National Institute of Technology Calicut

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NIT CAMPUS P.O., KERALA-673601, IDIA

Department of
ELECTRICAL ENGINEERING

Laboratory Record

Name: ALLADA SRI RUPESH KUMAR

Class: MTECH Year: 1st

Roll No: ....

Reg No: M160316EE

Certified that this is the bonafide record of the work done in the laboratories of the National institute of Technology, Calicut by

Mr./~~Miss~~ A Sai Rupesh Kumar

Staff member in charge .... *Professor & Head* ....

Place NITC *Date* 10/11/16

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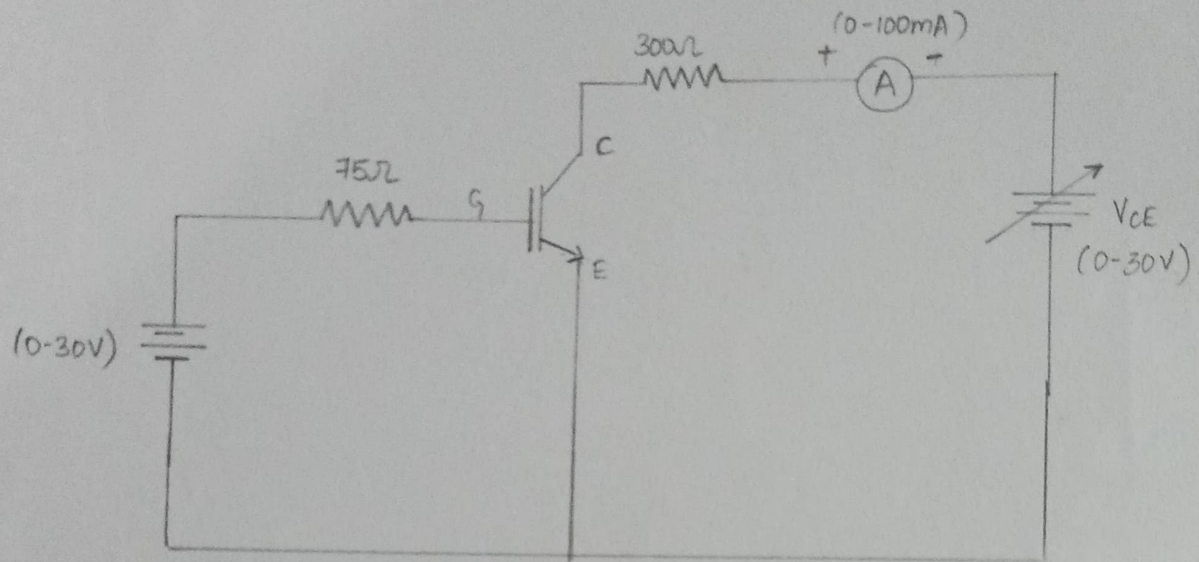
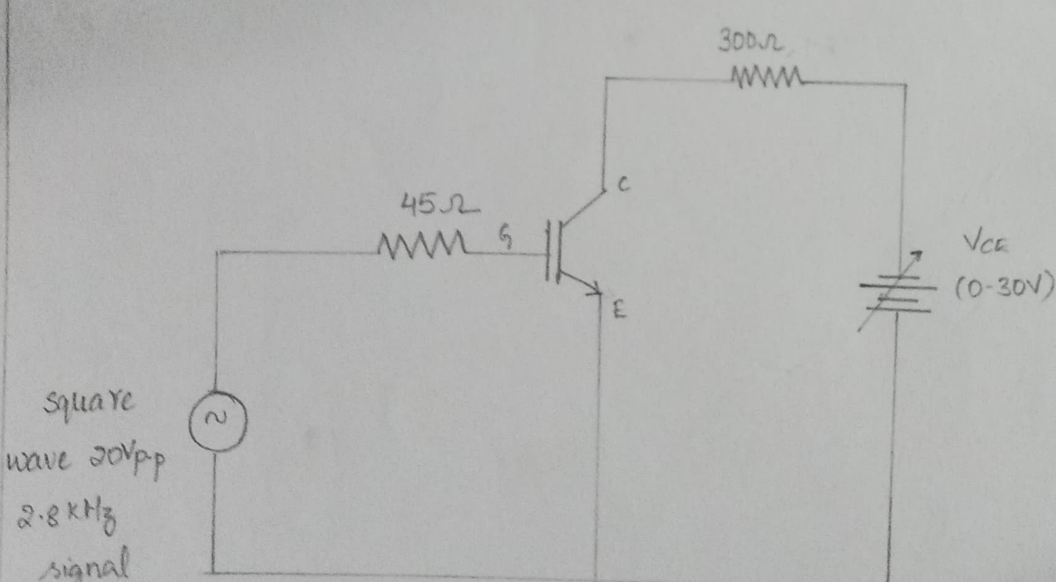
10/11/16



INPUT & OUTPUT CHARACTERISTICS



SWITCHING CHARACTERISTICS

Dt :- 09/08/16

EXP :- 01.

SWITCHING CHARACTERISTICS OF IGBT - [STATIC, TRASFER & SWITCHING]

AIM :- To perform switching characteristics of IGBT along with the input and output characteristics.

APPARTUS :-

Appartus		Quantity
IGBT - IRGPH40K		1
Regulated power supply (0-30V)		1
Resistors	45Ω	1
	75Ω	1
	300Ω	1
CRO		1

THEORY :-

It is a voltage controlled four-layer duice with the advantages of the MOSFET and BJT. IGBT can be classified as punch through (PT) and non-punch through structures. In ~~Non~~ punch through IGBT, a better trade off between the forward voltage drop and turn off time can be achived. Punch through IGBT are available up to about 1200V. NPT IGBTs of up to about 4KV have been reported in literature and they are more robust than PT IGBT particularly under short circuit conditions.

INPUT CHARACTERISTICS

$V_{CE} = 5V$		$V_{CE} = 12V$	
V_{GE} (V)	I_C (mA)	V_{GE} (V)	I_C (mA)
4.0	0	4.0	0
4.8	1	4.8	1
4.9	3	4.9	3
5	4	5	5
5.1	8	5.1	7
5.3	14	5.2	12
5.7	14	5.3	22
6.0	14	5.4	29.5
		5.5	38
		6	38

OUTPUT CHARACTERISTICS

$V_{GE} = 5.1$ V		$V_{GE} = 5.3$V		$V_{GE} = 5.4$ V	
V_{CE} (V)	I_{CE} (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)
0.9	1	0.5	1.2	0.9	1.3
1.6	3	0.7	1.5	1.1	3
1.9	3.8	1.1	2.5	1.8	5
2	4	1.5	3.5	2.5	6
2.1	4.5	1.8	4.5	2.8	7
2.4	5	2.3	5.8	3	7.5
2.7	5.5	2.5	6	3.5	9
2.8	6	2.8	7	3.7	10
		3	7.5	4.2	11.5
		3.2	8	4.6	13
		3.3	8	4.9	14
				6.4	24
				6.8	24

Its switching times can be suitably controlled by shaping the drive signal. This gives the IGBT a number of advantages, it doesn't require the protective circuits, it can be controlled when connected in parallel, series connections is possible without $\frac{dv}{dt}$ protection

Its gaining widespread applications, switching speed of 100 kHz a easy voltage drive and a square safe operating area devoid of a secondary breakdown voltage.

PROCEDURE :-

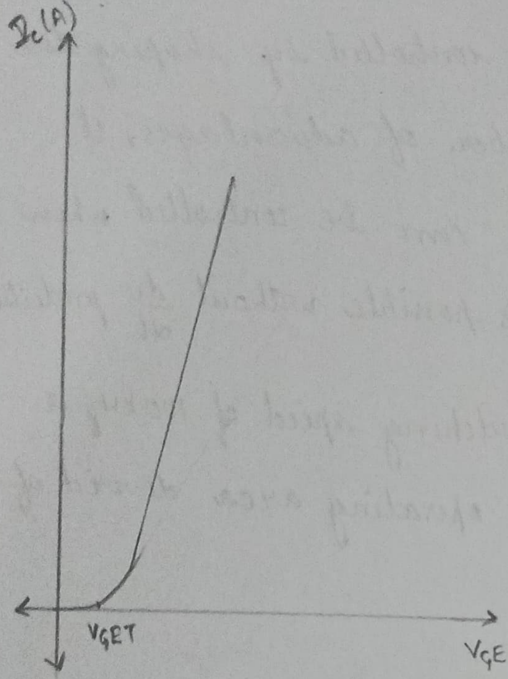
OUTPUT CHARACTERISTICS :-

1. connections are done as shown in figure.
2. keeping V_{GE} constant, measure I_C by varying V_{CE}.
3. Note down the readings
4. Plot the graph between I_C vs V_{GE}.

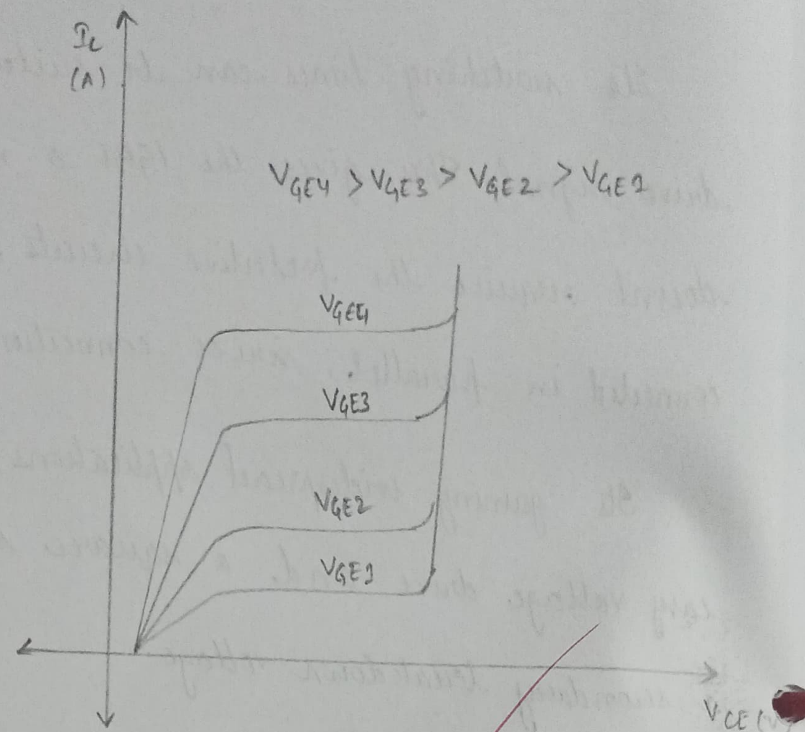
SWITCHING CHARACTERISTICS.

1. connections are done as shown in figure
2. A signal generator is connected across collector emitter pins of IGBT
3. Plot the switching characteristics using CRO.

IDEAL CHARACTERISTICS

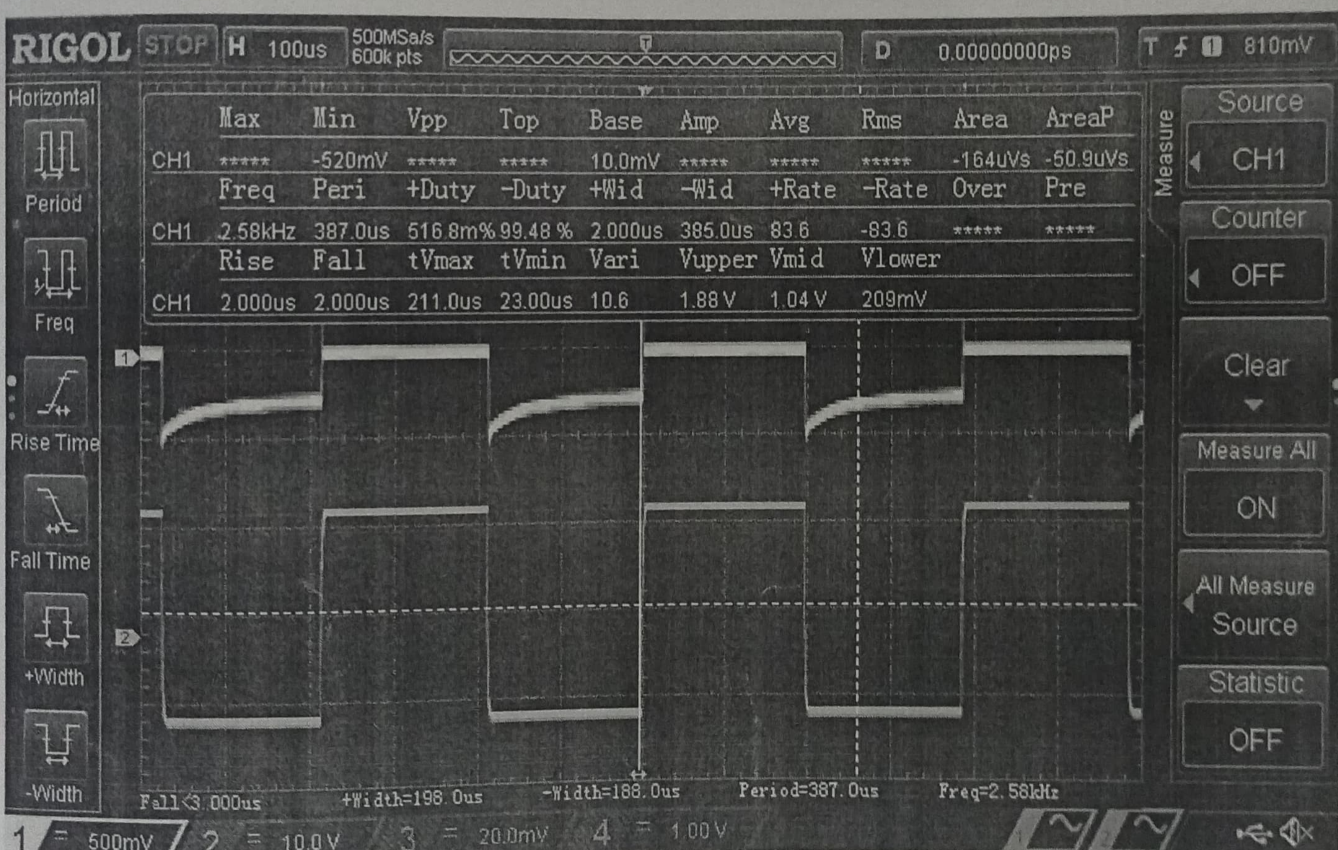


Transfer characteristics



Output characteristics

switching characteristics of IGBT

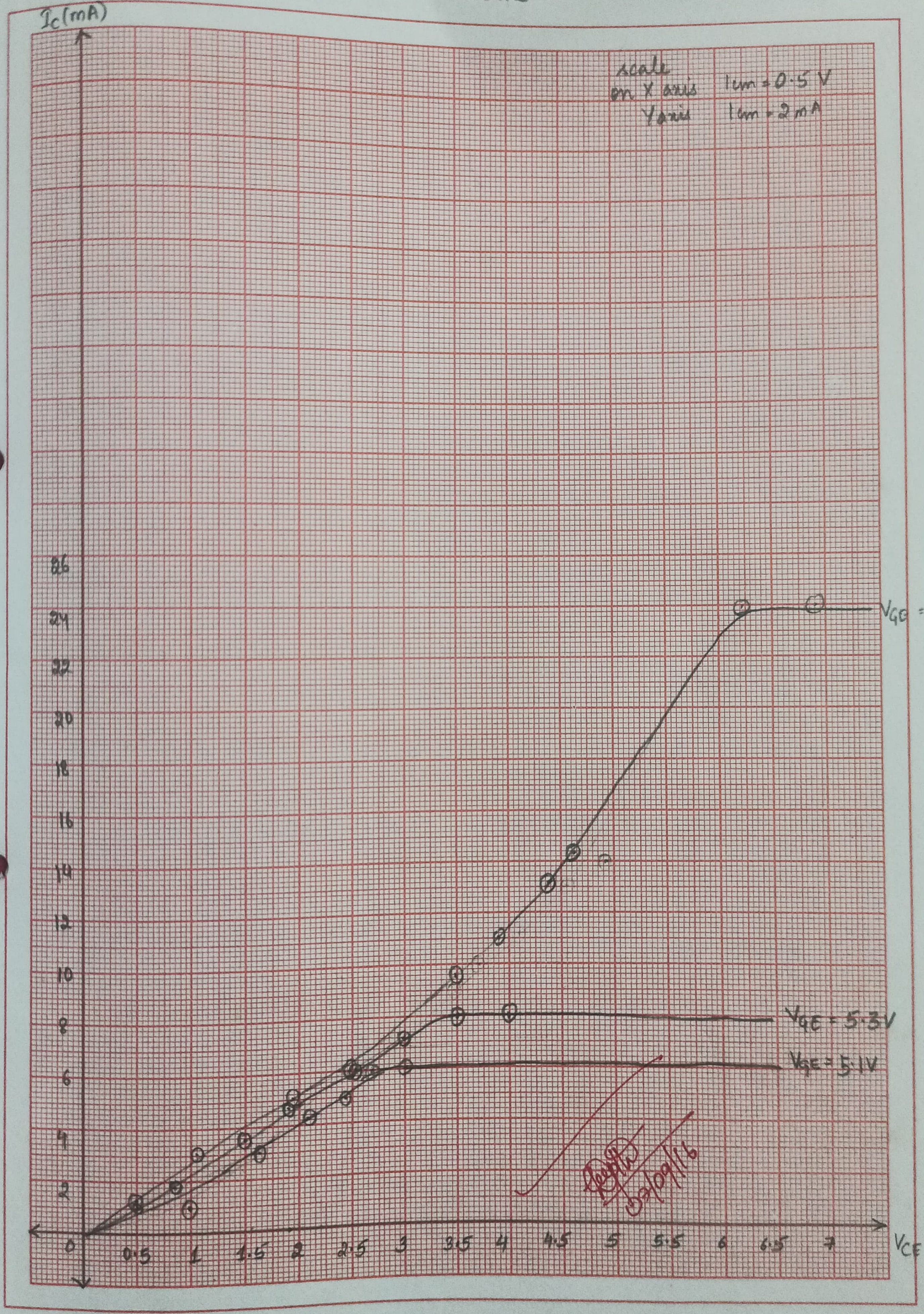


Channel 2 :- Input square at gate terminal

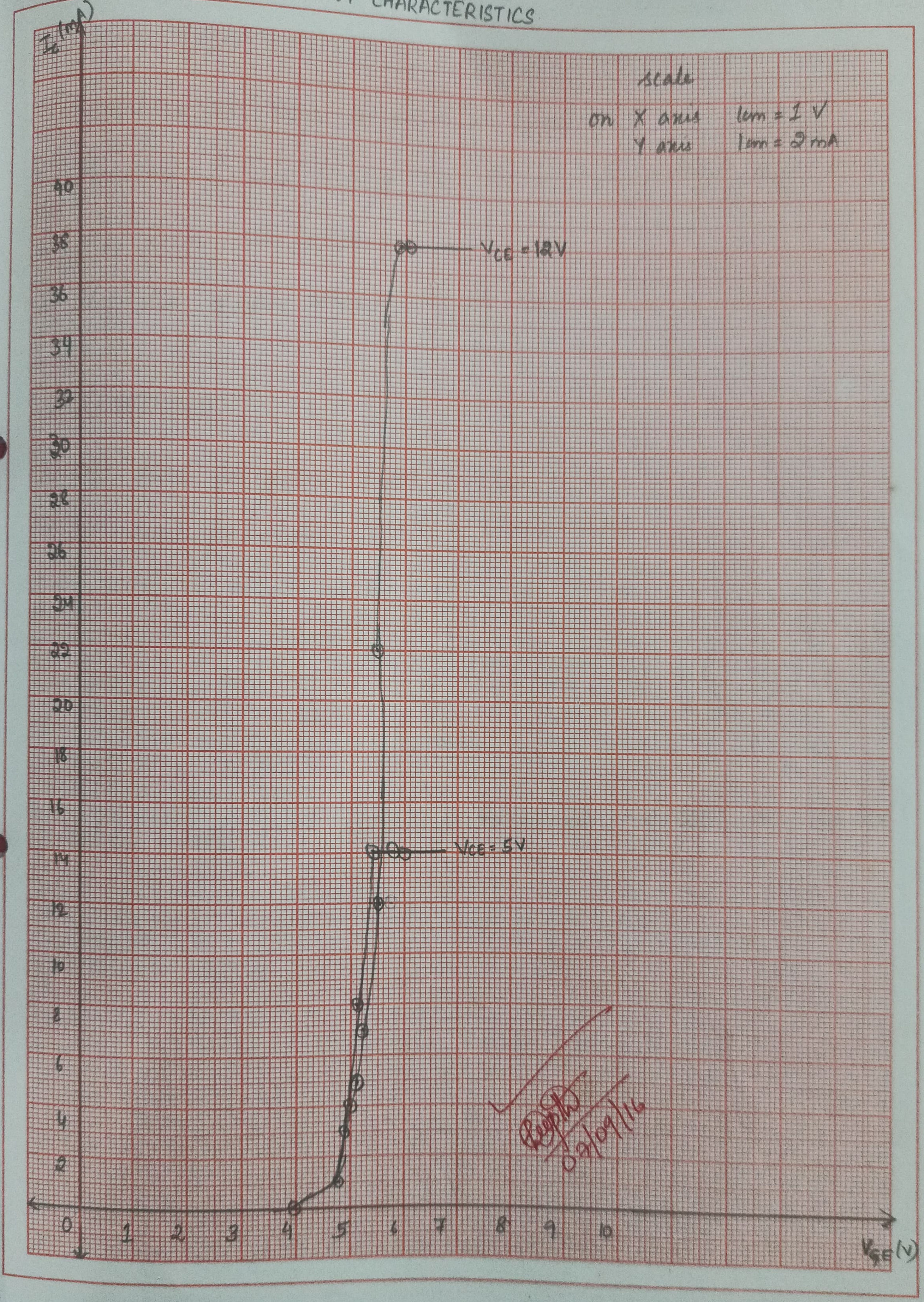
channel 1 :- output wave at drain source interval terminal.

07/09/16

OUTPUT CHARACTERISTICS



INPUT CHARACTERISTICS



TRANSFER CHARACTERISTICS :-

① Connections are done as shown in figure

② Measure I_c by varying V_{GE}, V_{CE} is kept constant here

③ Note down the readings

④ Plot the graph between I_c Vs V_{GE}.

OBSERVATIONS :-

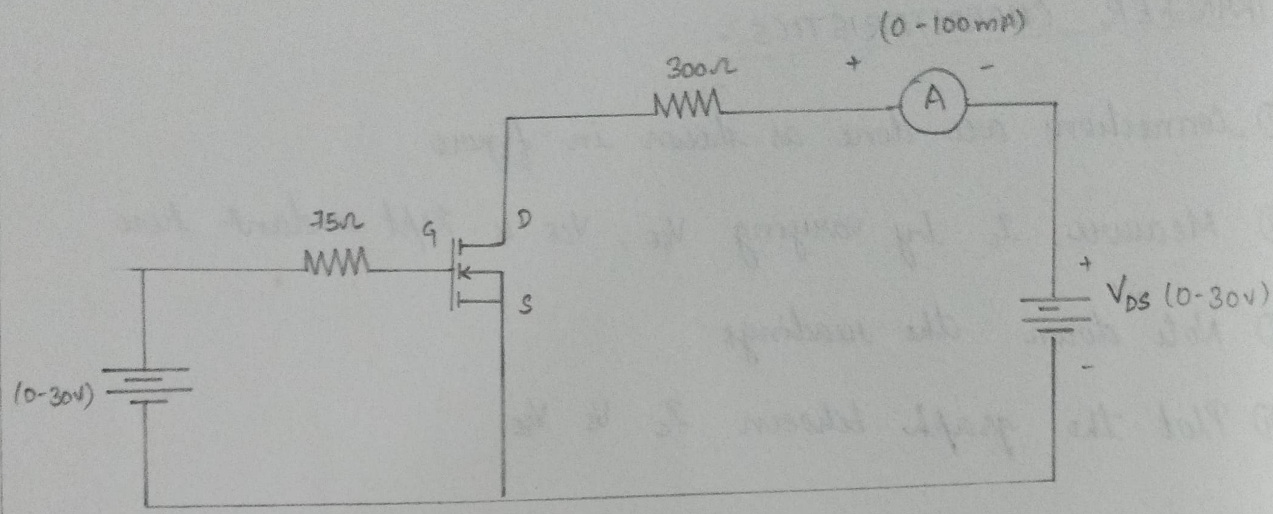
① ON time for given IGBT is (T_{ON}) = 2 μs

② OFF time for given IGBT is (T_{OFF}) = 2 μs.

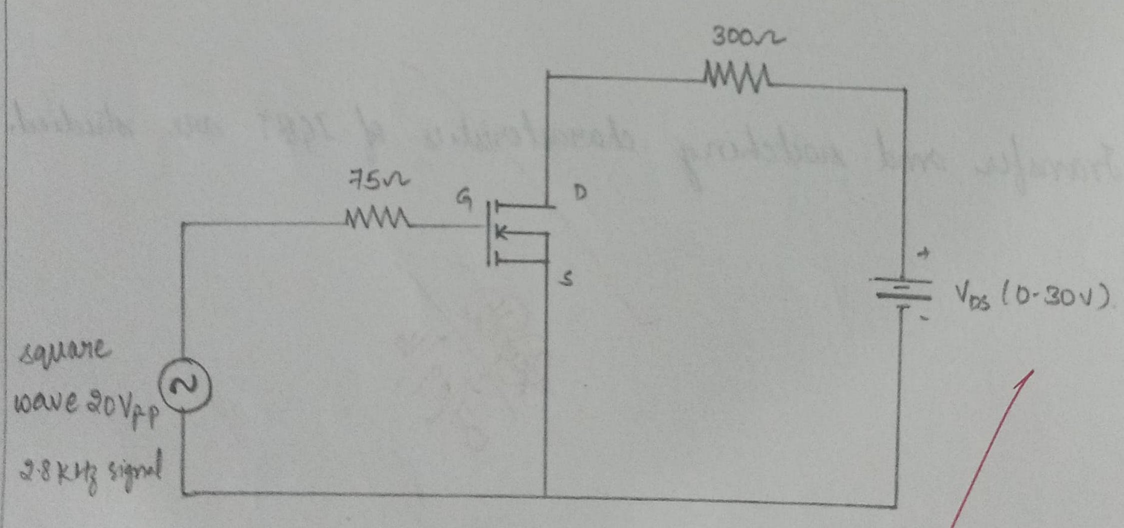
RESULT :-

Static, Transfer and switching characteristics of IGBT are studied.

Deepthi
07/09/16



OUTPUT AND INPUT CHARACTERISTICS



SWITCHING CHARACTERISTICS

Dt :- 16/08/16

EXP :-02. SWITCHING CHARACTERISTICS OF MOSFET

AIM :- To perform the switching characteristics of MOSFET.

APPARTUS :-

Appartus		Quantity
MOSFET		1
Regulated power supply. (0-30 V)		1
Resistors	45Ω	1
	75 Ω	1
	300 Ω	1
CRO		1.
Function Generator		1.

THEORY :-

MOSFET is a voltage controlled field effect transistor that differs from a JFET in that it has a "Metal oxide" Gate electrode which is electrically insulated from the main semiconductor n or p-channel by a thin layer of insulating material usually known as silicon dioxide; or

This isolation of the controlling GATE makes the input

$V_{DS} = 5V$		$V_{DS} = 6V$	
V_{GS} (V)	I_D (mA)	V_{GS} (V)	I_D (mA)
3.1	0	3.3	0
3.5	1	3.5	1
3.6	3	3.6	3
3.7	5	3.7	5
3.8	10	3.8	15
3.9	16	3.9	25
4	36	4.1	45
4.4	45	4.2	54.

TRANSFER CHARACTERISTICS

$V_{GS} = 3.6V$		$V_{GS} = 3.7V$		$V_{GS} = 3.9V$	
V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)
0.1	0	0.1	0	0.1	0
0.2	1	0.3	2	0.3	3
0.3	2	0.4	3	0.4	4
0.35	2	0.6	4	0.6	5
0.4	2	0.8	5	0.8	7
		0.9	5	0.9	8
		1	5	1	9
				1.5	12
				2	16
				2.2	18
				2.8	20
				3	20

OUTPUT CHARACTERISTICS

resistance of MOSFET extremely high way up in Mr region.

As the gate terminal is isolated from the main current carrying channel. No current flows into the gate.

It is a voltage controlled resistor where the current flowing through the main channel between the drain and source is proportional to the input voltage.

There are 2 types of MOSFET present

① Enhancement Type ② Depletion type.

There is no secondary breakdown in MOSFET and also have very low switching losses compared to BJT but has higher conduction losses. Hence for higher rating circuits MOSFET are not to be used.

PROCEDURE:-

i) SWITCHING CHARACTERISTICS:-

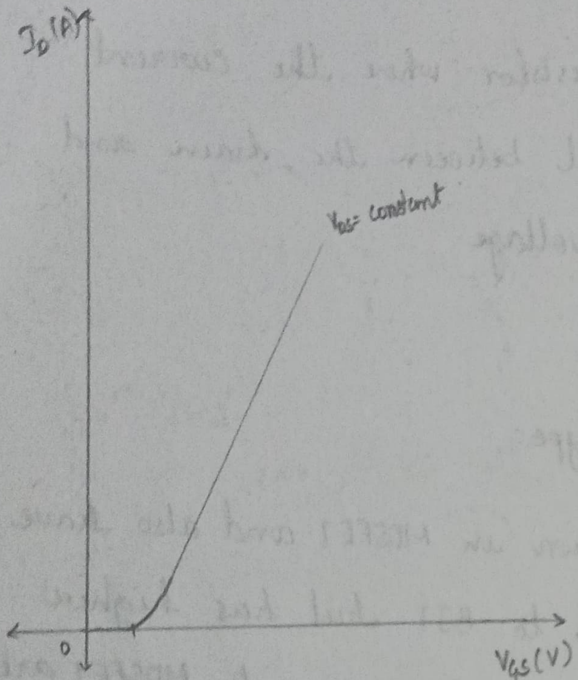
1) Connections are done as shown in the figure (b)

2) A signal generator is connected to the MOSFET and a square wave of certain amplitude and frequency is given to it.

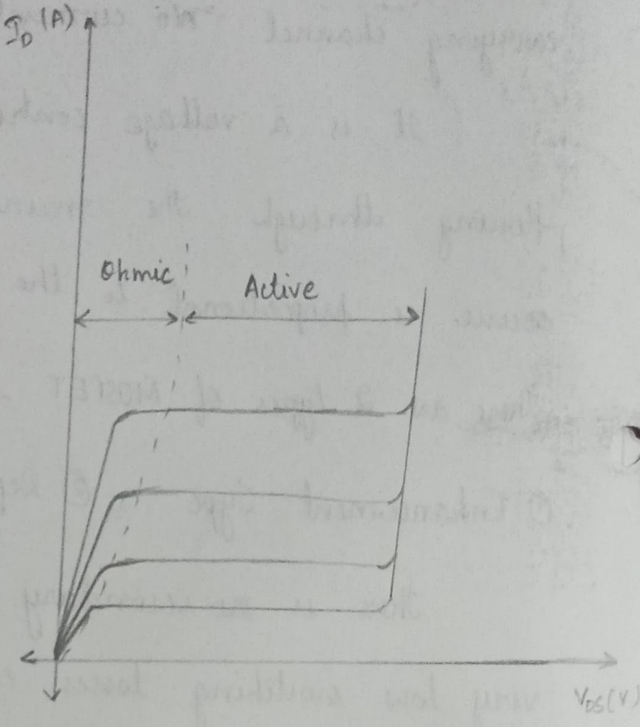
3) The waveform are observed on the CRO and calculate the required timing intervals.

IDEAL CHARACTERISTICS

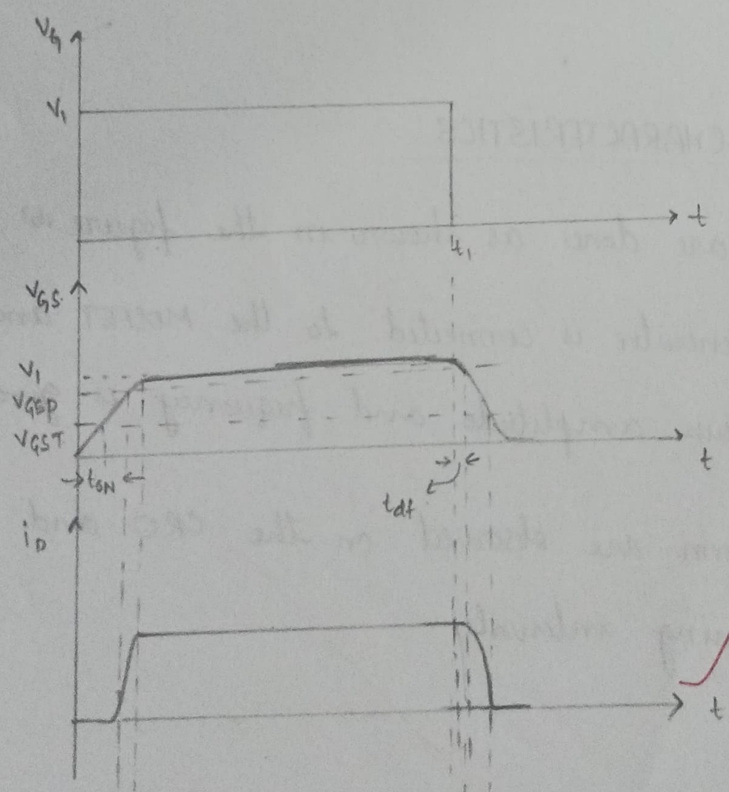
TRANSFER CHARACTERISTICS

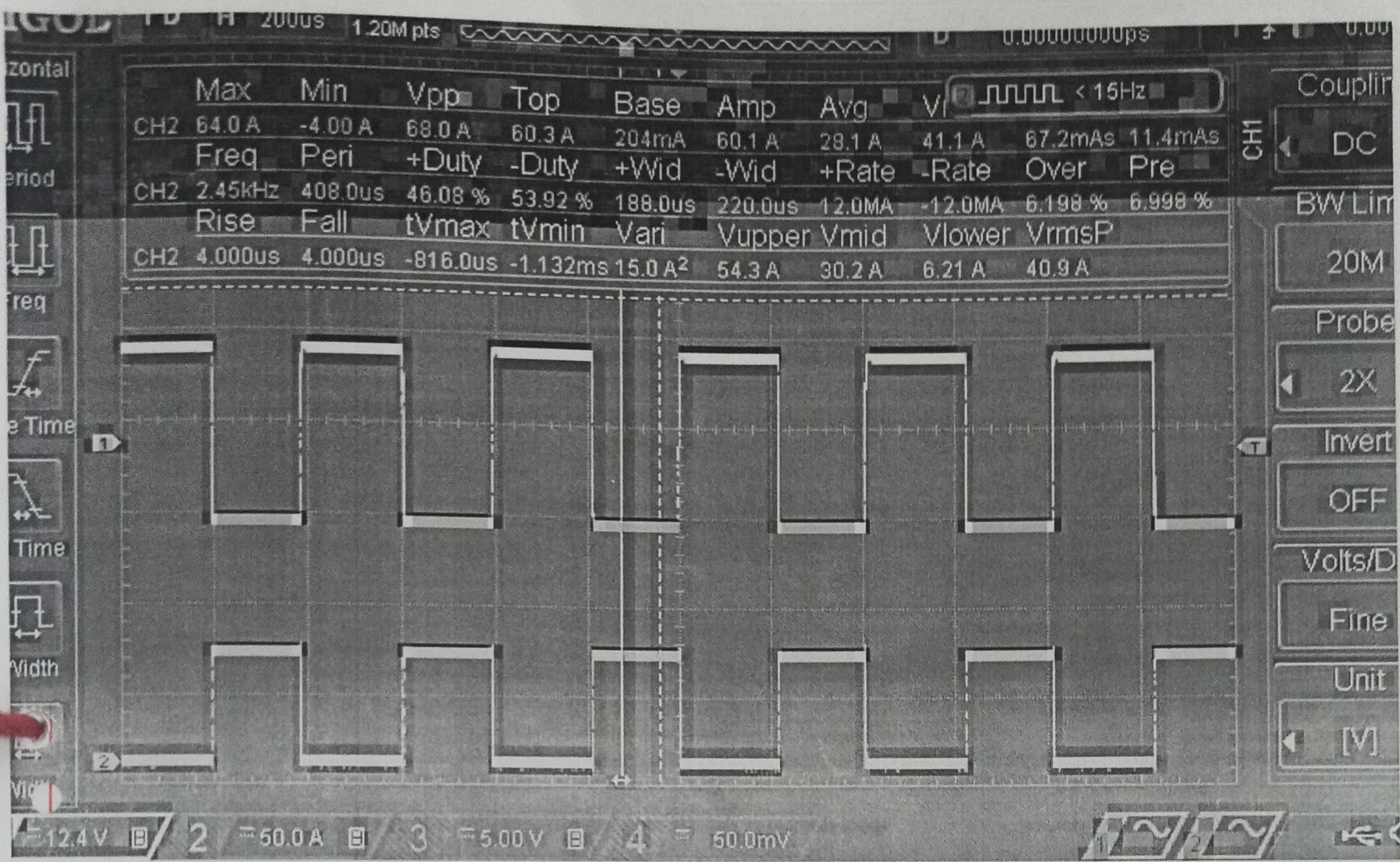


OUTPUT CHARACTERISTICS



SWITCHING CHARACTERISTICS





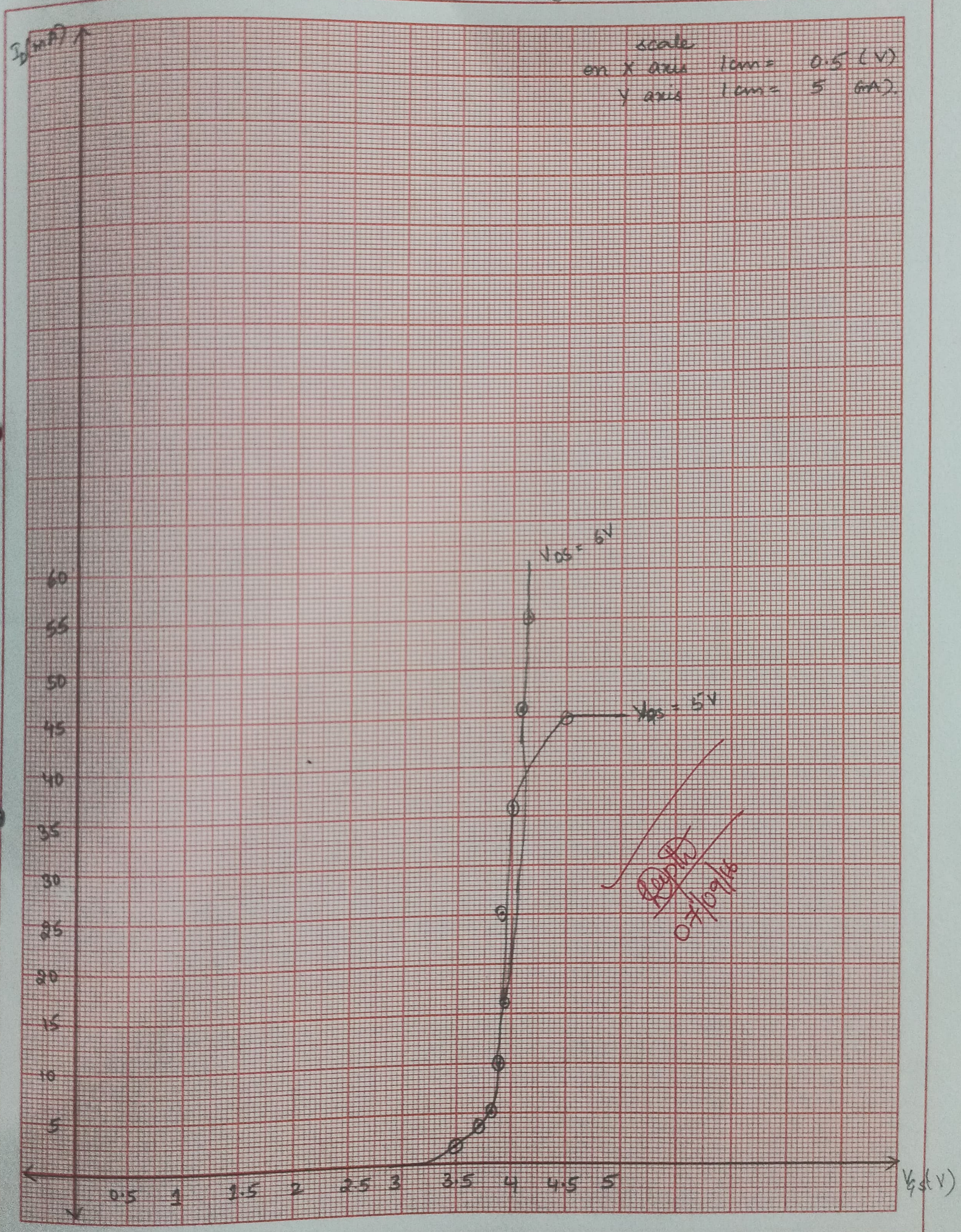
SWITCHING CHARACTERISTICS.

Channel 1 :- Switching characteristics of the MOSFET at V_{DS}.

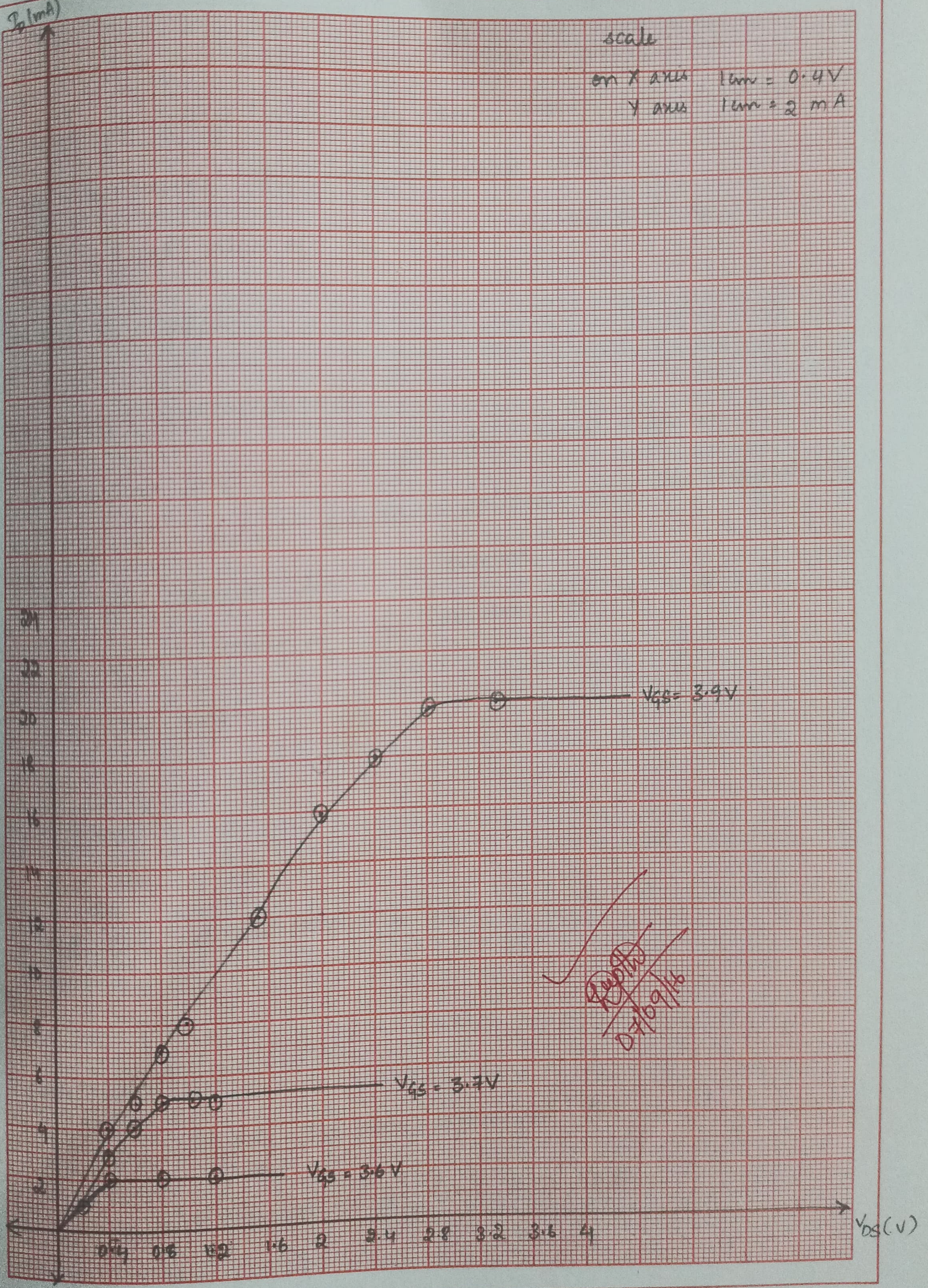
2 :- Input voltage given at gate V_{GS}

07/09/16

TRANSFER CHARACTERISTICS



OUTPUT CHARACTERISTICS



(ii) TRANSFER CHARACTERISTICS

1) Connections are made as per the circuit diagram.

2) Give gate voltage continuously and observe the drain current and by keeping the drain source voltage contant.

3) For different values of V_{GS} observe the V_{GS} and I_D.

4) Plot the graph.

(iii) OUTPUT CHARACTERISTICS

1) Connections are made as per the circuit diagram.

2) Give a constant gate source voltage, vary the drain source voltage and observe the drain current.

3) For different values of V_{GS} observe the V_{DS} and I_D.

4) Plot the graph.

RESULT

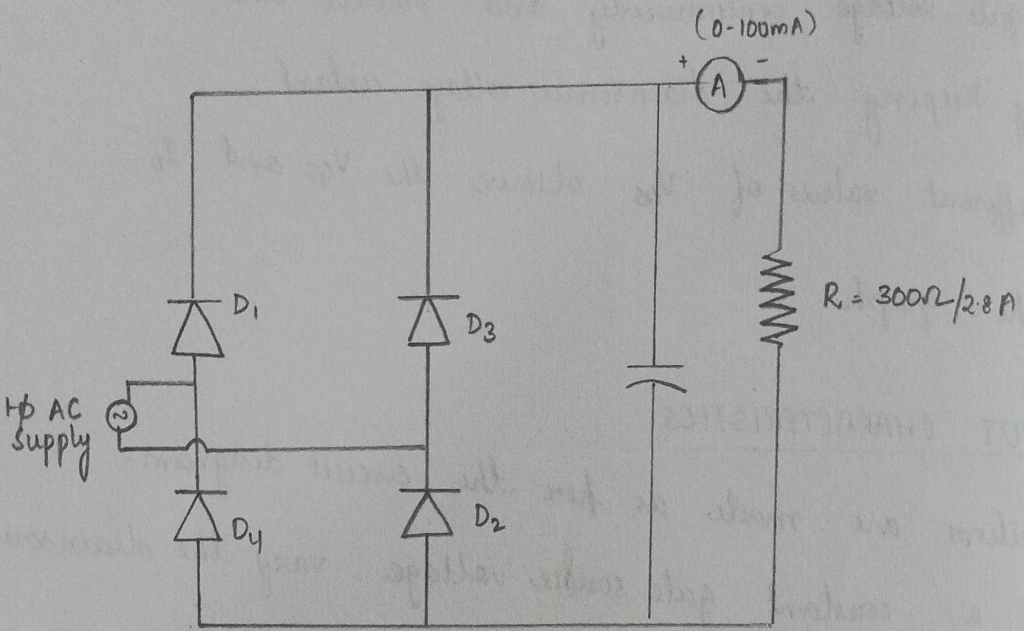
Rise time of the MOSFET = 4 µs

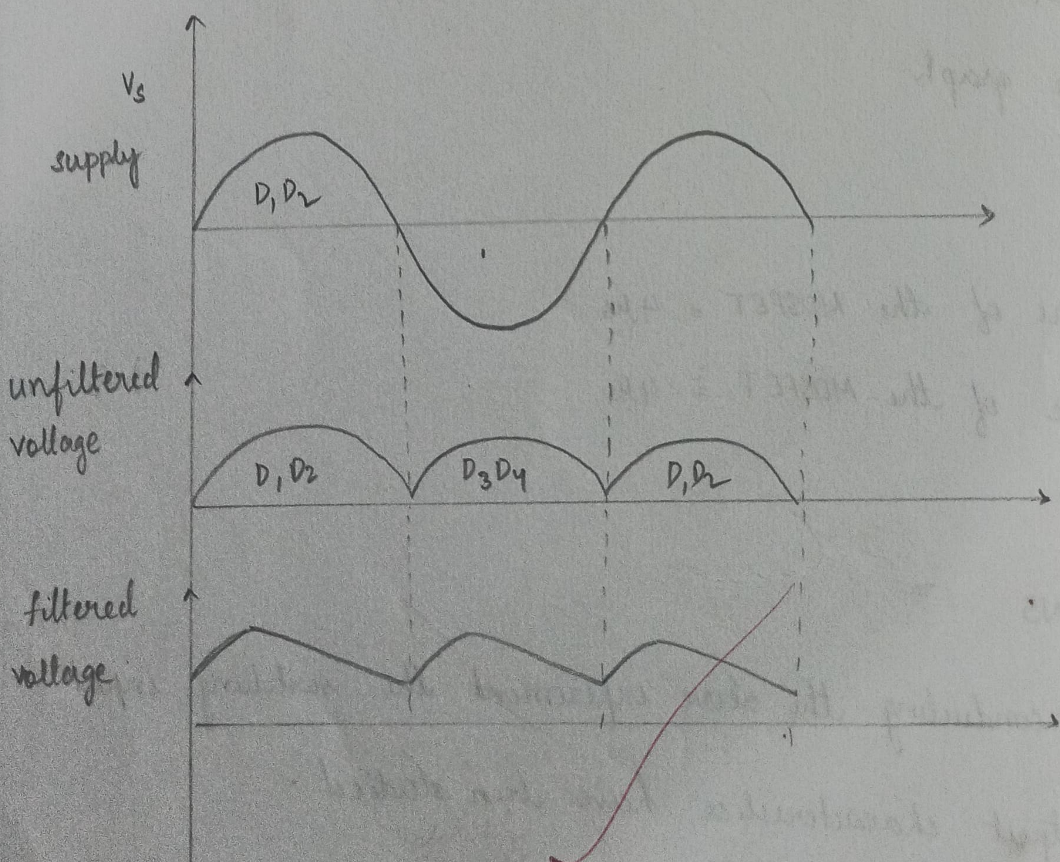
Fall time of the MOSFET = 4 µs

OBSERVATIONS

By conducting the above experiment the switching, input and output characteristics have been studied.

Reeptha
07/09/16


(0-100mA)
A
R = 300Ω/2.8A
D1
D3
D2
D4
I/P AC supply


Vs
supply
D1D2
unfiltered voltage
D1D2
D3D4
D1D2
filtered voltage

24/09/16

EXP :- 03 UNCONTROLLED RECTIFIER USING C - FILTER

AIM :- To study the behaviour of a fully uncontrolled rectifier when used with a capacitor filter.

APPARTUS :-

Diode	MIC 6A4	4
Capacitor	1000 μF	1
Resistor	300Ω/2.8A	1
Autotransformer	230 V	1
Ammeter	0-100m A	1.

THEORY :-

The uncontrolled rectifier when used doesn't give a pure DC but a pulsating DC of frequency 2f. This pulsating DC contains lots of harmonics of higher order. Due to this we cannot use it in any of the applications. Hence this pulsating DC should be converted into pure DC. This can be ideally achieved by using FILTERS.

In this experiment we have used a capacitor connected at the load terminal in order to remove the ripple content in voltage. Based on

LOAD REGULATION

$V_{in} = 10V$ $V_{NL} = 11.91V$

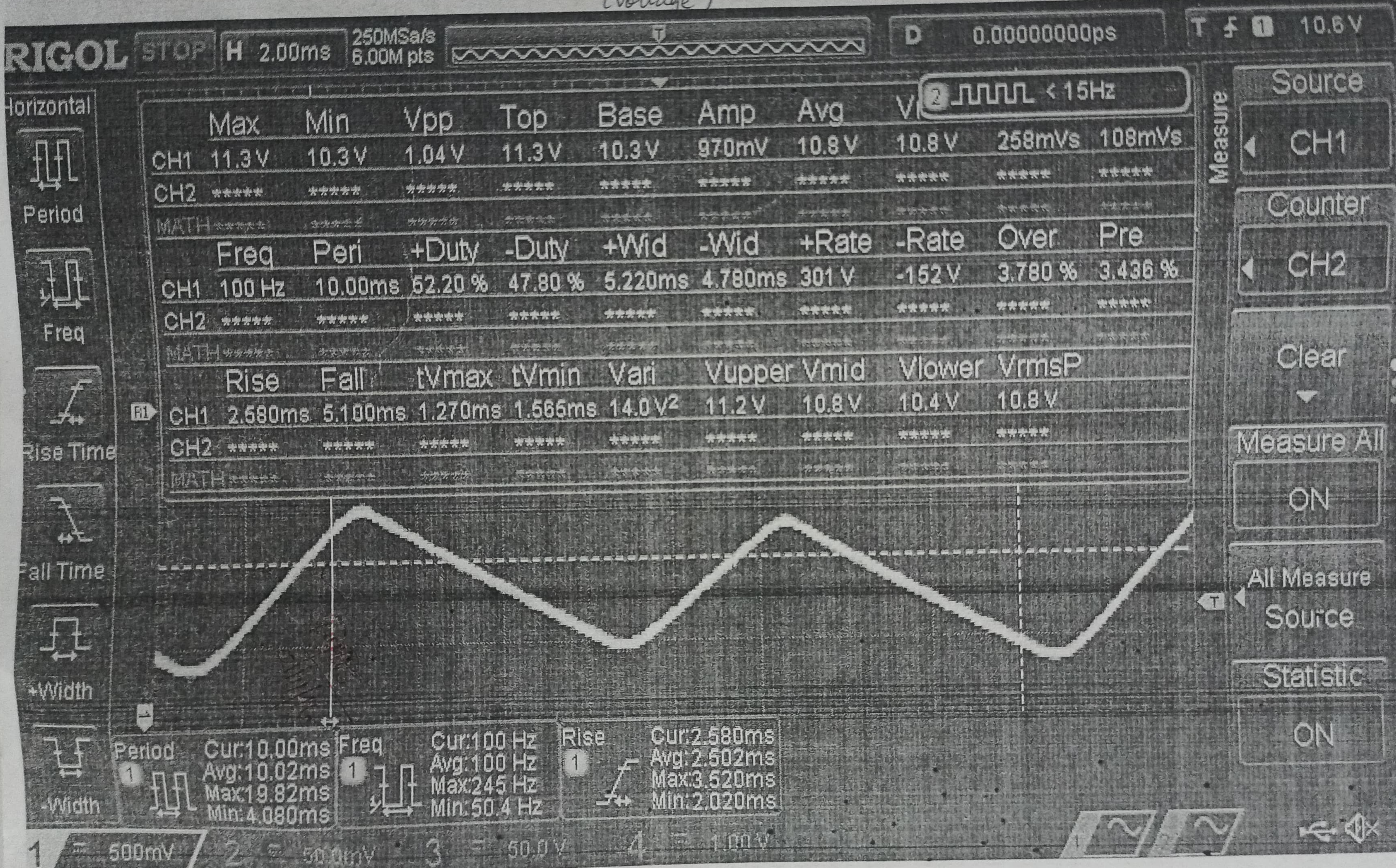
V_o (V)	I_o (A)	$\frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$
11.34	35	4.78
11.2	40	5.96
11.09	50	6.88
11	60	7.64
10.91	65	8.39
10.78	75	9.48
10.69	85	10.24
10.49	95	11.92

LINE REGULATION:-

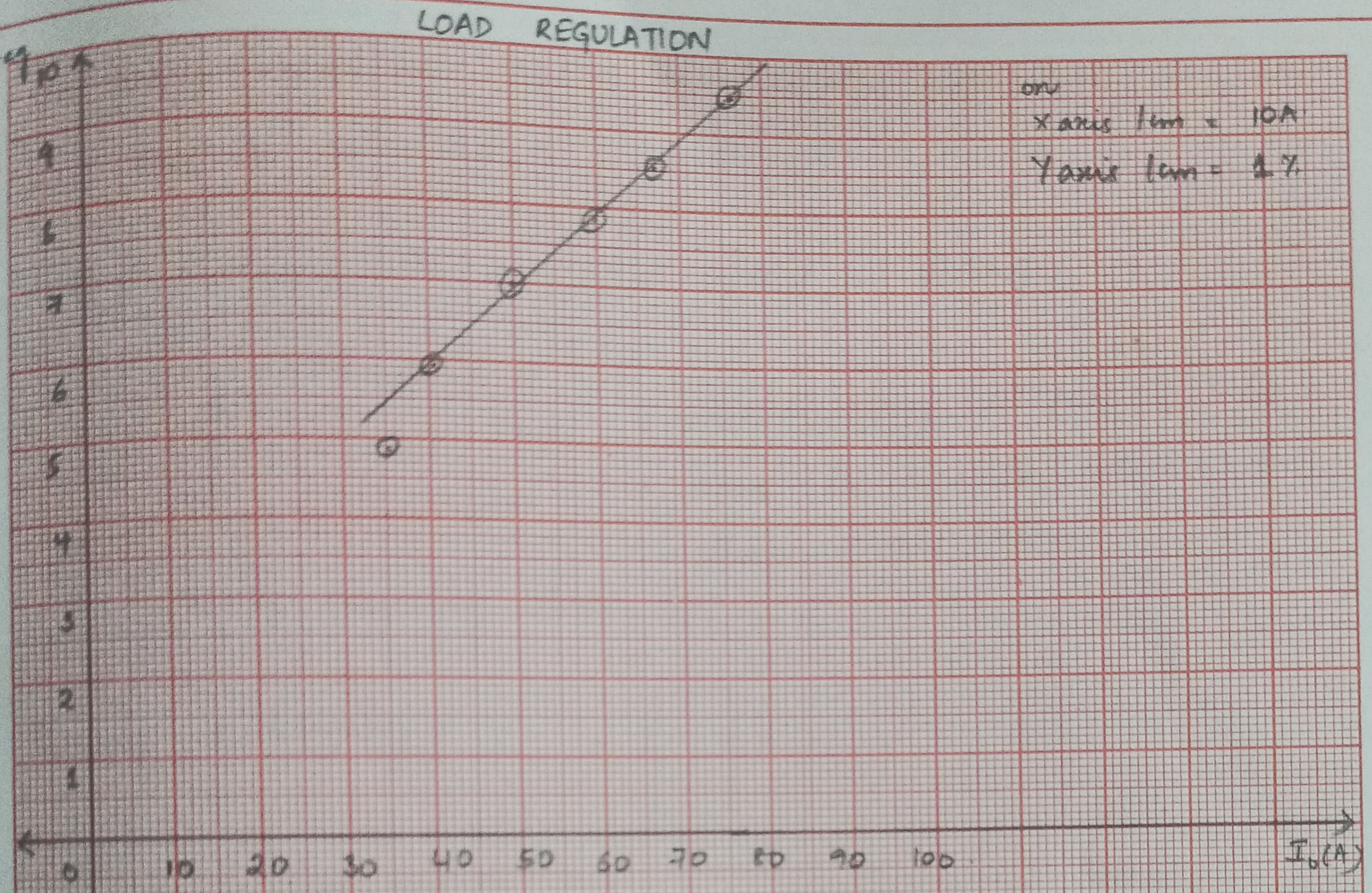
V_{in} (V)	V_o (no load)	V_o (FL)	% regulation
8	9.8	8.76	10.6
9.02	11.19	10.02	10.45
10	11.92	11.36	4.69
11.52	14.2	13.61	3.6
12.60	15.3	14.87	3.7
15.12	17.1	15.62	8.62

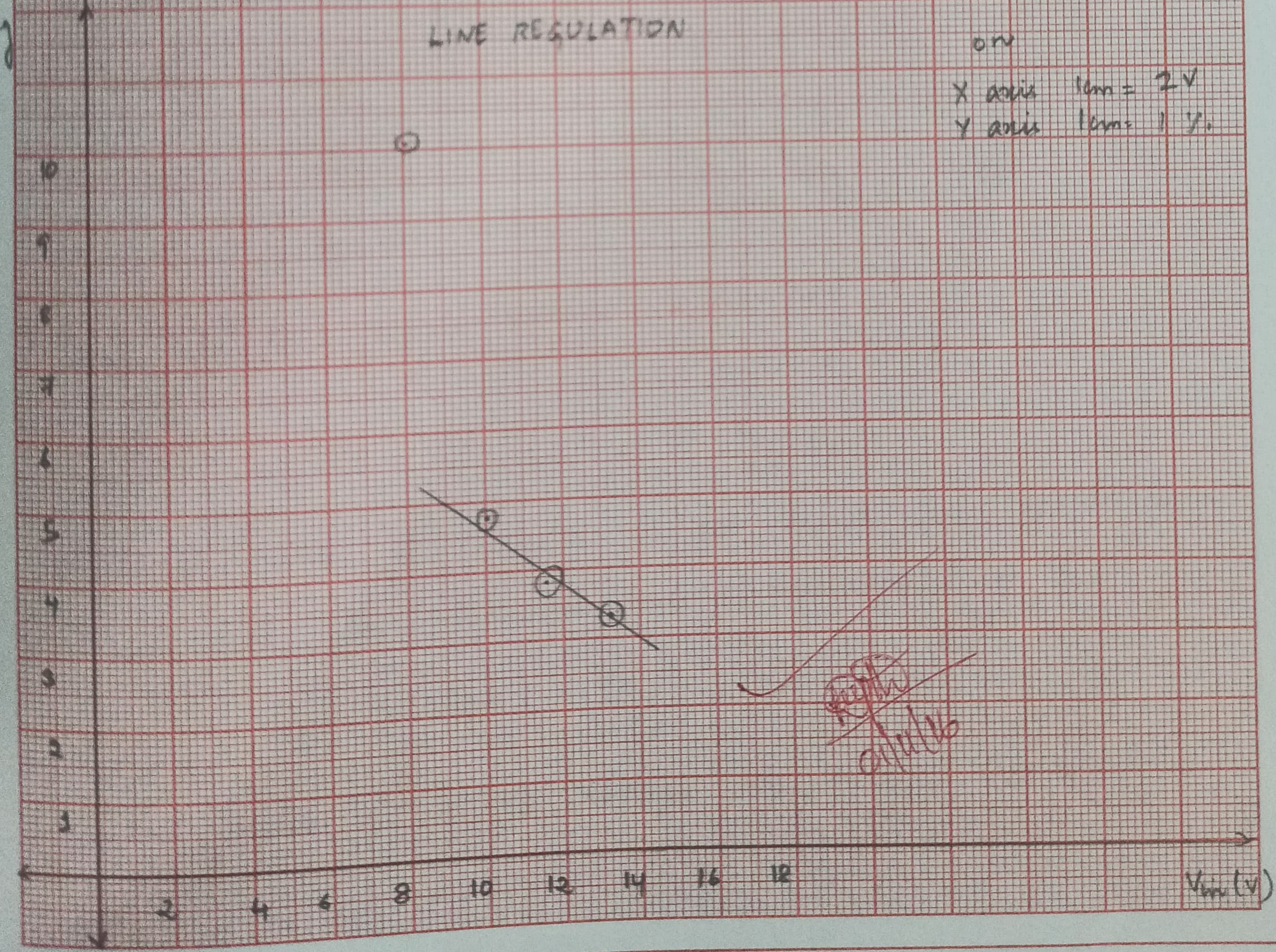
uncontrolled output of a C-filter (voltage)

Vin = 12V



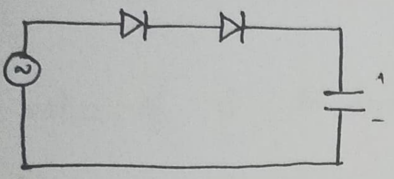
C-FILTER


LOAD REGULATION
X axis 1cm = 10A
Y axis 1cm = 1%
I₀(A)


LINE REGULATION
X axis 1cm = 2V
Y axis 1cm = 1%
Vin(V)

the ripple content we require as per our applications the value of C can be calculated as

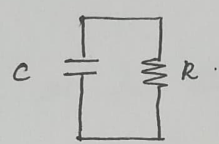
During charging the equivalent circuit is ~~develop~~ :-



This charging is possible only when the capacitor voltage is less than supply voltage

$V_c = V_s$ (neglecting diode drop)

During discharging :-



As the initial voltage now becomes V_m.

writing the KVL, $V_m + \frac{1}{C}\int i\,dt = R \cdot i_d$:

solving this $i_d = \frac{V_m}{R} \cdot e^{-t/RC}$

capacitor voltage $v_c = i_d \cdot R = V_m e^{-t/RC}$.

peak to peak ripple voltage $= V_m - V_m e^{-t_2/RC}$.

$$= V_m(1 - e^{-t_2/RC})$$

$$\cong \frac{V_m}{RC} \cdot t_2$$

A large value of capacitor to get ripple free capacitor current such that the discharging time t_2 approximated as $T/2$:

$$v_o(\text{ripple}) = \frac{V_m}{2fRC}$$

RMS value of ripple voltage $V_{ac} = \frac{V_{rpp}}{2\sqrt{2}}$ (approximated)

Average load voltage = V_m - average of ripple voltage.

$$= V_m - \frac{V_m}{4fRC}$$

Ripple Factor $= \frac{V_{rms}}{V_{avg}} = \frac{\frac{V_m}{4\sqrt{2}RCf}}{V_m\left(1 - \frac{1}{4fRC}\right)} = \frac{1}{\sqrt{2}(4fRC - 1)}$

The value of C to limit the ripple factor is

$$C = \frac{1}{4fR}\left[1 + \frac{1}{\sqrt{2}RF}\right].$$

PROCEDURE :-

1) Connections are made as per the circuit diagram.

2) The no load voltage is noted down when a input voltage of certain magnitude is applied

3) Now the load regulation is calculated for different values of given input voltage

4) Now the load resistance is connected and by varying the resistance the current and voltage readings are noted down.

CALCULATIONS :-

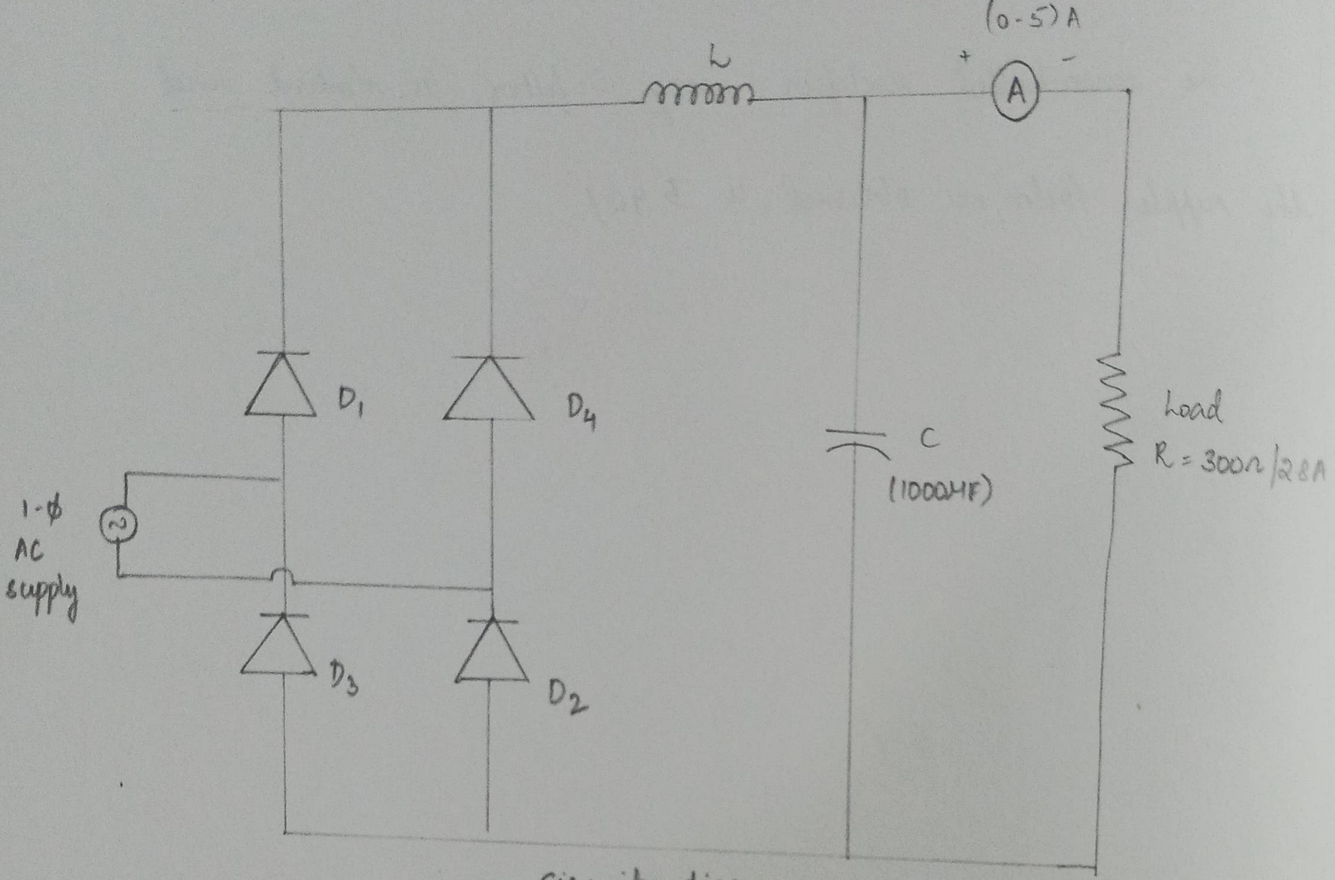
ripple factor $= \frac{V_{(p-p)} \text{ ripple rms}}{V_{avg}} = \frac{\frac{1.04}{2\sqrt{2}}}{10.8}$

$= 3.40\%$.

RESULT :-

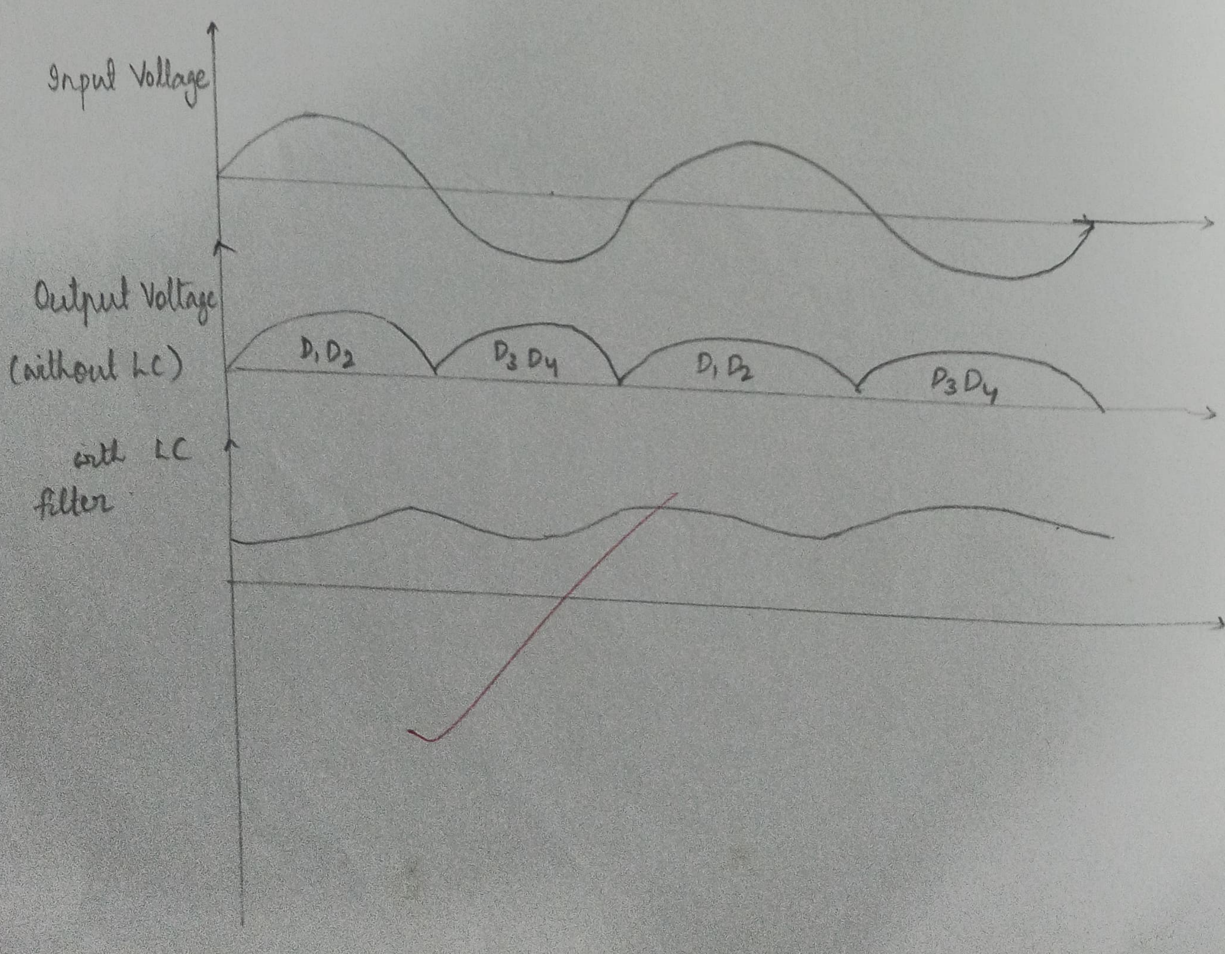
The uncontrolled rectifier using C-filter is studied and the ripple factor we obtained is 3.40%.

Deepthi
01/11/16



circuit diagram.

MODEL GRAPHS.



05/10/16

EXA :- 04

UNCONTROLLED RECTIFIER USING L-C. FILTER.

AIM :- To design a full wave uncontrolled rectifier with L-C filter and to find out regulation.

COMPONENTS :

Components	Range	Quantity
Diode	MIC6A4	4
Variac	0-230V	1.
Inductor		
capacitor	1000 μF	1.
Rheostat	300Ω/2.8A	1
Ammeter	(0-5 A)	1.
CRO	digital	1.

THEORY :-

These rectifier circuits are used to convert AC input voltage to DC output. There are 2 types uncontrolled and controlled. The uncontrolled & controlled rectifiers doesn't produce pure DC output voltage. Hence we need to use the filters to make

$V_{in} = 22V$ $V_{O}NL = 28.22$

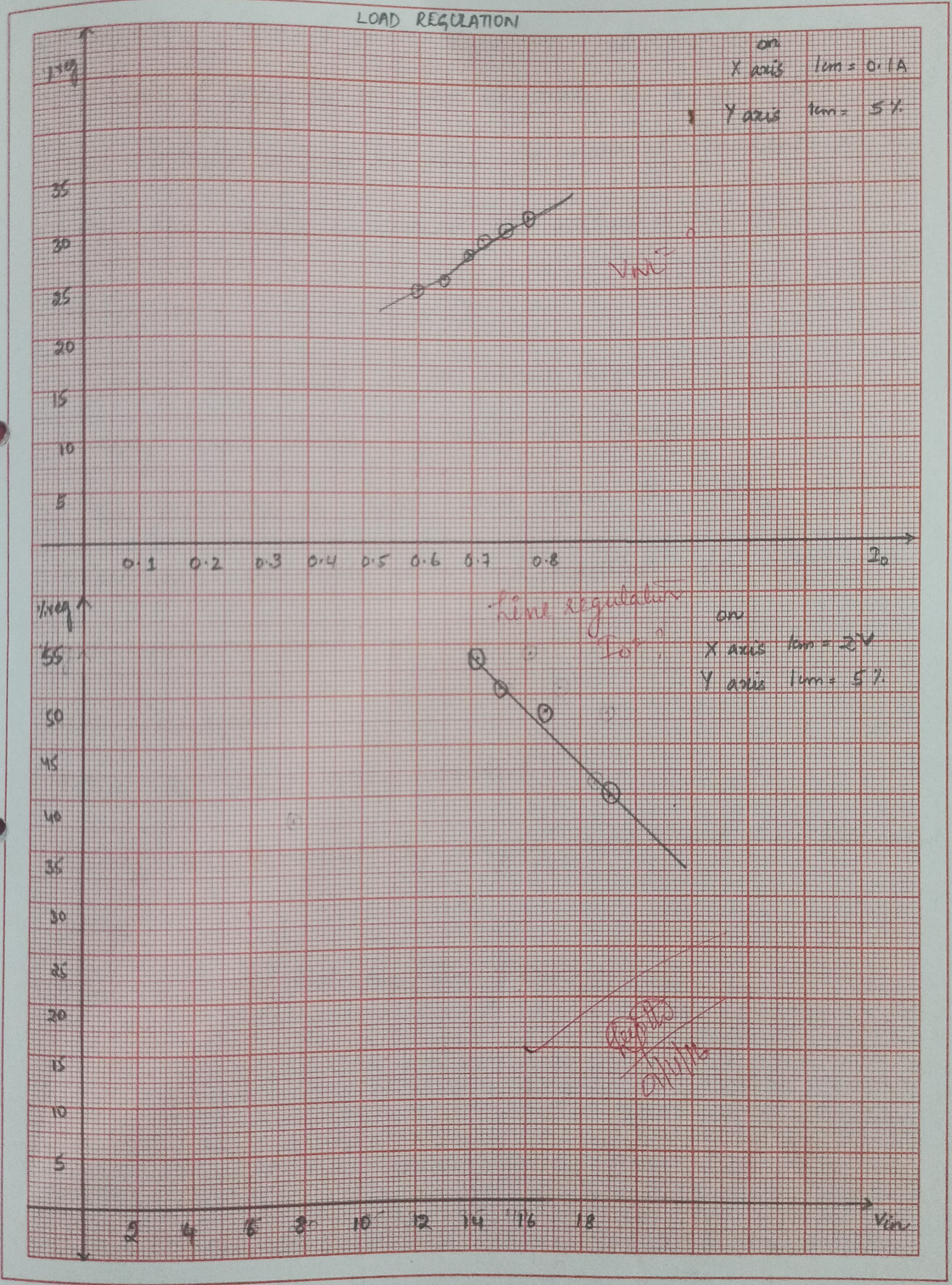
V_o (V)	I_o (A)	$\frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$ regulation
19.2	0.8	31.96
19.62	0.75	30.47
19.8	0.7	29.84
20.30	0.68	28.065
20.77	0.64	26.4
21.04	0.6	25.41

LINE REGULATION:-

$I_o = 0.5A$

Vin (V)	V_o (NL) (V)	V_o FL (V)	$\frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$ (regulation)
18.84	25.34	15.7	38.04
17.22	25.12	14.2	43.48
16.57	24.87	12.75	48.73
15.2	24.3	11.8	51.44
14.11	24.1	11.02	54.27

L-CFILTER



LOAD REGULATION
on
X axis 1cm = 0.1A
Y axis 1cm = 5%
%reg
35
30
25
20
15
10
5
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
Io
Line regulation
on
X axis 1cm = 2V
Y axis 1cm = 5%
%reg
55
50
45
40
35
30
25
20
15
10
5
2
4
6
8
10
12
14
16
18
Vin

There are 3 types of filters L filter, LC filter and C filter. The use of capacitor is used to make the output voltage constant and inductor is used to make the current constant. In this way the ripple in current and voltage is reduced.

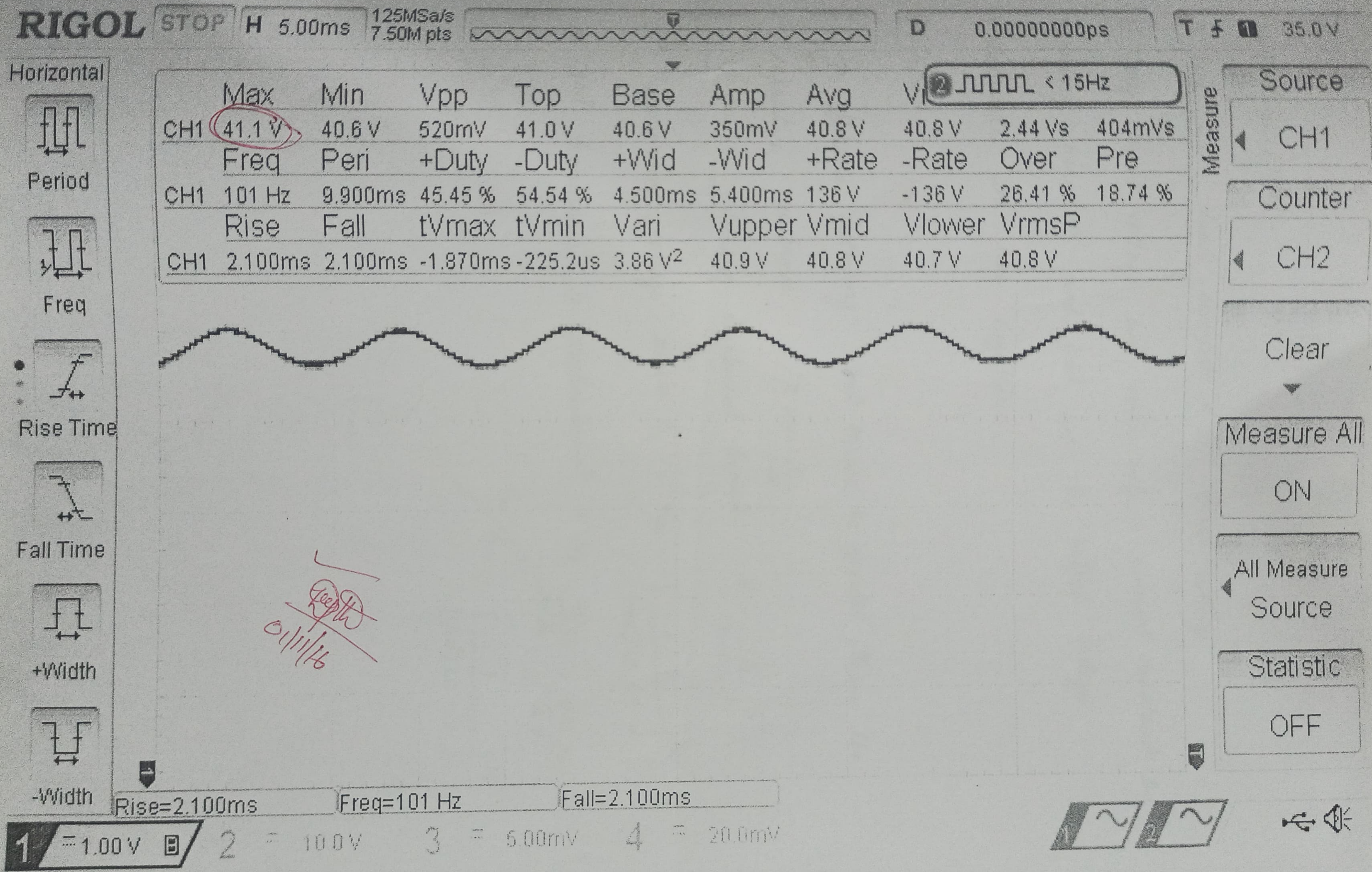
PROCEDURE :-

1) Connect the circuit as per circuit diagram.
2) Apply input voltage by using auto-transformer.
3) For each step of input, write down the voltage readings.
4) Calculate the ripple factor and regulation from maximum and minimum V and Vrpp.

LOAD REGULATION :-

1) Keep the input voltage constant
2) Vary output current by varying rheostat and then find output voltage
3) Find out the load regulation percentage.

$V_{in} = 42V$



output voltage of uncontrolled rectifier using L filter with $V_{in} = 42V$

LINE REGULATION :-

1) keep the load current at a fixed voltage

2) Vary input voltage and makes output current constant by varying rheostat and find out the output voltage.

3) Calculate the line regulation.

DESIGN :-

For effective filtering load should be greater than the capacitive reactance $R >>> \frac{1}{n\omega C}$.

taking emperical formula $R = \frac{10}{n\omega C}$:

n^{th} harmonic voltage across C $\Rightarrow V_{on} = \left[\frac{-1}{(n\omega)^2 LC - 1}\right]^{1/n}$

As 2nd harmonic is predominant $\Rightarrow V_2 = \frac{4V_m}{3\pi\sqrt{2}} = \frac{2\sqrt{2}\,V_m}{3\pi}$.

$\Rightarrow V_{o2} = \left[\frac{-1}{(2\omega^2) LC - 1}\right]^{1/2}$

CALCULATIONS:-

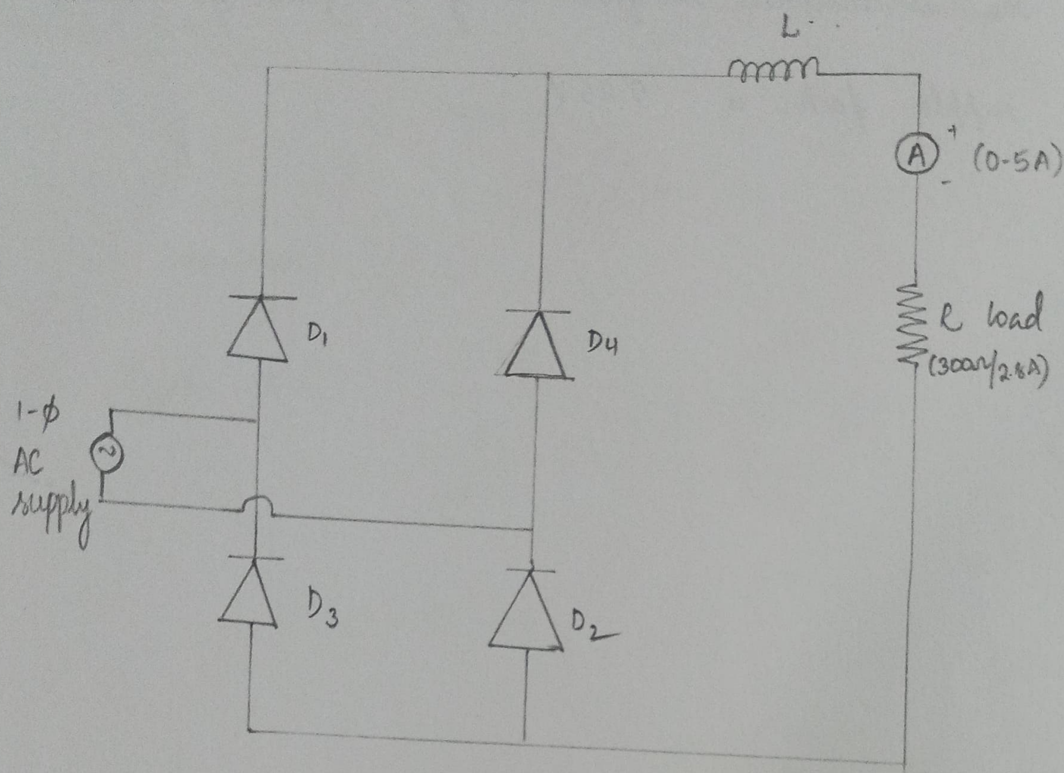
$$V_{in} = 42V$$

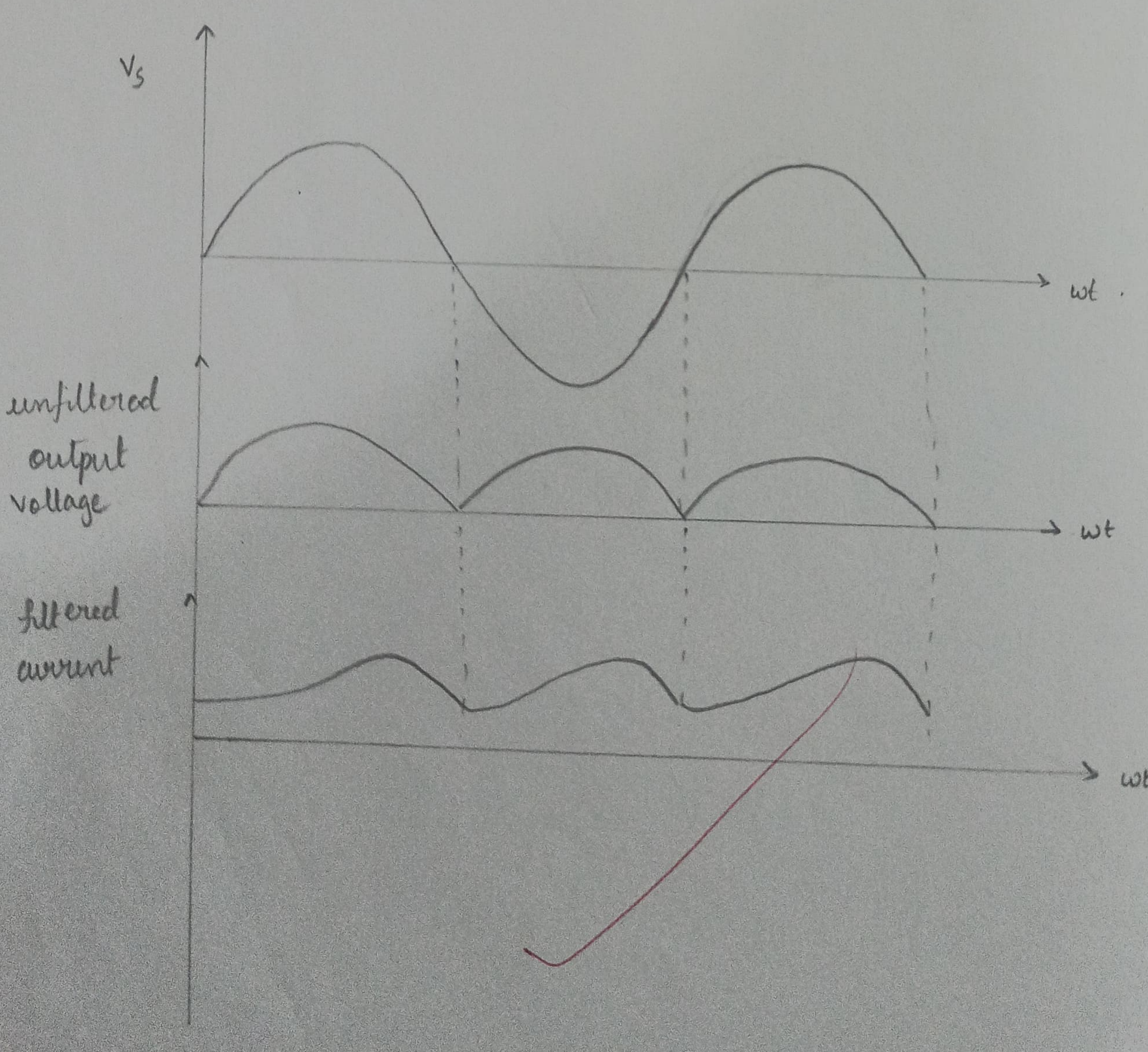
$$V_{(r-r)}\ peak = 520mV$$

$$\text{Ripple factor} = \frac{\frac{0.52}{2\sqrt{2}}}{40.8} = 4.5 \times 10^{-3}$$

RESULT:- The uncontrolled rectifier using L-C filter is studied and the ripple factor is 0.45%.

Deepthi
01/11/16


L
(0-5A)
R load
(300Ω/2.8A)
D1
D4
D3
D2
1-φ
AC
supply


Vs
wt
unfiltered
output
voltage
wt
filtered
current
wt

05/09/16

5. UNCONTROLLED RECTIFIER USING L - FILTER

AIM :- To design an uncontrolled rectifier using L - filter and to find out the ripple content.

APPARTUS :-

Components	Range	Quantity
Power diode	MIC6A4	4
Inductor	mH	1
1-ϕ variac	0-230V	1
Rheostat	300Ω/2.8A	1
Ammeter	0-5A	1
CRO	digital	1

THEORY :-

Rectifiers are used to convert AC to DC at supply frequency to different frequency based on the devices. The uncontrolled and controlled rectifier doesn't produce pure dc. Hence we need to reduce the ripple content in the output voltage by using filters.

$V_{in} = 25V$ $V_{NL} = 23.06V$

$V_o(V)$	$I_o(A)$	$\frac{V_{NL}-V_{FL}}{V_{NL}} \times 100$
21.14	0.1A	8.32
19.20	0.2A	16.73
16.48	0.38	28.53
13.20	1.20	42.75
11.18	1.5	51.52

high

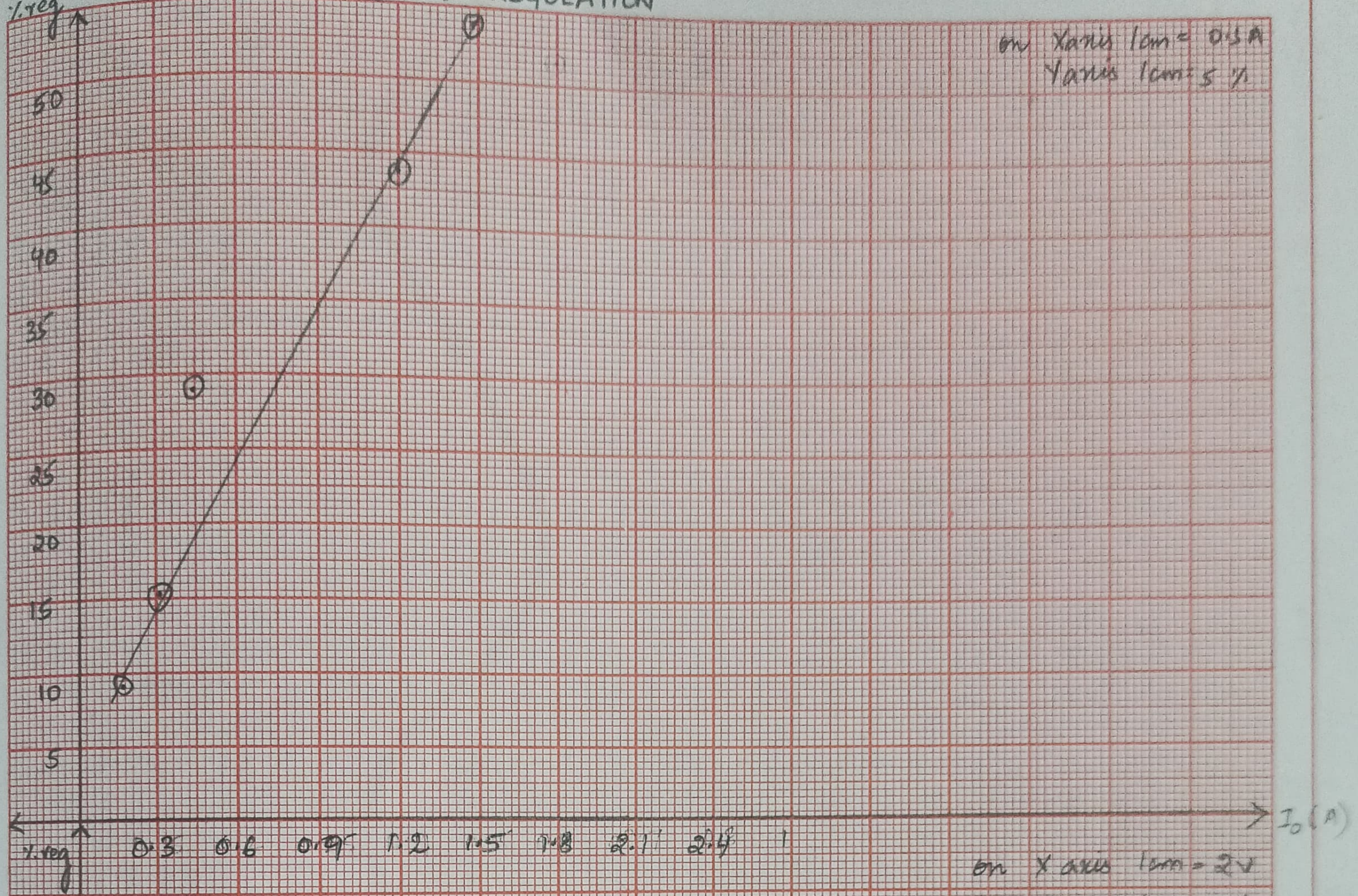
LINE REGULATION:

$I_o = 1.5A$

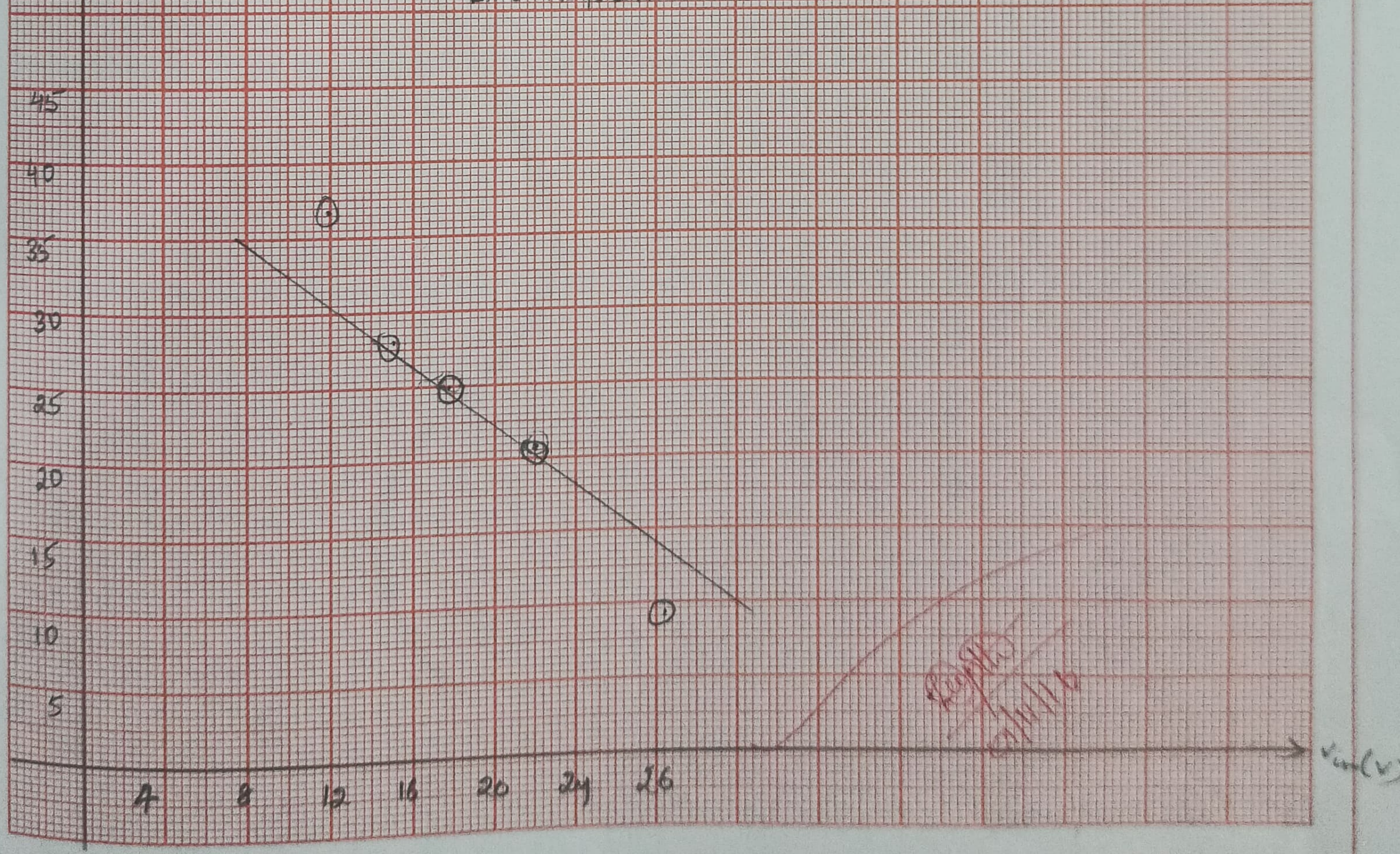
$V_{in}(V)$	$V_o(V)$ noload	$V_o(V)$ full load	% regulation
12	8.48	5.2	38.67
14	11.39	8.27	27.39
18	15.40	11.27	26.80
22	21.04	16.32	22.43
26.8	22.6	20.9	7.5

high

LOAD REGULATION

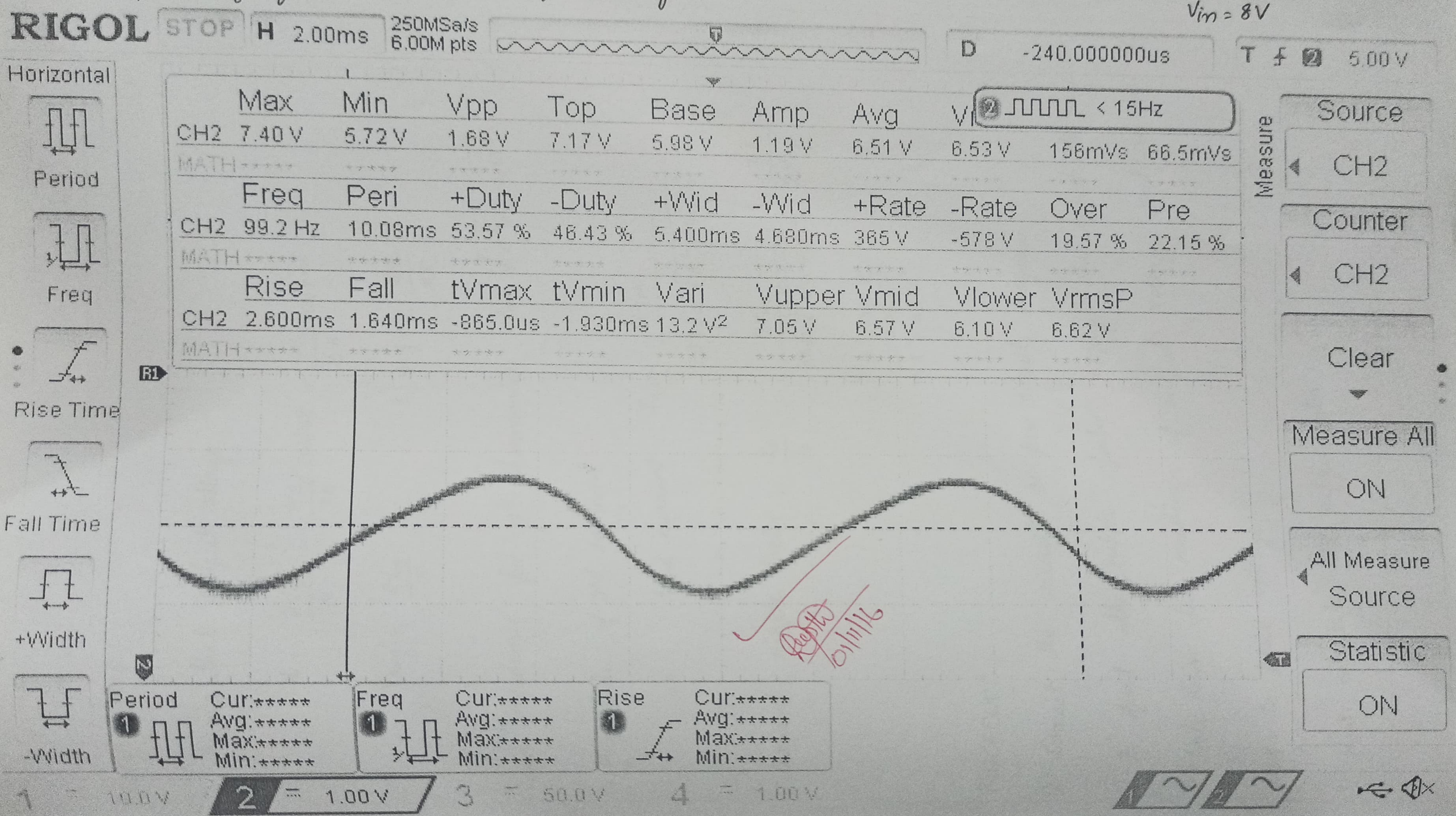


LINE REGULATION



output voltage of uncontrolled rectifier using L filter

$V_{in} = 8V$



CALCULATIONS :-

we know that output voltage,

$$V_0 = \frac{2V_m}{\pi} - \frac{4V_m}{3\pi}\cos 2\omega t - \frac{4V_m}{15\pi}\cos 4\omega t \cdots$$

$$V_{avg} = \frac{2V_m}{\pi} \qquad I_0\ avg = \frac{2V_m}{\pi R}.$$

Load impedance for n^{th} harmonics $Z_n = \sqrt{R^2 + (n\omega L)^2}$.

Magnitude of 2nd harmonic

load current $I_{02} = \frac{4V_m}{3\pi\sqrt{2}\sqrt{R^2 + 4\omega^2 L^2}}$

Current ripple factor $\frac{I_r}{I_0} = \frac{4V_m}{3\pi\sqrt{2}\sqrt{R^2 + 4\omega^2 L^2}} \times \frac{\pi R}{2V_m}$.

$$= \frac{0.4175\ R}{\sqrt{R^2 + 4\omega^2 L^2}}$$

PROCEDURE :-

1) Connect the circuit as per circuit diagram.
2) To find the ripple factor, apply the input to circuit.
3) Note down the readings of output voltage and calculate the peak-to peak voltage.
4) Now calculate the ripple factor.

CALCULATIONS :-

$$V_{in} = 8\,V$$

$$V_{avg} = 6.51\,V$$

$$\text{Ripple factor} = \frac{V_{(p-p)}\ \text{ripple}}{V_{avg}}$$

$$= \frac{\frac{1.68}{2\sqrt{2}}}{6.51}$$

$$= 18.24\,\%$$

5) To find the load regulation, keep the input voltage as constant.

6) Note down the no load output voltage.

7) By varying the load resistance, note down the o/p voltage and current readings.

8) Calculate load regulation.

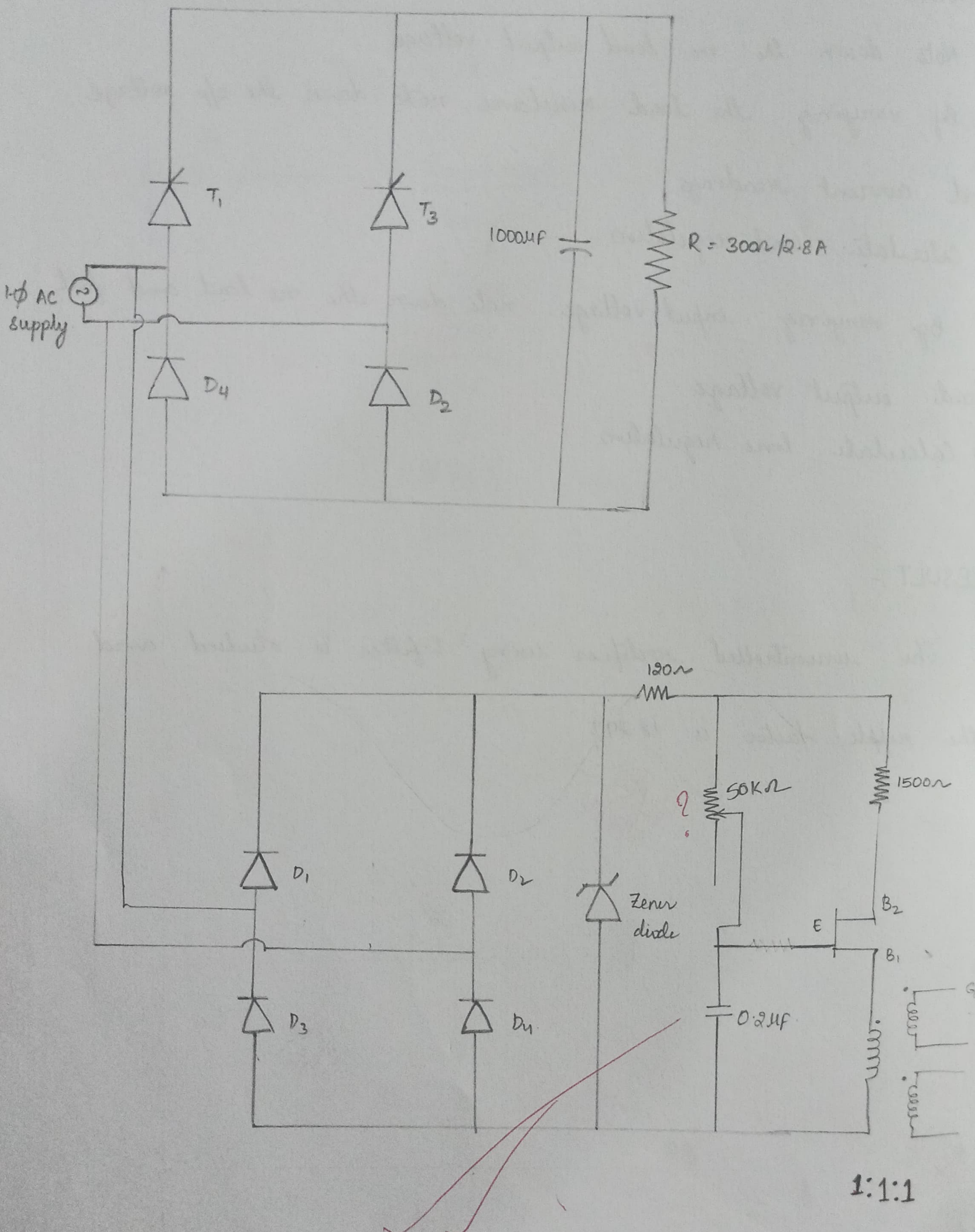
9) By varying input voltage, note down the no load and full load output voltage.

10) Calculate line regulation.

RESULT :-

The uncontrolled rectifier using L-filter is studied and the ripple factor is 18.29%.

01/11/16


T1
T3
1000µF
R = 300Ω/2.8A
1-Φ AC supply
D4
D2
120Ω
50KΩ
1500Ω
D1
D2
Zener diode
B2
E
B1
D3
D4
0.2µF
G1
G2
1:1:1

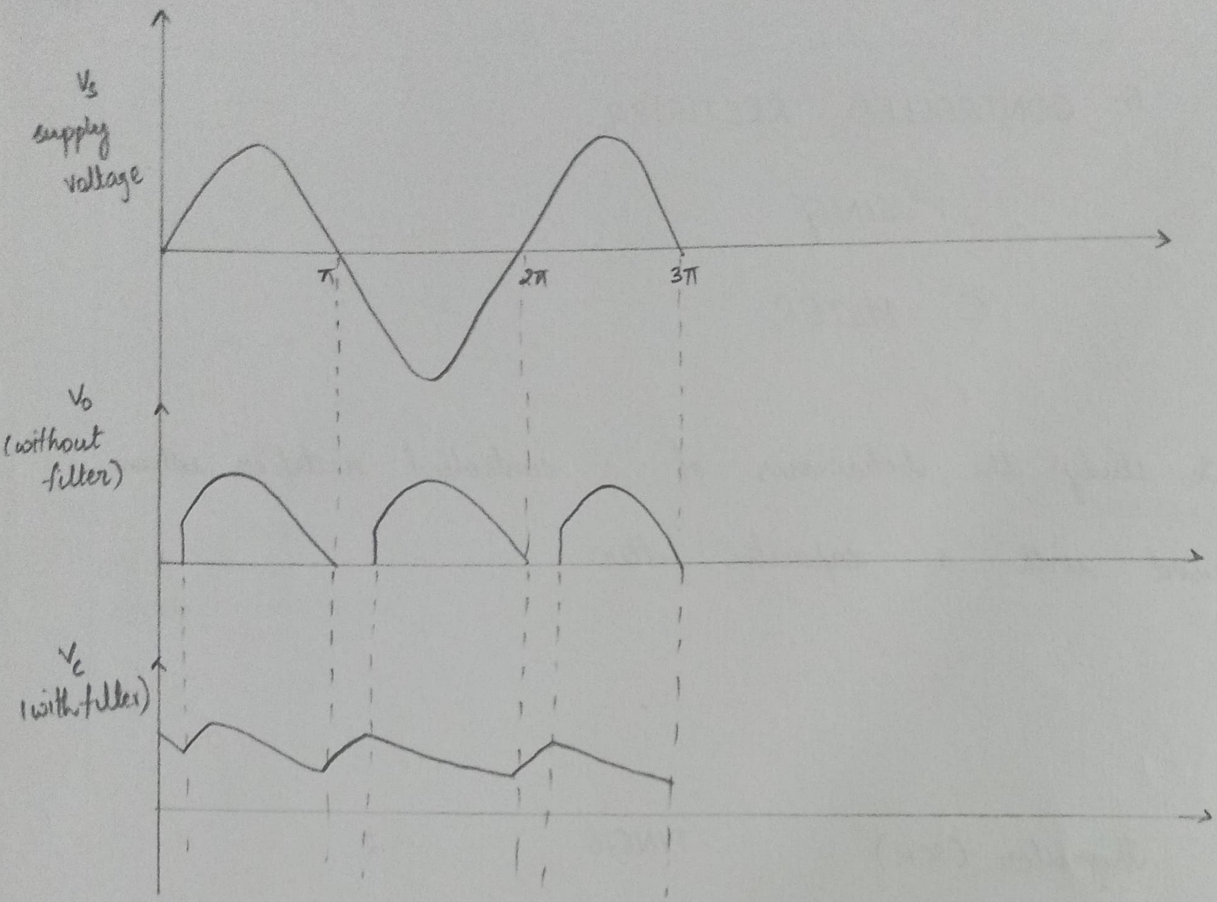
21/10/16

6. CONTROLLED RECTIFIER USING C- FILTER

AIM :- To study the behaviour of a controlled rectifier when used with a capacitor filter.

APPARTUS :-

Thyristor (SCR)	TYN616	2
Capacitor	1000 µF	1
Power diodes	MIC6A4	2
Rheostat	100 Ω / 3A	1
Diodes	IN4005	4
Zener diode	IN4744, 20V	1
Potentiometer	50K	1
Capacitor	0.2 µF	1
UJT	2N2646	1
Resistors	120Ω, 1500Ω	1
Pulse transformer	1 : 1	1
Auto-transformer	230V	1
CRO	-	digital



Triggering circuit design:-

$$\eta_{min} = 0.56 \qquad \eta = 0.75$$

$$T = RC \ln\left(\frac{1}{1-\eta}\right)$$

T should be in range in 0.5ms to 9.5ms.

Let $C = 0.22\ \mu F$.

$$R_{min} = \frac{0.5 \times 10^{-2}}{0.22 \times 10^{-6} \times \ln\left(\frac{1}{1-0.56}\right)} = 3k\Omega$$

$$R_{max} = \frac{9.5 \times 10^{-3}}{0.22 \times 10^{-6} \times \ln\left(\frac{1}{1-0.75}\right)} = 58k\Omega$$

$\therefore$ 100kΩ POT is used.

THEORY :-

A rectifier should provide an output voltage that should be as smooth as possible. The output voltage from rectifier consists of DC component plus AC component or ac ripple. The AC component is made of several dominant harmonics. It is more so in single phase rectifier with R. load.

A capacitor across load R offers direct short circuit to ac components. These are therefore not allowed to reach the load. However dc gets stored in the form of energy in C and this allows the maintainance of almost constant DC output voltage across the load.

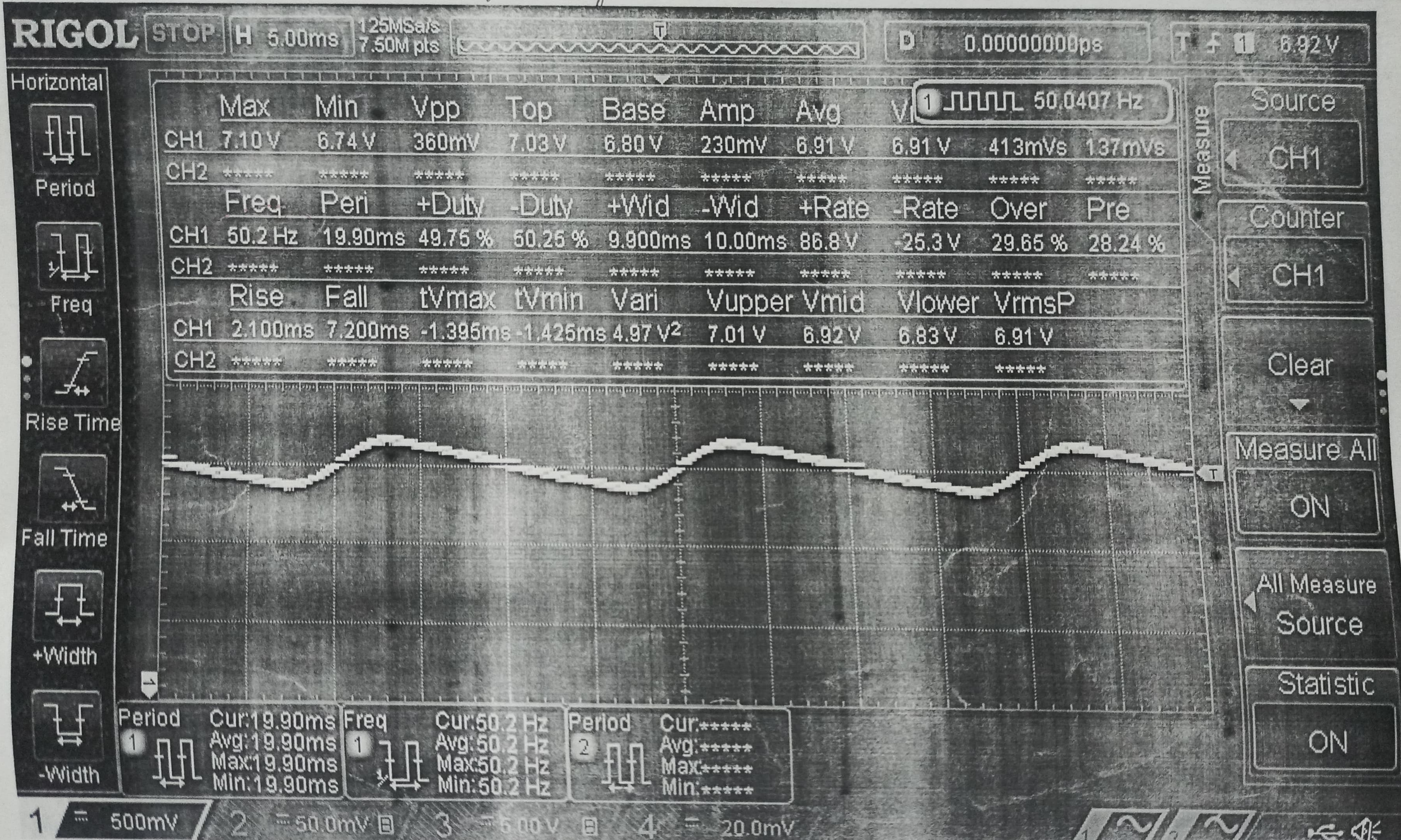
DESIGN :-

C filter ⇒ $C = \frac{1}{4fR}\left[1 + \frac{1}{\sqrt{2}\cdot RF}\right]$

Triggering circuit ⇒ $R_2 = \frac{10^4}{\eta \cdot V_{BB}}$

Time period of oscillation $\Big\}$ $T = RC \ln\left(\frac{1}{1-\eta}\right)$

Controlled Rectifier using C-Filter.



V_{in} =

PROCEDURE :-

1) Connect the circuit as shown in figure.

2) Apply the input voltage and check the trigger pulses from the trigger circuit in the CRO.

3) Give these trigger pulses, to SCR and these pulses can be varied by POT. The output of the converter is given to the C filter and the output is observed in the CRO.

4) Calculate the ripple.

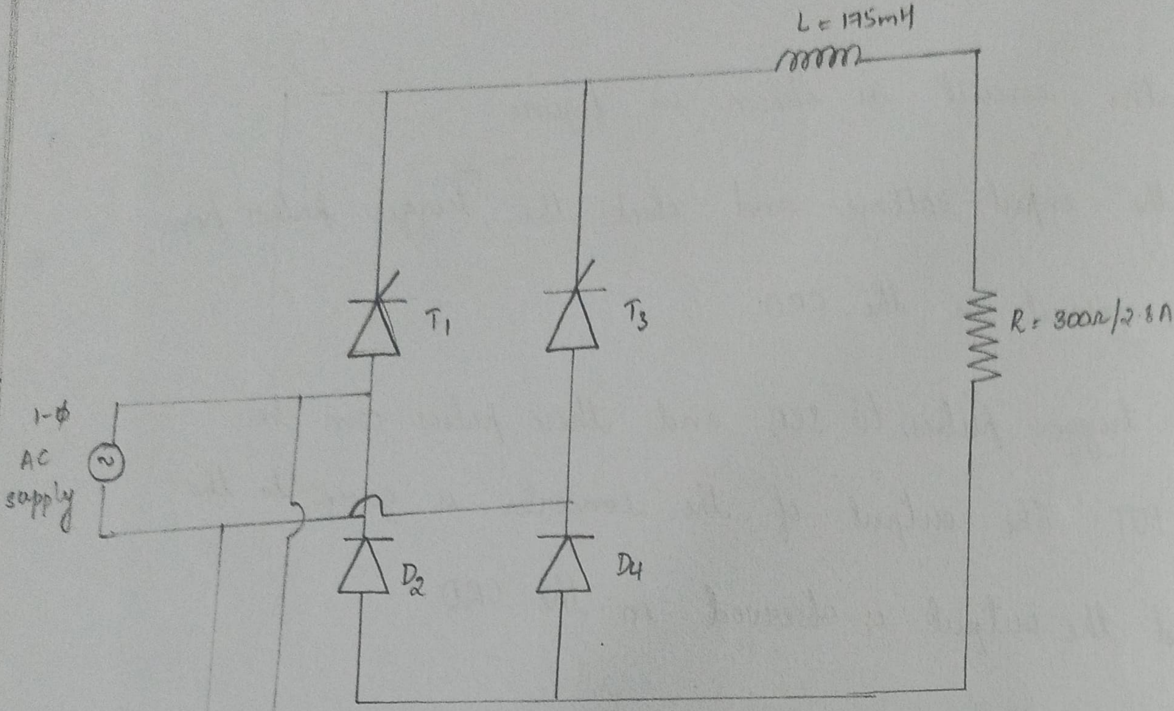
CALCULATIONS :-

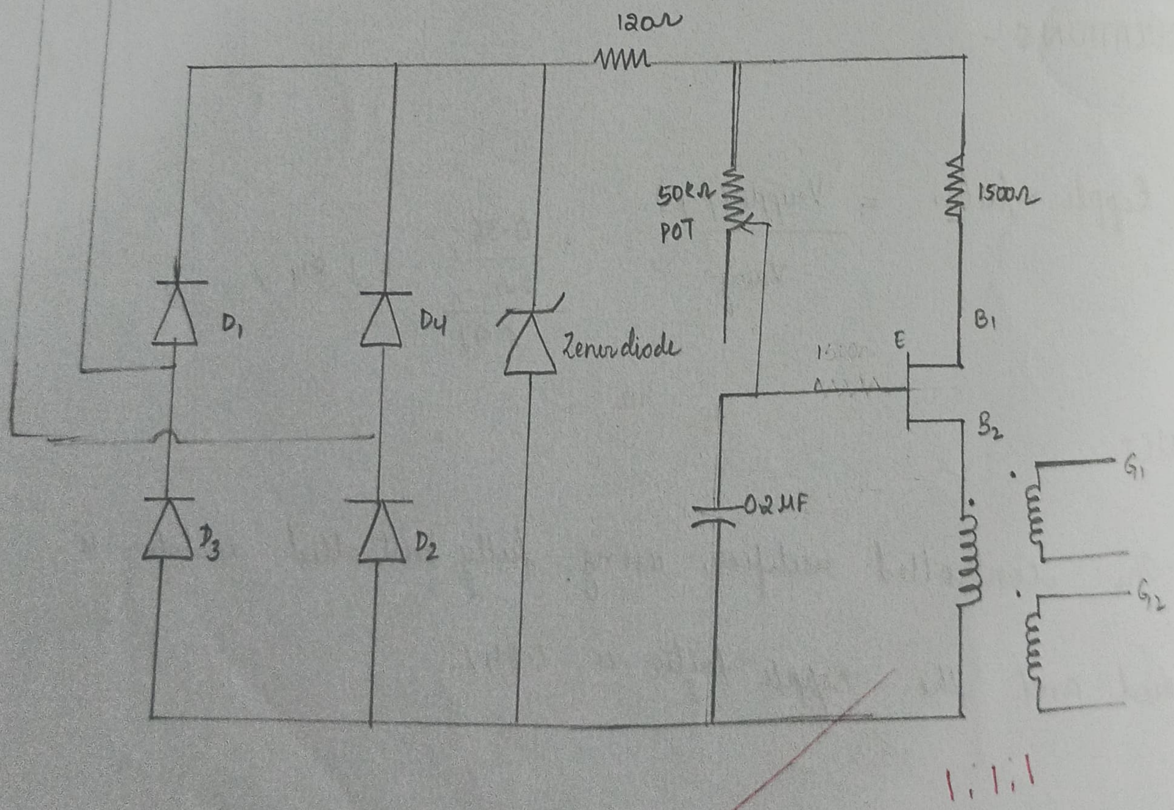
$$\text{Ripple factor} = \frac{V_{ripple\,(p-p)}}{V_{avg}} = \frac{\frac{0.36}{2\sqrt{2}}}{6.91} = 1.84\ \%.$$

RESULT :-

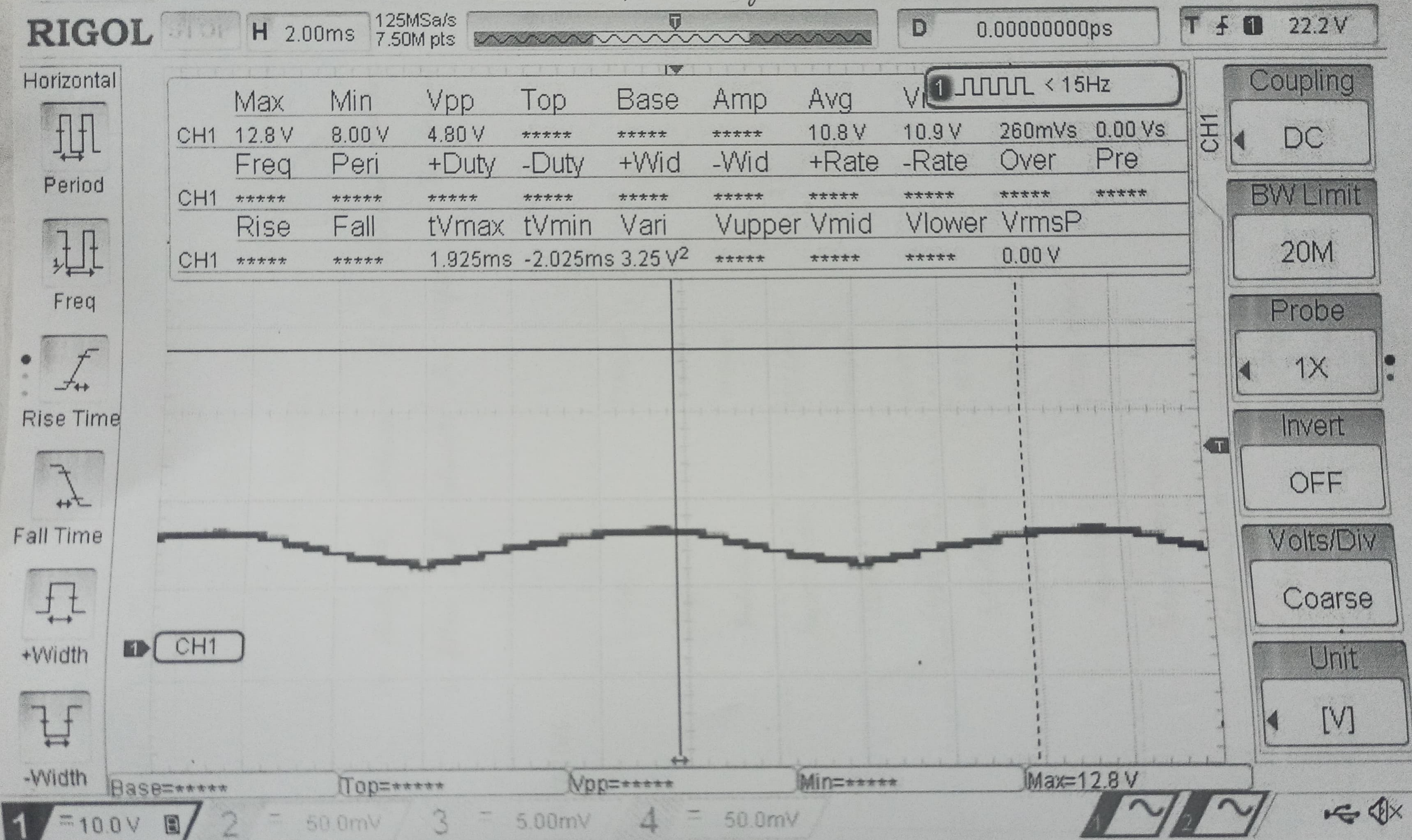
The controlled rectifier using fully controlled rectifier is studied and the ripple factor is 1.84%.

Rupthi 26/10/16


L = 175mH
T1
T3
R = 300Ω/2.8A
1-ϕ
AC
supply
D2
D4


120Ω
50kΩ
POT
1500Ω
D1
D4
Zener diode
B1
E
B2
0.2μF
D3
D2
G1
G2
1:1:1

controlled Rectifier using L- filter



V_{in} = ?14V

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14/10/16

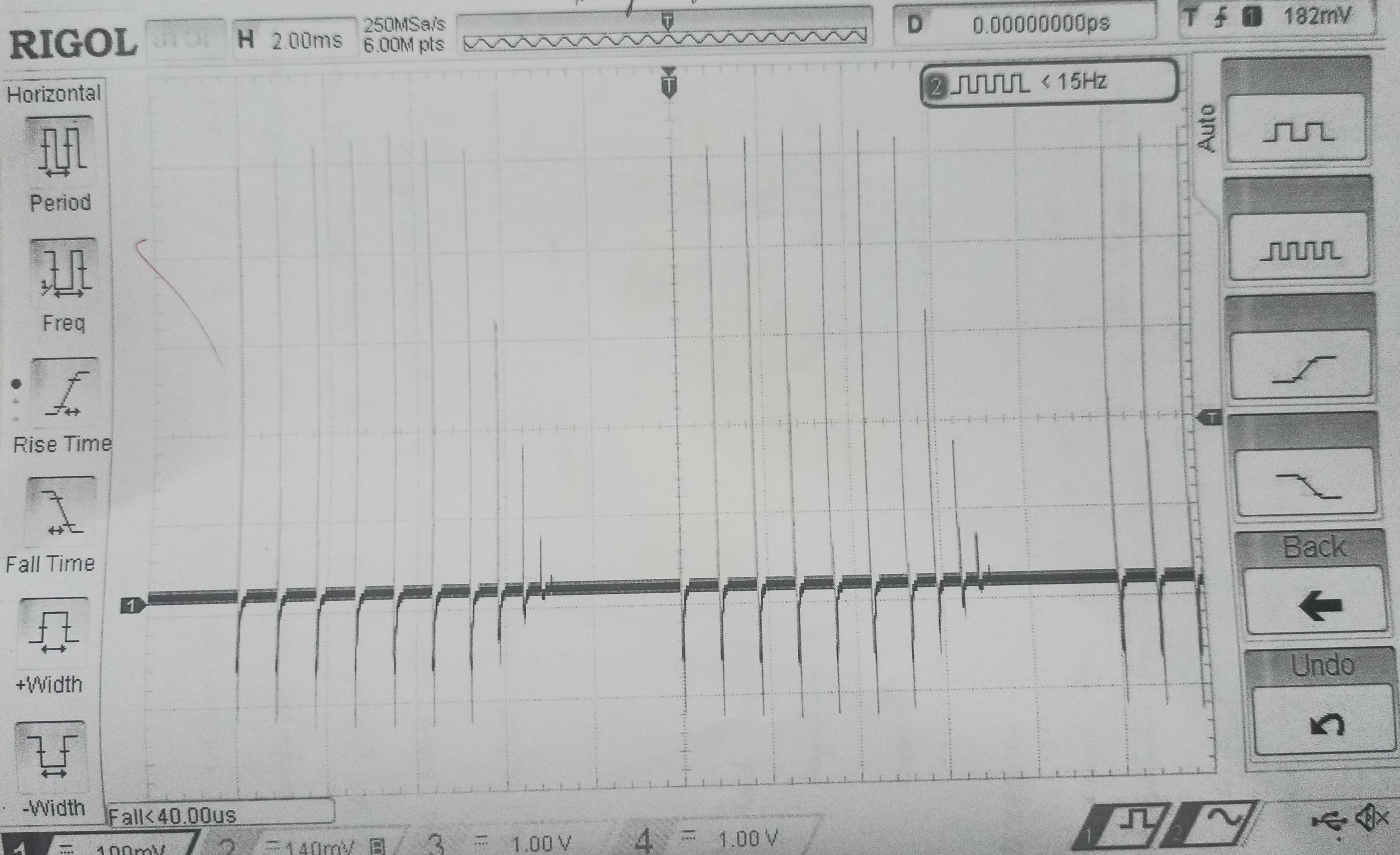
7. CONTROLLED RECTIFIER USING L- FILTER

AIM :- To study the behaviour of a controlled rectifier with L filter and calculate the ripple in the output.

APPARTUS :-

SCR	TYN616	2
Capacitor	0.2 μF	1
Inductor	175mH	1
Power diodes	MIC6A4	2
Diodes	IN4005	4
Zener diode	IN4744	1
Potentiometer	50 K	1
UJT	2N2646	1
Resistor	120Ω, 1500Ω	1
Pulse transformer	1 : 1	1.
Auto transformer	230V	1.
CRO	digital	1.

Gating sequence for the SCR



THEORY :-

Rectifiers are used to convert the AC to DC. But the DC component converted has so many harmonics which have to be filtered out. It is done by many filters L, C and L-C filters. The calculations for L filter are as shown

The output voltage,

$$V_0 = \frac{2V_m}{\pi} - \frac{4V_m}{3\pi}\cos 2\omega t - \frac{4V_m}{15\pi}\cos 4\omega t \dots$$

$$V_{avg} = \frac{2V_m}{\pi} \qquad I_{avg} = \frac{2V_m}{\pi R}$$

Load impedance for n^{th} harmonics $\quad Z_n = \sqrt{R^2 + (n\omega L)^2}$

Magnitude of 2^{nd} harmonic $\quad I_{o2} = \frac{4V_m}{3\pi\sqrt{2}\sqrt{R^2 + 4\omega^2 L^2}}$

current ripple factor $\quad \frac{I_{o2}}{I_0} = \frac{0.415R}{\sqrt{R^2 + 4\omega^2 L^2}}$

PROCEDURE :-

1. Connect the circuit as shown in the figure.
2. Generate the firing pulses using the trigger circuit.
3. Check the trigger signal in the CRO which can be varied by the POT.

Triggering circuit design:-

$\eta_{min} = 0.56$

$\eta_{max} = 0.75$

$T = RC \ln\left(\frac{1}{1-\eta}\right)$

Let $C = 0.22\,\mu F$.

$$R_{min} = \frac{0.5 \times 10^{-3}}{0.22 \times 10^{-6} \times \ln\left(\frac{1}{1-0.56}\right)} = 3k\Omega$$

$$R_{max} = \frac{9.5 \times 10^{-3}}{0.22 \times 10^{-6} \times \ln\left(\frac{1}{1-0.75}\right)} = 58k\Omega$$

$\therefore$ Hence $100k\Omega$ POT.

PRACTICAL CALCULATIONS:- for Vin

$V_{peak\ to\ peak}$ ripple voltage $= 4.80\,V$

$V_{average}$ voltage $= 10.8V$

$$\text{Ripple factor} = \frac{\frac{4.80}{2\sqrt{2}}}{10.8} = 15.7\%$$

④ Give the trigger pulses to the SCR and note down the waveforms on the CRO

⑤ Note down the ripple from the waveform.

RIPPLE FACTOR = 0.05

$$\Rightarrow 0.05 = \frac{0.4175 \cdot R}{\sqrt{R^2 + 4\omega^2 L^2}}$$

$\Rightarrow R = 13.2\Omega$; $L = 175mH$

PRACTICAL CALCULATIONS :-

~~V_{rms} of ripple $V_{AC} = \frac{V_r(pp)}{2\sqrt{2}} = \frac{1.68}{2\sqrt{2}} = 0.594$~~

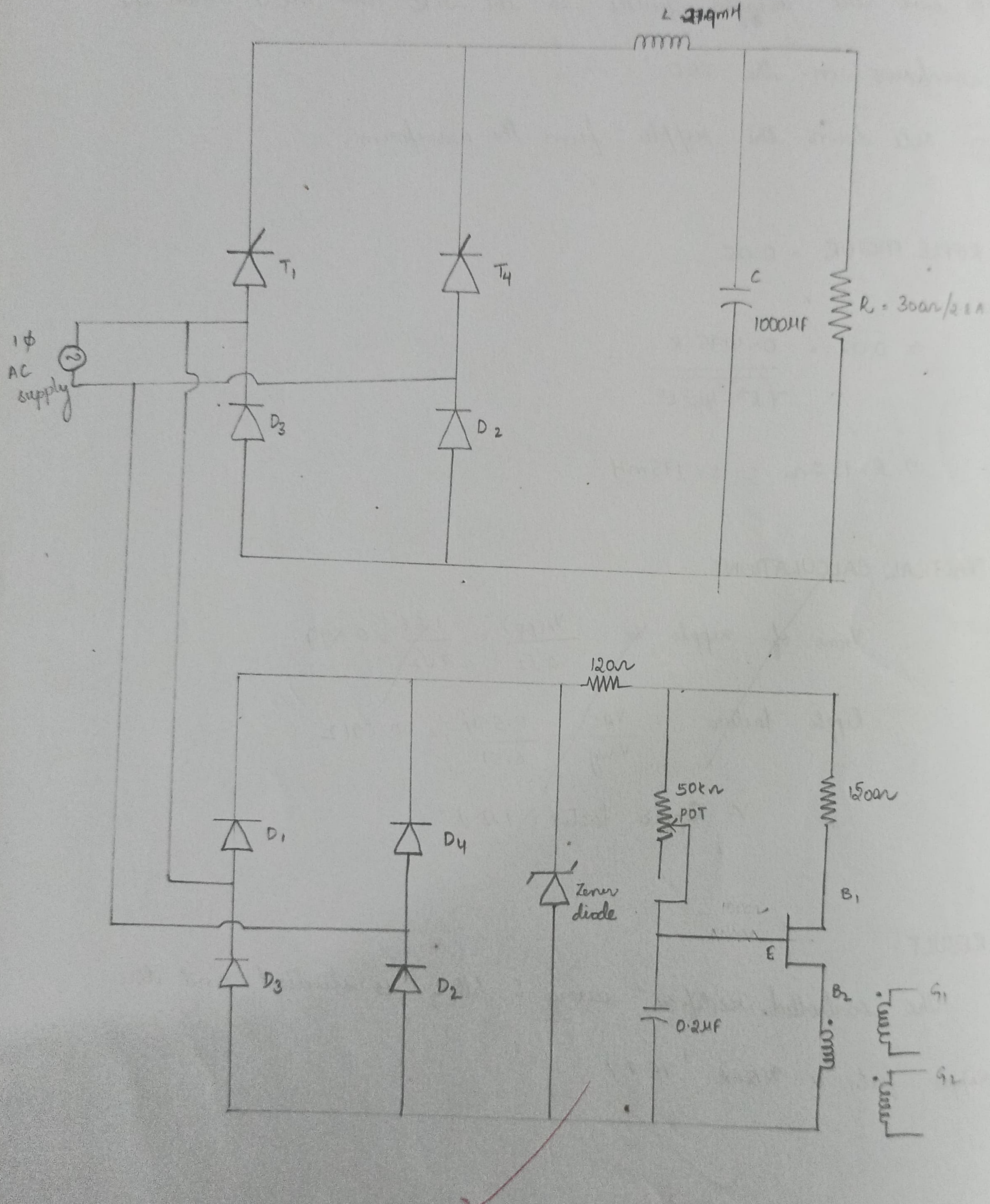
~~Ripple factor $= \frac{V_{AC}}{V_{avg}} = \frac{0.594}{6.51} = 0.0912$~~

% Ripple factor = 9.12%.

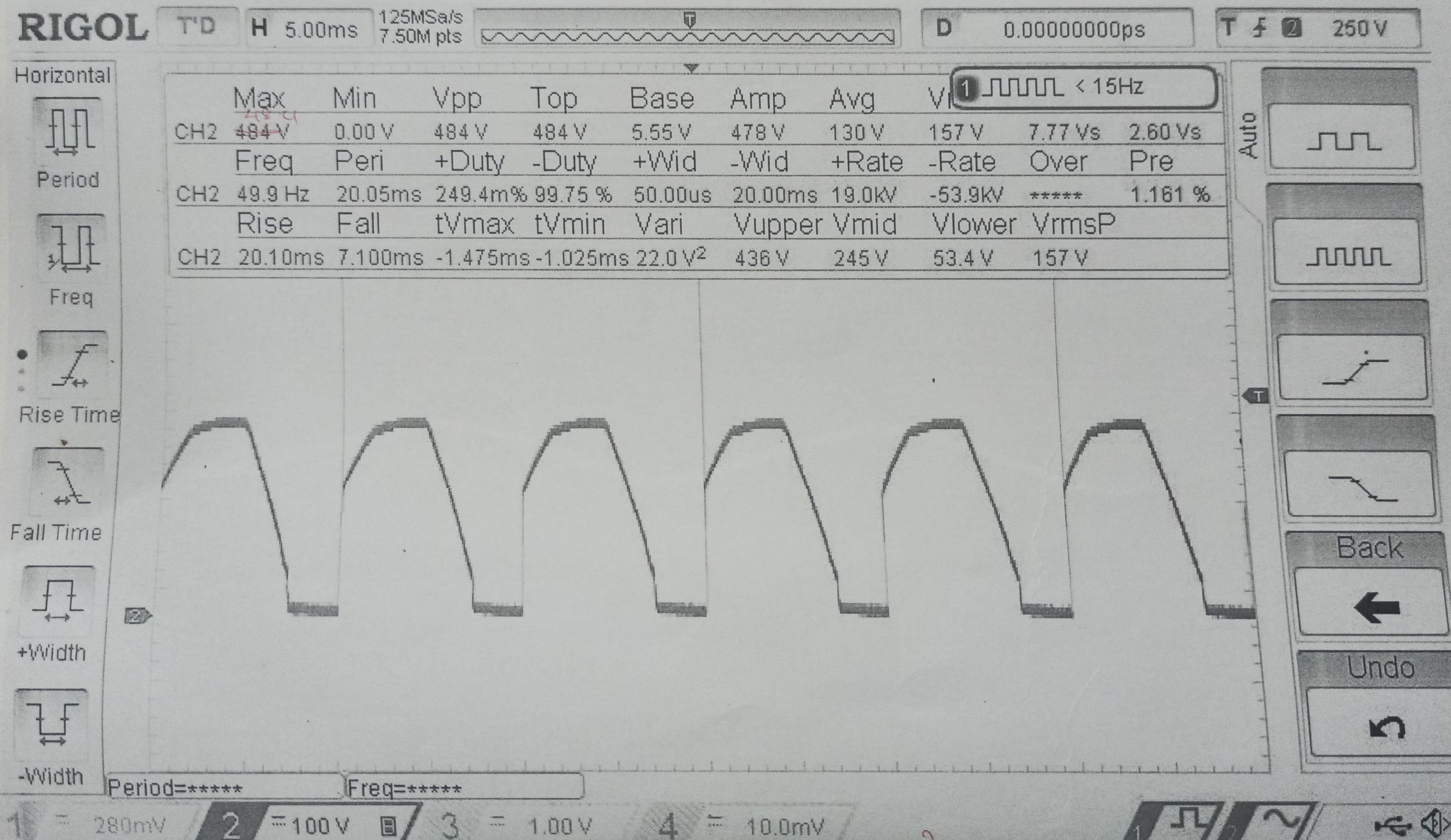
RESULT :-

The controlled rectifier using L filter is studied and the ripple factor is ~~9.12%~~ 15.7%.

26/10/16


L 27.9mH
T1
T4
C
1000μF
R = 300Ω/2.8A
1φ AC supply
D3
D2
120Ω
50kΩ POT
150Ω
D1
D4
Zener diode
B1
E
D3
D2
B2
G1
G2
0.2μF

controlled Rectifier without LC filter



Vin = ?

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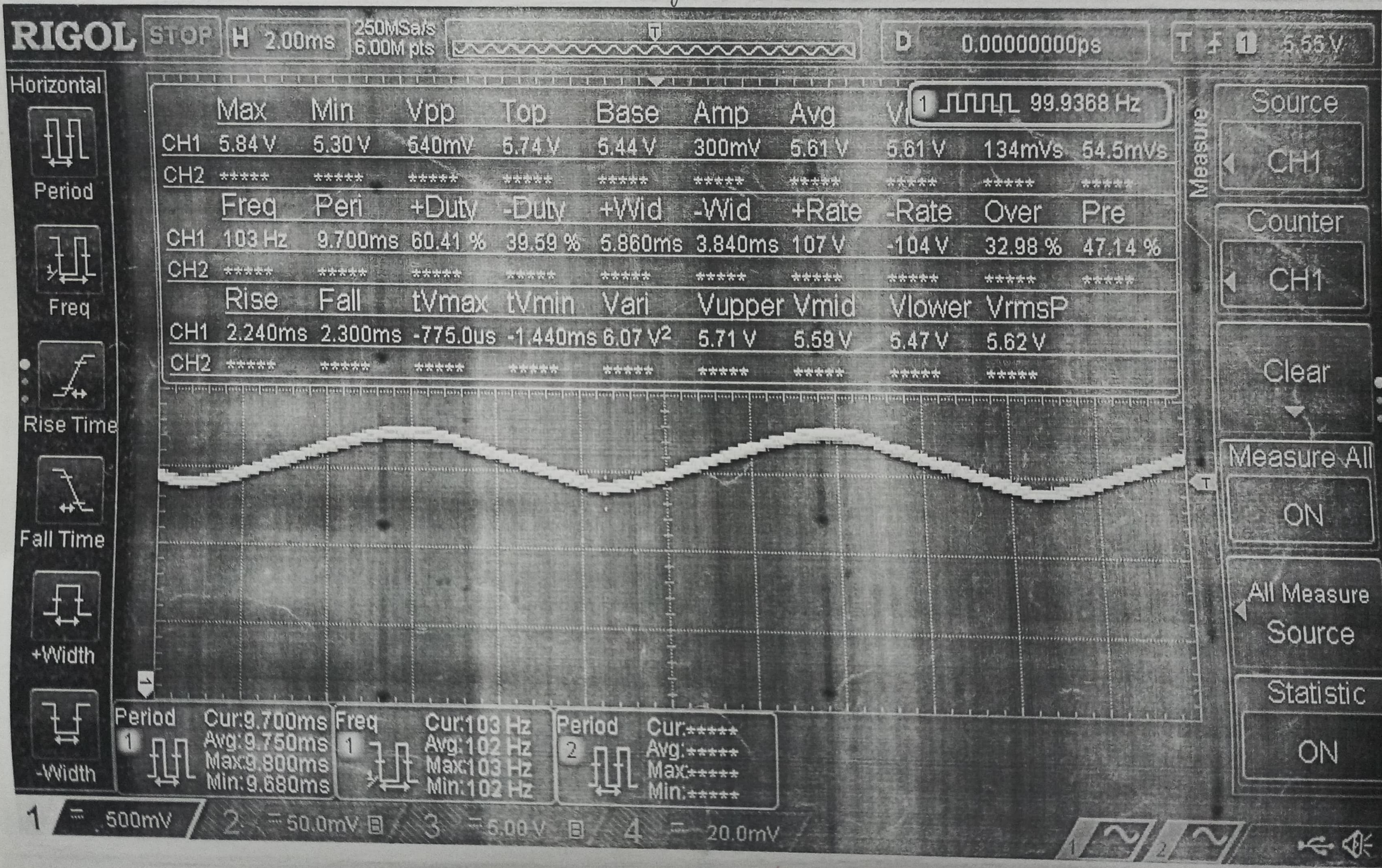
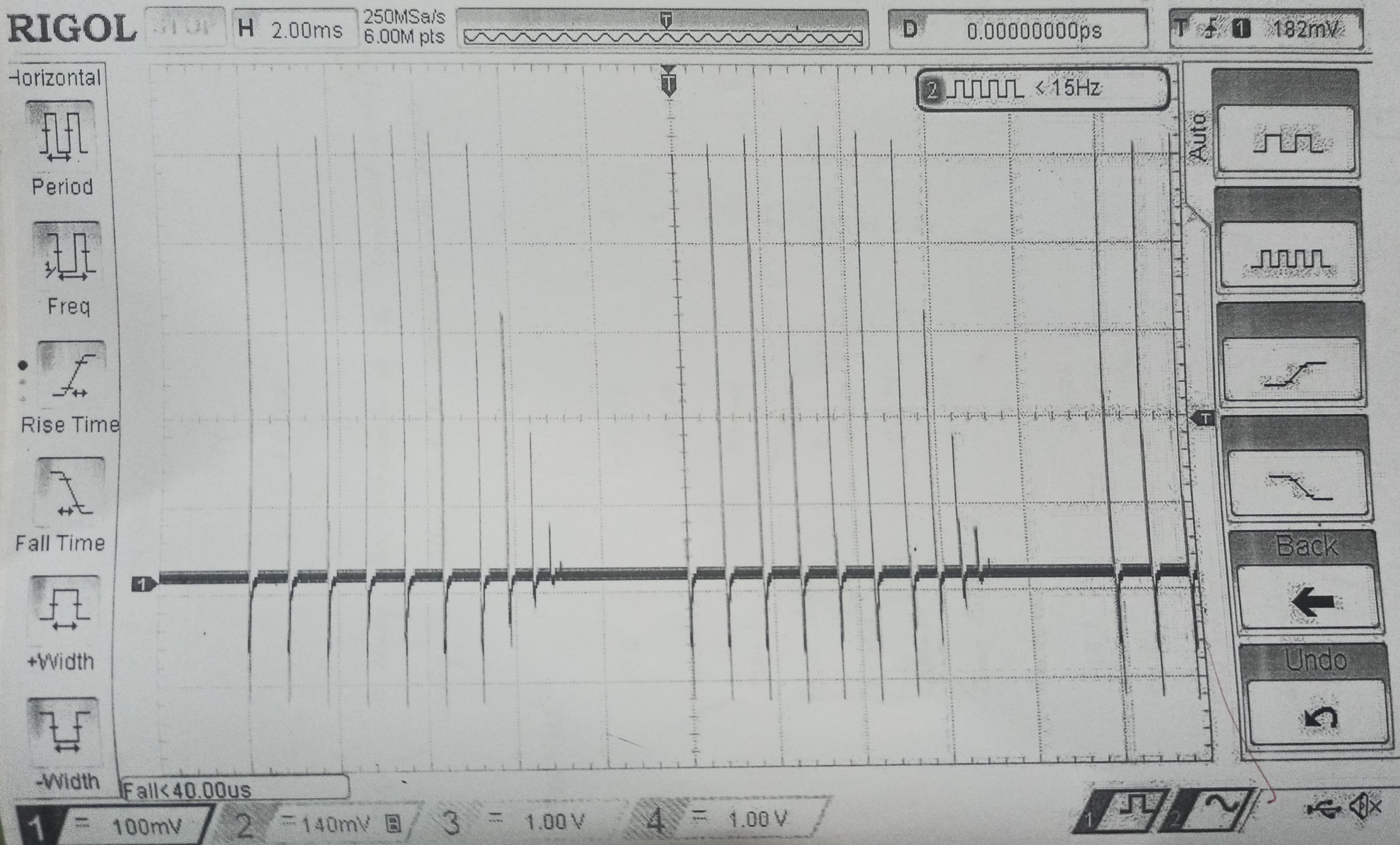
controlled rectifier using L-C filter.



Vin=? 26/10/16

Gating sequence for the SCR



20/10/16

8. CONTROLLED RECTIFIER USING L-C FILTER

AIM :- To study the behaviour of the controlled rectifier using L-C filter and to calculate the ripple

APPARATUS :-

SCR	TYN616	2
Capacitor	1000μF	1
Inductor	275mH	1
Power diodes	MIC6A4	2
Diodes	IN4005	4
capacitor	0.2 μF	1
Zener diodes	IN4744	1
Potentiometer	50K	1.
UJT	2N646	1.
Resistor	120Ω, 150Ω	1
Pulse Transformer	1: 1	1
Autotransformer	230V	1
CRO	digital	1.

THEORY :-

Rectifiers are used to convert AC to DC. There are 2 types uncontrolled and controlled. Depending upon the applications we use them differently. There are different filters L, C & L-C filter. The design of the LC filter is given as

DESIGN :-

For effective filtering $R >> \frac{1}{n\omega C}$

emphirical formula, $R = \frac{10}{n\omega C}$

n^{th} harmonic voltage across C $V_{on} = \left[\frac{-1}{(n\omega)^2 LC - 1}\right]^{1/n}$

since 2^{nd} harmonics is predominant,

$$V_2 = \frac{4V_m}{3\pi\sqrt{2}} = \frac{2\sqrt{2}\,V_m}{3\pi}.$$

$$V_{o2} = \left[\frac{-1}{(2\omega)^2 LC - 1}\right]^{1/2}$$

PROCEDURE :-

1) Connect the circuit as shown in the figure.

2) Generate the pulses from the pulse generator using UJT

3) Vary the pulses using the POT.

TRIGERRING CIRCUIT DESIGN:-

$$\eta_{min} = 0.56$$

$$\eta_{max} = 0.75$$

$$T = RC \ln\left(\frac{1}{1-\eta}\right)$$

Let $C = 0.22\ \mu F$

$$R_{min} = \frac{0.5\times10^{-3}}{0.22\times10^{-6}\times\ln\left(\frac{1}{1-0.56}\right)} = 3k\Omega$$

$$R_{max} = \frac{9.5\times10^{-3}}{0.22\times10^{-6}\times\ln\left(\frac{1}{1-0.75}\right)} = 58\,k\Omega$$

RIPPLE CALCULATIONS:- V_{in}

ripple $V_{(P-P)} = 0.54$

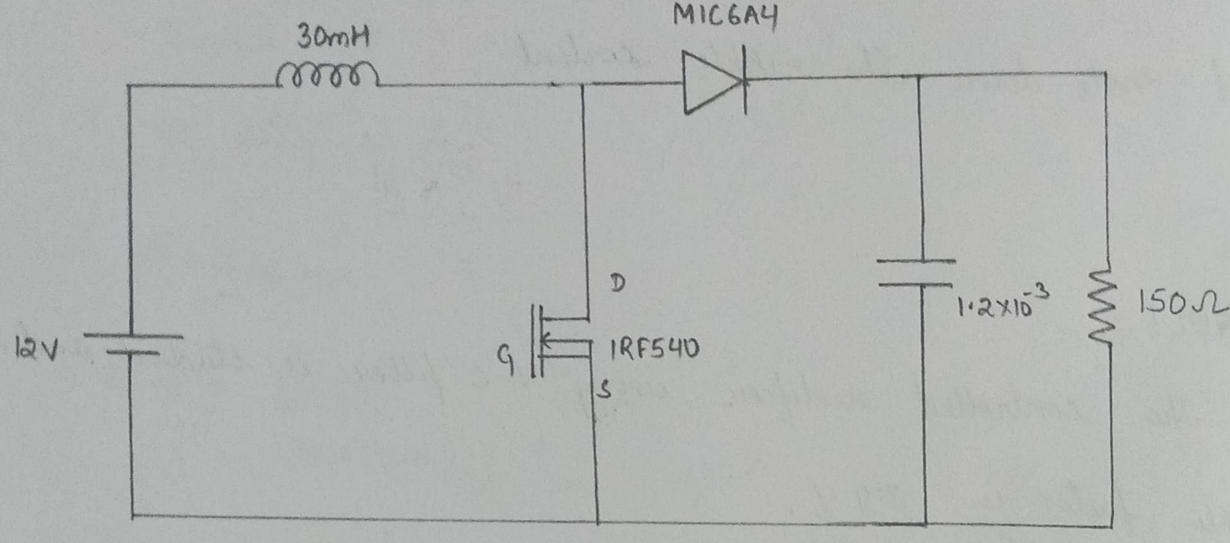
$$RF = \frac{\frac{V_{(p-p)}}{2\sqrt{2}}}{V_{avg}} = \frac{\frac{0.54}{2\sqrt{2}}}{5.61} = 3.4\ \%$$

4) Give the pulses to the SCR and note down the waveforms and note down the ripple content.

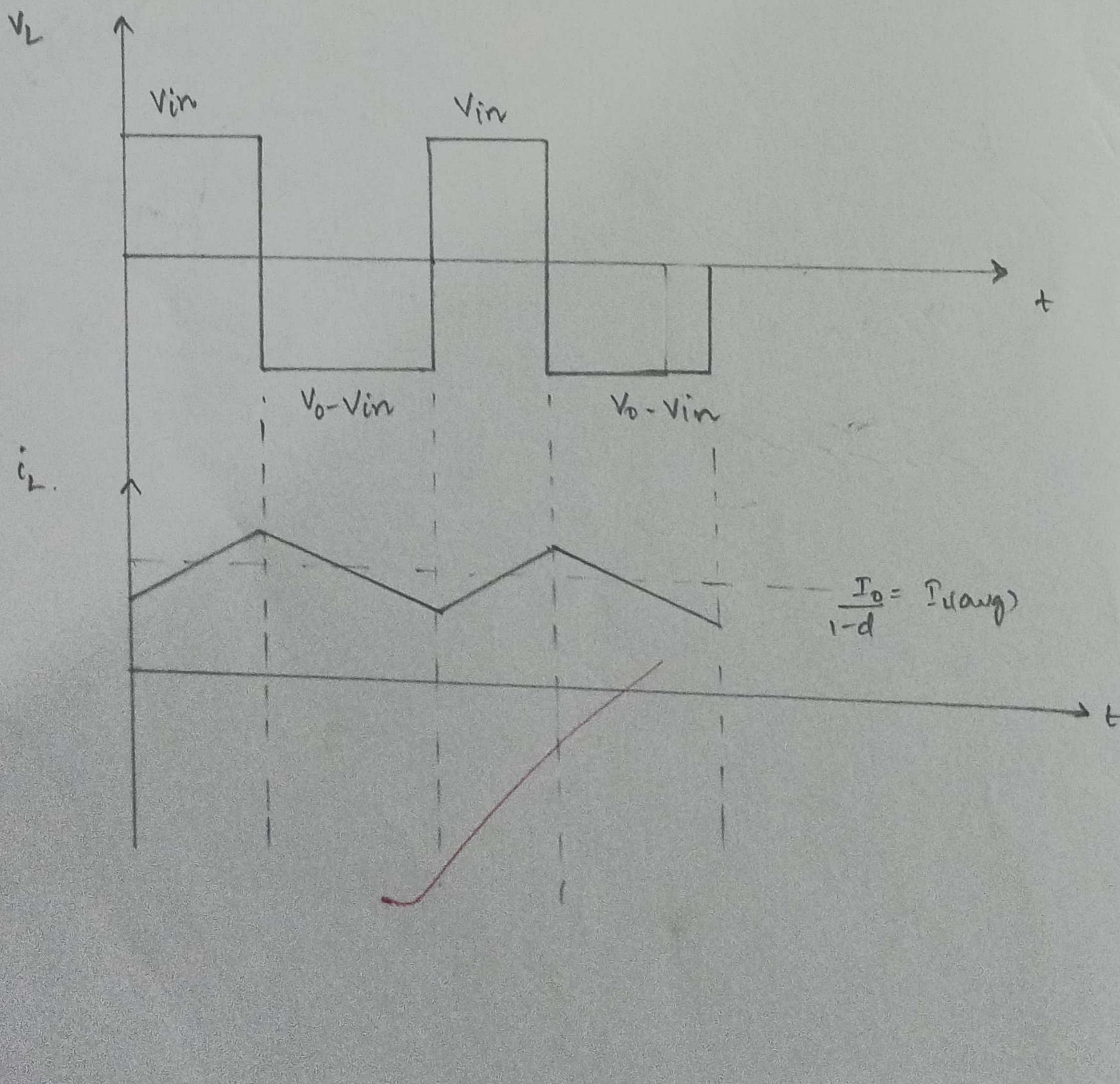
RESULT:-

The controlled rectifier using L-C filter is studied and the ripple factor is 3.4 %.

26/10/16.


30mH
MIC6A4
12V
D
G
IRF540
S
1.2x10^-3
150Ω

fig(b)


VL
Vin
Vin
t
Vo-Vin
Vo - Vin
iL.
Io/1-d = IL(avg)
t

26|10|15

9. BOOST CONVERTER

AIM :- To study the boost converter output voltage which has a duty ratio of 0.75.

APPARTUS :-

components	Range	Quantity
MOSFET	IRF540	1
Inductor	30 mH	1
Capacitor	100 μF	1
Diode	MIC6A4	1
Rheostat	300Ω / 1.7A	1
Power Supply	(0 - 30V)	3
555 timer		1
optocoupler	TCP250H	1
capacitor	0.1 μF	1
	0.01 μF	1
	0.1 μF.	1
		1
Resistors	750 Ω	1
	350 Ω	1
CRO	digital	1.

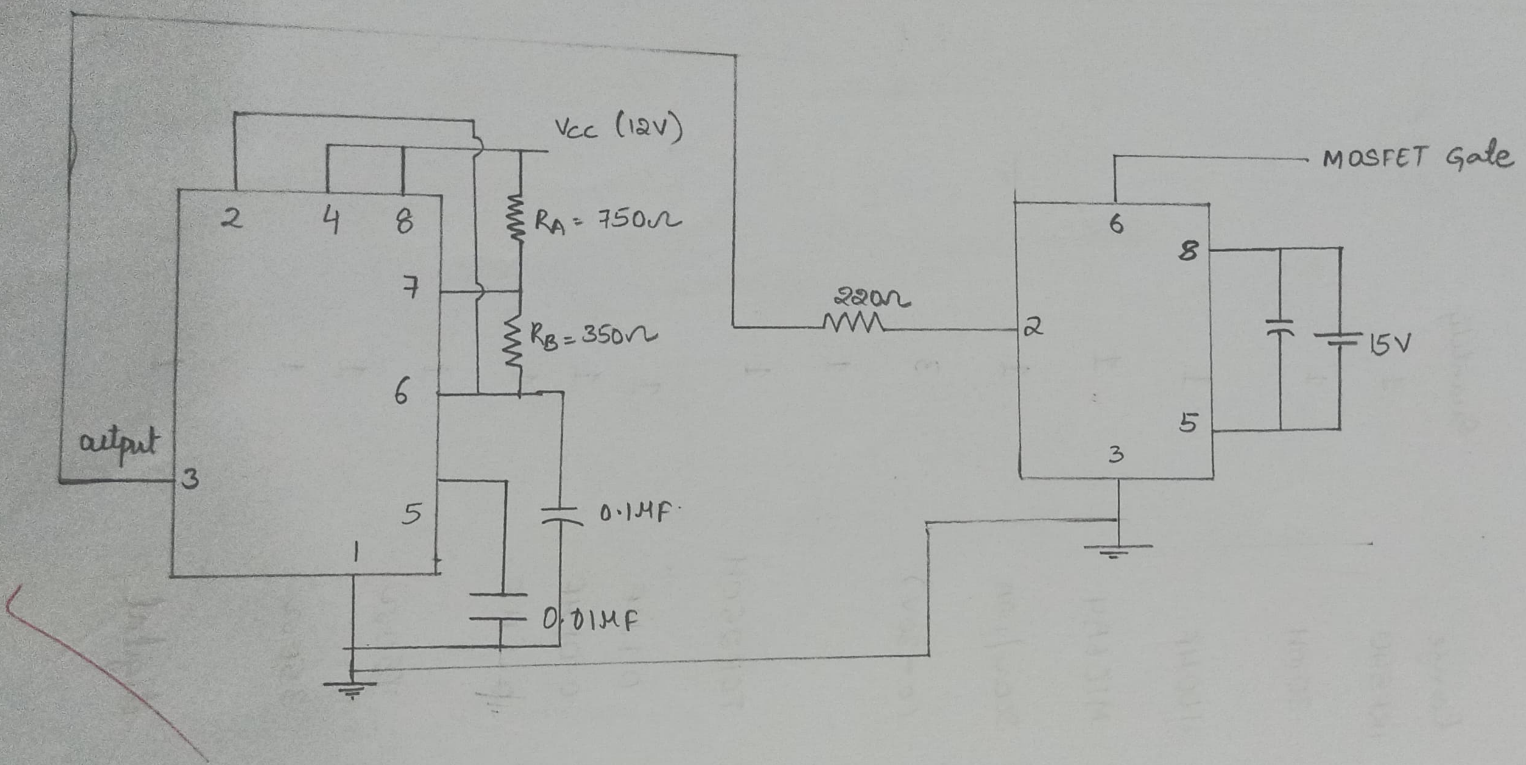

Vcc (12V)
$R_A = 750\Omega$
$R_B = 350\Omega$
0.1μF
0.01μF
output
2
4
8
7
6
5
1
3
220Ω
2
6
8
5
3
15V
MOSFET Gate

fig (a)

THEORY :-

A boost converter is a DC to DC power converter that steps up voltage with stepping down current from its supply to its load. The key principle that drives the boost converter is the tendency of an inductor to resist changes in current by creating and destroying a magnetic field. Some of the applications of the step up chopper are communication applications, battery power supplies, power amplifier applications.

DESIGN :-

V-S balance

$$V_i (D T_s) = (V_o - V_i)(1-D) T_s$$

$$\Rightarrow V_o = \frac{V_i}{1-D}.$$

(P-P) inductor ripple current $i_{(P-P)L} = \dfrac{V_{in} \cdot d}{f_s \cdot L}$.

(P-P) capacitor ripple voltage $v_{(P-P)r} = \dfrac{I_o \cdot d}{f_s \cdot C}$.

Design:-

we known that 555 timer $T = 0.69(R_A + 2R_B)C$

taking $d = 0.75$ and $f_s = 10KHz$; $C = 0.1\mu F$

$$\frac{d}{1-d} = \frac{R_A}{R_A + R_B}$$

$$\frac{d}{1-d} = \frac{R_A + R_B}{R_B}$$

$$\Rightarrow \boxed{R_A = 2R_B}$$

$$\Rightarrow R_B = 360.75\,\Omega \qquad R_A = 721.50\,\Omega$$

assuming (p-p) $i_L = 0.05A$;

$$\Rightarrow \frac{V_{in}\,d}{f_s\,L} = 0.05A \qquad \Rightarrow L = \frac{12 \times 0.75}{f_s}$$

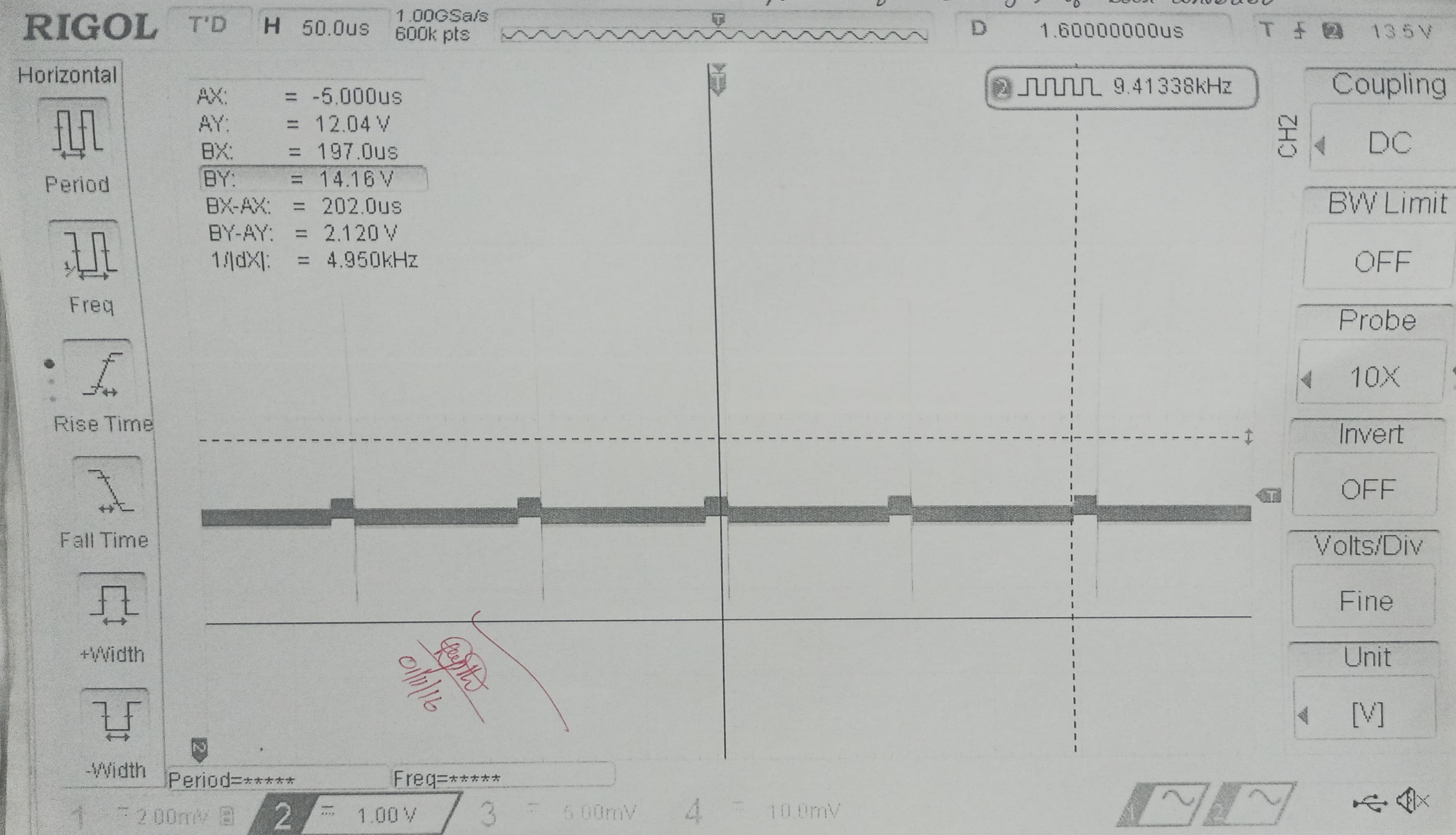
$$\boxed{L = 18\ mH}$$

$$V(p\text{-}p) = \frac{I_o \cdot d}{f_s \cdot C}$$

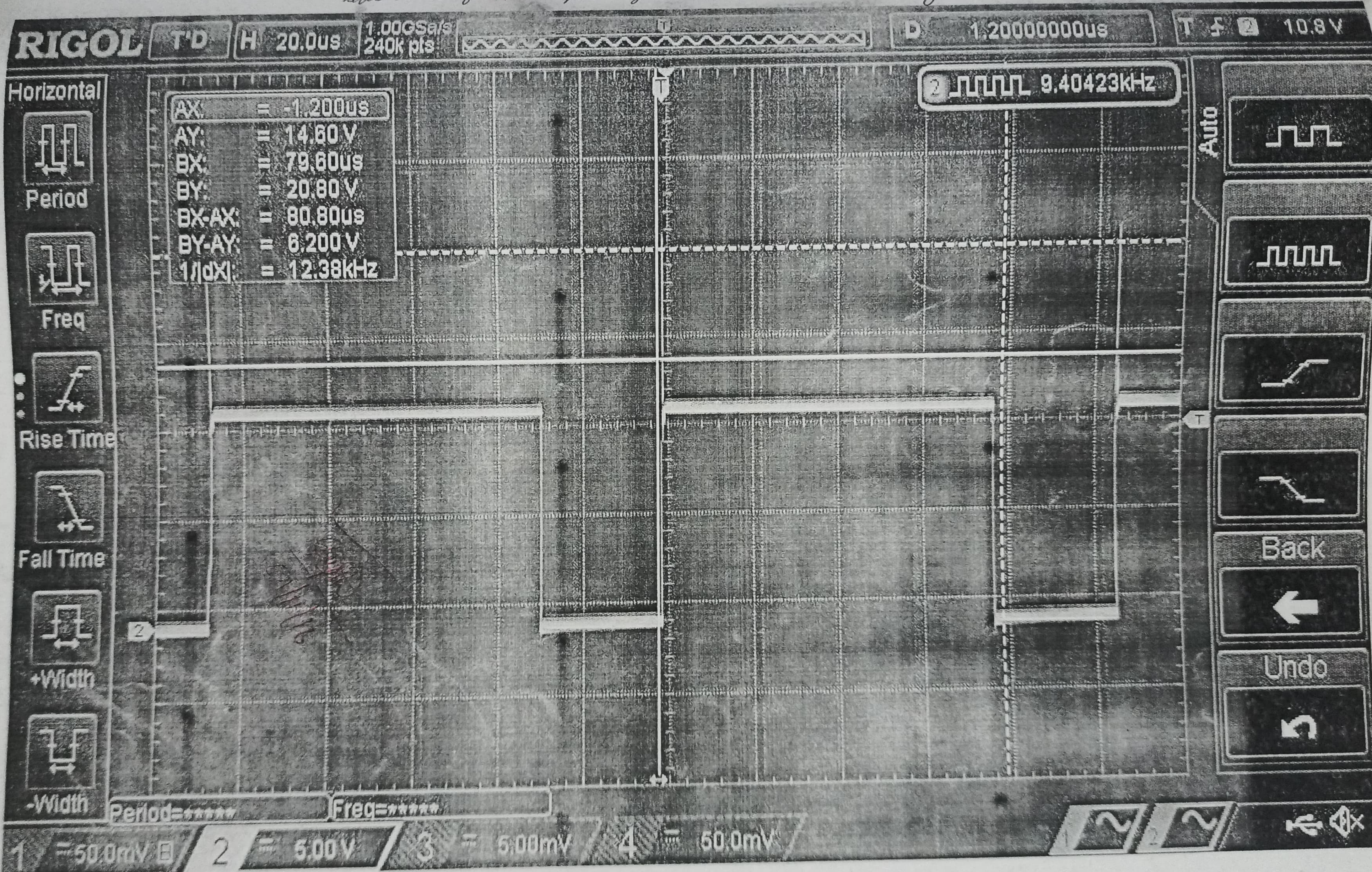
$$0.02 \times 10 \times 10^3 = \frac{0.32 \times 0.75}{C}$$

$$\Rightarrow \boxed{C = 1.2mF}$$

with $V_{in} = 3V$; output waveform (voltage) of Boost converter



Square waveform output generated with d=0.75 using 555 timer.



PROCEDURE :-

1) Connect the circuit as shown in the figure (a)

2) Given 12V to 555 timer the square wave generated not upto good magnitude to drive MOSFET hence we give it to the optocoupler

3) The output of optocoupler is given to fig (b)

4) The output waveforms are observed in the CRO.

RESULT :-

The voltage of the boost chopper is not a pure dc voltage due to various non linearities present in the ~~dc~~ circuit.

Rupitha
01/11/16