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# Designing a Smart Device to Optimize Power Consumption

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## *Abstract*

Power factor is one of the important factors in reducing of electricity energy consumption. This factor is less than 1 due to inductor and ohm elements which are used in air conditioners, washing machine, different kind's electromotor, refrigerators and fluorescent lamps. For this reason, reactive current parameter will create. In this paper, a smart device is proposed so that reduces electricity energy consumption in industrial places. This device by removing reactive power and the high frequency harmonics of the network reduce the energy consumption and increase the efficiency of the network.

***Keywords:*** *Energy optimization, Power factor correction, reactive power, analogue cooperator, zero crossing detector circuit.*

## 1. Introduction

Electricity is one of the most important energies which its consumption affects other energies'. A look at energy balance in recent years shows that about 30% of energy consumption in our country belongs to home and public sectors. Numerous reports, including the latest summary of statistical situation of the world's electricity industry show that the world's energy efficiency is very low and in some cases even worrisome. One of the important factors in electrical losses is power factor [1]. In this paper, while expressing the effect of power factor in reducing energy productivity, it is shown how the power factor correction influences on the increase of energy efficiency. Intelligent reactive power optimization devices are example of devices which can improve power efficiency and reduce network losses using the desired and smart increase of power factor. The rest of this paper is structured as follows. In Section 2, power factor and reactive power are defined. Section 3 provides the technical description of the device and Section 4 analyzes experimental results. In the last section conclusion is presented.

## 2. Power factor and Reactive power

In consumers that there is a phase difference between the voltage and current, the power can be positive or negative. It means that either consumer decreases network power or increase it. This led to create reactive power. Since it is not possible to zero the phase difference in these consumers, the result is that the reactive power cannot be eliminated. The power factor in an AC electric system refers to ratio between true power and apparent power and is between 0 and 1. Actually, true power



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represents the ability of a consumer to convert electrical energy to other forms of energy while apparent power is produced by the difference between voltage and current. Depending on the type of charges and the reactive power they have, the apparent power can also be greater than true power [4].

The low power factor (large apparent power versus true power) in a circuit increases the current in the circuit, resulting in higher losses in the circuit.

The reactive power in the network is essential because the nature of work in electronic equipment is reactive power. For example, in an electromotor, electromotor force cannot be generated without reactive power. it can cause harmful effects on your appliances and other motorized loads, as well as your electrical infrastructure. Since the current flowing through your electrical system is higher than that necessary to do the required work, excess power dissipates in the form of heat as the reactive current flows through resistive components like wires, switches and transformer[7].

On the other hand, its presence led to add network current and, as a result, increases the power losses in the wiring path as the heat. In electricity, capacitor and inductor elements create reactive power, so that reactive power can be classified into two types of inductive and capacitive. The reactive power required by the consumer can be supplied from a non-network-based way. To this end, due to the nature of the inductor and the capacitor which are work vice versa, it is enough to use inductive reactive power to reduce capacitive reactive power and vice versa. Since most consumers of network are inductive, this can be achieved using a capacitive bank [2].

It is worth to be noted that reactive power is not calculated in home bills and eliminating this power as well as high-frequency harmonics reduces the current of wires and thus reduces losses in wires.

## 3. Technical description of the device

The device consists of four separate parts:

1- The main processor of STM8 is required to sample the current (Trans-CT) and voltage (Trans-PT) of the network. The processor is an industrial microcontroller resistant against high-noise with a higher accuracy than other microcontrollers such as AVR.

2- Relays which insert or remove capacitors from the power grid.

3- Display to show the cousin angle between current and voltage (COS Ø). This section is only used to inform the user about the phase difference of the network. As the number shown is closer to 99, the network is in a better situation.

The technical description of the device is discussed below. Figures 1 and 2 represent schematic and wiring mode of the circuit respectively.

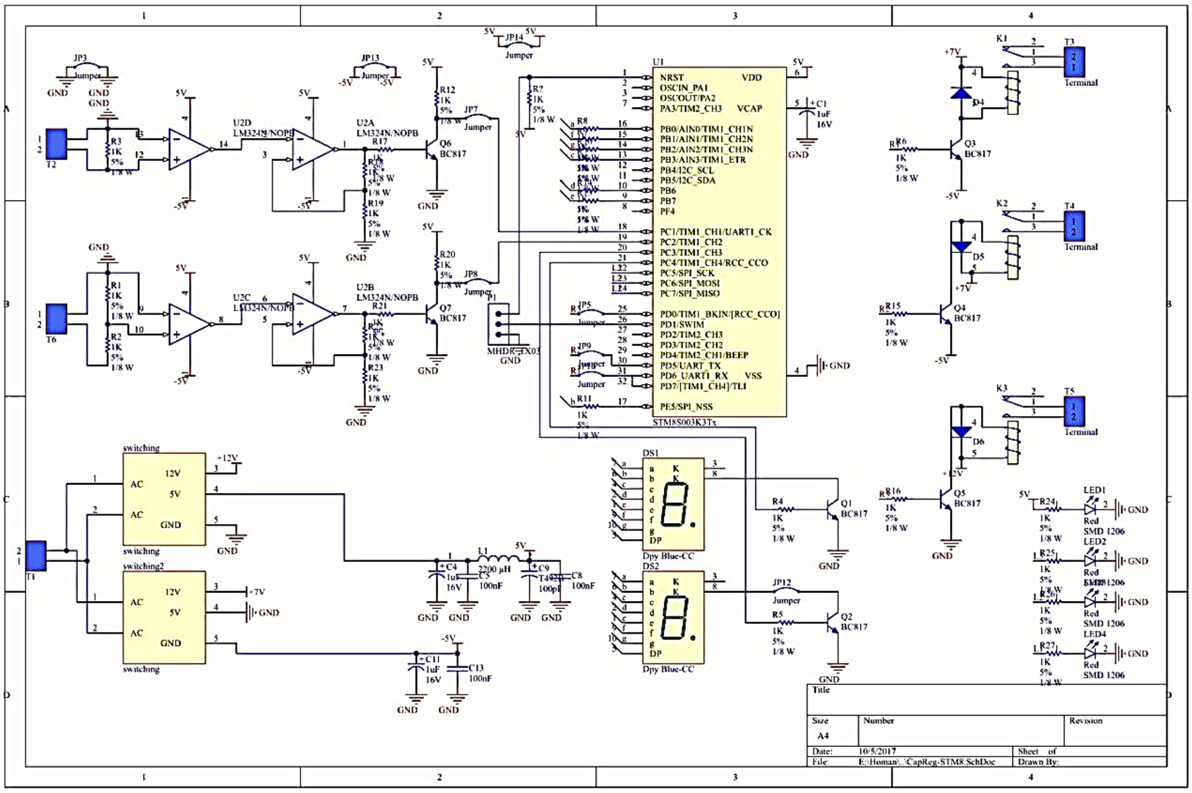


**Fig. 1:** Schematic circuit

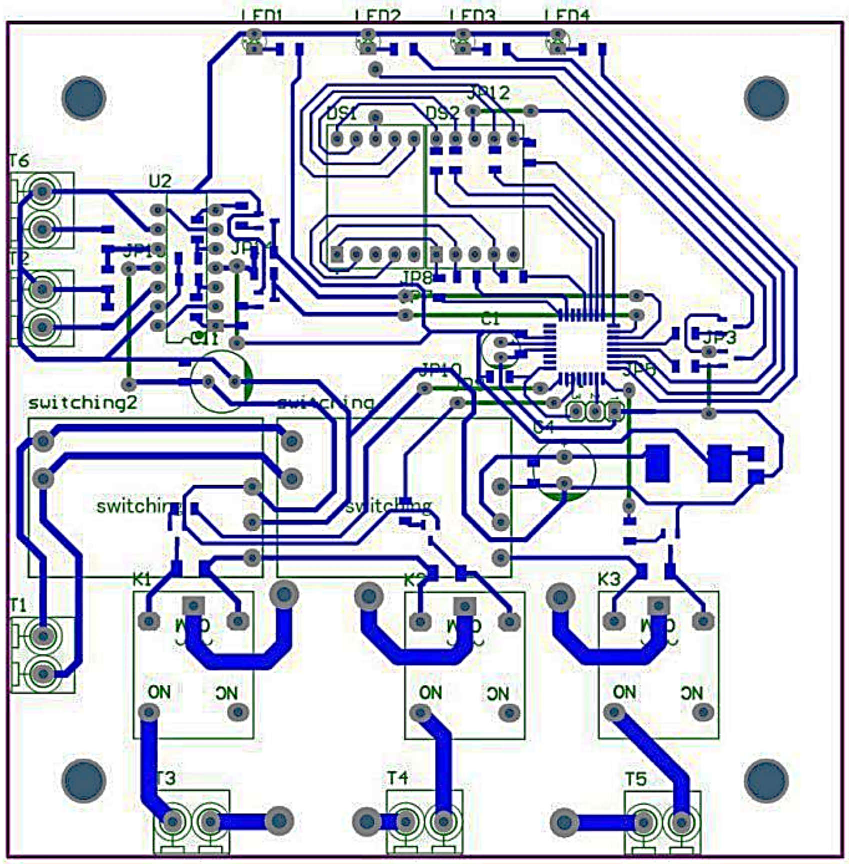


**Fig. 2:** Wired circuit

First, the network power factor is measured. For this purpose, using VT and CT trances, voltage and current of the city are sampled, respectively. The connection of trances of current (CT) and voltage (VT) to the power grid is shown in Fig. 3.

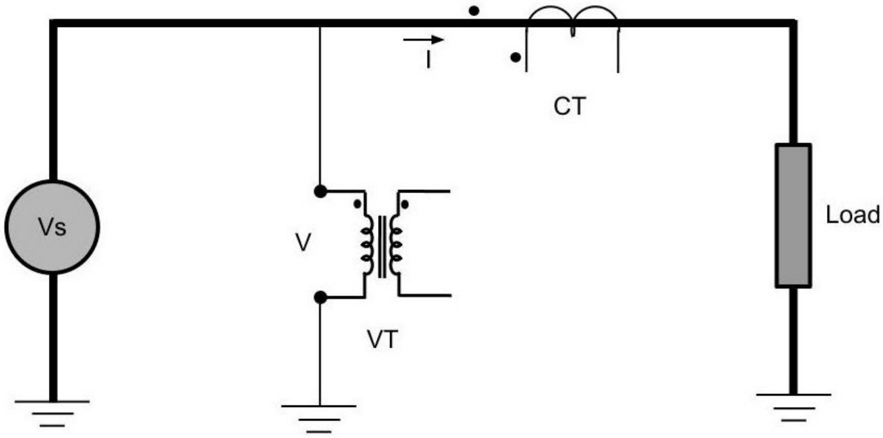
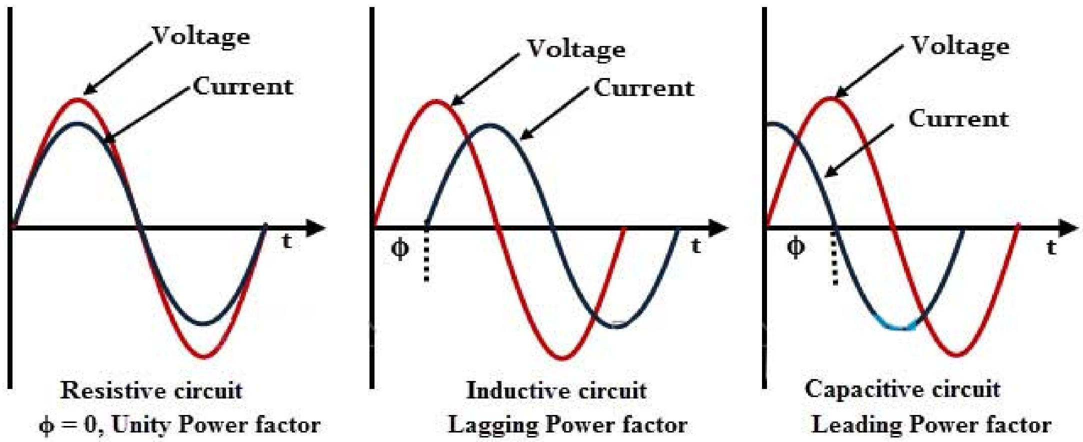



**Fig. 3:** Connection of trances of current (CT) and voltage (VT)

Depends on inductive or capacitive consumers, power grid can be post-phase or pre-phase, respectively, which means that there is an angle between the current and the voltage. The pure resistive load does not create an angle between voltage and current. The waveforms measured in the three pre-phase, post-phase and phase-phase modes are shown in figure 4(a, b, c), respectively. To process these signals, and to obtain the phase difference of the two sampled signals (voltage and current) by the STM8 microcontroller, these signals need to be converted to a square wave without phase (angle) manipulation. To square these signals, a zero-crossing detector circuit is used.




(a) (b) (c)

**Fig. 4:** Waveforms in the three pre-phase, post-phase and phase-phase modes

In this circuit, the LM324 chip is used as an analog comparator that converts the sinusoidal signal into a square wave.

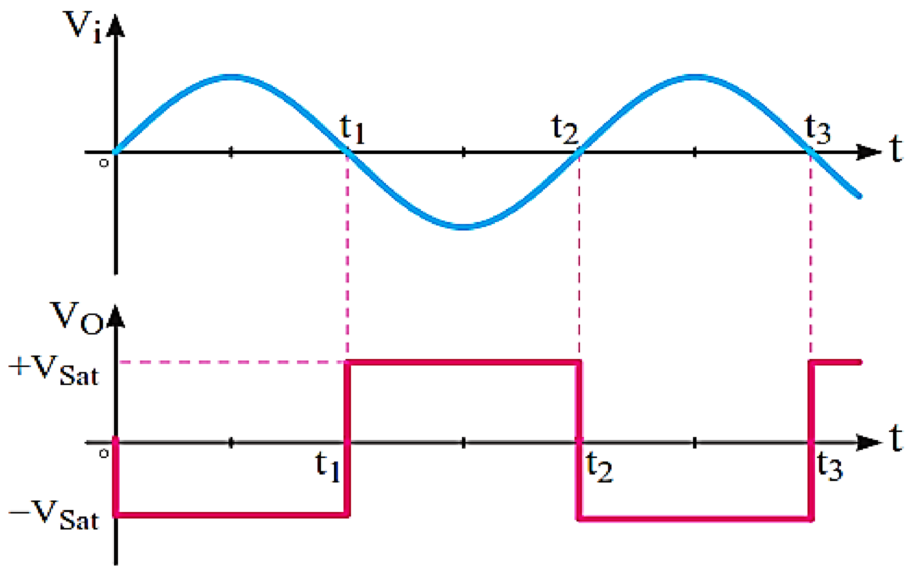



**Fig. 5:** Input and output waveforms

Then, the microcontroller measures the phase difference of two square waves and calculates the power of the network.

Power Factor=COSØ Ø= the angle between current and voltage

The microcontroller displays the amount of power factor by the seven segments that enable the user to view the status of the power grid. The angle between the voltage and the current is due to the presence of inductive loads in the power grid which to remove it, required capacitors should be simply add to the network.

Measured power factor in order to compensate network's post-phase. Therefore, reactive power is generated by inductive loads on the power grid by capacitors. This will reduce the current of wires and thus reduce losses and power consumption.

## 4. Experimental results

In this section, test results are summarized. Table 1 shows the power consumption in kWh for two consecutive years (the first year without power saver device and the second year by installing a power saver). In this table each columns shows power consumption at the end of month for 6 months. As the table shows, the amount of energy consumed using the smart device has dropped by 20%.

**Table 1:** consumption of energy for 60 days in last and current day

| Consumption for 60 days | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Last year | 1193 | 1661 | 1912 | 1785 | 846 | 624 |
| Current year | 975 | 1323 | 1564 | 1425 | 672 | 485 |

One of the advantages of using the optimizer is to reduce the harmonic voltage. The main effect of the harmonics is to warm the motor and transformers temperature, which will shorten their lifetime. If the temperature of the engine is reduced by ten degrees, its lifetime will increase about twice. An optimizer and its capacitor circuits in combination with the resistance of the conductor wires lead to the emergence of a low pass filter which prevents high frequencies move from input source to the load. As a result, it reduces the temperature of the electric motors and increases their lifetime.

## Conclusion

Electricity is one of the most important energies which its consumption affects other energies'. In this paper, a smart device was introduced that can reduce power losses in the network by eliminating reactive power and high-frequency harmonics of network. As a result, energy losses in network reduce and power consumption decreases about 15% to 20%. This decline is most commonly used in industries and public places where high-powered electric motors are available. Another advantage of this device is to reduce voltage harmonics, which can reduce the temperature of motor and transformers and thus increase their lifetime.

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