GAUTENG DEPARTMENT OF EDUCATION /
SENIOR CERTIFICATE EXAMINATION /

TECHNIKA (ELECTRONICS) SG /

Possible Answers / Moontlike Antwoorde
Feb / Mar / Maart 2006

QUESTION 1

1.1 1.1.1 XL = 2 p fL = 400 O

Xc = $\frac{1}{2 \text{ p } f\, C}$ = 200 O

R_1 = 250 O (4)

1.1.2 I_R = $\frac{V_T}{R_L}$ = $\frac{25}{250}$ = 0,1 amp

I_L = $\frac{V_T}{X_L}$ = $\frac{25}{400}$ = 0,0625 amp

I_C = $\frac{V_T}{X_C}$ = $\frac{25}{200}$ = 0,125 amp (6)

1.1.3 IT = $\sqrt{(IR)^2 + [Ic - Il]^2}$

= $\sqrt{(0,1)^2 + [0,125 - 0,0625]^2}$

= 0,118 amp (3)

1.1.4 Z = $\frac{V_T}{I_T}$

= $\frac{25}{0,118}$

= 211,9 O (3)

1.2 1.2.1 $Q = \frac{fr}{Bw}$

$Q = \frac{95\,MHz}{200\,kHz}$

$Q = 475$ (3)

1.2.2 $Xc = \frac{1}{2\,p\,f\,c}$

$= \frac{1}{2 \text{ x } p\ 95\,\text{MHz} \text{ x } 2{,}5\,pF}$

$= 670{,}12$ O

$XL = 2\,p\,$ Fl

$L = \frac{Xl}{2\,p\,f}$

$= 1{,}1$ uH (5)

1.2.3 $Q = \frac{Xl}{R}$

$R = \frac{Xl}{Q}$

$= 1{,}41$ O (3)

QUESTION 2

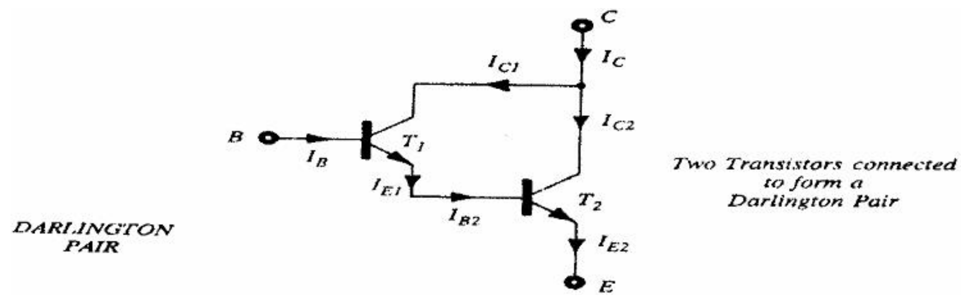
(2)

2.1 THE DARLINGTON PAIR (or the *SUPER TRANSISTOR*)

Manufacturers have not yet been able to produce a single transistor with a gain above roughly 1000 while the norm for transistors is only a few hundred. The technique of combining two transistors to form a "super transistor" which produces a "super gain" is called the Darlington Pair. This pair can either consist of two separate (discrete) transistors, or they may be combined into one single integrated circuit (IC) chip

THE DARLINGTON PAIR CIRCLUIT

The combination consists of two transistors T_1 and T_2 each sharing a common collector terminal. The emitter of T_1 feeds directly onto the base terminal of T_2. The emitter of T_2 is the emitter terminal of the pair and the base of T_1. is the base lead



The key to this circuits operation lies in the emitter current of T_1 forming the base current of T_2. This causes the current gain of the circuit to be the product of the two individual transistor gains

An analysis of this circuit provides an important exercise in manipulating transistor current relationships. A dc analysis begins by applying Kitchhoff's current law to the collector terminal:

$$I_C = I_{C_1} + I_{C_2} \tag{1}$$

The two equations governing all transistors are also used,

$$I_E = (\beta + 1)I_B$$

and $$I_C = \beta I_B$$

This information is applied to the circuit,

$$I_{C_1} = \beta_1 I_{B_1} \tag{2}$$

$$I_{C_2} = \beta_2 I_{B_2}$$

but $$I_{B_2} = I_{E_1}$$

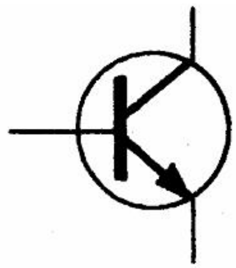
and $$I_{E_1} = (\beta + 1)I_B$$

$$I_{C_2} = \beta_2(\beta_1 + 1)I_B \tag{3}$$

(12)

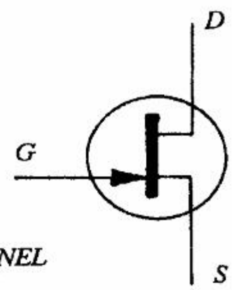
2.2 Open Question read every answer (10)

2.3

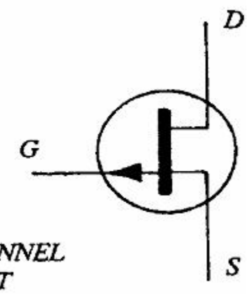


SIMBOOL VIR
NPN - TRANSISTOR

(2)

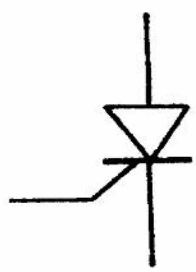


N - CHANNEL
JFET



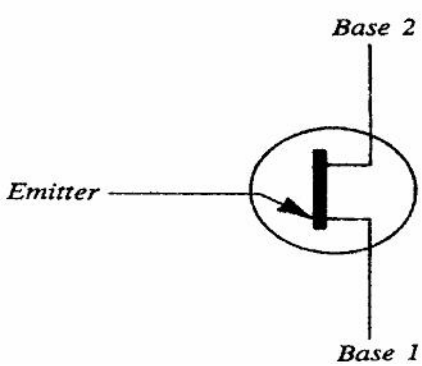
P - CHANNEL
JFET

(2)



SCR
Circuit
Symbol

(2)



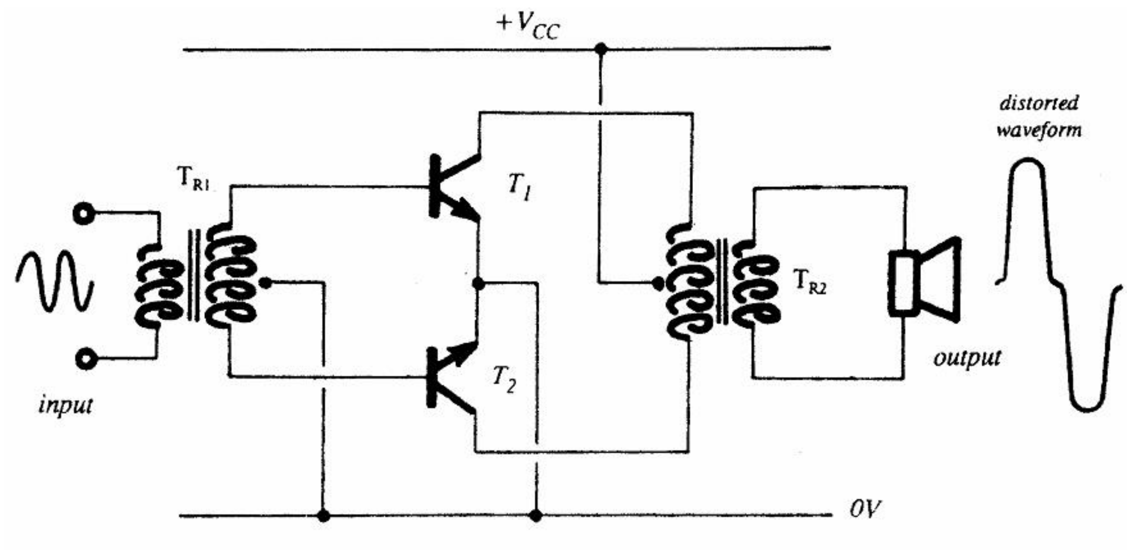
UJT
Circuit Symbol

(2)

QUESTION 3

3.1 Balanced

Split-phase transformer T_{RI} divides the input waveform into two identically equal but anti-phase signals. As the input waveform rises the transformer forward biases one transistor T_1 while at the same time reverse biasing T_2. This effect is reversed during the other half cycle. The second transformer T_{R2} provides impedance matching and coupling between the circuit and the load, usually a speaker.



Class B Non-Complimentary Push-Pull Amplifier

OPERATION:

With no input signal present both transistors are off and no current flows through transformer T_{R2}. When a signal is introduced it is first transformed and “split” into two identical halves by T_{RI}, each half driving one transistor. A rising input signal will forward bias the emitter-base junction of transistor T_1, turning it on while at the same time reverse biasing the emitter-base junction of T_2 turning it off (this is because their emitters are commoned to the low 0 V rail). During the second half cycle the signal reverses turning T_1 off and T_2 on.

As the transistors conduct alternately for each half cycle, current will flow through T_{R2} first in one direction through one half and then in the other direction through the other half. This appears as a single, alternating signal to the transformer which it transforms and presents to the load as a continuous amplified output waveform.

The advantage of this circuit is that it produces a much larger output signal than a single Class A biased transistor amplifier and, as it uses Class B biasing, efficiencies of between 70% and 75% can be reached.

The disadvantages of this circuit are:

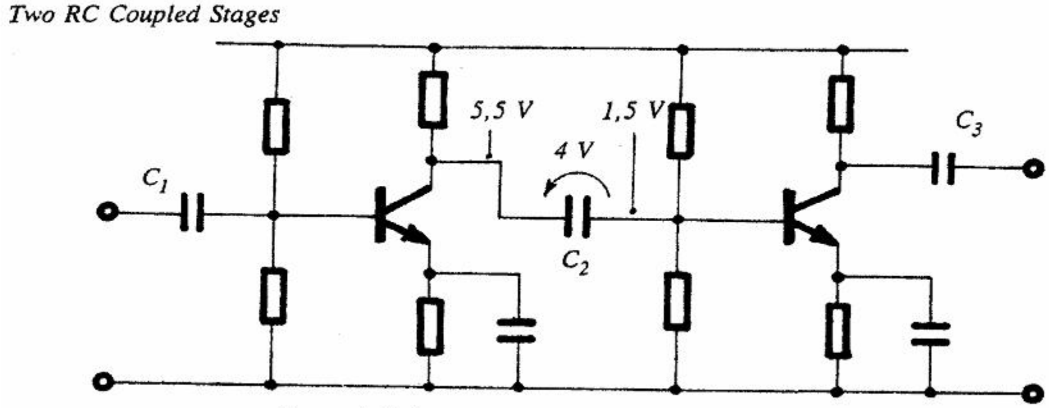
1. it introduces a distortion called cross-over distortion into a sound signal.

2. it requires the use of two transformers which are both bulky and expensive.

Resistor-Capacitor amplifier

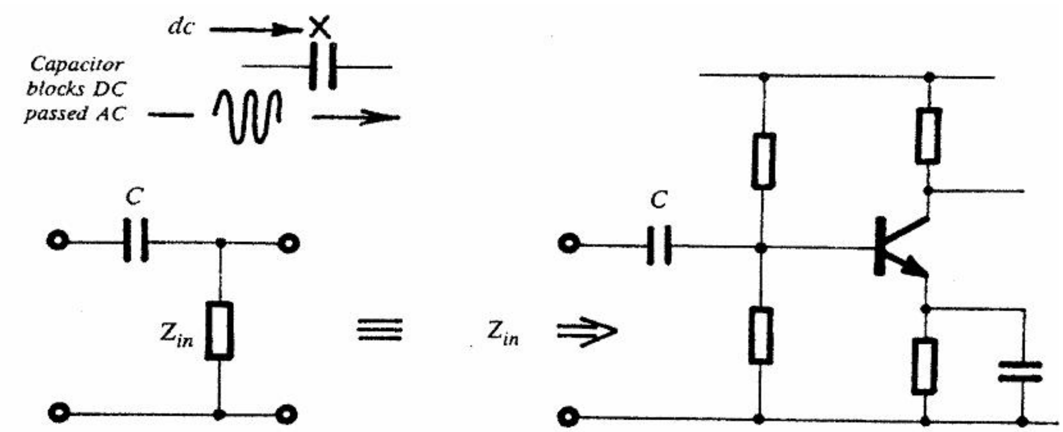
This is the most common and widely used method of coupling between stages. It uses a capacitor coupled from the output of the first stage to the input of the next, shown below as capacitor C_2. Capacitors C_l and C_3 also act as coupling capacitors between the signal source and output load.

Two RC Coupled Stages



Unequal Voltage points separated by a Capacitor

The coupling capacitor allows each stage to operate completely free of the next as it blocks any dc interference between stages. Each of the capacitor's plates sits at different voltages, in the example below that connected to the collector terminal sits at about 5,5 V while the other connected to the next transistors base sits at about 1,5 V. Therefore the capacitor stores a charge of 4 V between its plates, absorbing the difference in voltage between the stages. When an ac signal is introduced for amplification, the coupling capacitor behaves like a low impedance path, allowing the ac signal to pass with no obstruction at all.

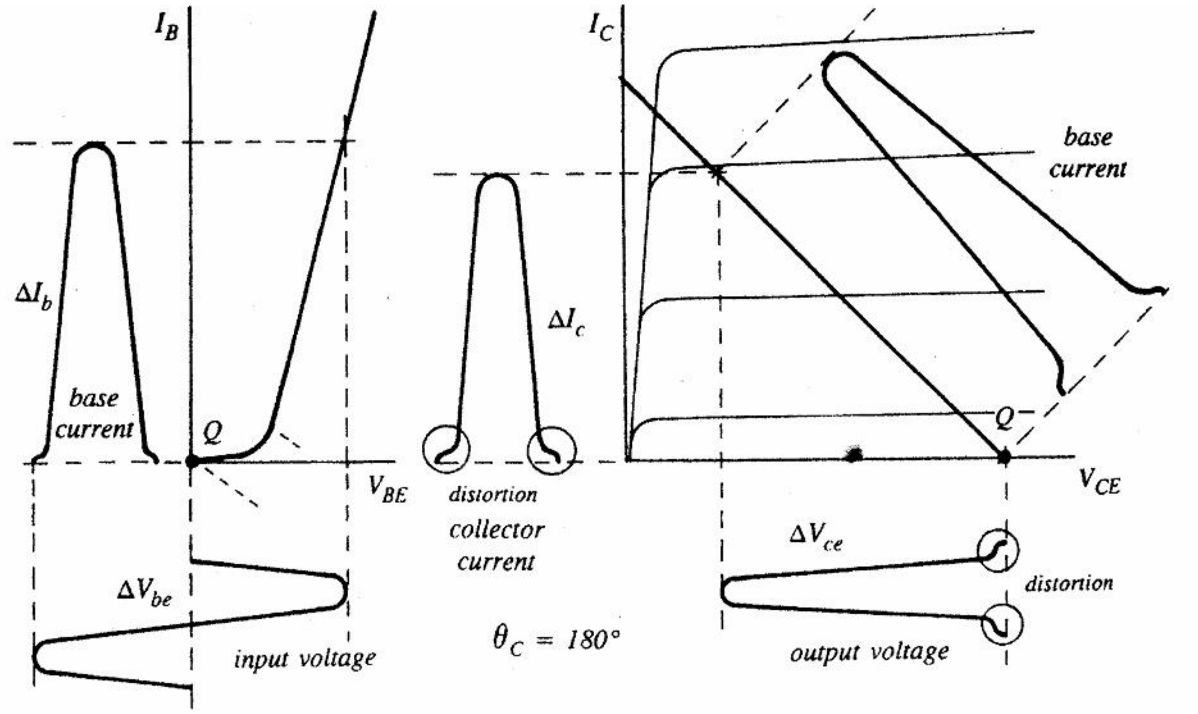


L-type filter

Input Circuit forms an "L" type Filter

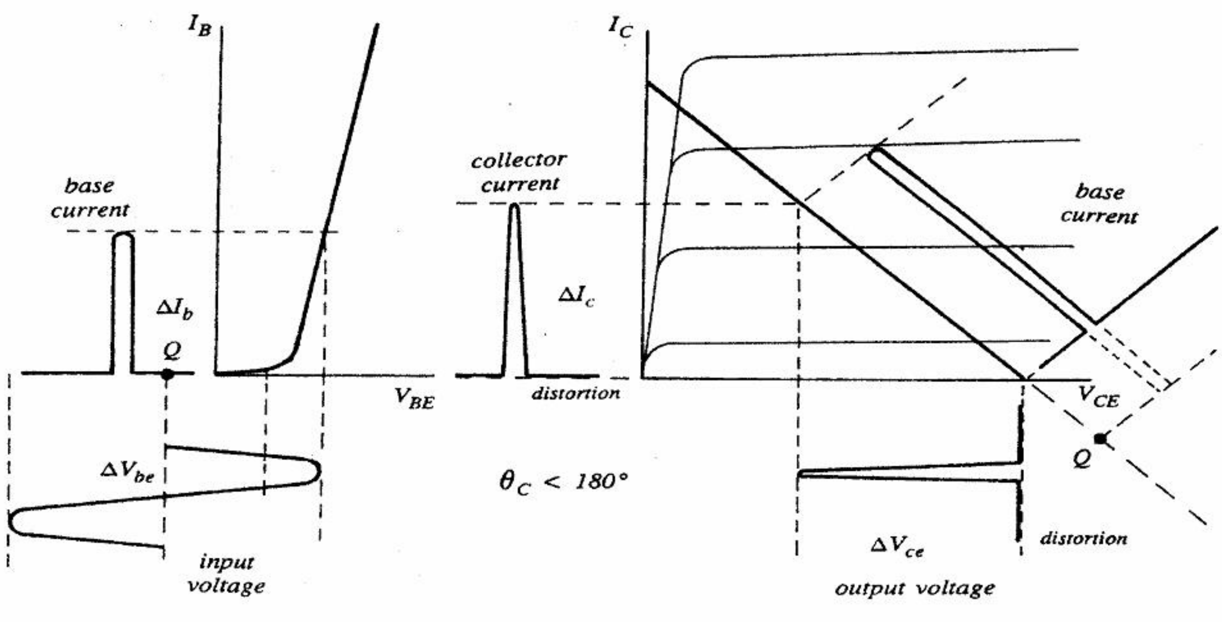
The coupling capacitor, together with the input impedance Z_{in} of the following stage forms an “L” type filter which has a marked negative loading effect on the stage’s frequency range especially the lower frequency range extending down to dc. To overcome this, coupling capacitors are purposely selected to be as large as possible for the range of frequencies required to be handled, with values of 10 .µF at audio frequencies and 1 nF at video frequencies quite common. These values are still comparatively quite small. (20)

3.2 Class B



A Pure Class B Biased Transistor

Class C



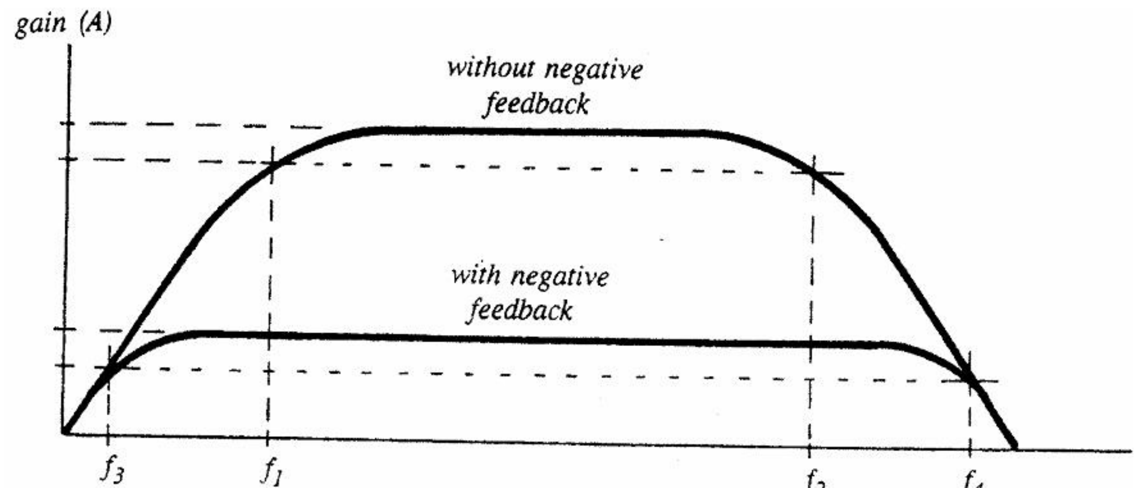
A Class C biased Transistor

(10)

3.3. Band width

The frequency response of an amplifier is greatly improved when a negative feedback circuit is used. The frequency response plot of a typical amplifier circuit is shown below with its upper and lower response frequencies being f_1 and f_2 The example shows typical figures of 80 Hz and 100 kHz for f_1 and f_2 with the circuits bandwidth lying between these two points.

As explained above, with negative feedback the circuit's gain falls, this is shown in the frequency response plot with the gain falling to a lower level. Although there is a loss of gain the advantage is that as the circuit becomes more stable its response remains constant over a wider frequency band only falling off when reaching frequencies f_3 and f_4 shown as 10 Hz and 250 kHz respectively. The new wider bandwidth now lies between these two wider frequencies f_3 and f_4. Any loss of gain can be overcome by adding another stage of amplification.



Negative Feedback Improves Bandwidth but Lowers Gain

QUESTION 4

4.1.1 Shunt voltage regulator

OPERATION:

Any change in load will affect the current supply, in turn affecting the output voltage. An increasing load demands a larger current from the regulator causing the output voltage to fall which directly affects the transistor which has a fixed voltage on its base terminal (the zener voltage V_Z). As V_0 falls the transistor experiences a rising emitter-base voltage V_{BE}, which increases conduction. This higher current through a heavier load causes the terminal voltage to rise to its original value and the cycle of events cancels the original change of conditions and stabilises the output voltage.

The operation also works in reverse, with a decreasing load causing a fall of current and the terminal voltage to rise The transistor's emitter-base voltage V_{BE} then falls shutting it down and supplying less current with the overall result again to stabilise the output terminal voltage

During steady state operation the zener circuit of R_S and V_z simply maintains a fixed base voltage, which keeps a constant base current I_B to the transistor. For the zener to provide the desired fixed voltage reference its operating point must always be kept in its reverse breakdown "constant voltage" region by series resistor R_S.

The transistor needs to be of a high power type as it carries the full load current through itself. During operation the volt drop across the BJT is the difference between the supply voltage and the desired output terminal voltage (V_S - V_0). The combination of high load current I_L together with this volt drop results in a large level of power dissipated in the transistor;

$$P_{diss} = I_L (V_S - V_O)$$

The transistor is usually protected against overheating by being mounted to a heat sink which is to be found at the back of all regulated power supplies.
The disadvantage of this circuit is that its terminal voltage is fixed at one value and not variable being set by the zener reference voltage and V_{BE} as determined by the equation for V_O. (6)

4.1.2. The differentiating circuit

Assuming that the capacitor possesses no initial charge then on receiving a square wave at its input the circuit operates as follows:

1. as a capacitor can not charge instantly, at the point when its left hand plate rises instantly to +V its right hand plate must also rise to +V at that instant (any difference between the left and right plates would mean that the capacitor had gained a charge).
2. as the input holds steady at +V the capacitor begins to charge through the series resistor R with the rate at which it charges determined by the circuit's RC time constant.
3. as the capacitor charges its right hand plate falls in potential because the left hand plate is held at +V.
4. the right hand plate continues falling until after SRC (5t), it reaches 0 V. At this point the capacitor has fully charged.
5. at the end of the period the square wave input falls to zero and the entire operation reverses. As the left hand plate is pulled down to 0 V the right hand plate instantly falls to -V because the capacitor was charged to +V and it can not discharge instantly.
6. as the capacitor begins discharging through R the right hand plate slowly rises until reaching 0 V when fully discharged. (6)

4.1.3. The Integrating circuit

The operation of this circuit relies simply on the charging rate of an RC circuit. As the output is connected directly across the capacitor its shape will be an exact representation of how the capacitor charges.

1. When the input is large and of a long duration (a good example is of a square wave) the capacitor has time to charge fully and the output will easily show this.
2. An input of short, sharp duration will hardly give the capacitor time to begin charging before dying away resulting in a small output of almost no significance.
3. A number of pulses following in rapid succession will each charge the capacitor up slightly with the combined effect of “pumping” it up. The output will show this as a series of small rises combined to increase the output which will rapidly fall away soon after the last pulse occurs.

If a square wave is applied to the input the shape of the output will again be determined by the duration of the RC time constant.
A short RC time constant will produce a waveform resembling a square wave with very rounded leading and trailing edges. This is because the capacitor charges rapidly, quickly reaching the maximum input voltage before remaining there until the input fails.
A longer time constant will produce a triangular output as the capacitor slowly charges and before fully charging the input falls, reversing the capacitor's direction of charge. (6)

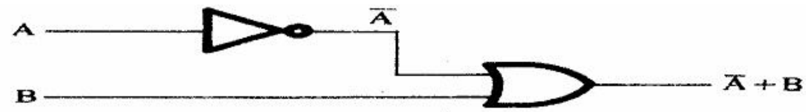
4.1.4. Thyristor Control of DC motor

A dc motor's speed can be controlled by changing anyone of these terms, some with more success than others. The three being;

1. As R_a is in series with the armature, changing its value leads to large changes of current and sizable losses of power which means that this is not a good or efficient manner of speed control.
2. Changing the field flux ϕ has an inversely proportional effect on the motor’s speed where a falling flux will increase the speed and a rising flux will decrease the speed. The advantage here would be that as the field coil circuit requires little current it is easy to control with a low-power circuit. But, although it is possible to reduce the flux surrounding a coil by controlling the current, it is not very easy or practical to increase the flux. So varying the flux is not the usual manner of motor speed control.
3. Varying the applied armature voltage V is the most common and widely used speed control method because it has the most direct affect on the motor over a wide range of speeds. It is also easily achieved by adding a thyristor in series with the armature and supplying the gate driving pulses from a separate controlling circuit. (6)

QUESTION 5

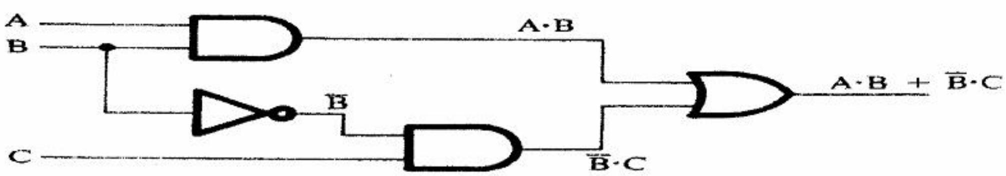
5.1.1



A	B	$\overline{A}$	$\overline{A} + B$
0	0	1	1
1	0	0	0
0	1	1	1
1	1	0	1

(7)

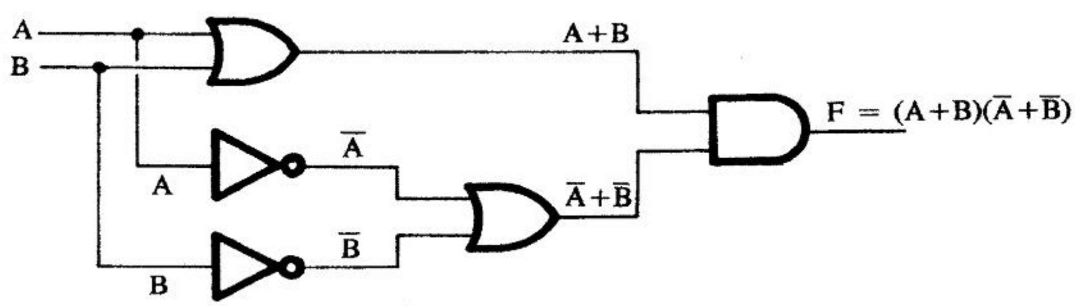
5.1.2



A	B	C	$\overline{B}$	A · B	$\overline{B}$ · C	A · B + $\overline{B}$ · C
0	0	0	1	0	0	0
1	0	0	1	0	0	0
0	1	0	0	0	0	0
1	1	0	0	1	0	1
0	0	1	1	0	1	1
1	0	1	1	0	1	1
0	1	1	0	0	0	0
1	1	1	0	1	0	1

(13)

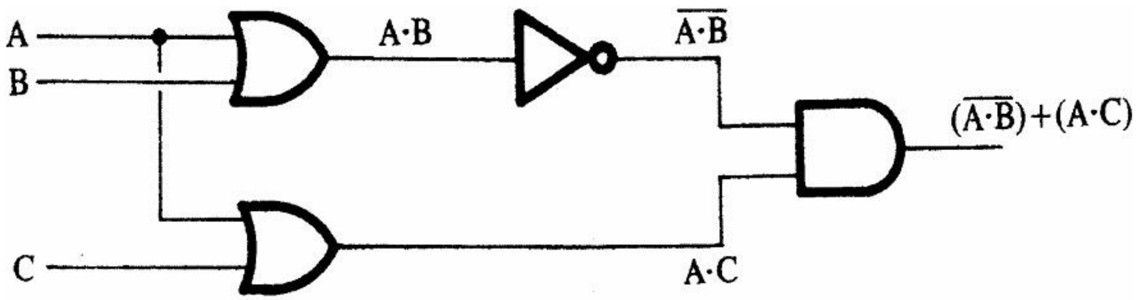
5.1.3



A	B	$\overline{A}$	$\overline{B}$	A + B	$\overline{A} + \overline{B}$	$(A + B) \cdot (\overline{A} + \overline{B})$
0	0	1	1	0	1	0
1	0	0	1	1	1	1
0	1	1	0	1	1	1
1	1	0	0	1	0	0

(13)

5.1.4

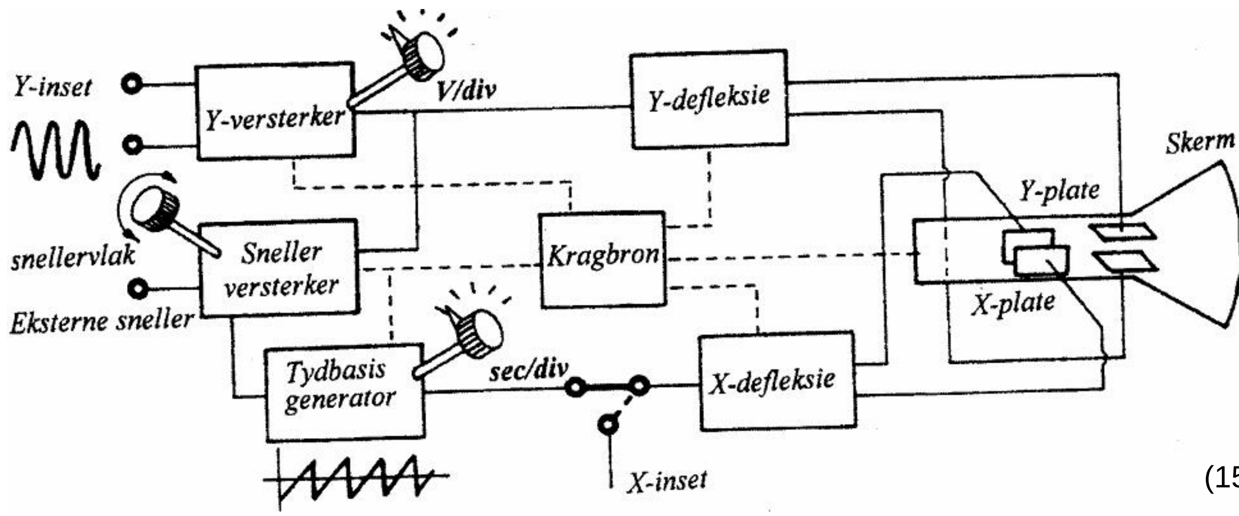


A	B	C	A • B	$\overline{A \bullet B}$	B • C	$(\overline{A \bullet B}) + (A \bullet C)$
0	0	0	0	1	0	1
1	0	0	0	1	0	1
0	1	0	0	1	0	1
1	1	0	1	0	0	0
0	0	1	0	1	0	1
1	0	1	0	1	1	1
0	1	1	0	1	0	1
1	1	1	1	0	1	1

(10)

QUESTION 6

6.1 Oscilloscope

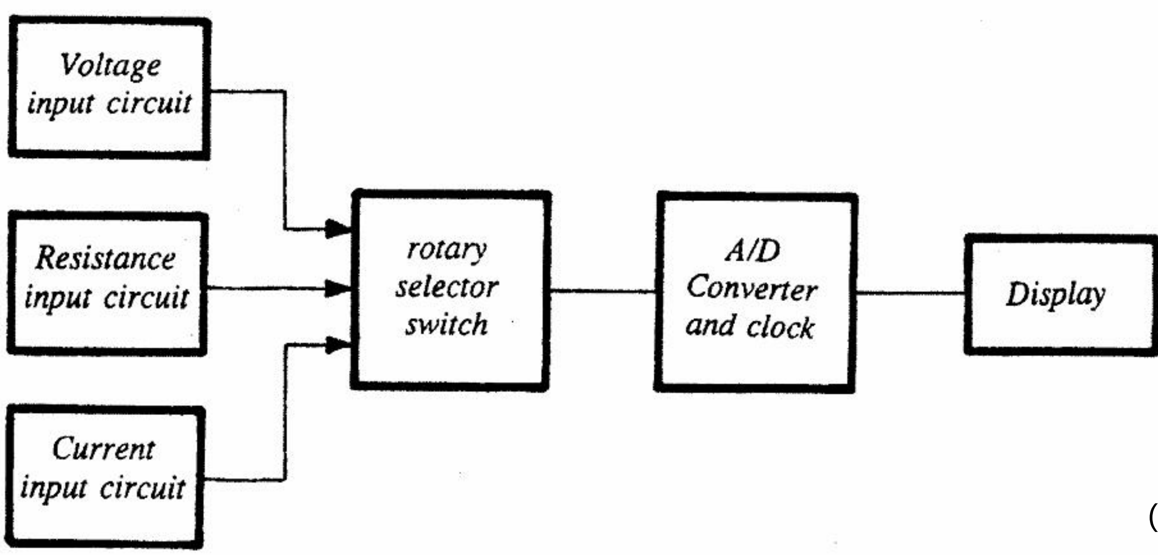


(15)

6.2 To measure current
To measure voltage
To measure resistance
Any acceptable answer.

(3)

6.3



(6)

QUESTION 7

7.1 An unsafe act is something a person does wrong. An unsafe condition is something , that is wrong in the building. (3)

7.2 * Working without permission.
* Working at unsafe speeds.
* The placing of objects in dangerous places.
* Working with the wrong tools.
* Do not wear loose clothing.
* Don't play in the workshop. (Any Four) (4)

7.3 Unsuitable ventilation
Unsuitable light
Unsuitable store places
No fire equipment
Material lying in passages
Any acceptable answer. (Any Four) (4)

7.4 To prevent blood from leaking everywhere.
So that the bleeding can stop.
To regain blood pressure.
Any acceptable answer. (5)

7.5 Make sure the scale that you use is correct.
Do not drop the meter.
Make sure the meter is connected in series for current measurement.
Make sure the meter is connected in parallel for voltage measurement.
Any acceptable answer (Any Two) (2)

TOTAL: 200

END