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EFFECTS OF HARMONICS IN ELECTRIC POWER SYSTEMS AND SOLUTION METHODS

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ABSTRACT
In electrical power systems, the periodic and steady state disturbances of the current and voltage in wave form are called harmonics. Due to the symmetrical structure of the sinusoidal wave in power systems, single harmonic components such as 3, 5 and 7 are formed. The presence of harmonic current and voltage in the electrical power system causes the sinusoidal wave to be disturbed. The harmonic currents flowing from the mains generate negative effects on the devices connected to the grid and impair the quality of the energy. Especially with the harmonics they produce, the loads that disrupt the energy quality; Switchable power supplies are lighting elements, transformers, generators, converters and arc furnaces operating in accordance with the principle of gas discharge. Adverse effects caused by harmonics; overloading of the compensation systems, overheating of the transformers, decreasing of the voltage values and consequently increasing the losses, deterioration of the insulation levels of the devices and the malfunction of microprocessors can be listed. One of the effective methods used to eliminate the effects of harmonics is to use a harmonic filter.

KEY WORDS: Harmonic filters, power systems, energy quality

INTRODUCTION
The concept of reliable and high quality energy has emerged as a result of technological developments. New electrical loads are being connected to the electrical systems used today. These added loads cause densities in the energy transmission lines. Due to these loads, it causes serious damage to devices and loads in electrical energy systems. Overloads reduce the life of the devices and cause the consumer to use poor quality energy [1].
The most important condition of power quality in electrical power systems; The system is fast, safe and efficient operation. Harmonics caused by non-linear loads in the system have negative effects especially on energy quality. The factors that distort current and voltage shapes in electrical power systems are called harmonics. Current and voltage waveforms; It consists of both non-linear loads used in industry (power electronics elements, arc furnaces, etc.) and the sum of the fundamental sinusoidal wave and other harmonic waves whose frequency and amplitude have different frequency and amplitude. The size of the harmonics in power systems was limited to only transformers, motors and rectifiers in the early 1920s, but a significant increase in the size of harmonics was observed with the increasing technology used in the industry with the development of power electronics elements. With the use of modern and sensitive loads in the production processes, harmonics have become a more serious problem and have become an important topic in which studies are concentrated [2].
Harmonics that occur in power systems cause the devices to work incorrectly or not at all, overheating of transformers and motors, interferences in communication lines, incorrect measurements, decreasing the life of electrical devices and increasing the power losses of the receivers and systems.

THE STUDY
According to the results of the theoretical and practical researches conducted for the last 50 years; harmonic sources can be analyzed in two groups as classical harmonic sources and new harmonic sources that may occur in the future [3].

CLASSICAL HARMONIC SOURCES:
- Harmonics of teeth and grooves in electrical machines
- Harmonics of reluctance changes in air gap in synchronous pole machines

- Harmonics of the air space rotary field of synchronous machines
- Magnetizing currents of transformers operating in saturation zone
- Nonlinear loads in the network; rectifiers, inverters, welding machines, arc furnaces, voltage regulators, frequency inverters, etc.

NEW HARMONIC SOURCES:

- Engine speed control devices,
- Energy transfer with direct current (HVDC),
- Static VAR generators,
- Uninterruptible power supplies,
- Expansion of electric vehicles in the future and their effects on battery charging circuits,
- Devices and methods used for energy saving,
- The motors fed by the direct frequency inverter have large speed and small torque.

THE MOST IMPORTANT ELEMENTS CAUSING HARMONIC GENERATION ARE AS FOLLOWS:

- Transformers
- Rotary machines
- Power electronics components
- Energy transfer with direct current (HVDC)
- Static VAR generators
- Arc furnaces
- Uninterruptible power supplies
- Gas discharge lighting
- Electronic ballasts
- Photovoltaic systems
- Computers

2.1 Effects of harmonics on electrical systems

Harmonics that occur in the power system affect both the elements connected to the system and the power system in a negative way. As a result of the disturbing effects of harmonics, the nonsuidal waveform created by voltage and current causes a wide variety of problems.

The negative effects observed in energy systems as a result of the effect of harmonics are as follows [4]:

- Overheating of transformers
- Increased voltage drop
- Increase in energy consumption
- Heating problem in devices
- Waveform deterioration of generator and mains voltage
- Over reactive load in compensation systems
- Formation of torque oscillations and overheating in rotating machines
- Interference in audio and video systems
- Change in power factor
- Resonance events occurring in the network, resonance induced overvoltage and current effect

2.2 Methods of Eliminating Harmonics

Harmonics that have negative effects on electrical energy systems must be eliminated or rendered harmless. There are two different methods for this. The first is that during the production of harmonic generating elements, the structure is designed to produce little or no harmonic generation or proper connection to the network. This method can be called as measures that can be taken during the design. The second method is to eliminate the harmonics after they are produced. This method is called the filtering of harmonics [5]. Harmonic filters are divided into active and passive:

2.2.1 Active Filters

Although the investment cost of active filters is higher than passive filters, it is inevitable to use them in some systems. Passive filters are determined according to a certain distribution power, that is, if the power of the system increases, passive filters become useless. It is also very difficult to include passive filters in the system. Compared to these negative aspects of passive filters, active filters are capable of eliminating the harmonic problem due to their ability to adjust for more than one harmonic frequency. In addition, the most important feature of active filters; Despite the changes made in the existing distribution system is to continue harmonic compensation.

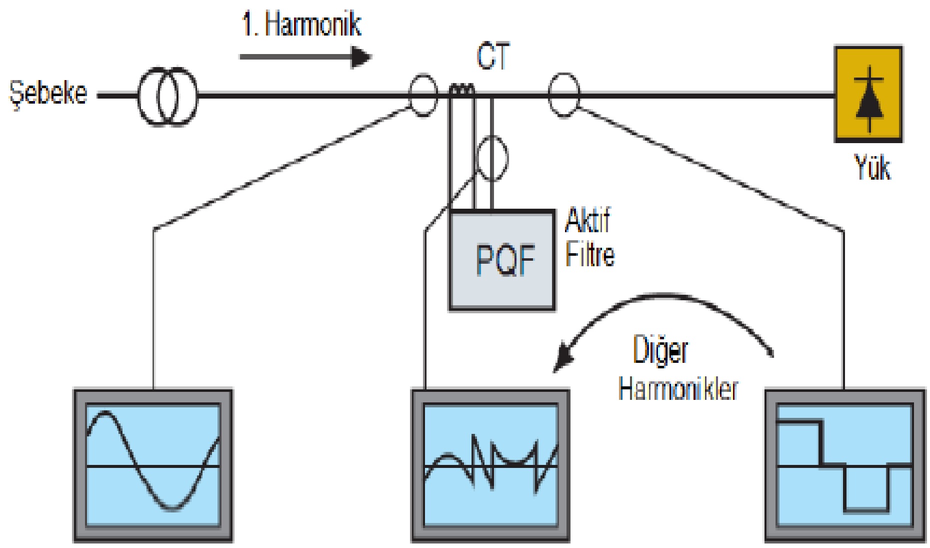

Fig. 1 Operating principle of active harmonic filter [6]

2.2.2 Passive Filters

Passive filters are circuits consisting of capacitor (C), inductance (L) and in some cases resistance (R) elements, which are placed between the source and the receiver and designed to destroy components other than the basic frequency. Passive filters are divided into series passive filters and parallel passive filters [7]:

2.2.2.1 Series Passive Filters

In series passive filters application; Used in front of AC motor drive circuits and high power AC / DC inverters. An example of a series passive filter is shown in Fig. 2.

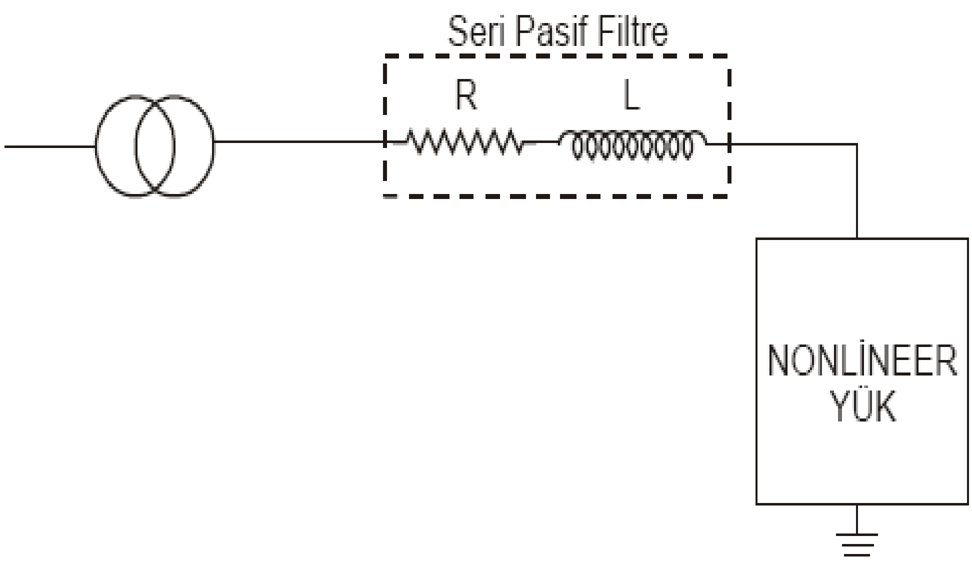

Fig. 2 Series Passive Filter

The biggest difficulty in the application of series filters is that the entire load current passes over the filter and the filter is made according to the full line voltage and even causes a voltage drop.

2.2.2.2 Parallel Passive Filters

Parallel passive filters are the circuits consisting of connecting capacitor (C), inductance (L) and resistance (R) elements in parallel between the harmonic source and the mains. An example of a parallel passive filter is shown in Figure 3.

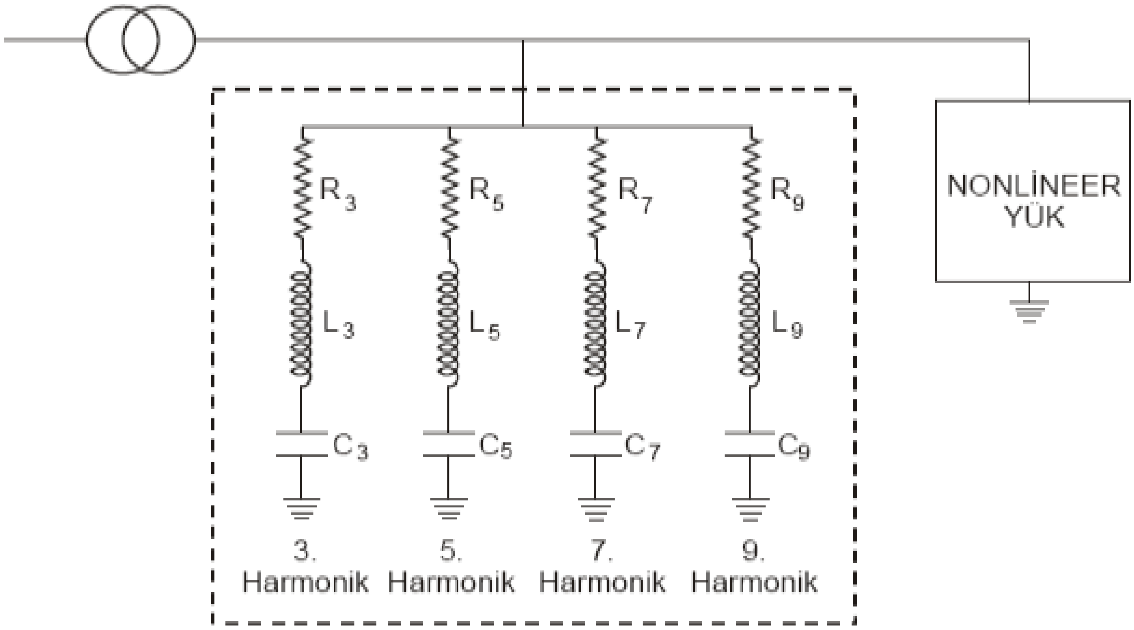

Fig. 3 Parallel Passive Filter

CONCLUSION

Problems caused by current and voltage harmonics in transmission and distribution systems are becoming more and more important. The most important disadvantages of passive filters used in solving these problems are; Although their economic performance depends on the network parameters and cause resonance events. Active power filters, another solution method, offer a lot of opportunities to improve the power quality. Nowadays, the increase in the use of loads sensitive to power quality and developments in power electronics have increased the interest in active solution methods and enabled active power filters to be ready for use as final products.

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