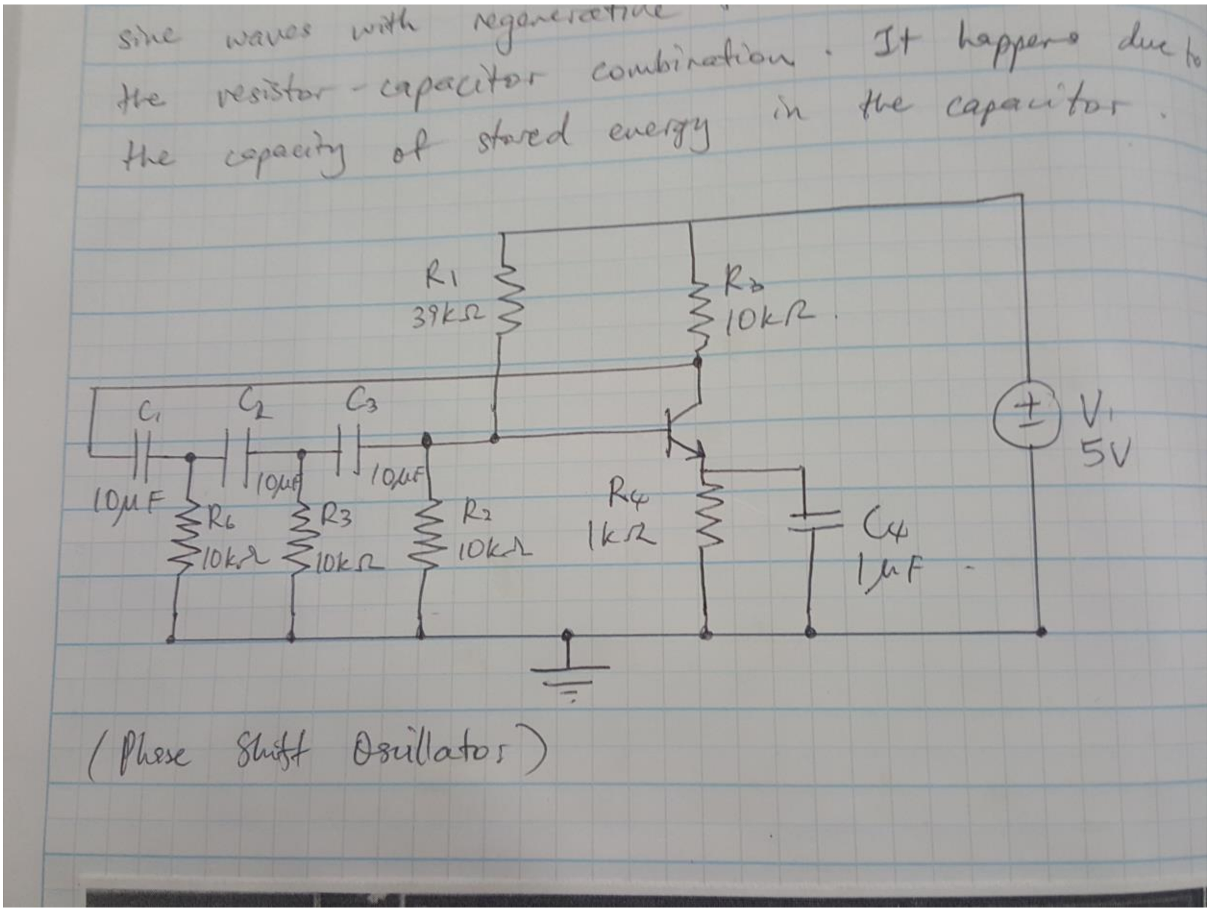
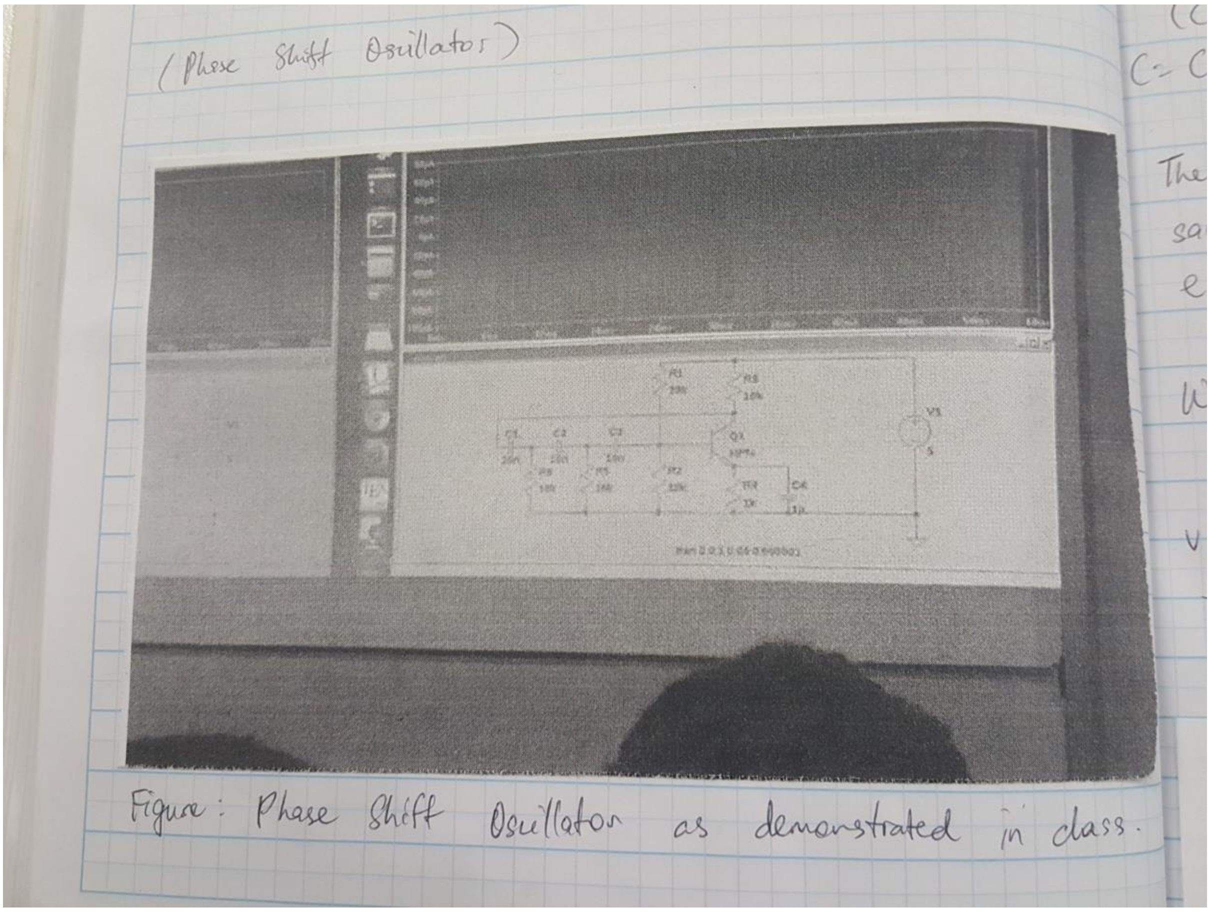
Workshop 4: Phase Shift Oscillator

The phase shift oscillator (PSO) is a circuit that creates sine waves with regenerative feedback obtained from the resistor-capacitor combination. It happens due to the capacity of stored energy in the capacitor.

PSO Diagrammmmmmmmm



Dr. Peter M. Farrell

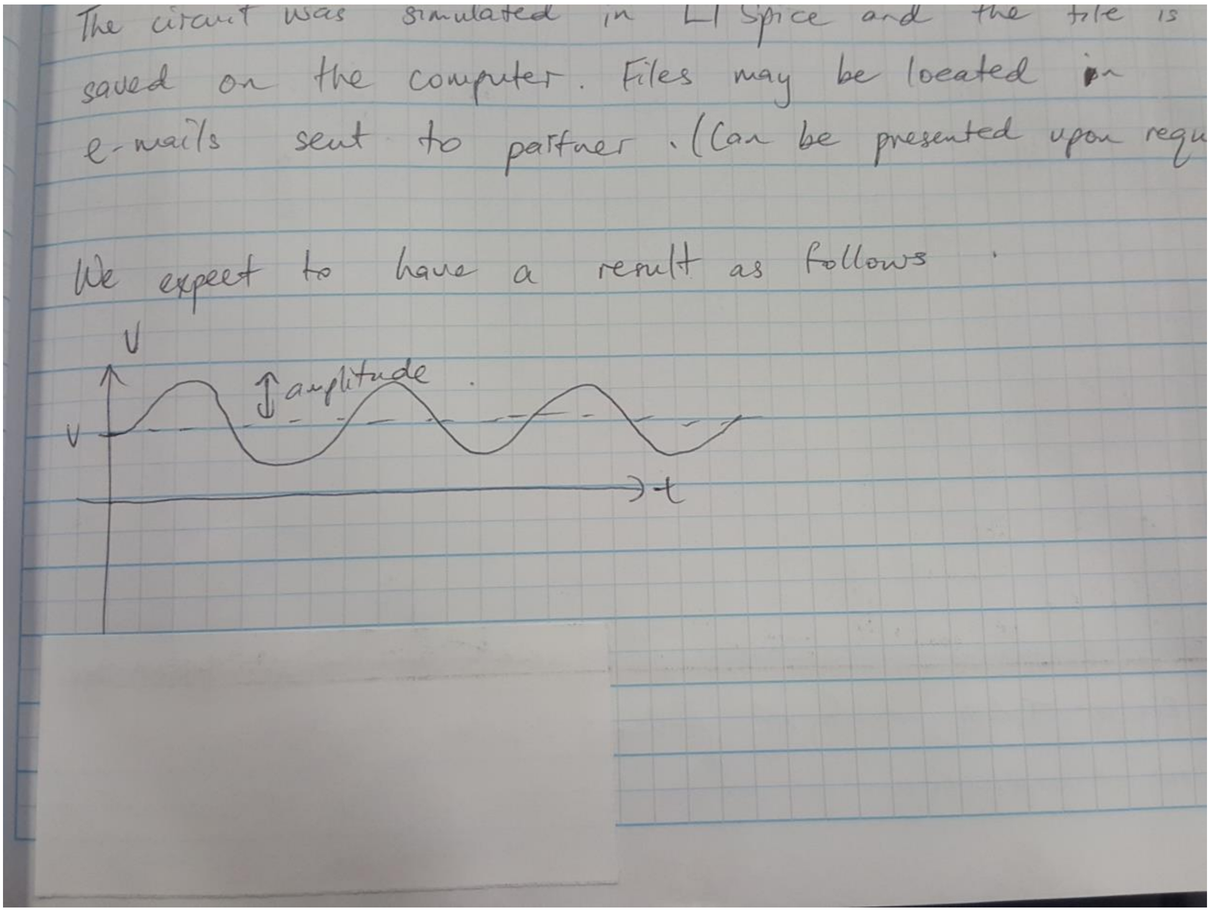


The above circuit shows the one we are to assemble. The transistor to be used is the BC548 (Datasheet attached). Could not determine manufacturer so assume it is Fairchild Conductors (as we needed to know pin orientations of transistor).

The PSO has a phase shift of 180 degrees, since each RC combination [(C1 and R6), (C2 and R5), (C3 and R2)] has a phase shift of 60 degrees if C=C1=C2=C3 and R2=R5=R6=R.

The circuit was simulated in LTSpice. Files may be located in emails.

We expect to have a result as follows.


The circuit was simulated in LT Spice and the file is saved on the computer. Files may be located in e-mails sent to partner. (Can be presented upon requ

We expect to have a result as follows.

PICTUREEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE

The PSO required a number of iterations to get it working right. Below shows the attempts to find the desired oscillations from the circuit.

V_B needs to be shifted towards the left in this case so increase the value of the resistor (i.e. 39kohms to 41kohms).

39kohms – sine wave with 3.9V

43kohms – good sine wave with a little clipping

Dr. Farrell suggests keeping the R value and continue with other aspects of PSO calibration.

Note: Oscilloscope used 10x and not 1x, hence gives distorted values and oscillations. Problems were fixed with the change. 1x gives good FFT.

PICUTRE

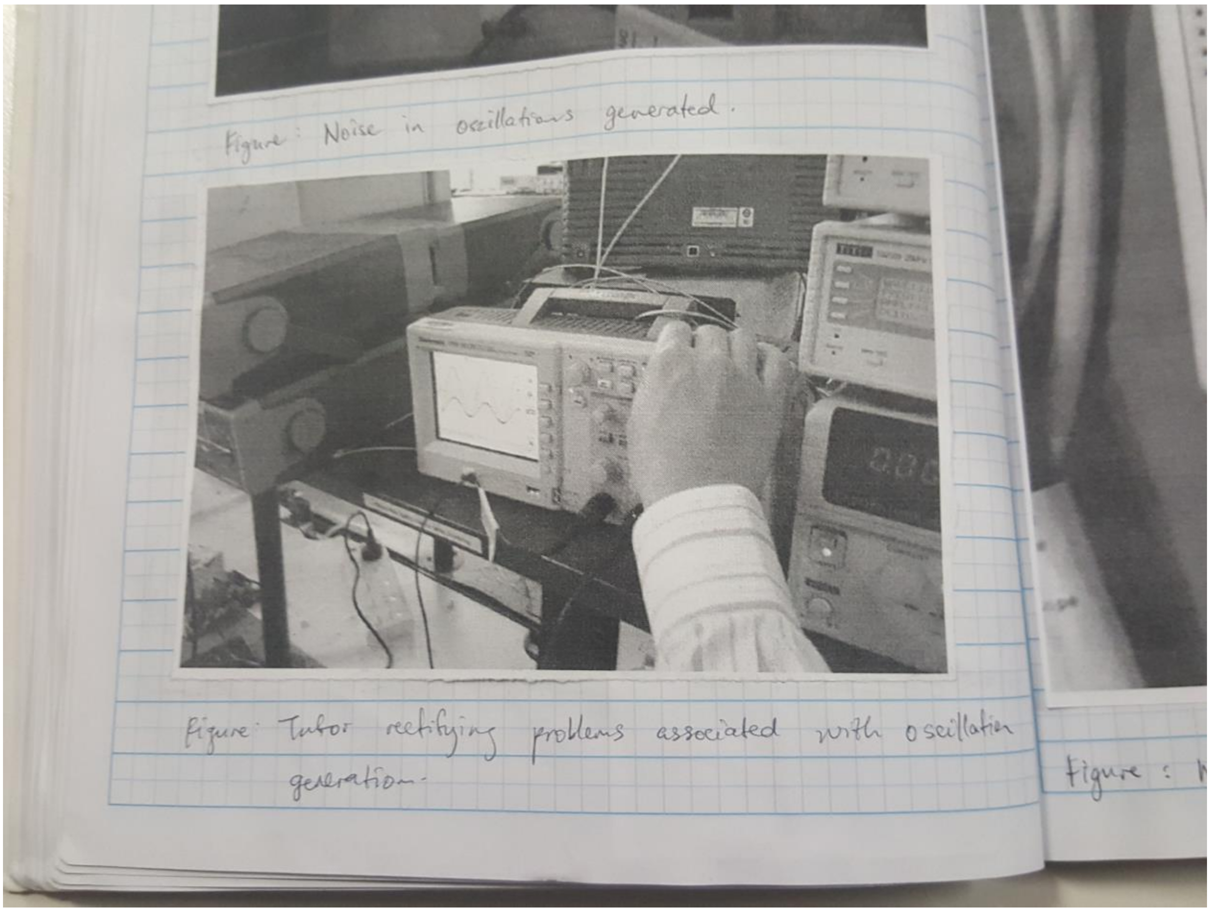
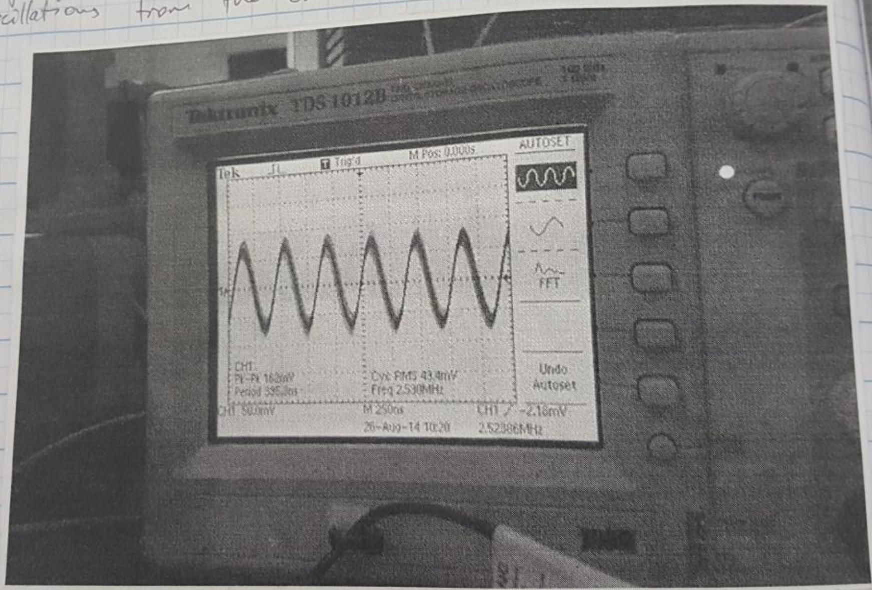


Figure: Noise in oscillations generated.
Figure: Tutor rectifying problems associated with oscillation generation.
Figure :

The PSO required a number of iterations to get it work right. Below shows the attempts to find the desired oscillations from the circuit.



$\rightarrow V_B$

n be
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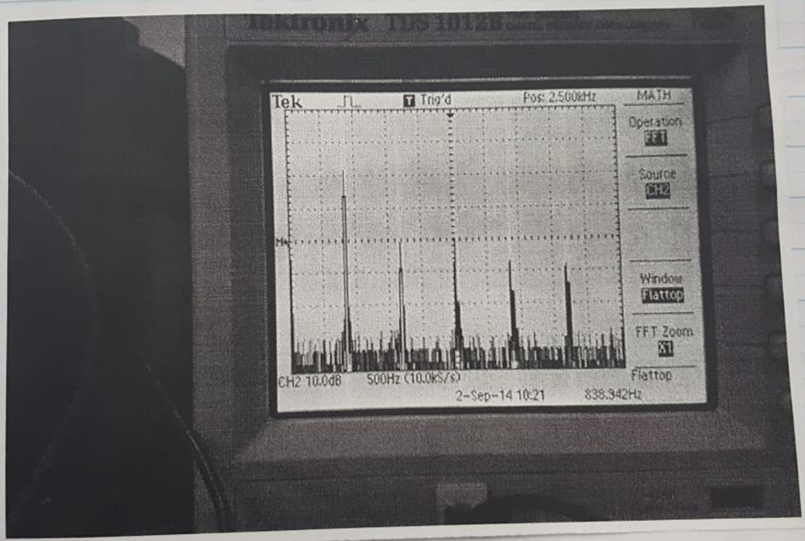
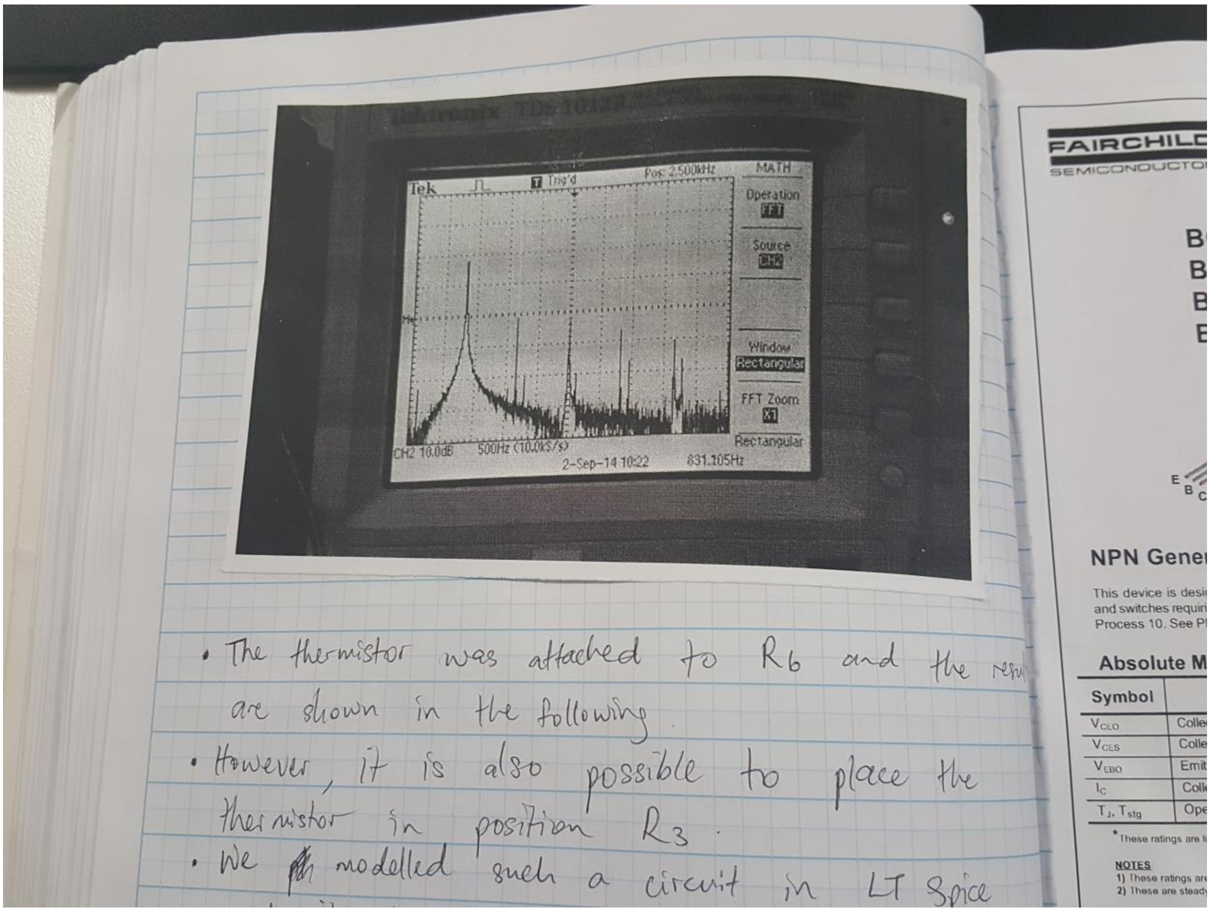
ired V

Note: Serial number of devices used are as follows:

DC Power Supply - EE 06546
Frequency Generator - EE 04897
Oscilloscope - TDS 1012B C057264
Multimeter - 1110225866





PCITRE FFT

- The thermistor was attached to R6 and the results are shown in the following.
- However, it is also possible to place the thermistor in position R3.
- We modelled such a circuit in LTSpice and it showed similar characteristics to the initial circuit.
- This LTSpice file can be found in Draft 14.

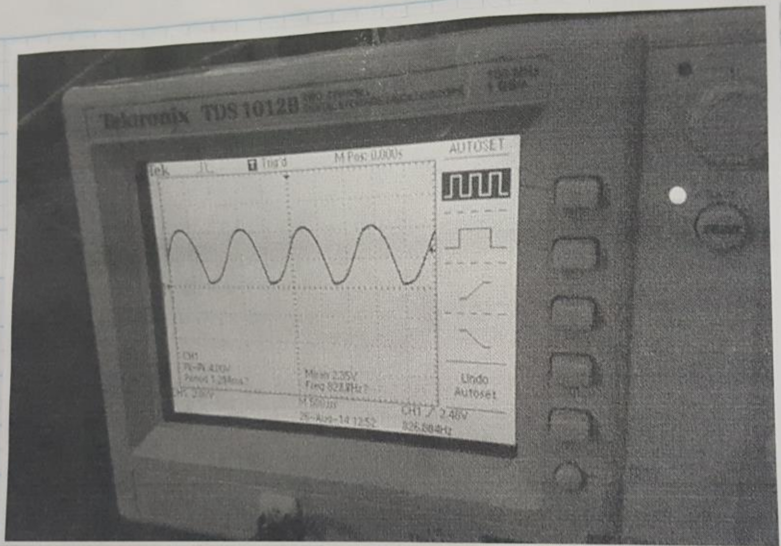


Figure : Oscillations generated by working Phase Shift Oscillator

Notice that the sine waves are not exactly smooth.

V_B needs
so incr
39 kΩ
43 kΩ
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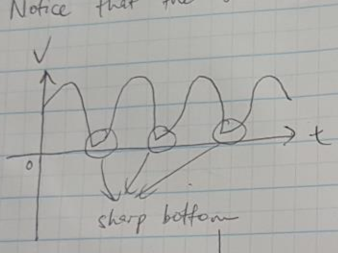
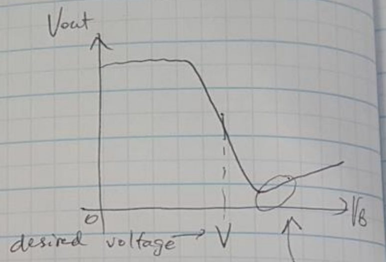
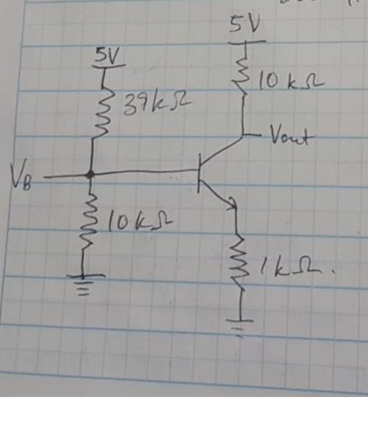
Figure : Oscillations generated by working Phase Shift Oscillator

Notice that the sine waves are not exactly smooth.





due to V_B reaching this region



$$V_{out} = V_B \frac{10k}{10k + 39k}$$

↳ ∴ can be adjusted to desired V

Note : Seri
DC
Freq
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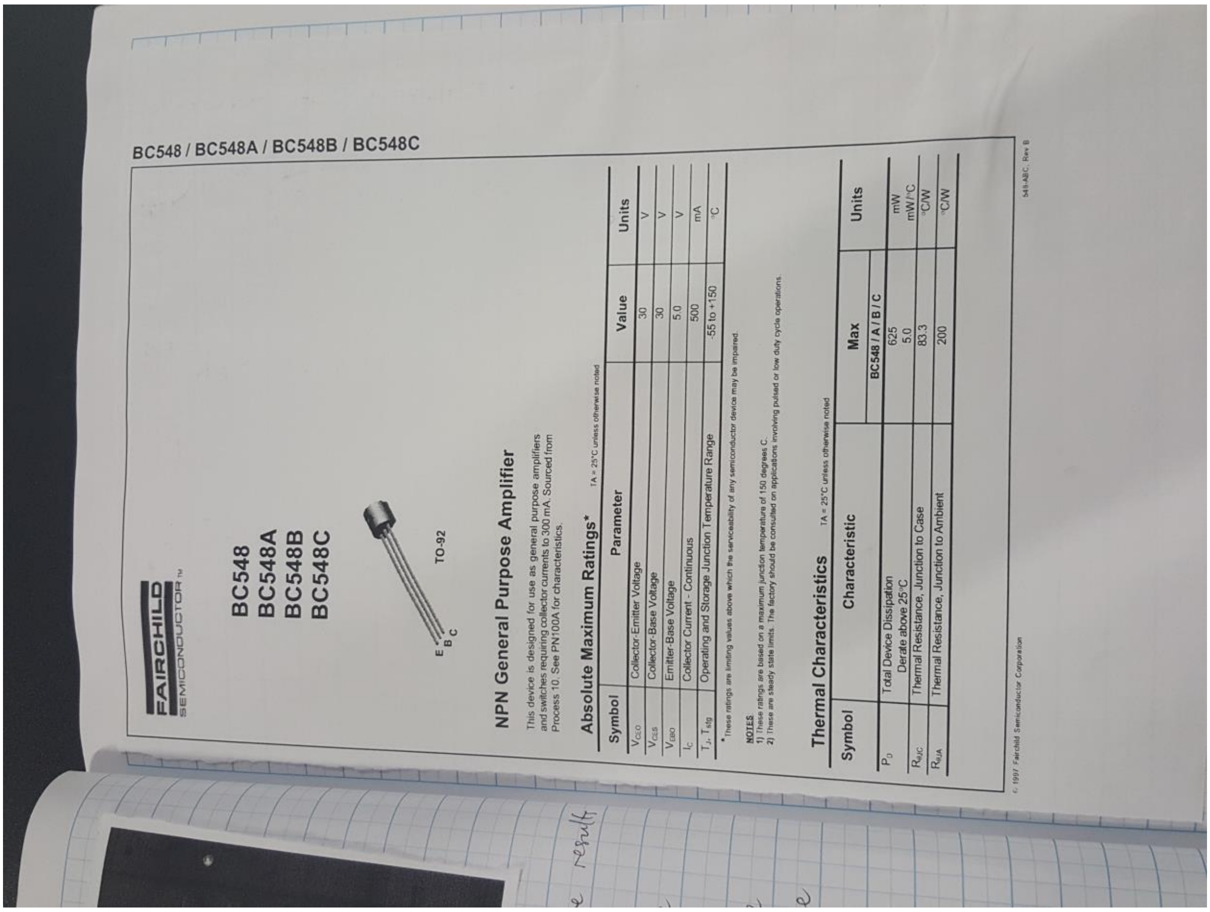
DATASHEETETTTETETT



BC548 / BC548A / BC548B / BC548C

FAIRCHILD
SEMICONDUCTOR ™

BC548
BC548A
BC548B
BC548C

E B C

TO-92

NPN General Purpose Amplifier

This device is designed for use as general purpose amplifiers and switches requiring collector currents to 300 mA. Sourced from Process 10. See PN100A for characteristics.

Absolute Maximum Ratings*

TA = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CEO}	Collector-Emitter Voltage	30	V
V_{CES}	Collector-Base Voltage	30	V
V_{EBO}	Emitter-Base Voltage	5.0	V
I_C	Collector Current - Continuous	500	mA
T_J, T_{stg}	Operating and Storage Junction Temperature Range	-55 to +150	°C

* These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

NOTES
1) These ratings are based on a maximum junction temperature of 150 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

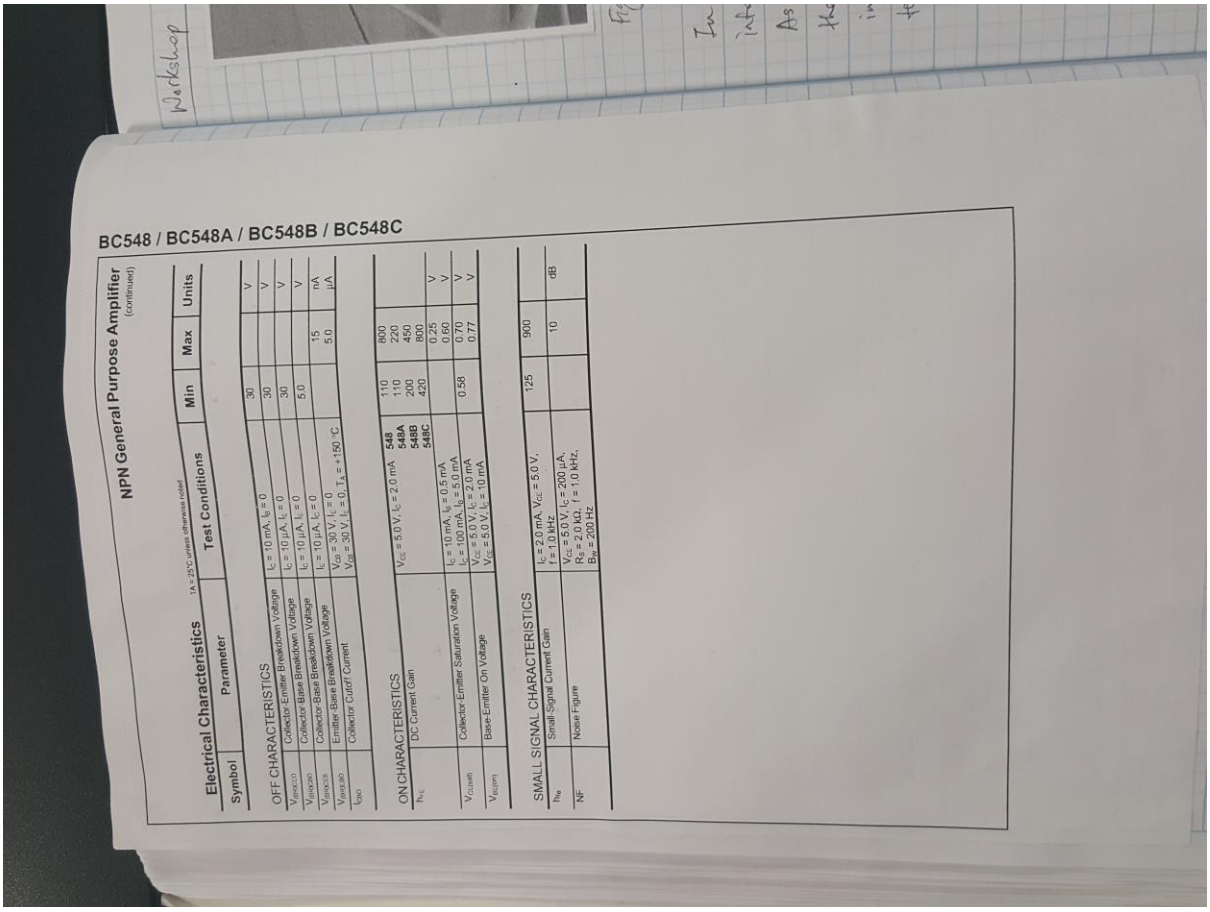
Thermal Characteristics

TA = 25°C unless otherwise noted

Symbol	Characteristic	Max	Units
		BC548 / A / B / C	
P_D	Total Device Dissipation Derate above 25°C	625 5.0	mW mW/°C
$R_{\theta JC}$	Thermal Resistance, Junction to Case	83.3	°C/W
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient	200	°C/W

548-ABC, Rev B

e result



BC548 / BC548A / BC548B / BC548C

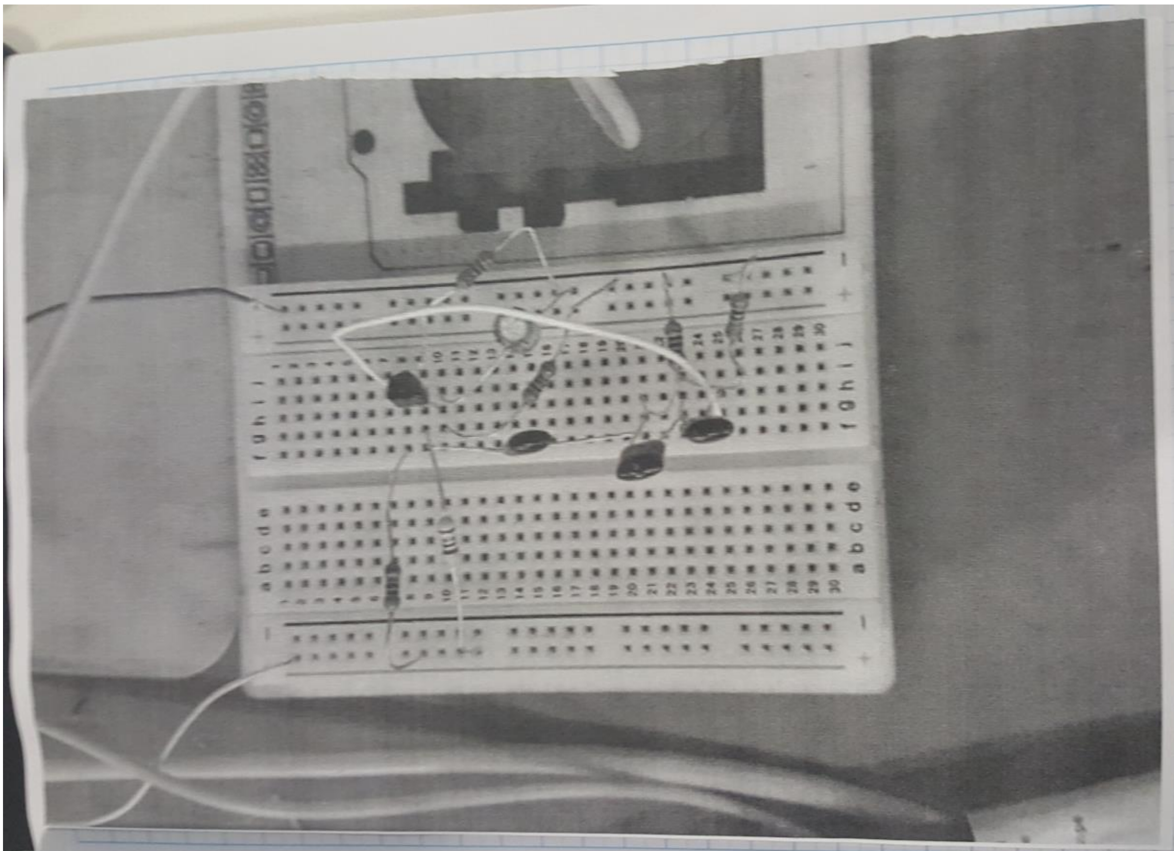
NPN General Purpose Amplifier
(continued)

Electrical Characteristics TA = 25°C unless otherwise noted

Symbol	Parameter	Test Conditions	Min	Max	Units
	OFF CHARACTERISTICS				
$V_{(BR)CEO}$	Collector-Emitter Breakdown Voltage	$I_C = 10$ mA, $I_B = 0$	30		V
$V_{(BR)CBO}$	Collector-Base Breakdown Voltage	$I_C = 10$ μA, $I_E = 0$	30		V
$V_{(BR)CES}$	Collector-Base Breakdown Voltage	$I_C = 10$ μA, $I_E = 0$	30		V
$V_{(BR)EBO}$	Emitter-Base Breakdown Voltage	$I_E = 10$ μA, $I_C = 0$	5.0		V
I_{CBO}	Collector Cutoff Current	$V_{CB} = 30$ V, $I_E = 0$ $V_{CB} = 30$ V, $I_E = 0$, $T_A = +150$ °C		15 5.0	nA μA
	ON CHARACTERISTICS				
h_{FE}	DC Current Gain	$V_{CE} = 5.0$ V, $I_C = 2.0$ mA 548 548A 548B 548C	110 110 200 420	800 220 450 800	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C = 10$ mA, $I_B = 0.5$ mA $I_C = 100$ mA, $I_B = 5.0$ mA		0.25 0.60	V V
$V_{BE(on)}$	Base-Emitter On Voltage	$V_{CE} = 5.0$ V, $I_C = 2.0$ mA $V_{CE} = 5.0$ V, $I_C = 10$ mA	0.58	0.70 0.77	V V
	SMALL SIGNAL CHARACTERISTICS				
h_{fe}	Small-Signal Current Gain	$I_C = 2.0$ mA, $V_{CE} = 5.0$ V, f = 1.0 kHz	125	900	
NF	Noise Figure	$V_{CE} = 5.0$ V, $I_C = 200$ μA, $R_S = 2.0$ kΩ, f = 1.0 kHz, $B_W = 200$ Hz		10	dB

Workshop 5: PSO Calibration

FIGUREEEEEEEEEEEEEEE



2/9/2014.

Workshop 5: Phase Shift Oscillator Calibration

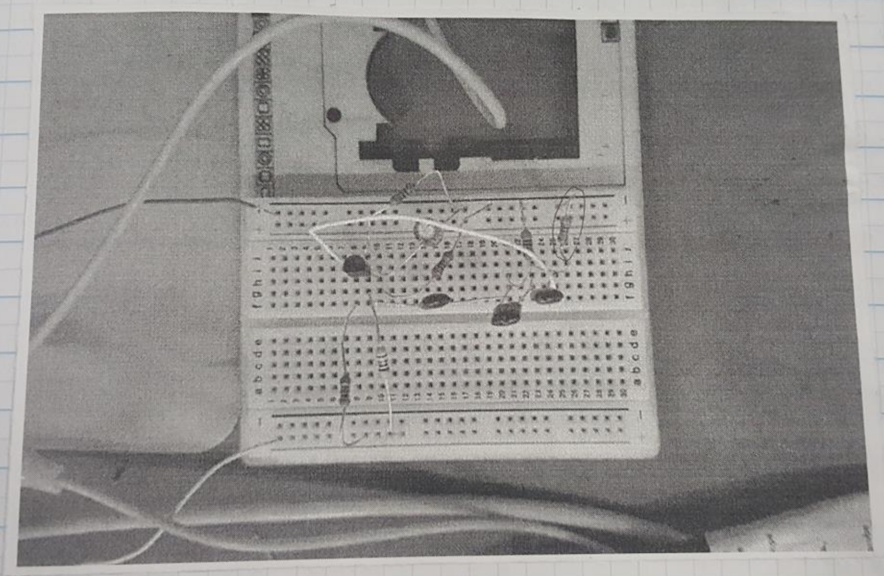


Figure: Phase Shift Oscillator from previous workshop.

In this workshop, we need to integrate the thermistor into the circuit and calibrate the phase shift oscillator. As such, the circled resistor is replaced with a thermistor and the circuit's frequency is calibrated in the Arduino such that it corresponds to a specific temperature. The formula used is:

1/T=A+BlogRT/R25+C(logRT/R25)^2+D(logRT/R25)^3

Where A,B,C,D are the constants used in workshop 2

Procedure:

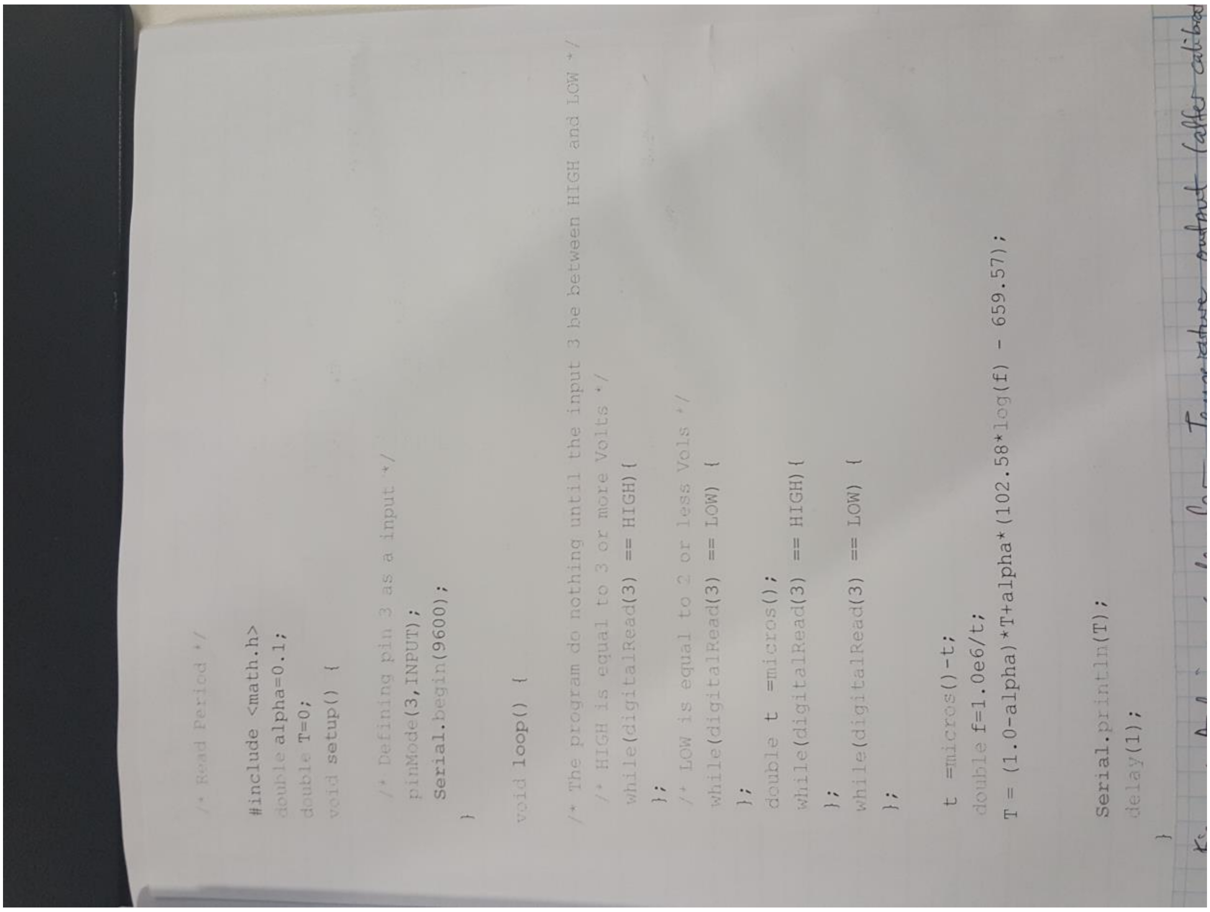
1. Choose random values of resistors (in the range 3kohms to 25kohms) based on the range of temperatures desired.
2. Connect the resistor to the point where the thermistor is supposed to be found.
3. Record the average of the frequencies using the Arduino.
4. Record resistance and temperature in a table in Microsoft Excel.
5. Calculate T based on formula on previous page.
6. Plot T against R and find trendline.
7. Insert trendline (best fit line) equation into Arduino (calibration). Now rewrite code for Arduino so it outputs T.

Values of R chosen: 16kohms, 18kohms, 6.2 kohms, 9k 7.5k 18k 18k 22k 3.9k 16k 10k 12k 23k 9k 25k 6.7k 22k 13k 3.6k

16k ohm	18k ohm	6.2k ohm	9k ohm	7.5k ohm	18k ohm	18k ohm	22k ohm	3.9k ohm
710.23	694.44	868.06	809.06	850.34	694.44	694.44	670.24	984.25
710.23	694.44	919.12	806.45	844.59	694.44	694.44	666.67	984.25
710.23	694.44	919.12	811.69	844.59	694.44	694.44	668.45	992.06
710.23	694.44	868.06	811.69	844.59	702.25	694.44	666.67	976.56
726.74	694.44	919.12	809.06	844.59	694.44	694.44	670.24	992.06
710.23	679.35	919.12	811.69	850.34	694.44	694.44	668.45	984.25
710.23	694.44	868.06	809.06	844.59	694.44	694.44	670.24	984.25
710.23	694.44	868.06	811.69	850.34	694.44	702.25	670.24	976.56
710.23	694.44	919.12	809.06	850.34	694.44	702.25	670.24	992.06
710.23	694.44	919.12	806.45	844.59	694.44	694.44	668.45	992.06
726.74	694.44	868.06	811.69	856.16	694.44	694.44	666.67	992.06
710.23	694.44	868.06	811.69	850.34	702.25	694.44	666.67	984.25
726.74	710.23	919.12	809.06	856.16	694.44	694.44	668.45	976.56
726.74	694.44	868.06	811.69	850.34	694.44	694.44	670.24	992.06
710.23	694.44	868.06	809.06	850.34	694.44	694.44	666.67	976.56
726.74	694.44	919.12	806.45	850.34	694.44	702.25	668.45	992.06
710.23	694.44	868.06	809.06	844.59	694.44	694.44	668.45	976.56
710.23	694.44	868.06	809.06	844.59	694.44	686.81	668.45	992.06
710.23	694.44	868.06	809.06	862.07	694.44	694.44	668.45	976.56
710.23	694.44	868.06	811.69	850.34	702.25	702.25	668.45	984.25
710.23	710.23	868.06	811.69	850.34	702.25	694.44	668.45	984.25
710.23	694.44	919.12	809.06	844.59	694.44	694.44	668.45	976.56
710.23	694.44	868.06	814.33	850.34	694.44	694.44	666.67	992.06
710.23	694.44	868.06	811.69	844.59	694.44	694.44	668.45	984.25
710.23	694.44	868.06	806.45	844.59	694.44	694.44	668.45	992.06
710.23	694.44	919.12	811.69	844.59	694.44	702.25	668.45	976.56
710.23	694.44	868.06	811.69	844.59	702.25	694.44	666.67	984.25
710.23	694.44	868.06	811.69	850.34	694.44	694.44	666.67	976.56
710.23	694.44	919.12	811.69	844.59	702.25	694.44	668.45	984.25
710.23	679.35	919.12	809.06	844.59	694.44	694.44	670.24	992.06
710.23	694.44	868.06	809.06	844.59	694.44	694.44	668.45	992.06
710.23	694.44	868.06	809.06	844.59	694.44	694.44	670.24	984.25
710.23	694.44	919.12	811.69	850.34	694.44	694.44	666.67	976.56
726.74	694.44	868.06	809.06	844.59	694.44	694.44	670.24	992.06
710.23	694.44	868.06	814.33	850.34	694.44	694.44	666.67	984.25
710.23	694.44	919.12	811.69	850.34	694.44	694.44	668.45	992.06
710.23	694.44	868.06	809.06	850.34	694.44	694.44	668.45	984.25
710.23	694.44	868.06	811.69	844.59	694.44	694.44	670.24	992.06
710.23	710.23	868.06	806.45	856.16	694.44	694.44	666.67	984.25
710.23	694.44	868.06	809.06	850.34	694.44	694.44	670.24	976.56
710.23	694.44	868.06	809.06	856.16	694.44	686.81	668.45	992.06
710.23	694.44	919.12	811.69	850.34	694.44	694.44	670.24	992.06
710.23	694.44	919.12	811.69	850.34	694.44	694.44	670.24	992.06
710.23	694.44	868.06	806.45	850.34	702.25	694.44	668.45	984.25
710.23	679.35	868.06	811.69	850.34	694.44	694.44	668.45	976.56
710.23	694.44	919.12	806.45	856.16	702.25	686.81	668.45	984.25
710.23	694.44	919.12	811.69	850.34	694.44	694.44	668.45	984.25
710.23	694.44	868.06	811.69	850.34	694.44	694.44	668.45	984.25

Figure: Frequency and resistance data.

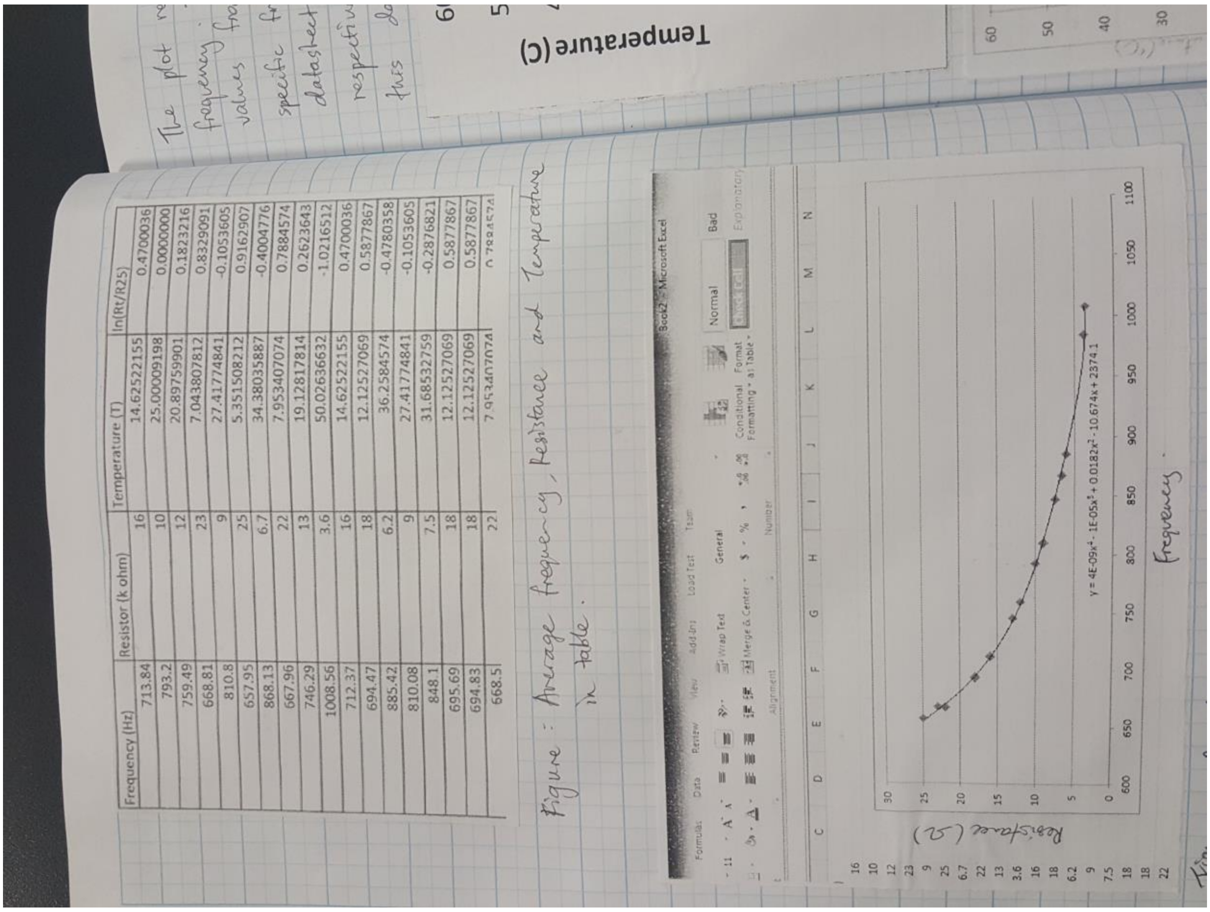
EXCEL:LLLLLLLLLLLLLLLLLLLLL



```
/* Read Period */

#include <math.h>
double alpha=0.1;
double T=0;
void setup() {

  /* Defining pin 3 as a input */
  pinMode(3,INPUT);
   Serial.begin(9600);
}

void loop() {

/* The program do nothing until the input 3 be between HIGH and LOW */
  /* HIGH is equal to 3 or more Volts */
  while(digitalRead(3)  == HIGH){
  };
  /* LOW is equal to 2 or less Vols */
  while(digitalRead(3)  == LOW)  {
  };
  double  t  =micros();
  while(digitalRead(3)  == HIGH){
  };
  while(digitalRead(3)  == LOW)  {
  };

  t =micros()-t;
  double f=1.0e6/t;
  T = (1.0-alpha)*T+alpha*(102.58*log(f) - 659.57);

  Serial.println(T);
  delay(1);
}
```

CODEEEEEEEEEEEEEEEEEEEEE

The code gives the temperature of the measurement measured by thermistor.To calculate the temperature from frequency, resistance is correlated with frequency from the data and then the equation is used.



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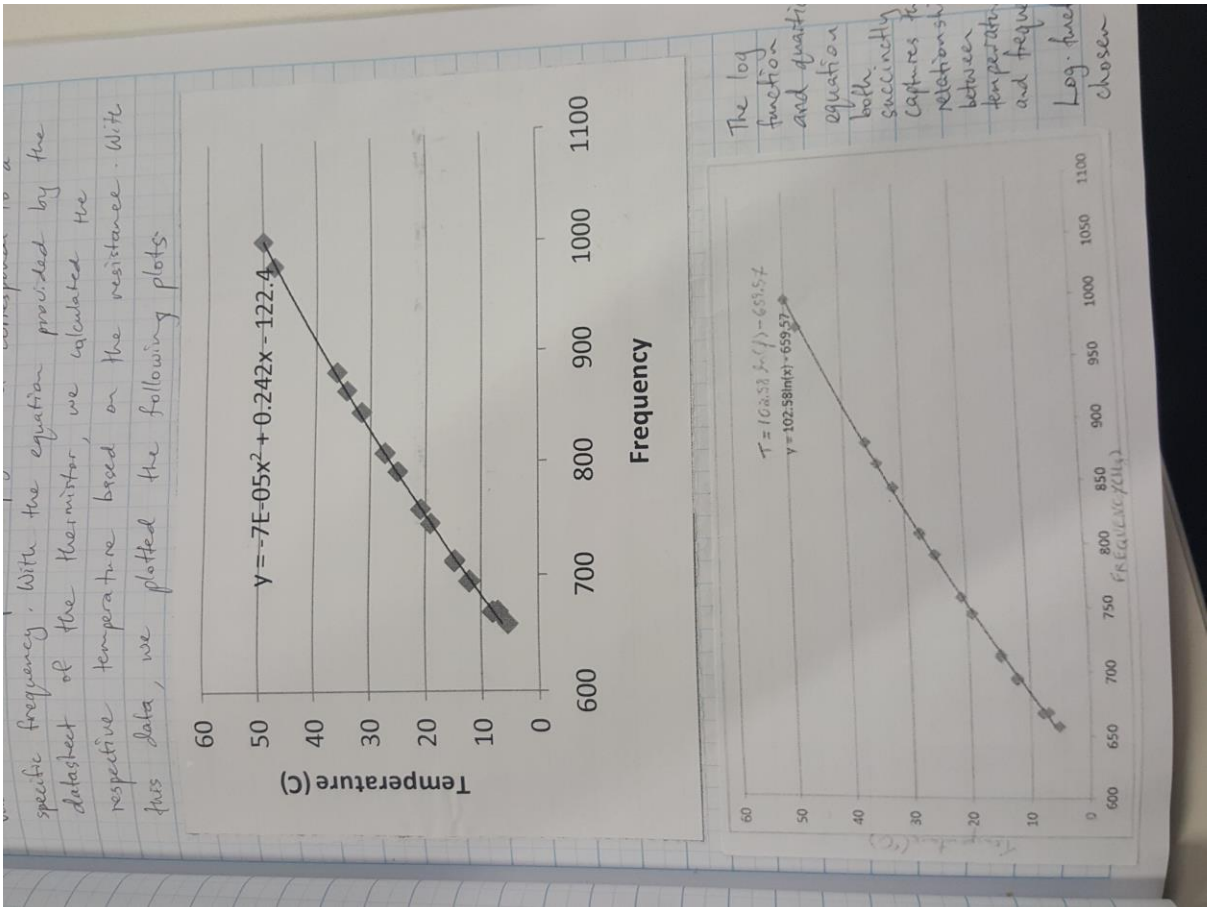
The plot represents the relation between resistance and frequency. It was calculated using different resistance values from the previous pages and corresponds to a specific frequency. With the equation provided by the datasheet of the thermistor, we calculated the respective temperature based on the resistance. With this data, we plotted the following plots.



PLOTSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS 7E05x^2

The log function and quartic equation both succinctly captures the relationship between temperature and frequency. Log function chosen.

Filter in the output of the PSO:

For better signal accuracy from the oscillator, we put an RC filter on the output to cutoff any frequencies above 1200 Hz. This is to avoid aliasing.

Low pass filter

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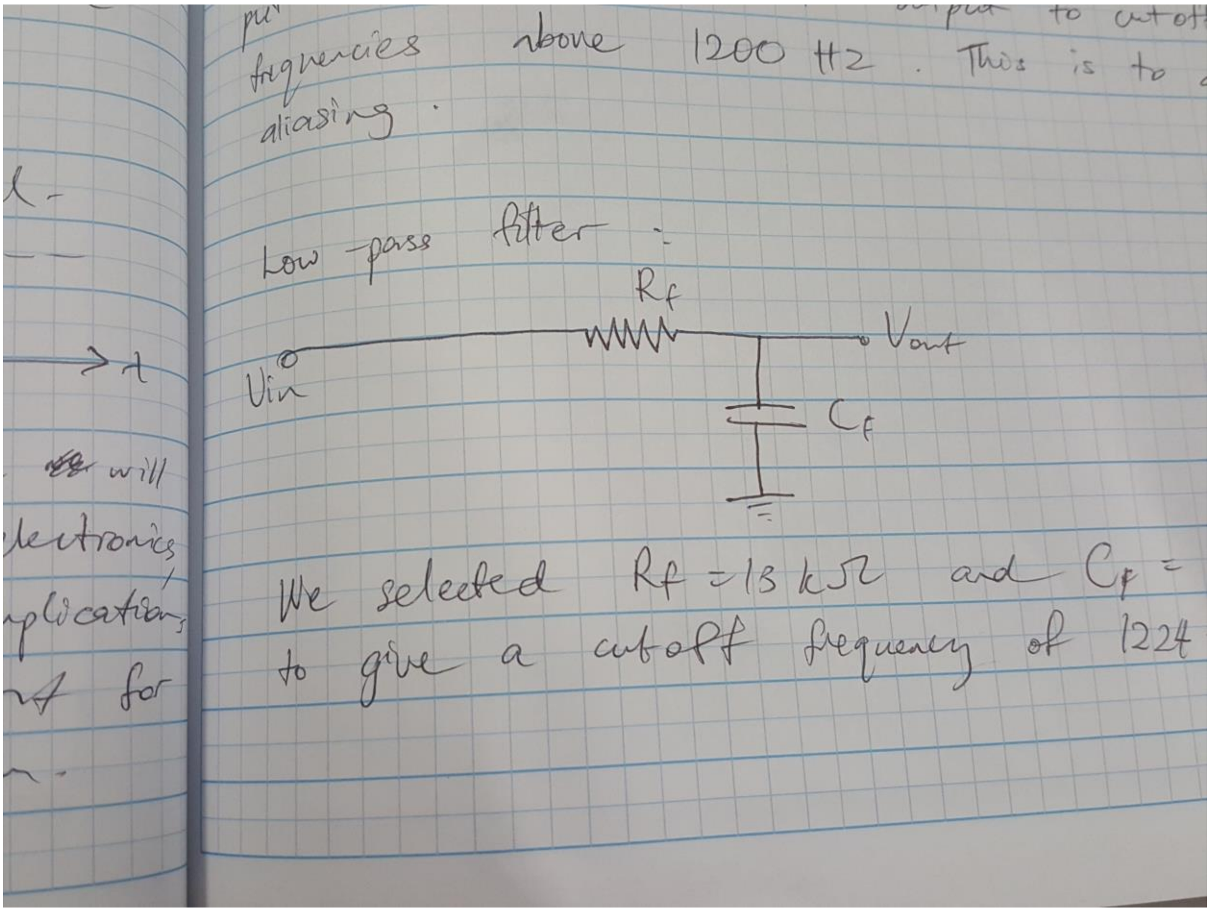
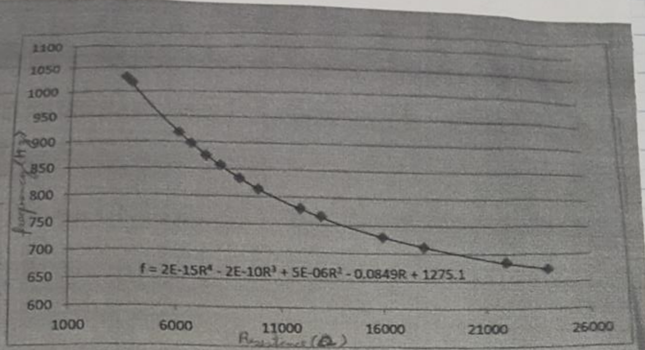
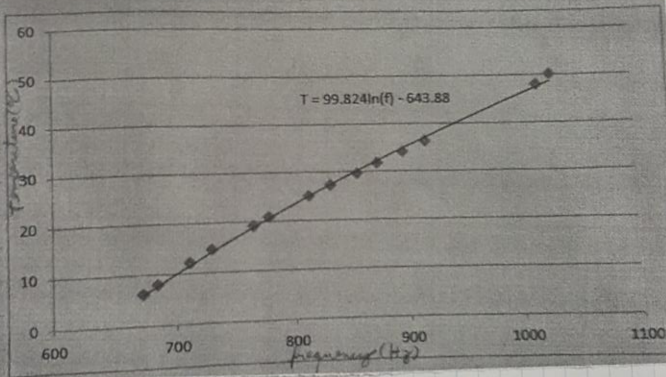
We selected RF = 13 kohms, and CF = 10nF to give a cutoff frequency of 1224 Hz.







- With this, we updated the code for the new equation

Code:

> ~~Desktop~~ Documents > Subjects > ESI > Workshop 8 > W8c

- Next, we deal with the display screen.

Partner : Victo...

Demonstrator : Merid Lgesngane...

- Using the phase shift oscillator circuit in workshop 4, rewired the circuit. Wires were better organized and overall was neater. (Not ~~like~~ like a bird's ...

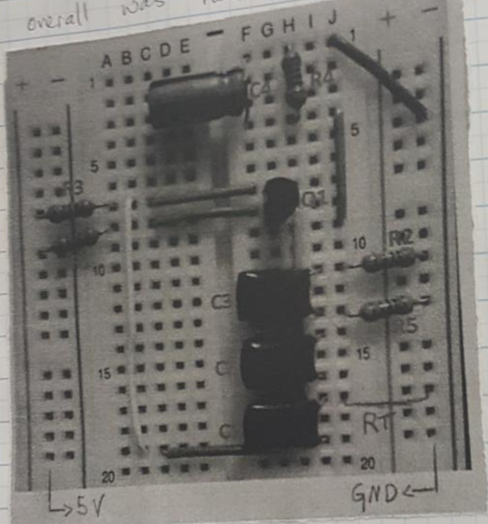


Figure : Phase shift oscillator circuit

R(kΩ)	F(Hz)	T (°C)	ln(Rt/R25)
16000	729.37	14.62522	0.4700036
12000	778.48	20.8976	0.1823216
9100	832.75	27.16255	-0.0943107
24000	672.69	6.177771	0.8754687
3600	1030.13	50.02637	-1.0216512
3900	1018.18	47.93002	-0.9416085
7500	874.4	31.68533	-0.2876821
18000	711.42	12.12527	0.5877867
10000	813.73	25.00009	0.0000000
22000	684.48	7.953407	0.7884574
6800	897.16	34.02394	-0.3856625
6200	917.71	36.25846	-0.4780358
13000	765.07	19.12818	0.2623643
8200	856.67	29.58322	-0.1984509

Table : Correlation between resistance, frequency, temperature and $\ln\left(\frac{R_T}{R_{25}}\right)$.