUT PUT DECREASES.

INCREASE IN INPUT CAUSES DECREASES IN OUT PUT

(180° OPPOSITE)

$A_V = \frac{g_m}{H}$

g_m = MUTUA

R_d = VALUE

R_L = VALUE

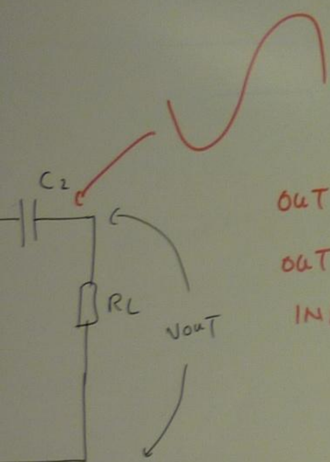
R_S = VALU

$A_V = g_m (R_d$

$A_V = g_m R$

$r_{in} = R_g$

$r_{out} = R_d$



OUT PUT IS 180° OUT OF PHASE WITH INPUT.

...TTER FOLLOWER

INCREASE IN INPUT CAUSES DECREASES IN OUT PUT

(180° OPPOSITE)

$$A_v = \frac{g_m (R_d \| R_L)}{1 + g_m R_s}$$

g_m = MUTUAL CONDUCTANCE Amp/VOLT

R_d = VALUE OF DRAIN RESISTOR

R_L = VALUE OF LOAD RESISTOR

R_s = VALUE OF UNBYPASSED SOURCE RESISTOR.

$A_v = g_m (R_d \| R_L)$ (R_s IS BYPASSED)

$A_v = g_m R_d$ (R_s IS BYPASSED, NO LOAD RESISTOR CONNECTED)

$r_{in} = R_g$

$r_{out} = R_d$

J-FET AMPLIFIER

THE J FET AMPLIFIER IS SIMPLER THAN BJT. IT USES LESS COMPONENT AND VOLTAGE OPERATED.

THE GATE-SOURCE VOLTAGE OF FET CONTROLS IT'S DRAIN CURRENT

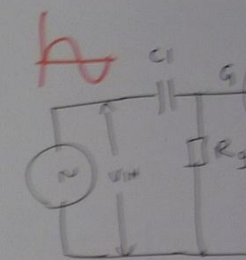
(IN BJT- BASE CURRENT CONTROLS COLLECTOR CURRENT)

- INPUT IMPEDANCE OF FET IS HIGHER THAN BJT

CD - COMMON DRAIN, CS— COMMON SOURCE.

JFET		BJT
CD		CE
CS	—	EMITTER FOLLOWER

J FET - CS



A C CONDITION

V_{IN} ↑ -->

VS CONST

I_d ↑

V_d ↓

∴ OUT P

...LIFIER

SIMPLER THAN BJT. IT USES LESS

...ATED.

FET CONTROLS IT'S DRAIN CURRENT

...TROLS COLLECTOR CURRENT)

HIGHER THAN BJT

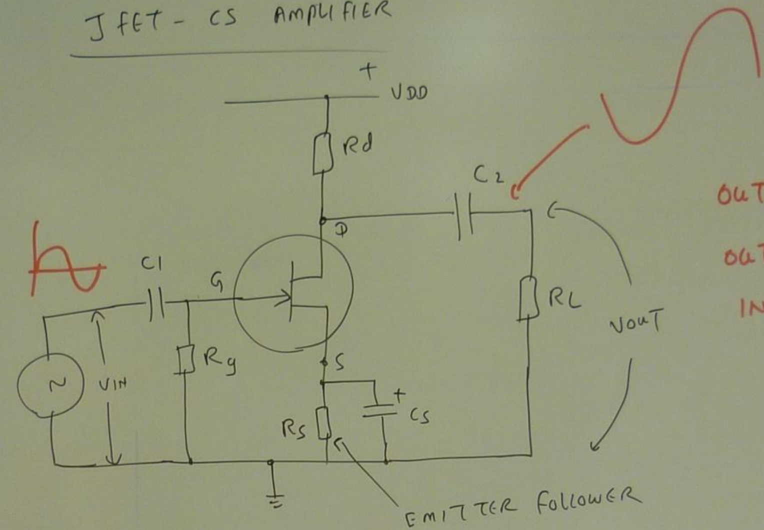
COMMON SOURCE.

BJT

CE

EMITTER FOLLOWER

JFET - CS AMPLIFIER



OUT PUT IS 180° OUT OF PHASE WITH INPUT.

AC CONDITION

$V_{IN} \uparrow \rightarrow V_g \uparrow$

Vs CONSTANT

$I_d \uparrow$

$V_d \downarrow$

∴ OUT PUT DECREASES.

INCREASE IN INPUT CAUSES DECREASES IN OUTPUT

(180° OPPOSITE)

$A_v =$ ...

$g_m =$ m...

$R_d =$ VA...

$R_L =$ UA...

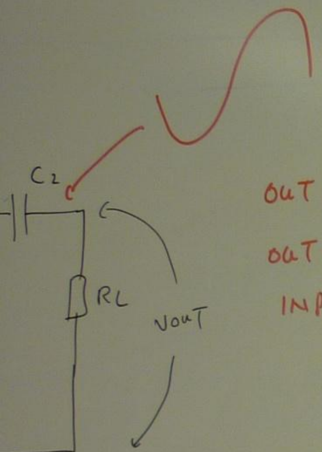
$R_S =$ U...

$A_v = g_m (R$...

$A_v = g_m$ ...

$r_{in} = R_g$...

$r_{out} = R$...



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...TTER FOLLOWER

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$A_v = g_m (R_d \| R_L)$ (R_s IS BYPASSED)

$A_v = g_m R_d$ (R_s IS BYPASSED, NO LOAD RESISTOR CONNECTED)

$r_{in} = R_g$

$r_{out} = R_d$

pb

FOR THE ...

CALCULA...

(a) ...

(b) ...

(c) ...

(d) ...

Pb

FOR THE GIVEN JFET CIRCUIT, $g_m = 3\ mA/V$

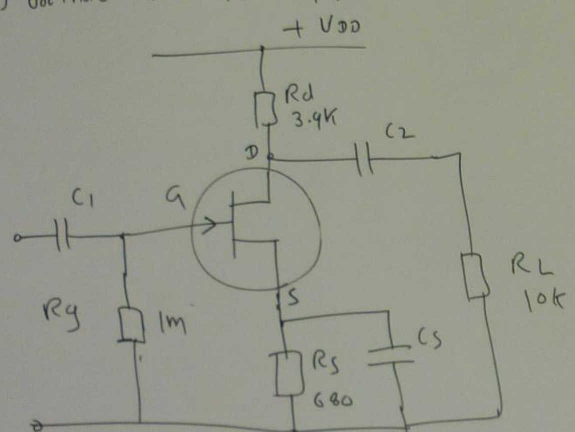
CALCULATE

(a) VOLTAGE GAIN OF THE CIRCUIT

(b) INPUT RESISTANCE

(c) OUTPUT RESISTANCE

(d) VOLTAGE GAIN IF BYPASS CAPACITOR IS REMOVED



$$R_d \| R_L = \frac{R_d R_L}{R_d + R_L}$$

(a) $$A_v = \frac{g_m (R_d \| R_L)}{1 + g_m R_s}$$

$$= \frac{g_m \times \frac{R_d R_L}{R_d + R_L}}{1 + g_m R_s}$$

$$= \frac{3\times10^{-3} \times \frac{3.9\times10}{3.9+10}}{1 + 3\times10^{-3} \times 680}$$

$$= 2.76$$

(b) $r_{in} = r_g = 1\ M\Omega$

(c) $r_{out} = R_d = 3.9k\Omega$

(d) $A_v = g_m (R_d \| R_L)$

$$= 3\times10^{-3}\left(\frac{3.9\times10}{3.9+10}\right) = 8.4$$

$= 3\ mA/V$

...OR IS REMOVED

R_L
10k

(a) $A_v = \dfrac{g_m (R_d || R_L)}{1 + g_m R_s}$

$= \dfrac{g_m \times \dfrac{R_d R_L}{R_d + R_L}}{1 + g_m R_s}$

$= \dfrac{3\times10^{-3} \times \dfrac{3.9 \times 10}{3.9 + 10}}{1 + 3\times10^{-3} \times 680}$

$= 2.76$

(b) $r_{in} = r_g = 1\ M\Omega$

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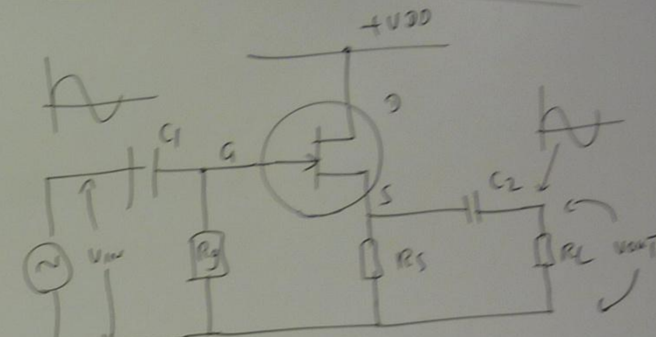
(d) $A_v = g_m (R_d || R_L)$

$= 3\times10^{-3} \left(\dfrac{3.9 \times 10}{3.9 + 10} \right) = 8.4$

COMMON DRAIN JFET AMPLIFIER



- HIGH INPUT RESISTANCE
- LOW OUTPUT RESISTANCE
- VOLTAGE GAIN $\simeq 1$

$A_v = \dfrac{g_m (R_s || R_L)}{1 + g_m R_s}$

$r_{in} = R_g$

$r_{out} = \dfrac{R_s}{1 + g_m R_s}$

- APPLICAT...

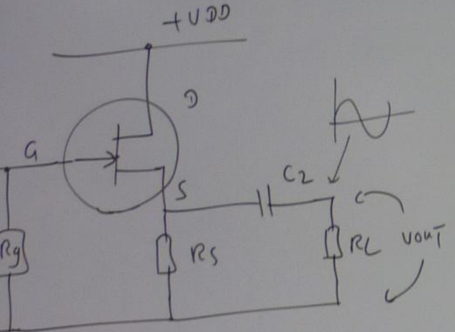
TOUCH...
COMPUT...

Pb

FOR TH...

(a)
(b)
(c)

AIN JFET AMPLIFIER



PUT RESISTANCE

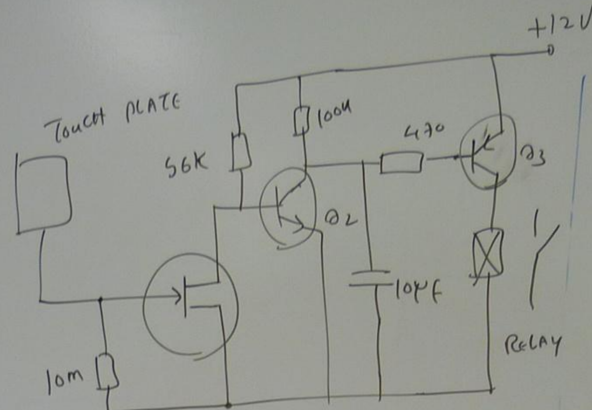
PUT RESISTANCE

GAIN $\simeq 1$

$$\frac{g_m (R_S \| R_L)}{1 + g_m R_S}$$

$= R_g$

$$= \frac{R_S}{1 + g_m R_S}$$

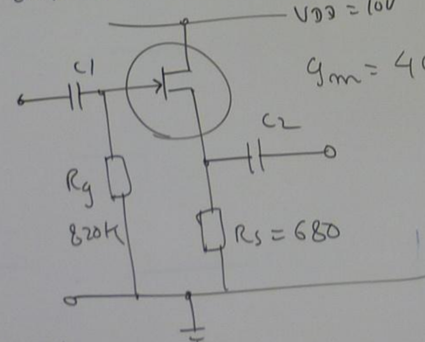


- APPLICATION

TOUCH SCREEN TECHNOLOGY

COMPUTER TOUCH SWITCH

pb



$g_m = 4\,mA/V$

FOR THE GIVEN CIRCUIT, CALCULATE

(a) VOLTAGE GAIN

(b) INPUT RESISTANCE

(c) OUTPUT RESISTANCE

(a) $A_V \simeq 1$

(b) $r_{in} = R_g = 820K$

(c) $r_{out} = \dfrac{R_S}{1 + g_m R_S}$

$$= \frac{680}{1 + 4 \times 10^{-3} \times 680}$$

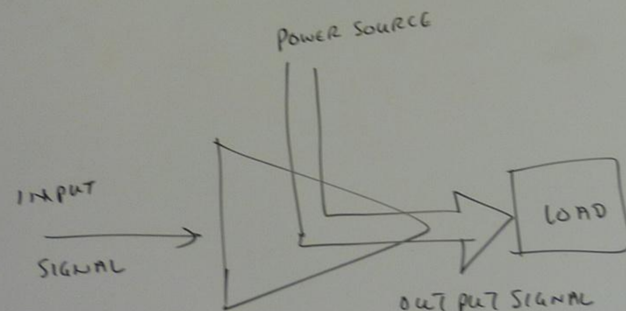
$$= 182\,\Omega$$

POWER OUT PUT STAGE (PART-1)

FIRST AND INTER MEDIATE STAGE AMPLIFIERS CAN NOT HANDLE THE LARGE POWER.

THE OUT PUT 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

OUT PUT STAGE AMPLIFIERS

(1) CLASS (A)

(2) CLASS (B)

(3) CLASS (A+B)

CLASS (A)

— OUTPUT DEV

R_1

C_1

V_{IN}

COM

CLA

CLASS(A)

— MAXIM

— MAXIM

— LOW D

— HIGH

— OUT

...RGE POWER.

...E MAY BE

...AGE AMPLIFIERS

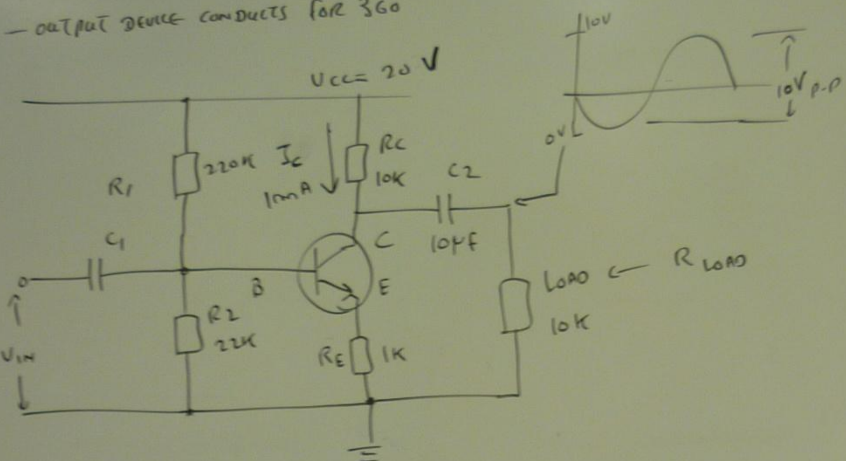
A)

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

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

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

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

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

PD 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

%n

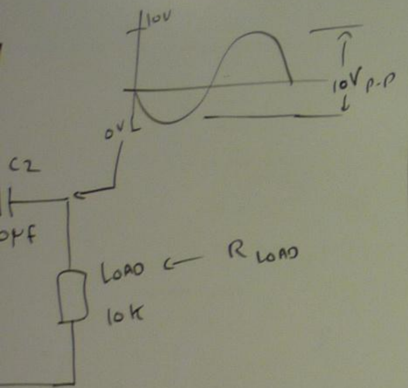
PD

REQ

SYS

20%

OF



...UPLED

...TERISTICS

...% FOR RC COUPLED TYPE

...% FOR TRANSFORMER COUPLED TYPE

...ASS(B)

...S 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

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

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

$$= 3.53V$$

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

$$= \frac{(3.53)^2}{10k} = 1.25\ mW$$

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

$$= \frac{1.25}{20} \times 100 = 6.25\%$$

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

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

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

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

$$=$$

$P_{IN} = V_{cc} \times I_c$

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

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

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

$= 1041.67\ A$

CLASS(

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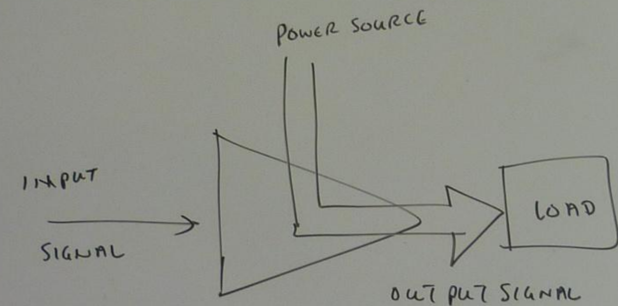


THE BASIC REQUIREMENTS FOR ANY POWER OUTPUT STAGE ARE

- HIGH EFFICIENCY
- LOW DISTORTION
- LOW OUTPUT IMPEDANCE

OUTPUT STAGE AMPLIFIERS

(1) CLASS (A)

(2) CLASS (B)

(3) CLASS (A+B)

GE POWER.

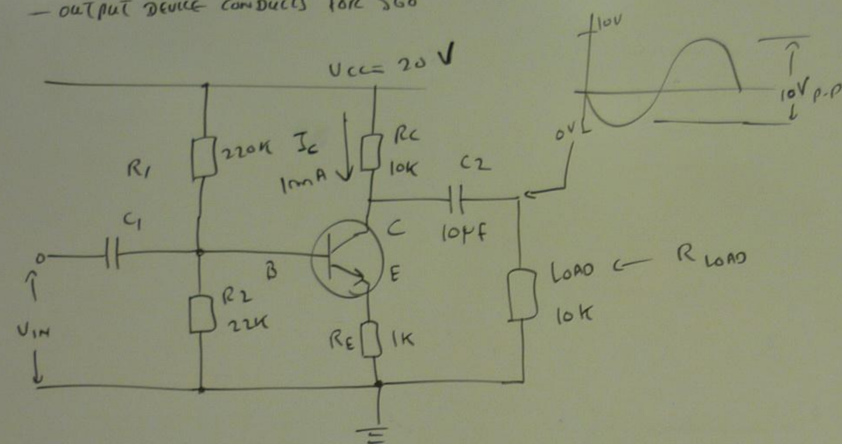
MAY BE

AMPLIFIERS

+B)

CLASS (A) AMPLIFIER

— OUTPUT DEVICE CONDUCTS FOR 360°



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$$= 3.53V$$

$P_{OUT} = ($

$= ($

$\%\eta = \frac{P_{O}}{P_{IN}}$

$= \frac{1}{2}$

Pb CALCULA

REQUIRED F

SYSTEM WIT

20% THAT

OF 50kW.

$\%\eta =$

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

$V_{cc} \times I_c$

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

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

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

...LATE (a) P_{IN} (b) P_{OUT}
...rms (d) EFFICIENCY of
CLASS(A) AMPLIFIER

$\times I_c = 20 \times 1mA = 20mW$

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

$= 3.53V$

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

$= \frac{(3.53)^2}{10k} = 1.25\ mW$

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

$= \frac{1.25}{20} \times 100 = 6.25\%$

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

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

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

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

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

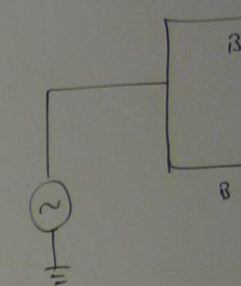
$= 1041.67\ A$

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) 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

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

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

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

$$= 1041.67\text{ A}$$

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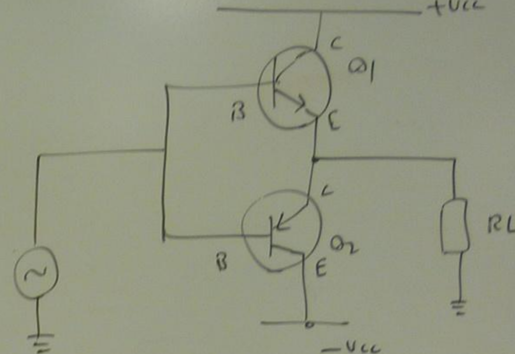
- TWO OUTPUT DEVICES NEEDED BOTH CONDUCT FOR 180°.
- VOLTAGE GAIN (A_V) = UNITY

  POWER GAIN (A_P) = CURRENT GAINS OF TRANSISTOR

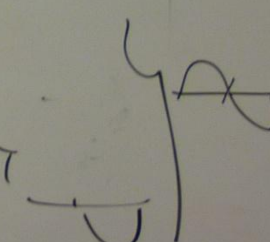
CLASS (B) POWER OUTPUT STAGE



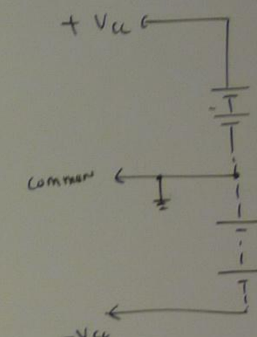
- CLASS (B) AMPLIFIER REQUIRES A MINIMUM OF TWO OUTPUT DEVICES
- Q_1 CONDUCTS FOR THE POSITIVE HALF OF THE INPUT SIGNAL
- Q_2 CONDUCTS FOR THE NEGATIVE HALF.
- THE OUTPUT SIGNAL IS PRODUCED BY BOTH TRANSISTORS.

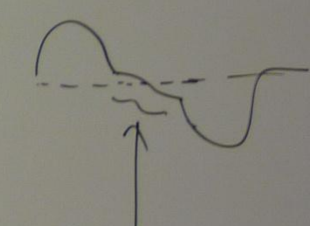

Q_1 CONDUCTS - Q_2 OFF

Q_1 OFF - Q_2 CONDUCT



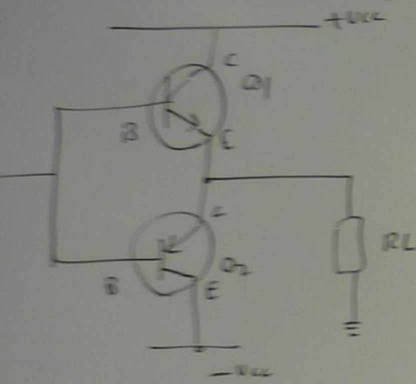
DUAL POLARITY POWER S...





CROSS OVER DIS...

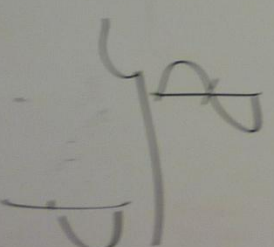
(B) POWER OUTPUT STAGE



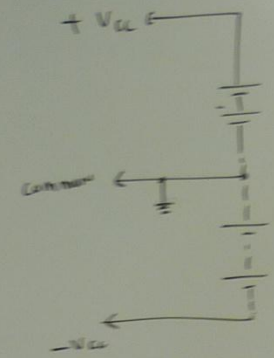
) AMPLIFIER REQUIRES A MINIMUM
OUTPUT DEVICES
TS FOR THE POSITIVE HALF OF
PUT SIGNAL
DUCTS FOR THE NEGATIVE HALF.
PUT SIGNAL IS PRODUCED BY
TRANSISTORS.

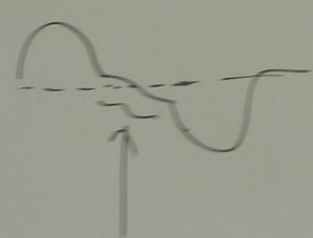
CONDUCTS - Q_2 OFF

OFF - Q_2 CONDUCT



DUAL POLARITY POWER SUPPLY





CROSS OVER DISTORTION

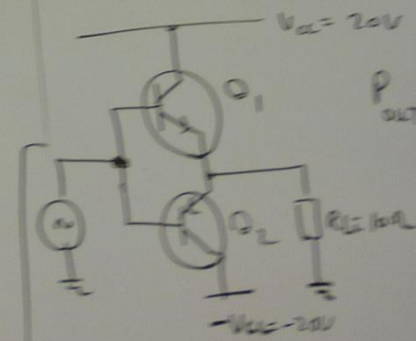
POWER OUTPUT EQUATION

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

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

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

P3 CALCULATE THE MAXIMUM OUTPUT POWER FOR THE GIVEN CIRCUIT



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

1.25 mW

6.25%

...UT POWER
...STRIAL SOUND
...CIENCY OF
...TPUT POWER

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

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

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

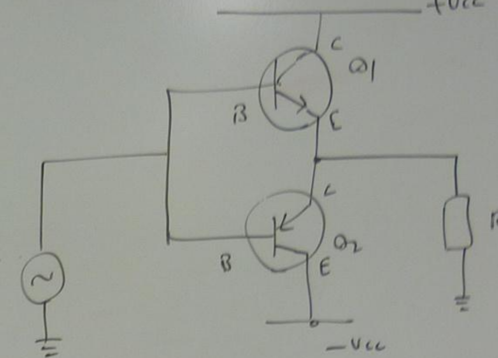
$$= 1041.67\ A$$

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

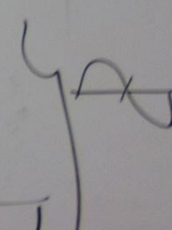
CLASS (B) POWER OUTPUT STAGE



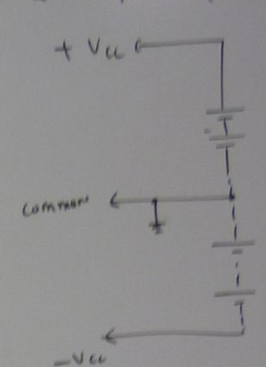
- CLASS (B) AMPLIFIER REQUIRES A MINIMUM OF TWO OUTPUT DEVICES
- Q_1 CONDUCTS FOR THE POSITIVE HALF OF THE INPUT SIGNAL
- Q_2 CONDUCTS FOR THE NEGATIVE HALF.
- THE OUTPUT SIGNAL IS PRODUCED BY BOTH TRANSISTORS.

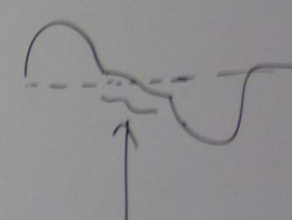
Q_1 CONDUCTS - Q_2 OFF

Q_1 OFF - Q_2 CONDUCT



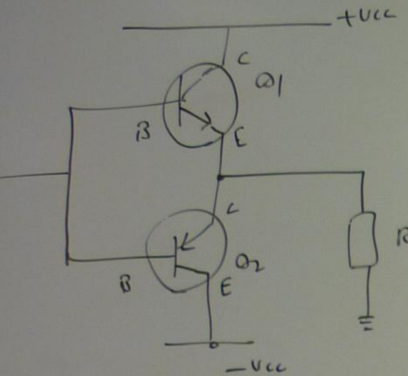
DUAL POLARITY POWER SUPP...





CROSS OVER DISTO...

...S (B) POWER OUTPUT STAGE



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

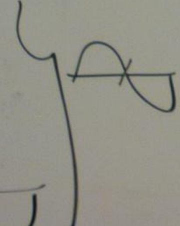
...UCTS FOR THE POSITIVE HALF OF ...NPUT SIGNAL

...NDUCTS FOR THE NEGATIVE HALF.

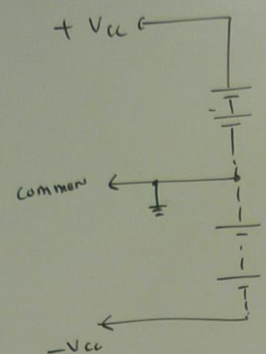
...TPUT SIGNAL IS PRODUCED BY ... TRANSISTORS.

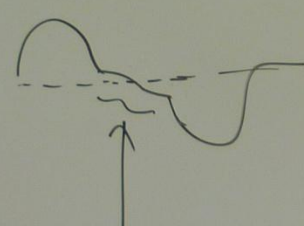
... CONDUCTS - Q_2 OFF

... OFF - Q_2 CONDUCT



DUAL POLARITY POWER SUPPLY





CROSS OVER DISTORTION

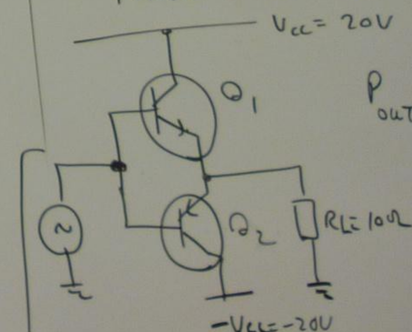
POWER OUTPUT EQUATION

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

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

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

Pb CALCULATE THE MAXIMUM OUTPUT POWER FOR THE GIVEN CIRCUIT



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

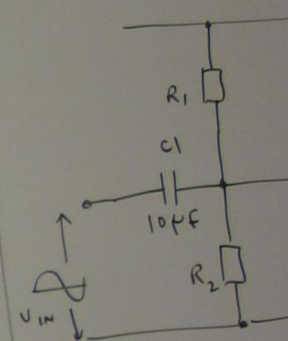
Pb FOR THE GIVEN ...

(a) STATE THE OPT...

(b) CALCULATE THE ...

(c) CALCULATE TH...

(d) STATE THE ...



$V_{C(RMS)} = V$...

$V_{C(MAX)} = \sqrt{}$...

$P_{OUT} = (V_o$...

$I_C = \frac{V_{CC} -}{R}$...

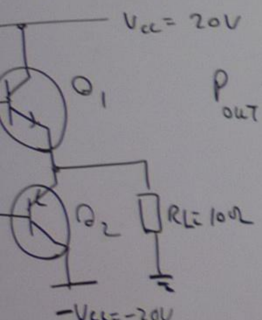
...OWER OUTPUT EQUATION

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

$$= \frac{\left(\frac{V_{o\,p\text{-}p}}{2\sqrt{2}}\right)^2}{R_{LOAD}}$$

$$= \frac{(V_{o\,p\text{-}p})^2}{8\,R_{LOAD}}$$

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



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

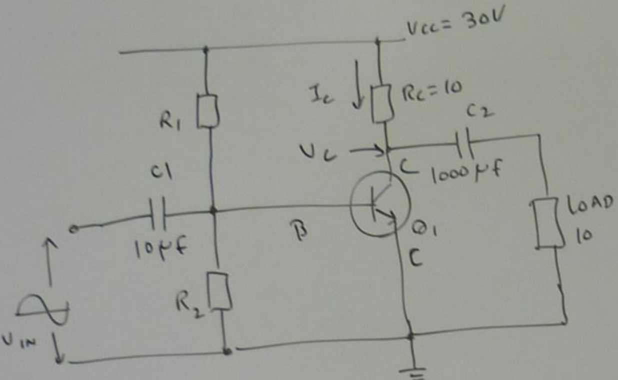
Q) FOR THE GIVEN CIRCUIT

(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.



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

$$V_{c(MAX)} = \sqrt{2}\,V_{C\,RMS} = \sqrt{2}\times15 = 21.2V$$

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

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

$$P_{IN} = V_{CC}\times I_C = 30\times1.5 = 45W$$

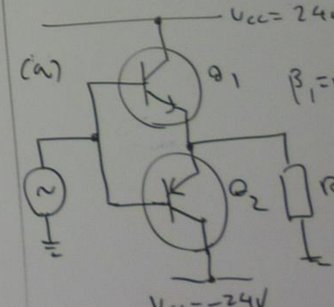
$$\%\eta = \frac{P_{OUT}}{P_{IN}}\times100 = \frac{22.5}{45} = 50\%$$

Q) FOR THE GIVEN CIRCUIT, CALCULATE

(a) THE THEORETICAL MAXIMUM OUTPUT POWER

(b) THE POWER GAIN OF THE CIRCUIT.

(a)



$\beta_1 = \beta_2 = 80$

$$P_o = \frac{(V_{o\,p\text{-}p})^2}{8R_L} = \frac{(2\times24)^2}{8\times5.76} = 50W$$

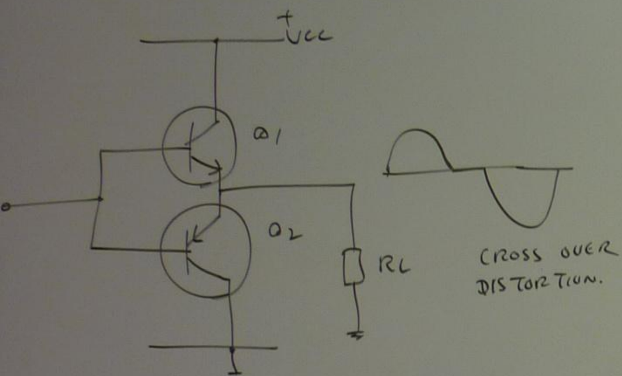
(b)

$A_p = \beta_1 = \beta_2$

$A_p = 80$

POWER OUTPUT STAGE (PART-2)

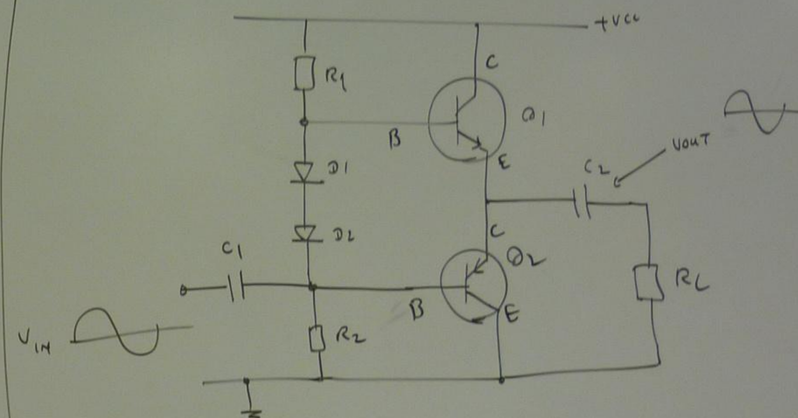
CLASS (AB) AMPLIFIER



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

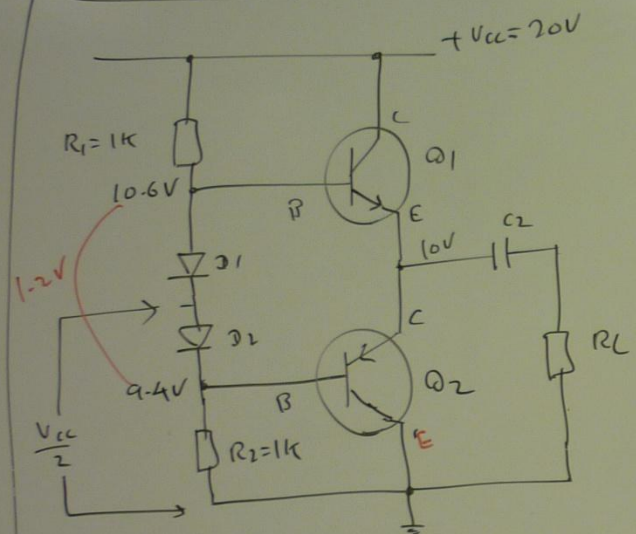
THE BASIC CLASS AB COMPLEMENTARY SYMMETRY AMPLIFIER



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

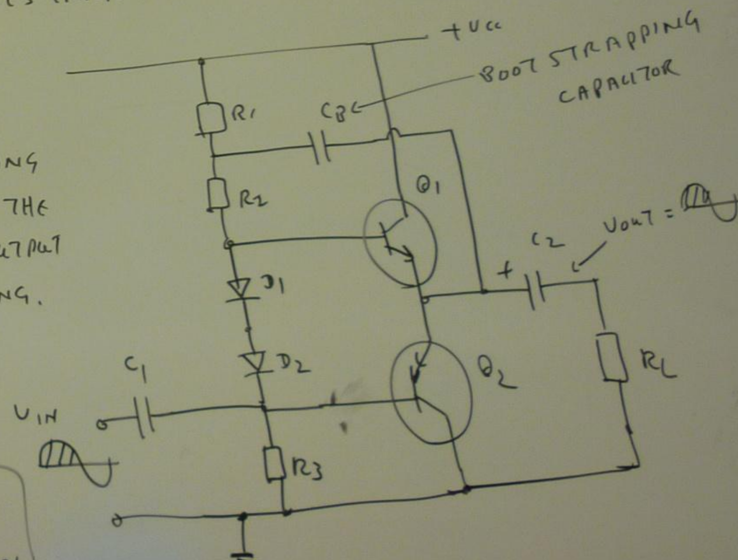
EMITTER VOLTAGE MUST ALWAYS BE LESS 0.6V THAN BASE VOLTAGE.

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.

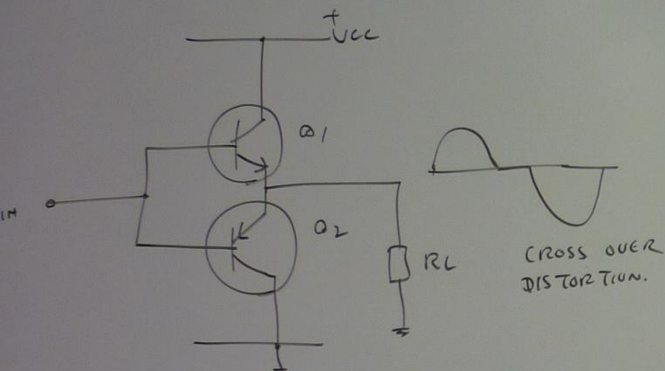
APPLYING BOOTSTRAPPING TO OBTAIN THE GREATER OUTPUT SIGNAL SWING.



I =

POWER OUTPUT STAGE (PART-2)

CLASS (AB) AMPLIFIER



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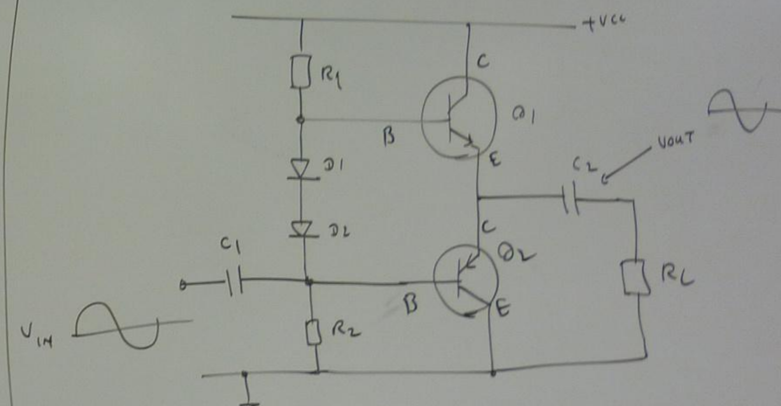

CHARACTERISTICS

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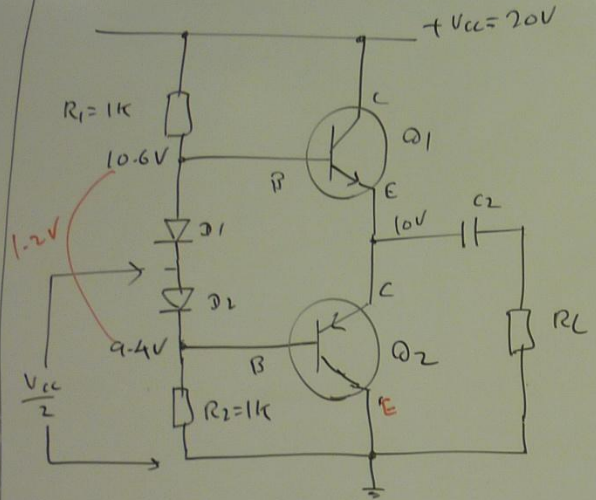
- EACH TRANSISTOR CONDUCTS FOR EXACTLY 180° OF THE INPUT SIGNAL
- THE CROSS OVER DISTORTION IS ELIMINATED
- THE FORWARD BIAS FOR THE TRANSISTOR IS SUPPLIED BY THE INPUT SIGNAL

AMPLIFIER

= THE

PPLIED

DC CONDITION



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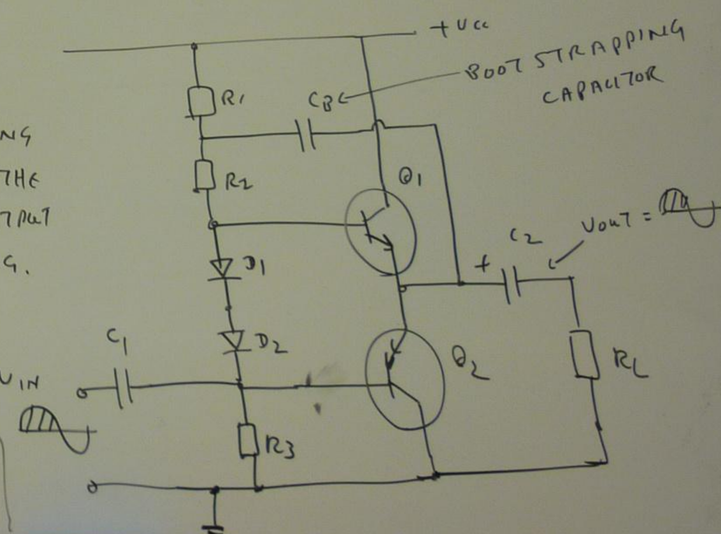
SOME TIME, IT WILL NOT FULFILL $V_E - V_B = 0.6V$ WHEN THE SIGNAL SWING IS HIGHER. THE CROSS OVER DISTORTION CAN HAPPEN AGAIN.

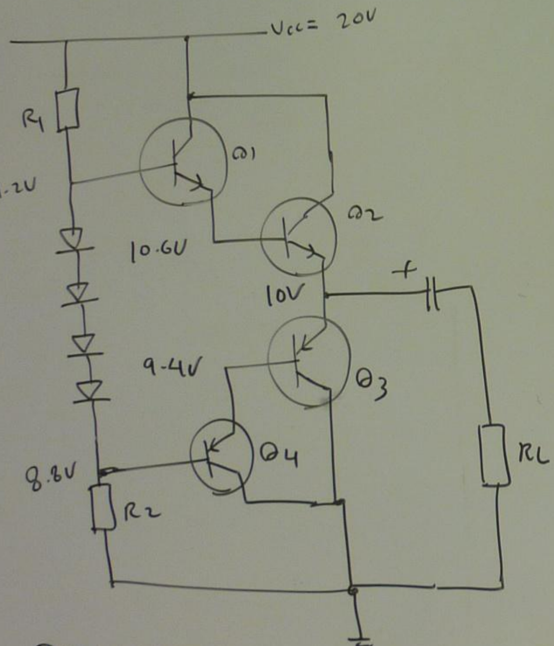
TO ELIMINATE THE CROSS OVER DISTORTION AT HIGH SIGNAL SWING, THE BOOTSTRAPPING CIRCUIT IS APPLIED.

APPLYING BOOTSTRAPPING TO OBTAIN THE GREATER OUTPUT SIGNAL SWING.



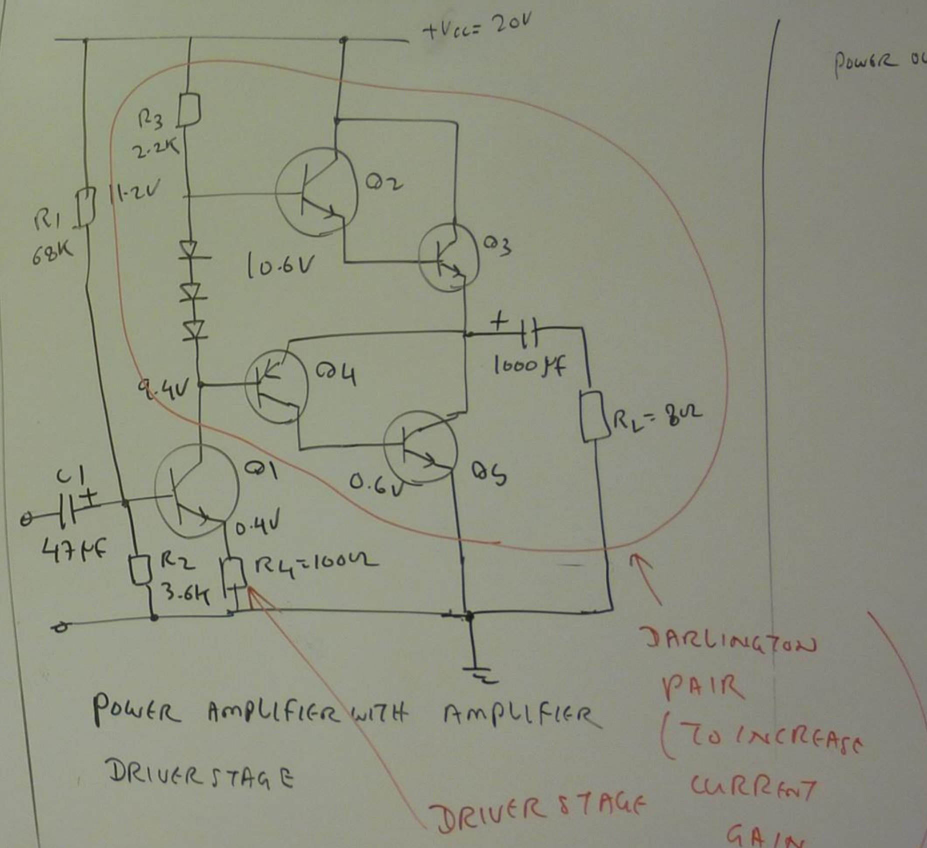
DARLINGTON OUTPUT TRANSISTORS

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



DARLINGTON OUTPUT

QUASI COMPLEMENTARY AMPLIFIER

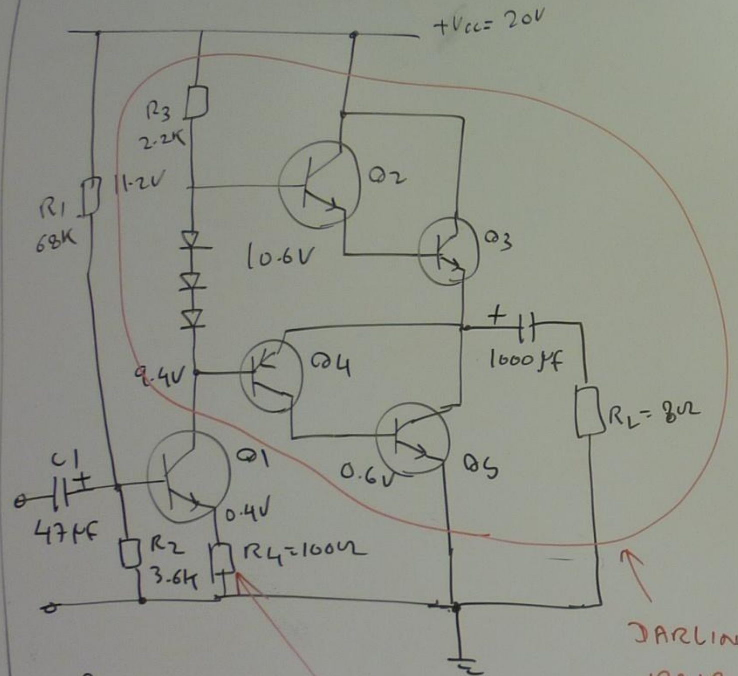


POWER AMPLIFIER WITH AMPLIFIER DRIVER STAGE

POWER OUT P

NSISTORS,

QUASI COMPLEMENTARY AMPLIFIER



DARLINGTON PAIR (TO INCREASE CURRENT GAIN

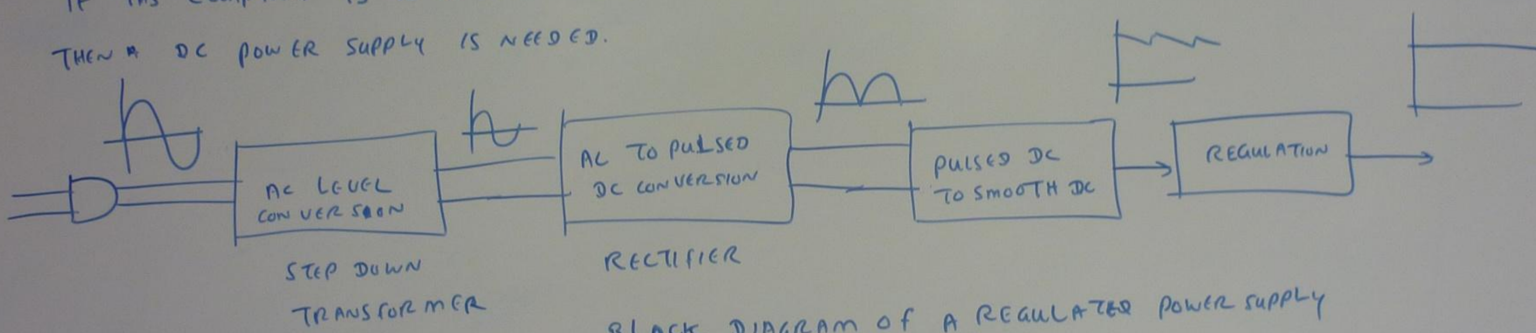
POWER AMPLIFIER WITH AMPLIFIER DRIVER STAGE

DRIVER STAGE

POWER OUTPUT CALCULATION= $\frac{(V_0 \ p-p)^2}{8 R_L}$

POWER SUPPLIES PART (1)

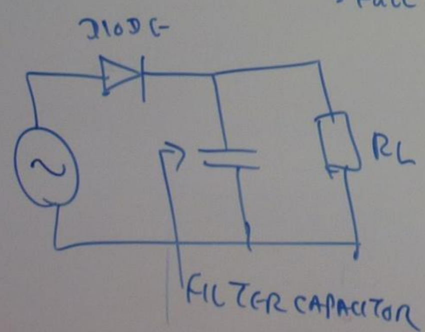
MOST ELECTRONIC EQUIPMENTS REQUIRE SOME FORM OF DC POWER TO OPERATE.
IF THIS EQUIPMENT IS TO BE OPERATED FROM A STANDARD AC OUTLET
THEN A DC POWER SUPPLY IS NEEDED.

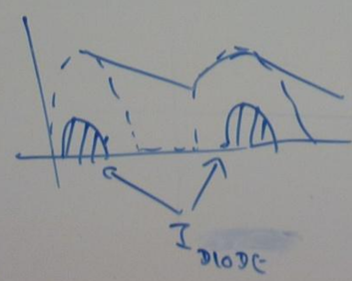


BLOCK DIAGRAM OF A REGULATED POWER SUPPLY

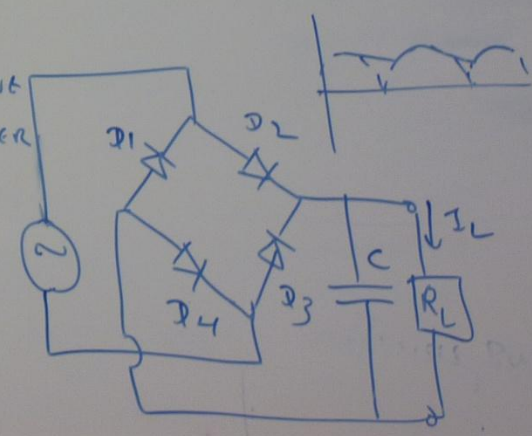
REGULATED POWER SUPPLY → HALF WAVE RECTIFIER
REGULATED POWER SUPPLY → FULL WAVE RECTIFIER

HALF WAVE RECTIFIER

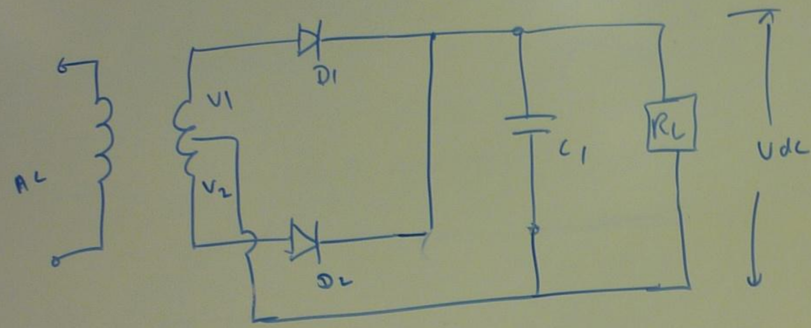




FULL WAVE RECTIFIER



THE CENTRE TAPPED FULL WAVE RECTIFIER



$$V_1 = V_2$$

$$V_{dc} = V_r \, f_r \, R_L \, C$$

V_{dc} = DC OUTPUT VOLTAGE

V_r = PEAK TO PEAK RIPPLE VOLTAGE

f_r = RIPPLE FREQUENCY

C = CAPACITANCE

R_L = LOAD SEEN BY CAPACITOR

Pb CALCULATE THE LOAD RESISTANCE AND CAPACITOR SIZE OF A FULL WAVE RECTIFIER THAT SUPPLIES A 40V DC WITH 2% RIPPLE VOLTAGE (PEAK TO PEAK) AT 250 mA TO A RESISTIVE LOAD. ASSUME THE RECTIFIER IS SUPPLIED WITH 50 HZ AC.

$$R_L = \frac{V_0}{I_L} = \frac{40}{250 \times 10^{-3}} = 160\,\Omega$$

$$V_r = 2\% \times \text{DC VOLTAGE}$$

$$= \frac{2}{100} \times 40 = 0.8\,V$$

$$\boxed{f_r = 2 f_{supply} \qquad f_r = 2 \times 50 = 100\,Hz}$$

$$V_{DC} = V_r \, f_r \, R_L \, C$$

$$40 = 0.8 \times 100 \times 100 \times C$$

$$C = \frac{40}{0.8 \times 100 \times 100} = 3125 \times 10^{-6}\,F$$

$$= 3125\,\mu F$$

CIRCUIT	V_{DC}	RIPPLE FREQUENCY
1/2 WAVE	U_{max}	f_{supply}
BRIDGE	U_{max}	$2f_{supply}$
C.T FULL WAVE	V_{max}	$2f_{supply}$

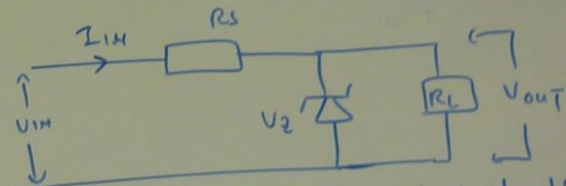
LOAD REGULATION

$$\%\text{ LOAD REGULATION} = \frac{V_{dc(NO\ LOAD)} - V_{dc(FULL\ LOAD)}}{V_{dc(FULL\ LOAD)}} \times 100$$

POWER SUPPLIES – PART (2)

THE PURPOSE OF VOLTAGE REGULATION IS TO MAINTAIN A CONSTANT VOLTAGE ACROSS A LOAD REGARDLESS OF ANY CHANGE IN LOAD CONDITION OR SUPPLY VOLTAGE.

THE BASIC REGULATING DEVICE IS ZENER DIODE.



THE OUTPUT VOLTAGE ACROSS LOAD L IS EQUAL TO ZENER VOLTAGE V_Z.

THE OUTPUT VOLTAGE IS KEPT CONSTANT DESPITE THE CHANGES IN V_{IN} AND I_L BECAUSE THE ZENER CURRENT VARIES TO CHANGE THE VOLTAGE ACROSS THE SERIES RESISTOR R_S TO COMPENSATE.

POWER SUPPLIES – PART (2)

THE PURPOSE OF VOLTAGE REGULATION IS TO MAINTAIN A CONSTANT VOLTAGE ACROSS A LOAD REGARDLESS OF ANY CHANGE IN LOAD CONDITION OR SUPPLY VOLTAGE.

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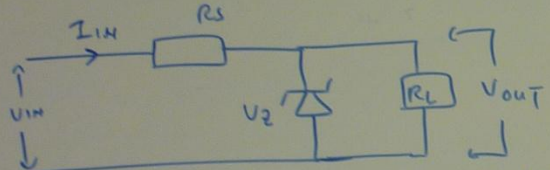

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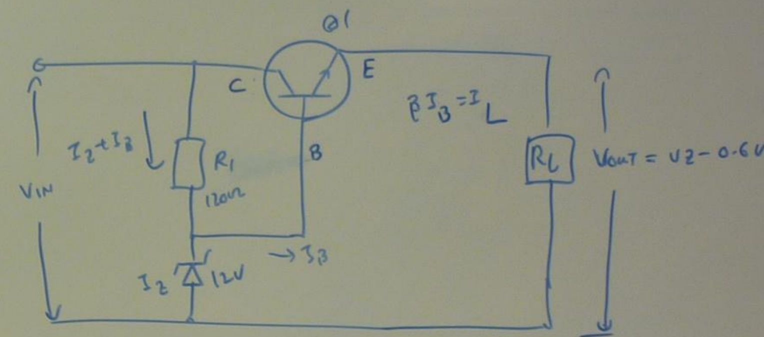
THE OUTPUT VOLTAGE IS KEPT CONSTANT DESPITE CHANGES IN V_{IN} AND I_L BECAUSE THE ZENER CURRENT VARIES TO CHANGE THE VOLTAGE ACROSS THE SERIES RESISTOR R_S TO COMPENSATE.

SERIES TRANSISTOR REGULATOR

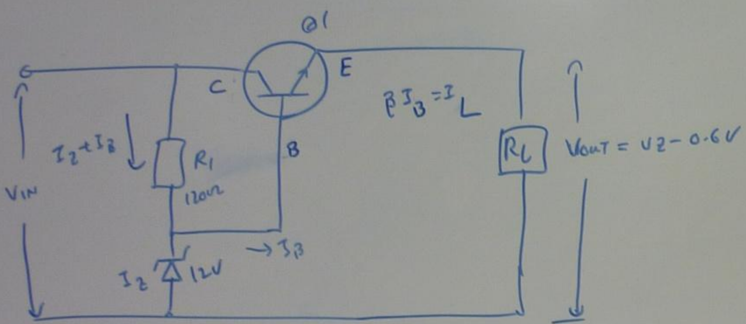


AN INCREASE IN THE LOAD CURRENT WILL CAUSE THE ZENER CURRENT TO REDUCE AS MORE BASE CURRENT IS REQUIRED BY THE TRANSISTOR.

IF THE INPUT VOLTAGE CHANGES, THE ZENER CURRENT WILL ALSO CHANGE, BUT THE ZENER VOLTAGE WILL REMAIN CONSTANT KEEPING THE OUTPUT CONSTANT.

THE INPUT VOLTAGE MUST BE HIGHER THAN REQUIRED OUTPUT VOLTAGE BY AT LEAST 2V.

SERIES TRANSISTOR REGULATOR



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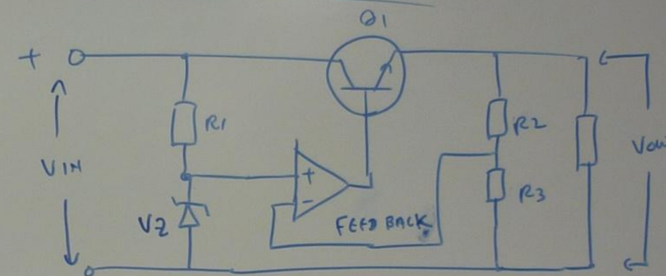
REGULATOR WITH FEEDBACK

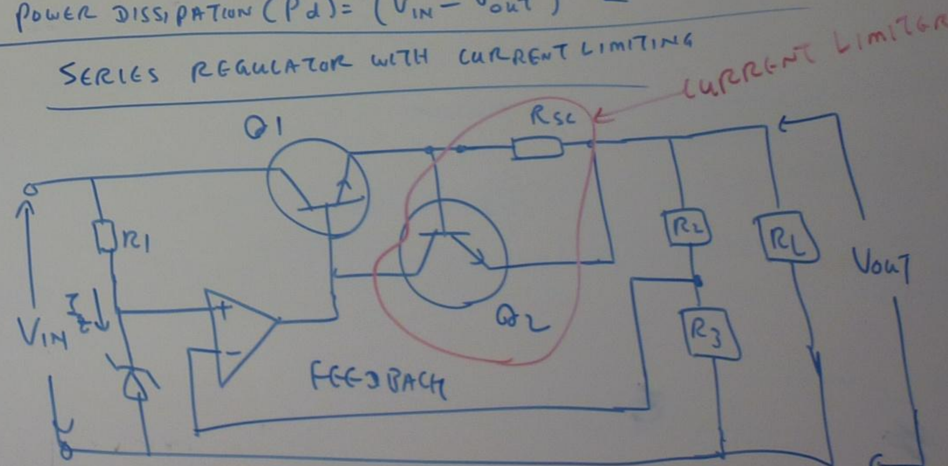


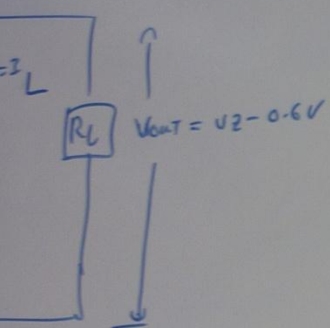
$$V_{OUT} = \left(\frac{R_2}{R_3} + 1\right) \times V_{REF}$$

$$V_{REF} = V_Z$$

$$\text{POWER DISSIPATION } (P_d) = (V_{IN} - V_{OUT})\, I_L$$

SERIES REGULATOR WITH CURRENT LIMITING



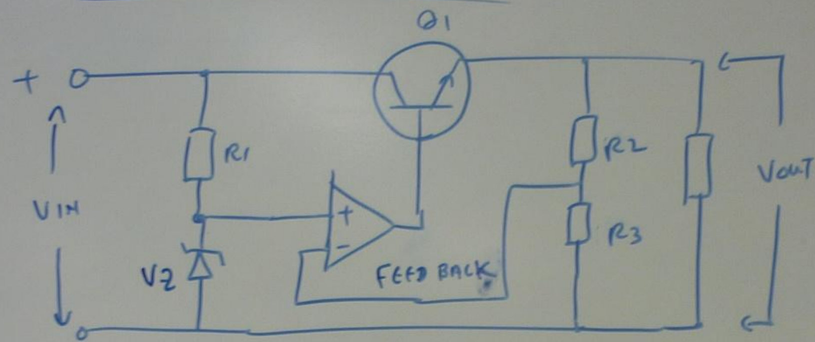


RRENT WILL CAUSE
LCE AS MORE
BY THE TRANSISTOR.

LES, THE ZENER
BUT THE ZENER
TANT KEEPING

= HIGHER THAN
BY AT LEAST 2V.

REGULATOR WITH FEEDBACK



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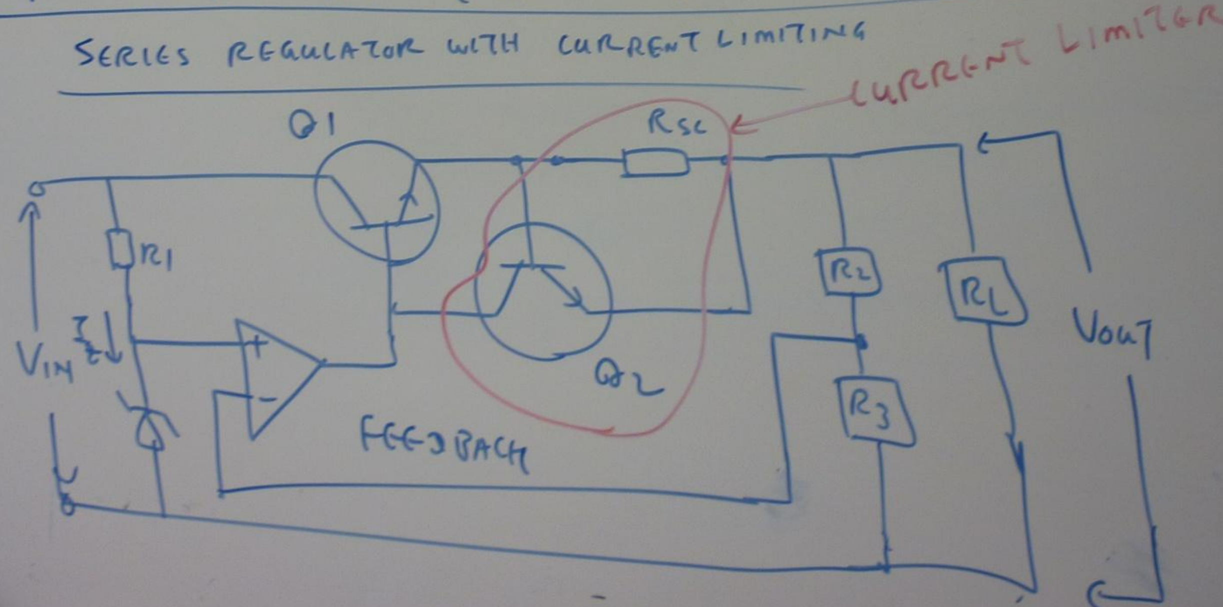
SERIES REGULATOR WITH CURRENT LIMITING



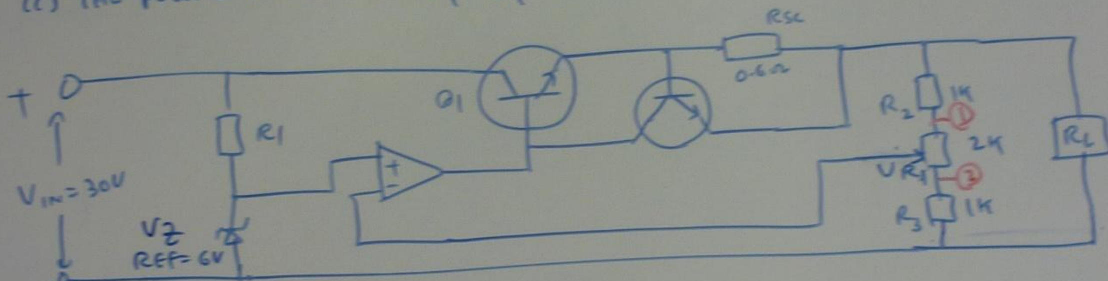
Pb

FOR THE GIVEN CIRCUIT, CALCULATE

(a) THE MAXIMUM AND MINIMUM OUTPUT VOLTAGES

(b) THE CURRENT THAT WILL FLOW IF THE OUTPUT IS SHORT CIRCUITED

(c) THE POWER DISSIPATED BY Q_1 IF THE OUTPUT IS SHORT CIRCUITED



$$V_{OUT} = \left(\frac{R_2}{R_3} + 1\right) \times V_{REF}$$

$$V_{REF} = V_Z = 6V$$

V_{R1} AT POSITION 1 $R_2 = 1K\Omega$, $R_3 = 3K\Omega$

$$V_{OUT} = \left(\frac{1}{3} + 1\right) \times 6 = 8V$$

V_{R1} AT POSITION 2 $R_2 = 3K$ $R_3 = 1K$

$$V_{OUT} = \left(\frac{3}{1} + 1\right) \times 6 = 24V$$

$$I_{SC} = \frac{0.6}{R_{SC}}$$

$$= \frac{0.6}{0.6}$$

(MAXIMUM POW

$$P_d = (V_{IN} -$$

$$= (30 - 0$$

$$= 30W$$

THREE TERM

78XX,

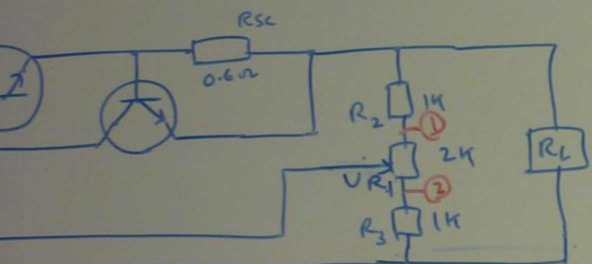
LM31

...LATE

...PUT VOLTAGES

...IF THE OUTPUT IS SHORT CIRCUITED

IF THE OUTPUT IS SHORT CIRCUITED



$\times V_{REF}$

$V_{REF} = V_Z = 6V$

$R_2 = 1k\Omega$, $R_3 = 3k\Omega$

$+1) \times 6 = 8V$

$R_2 = 3k$ $R_3 = 1k$

$+1) \times 6 = 24V$

$I_{sc} = \dfrac{0.6}{R_{sc}}$

$= \dfrac{0.6}{0.6} = 1A$

(MAXIMU POWER DISSIPATION → OUTPUT SHORT CIRCUIT

$V_{OUT} = 0$, $I_{sc} = I_L$

$P_d = (V_{IN} - V_{OUT}) \times I_{sc}$

$= (30 - 0) \times 1$

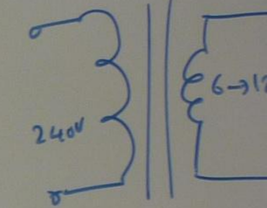
$= 30W$

THREE TERMINALS REGULATORS

78XX, 79XX, 78HOS

LM317

5 V...



1 — INPUT...

2 — COMMON...

3 — OUTPU...

MAXIMUM R...

INPUT VO...

OUTPUT ...

POWER DIS...

$I_{SC} = \frac{0.6}{R_{SC}}$

$= \frac{0.6}{0.6} = 1A$

(MAXIMUM POWER DISSIPATION → OUTPUT SHORT CIRCUIT

$V_{OUT} = 0$, $I_{SC} = I_L$

$P_d = (V_{IN} - V_{OUT}) \times I_{SC}$

$= (30 - 0) \times 1$

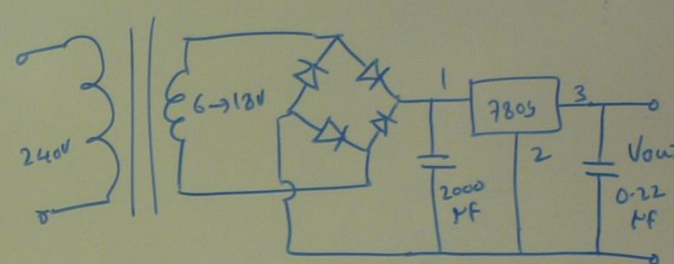
$= 30W$

THREE TERMINALS REGULATORS

78XX, 79XX, 78H05

LM317

5V POWER SUPPLY



1 — INPUT

2 — COMMON

3 — OUTPUT

MAXIMUM RATINGS

INPUT VOLTAGE = 35V

OUTPUT CURRENT = 1A

POWER DISSIPATION — INTERNALLY LIMITED.

Q) CALCULA

SIZE OF A FU

40V DC WIT

AT 250 mA

RECTIFIER IS

$R_L =$

$V_r = 2$

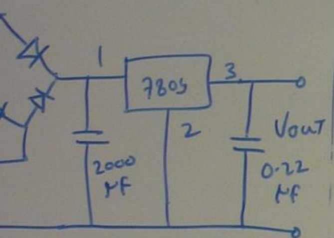
$=$

$V_{DC} =$

$40 =$

$C =$

...ER SUPPLY



= 35V

...NT = 1A

...ON – INTERNALLY LIMITED.

Pb) CALCULATE THE LOAD RESISTANCE AND CAPACITOR SIZE OF A FULL WAVE RECTIFIER THAT SUPPLIES A 40V DC WITH 2% RIPPLE VOLTAGE (PEAK TO PEAK) AT 250 mA TO A RESISTIVE LOAD. ASSUME THE RECTIFIER IS SUPPLIED WITH 50 HZ AC.

$$R_L = \frac{V_0}{I_L} = \frac{40}{250\times10^{-3}} = 160\,\Omega$$

$V_r = 2\% \times$ DC VOLTAGE

$$= \frac{2}{100} \times 40 = 0.8V$$

$$\boxed{\begin{aligned} f_r &= 2 f_{supply} \\ f_r &= 2\times50 \\ &= 100Hz \end{aligned}}$$

$$V_{DC} = V_r\, f_r\, R_L\, C$$

$$40 = 0.8 \times 100 \times 160 \times C$$

$$C = \frac{40}{0.8\times100\times160} = 3125\times10^{-6}\, F$$

$$= 3125\,\mu F$$

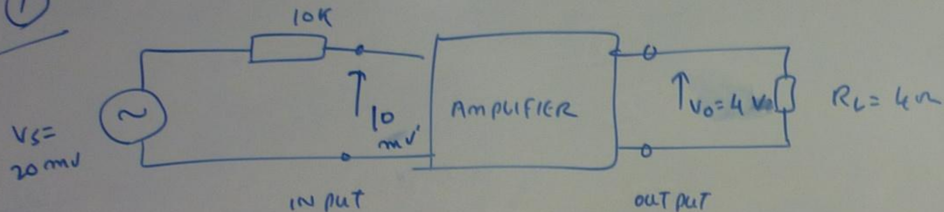
CIRCUIT	V_{DC}	RIPPLE FREQUENCY
½ WAVE	V_{max}	f_{supply}
BRIDGE	V_{max}	$2 f_{supply}$
C.T FULL WAVE	V_{max}	$2 f_{supply}$

LOAD REGULATION

$$\%\,\text{LOAD REGULATION} = \frac{V_{dc(\text{NO LOAD})} - V_{dc(\text{FULL LOAD})}}{V_{dc(\text{FULL LOAD})}} \times 100$$

POWER AMPLIFIER CIRCUIT CALCULATIONS

pb 1



FIND (a) VOLTAGE GAIN (b) INPUT CURRENT
(c) OUTPUT CURRENT (d) CURRENT GAIN.
(e) OUTPUT POWER (f) POWER GAIN
(g) TRANRESISTANCE (h) TRANSCONDUCTANCE.

(a) VOLTAGE GAIN $(A_V) = \frac{V_O}{V_{IN}} = \frac{4}{10 \times 10^{-3}}$

$= \frac{4000}{10} = 400$

(b) VOLTAGE DROP ACROSS 10 KΩ RESISTOR $= 20 - 10 = 10 mV$

$I = \frac{10 mV}{10k} = \frac{10 \times 10^{-3}}{10 \times 10^{3}} = 1 \times 10^{-6}$

$= 1 \mu A$

(c) $I_{OUT} = \frac{4V}{4\Omega} = 1A$

(d) CURRENT GAIN $= \frac{I_{OUT}}{I_{IN}}$

$= \frac{1}{1 \mu A}$

$= \frac{1}{1 \times 10^{-6}}$

$= \frac{10^6}{1}$

$= 10^6$

(e) $P_{OUT} = V_{OUT} \times I_{OUT}$

$= 4 \times 1 = 4W$

(f) $P_{IN} = V_{IN} \times I_{in} = 10 \times 10^{-3} \times 1 \times 10^{-6}$

$= 10 \times 10^{-9}$ W

$P_{OUT} = 4W$

$R_L = 4\Omega$

$\ldots \times 10^{-3}$

$\frac{4000}{10} = 400$

$\ldots mV$

1×10^{-6}

$= 1\ \mu A$

(c) $I_{OUT} = \frac{4V}{4\Omega} = 1A$

(d) CURRENT GAIN $= \frac{I_{OUT}}{I_{IN}}$

$= \frac{1}{1\mu A}$

$= \frac{1}{1\times10^{-6}}$

$= \frac{10^6}{1}$

$= 10^6$

(e) $P_{OUT} = V_{OUT} \times I_{OUT}$

$= 4 \times 1 = 4W$

(f) $P_{IN} = V_{IN} \times I_{IN} = 10\times10^{-3} \times 1\times10^{-6}$

$= 10\times10^{-9}$ W

$P_{OUT} = 4W$

$A_P = \frac{P_{OUT}}{P_{IN}} = \frac{4}{10\times10^{-9}} = \frac{4\times10^9}{10}$

$= 0.4\times10^9$

$= 4\times10^8$

(g) TRAN RESISTANCE $= \frac{V_{OUT}}{I_{IN}}$

$= \frac{4}{1\times10^{-6}} = 4\times10^6\ \Omega$

$= 4M\Omega$

(h) TRANS CONDUCTANCE $= \frac{I_{OUT}}{V_{IN}}$

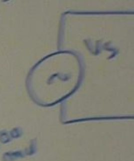
$= \frac{1}{10mV}$

$= \frac{1}{10\times10^{-3}}$

$= \frac{10^3}{10}$

$= 100\ \mho$

pb ②



IN ABOVE…

(b) TOT…

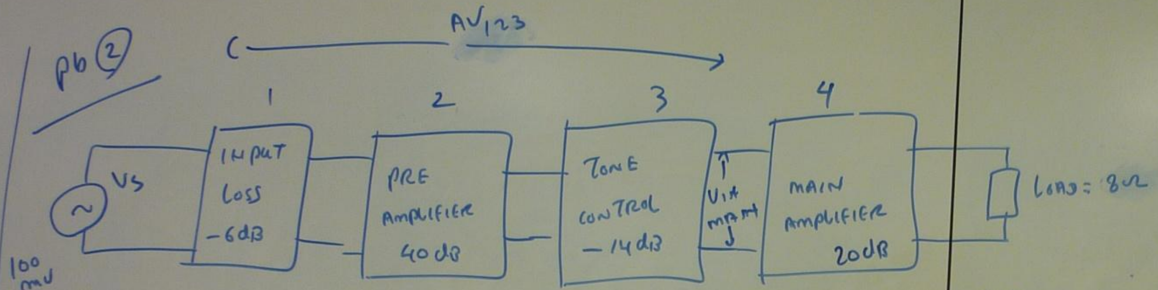
PRE-AM…

(c) OUT…

A_V

(a) dB_T…

pb ②



IN ABOVE CIRCUIT. FIND (a) TOTAL VOLTAGE GAIN IN dB (b) TOTAL VOLTAGE GAIN IN DIRECT RATIO (c) INPUT VOLTAGE OF PRE-AMPLIFIER (d) INPUT VOLTAGE OF MAIN AMPLIFIER (e) OUTPUT VOLTAGE OF AMPLIFIER

$$A_V(dB) = 20\log_{10}\frac{V_2}{V_1}$$

$$\frac{V_2}{V_1} = 10^{\frac{AV(dB)}{20}}$$

$$A_V = 10^{\frac{AV(dB)}{20}}$$

$$dB_T = dB_1 + dB_2 + dB_3$$

$$AV_T = A_1 \times AV_2 \times AV_3$$

(a) $dB_T = dB_1 + dB_2 + dB_3 + dB_4$

$$= (-6) + (40) + (-14) + 20 = 40$$

(b) $AV_T = AV_1 \times AV_2 \times AV_3 \times AV_4$

$$= 10^{\frac{AV_1(dB)}{20}} \times 10^{\frac{AV_2(dB)}{20}} \times 10^{\frac{AV_3(dB)}{20}} \times 10^{\frac{A_4(dB)}{20}}$$

$$= 10^{\frac{-6}{20}} \times 10^{\frac{40}{20}} \times 10^{\frac{-14}{20}} \times 10^{\frac{20}{20}}$$

$$= 10^{-0.3} \times 10^{2} \times 10^{-0.7} \times 10^{1}$$

$$= 10^{(-0.3)+2+(-0.7)+1}$$

$$= 10^{2} = 100$$

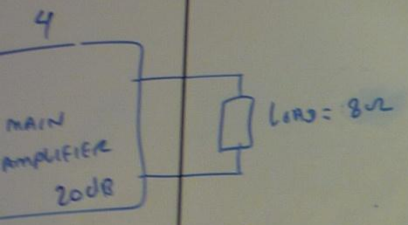
(c) $AV_{123} = 10^{\frac{AV_1(dB)}{20}} \times 10^{\frac{AV_2(dB)}{20}} \times 10^{\frac{AV_3(dB)}{20}}$

$$= 10^{-0.3} \times 10^{2} \times 10^{-0.7}$$

$$= 10^{-0.3+2+(-0.7)} = 10^{1} = 10$$

(d) V_{IN}

(e) V



dB

TAGE OF
FIER

dB3

AV3

(b) $A_{V_T} = A_{V_1} \times A_{V_2} \times A_{V_3} \times A_{V4}$

$= 10^{\frac{A_{V_1}(dB)}{20}} \times 10^{\frac{A_{V_2}(dB)}{20}} \times 10^{\frac{A_{V_3}(dB)}{20}} \times 10^{\frac{A_4(dB)}{20}}$

$= 10^{\frac{-6}{20}} \times 10^{\frac{40}{20}} \times 10^{\frac{-14}{20}} \times 10^{\frac{20}{20}}$

$= 10^{-0.3} \times 10^{2} \times 10^{-0.7} \times 10^{1}$

$= 10^{(-0.3)+2+(-0.7)+1}$

$= 10^{2} = 100$

(c) $A_{V123} = 10^{\frac{A_{V_1}(dB)}{20}} \times 10^{\frac{A_{V_2}(dB)}{20}} \times 10^{\frac{A_{V_3}(dB)}{20}}$

$= 10^{-0.3} \times 10^{2} \times 10^{-0.7}$

$= 10^{-0.3+2+(-0.7)} = 10^{1} = 10$

(d) $V_{IN\,(MAIN)} = V_S \times A_{V\,123}$

$= (100 \times 10^{-3}) \times 10$

$= 100 \times 10^{-3} \times 10$

$= 1V$

(e) $V_{OUT} = V_{IN\;MAIN} \times A_{V4}$

$= 1 \times 10^{\frac{A_{V4}(dB)}{20}}$

$= 1 \times 10^{\frac{20}{20}}$

$= 1 \times 10^{1}$

$= 10V$

Pb(3)

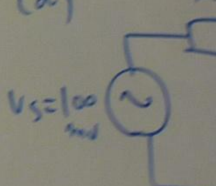
FOR THE

SIGNAL SOURCE
$V_S = 100mV$
$R_S = 1K$

(a) DRAW THE E
(b) DETERMINE
(c) DETERMINE
(d) DETERMINE
TO ACHIEVE

AMPLIFI

(a)



(d) $V_{IN\,(MAIN)} = V_S \times A_{V\,123}$

$= (100 \times 10^{-3}) \times 10$

$= 100 \times 10^{-3} \times 10$

$= 1V$

(e) $V_{OUT} = V_{IN\,MAIN} \times AV_4$

$= 1 \times 10^{\frac{AV_4\,(dB)}{20}}$

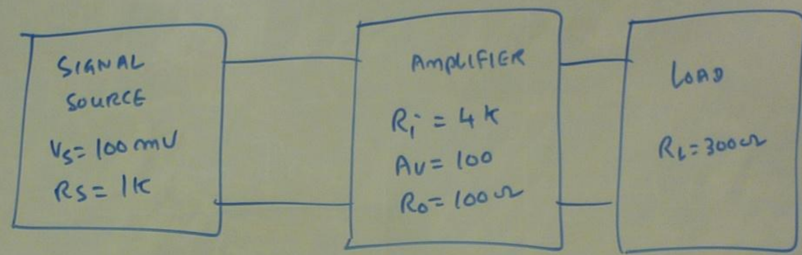
$= 1 \times 10^{\frac{20}{20}}$

$= 1 \times 10^{1}$

$= 10V$

pb(3)

FOR THE AMPLIFIER CONNECTION BELOW

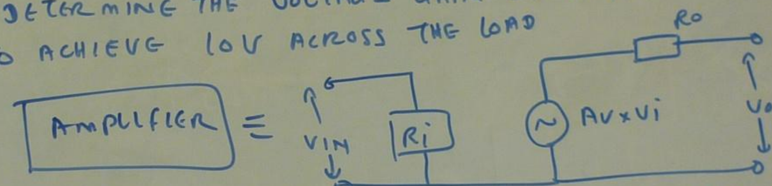


(a) DRAW THE EQUIVALENT CIRCUIT

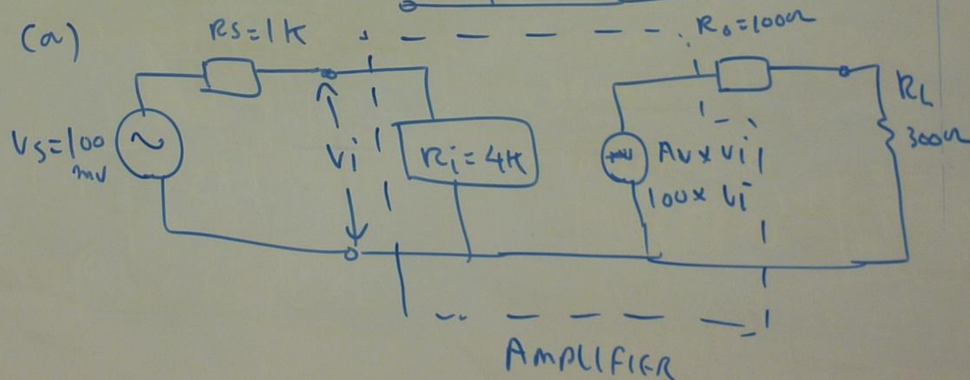
(b) DETERMINE THE INPUT VOLTAGE OF AMPLIFIER

(c) DETERMINE THE OUTPUT VOLTAGE OF AMPLIFIER

(d) DETERMINE THE VOLTAGE GAIN OF AMPLIFIER TO ACHIEVE 10V ACROSS THE LOAD



(a)



(b) $V_i = V_S \times \frac{R_i}{R_S + R_i}$

(c) $V_{OUT} = A_V \times V_i$

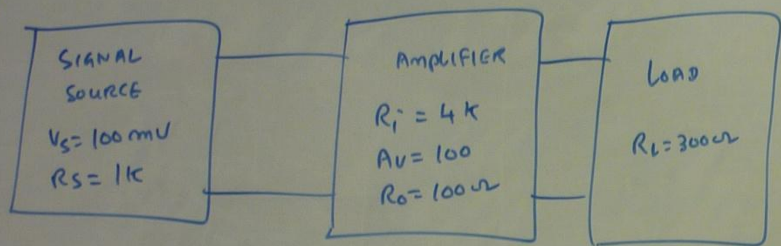
(d) $V_{OUT} = 10V$

$V_{IN} = 80\,mV$

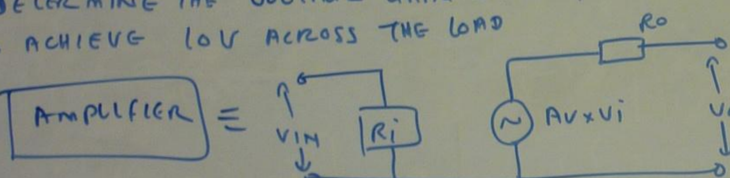
$A_V = \frac{V_{OUT}}{V_{IN}}$

pb(3)

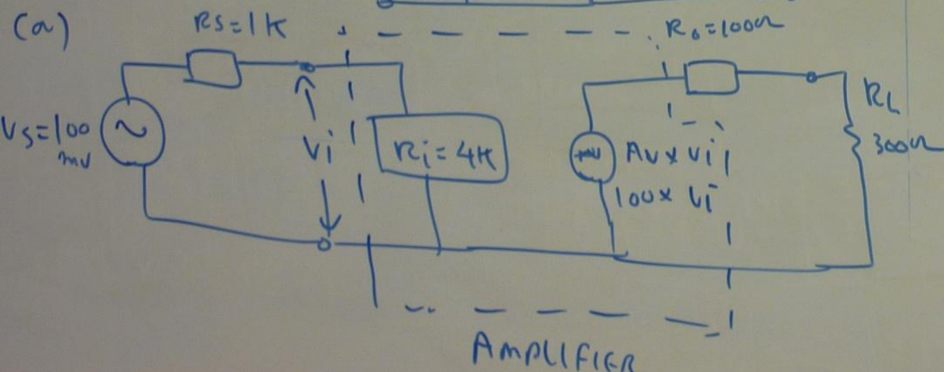
FOR THE AMPLIFIER CONNECTION BELOW



(a) DRAW THE EQUIVALENT CIRCUIT
(b) DETERMINE THE INPUT VOLTAGE OF AMPLIFIER
(c) DETERMINE THE OUTPUT VOLTAGE OF AMPLIFIER
(d) DETERMINE THE VOLTAGE GAIN OF AMPLIFIER TO ACHIEVE 10V ACROSS THE LOAD



(a)



(b) $V_i = V_S \times \dfrac{R_i}{R_S + R_i} = 100 \times \dfrac{4}{1+4} = \dfrac{100 \times 4}{8} = 80\,mV$

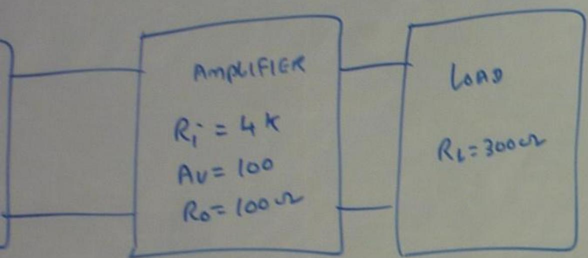
(c) $V_{OUT} = A_V \times V_i = 100 \times 80\,mV = 100 \times 80 \times 10^{-3} = 8V$

(d) $V_{OUT} = 10V$

$V_{IN} = 80\,mV$

$A_V = \dfrac{V_{OUT}}{V_{IN}} = \dfrac{10}{80 \times 10^{-3}} = \dfrac{1000}{80} = 12.5$

E AMPLIFIER CONNECTION BELOW



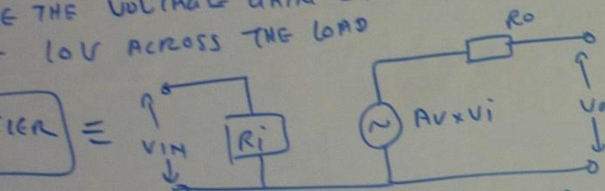
QUIVALENT CIRCUIT

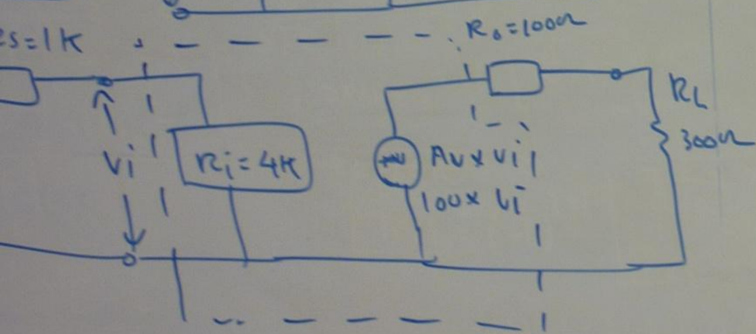
THE INPUT VOLTAGE OF AMPLIFIER

THE OUTPUT VOLTAGE OF AMPLIFIER

E THE VOLTAGE GAIN OF AMPLIFIER

\- 10V ACROSS THE LOAD





AMPLIFIER

(b) $v_i = V_s \times \dfrac{R_i}{R_s + R_i} = 100 \times \dfrac{4}{1+4} = \dfrac{100 \times 4}{8} = 80\,mV$

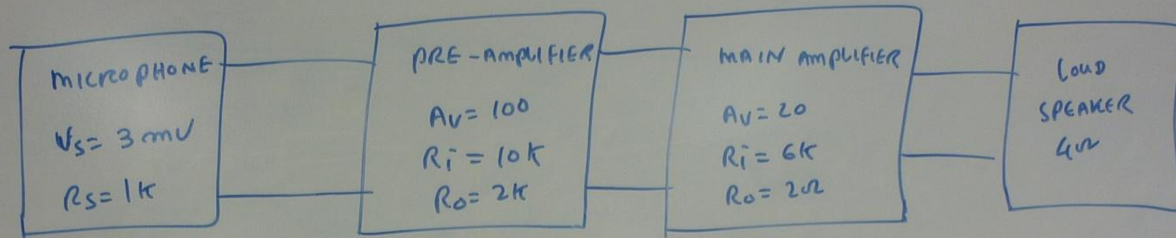
(c) $V_{OUT} = A_v \times v_i = 100 \times 80\,mV = 100 \times 80 \times 10^{-3} = 8V$

(d) $V_{OUT} = 10V$

$V_{IN} = 80\,mV$

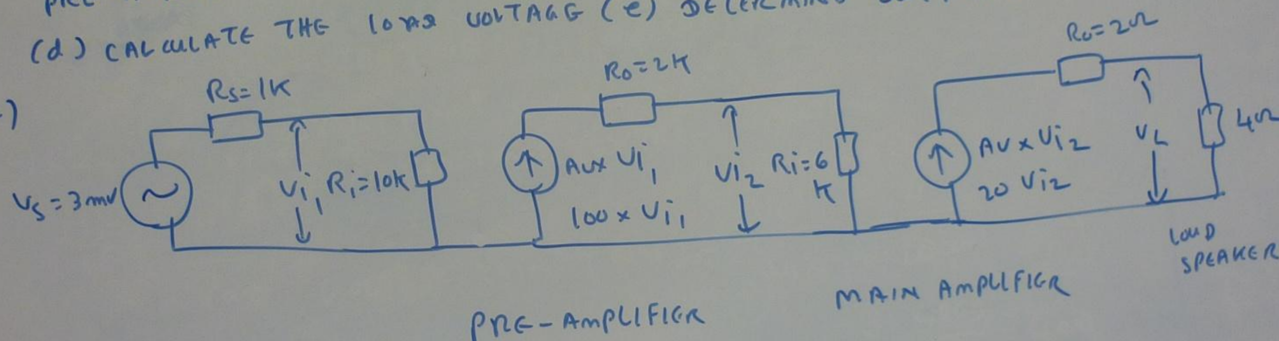
$$A_v = \frac{V_{OUT}}{V_{IN}} = \frac{10}{80 \times 10^{-3}} = \frac{1000}{80} = 12.5$$

Pb 4



THE ABOVE DIAGRAM IS A MULTI STAGE AMPLIFIER
(a) DRAW AN EQUIVALENT CIRCUIT (b) CALCULATE THE INPUT VOLTAGE OF PRE-AMPLIFIER (c) CALCULATE THE INPUT VOLTAGE OF MAIN AMPLIFIER (d) CALCULATE THE LOAD VOLTAGE (e) DETERMINE OUTPUT POWER.

(a)



(b) $V_{i_1} = ?$

$$V_{i_1} = V_s \times \frac{R_i}{R_s + R_i} = 3\,mV \times \frac{10K}{(1+10)K} = 2.72\,mV$$

(c) $A_v \times V_{i_1} = 2.72 \times 100 = 272\,mV$
mV

$V_{i_2} =$

=

=

(d) $A_v \times$

$V_L =$

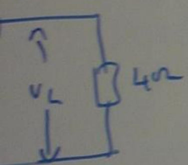
=

LOUD SPEAKER 4Ω

OF

R

2Ω



72 mV

$Vi_2 = AV \times vi_1 \times \frac{Ri}{Ri + Ro}$

$= 272 \times \frac{6}{6+2}$

$= 204\ mV$

(d) $AV \times Vi_2 = 20 \times 204\ mV$

$= 20 \times 0.204$

$= 4.08\ V$

$V_L = (AV \times Vi_2) \times \frac{RL}{Ro + RL}$

$= 4.08 \times \frac{4}{4+2}$

$= \frac{4.08 \times 4}{6} = \frac{16.32}{6}$

$= 2.7\ V$

$P_{OUT} = \frac{V_{OUT}^2}{RL}$

$= \frac{(2.7)^2}{4}$

$= \frac{2.7 \times 2.7}{4}$

$= 1.8225\ W$

pb 5 PLOT THE FREQUENCY RES

FROM AN AMPLIFIER AND INDICAT

VOLTAGE GAIN $Av = \frac{Vo}{Vi}$,

POWER AT LOAD $= \frac{V_o^2}{R}$, Po

FREQUENCY (HZ)	Vi (mV)	Vo (V)	VOLTAGE
10	100	1	$\frac{1}{100 \times 10^{-3}}$
20	100	1.96	$\frac{1.96}{100 \times 10^{-3}}$
40	100	3.71	37
100	100	7.07	70
200	100	8.44	8
400	100	9.28	
1k	100	9.95	
2k	100	10	
4k	100	10	
10k	100	9.95	
20k	100	9.81	

MID BAND

$P_{OUT} = \frac{V_{OUT}^2}{R_L}$

$= \frac{(2.7)^2}{4}$

$= \frac{2.7 \times 2.7}{4}$

$= 1.8225\ W$

pb 5 PLOT THE FREQUENCY RESPONSE OF THE FOLLOWING DATA OBTAINED FROM AN AMPLIFIER AND INDICATE MID BAND AND HALF POWER POINT.

VOLTAGE GAIN $A_V = \frac{V_O}{V_I}$, VOLTAGE GAIN (dB) = $20 \log_{10} \frac{V_O}{V_I}$

POWER AT LOAD = $\frac{V_O^2}{R}$, POWER GAIN (dB) = $10 \log \frac{\text{POWER AT LOAD}}{\text{BASE POWER}}$

FREQUENCY (HZ)	VI (mV)	VO (V)	VOLTAGE GAIN	VOLTAGE GAIN (dB)	LOAD POWER 10Ω	POWER GAIN (dB) 1mW = 0 dB
10	100	1	$\frac{1}{100 \times 10^{-3}} = 10$	$20 \log_{10} \frac{1}{100 \times 10^{-3}} = 20$	$\frac{1^2}{10} = 0.1\ W$	$10 \log \frac{0.1}{1 \times 10^{-3}} = 10$
20	100	1.96	$\frac{1.96}{100 \times 10^{-3}} = 19.6$	$20 \log_{10} \frac{1.96}{100 \times 10^{-3}} = 25.8$	$\frac{1.96^2}{10} = 0.384\ W$	$10 \log \frac{0.384}{1 \times 10^{-3}} = 15.3$
40	100	3.71	37.1	31.3	1.376	31.3
100	100	7.07	70.7	36.9	4.99	36.9
200	100	8.94	89.4	39	7.94	39.02
400	100	9.28	92.8	39.3	8.61	39.35
1k	100	9.95	99.5	19.5	9.9	39.95
2k	100	10	100	40	10	40
4k	100	10	100	40	10	40
10k	100	9.95	99.5	39.9	9.9	39.95
20k	100	9.81	98.1	39.8	9.62	39.83

MID BAND

HALF P

MID

$\frac{V_{OUT}^2}{R_L}$

$\frac{(2.7)^2}{4}$

$\frac{2.7 \times 2.7}{4}$

1.8225 W

pb 5 PLOT THE FREQUENCY RESPONSE OF THE FOLLOWING DATA OBTAINED FROM AN AMPLIFIER AND INDICATE MID BAND AND HALF POWER POINT.

VOLTAGE GAIN $A_V = \frac{V_O}{V_I}$, VOLTAGE GAIN (dB) = $20 \log_{10} \frac{V_O}{V_I}$

POWER AT LOAD = $\frac{V_O^2}{R}$, POWER GAIN (dB) = $10 \log \frac{\text{POWER AT LOAD}}{\text{BASE POWER}}$

FREQUENCY (HZ)	Vi (mV)	Vo (V)	VOLTAGE GAIN	VOLTAGE GAIN (dB)	LOAD POWER 10Ω	POWER GAIN (dB) 1mW = 0 dB
10	100	1	$\frac{1}{100\times10^{-3}} = 10$	$20 \log_{10} \frac{1}{100\times10^{-3}} = 20$	$\frac{1^2}{10} = 0.1$ W	$10 \log \frac{0.1}{1\times10^{-3}} = 10$
20	100	1.96	$\frac{1.96}{100\times10^{-3}} = 19.6$	$20 \log_{10} \frac{1.96}{100\times10^{-3}} = 25.8$	$\frac{1.96^2}{10} = 0.384$ W	$10 \log \frac{0.384}{1\times10^{-3}} = 15.3$
40	100	3.71	37.1	31.3	1.376	31.3
100	100	7.07	70.7	36.9	4.99	36.9
200	100	8.94	89.4	39	7.94	39.02
400	100	9.28	92.8	39.3	8.61	39.35
1k	100	9.95	99.5	19.5	9.9	39.95
2k	100	10	100	40	10	40
4k	100	10	100	40	10	40
10k	100	9.95	99.5	39.9	9.9	39.95
20k	100	9.81	98.1	39.8	9.62	39.83

MID BAND

HALF POWER POINT(

MID BAND

FREQUENCY (
40k
100k
200k
400k
1m

FREQUENCY (HZ)	Vi (mV)	Vo (V)	VOLTAGE GAIN	VOLTAGE GAIN (dB)	10Ω LOAD POWER	POWER GAIN (dB)
40K	100	9.28	92.8	39.8	8.61	39.35
100K	100	7.07	70.7	36.9	4.99	36.9
200K	100	4.47	44.7	33	1.99	32.9
400K	100	2.43	24.3	27.7	0.59	27.7
1M	100	1	10	20	0.1	10

HALF POWER POINT (2)

...ER GAIN (dB)

...mW = 0 dB

$\frac{0.1}{1\times10^{-3}} = 10$

$\frac{0.384}{1\times10^{-3}} = 15.3$

31.3

36.9

39.02

39.35

39.45

40

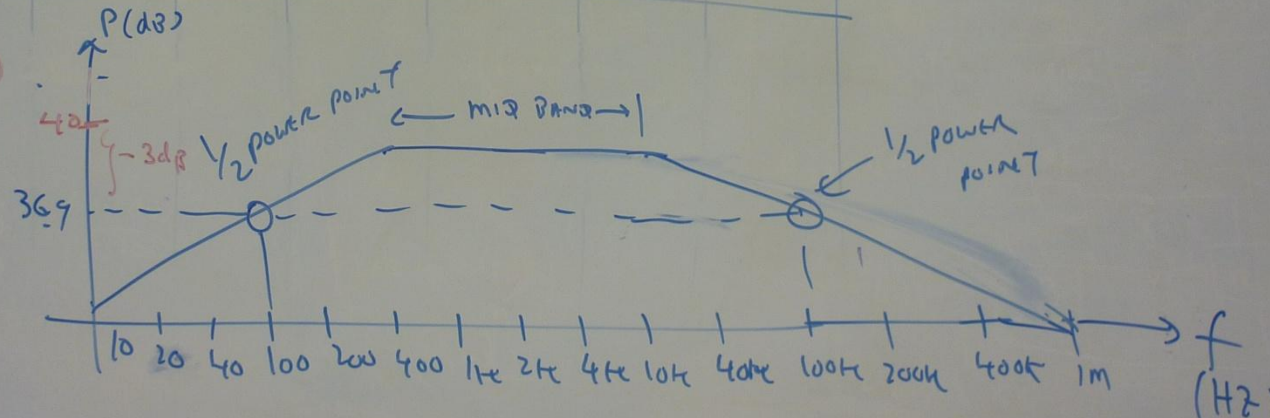
40

39.45

39.83

HALF POWER POINT (1)

MID BAND



pb 6

AN AUDIO SIGNAL GENERATOR WHOSE SOURCE RESISTANCE IS 600 Ω IS CONNECTED TO AN AMPLIFIER WHICH HAS A 3 kΩ INPUT RESISTANCE. A 1 μF COUPLING CAPACITOR IS EMPLOYED THE SIGNAL SOURCE AND THE AMPLIFIER. DETERMINE THE LOWER HALF POWER FREQUENCY.

$$f_{L-3dB} = \text{LOWER HALF POWER FREQUENCY} = \frac{1}{2\pi (R_S + R_i) C}$$

R_S = SOURCE RESISTANCE, R_i = INPUT RESISTANCE OF AMPLIFIER, C = COUPLING CAPACITOR

$$f_{L-3dB} = \frac{1}{2 \times 3.1416 \times (600 + 3\times 10^{3}) \times 1 \times 10^{-6}} = 44.2\ Hz$$

pb 7

AN AMPLIFIER HAS AN INPUT IMPEDANCE 10 kΩ. CALCULATE THE VALUE OF COUPLING CAPACITOR REQUIRED FOR 40 Hz LOWER −3dB FREQUENCY. SOURCE RESISTANCE = 600 Ω

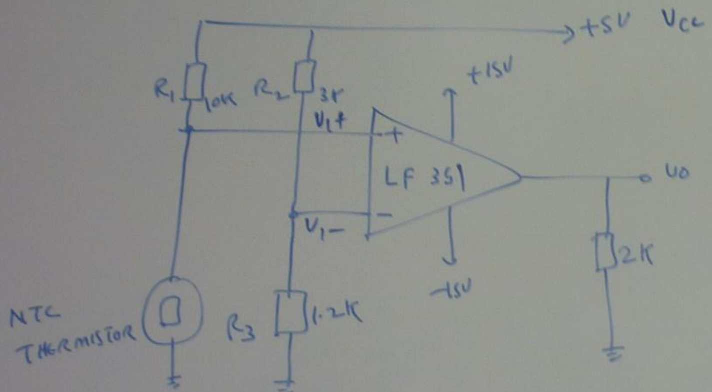
$$40 = \frac{1}{2 \times 3.1416 (600 + 1000) C}$$

$$C = \frac{1}{2 \times 3.1416 \times 40 \times 1600} = 2.486\ \mu F$$

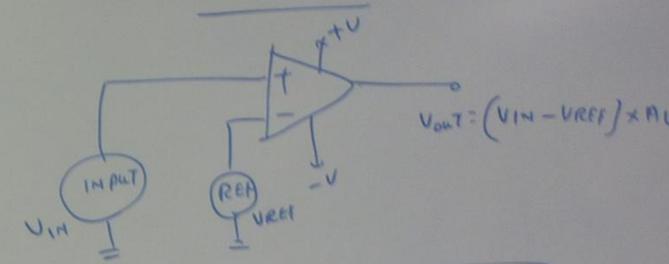
f

(Hz)

P3 → AN NTC (NEGATIVE TEMPERATURE COEFFICIENT) THERMISTOR IS EMPLOYED TO CONTROL THE TEMPERATURE AS SHOWN BELOW



COMPARATOR



$V_{OUT} = (V_{IN} - V_{REF}) \times A_V$

$\boxed{R_t = R_0(1+\alpha \Delta t)}$

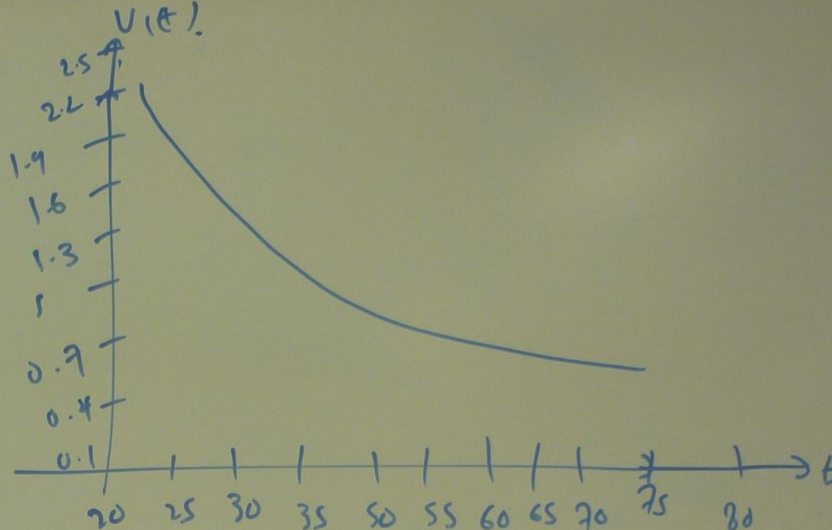
TEMPERATURE (°C)	20	25	30	35	40	45	50	55	60	65	70	75	80
R (kΩ) (RNTC)	9.5	8.2	6.8	5.7	4.9	4.3	3.7	3.3	3	2.7	2.5	2.3	2.2
V_1+	2.436	2.252	2.02	1.81	1.64	1.5	1.35	1.24	1.15	1.06	1	0.93	0.9

DRAW V_1+ GRAPH

AV

$$V_{1(+)} = V_{cc} \times \frac{R_{NTC}}{R_1 + R_{NTC}}$$

$$V_{1(-)} = V_{cc} \times \frac{R_3}{R_2 + R_3}$$



IF $R_{NTC} = 9.5k\Omega$

$R_1 = 10\,K$

$$V_{1(+)} = \frac{9.5}{10+9.5} \times 5 = 2.435$$

IF $R_{NTC} = 8.2k\Omega$

$R_1 = 10K$

$$V_1(+) = \frac{8.2}{10+8.2} \times 5 = 2.252\Omega$$

IN ABOVE PROBLEM

(i) CALCULATE INVERTING INPUT VOLTAGE $V_{1(-)}$

(ii) DETERMINE THE TRANSITION TEMPRATURE

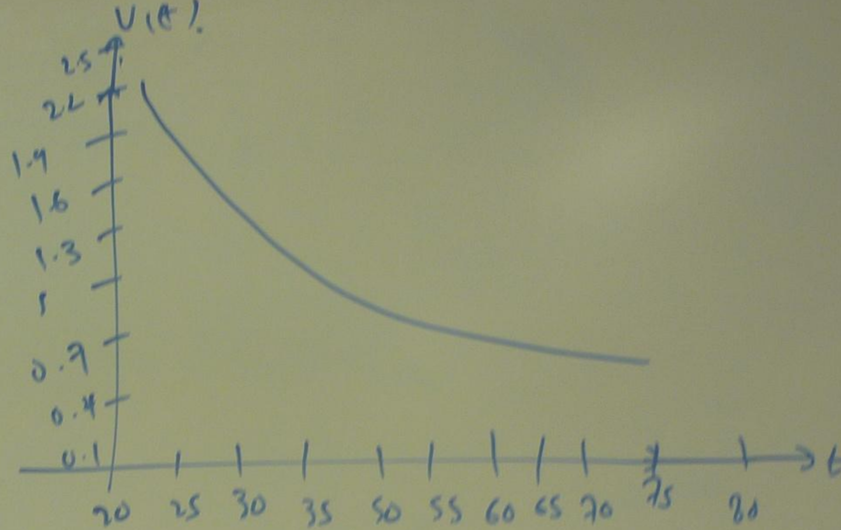
(iii) DETERMINE THE VALUE OF R_3 FOR 70°C TRANSITION TEMPERATURE

(iv) SHOW A RELAY INTERFACE CIRCUIT TO THE OUTPUT TERMINAL TO OPERATE A 240V HEATING ELEMENT.

AV

$$V_{1(+)} = V_{cc} \times \frac{R_{NTC}}{R_1 + R_{NTC}}$$

$$V_{1(-)} = V_{cc} \times \frac{R_3}{R_2 + R_3}$$



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IF $R_{NTC} = 8.2k\Omega$

$R_1 = 10K$

$$V_{1(+)} = \frac{8.2}{10 + 8.2} \times 5 = 2.252\Omega$$

IN ABOVE PROBLEM

(i) CALCULATE INVERTING INPUT VOLTAGE $V_{1(-)}$

(ii) DETERMINING THE TRANSITION TEMPERATURE

(iii) DETERMINING THE VALUE OF R_3 FOR $70°C$ TRANSITION TEMPERATURE

(iv) SHOW A RELAY INTERFACE CIRCUIT TO THE OUTPUT TERMINAL TO OPERATE A 240V HEATING ELEMENT.

(b)
(i) $V_{1(-)} = V_{cc} \times \frac{R_3}{R_3+R_2}$

$= 5 \times \frac{1.2}{1.2+3}$

$= 1.43\ V$

AT 50°C, $V_{1(+)} < V_{1(-)}$

1.35V   1.43V

(ii) 50°C IS TRANSITION TEMPERATURE

(iii) FOR 70°C TEMPERATURE TO BEOME TRANSITION TEMPERATURE

$V_{1(-)}$ MUST BE ATLEAST 1V

$V_{1(-)} = V_{cc} \times \frac{R_3}{R_2+R_3}$

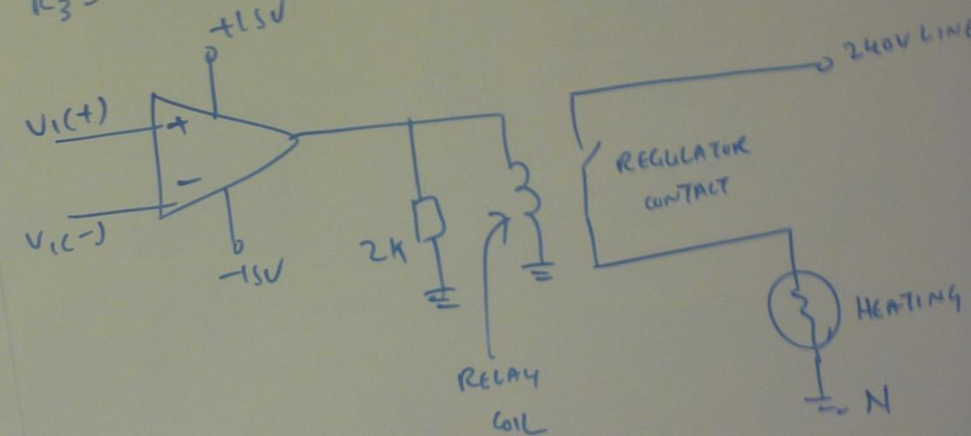
$1 = 5 \times \frac{R_3}{R_3+3}$

$1 = \frac{5R_3}{R_3+3}$

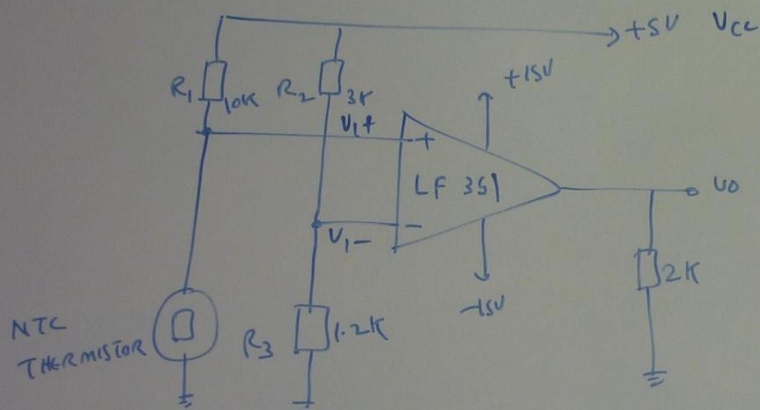
$R_3+3 = 5R_3$

$4R_3 = 3$

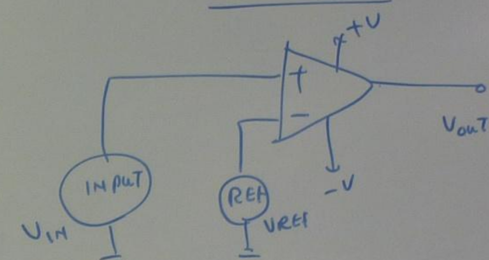
$R_3 = 0.75\ k\Omega$



PB → AN NTC (NEGATIVE TEMPERATURE COEFFICIENT) THERMISTOR IS EMPLOYED TO CONTROL THE TEMPERATURE AS SHOWN BELOW



COMPARATOR



$V_{OUT} = (V_{IN} - V_{REF}) \times A_V$

$\boxed{R_t = R_0(1+\alpha\Delta t)}$

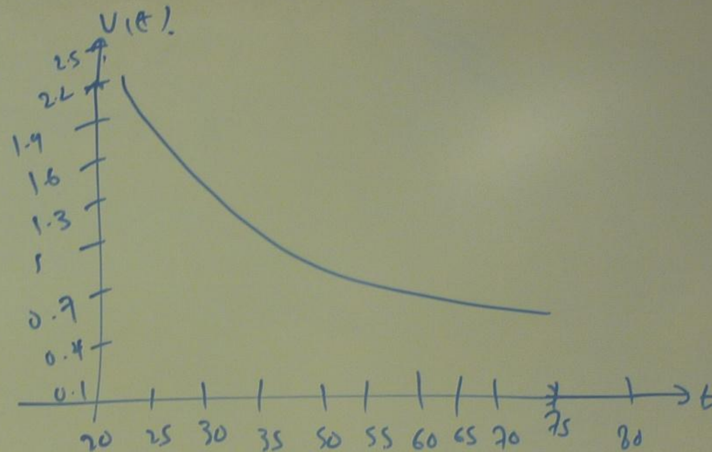
TEMPERATURE (°C)	20	25	30	35	40	45	50	55	60	65	70	75	80
R (kΩ) (RNTC)	9.5	8.2	6.8	5.7	4.9	4.3	3.7	3.3	3	2.7	2.5	2.3	2.2
V_{1+}	2.436	2.252	2.02	1.81	1.64	1.5	1.35	1.24	1.15	1.06	1	0.93	0.9

DRAW V_{1+} GRAPH

VIN − VREF) × AV

)

$$\boxed{V_1(+) = V_{cc} \times \frac{R_{NTC}}{R_1 + R_{NTC}} \qquad V_1(-) = V_{cc} \times \frac{R_3}{R_2 + R_3}}$$



IF $R_{NTC} = 9.5\,k\Omega$

$R_1 = 10\,K$

$$V_1(+) = \frac{9.5}{10 + 9.5} \times 5 = 2.435$$

IF $R_{NTC} = 8.2\,k\Omega$

$R_1 = 10\,K$

$$V_1(+) = \frac{8.2}{10 + 8.2} \times 5 = 2.252\,\Omega$$

IN ABOVE PROBLEM

(i) CALCULATE INVERTING INPUT VOLTAGE $V_1(-)$

(ii) DETERMINE THE TRANSITION TEMPERATURE

(iii) DETERMINE THE VALUE OF R_3 FOR 70°C TRANSITION TEMPERATURE

(iv) SHOW A RELAY INTERFACE CIRCUIT TO THE OUTPUT TERMINAL TO OPERATE A 240V HEATING ELEMENT.

(b) V

(i)

AT 50

(ii) 50°C

(iii)

(b) (i)

$$V_{1(-)} = V_{cc} \times \frac{R_3}{R_3 + R_2}$$

$$= 5 \times \frac{1.2}{1.2 + 3}$$

$$= 1.43\ V$$

AT 50°C, $V_{1(+)} < V_{1(-)}$

$1.35V \qquad 1.43V$

(ii) 50°C IS TRANSITION TEMPERATURE

(iii) FOR 70°C TEMPERATURE TO BEOME TRANSITION TEMPERATURE $V_{1(-)}$ MUST BE ATLEAST 1V

$$V_{1(-)} = V_{cc} \times \frac{R_3}{R_2 + R_3}$$

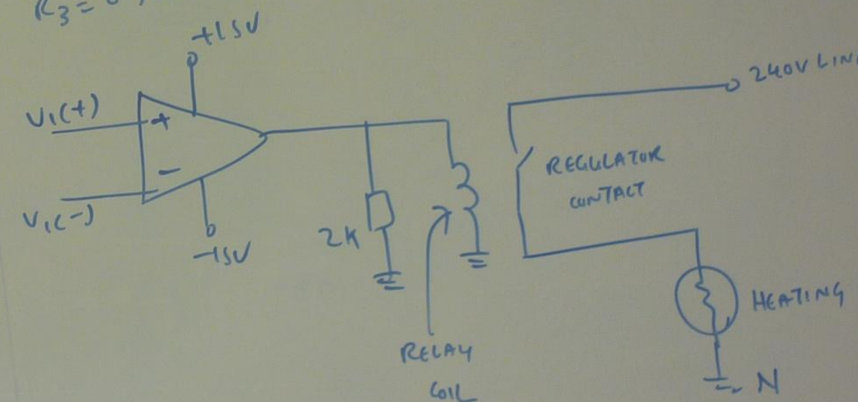
$$1 = 5 \times \frac{R_3}{R_3 + 3}$$

$$1 = \frac{5R_3}{R_3 + 3}$$

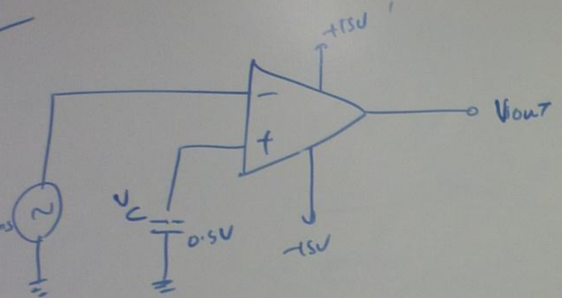
$$R_3 + 3 = 5R_3$$

$$4R_3 = 3$$

$$R_3 = 0.75\ k\Omega$$



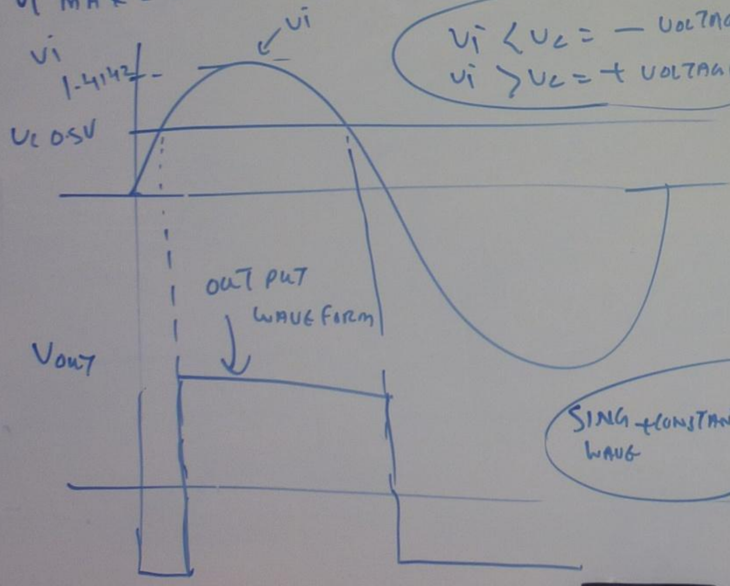
pb



DRAW BOTH INPUT AND OUTPUT WAVE FORMS

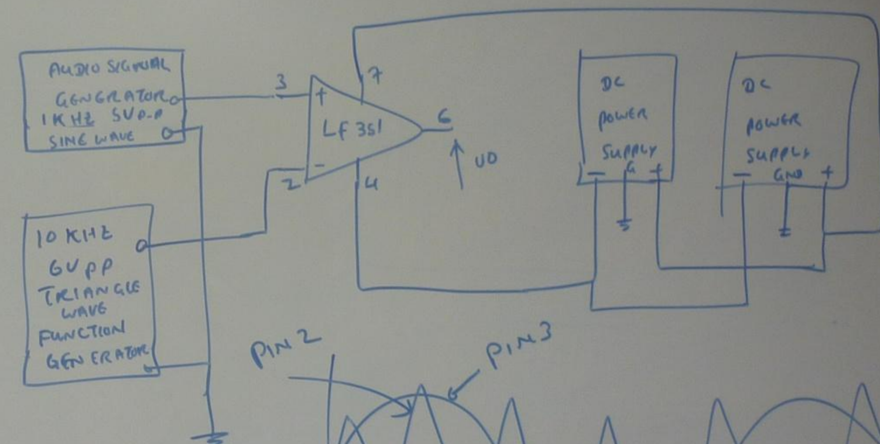
$V_i\ MAX = \sqrt{2}\ V_i\ rms = 1.4142 \times 1 = 1.4142V$

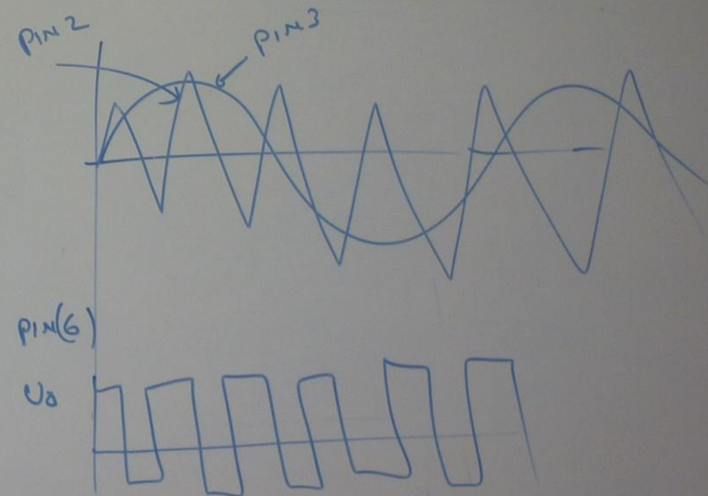
$V_i < V_C = -$ VOLTAGE
$V_i > V_C = +$ VOLTAGE



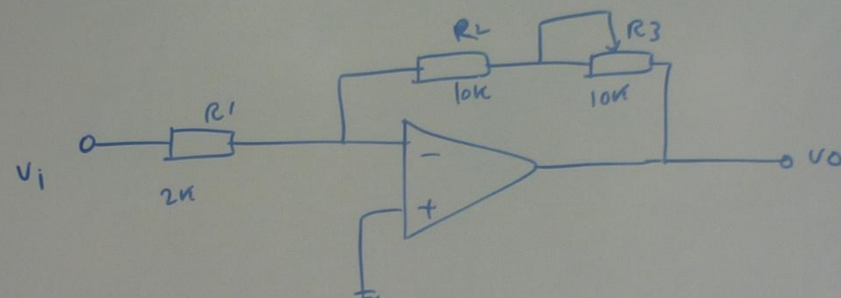
SING + CONSTANT ⇒ SQUARE WAVE
WAVE

BASIC PWM CIRCUIT





Pb/ FOR THE AMPLIFIER CIRCUIT SHOWN BELOW, DETERMINE MINIMUM VOLTAGE GAIN AND MAXIMUM VOLTAGE GAIN.



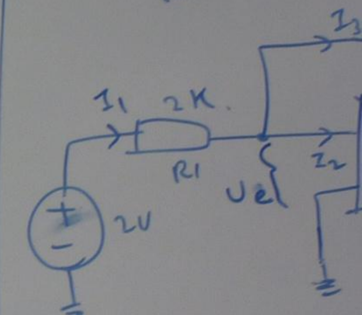
$$A_V = -\frac{R_f}{R_i} = -\frac{(R_2+R_3)}{R_1}$$

MAX $R_3 = 10K \longrightarrow A_V = -\frac{(10+10)}{2} = -10$

MIN $R_3 = 0 \longrightarrow A_V = -\frac{(10+0)}{2} = -5$

Pb/ FOR THE CIR

THE CURRENT



$$\boxed{I_1 = \frac{V_{IN}}{R_1}} = \frac{2}{2}$$

$I_2 = 0$

$\therefore I_1 = I_3 = 1$

$V_{Ref} = I_3$

$= 1$

$=$

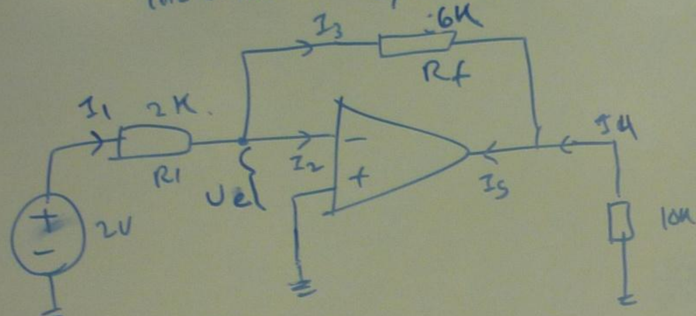
BELOW, DETERMINE

UM VOLTAGE GAIN.

$$\frac{(+10)}{} = -10$$

$$\frac{(+0)}{2} = -5$$

PD/ FOR THE CIRCUIT SHOWN BELOW FIND THE CURRENT $I_1 \sim I_5$



$$\boxed{I_1 = \frac{V_{IN}}{R_1}} = \frac{2}{2K} = 1\,mA$$

$$I_2 = 0$$

$$\therefore I_1 = I_3 = 1\,mA$$

$$\boxed{V_{Ref} = I_3 \times R_f}$$

$$= 1\,mA \times 6K$$

$$= 6V$$

$$\boxed{V_0 = V_e - V_{Ref}}$$

$$= 0 - 6 = -6\,V$$

$$I_4 = \frac{V_{OUT}}{R_4} = \frac{-6}{10}$$

$$= -0.6\,mA$$

$$I_5 = I_3 + I_4$$

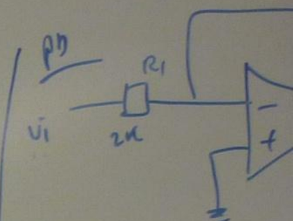
$$= 1 + (-0.6)$$

$$= 0.4\,mA$$

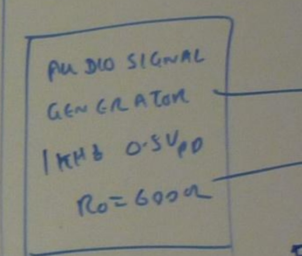
$$I_1 \sim I_5 = 1 - 0.4$$

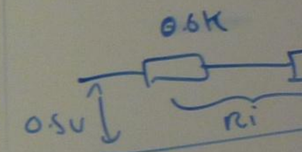
$$= 0.6\,mA$$

PD/



DETERMINE IN





$R_i = $

$$\boxed{V_0 = V_c - V_{Ref}}$$

$$= 0 - 6 = -6\,V$$

$$I_4 = \frac{V_{OUT}}{R_4} = \frac{-6}{10}$$

$$= -0.6\,mA$$

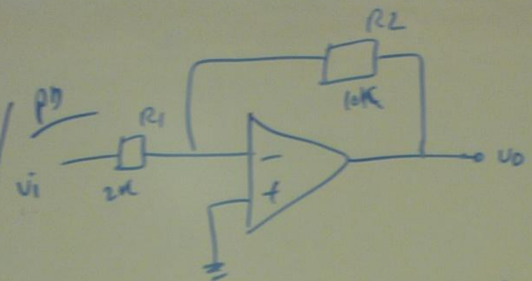
$$I_5 = I_3 + I_4$$

$$= 1 + (-0.6)$$

$$= 0.4\,mA$$

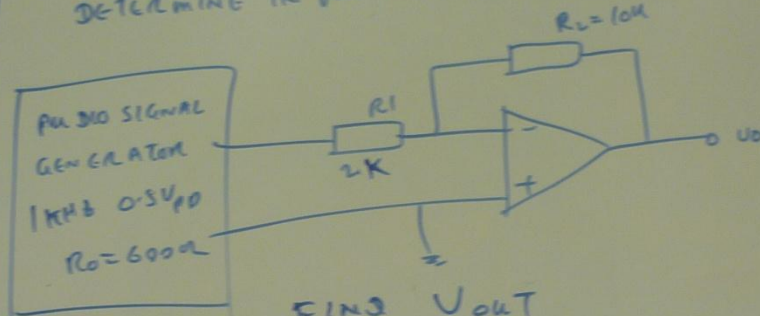
$$I_1 \sim I_5 = 1 - 0.4$$

$$= 0.6\,mA$$

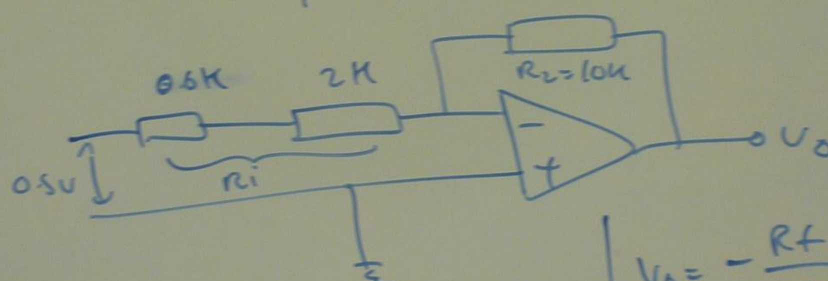


DETERMINE INPUT RESISTANCE

$$R_{IN} = R_1 = 2K$$



FIND V_{OUT}



$$R_i = 0.6 + 2 = 2.6K$$

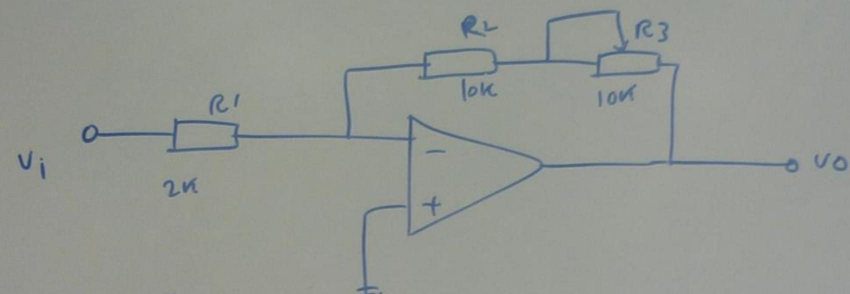
$$V_0 = -\frac{R_f}{R_i} \times V_{IN}$$

$$= \frac{-10}{2.6} \times 0.5$$

$$= -1.92V$$

(b)
(i)
AT
(ii) So
(iii)

pb FOR THE AMPLIFIER CIRCUIT SHOWN BELOW, DETERMINE MINIMUM VOLTAGE GAIN AND MAXIMUM VOLTAGE GAIN.



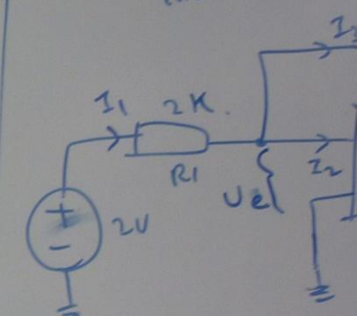
$$A_V = -\frac{R_f}{R_i} = -\frac{(R_2+R_3)}{R_1}$$

MAX $R_3 = 10k \longrightarrow A_V = -\frac{(10+10)}{2} = -10$

MIN $R_3 = 0 \longrightarrow A_V = -\frac{(10+0)}{2} = -5$

pb FOR THE CIR

THE CURRENT



$\boxed{I_1 = \frac{V_{IN}}{R_1}} = \frac{2}{2}$

$I_2 = 0$

$\therefore I_1 = I_3 = 1$

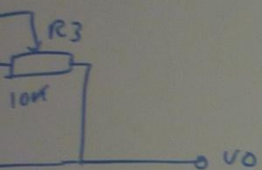
$V_{Ref} = I_3$

$= 1$

$= 6$

...N BELOW, DETERMINE

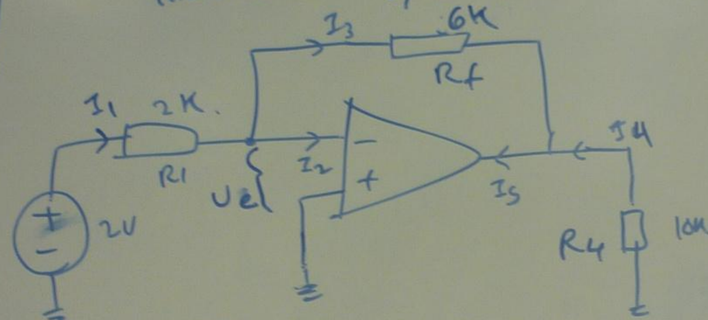
...AXIMUM VOLTAGE GAIN.



$$\frac{(10+10)}{2} = -10$$

$$\frac{(10-10)}{2} = -5$$

Pn/ FOR THE CIRCUIT SHOWN BELOW FIND THE CURRENT $I_1 \sim I_5$



$$\boxed{I_1 = \frac{V_{IN}}{R_1}} = \frac{2}{2K} = 1\,mA$$

$I_2 = 0$

$\therefore I_1 = I_3 = 1\,mA$

$$\boxed{V_{Ref} = I_3 \times R_f}$$

$= 1\,mA \times 6K$

$= 6V$

$$\boxed{V_o = V_e - V_{Ref}}$$

$= 0 - 6 = -6\,V$

$$I_4 = \frac{V_{OUT}}{R_4} = \frac{-6}{10}$$

$= -0.6\,mA$

$I_5 = I_3 + I_4$

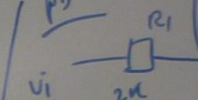
$= 1 + (-0.6)$

$= 0.4\,mA$

$I_1 \sim I_5 = 1 - 0.4$

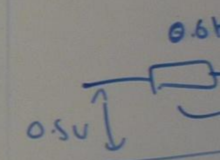
$= 0.6\,mA$

Pn/



DETERMI...

AUDIO SIGNAL GENERATOR
1KHz 0.5Vp...
Ro=600Ω



$$V_o = V_c - V_{Ref}$$

$$= 0 - 6 = -6\,V$$

$$I_4 = \frac{V_{out}}{R_4} = \frac{-6}{10}$$

$$= -0.6\,mA$$

$$I_5 = I_3 + I_4$$

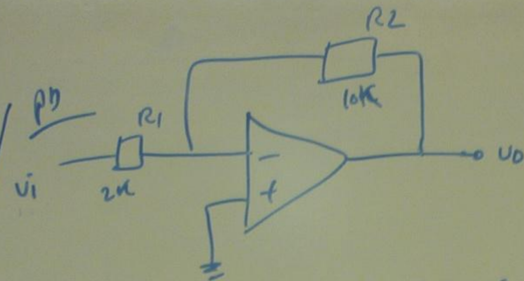
$$= 1 + (-0.6)$$

$$= 0.4\,mA$$

$$I_1 \sim I_5 = 1 - 0.4$$

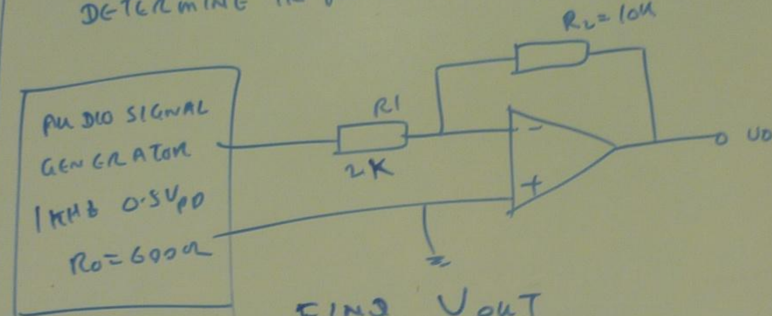
$$= 0.6\,mA$$

pb

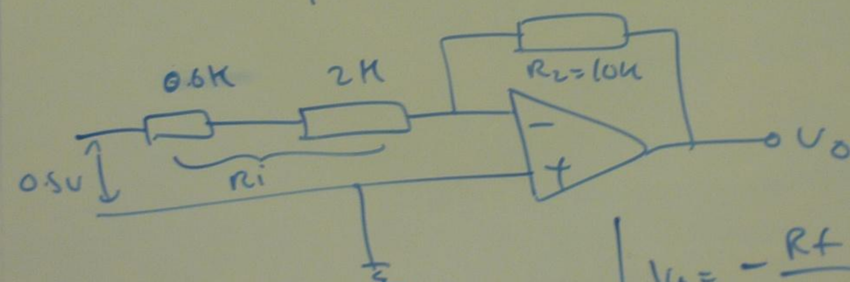


$$R_{IN} = R_1 = 2K$$

DETERMING IN PUT RESISTANCE



FIND V_{out}



$$R_i = 0.6 + 2 = 2.6K$$

$$V_o = -\frac{R_f}{R_i} \times V_{IN}$$

$$= \frac{-10}{2.6} \times 0.5$$

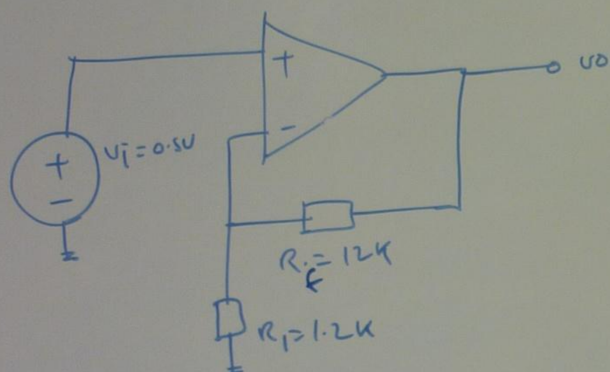
$$= -1.92V$$

pb

$V_o =$

pb

FOR THE GIVEN CIRCUIT, CALCULATE OUTPUT VOLTAGE



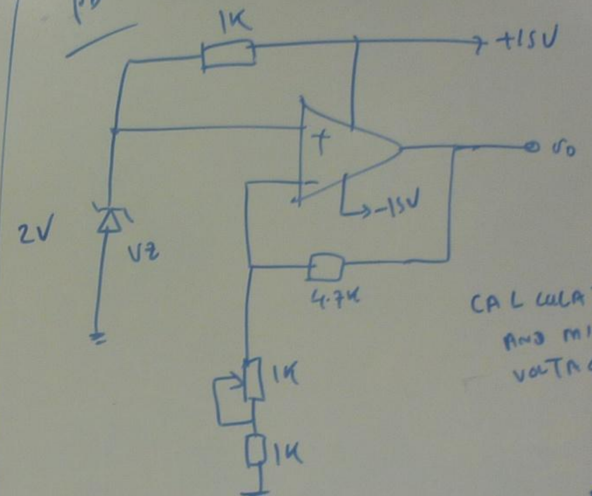
$$V_o = \left[1 + \frac{R_f}{R_1}\right] V_i$$

$$= \left[1 + \frac{12}{1}\right] \times 0.5$$

$$= [13] \times 0.5$$

$$= 6.5V$$

pb



CALCULATE MAXIMUM AND MINIMUM OUTPUT. VOLTAGES

$$V_o = (V_{IN} - V_Z)\left(1 + \frac{R_f}{R_i}\right)$$

$R_i = 1K$

$$V_o = (15-2)\left(1 + \frac{4.7}{1}\right) = 39V$$

$R_i = 2K$

$$V_o = (15-2)\left(1 + \frac{4.7}{2}\right) = 65V$$

pb

$V_i = 1$ rms

OR

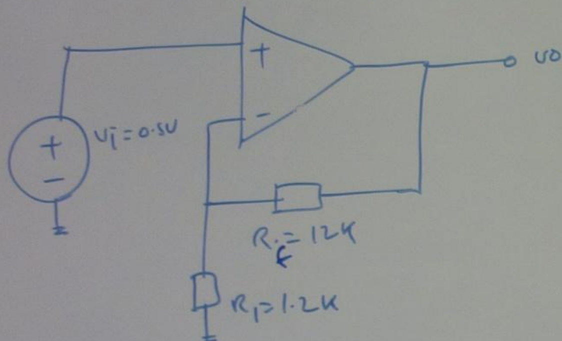
V_i max

V_i 1.414

V_i 0.5V

V_{out}

pb FOR THE GIVEN CIRCUIT, CALCULATE OUTPUT VOLTAGE



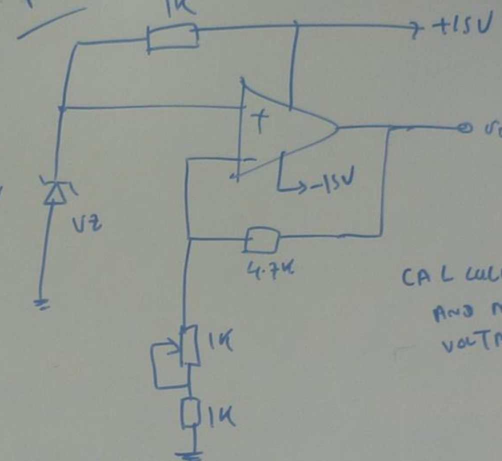
$$V_o = \left[1 + \frac{R_f}{R_1}\right] v_i$$

$$= \left[1 + \frac{12}{1}\right] \times 0.5$$

$$= [13] \times 0.5$$

$$= 6.5V$$

pb



CALCULATE MAXIMUM AND MINIMUM OUTPUT VOLTAGES

$$V_o = (V_{IN} - V_Z)\left(1 + \frac{R_f}{R_i}\right)$$

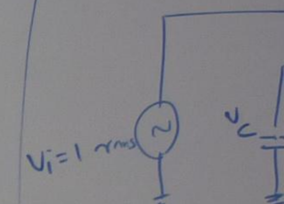
$R_i = 1K$

$$V_o = (15-2)\left(1 + \frac{4.7}{1}\right) = 39V$$

$R_i = 2K$

$$V_o = (15-2)\left(1 + \frac{4.7}{2}\right) = 65V$$

pb



DRAW BOTH

$V_i\ max = \sqrt{2}\ V_i$