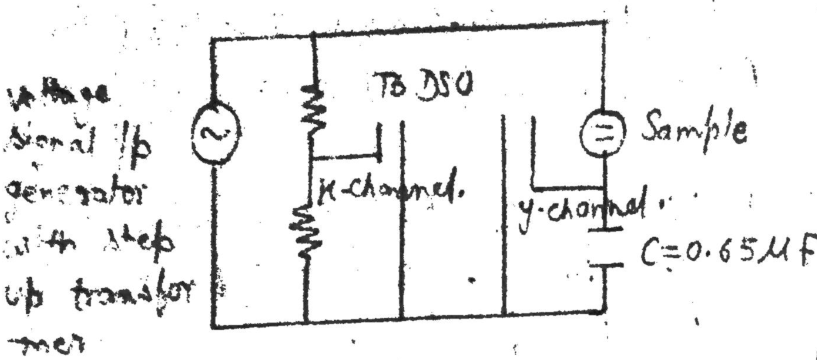
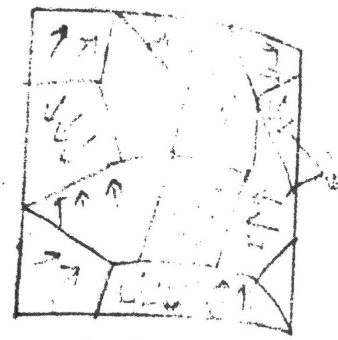
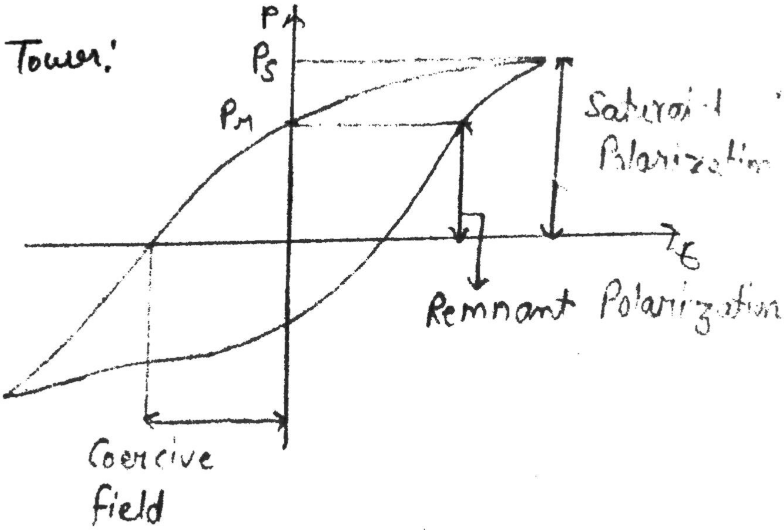


Circuit Diagram

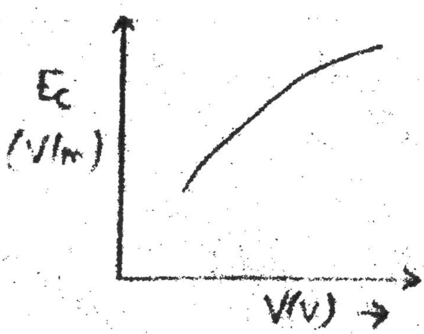


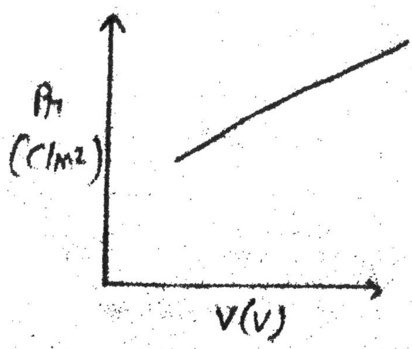
Ferro-electric crystal.

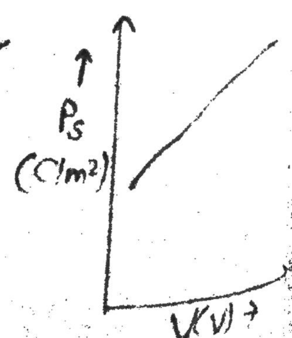
Swayer Tower:



Expected graphs:







PE Hysterises of Ferroelectric Crystal

Aim - To study the hysterises loop of the given ferroelectric material and to observe the variation of parameters like coersive field, Remmant Polarization and Saturated Polarization.

Apparatus Required - Ferroelectric sample, sample Holder, Polarization vs electric field set-up, DSO.

Formula Used -

(i) Coersive Field $(E_c) = \frac{K_I \times S_x}{t}$; K_I - x intercept of PE loop

S_x - Volts/division of graph

t - thickness of sample

(ii) Remmant Polarization $(P_r) = \frac{C \times y_{\text{intercept of PE loop}} \times y_{\text{volts/div}}}{\text{Area of sample}}$

C - Capacitance of standard Capacitor.

(iii) Saturated Polarization $(P_s) = \frac{C \times y_{\text{max of PE loop}} \times y_{\text{volts/div}}}{\text{Area of Sample}}$

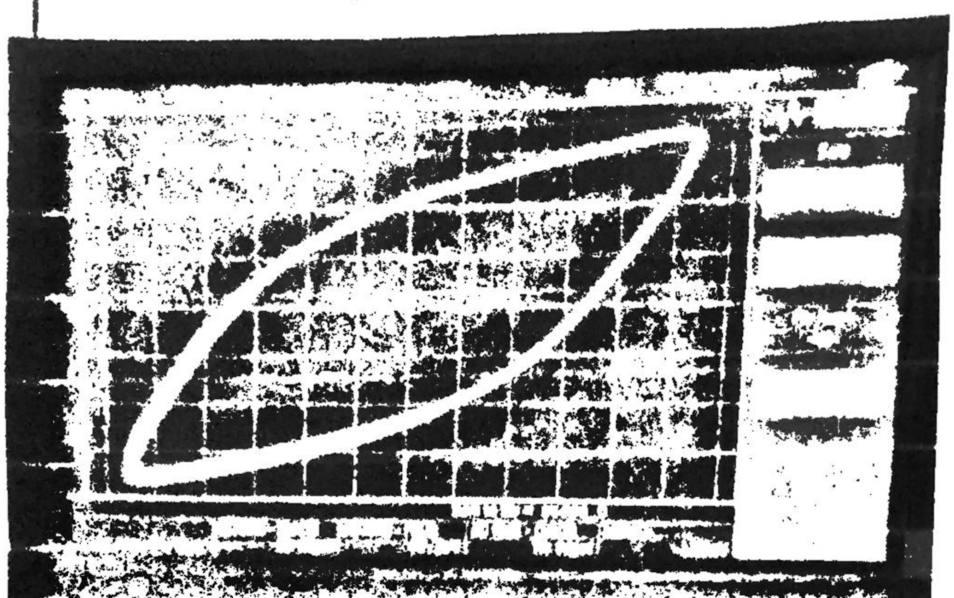
Precautions - (i) Handle apparatus with care, as we are dealing with High voltage.

(ii) Do not disturb the sample throughout the experiment.

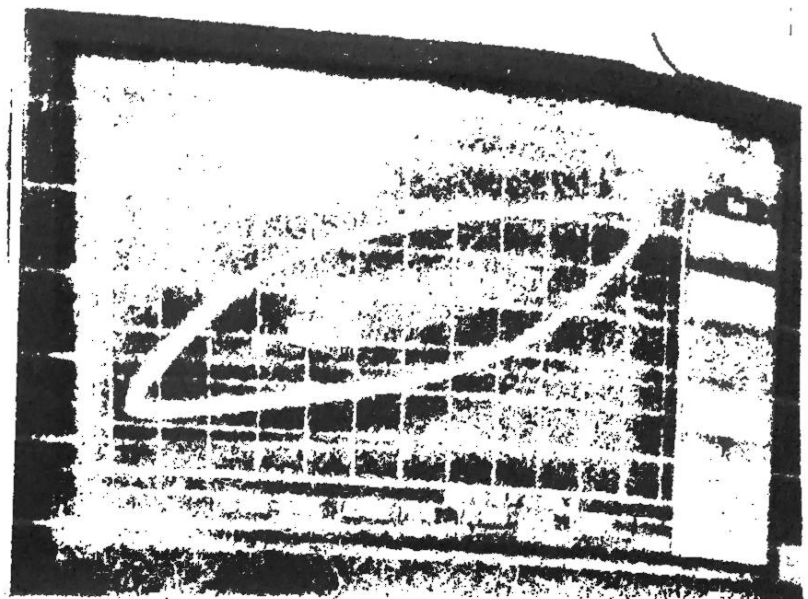
1. V = 503 V

2. V = 566 V

3. V = 617 V



4. V = 625 V



(iii) Make sure the sample is dipped in low viscosity oil (say Silicon Oil) to prevent discharge due to High voltage.
(iv) Cover sample holders with a lid while performing the experiment, This helps to have a stable temperature for the sample.

Observations: Sample dimensions : 5mm x 5mm
Thickness of sample : 0.5mm
Capacitance of standard capacitor, $C = 0.65\mu F$

Symbols used in observation table:
x_{IL}, x_{IR} – Left and Right x intercepts of PE loop respectively
x_I - Mean of x_{IL} & x_{IR}
y_{IU}, y_{ID} - Up and Down y-intercepts of PE loop respectively
y_I - Mean of y_{IU} and y_{ID}
y_{MU}, y_{MD} - Up & down y-coordinates of the maximum y-value in PE loop.
V - Applied voltage across the sample.

S.No	V	S_x (V/div)	S_y (V/div)	x_{IL}	x_{IR}	y_{IV}	y_{ID}	y_{MV}	y_{MD}	x_I	y_I	y_M
1.	503 ~~0.074~~	0.5	0.074	3.0	2.8	1.8	2.0	2.8	3.2	2.9	1.9	3.0
2.	566 ~~0.074~~	0.5	0.074	3.2	3.2	2.2	2.4	3.4	3.8	3.2	2.3	3.6
3.	617 ~~0.090~~	0.5	0.090	3.4	3.4	2.2	2.4	3.4	3.6	3.4	2.3	3.5
4.	625	0.5	0.124	3.4	3.6	1.6	1.8	2.4	2.6	3.5	1.7	2.5
5.	660	0.5	0.124	3.6	3.6	1.6	2.0	2.6	2.6	3.6	1.8	2.0
6.	700	1.0	0.124	1.8	2.0	1.8	2.0	2.8	3.0	1.9	1.9	2.9
7.	720	1.0	0.128	2.0	2.0	1.8	2.0	2.8	3.2	2.0	1.9	3.0
8.	760	1.0	0.128	2.0	2.0	2.0	2.2	3.0	3.4	2.0	2.1	3.2
9.	820	1.0	0.136	2.2	2.2	2.0	2.2	3.2	3.4	2.2	2.1	3.3
10.	840	1.0	0.140	2.2	2.2	2.0	2.2	3.2	3.4	2.2	2.1	3.3
11.	900	1.0	0.140	2.2	2.4	2.2	2.4	3.4	3.6	2.3	2.3	3.5
12.	940	1.0	0.152	2.4	2.4	2.0	2.2	3.4	3.6	2.4	2.1	3.5
13.	1000	2.0	0.220	1.2	1.4	1.6	1.8	2.6	2.8	1.3	1.7	2.7

Calculations: Area of sample $= (5 \times 5)\,mm^2 = 25 \times 10^{-6}\,m^2$

S.No.	V (V)	E_c (V/m)	P_r (C/m²)	P_s (C/m²)
1.	503	2900	0.00363	0.00577
2.	566	3200	0.00443	0.00693
3.	617	3400	0.00538	0.00819
4.	625	3500	0.00548	0.00806
5.	660	3600	0.00580	0.00645
6.	700	3800	0.00613	0.00935
7.	720	4000	0.00632	0.00998
8.	760	4000	0.00699	0.01065
9.	820	4400	0.00743	0.01167

10.	840	4400	0.00764	0.01201	
11.	900	4600	0.00837	0.01274	
12.	940	4800	0.00830	0.01383	
13.	1000	5200	0.00972	0.01544	

Result: Hysteresis loop of ferroelectric material is studied and variation of coercive field, remmanent polarisation and saturated polarisation are plotted wrt applied sample voltage.

Discussion - X- signal of PE setup represents voltage across sample while Y signal is proportional to charge on capacitor and Polarisation.

In general, polarisation is proportional to field applied But in case of ferro-electric there is remmant polarisation, i.e. polarisation remains in the direction of applied field even after this field is removed hence Hysteresis is displayed.

When applied voltage across sample is increasing, two things can be changed in ferroelectric material.

Swayer tower circuit:

It is used to analyse hysteresis loop for material which has low loss and high Polarisation. Sample is attached to series capacitance (C_s) where capacitance should be more than sample capacitance (C_x). C_s is reference capacitor that is known & independent