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Compensating linear and non linear loads using distribution static compensator (DSTATCOM)

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Distribution static compensator (DSTATCOM) is very popular in compensating the linear, nonlinear, balanced and unbalanced loads. Any change in the load affects the DC-link voltage (DCLV) directly. The proper operation of DSTATCOM requires variation of the DCLV within the prescribed limits. This paper presents modified synchronous reference frame (SRF) method for real time generation of compensating current for harmonic mitigation and instantaneously active and reactive power compensation. Conventionally, a PI controller is used to maintain the DCLV to the reference value it uses deviation of the capacitor voltage from its reference value as its input. However, the transient response of the conventional PI DCLV is slow. In this paper, a fast-acting DCLV controller based on the energy of a dc-link capacitor is proposed. Mathematical equations are given to compute gains of proposed controller and the detailed simulations of the four cases such as balanced linear, balanced non linear, unbalanced linear, unbalanced nonlinear are carried out on MATLAB/SIMULINK R2009b environment employing a three phase three wire DSTATCOM test system.

Key words: DC-link voltage (DCLV), distribution static compensator (DSTATCOM), point of common coupling (PCC), linear, nonlinear, power factor, power quality (PQ), voltage source converter (VSC), proportional-Integral (PI) control, CHB multilevel inverter, P-Q reference frame theory.

INTRODUCTION

Maintaining power quality in a power system is very essential in today's scenario because of the increase in wide variety of loads that pollute the power system. Inductive loads like induction generators, induction motors, power transformers and arc furnaces, require reactive power for their magnetization and if the reactive power is consumed from the grid, a voltage dip occurs. This voltage dip affects other sensitive loads that are connected to the grid. Hence, it is necessary for inductive load users to compensate for the required reactive power. If the reactive power supplied by the compensator is more than the requirement of the grid, voltage swell occurs, which again affects sensitive loads. The use of non-linear loads in heavy industries leads to harmonics and wide variations in reactive power in power system. Normally the current drawn by this type of non linear loads are non sinusoidal and therefore contains harmonics.

FACTS devices have been proposed for fast dynamic voltage, impedance, and phase angle control on high-voltage ac lines. The advent of such devices has given rise to a new family of power electronic equipment to control and optimize the power system dynamic performance, for example, static synchronous compensator (STATCOM), static synchronous series compensator (SSSC), and Unified Power Flow Controller (UPFC). The use of series and shunt compensation devices has been widely accepted as the new generation

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of flexible reactive power compensation to replace other conventional reactive compensators, such as the Thyristor Switched Capacitor (TSC) and Thyristor Controlled Reactor (TCR). The application of this technology has opened new and better opportunities for an appropriate transmission and distribution control. Static synchronous compensator (STATCOM) is one of the FACTS devices which play a vital role in controlling the reactive power in power system. By proper control strategy we can also suppress the harmonics.

There are many controllers that have been suggested for statcom like fixed gain Proportional-Integral (PI) controller, sliding mode controller and nonlinear controllers. Due to the abundant use of nonlinear loads, nonlinear controllers are more preferred than linear controllers. The power-electronics based equipment, linear, nonlinear, balanced and unbalanced loads has evaluated the power-quality (PQ) problems in the power distribution network. They cause excessive neutral currents, overheating of electrical apparatus, poor power factor, voltage distortion, high levels of neutral-to-ground voltage, and interference with communication systems (Bollen, 1999). The literature says that the evolution of different custom power devices to mitigate the above power-quality problems by injecting voltages/currents or both in to the system (Dinavahi et al., 2004; Vilathgamuwa et al., 2006).

The shunt-connected custom power device, called the STATCOM is often used in transmission system. When it is used in Distribution system, it is called DSTATCOM. The DSTATCOM is a key FACTS controller and utilizes power electronics to solve many PQ problems commonly faced in distribution system, injects current at the point of common coupling (PCC) so that harmonic filtering, power factor correction, voltage regulation and load balancing can be achieved. The DSTATCOM consists of a current-controlled voltage-source inverter (VSI) which injects current at the PCC through the interface inductor. The operation of VSI is supported by a dc storage capacitor with proper dc voltage across it. Various control algorithms are available in literature (Akagi et al., 1984; Kim et al., 2002) to compute the reference compensator currents. However, instantaneous symmetrical component theory is preferred. Based on this algorithm, the compensator reference currents are given in (Equations 1, 2 and 3).

$$i_{fa}^{*} = i_{la} - \frac{V_{sa} + \gamma (V_{sb} - V_{sc})}{\sum_{i=a,b,c} V_{si}^{2}} \left(P_{lavg} + P_{dc} \right) \quad (1)$$

$$i_{fb}^{*} = i_{lb} - \frac{V_{sb} + \gamma (V_{sc} - V_{sa})}{\sum_{i=a,b,c} V_{si}^{2}} \left(P_{lavg} + P_{dc} \right) \quad (2)$$

$$i_{fc}^{*} = i_{lc} - \frac{V_{sc} + \gamma (V_{sa} - V_{sb})}{\sum_{i=a,b,c} V_{si}^{2}} \left(P_{lavg} + P_{dc} \right) \quad (3)$$

Where $\gamma = \tan \varphi / \sqrt{3}$, and φ is the desired phase angle between the supply voltages and compensated source currents in the respective phases. The term P_{lavg} is the dc or average value of the load power. The term P_{dc} accounts for the losses in the VSI without any dc loads in its dc link. To generate P_{dc}, a suitable closed-loop dc-link voltage controller should be used, which will regulate the dc voltage to the reference value. The transient performance of the compensator is decided by the computation time of average load power and losses in the compensator. Therefore, the transient performance of the compensator mostly depends on the computation of P_{lavg}. In this paper, P_{lavg} is computed by using a moving average filter (MAF) to ensure fast dynamic response. The settling time of the MAF is a half-cycle period in case of odd harmonics and one cycle period in case of even harmonics presence in voltages and currents. Although the computation of P_{dc} is generally slow and updated once or twice in a cycle, being a small value compared P_{lavg} to, it does not play a significant role in transient performance of the compensator. The load sharing by the ac and dc bus depends upon the design and the rating of the VSI. Here, there are two important issues. The first one is the regulation of the dc-link voltage within prescribed limits under transient load conditions. The second one is the settling time of the dc–link voltage controller. Conventionally, a PI controller is used to maintain the dc-link voltage. It uses the deviation of the capacitor voltage from its reference value as its input. However, the transient response of the conventional dc-link voltage controllers is slow, especially in applications where the load changes rapidly. Some work related to dc-link voltage controllers and their stability was reported by Eissa et al., (1996). In this paper, a fast-acting dc-link voltage controller based on the dc-link capacitor energy is proposed. The detailed modeling and simulation verifications are carried out by using MATLAB environment to prove the efficacy of this fast-acting dc-link voltage controller. There is no systematic procedure to design the gains of the conventional PI controller used to regulate the dc-link voltage of the DSTATCOM (Mishra and Karthikeyan, 2009). But some, mathematical equations are given to design the gains of the conventional controller based on the fast-acting dc-link voltage controllers to achieve similar fast transient response.

DESIGN OF DISTRIBUTION STATIC COMPENSATOR (DSTATCOM)

Principle of distribution static compensator (DSTATCOM)

A D-STATCOM (Distribution Static Compensator), which is schematically depicted in Figure 1, consists of a two-level voltage source converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through an interfacing

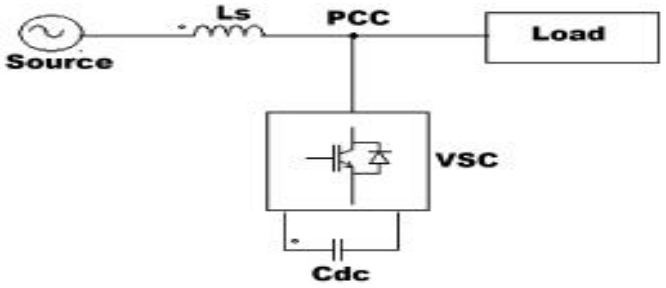

Figure 1. Schematic Diagram of a DSTATCOM.

inductor. The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the DSTATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power.

The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

1. Voltage regulation and compensation of reactive power
2. Correction of power factor.
3. Elimination of current harmonics.

The AC terminals of the VSC are connected to the Point of Common Coupling (PCC) through an inductance, which could be a filter inductance or the leakage inductance of the coupling transformer, as shown in Figure 1. The DC side of the converter is connected to a DC capacitor, which carries the input ripple current of the converter and is the main reactive energy storage element. This capacitor could be charged by a battery source, or could be precharged by the converter itself. If the output voltage of the VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage is greater than the AC terminal voltage, the DSTATCOM is in the capacitive mode of operation and vice versa. The quantity of reactive power flow is proportional to the difference in the two voltages. It is to be noted that voltage regulation at PCC and power factor correction cannot be achieved simultaneously. For a DSTATCOM used for voltage regulation at the PCC, the compensation should be such that the supply currents should lead the supply voltages; whereas, for power factor correction, the supply current should be in phase with the supply voltages. The control strategies studied in this paper are applied with a view to studying the performance of a DSTATCOM for power factor correction and harmonic mitigation.

Voltage source converter

A voltage-source converter is a power electronic device in Figure 1 which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable-speed drives, but can also be used to mitigate voltage dips. The VSC is used to either completely replace the voltage or to inject the 'missing voltage'. The 'missing voltage' is the difference between the nominal voltage and the actual. The converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the VSC is not only used for voltage dip mitigation, but also for other power quality issues, for example, flicker and harmonics.

Control for harmonic compensation

The Modified Synchronous Frame method is presented in (Akagi et al., 1984). It is called the instantaneous current component (id-iq) method. This is similar to the Synchronous Reference Frame theory (SRF) method. The transformation angle is now obtained with the voltages of the ac network. The major difference is that, due to voltage harmonics and imbalance, the speed of the reference frame is no longer constant. It varies instantaneously depending of the waveform of the 3-phase voltage system. In this method the compensating currents are obtained from the instantaneous active and reactive current components of the nonlinear load. In the same way, the mains voltages V (a, b, c) and the available currents I_L (a, b, c) in α-β components must be calculated as given by (4), where C is Clarke Transformation Matrix. However, the load current components are derived from a SRF based on the Park transformation, where 'θ' represents the instantaneous voltage vector angle (5)

$$\begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} = [C] \begin{bmatrix} I_{l_a} \\ I_{l_b} \\ I_{l_c} \end{bmatrix}$$

$$\begin{bmatrix} i_d \\ i_q \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad \theta = \tan^{-1}\frac{v_\beta}{v_\alpha} \qquad \text{(4) and (5)}$$

Figure 2 shows the block diagram SRF method. Under balanced and sinusoidal voltage conditions angle θ is a uniformly increasing function of time. This transformation angle is sensitive to voltage harmonics and unbalance; therefore dθ/dt may not be constant over a mains period. With transformation given below the direct voltage component.

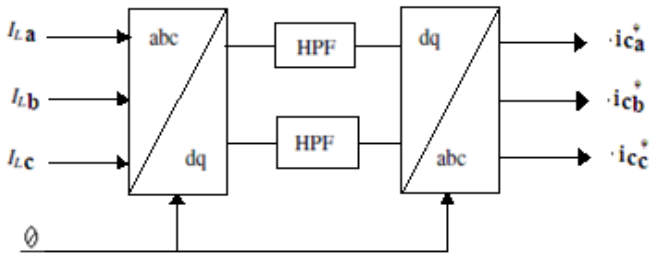

Figure 2. Block diagram of SRF method.

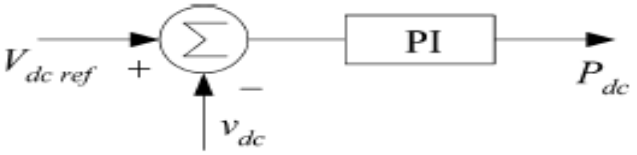

Figure 3. Schematic diagram of the conventional dc-link voltage controller.

DC-LINK VOLTAGE CONTROLLERS

The sudden removal of load would result in an increase in the dc-link voltage above the reference value, whereas a sudden increase in load would reduce the dc-link voltage below its reference value. As mentioned before, the source supplies an unbalanced nonlinear ac load directly the dc link of the DSTATCOM, as shown in Figure 1. Due to transients on the load side, the dc bus voltage is significantly affected. To regulate this dc-link voltage, closed-loop controllers are used. The proportional-integral-derivative (PID) control provides a generic and efficient solution to many control problems. The control signal from PID controller to regulate dc link voltage is expressed as

$$U_c = K_p (V_{dc\ ref} - V_{dc}) + K_i \int (V_{dc\ ref} - V_{dc}) + K_d\ d/dt\ (V_{dc\ ref} - V_{dc}) \quad (6)$$

In Equation (6), K_p, Ki and K_d are proportional, integral, and derivative gains of the PID controller, respectively. The proportional term provides overall control action proportional to the error signal. An increase in proportional controller gain (K_p) reduces rise time and steady-state error but increases the overshoot and settling time. An increase in integral gain (K_i) reduces steady state error but increases overshoot and settling time. Increasing derivative gain (K_d) will lead to improved stability. However, practitioners have often found that the derivative term can behave against anticipatory action in case of transport delay. A cumbersome trial-and-error method to tune its parameters made many practitioners switch off or even exclude the derivative term (Ang et al., 2005). Therefore, the description of conventional and the proposed fast-acting dc-link voltage controllers using PI controllers are given in the following subsections.

Conventional DC-Link voltage controller

The conventional PI controller used for maintaining the dc-link voltage is shown in Figure 3. To maintain the dc-link voltage at the reference value, the dc-link capacitor needs a certain amount of real power, which is proportional to the difference between the actual and reference voltages. The power required by the capacitor can be expressed as follows:

$$P_{dc} = K_p (V_{dc\ ref} - V_{dc}) + K_i \int (V_{dc\ ref} - V_{dc}) \quad (7)$$

The dc-link capacitor has slow dynamics compared to the compensator, since the capacitor voltage is sampled at every zero crossing of phase supply voltage. The sampling can also be performed at a quarter cycles depending upon the symmetry of the dc-link voltage waveform. The drawback of this conventional controller is that its transient response is slow, especially for fast-changing loads. Also, the design of PI controller parameters is quite difficult for a complex system and, hence, these parameters are chosen by trial and error. Moreover, the dynamic response during the transients is totally dependent on the values of K_p, and K_i, when P_{dc} is comparable to P_{lavg}.

Fast-Acting DC Link voltage controller

To overcome the disadvantages of the aforementioned controller, an energy-based dc-link voltage controller is proposed. The energy required by the dc-link capacitor (W_{dc}) to charge from actual voltage (V_{dc}) to the reference value ($V_{dc\ ref}$) can be computed as in Mishra and Karthikeyan (2009).

$$W_{dc} = ½\ C_{dc} (V_{dc\ ref}^{\ 2} - V_{dc}^{\ 2}) \quad (8)$$

In general, the dc-link capacitor voltage has ripples with double frequency, that of the supply frequency. The dc power (P'_{dc}) required by the dc-link capacitor is given as

$$P_{dc} = W_{dc} / T_c = ½\ C_{dc} (V_{dc\ ref}^{\ 2} - V_{dc}^{\ 2}) / T_c \quad (9)$$

Where T_c is the ripple period of the dc-link capacitor voltage. Some control schemes have been reported in Mishra and Karthikeyan (2009). However, due to the lack of integral term, there is a steady-state error while compensating the combined ac and dc loads. This is eliminated by including an integral term. The input to this controller is the error between the squares of reference and the actual capacitor voltages. This controller is shown in Figure 4 and the total dc power required by the dc-link capacitor is computed as follows:

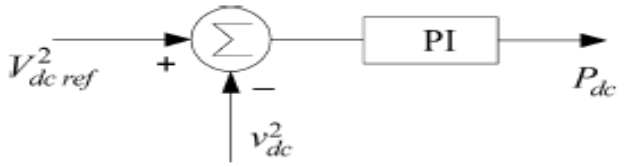

Figure 4. Schematic diagram of the fast-acting dc-link voltage controller.

$$P_{dc} = K_{pe} (V_{dc\ ref}{}^2 - V_{dc}{}^2) + K_{ie} \int (V_{dc\ ref}{}^2 - V_{dc}{}^2) \quad (10)$$

The coefficients K_{pe} and K_{ie} are the proportional and integral gains of the proposed energy-based dc-link voltage controller. As an energy-based controller, it gives fast response compared to the conventional PI controller. Thus, it can be called a fast acting dc-link voltage controller. The ease in the calculation of the proportional and integral gains is an additional advantage. The value of the proportional controller gain (K_{pe}) can be given as

$$K_{pe} = C_{dc} / 2T_c \quad (11)$$

For example, if the value of dc-link capacitor is 2200 μF and the capacitor voltage ripple period as 0.01 s, then K_{pe} is computed as 0.11 by using (11) the selection of K_{ie} depends upon the tradeoff between the transient response and overshoot in the compensated source current. Once this proportional gain is selected, integral gain is tuned around and chosen to be 0.5. It is found that if K_{ie} is greater than K_{pe} / 2, the response tends to be oscillatory and if K_{ie} is less than K_{pe} / 2, then response tends to be sluggish. Hence, K_{ie} is chosen to be K_{pe} / 2.

DESIGN OF CONVENTIONAL CONTROLLER BASED ON THE FAST-ACTING DC-LINK VOLTAGE CONTROLLER

The conventional dc-link voltage controller can be designed based on equations given for the fast acting dc-link voltage controller as in (10) and can be written as

$$P_{dc} = K_{pe} (V_{dc\ ref} + V_{dc}) (V_{dc\ ref} - V_{dc}) + K_{ie} \int (V_{dc\ ref} + V_{dc})(V_{dc\ ref} - V_{dc}) \quad (12)$$

It can also be written as

$$P_{dc} = K_{p'} (V_{dc\ ref} - V_{dc}) + K_{i'} \int (V_{dc\ ref} - V_{dc}) \quad (13)$$

It is observed from the aforementioned equations that the gains of proportional and integral controllers vary with respect to time. However, for small ripples in the dc-link voltage, $V_{dc} \approx V_{dc\ ref}$, therefore, we can approximate the above gains to the following

$$K_{p'} = 2K_{pe} V_{dc\ ref} \quad (14)$$
$$K_{i'} = 2K_{ie} V_{dc\ ref}$$

The relations give approximate gains for a conventional PI controller. This is due to the fact that $V_{dc\ ref} + V_{dc}$ is not really equal to $2V_{dc\ ref}$ until variation in V_{dc} is small during transients. Hence, the designed conventional PI controller works only on approximation. The open-loop gains for the two cases are given by

$$P_{dc} / E = K_{p'} (S + K_{i'} / K_{p'}) / S \quad (15)$$
$$E = V_{dc\ ref} - V_{dc}$$

Since $K_{i'} / K_{p'}$ is the same as K_{ie} / K_{pe}, the higher gain in the conventional PI controller renders less stability than that of the proposed energy-based dc-link controller. For nearly the same performance, the conventional PI controller has gains which are 183 (18.3/0.1) times larger than that of that proposed one. Also, the amplifier units used to realize these gains need more design considerations and are likely to saturate when used with higher gains.

Simulation parameters

Supply voltage V (L-L) =415 v, f=50 Hz,
Line parameters R=0.1 Ω, L=0.9 mH,
Unbalanced Load Za=25Ω, Zb=44 + j25.45 Ω, Zc=50 + j78.55 Ω,
Nonlinear load Z=150 + j9.425 Ω, C_{dc}=1500 μF,
Interface Inductor Lf=10mH, Rf=0.0001 Ω. $V_{dc\ ref}$ =880 v,
Hysterisis Band h= +_0.01A,
Gains of Conventional DC link controller K_p =18.3, K_i=4.3,
Gains of Fast acting DC link controller K_p =0.1, K_i =1

SELECTION OF THE DC-LINK CAPACITOR

The value of the dc-link capacitor can be selected based on its ability to regulate the voltage under transient conditions. Let us assume that the compensator in Figure 1 is connected to a system with the rating of X kilovolt amperes. The energy of the system is given by X x 1000 J/s. Let us further assume that the compensator deals with half (that is, X/2) and twice (that is, 2X) capacity under the transient conditions for cycles with the system voltage period of Ts. Then, the change in energy to be dealt with by the dc capacitor is given as

$$\Delta E = (2X - X/2)\ nT \quad (16)$$

Now this change in energy (16) should be supported by the energy stored in the dc capacitor. Let us allow the dc capacitor to change its total dc-link voltage from 1.4 V_m to 1.8 V_m during the transient conditions where V_m is the peak value of phase voltage. Hence, we can write

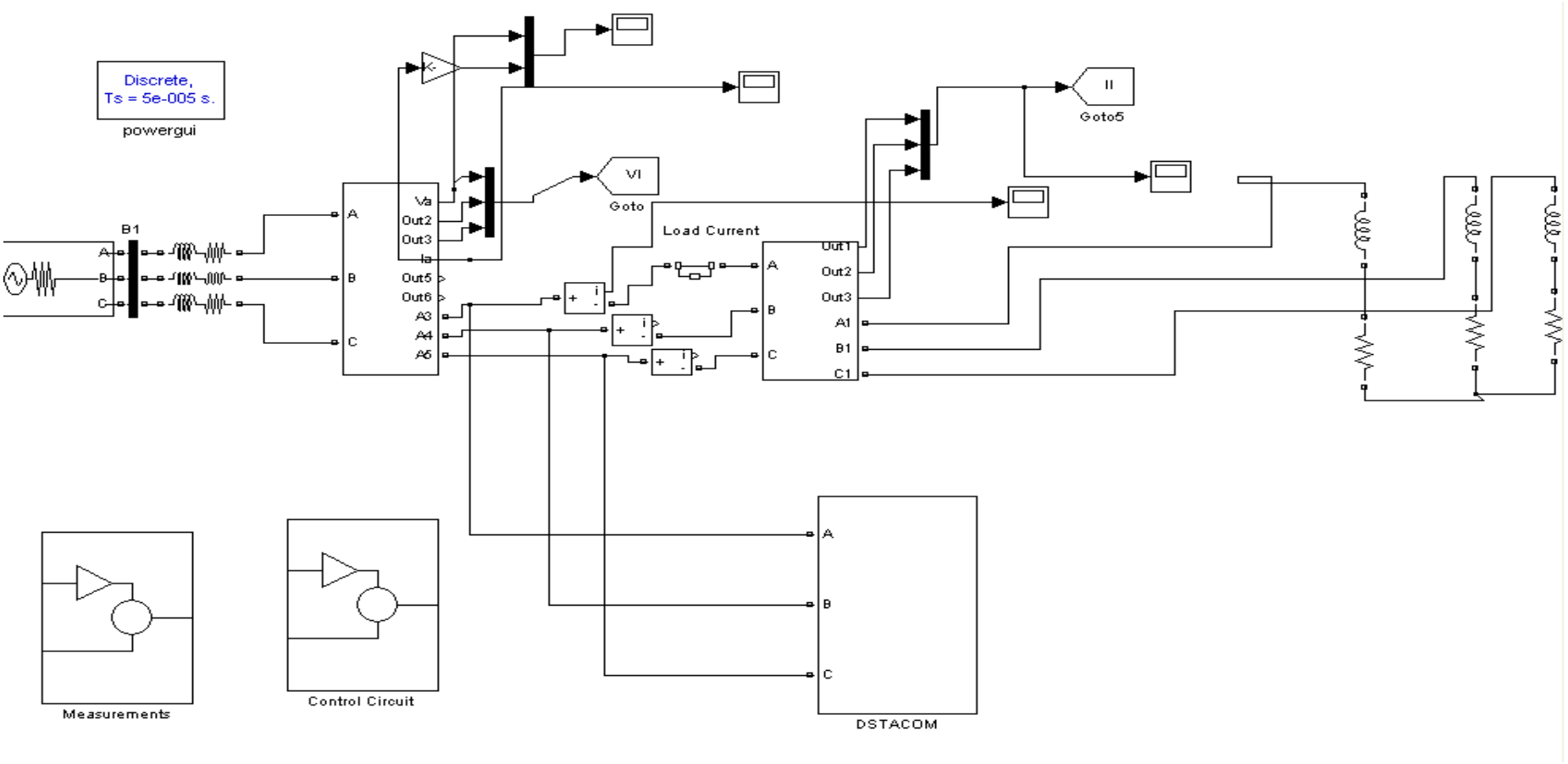

Figure 5. Matlab/Simulink power circuit model of DSTATCOM with balanced linear load.

$$\tfrac{1}{2}\, C_{dc}\, [(1.8V_m)^2 - (1.4V_m)^2] = (2X - X/2)\, nT \qquad (17)$$

For example, consider a 10-kVA system (that is, X = 10 kVA), system peak voltage V_m = 325.2 V, n = 0.5, and T = 0.02 s. The value of C_{dc} computed using (17) is 2216 μF. Practically, 2000 μF is readily available and the same value has been taken for simulation and experimental studies.

METAL/SAMULINK MODELING AND SIMULATION RESULTS

Figure 5 shows the Matlab/Simulink power circuit model of DSTATCOM with balanced linear load. It consists of five blocks named as source block, linear load block, control block, DSTATCOM block and measurements block. The system parameters for simulation study are source voltage of 415 v, 50 Hz AC supply, DC bus capacitance 1500e-6 F, Inverter series inductance 10 mH, Source resistance of 0.1 Ω and inductance of 0.9 mH. Load resistance and inductance are chosen as 60 mH and 50 Ω respectively (Figure 6).

Figure 7 shows the MATLAB circuit of the

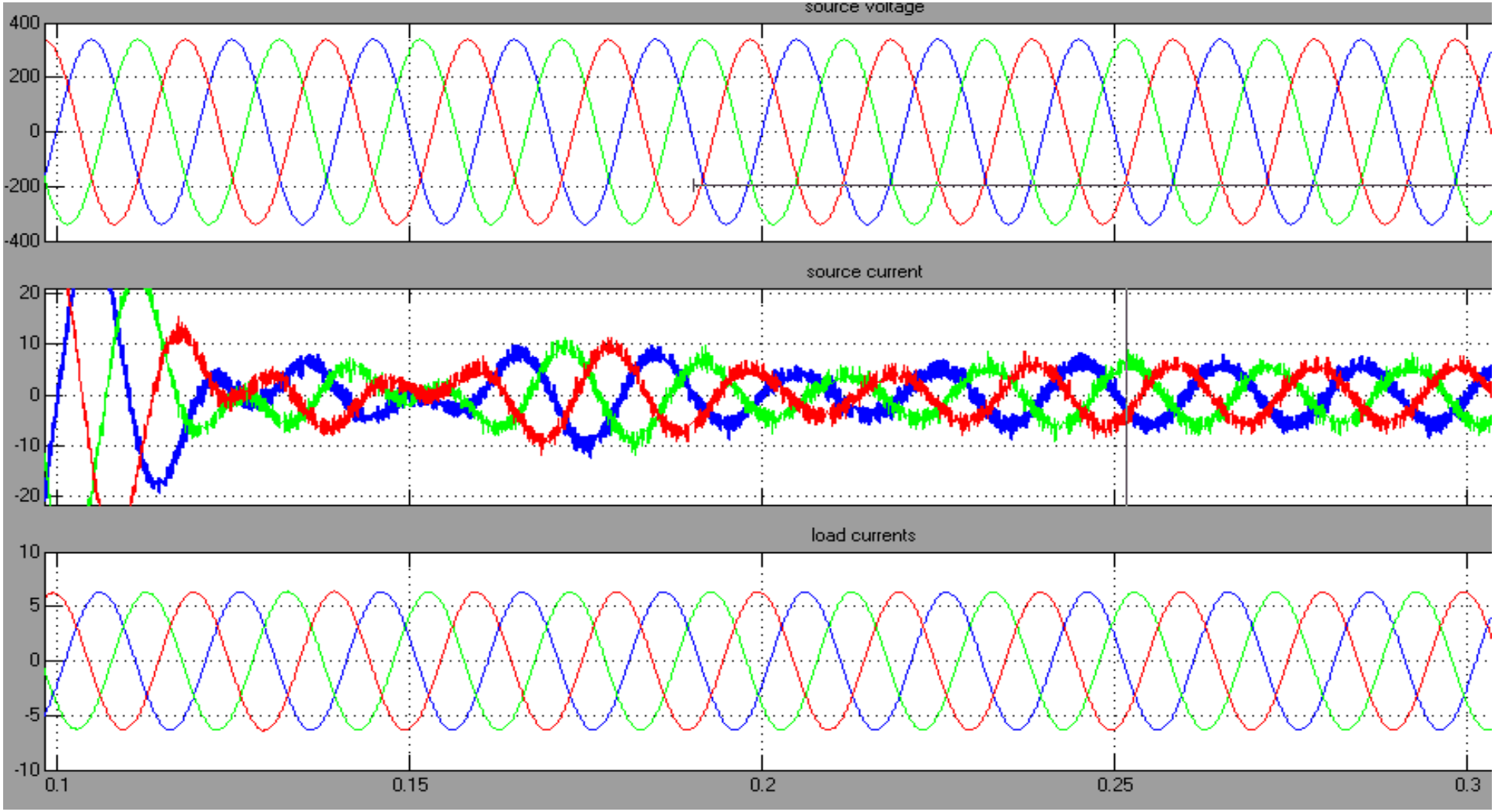

Figure 6. Source voltage, current and load current of DSTATCOM with balanced linear load.

DSTATCOM having balanced nonlinear load. It consists of five blocks named as source block, non linear load block, control block, DSTATCOM block and measurements block. The system parameters for simulation study are source voltage of 415 v, 50 Hz AC supply, DC bus capacitance 1500e-6 F, Inverter series inductance 10 mH, source resistance of 0.1 Ω and inductance of 0.9 mH. Load resistance and inductance are chosen as 30 mH and 60 Ω respectively.

Figure 8 shows the three phase source

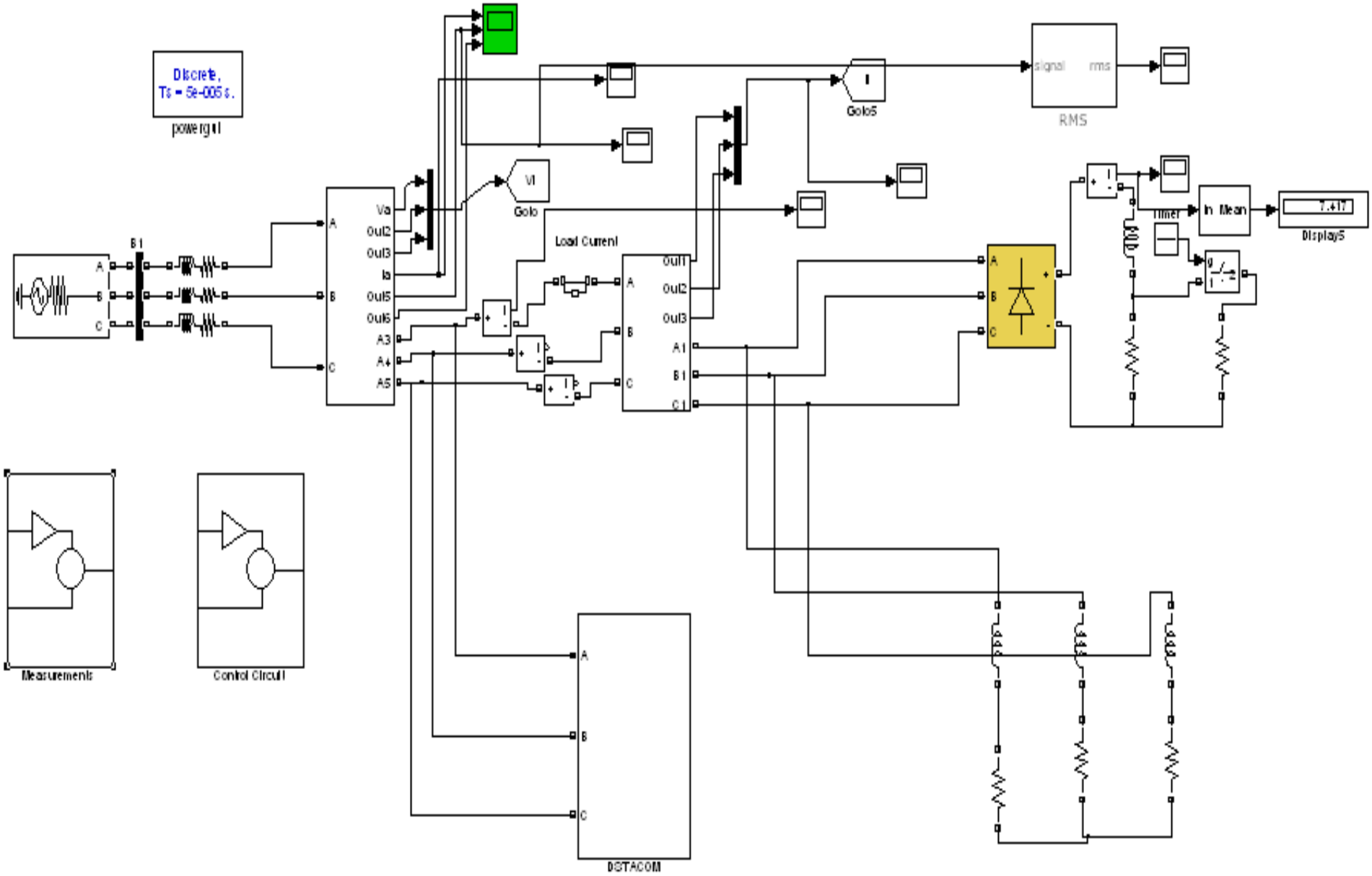

Figure 7. Shows the MATLAB circuit of the DSTATCOM having balancedNon linear load.

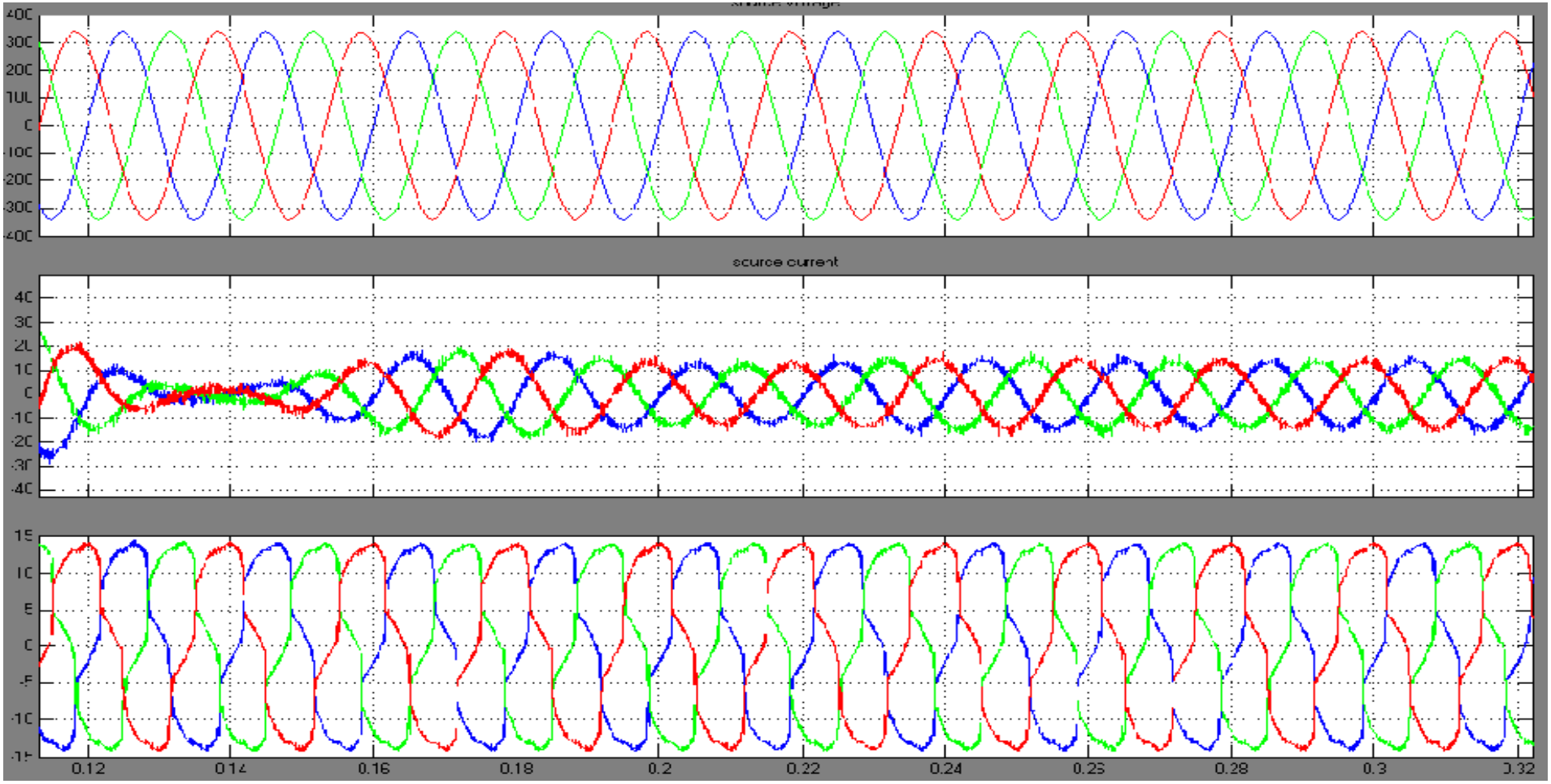

Figure 8. Source voltage, current and load current of DSTATCOM with balanced non linear load.

voltages, three phase source currents and load currents respectively with DSTATCOM having balanced non linear load. It is clear that the load current is non sinusoidal but balanced.

Figure 9 shows the unity power factor for balanced nonlinear load.

Figure 10 shows the MATLAB circuit of the DSTATCOM having unbalanced linear load. It consists of five blocks named as source block, non linear load block, control block, DSTATCOM block and measurements block. The system parameters for simulation study are source voltage of 415 v, 50 Hz AC supply, DC bus capacitance 1550e-6 F, Inverter series inductance 10 mH, Source resistance of 0.1 Ω and inductance of 0.9 mH. Load resistance and inductance are chosen as 30 mH and 60 Ω respectively.

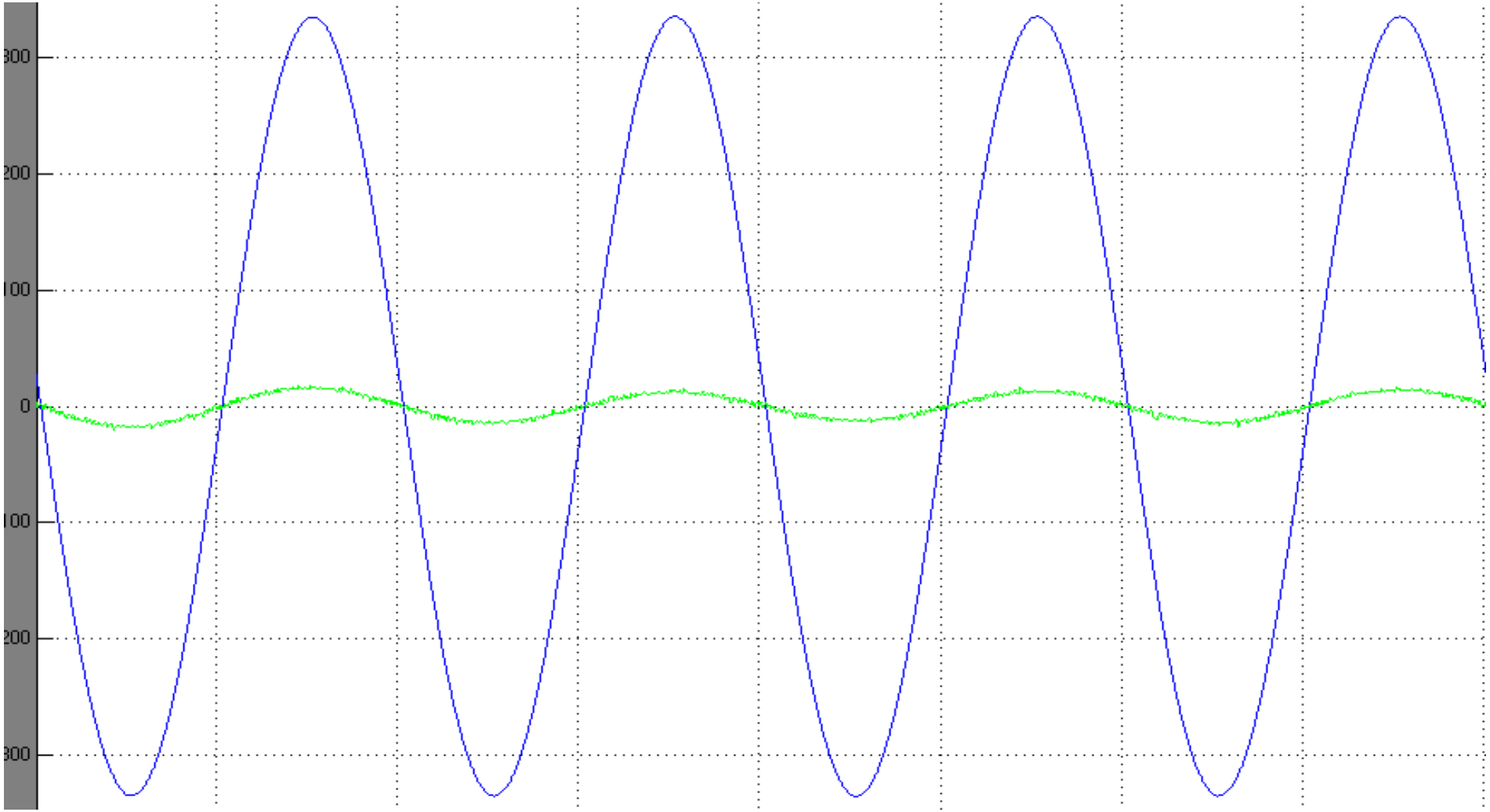

Figure 9. Waveform showing unity power factor.

Figure 11 shows the three phase source voltages, three phase source currents and load currents respectively with DSTATCOM having unbalanced linear load. It is clear that the load current is sinusoidal and balanced.

Figure 12 shows the unity power factor for unbalanced nonlinear load.

Figure 13 shows the MATLAB circuit of the DSTATCOM having unbalanced non linear load. It

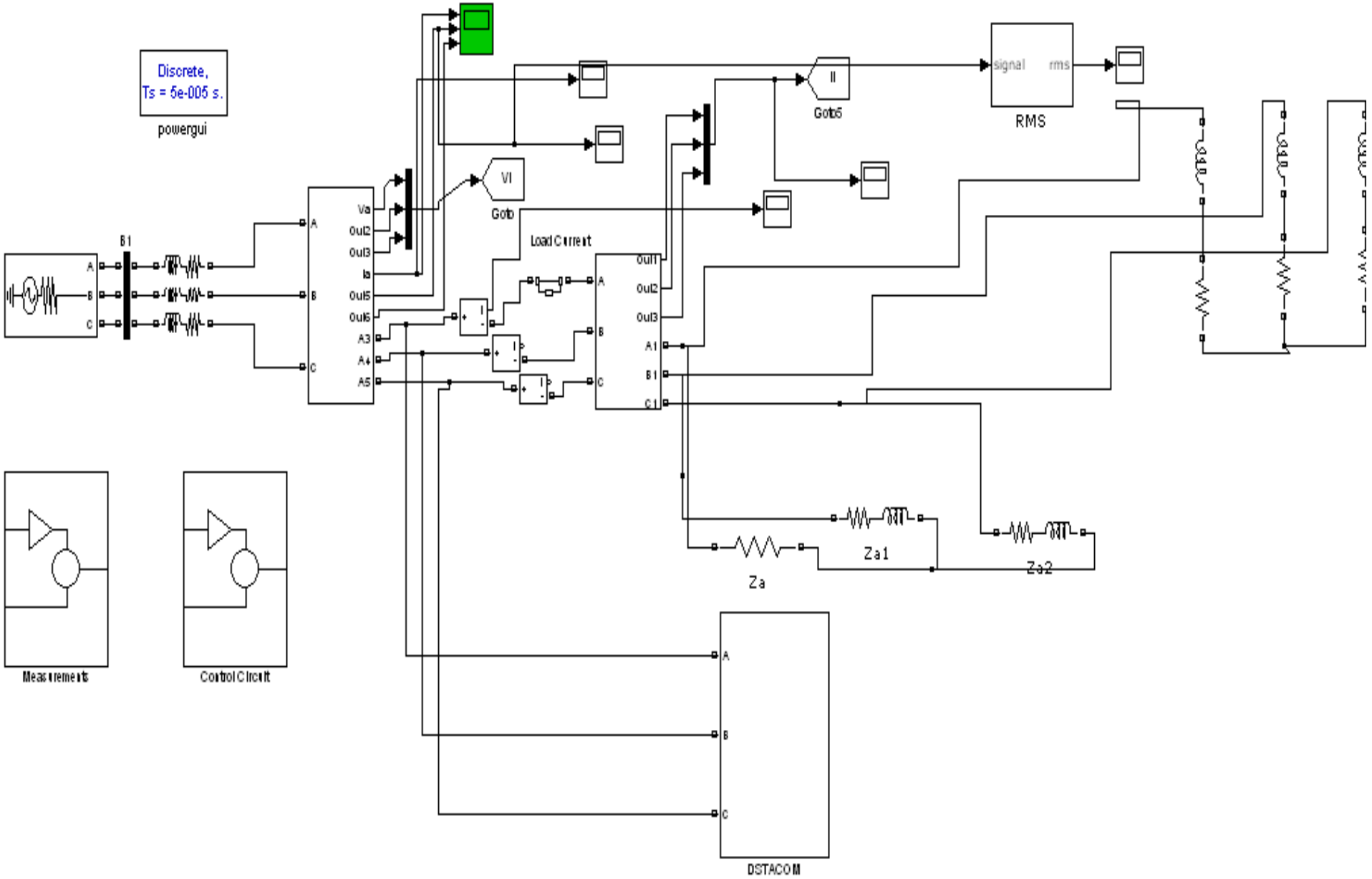

Figure 10. MATLAB circuit of the DSTATCOM having unbalanced linear load.

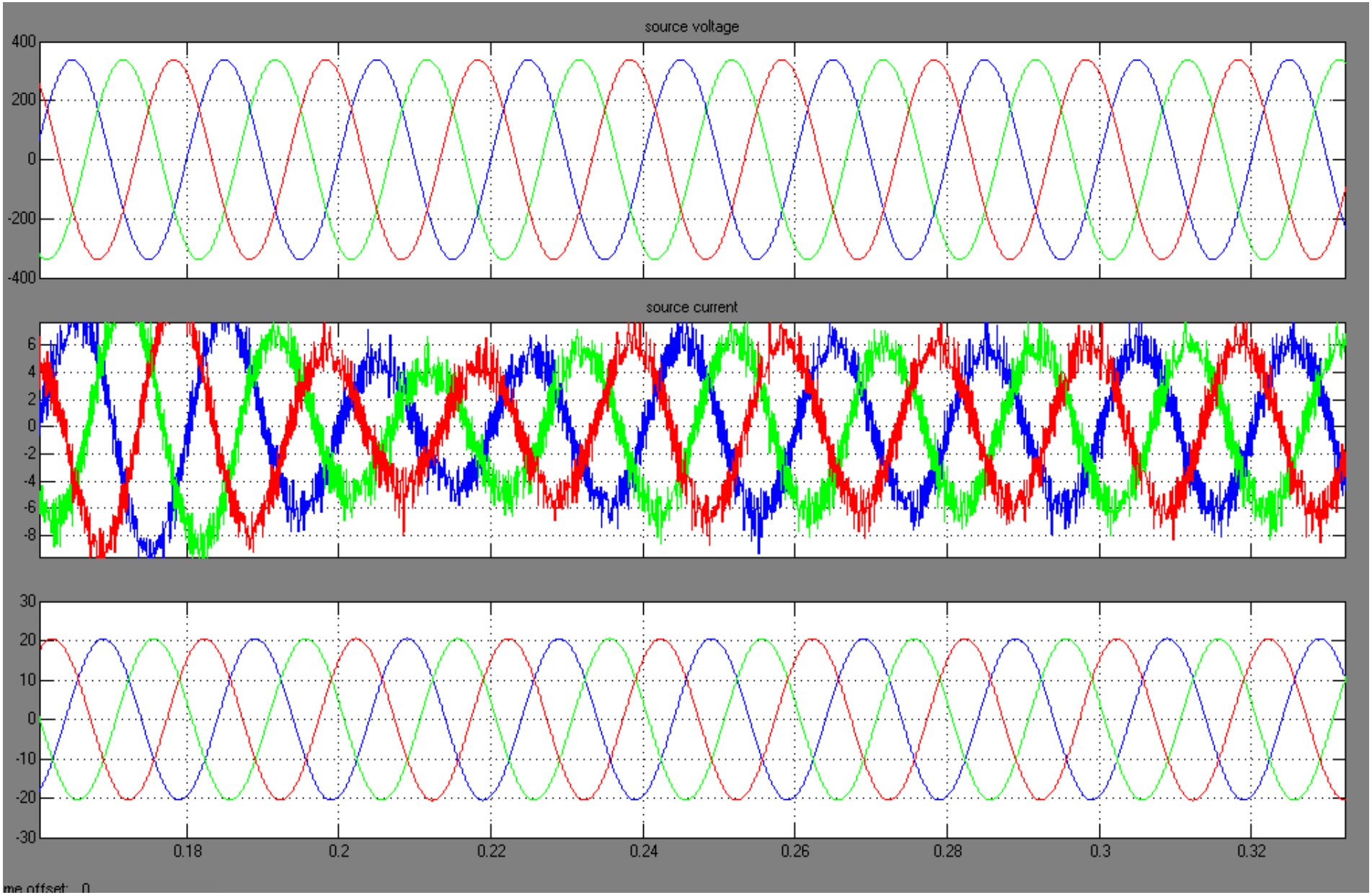

Figure 11. Source voltage, current and load current of DSTATCOM with unbalanced linear load.

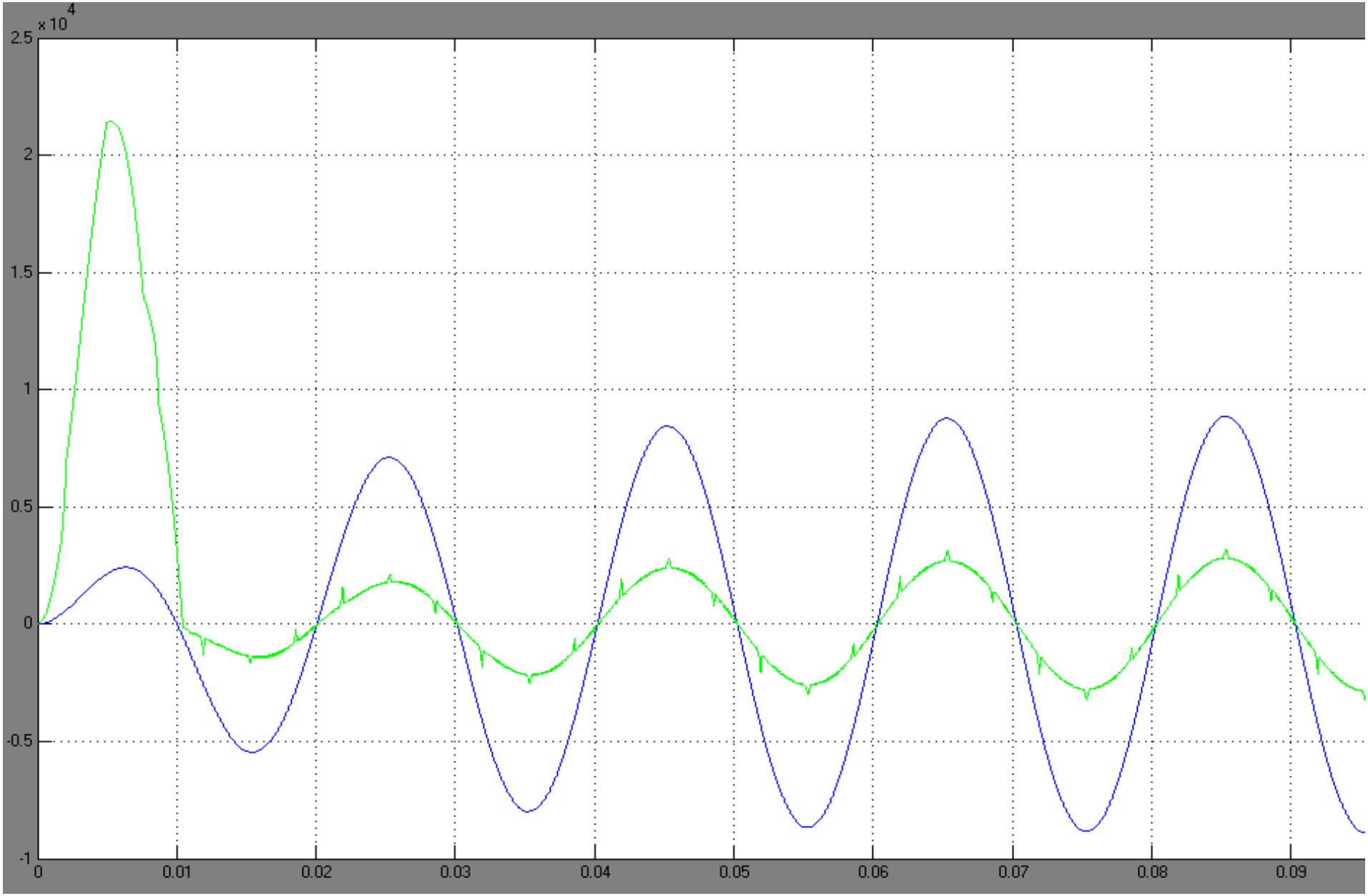

Figure 12. Waveform showing unity power factor.

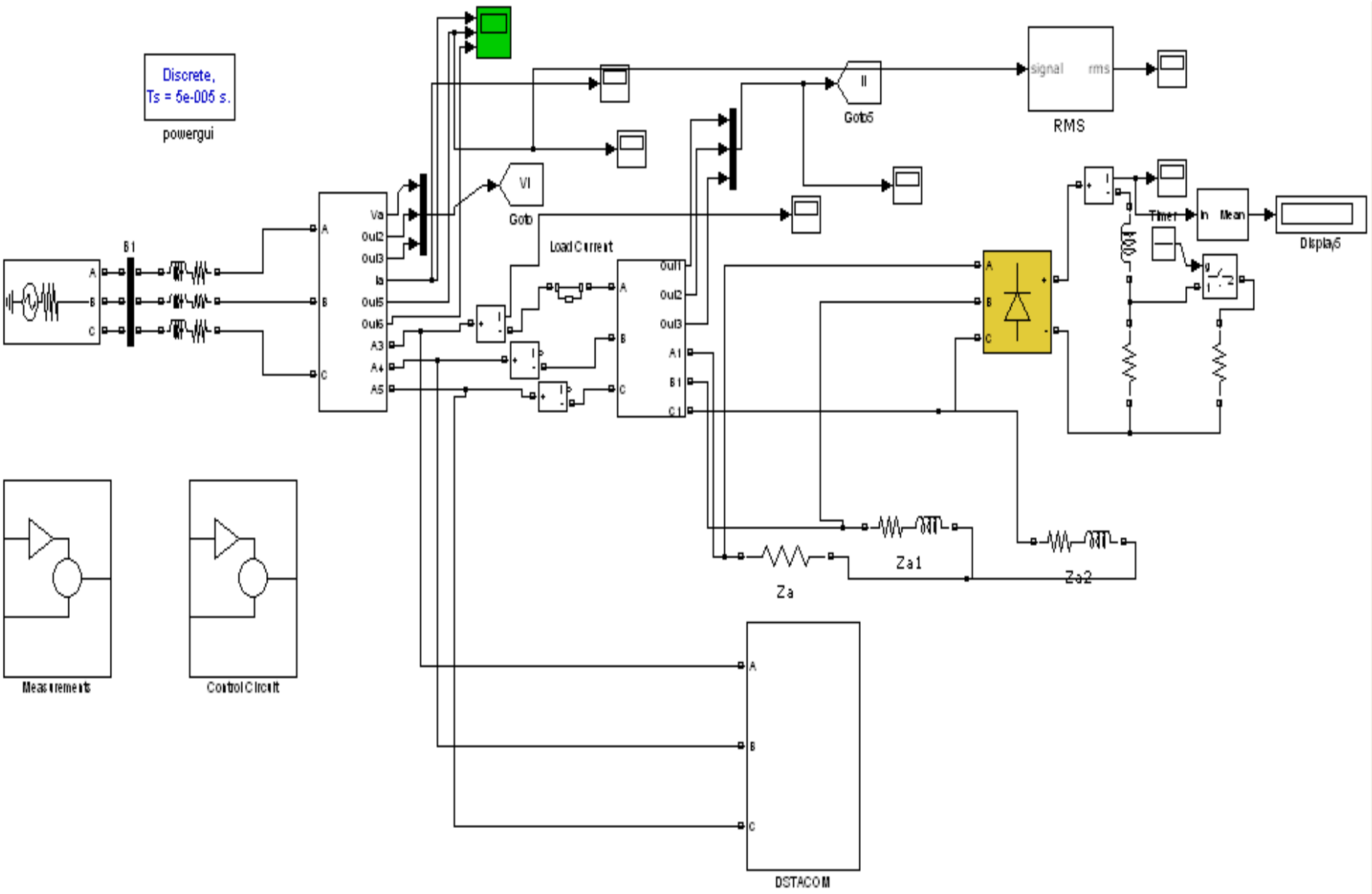

Figure 13. MATLAB circuit of the DSTATCOM having unbalanced non linear load.

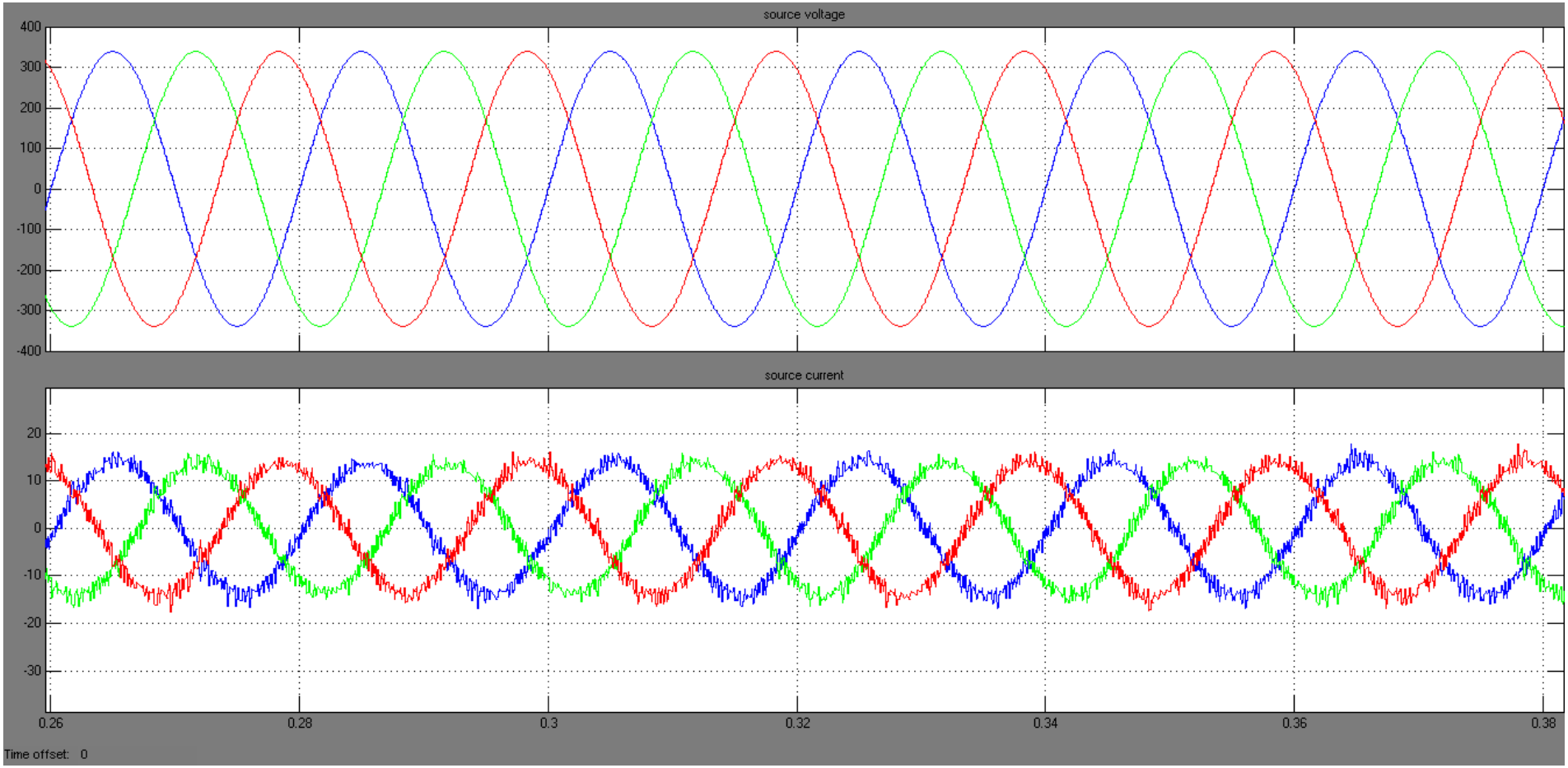

Figure 14. Source voltages, three phase source currents with DSTATCOM having unbalanced non linear load.

consists of five blocks named as source block, non linear load block, control block, DSTATCOM block and measurements block. The system parameters for simulation study are source voltage of 11 kv, 50 Hz AC supply, DC bus capacitance 1550e-6 F, Inverter series inductance 10 mH, Source resistance of 0.1 Ω and inductance of 0.9 mH. Load resistance and inductance are chosen as 30 mH and 60 Ω respectively.

Figure 14 shows the three phase source voltages, three phase source currents with DSTATCOM having unbalanced non linear load. It is clear that the load current is non sinusoidal.

DISCUSSION

In previous literature shows the comparison between conventional and fast acting DCLV controller for improving the transient performance of the compensator for nonlinear unbalanced load to improve power quality. This paper simulate the

concept fast acting DCLV controller of the compensator for different loads both linear and nonlinear loads of balanced and unbalanced cases of source voltage and currents are in phase to form unity power factor to improve power quality of AC loads.

CONCLUSION

Energy based fast acting PI for DSTATCOM compensating balanced, unbalanced, linear and nonlinear loads supplied by the dc link of the compensator in distribution system is presented. The fast-acting DCLV controller is used to get the harmonic filtering, voltage regulation, load balancing and unity power factor is achieved. Mathematical equations are developed to compute the gains of this conventional based on proposed controller is presented. Finally Matlab/Simulink based model are developed and simulation results are presented.

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