SINGLE PHASE STATCOM –ITS CONTROL ALGORTHIM

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Abstract- In this paper, a new type of single phase static compensator (STATCOM) for low rating used in customer side is proposed. This new STATCOM is constructed by cascading a full-bridge (H Bridge) voltage-source inverter (VSI's) to the point of common coupling (PCC.) A so-called sinusoidal pulse width modulation (SPWM) unipolar voltage switching scheme is applied to control the switching devices of each VSI. A new control strategy is adopted for compensating the harmonics and reactive current required by the load. The proposed STATCOM has the advantage of a fewer number of VSI's, the VSI's being identical and extremely fast in response to reactive power change and the control strategy adopted shows a good response.
Index Terms—Static compensator, voltage-source inverter*, PCC, *reactive power, harmonic current.

1. **Introduction**

The proliferation of power electronics systems in a wide range of equipments, from home VCRs and digital clocks to automated industrial assembly lines and hospital diagnostics systems has increased the vulnerability of such equipment to power quality problems. These problems include a variety of electrical disturbances, which may originate in several ways and have different effects on various kinds of sensitive loads. As a result of this vulnerability, increasing numbers of industrial and commercial facilities are trying to protect themselves by investing in more sophisticate equipment to improve power quality. Moreover, the proliferation of nonlinear loads with large rated power has increased the contamination level in voltages and currents waveforms, forcing to improve the compensation characteristics required to satisfy more stringent harmonics standards.

Now a days the requirement for power quality becomes more and more important to keep safety of the electrical devices and consumer satisfaction. The growth of the non-linear loads like the devices with switching power supplies have increased current harmonics, EMI problems, unnecessary reactive power and power losses. Fast switching devices like CMOS or IGBT transistors provide implementation of full bridge inverters to serve as a real time parallel compensators by bidirectional energy flow to control and compensate reactive power and current harmonics. Static Var Compensator can be utilized to regulate voltage, control power factor, and stabilize power flow [1].

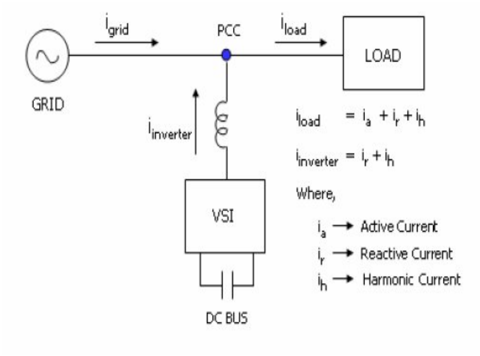
Most of Var compensators employ a combination of fixed or switched capacitance and thyristor controlled reactance. Several Var compensator based on a voltage sourced inverter, known as STATCOM, have been proposed and demonstrated [2-4].

In this paper the main goal is proposing a low cost single phase commercial STATCOM control topology to act as an active filter for single phase nonlinear load by using controller using PIC microcontroller. The control technique is useful to modify harmonics current required by the load and compensate reactive power due to relatively asymmetrical unbalanced non-linear loads. The required data's are achieved from dc bus voltage, grid voltage, load current and inverter current. Main tuning parameters are obtained from conventional PI controller.

2. CIRCUIT CONFIGURATION

2.1**) Statcom a simplified picture**

STATCOM is a Voltage Source Inverter (VSI) connected in shunt to the system at the point of common coupling (PCC) as shown in Fig.1. The load current can be thought of as having three components – active, reactive and harmonic. The idea is to control the voltage source inverter in such a way as to make it deliver the reactive and harmonic currents demanded by the load so that the grid has to supply only the active current. This means that the grid current will be purely sinusoidal and will be in-phase with the grid voltage on connecting the STATCOM. Ideally, it is possible to supply the reactive and harmonic current requirement of the load with a VSI having a DC bus capacitor and no external power source as the net power supplied by the STATCOM during any given fundamental period is zero. However, a small amount of real power will be absorbed from the grid practically – to compensate for the energy losses in the system.



Al Fig.1 Voltage source inverter as a grid connected STATCOM

to the power system. In these types of applications PWM-VSI operates as current controlled VSI. In Statcom the aim is to make VSI continuously track and deliver the reactive and harmonic currents demanded by load. This calls the use for current controller. The VSI act as a bidirectional converter operates as an inverter to supply the compensating voltage to load and as a converter when charging the capacitor. The topology adopted for the bidirectional converter is full bridge topology [6] and a capacitor of medium rating.

2.2) Circuit explanation

The Statcom should essentially consist of a single phase inverter, Dc side capacitor meant for dc voltage for inverters, filter components to filter out high frequency components of inverter output voltage, link inductor that links the inverter output to the ac supply side and interface magnets(if required)and related control blocks.

Figure2 shows the circuit diagram consisting of 4 self commutated semiconductor switches (IGBT, MOSFET) with anti-parallel diodes which, act as a full bridge converter. In this converter configuration, IGBT constitute the switching devices. With a dc voltage source (i.e. charged capacitor), the converter can produce balanced voltage waveforms of given frequency.

The reference signals are generated by sensing the grid voltage, dc voltage, converter current and load current. The sensed values are given as the input to the controller so as to generate the reference values for compensation.

The inverter generates a three phase voltage which is synchronized with the ac supply, from the dc side capacitor and links this voltage to ac source. The current drawn by the inverter from ac mains is controlled to be reactive with little active component which is needed to supply the loses. Main condition for operation of the circuit is the amount of charged voltage on the dc link capacitors, so as to have bidirectional current flow of current, the following condition should be satisfied

$$Vc \geq \sqrt{2}Vl \qquad \text{----------(1.1)}$$

Term Vc is capacitor voltage and Vl is effective grid voltage. For this the converter acts like a Boost converter to transfer the stored energy to the load.

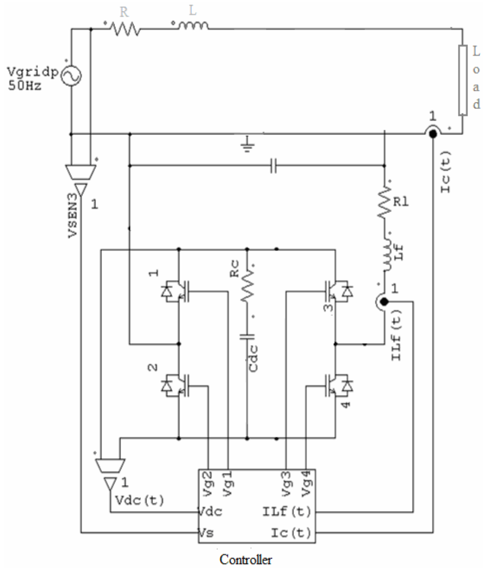


Fig.2. Proposed circuit configuration

3. CONTROL STRATEGY FOR THE SYSTEM

The control strategy has mainly three sections, as follows

1. Extraction of harmonic or reactive current from load current
2. Generation of Unit Vectors from Grid Voltage
3. Reference voltage for PWM generation

3.1)Control block of STATCOM

The main control block diagram is shown in the figure 3.The required data's are sensed d from dc bus voltage Vdc, grid voltage Vg, load current ic(t)and inverter current. iL(t), and corresponding unit vectors is generated which is in phase and 90^o phase shift sine and cosine waves respectively. With respect to these voltage vectors the pulse is generated.

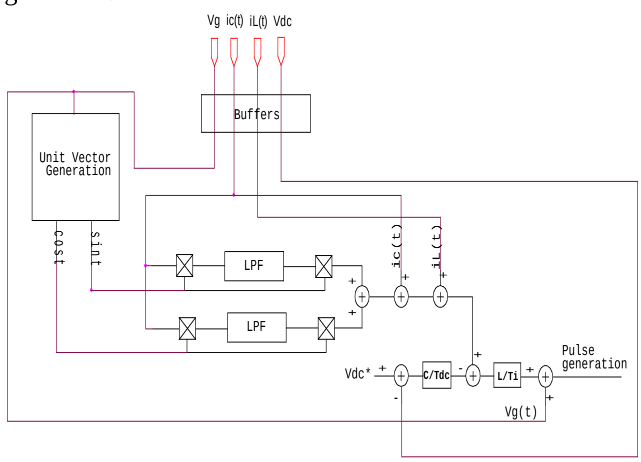


Fig.3. Control block of the Statcom controller

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3.2) Unit Vector Generation

There is no backup or battery for the system. Taking voltage from the grid and using it for compensation but grid voltage cannot be pure sinusoid, it consist of harmonics and therefore corresponding to grid voltage the current cannot be generated. One method for PWM generation is creating truth table for grid voltage and then triangular comparison can be done, but the change in grid voltage affect the truth table. More the values in truth table more accurate will be the signals but then memory required increases therefore a strategy known as Unit vector generation is adopted.

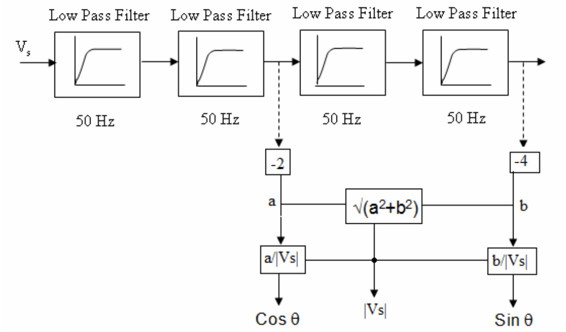

Fig.4 Block diagram for unit vector generation

In this method corresponding voltage is generated whose magnitude is always unity. Fig.4 shows the block diagram for unit vector generation in which the peak value of the grid voltage is sensed by sensing the zero crossing of the cosine wave (i.e. 90^o phase lag with the grid voltage.). Each low pass filter has 45^o phase difference which create cosine and in phase component.

3.3) Harmonic current generation:

Let us assume that unit vectors are known and the direction of current from inverter to grid is taken as positive.

Let the grid voltage be

$$Vgrid = Vg * \sin \omega st \quad \ldots\ldots\ldots\ldots\ldots \quad (3.1)$$

Generalised Load current be

$$Iload = Io + IpSin\omega st + IqCos\omega st + Iharmonic \ldots(3.2)$$

$$Iharmonic = Iload - (Io + IpSin\omega st + IqCos\omega st) \ldots(3.3)$$

Where *Io*=dc component, *Ip*=peak of active current, *Iq*=peak of reactive current.

Figure 6 shows the diagram for generating the harmonic current that's required by load for compensation. The dc component can be neglected as it the low value and then the harmonic current is obtained by

$$Iharmonic = Iload - (IpSin\omega st + IqCos\omega st) \ldots(3.4)$$

The active part is obtained by multiplying by in phase component and the reactive part by phase lag component.

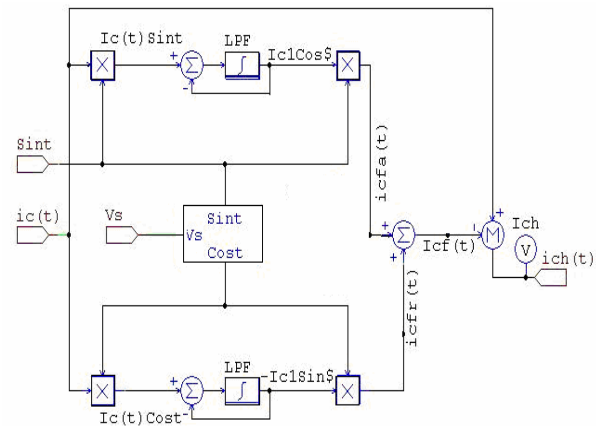

Fig 5 Block Diagram for Harmonic current extraction

Sint and Cost are generated unit vectors, icfa(t) and icfr(t) are active and reactive components respectively.

4. CONTROL ALGORITHM FOR SINGLE PHASE STATCOM

This section describes about the control of the proposed circuit. The flow diagram given explains the control of Statcom for compensating the harmonic current. The controller used is PIC microcontroller aiming for low cost system. The controller used here is PIC18FXXXX series.

The main concept is

1. First sense the DC bus voltage and make sure it's greater than grid voltage
2. Check if grid voltage within range, if it's within range then starts charging the capacitor and enter the Statcom Controller loop.

At the time of start, the condition of the controller is unknown there may be chance of starting the system with the previous conditions therefore the controller has to be reset first then the initialisation process takes place. After that the controller has to be started for that first the timers are started and then unit vector generation takes place according to the fig.4, in user interface the protection algorithm is given such that over current, overvoltage, initial start-up conditions are all satisfied according to the conditions and then if flag is set then Statcom controller is called after the conditions the ADC process takes place and the parameters are displayed through DAC and the process continues.

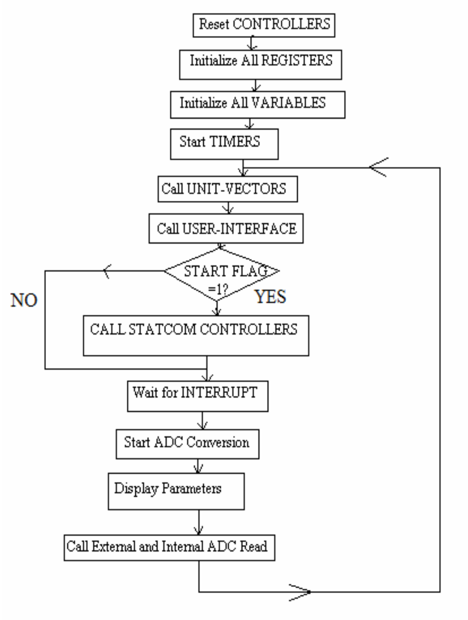

Fig.6. Flow diagram of proposed circuit

The PWM generation takes place according to the sensed value. The switching frequency given is 10 kHz and therefore controller has to complete one full cycle within 100μsec.

5. CONCLUSION

The basic principle and controller design of a STATCOM was studied in detail in the present work. The methods so far used were depending upon the synchronous reference frame, hysteresis band control and many more. In this paper a new control strategy was developed and the harmonic current compensation was made .On focusing the low cost factor the controller used is PIC microcontroller. The control strategy shows good results.

7. References:

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