POWER FACTOR IMPROVEMENT PLANT

DISADVANTAGE OF LOW POWER FACTOR

Load current is **inversely proportional** to the power factor. Lower the power factor higher the load current

Low p.f we face the following disadvantages:

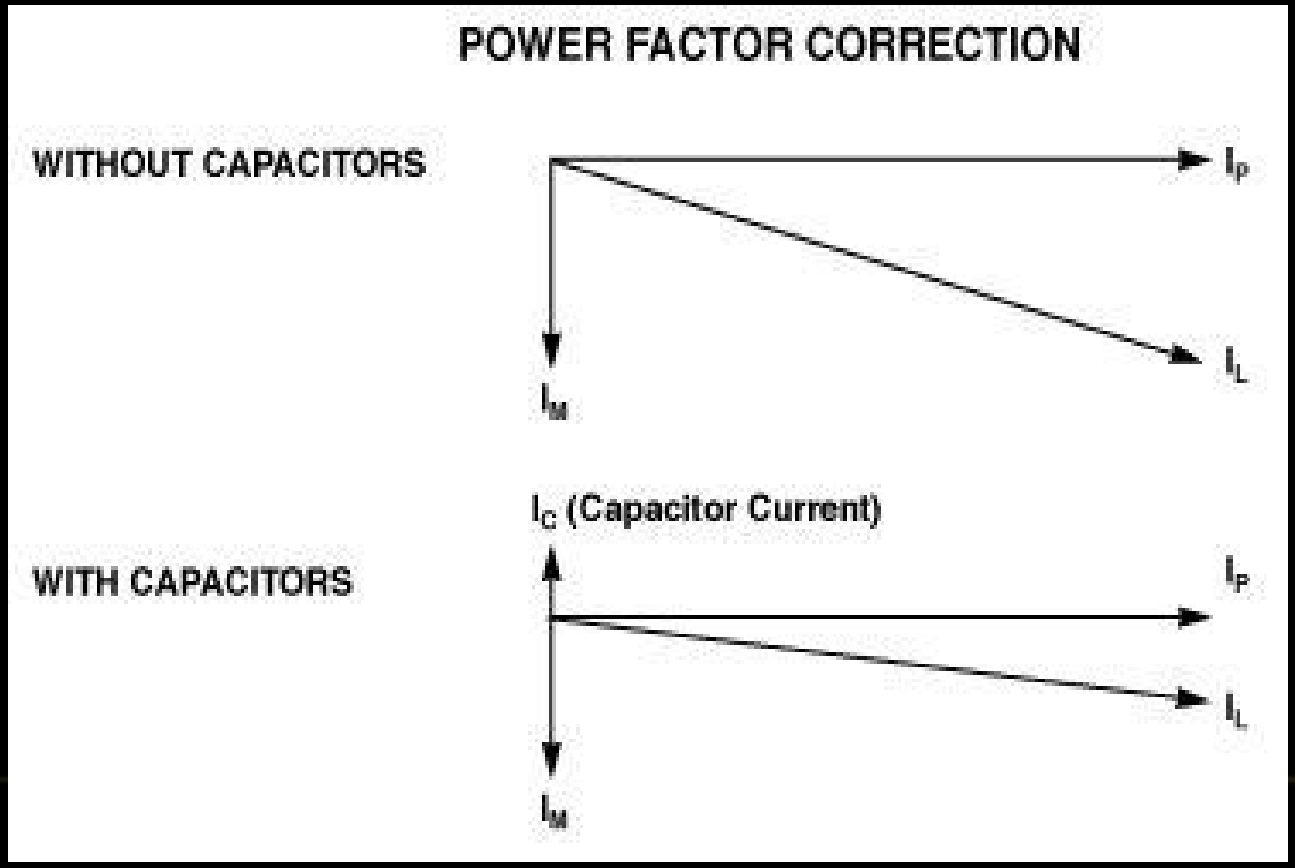
- Large KVA rating of equipment
- Greater inductor size
- Large copper losses
- Poor voltage regulation
- Reduced handling capacity of the system

CAUSES OF LOW POWER FACTOR

- Most of the ac motors, electric lamps, industrial heating furnaces are of induction type.
- The load on the power system is varying. During low load period, supply voltage is increased which increases the magnetization current resulting in decreased power factor.

POWER FACTOR IMPROVEMENT

- Capacitor draws leading current and partly or completely neutralizes the lagging reactive component of load current.

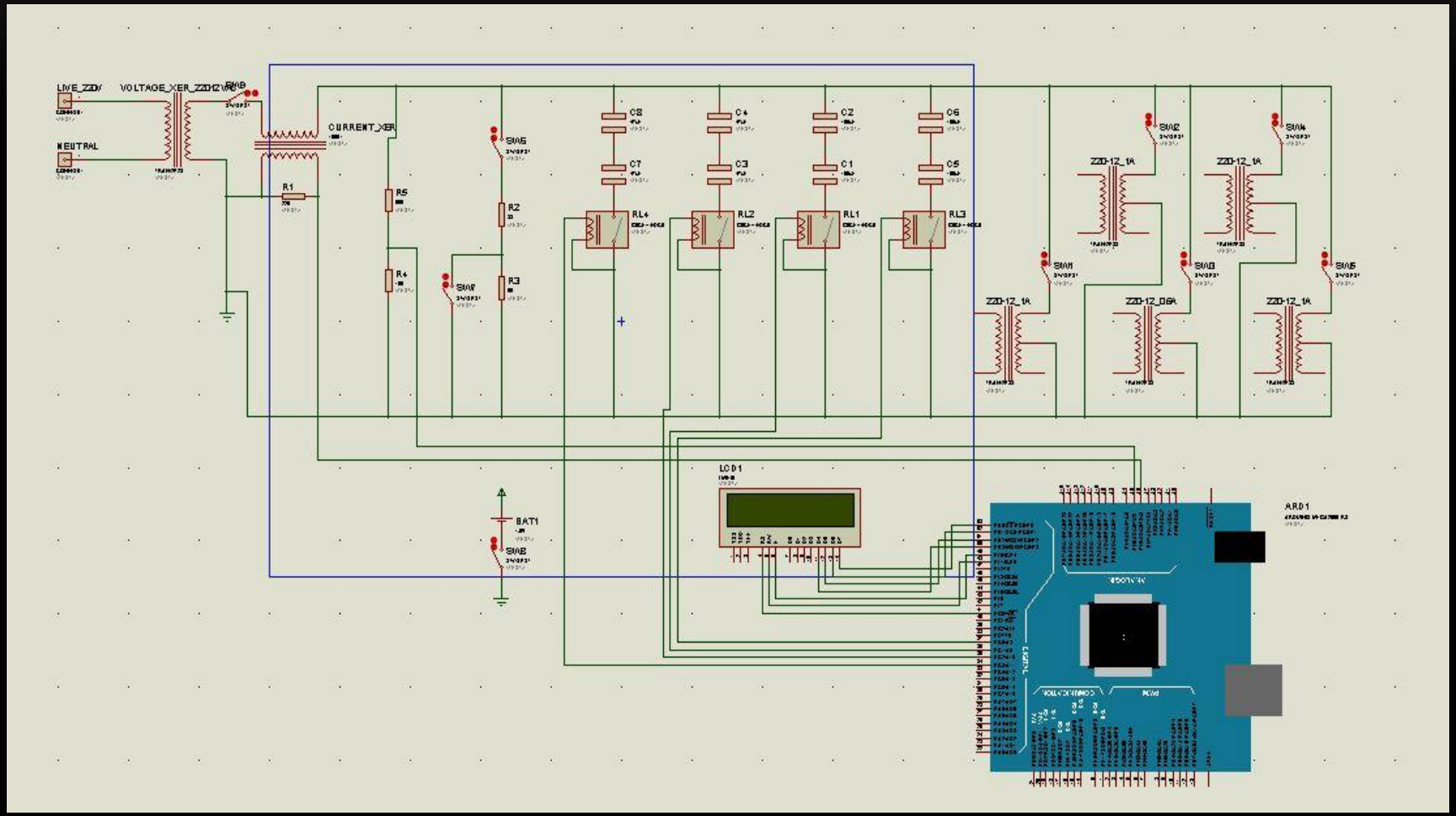


CALCULATION OF POWER FACTOR CORRECTION

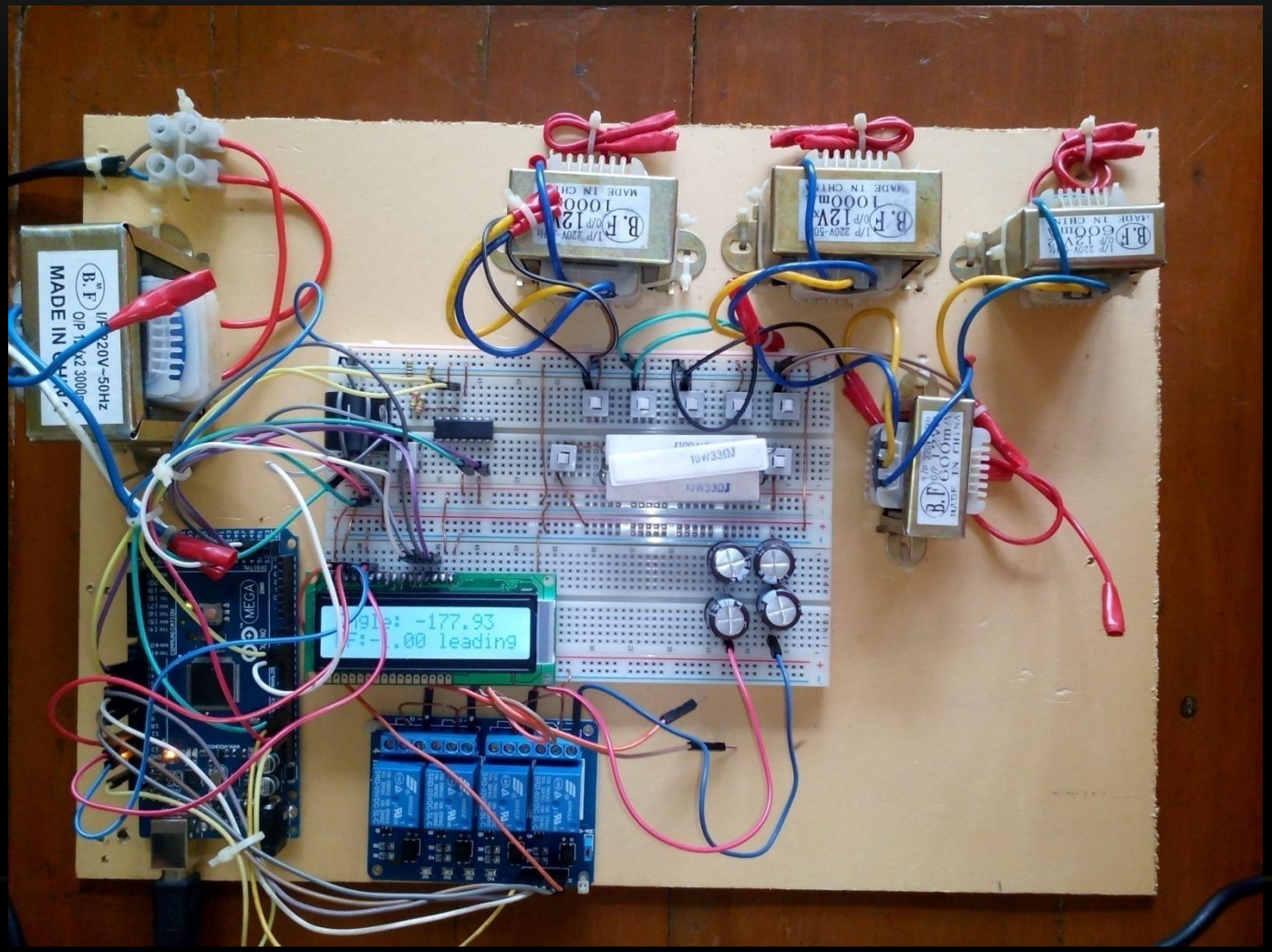
- $I_2 \sin \Phi_2 = I_1 \sin \Phi_1 - I_c$
- $I_c = I_1 \sin \Phi_1 - I_2 \sin \Phi_2$

- $X_c = V / I_c = 1/ (\omega C)$
- or, $C = I_c / (\omega V)$

SCHEMATIC DIAGRAM OF THE PLANT



MINIATURE POWER FACTOR IMPROVEMENT PLANT



PROJECT DEVELOPMENT

DIFFICULTIES FACED DURING DEVELOPING MINIATURE PFI PLANT:

- METHOD OF SAMPLING
- CURRENT SAMPLING
- SELECTING INDUCTIVE LOAD
- HARMONICS ASSOCIATED IN LOAD CURRENT
- SELECTING CAPACITOR

SAMPLING METHOD

Firstly we decided to use sample the voltage and current using comparator circuits. The intention was to detect the zero crossing points and hence calculate the phase angles.

But the arduino board which we were using as our microprocessor already has built in facilities for high quality sampling. So it was convenient not to use extra peripheral circuits but directly use the microprocessor board built in facilities.

Moreover in some cases there were noise introduced in the comparator which was not acceptable at all. The Arduino handled this problem very efficiently.

For these reasons we used analog sampling method and acquired voltage and current samples as discrete values in small time intervals.

CURRENT SAMPLING

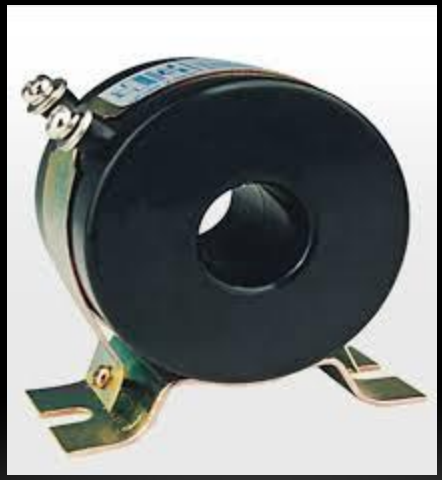
Current transformer is used to sample the current without disrupting the flow. The available model which was found had the transformation ratio 1000:1. Which means 5A load current in the main line will result in 5mA current in the secondary coil. The rated sampling resistance is 200 ohms. So the current transformer samples 5A current into 1V.

In this case the sampling may not be precise because we are not dealing with current as high as 5A in the miniature version and moreover Arduino samples with reference to 5V.

this case was solved by coiling the main line 3 times through the current transformer which reduced the ratio down to 333:1 and furthermore we manually set the sampling voltage to 3.3V instead of 5V by using external reference (AREF pin).

MODIFICATION IN CURRENT TRANSFORMER

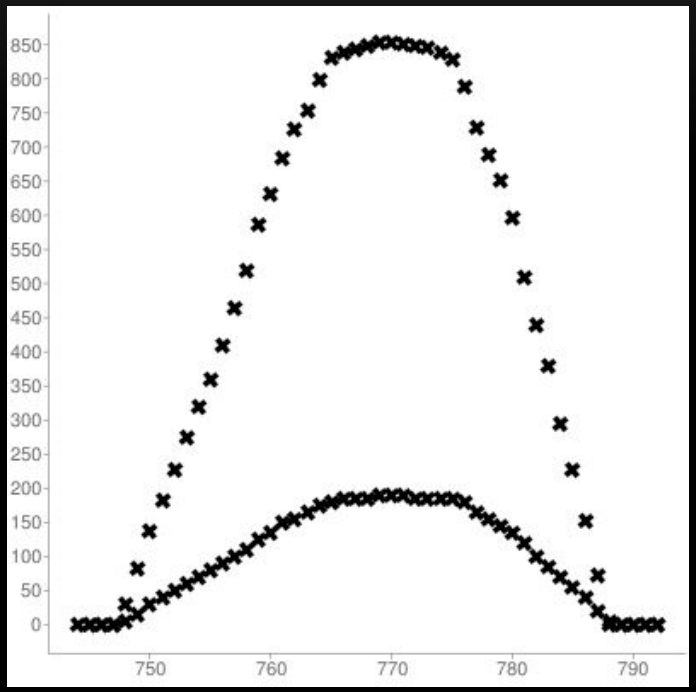
- The turns ratio of the current transformer was decreased to 333:1 from 1000:1 so that we get 5mA current in the secondary for 1.67A in primary. This was done by increasing number of turns in the secondary winding.



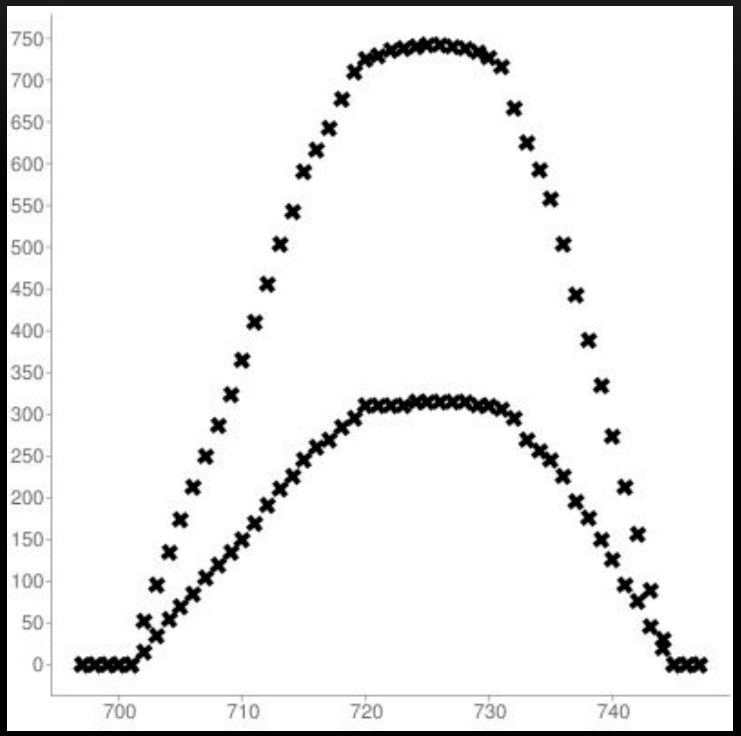
SELECTING INDUCTIVE LOAD

- Miniature inductor which could not withstand high current, so overheat and burn
- Air core inductor produced an inductive value which was very less in microhenry range
- 12V dc motor works as resistive element not inductive.
- At last transformer was used which is though not purely inductive, but works well.

WAVEFORM ANALYSIS

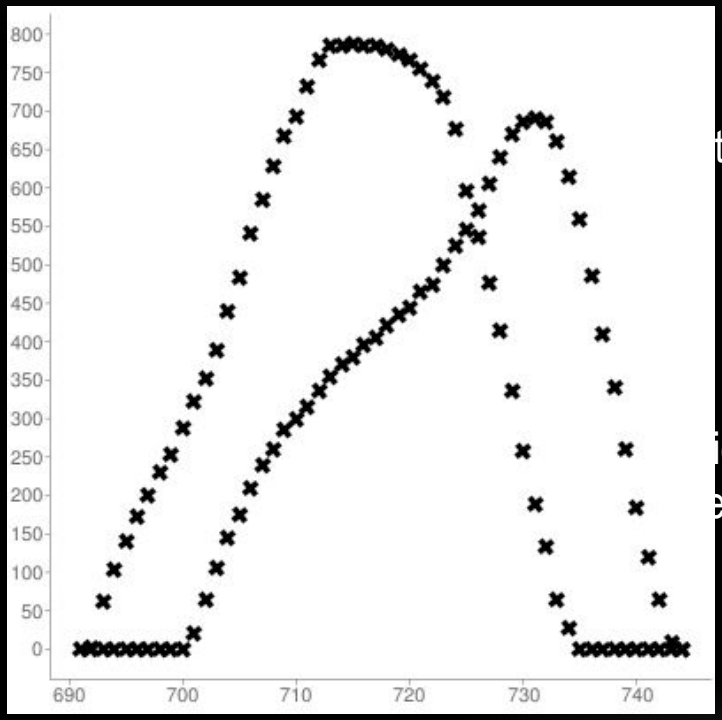


66 ohms resistive load



33 ohms resistive load

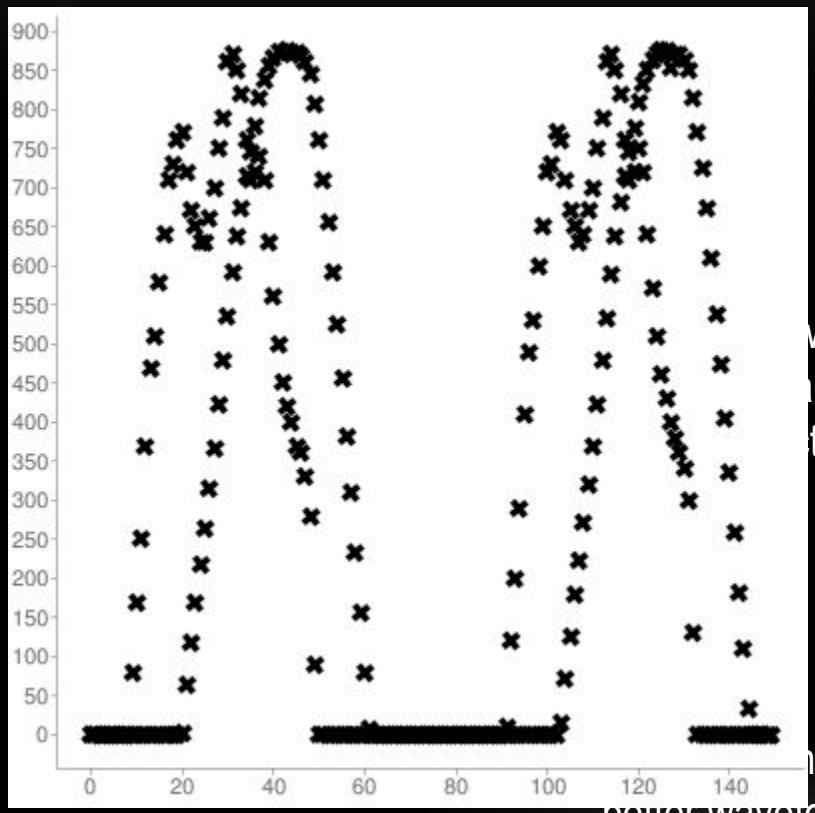
Waveform for inductive load:



When we added transformrs as
inductive load what we observed is
there was harmonics associated due
turation.

As the current waveform is not
sinusoidal anymore we had to
calculate RMS value by individually
idering each points rather than
e peak value by root(2).

SELECTING CAPACITORS

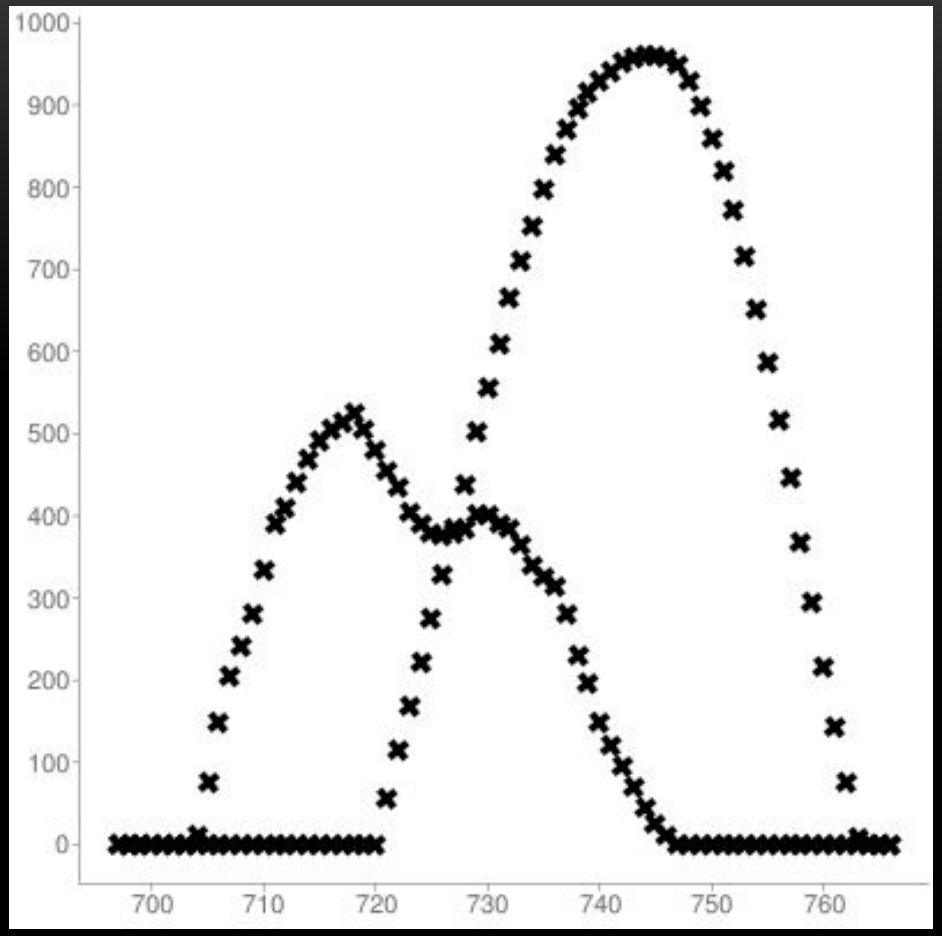


Cyramic capacitors are available for
220V which if used in this miniature
2V system will result in negligible

As we used electrolytic capacitors
which is mainly used for DC purposes
nalyzing the waveform we
ted waveform

The problem was solved by
connecting two capacitors back to
series which resulted in
better waveform

CAPACITIVE LOAD



CAPACITIVE LOAD BANKING 2 CAPACITORS BACK TO BACK

ALGORITHM FOR POWER FACTOR CALCULATION

- Voltage and current values are sampled
- Then we identify the points of both voltage and current values rises from 0 to positive and stored as a variable.
- In the same way we determine the points at which the values fall from positive to zero.
- Time period is determined from the two equivalent rising points.
- Phase difference is calculated from the difference of the rising points of current and voltage.
- Φ = (phase difference/T)* 360
- Power factor= cos Φ

ALGORITHM FOR RELAY SWITCH

- Relay switch will not be active if power factor is greater than 0.95
- Four capacitors (two 50uF , two 23.5uF) each are connected in parallel
- For each combination of capacitors, power factor is calculated using the algorithm shown above.
- This method is carried out until all the possible 16 combinations are tried.
- The best combination and improvements are displayed in the LCD.

ALGORITHM FOR RMS CURRENT AND VOLTAGE DISPLAY

- Only the half cycle the voltage and current is considered.
- The sampled input was converted to the original values, using linear interpolation.
- Conversion for actual voltage (Y)= , where x= sampled voltage.
- Conversion for actual current (Y)= , where x= sampled current.
- The values are squared and then summed up, for the whole half cycle, and ten divided by the count interval.
- The square root of the result is the RMS value, for both current and voltage

IMPLEMENTATION SUBTLETIES AND ERRORS

- The calculated RMS is inaccurate, since the calculation was done on discrete values.
- Analog sampling was chosen since digital sampling yielded a lot of noise in the voltage. However, analog sampling yielded noise in the sampled currents.
- For better precision, multiple phase angles were calculated from the rising and the falling points
- Four capacitors and hence 16 permutations were chosen for better correction.

THANK YOU FOR WATCHING