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Proposed Model of DSTATCOM Using Modified SVPWM

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ABSTRACT: As the power electronics achieving new miles day by day in the era of energy with emergence of less power consumption and high reliability devices, FACTS devices came out as a ray of light in the power industry. Since the emergence of FACTS devices power controlling becomes easier and devices become simple as well as lighter in weight. In this paper we have proposed a new DSTATCOM using modified SVPWM technique. The previous DSTATCOM are basically controlled by PWM, or SPWM technique which produce high harmonics distortion but using SVPWM technique distortion reduces up to some extent. In our design we also have considered the losses due to DSTATCOM when connected in the distribution system. All the design and simulink work has been completed in Matlab for the system and simulation results shows that designed system is able to recover the drop in bus voltage when any loading effect occur, but due to 5^{th} harmonic performance of DSTATCOM degrades somewhere. Some suggestion are given to improve the quality of it.

KEYWORDS: DSTATCOM, FACTS, VCI, SVPWM, THD

I. INTRODUCTION

Ever since the discovery of a shuttle system for the production and transmission of electricity power was on its improvement. The first step is the use of any power transformer, which enabled increasing the voltage level, and also increasing the distance at which electricity can be transmitted. Today's power systems are complex networks with hundreds of generator and consumer nodes, interconnected transmission lines [1].The main purpose of the system is to supplying consumer noblest aspect of energy electricity which is reliable and quality Power.

Reliability is defined as a measure continuity of electricity supply. In recent times, there is the concept of power quality, which is development of systems and new technologies become a significant factor. Simply put, quality of electrical energy is a measure of similarity between sinusoidal voltages (current) at the ends of the consumers. To meet the demands of consumers, the system begins to use the new devices that can influence the increase in quality of electricity. For full filling these demands in early days we use synchronous compensators, which are used for reactive power compensation. Sometime later, there was a need for devices have a faster response. The development of power electronics in power system introduced more FACTS (Flexible Alternating Current Transmission Systems) devices. Such as their name suggests, these devices are intended for use in notebook networks. It seems to them a multitude of different devices, based on the work of the inverter power electronics (rectifiers, inverters, back-to-back1 converter) combined with static components such as batteries, capacitors and inductors. Their primary goal is reactive power compensation, voltage correction, the correction factor power, voltage filtering and so on.

One of the many FACTS devices is STATCOM (Static Compensator). The primary purpose was to compensate power at appropriate bus bars in the transmission subsystem. The main disadvantage of the classical Reactive power is that the increase in voltage above the nominal value, in system injects more reactive power, which is paradoxical. Using STATCOM this problem is overcome by using a control system which operated circuit breaker in the power electronic converter in a way that the system still injects the required amount of reactive power, or to the system absorbs excess reactive energy.

Over time, the use of FACTS devices includes leaving the transmission subsystem and extends to the distribution subsystem. Thus, the distribution subsystem, the model of STATCOM appears similar device called DSTATCOM (Eng. Distribution Static Compensator). Although they use the same topology, but have different use. DSTATCOM has

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much wider range of applications relating to the compensation of consumption, repair power factor, voltage filtering, balancing spending and so on. This paper describes DSTATCOM, the basic working principle, Commanding algorithm and scope, and will be a simulation in MATLAB try to confirm the theoretical considerations.

II. DSTATCOM AND ITS WORKING PRINCIPLE

DSTATCOM the in the distribution the network can perform a number of functions in terms of improving quality electricity that is delivered to the consumer. Their operation is based on the principle the use of power electronic converters. In this regard, largely determined by and its topology, shown in Figure 2.1.

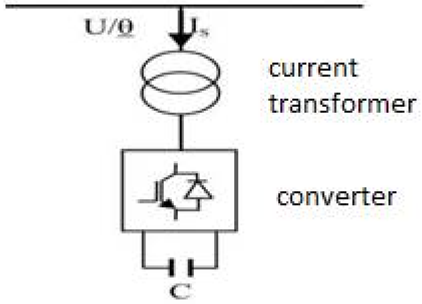

Fig. 2.1 - Topology distribution static compensator

As with Figure 2.1 can be noticed, drive through coupling transformer connects to the distribution hub. It often is used to filter inverter output in order to reduce the impact of higher harmonics on the voltage and current in the network. At the other end of the inverter is connected to a capacitor that provides reactive power that injected into the network. The inverter allows the capacitor full or empty, depending on the required operating mode.

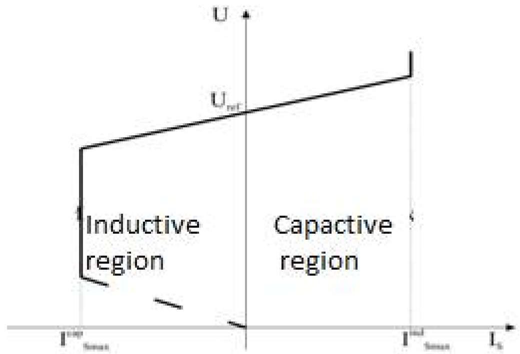

Fig. 2.2-a characteristic DSTATCOM

Using the given characteristic in Figure 2.2 can be simply described the way DSTATCOM's works. Specifically, when a voltage equal to the reference voltage U DSTATCOM-a Uref, then the current Is becomes zero. This means that there is no exchange of energy between DSTATCOM and the network, because the voltage is equal to reference. Assume that the voltage in the grid rises above the reference value. In this case, the current Is will be positive, as adopted by the reference direction in the figure 2.1 which means that the current flowing to the battery capacitor, or DSTATCOM works in inductive mode and is trying to return the voltage to a reference value. In the second case, if the supply voltage falls below the reference value, which is more often, current Is has a negative sign, so that it flows from the battery to the capacitor network. This means that the network inject reactive power in order to raise the voltage benchmark. Part of the characteristics corresponding to the capacitive mode is also linear up to the breaking point, which is determined by the maximum current (I_{CAP} $Smax$), or reactive power by battery capacitors can give. In this case, the goal is that, regardless of the the size of the collapse or increase mains

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voltage, the voltage on the buses keep constant. In order to achieve this, a more complex control system, in charge of appropriately managed switches in the inverter power electronics, so to the bus bars always, when possible, give constant voltage.

III. APPLICATION OF SPACE VECTOR MODULATION VOLTAGE MANAGEMENT DSTATCOM

SVPWM modulator is that based on the reference voltage in the αβ-coordinate system which generates control impulses that lead to the base of transistor in control bridge and thereby generates torfazni symmetrical voltage system. Reference can simply is a sine wave of the desired amplitude, frequency and initial phase. Then, from such references simply applying Klarkine transformation gets a reference to αβ- domain. So, all that is needed to generate the output voltage is prostoperiodičan reference amplitude value (effective value) and the initial phase of the desired napona. Reference amplitude (rms) is data that is set externally. This is essentially a rated voltage bus that is connected DSTATCOM. Reference phase signal can be obtained using the PI controller. The PI controller introduces the difference normalized rms values, reference voltage and measured voltage phase A. The output of the PI controller is the value of phase which will be used to generate the sine reference signal.
The only outstanding issue is at what point DSTATCOM need to go to work. Of course, in order to answer this question it is necessary to first define the segment improving the quality of electricity is DSTATCOM charge. Suppose in this case it is necessary to maintain a constant voltage on the buses osjetiljivih consumers. In this case, DSTATCOM become operational when the detected voltage drops bus bars. For this purpose there are already constructed electronic circuits used and in relay protection.
Length of work DSTATCOM's, in the event of a failure of rehabilitation, not should not be more than 30 periods of 50 [Hz] signal is reflected in the definition of collapse voltage. The DSTATCOM is primarily intended for the rehabilitation of a voltage dip. Ruin voltage (Voltage sag), according to the IEEE 1159-1995 is defined as a voltage which is typically equal to the amplitude of 10% to 90% of nominal voltage, the amplitude and duration this voltage is typically from 0.5 to 30 periods of the signal frequency of 50 [Hz].

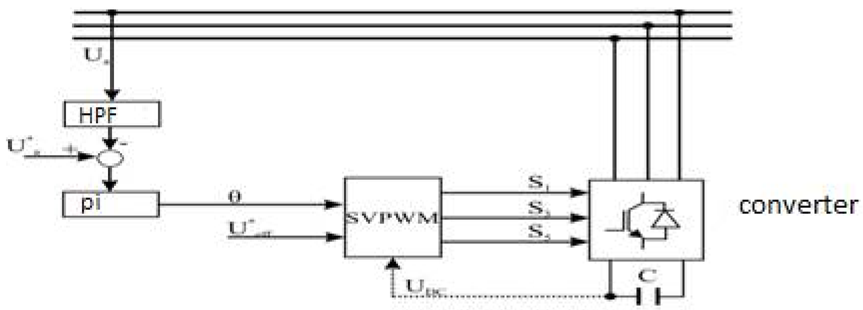

Fig. 3.1 - Block diagram of the control system with SVPWM

IV. MODIFICATION OF SVPWM ALGORITHM FOR USE IN THE MANAGEMENT DSTATCOM INFECTION

The previous SVPWM algorithm used are complex and were intended for sophisticated management of asynchronous machines. It is demand of time to simplify the algorithm as much as possible to make it possible to be performed and the simpler hardware (microcontroller). Keeping the main goal in mind, algorithm is designed so, that nothing essential cannot be changed. The main changes that can be made is to not let the reference poly phasor goes through all sectors because it takes a lot of processing time and slows down the performance of the algorithm. It is enough that the current phase of the reference poly phasor reduced to the first sector, and to poly phasor still observed only in the first sector. it then implies that simplifies the equation for calculating the time of application Reference poly phasor given as

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$$T_a = \frac{\sqrt{3}}{\pi} m T_s \sin\left(k\frac{\pi}{3} - \theta\right)$$

$$T_b = \frac{\sqrt{3}}{\pi} m T_s \cos\left(\theta - (k-1)\frac{\pi}{3}\right)$$

Other simplification means that the budget is done at periodic PWM and not in the half-period. In this way we can get half the equation for the budget. The reason for this simplification is that the algorithm for precise management of asynchronous machines may not literally be applied to DSTATCOM's. It can be said that DSTATCOM does not require so much precision. When you combine these two mentioned simplification, then we get.

$$T_a = \frac{\sqrt{3}U^{*}T_s}{U_{DC}} \sin\left(\frac{\pi}{3} - \theta\right)$$

$$T_b = \frac{\sqrt{3}U^{*}T_s}{U_{DC}} \cos(\theta)$$

$$T_0 = T_s - T_a - T_b$$

V. PRACTICAL SET UP FOR TRANSMISSION OF ELECTRICAL POWER WITH DSTATCOM

To perform a simulation on a computer, it is necessary, among other things, to know the exact parameters that will be used in the simulation. This includes the value of voltage, current, capacitance of the capacitor battery, and the value element filter. The parameters are determined on the basis of known size, or on the basis of the size of which is obtained by calculating.

First of all, a brief description will be given part of the system on which the simulation work done DSTATCOM-a. Based on the known parameters of the network, it is possible to determine some of the size required for dimensioning DSTATCOM-a.

In order to minimize strain on the MATLAB simulation, the system performance that is seen is quite simplified. This implies that it is not used coupling transformer, and that is seen only one part of the distribution system and to a voltage of 0.4 [kV].

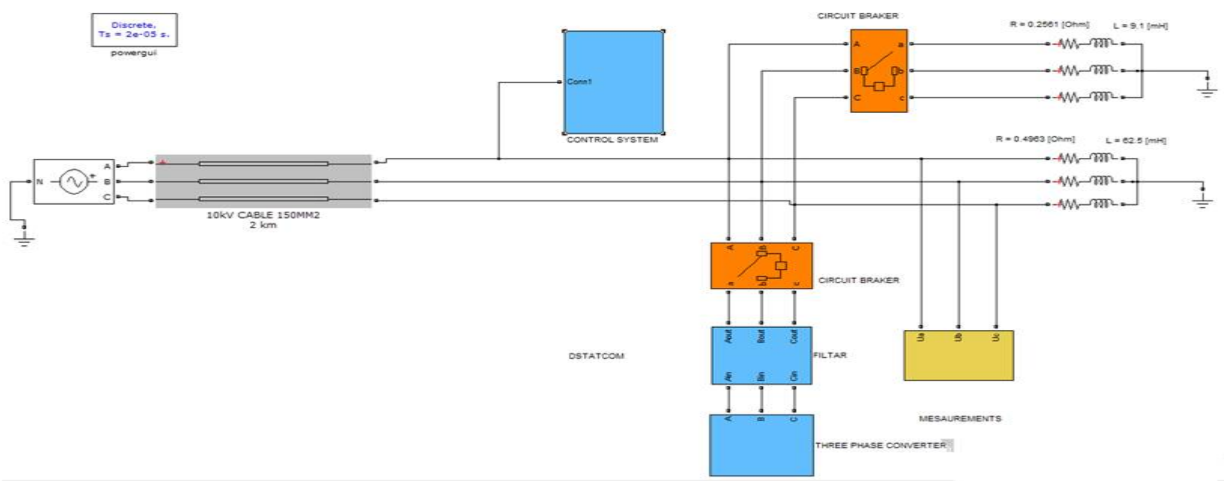

Fig. 5.1- The network configuration used in the simulation

It is assumed that this part of the network is powered by the secondary distribution transformers. At the same bus is connected to a sensitive consumer and consumer group that has a difficult start. These may be, for example, asynchronous motors. At the time t = 0.1 [s] closes the switch, which these consumers are connected to the network. This only simulates engaging consumers, who at the start have a high starting current value. This causes the collapse of the voltage to 0.7 [r.j.]. The moment we engage consumers to the network, and includes DSTATCOM which compensates for voltage collapse and improve voltage profile in the network. Chosen to collapse takes 0.2 [s].

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VI. SIMULATION RESULTS

Upon simulating the presented distribution system some interesting results coming out which are briefly explained in this section. With the help of ideal voltage generator electrical energy is transmitted through a secondary distribution transformer having rated voltage of 0.4 [kV]. The energy is transferred to the observed consumer via cable section of 150 [mm^2], a distance of 3.5 [km]. On the same bus two consumers R1, R2 are connected. Consumer (R1) requires constant voltage at the ends and the consumer (R2) has a difficult start. DSTATCOM, whose task is to maintain a constant voltage during start consumer R2. It is taken that the inclusion of consumers R2 on the network occurs at time t = 0.1s, and start takes about 0.2 s. The parameters of the elements of the system are given in Table 6.1.

Table 6.1- The parameters used for the simulation

Parameter	Value
Consumer R1	R = 0.4963 [Ω]; L = 62.5 [mH]
Consumer R2	R = 0.2561 [Ω]; L = 9.1 [mH]
Portable water	r = 0.4 [Ω / km]; l = 0.636 [H / km]; d = 2 [km]
DSTATCOM	C = 750 [μF]
Filter	R = 1.1 [Ω]; L = 680 [MH]; C = 680 [μF]
Frequency PWM	fs = 3 [kHz]

We will observe the first normalized value of the effective value of the voltage on buses when DSTATCOM not connected to the bus. From Figure 6.1 it is very much evident that the voltage is maintained at a value of perceptual = approximately 0.96 V. As the time t = 0.1s occurs R2 engages the network, and bus voltage drops to the 0.7 V for about 0.2s. So for the time interval between 0.1s to 0.3s voltage collapses to 0.7 V.
From Figure 6.2 it can be seen that the moments when connection and disconnection of consumers R2 occur, higher harmonics (especially the third and fifth) enters in the network, which results collapse of voltage for a period of about 0.2 s.
In Figure 6.3 it can be seen that the voltage to consumers now held all the time at approximately constant value 0.94V. In times of change of switching state switch which simulates engaging consumers R2 and DSTATCOM the Network occurs small collapse voltage at approximately 0.85 V But this collapse takes only 0.02s. It should be noted that is approximated by the effective voltage value shown in Figure 6.3 includes a sum the effective value of the initial, third and fifth harmonic voltage observed. It turns out that these harmonics injected into the network and that their actions affect the total energy that is delivered to the consumer.
Figure 6.4 shows the waveform of the phase voltage in the case where the DSTATCOM included for the purpose of rehabilitation of voltage drop on the buses. It can be seen that for the duration of the malfunction, the voltage is not sinusoidal, but there is little distortion, which are the result of higher harmonics which originates from power electronic converters.
Figure 6.5 showing that in addition to the main balance significantly expressed and third, fifth and seventh harmonic. It can be seen that fifth harmonic carries significant power. In addition, the estimated THD is only 5.87 [%], which is an acceptable value.
From Figure 6.6 it can be seen that when the DSTATCOM-a-way capacitor voltage is maintained approximately constant at a value of approximately 500 [V]. Speed establishing AC voltage is satisfactory and is approximately 0.02 [s]. it is exactly the time that is obtained by a slight decline of phase voltage at the time of inclusion DSTATCOM times.

VII. CONCLUSION

From the above results some conclusion can be drawn about presented work is that, although intended work is in direction to improve power quality DSTATCOM performs a dual function in this regards. On the one hand, it improves the quality of power delivered to the consumer by improving voltage conditions. However, on the other hand, by injecting higher harmonics in the network it affects the degradation of power quality. So it is not easy making a device

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that will be carried out simultaneously repair more quality indicators electricity without reducing some of them. As the presented DSTATCOM utilizing SVPWM, so it gives greater utilization of AC voltage source [6], which is very important in this case.
It means to couple the capacitor capacitance, therefore less expensive, can be achieved is equal impact in terms of effects on the improvement of voltage conditions in the network.
However, the negative side of SVPWM algorithm is that it requires complicated hardware on which will run the main program, and in addition this algorithm is complicated and prone to errors. To execute the algorithm SVPWM it is necessary to use a digital signal processor, which is more expensive than classic microcontroller. This paper is only an introduction to the possibilities for development of the algorithm on SVPWM field management devices to improve power quality in the network.

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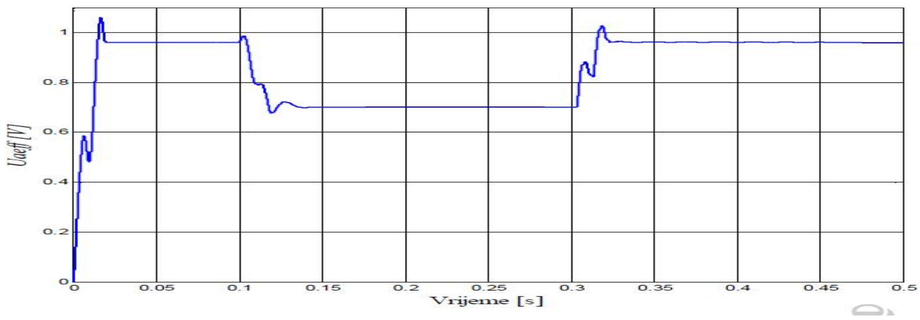

Fig. 6.1- Normalized effective value of the phase voltage phase A busbar when not connected DSTATCOM

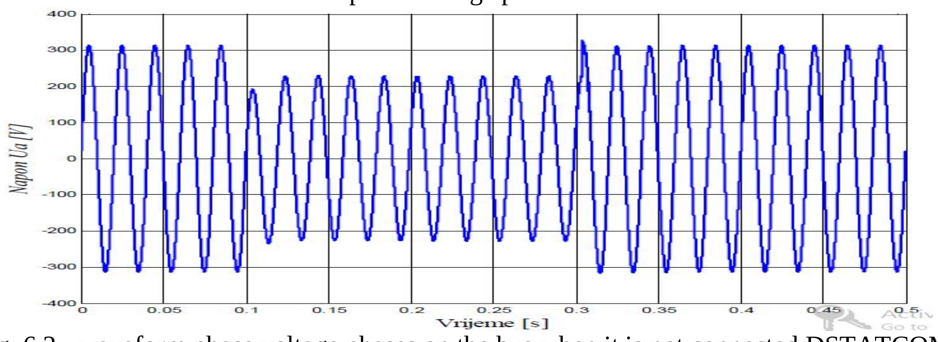

Fig. 6.2 - waveform phase voltage phases on the bus when it is not connected DSTATCOM

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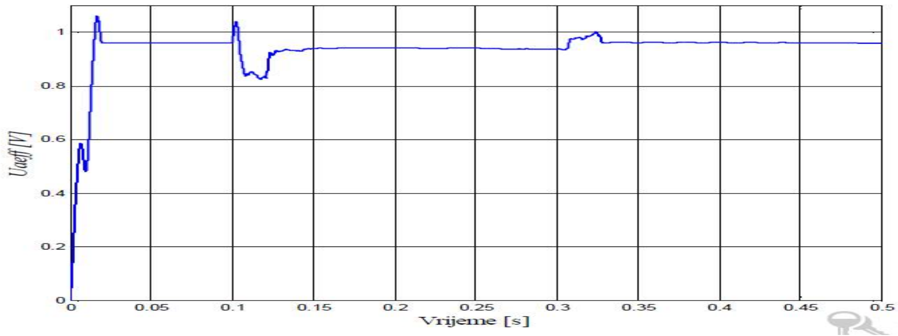

Fig. 6.3 - Normalized effective value of the phase voltage phase A busbar when connected DSTATCOM, the sum of the first, third and fifth harmonic voltage

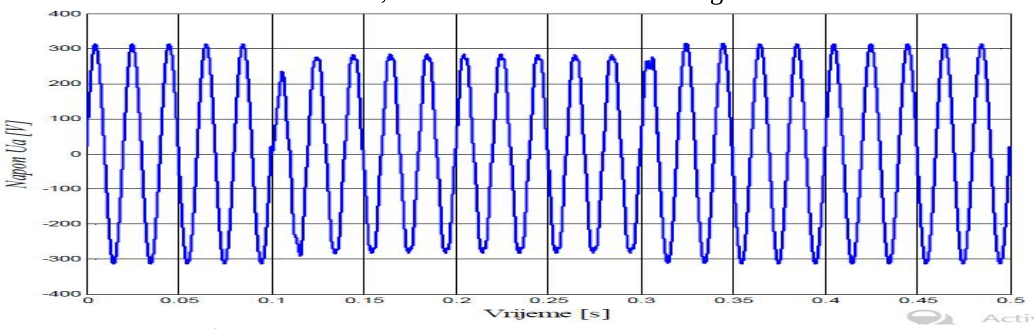

Fig. 6.4- waveform phase voltage phases on the bus when the connected DSTATCOM

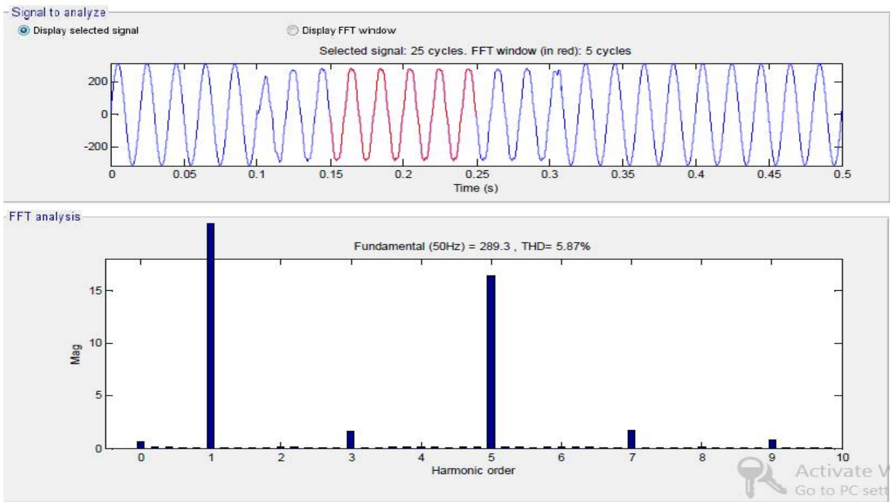

Figure 6.5 presents the distribution of harmonics in the spectrum of phase voltage for the case when the DSTATCOM connected to the network

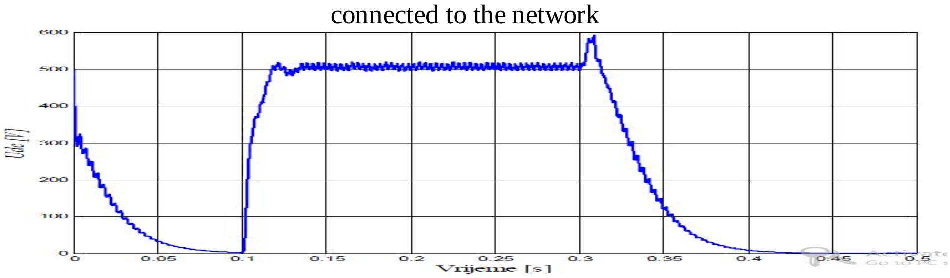

Fig. 6.6- waveform voltage on the capacitor DSTATCOM-a