REACTIVE ELECTRICAL POWER COMPENSATION IN HOUSEHOLD SECTOR

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Abstract. The article presented is devoted to the research of the household sector reactive electrical power compensation. Power factor (PF) is changing the value due to the active and reactive electrical power change. Some of electrical appliances have a very low power factor (about 0.4). Electrical power grid encounters with a noise and fluctuation problems that are caused by reactive electrical power. The research provided shows some reactive electrical power compensation methods and MatLab Simulink example model, which has been made for the research object. Some of the reactive electrical power compensation models need long-term electrical consumption information collection, where the power supplier's company has access to, or the electrical power consumers, who are interested in the electrical power optimization and reactive electrical power compensation. Some of the reactive electrical power methods presented are usable in the all electrical consumer sectors, such as household, industrial, building, producers, selling etc. The article shows the benefits and disadvantages of these methods, what must be evaluated in the reactive electrical power compensation method. The described conclusions show the benefits, what electrical suppliers and total electrical users can gain. As an example, voltage loss decreases by 4 %, or total electrical grid current decreases by 3 % by full reactive electric power compensation, and the transformer load decreases by 5 % at 0.95. The values can change due to the load and the compensation method used.

Keywords: compensation, methods, smart logic, algorithm.

Introduction

According to the Ministry of Economics of Latvia data the household sector covers 24.1 % of the total electrical power consumption of Latvia [1]. If agricultural and boiler electrical consumption (household development is developed there) can be evaluated as the household electrical power consumption, it will gain about 27 % of the electrical power consumption of Latvia. This proportion forces researchers to study this problem in the household sector.

Modern electrical appliances appeared in the electrical appliance market and solving of the reactive electrical power compensation problem becomes more actual [2]. This problem is the cheap China-made electrical appliances (such as cheap LED bulbs), which are provided in the most part of the available electrical appliance markets. Electrical lighting has a big part of electrical power consumption in the household sector, as it can be seen in [3]. Most of the electrical appliances (fans, refrigerators, TV, lighting etc.) do not have only active electrical power character and it is PF, not 1. As the consumer survey shows, consumers try to save money by changing electrical bulbs to power-saving bulbs available in the market [3].

Modern appliances make some voltage noises, what causes voltage fluctuations in the power grid [3], what can be explained by the reactive electrical power disturbance, because active electrical power does not made such noises in the power grid.

PF is the secondary factor, which is linked with reactive electrical power, but shows overall electrical grid state. The most part of electrical appliances available on the market has low PF [4], which buyers and users have no interest in. Electrical appliance market research shows what cheap and low-quality electrical appliances are still available. China-made cheap LED bulbs have such low PF, its value being not greater than 0.4 or even 0.3. They have better price in the market and are more interesting for the buyers than good-quality expensive ones. Modern electrical appliance buyers do not consider such parameters as PF, electrical current etc., such are not even shown on the all electrical appliances (even in the technical documentation).

The power factor research made in the household sector shows that its value is decreasing very fast and becomes less than 0.95 [2]. Modern electrical appliances used in household development decrease the average value by electrical efficient friendly devices bought and used.

Considering the renewable electrical resource usage in Latvia, it shows that they are used more in households, less in the machinery and produce sectors.

Materials and methods

PF change happens in two ways:

1. Natural way – PF change occurs naturally due to the electrical parameter change:
   a. By the opposite nature reactive electrical power connection:

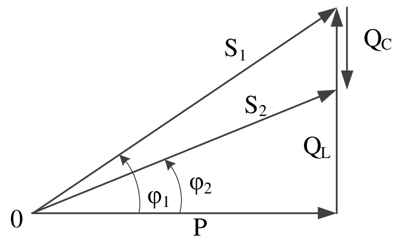

Fig. 1. **Opposite character reactive electrical power connection, vector diagram and PF change**

   b. By the active electrical power increasing.

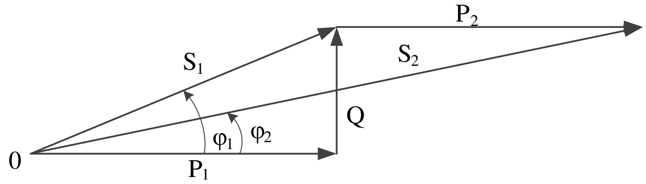

Fig. 2. **PF change by electrical power increasing**

2. Artificial (corrected) way – PF increasing method by connecting reactive power compensation appliances.

- Several reactive electrical power compensation artificial ways were discovered:
- Passive compensation (PasC) – reactive electrical power compensation has been made by connecting one value of the opposite direction reactive to electrical power compensation appliances.
- Active compensation (ActC) – reactive electrical power compensation has been made by connecting some values and steps of the opposite direction to reactive electrical power compensation appliances in different times.
  – Active Time compensation (ATC) – reactive electrical power compensation has been reached by connecting predictable size in predictable time.
  – Smart Logic compensation (SLC) – reactive electrical power compensation has been reached by connecting a special Smart Logic programmable controller that measures and connects the needed opposite reactive electrical power direction compensation powers.
  – Algorithm compensation (AlgC) – reactive electrical power compensation has been reached by connecting predictable size in predictable time by the calculated and predicted algorithm.

Results and discussion

The PF trend [2] found in the research allows to make the MatLab Simulink model (Fig. 3). The model made for this trend allows to predict the PF changes in different periods.

Using this block scheme new reactive electrical power compensation and PF increasing methods can be proved and used. The block scheme allows to build ActC and PasC trends in several periods, if they are known.

By the PF trend analysis across full year, PF is predictable, if electrical appliances and the appliance usage trend have not been changed. Considering the predicted PF trend the MatLab Simulink model has been build (Fig. 4) according to the described block scheme and criteria.

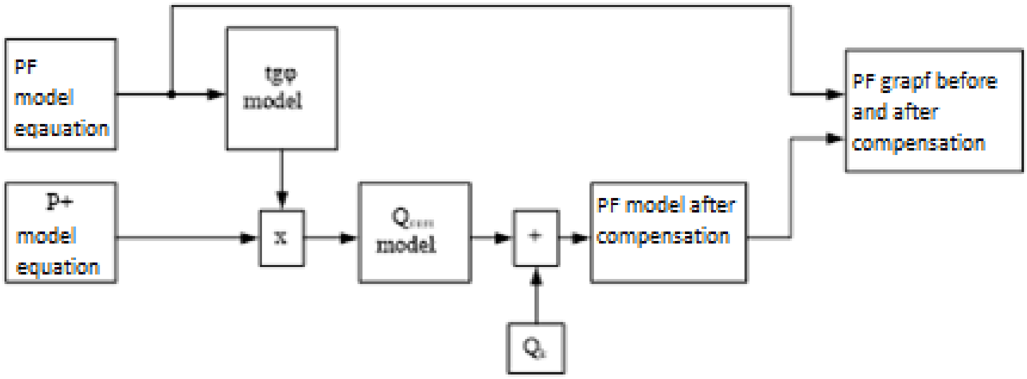

Fig. 3. **MatLab Simulink PF increasing block scheme**

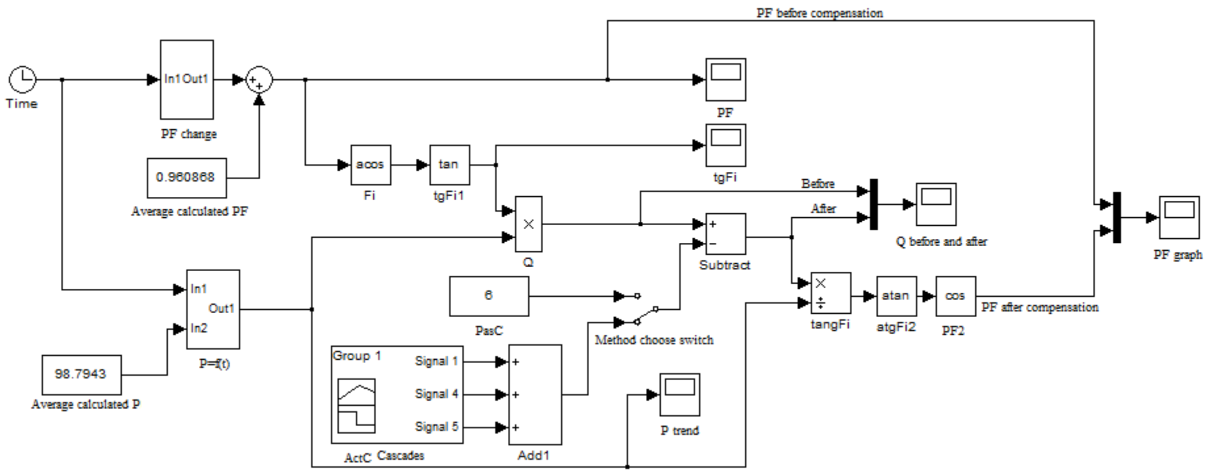

Fig. 4. **Matlab Simulink PF increasing simplified model**

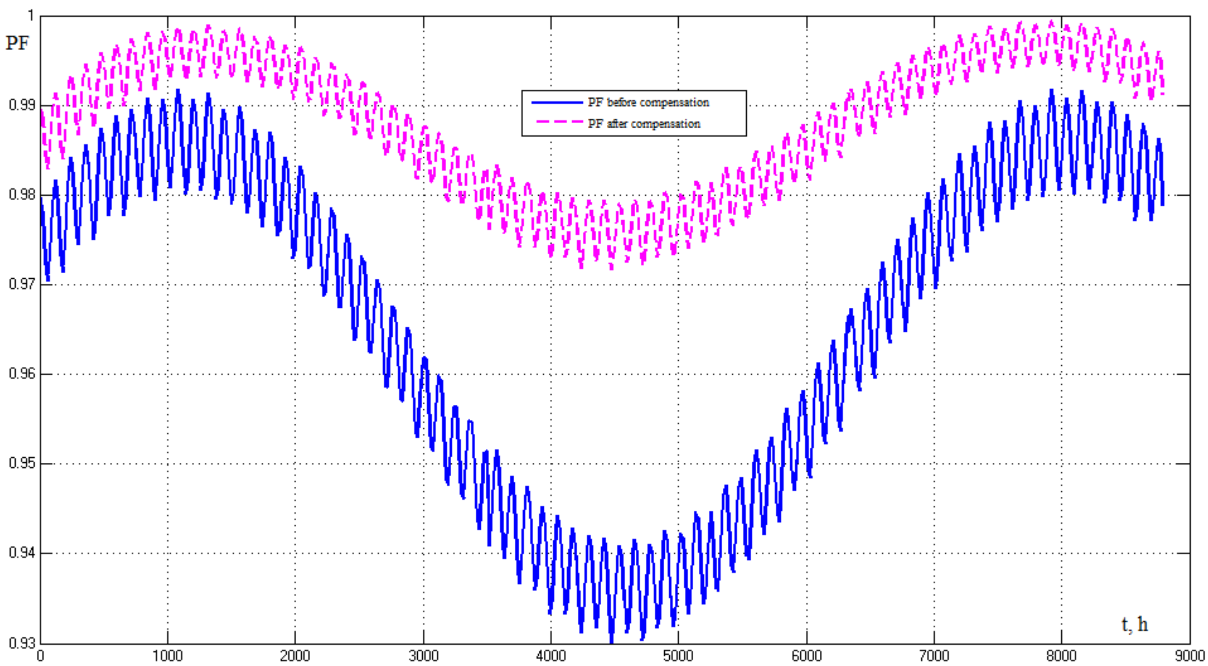

Fig. 3. **Reactive electrical power compensation by PasC**

By the calculation and trend developing the average compensation power has been chosen. By adding the calculated compensation power the PF average value has been increased from 0.965 to 0.990, or by 2.5 %.

It can be seen that compensation is not ideal and needs more proof for the PasC method, so ActC is needed. By the calculation and PasC method observation new compensation powers were chosen and connected to the model in the logical time points. By connecting 1 extra compensation cascade (Fig. 4) better PF has been reached.

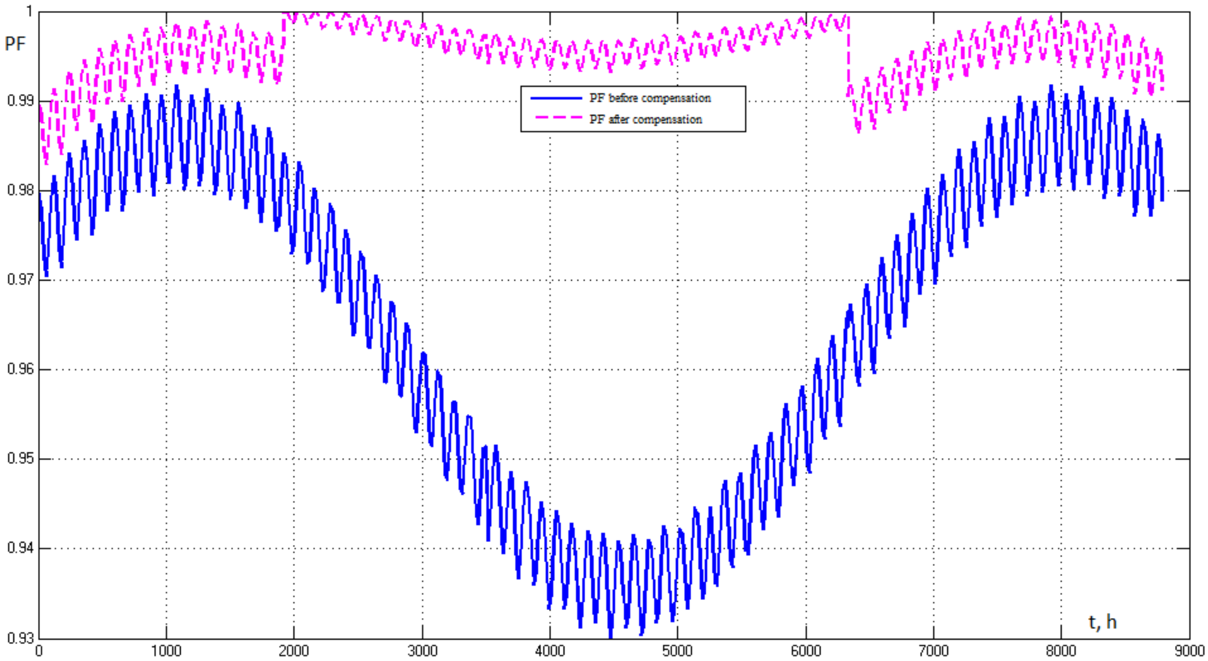

Fig. 4. **ATC by 1 extra compensation cascade connection**

Its values have been increased from average 0.965 to 0.995, it has been improved by 3 %. The ACT method is improved, but by Fig. 4 analysis even the 1 extra cascade method can be improved.

By the previous methods proof of ACT by several cascade connections (Fig. 5) has been discovered.

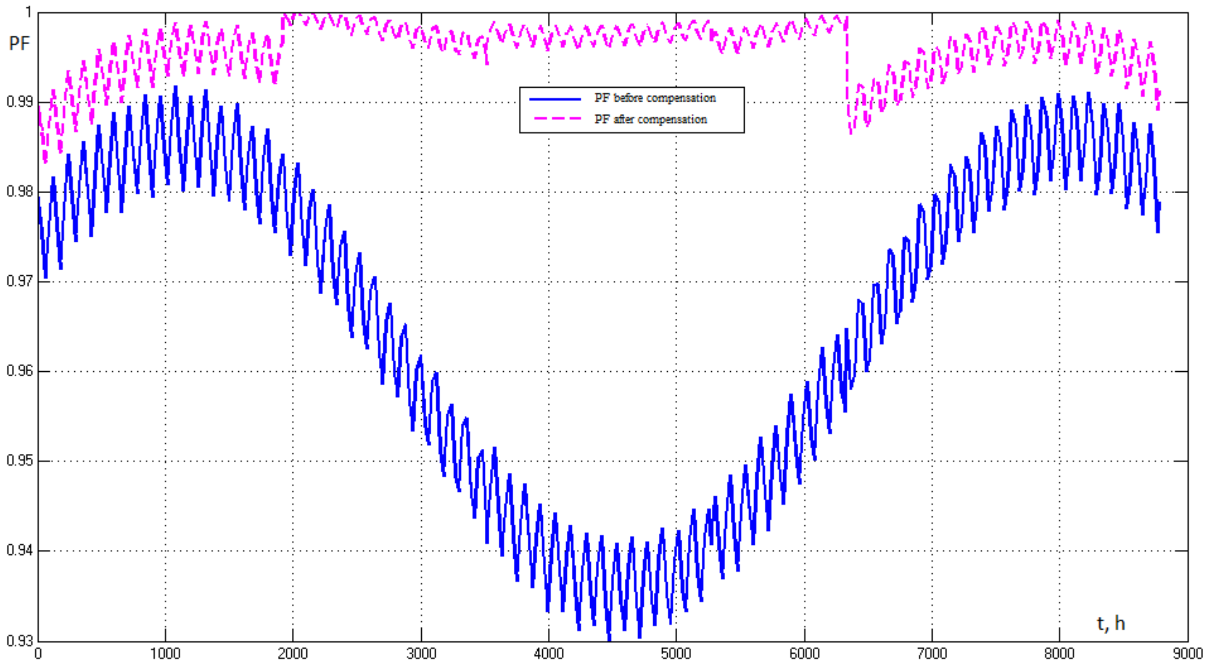

Fig. 5. **ACT by several cascade connection**

The research object PF can been improved from average 0.965 to 0.997, it has been improved by 3.3 %.

The SLC method has not been researched by connecting it to the network, but several producers guarantee that the PF will be increased by installed values in the needed period of time automatically.

Of course, all mentioned methods give PF improvement, when previous reactive electrical powers and their times were known. When their values and times are not known, only PasC can be used making several measurements. And these ACT methods must be described as AlgC.

By the price and needed appliance calculation economical evaluation has been made:

1. For PasC no special appliance needed;
2. For ActC – timers and trend analysis needed;
3. For SLC – special Smart controller.

It can be seen that the special smart controller made a big price difference, and is not needed in household development, because improved PF does not give the price feedback for the Smart controller. Of course, the SLC method is better, because PF=1 can be reached, but it is very expensive.

Some advantages from reactive electrical power compensation can be calculated:

- Voltage losses have been decreased from 19.76 V (4.94 % from allowed 5 %) to 18.98 V (4.75 %), by 0.78 V or decreased by 0.15 %, if reactive electrical power will be compensated till PF = 1. (Discovered voltage loss till 4 % [5]).
- Wire electrical load by electrical current can be reduced from 217 A to 211 A, or by 6 A.
- Transformer load can be calculated and decreased from 630 kVA at PF = 0.95 to about 600 kVA, what allows to connect more consumers.

It is well known that reactive electrical power brings voltage noises and flickers [5; 6], cable heating and contact resource decrease, but it is not calculable.

One of the AlgC difficulties is the long-term analysis, what is needed to understand the reactive electrical power character trend, by appliance work interval detection and understanding. It has been proofed, what reactive electrical power trend has been found [4]. Weather change is predictable and leads to an impact on the electrical appliance usage and on the electrical consumption [7].

If the active and reactive electrical powers are known, all change the trends and can be inserted as the trend in the MatLab model. As an example the Active electrical power trend is taken (Fig. 6).

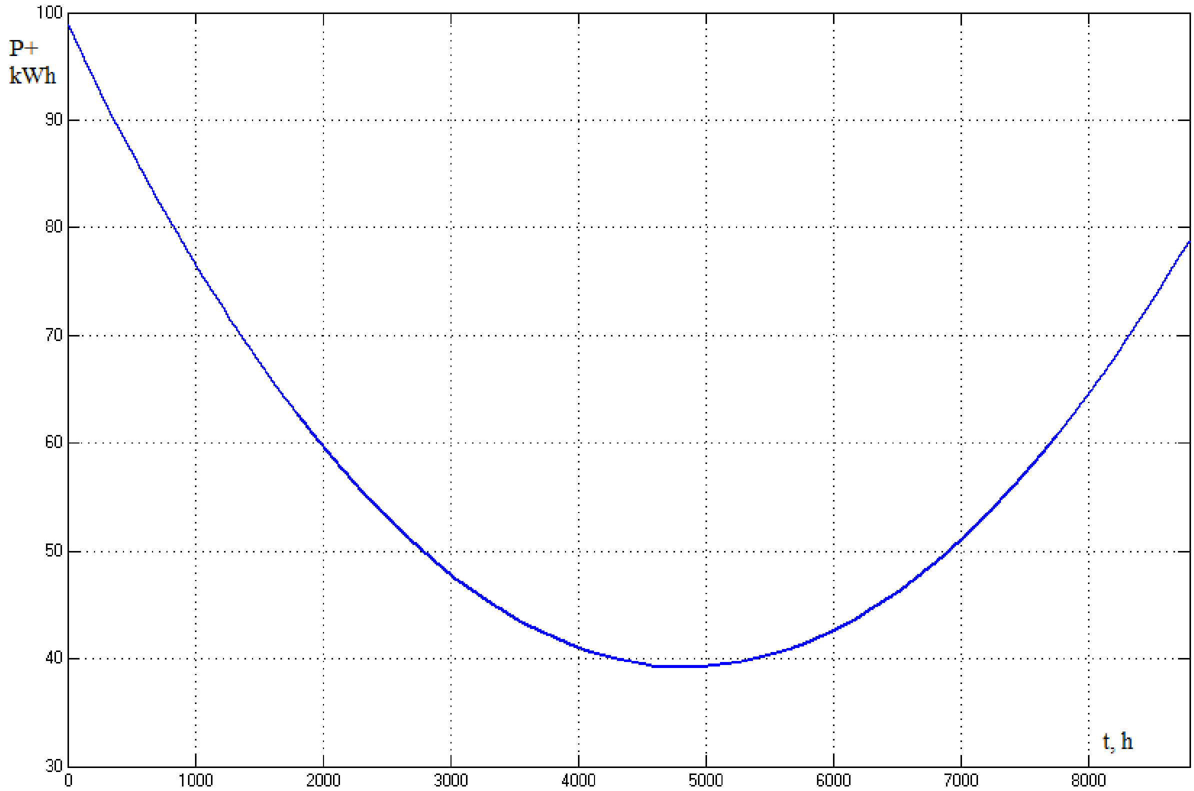

Fig. 6. **Active electrical power trend**

This Active electrical power trend can be inserted in the MatLab model and the PF calculated, what can be reached by the ActC method (Fig. 7).

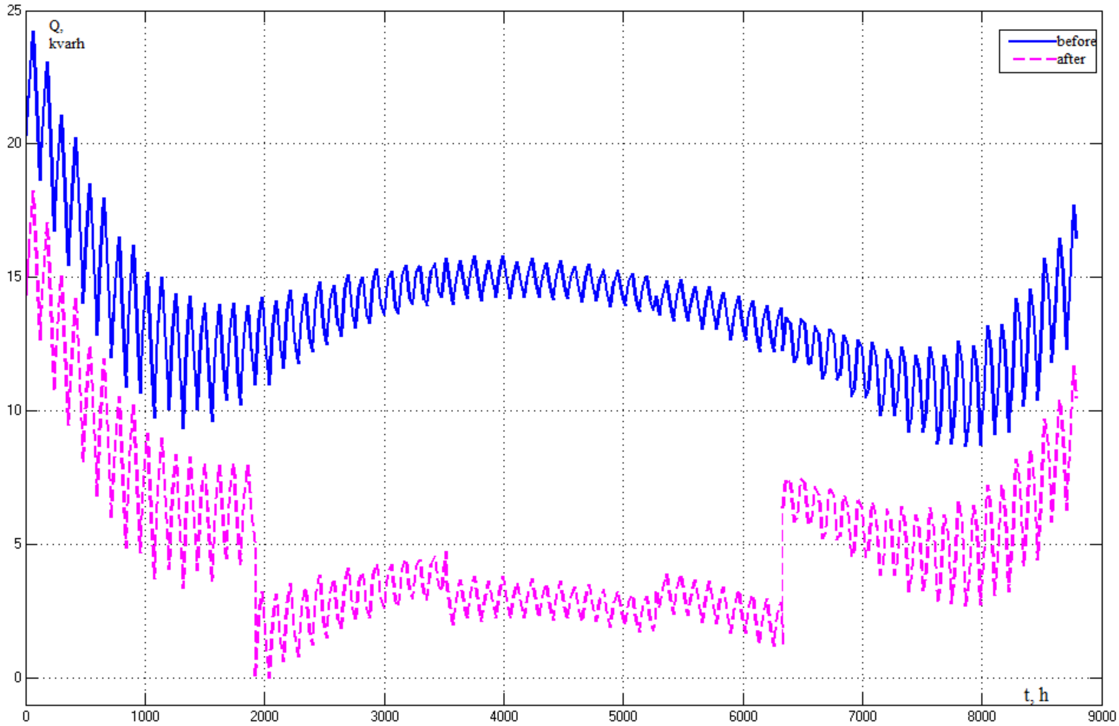

Fig. 7. **Calculated reactive electrical energy in MatLab Simulink by ActC full method**

Conclusions

The provided MatLab Simulink model is usable only for this research object. This research shows that the PF trend is possible to increase and to moderate with reactive electrical power compensators.

Some advantages can be gained by reactive electrical power compensation and by the power factor increase:

1. Voltage losses can be decreased by 4 %, such input voltage increasing on compensation point;
2. Cable cross-section decreases by electrical current decrease by 3 %;
3. Transformer load is decreasing by apparent electrical power decrease (by 5 % at PF = 0.95);
4. Reactive electrical power brought voltage noises and flickers;
5. Cable heating is decreasing by RL electrical energy decrease;
6. Connection device and appliance contact resource is increasing by RC electrical energy decrease.

References

1. Ministry of Economics of the Republic of Latvia. Latvian energy in figures. Ministry of Economics of the Republic of Latvia, Riga, 2013.
2. Jakusenoks A., Laizans A.. Household electric power supply grid power factor trends. 14th International Scientific Conference Engineering for rural development 2015, 2015, pp. 355-360.
3. Esa N.F., Abdullah M.P., Hassan M.Y. A review disaggregation method in Non-intrusive Appliance Load Monitoring. Renew. Sustain. Energy Rev., vol. 66, pp. 163-173, 2016.
4. Jakusenoks A., Laizans A.. Impact of household electric energy usage trends on electrical power supply net power factor. Research for Rural Development 2015, 2015, pp. 253-257.
5. Department of Energy. Application of Automated Controls for Voltage and Reactive Power Management – Initial Results, 2012.
6. Make the most of your energy SM AccuSine Harmonic filtering and reactive power compensation.
7. Jakusenoks A., Laizans A. Weather impact on the household electricity consumption. Research for Rural Development 2016, 2016, pp. 248-253.