SVC for Performance Improvement in Electrical Distribution System

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Abstract— Electrical energy is the key for developing the growth of nation. It also plays vital role in the phase of globalization currently there should some major issues while Transmission and Distribution (T & D) losses, power theft, poor power quality, fluctuations in power supply, etc. hence to solve this issue initiative and restructuring of power system is required. This paper present practical solution and various ideas for Electrical power system performance improvement at Distribution end. Static Var Compensator (SVC) is considered and design for regulation of power. The result shows active power improvement by minimizing reactive power. The overall effect of SVC is deliver maximum active or true power (Pmax) at consumer end with improve in power factor (p.f. or cosϕ), system efficiency and reduction in breakdown due to various reasons viz. overvoltage, overcurrent, low power factor, etc. Also the SVC operates with variable operating conditions.

Keywords— Maximum Power (Pmax), Power factor (p.f. or cosϕ), Power quality (PQ), Reactive power, Static var compensator (SVC), Thyristor controlled reactor (TCR),Transmission and Distribution (T & D) losses.

I. INTRODUCTION

With the fast and rapid development of Electrical power system, it has become both practical and economical aspects to implement various types of power electronics equipments and technology viz., static var compensator (SVC), FACTS controller, voltage source controller (VSC-base shunt and series compensator, static compensator (STATCOM), Unified Power Flow Controller (UPFC), static synchronous series compensator (SSSC), thyristor controlled series compensator (TCSC), Thyristor controlled phase shifters (TCPS), etc. are the available for various practical applications viz., contingency analysis, generation rescheduling, linear programming, load shedding, power system damping improvement, increase system oscillation stability, mitigation of voltage sags and swells, regulating the load bus voltage, other PQ issues, viz., load voltage harmonics, source current harmonics, unbalancing, etc. The purpose of all aforesaid devices use under steady state to obtain more benefits during their continuous operation as there have been varieties of control strategies.

Now days the main measure to keep power system a running with high quality, minimization of reactive power is primitive. But complexity of network and diversity of electrical equipment, electrical power system becomes a complex nonlinear system and therefore it difficult to set precise mathematical models for power system. So satisfactory controlling results with justification cannot be archive by using any traditional controlled strategy.

A detailed study of electrical power system and its performance mainly depends upon PQ. Hence reactive power compensation is the main task because afterword transmission losses, line breakdown, leaking and loss of power, over loading of lines, etc. practically minimizes and hence improvement in PQ, power reliability, transmission efficiency with contingency reduction takes place.

In this paper it has been recognize that Electrical distribution systems are incurring large losses as the loads are wide spread, inadequate reactive power compensation facilities and their improper control. A comprehensive static VAR compensator consisting of capacitor bank in five binary sequential steps in conjunction with a thyristor controlled reactor of smallest step size is employed in the investigative work. The work deals with the performance evaluation through analytical studies and practical implementation on an existing system. A fast acting error adaptive controller is developed suitable both for contactor and thyristor switched capacitors. The switching operations achieved are transient free, practically no need to provide inrush current limiting reactors, TCR size minimum providing small percentages of non-third harmonics, facilitates step less variation of reactive power depending on load requirement so as maintain power factor near unity always. It is elegant, closed loop microcontroller system having the features of self-regulation in adaptive mode for automatic adjustment. For this the suitable controller developed, which is new adoptable to both LT & HT system and practically gives reliable performance 11kV/ 440V with suitable capacity distribution three phase transformer, 50Hz, Dy, Dd connection.

II. EASE OF USE

A. The structural and operational features of SVC

In general, the SVC is made up of fixed capacitor (FC) or switched capacitor (SC) and thyristor controlled reactor (TCR). For distributed electrical power system, the dynamic load with reactive power changing in large range, the use of SC+TCR can improve compensation precision, in such device, the control of capacitor switching and trigger/ firing angle of TCR is the key for good compensating result.

The SC+TCR can improve with the microcontroller 89C51 interface with LCD display for this purpose analog to digital convertor (ADC) is inserted in the Fig. 1

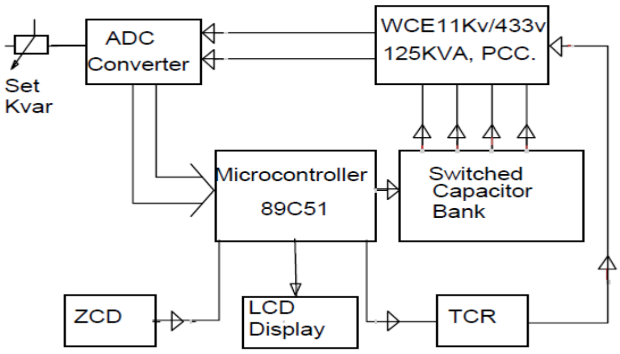


Fig. 1 Structure of Schematic Diagram of Digital SVC

B. About methodology

It is well documented in literature and through public discussions at various levels that a substantial power loss is taking place in our low voltage distribution systems on account of poor power factor, due to inadequate reactive power compensation facilities and their improper control. The expansion of rural power distribution systems with new connections and catering to agricultural sector in wide spread remote areas, giving rise to more inductive loads resulting in very low power factors. Thus there exists a great necessity to closely match reactive power with the load so as to improve power factor, boost the voltage and reduce the losses.

In addition a thyristor controlled reactor of the lowest step size is operated is conjunction with capacitor bank, so as to achieve continuously variable reactive power. Besides the enhancement transformer loading capability the shunt capacitor also improves the feeder performance, reduces voltage drop in the feeder & transformer, better voltage at load end, improves power factor, improves system security with enhanced utilization of transformer capacity, gives scope for additional loading, increases over all efficiency, saves energy due to reduced system losses, avoids low power factor penalty, and reduces maximum demand charges.

1) Thyristor Controlled Reactor (TCR)

A thyristor controlled reactor is usually a three-phase assembly, normally connected in a delta arrangement to provide partial cancellation of Harmonics. Often the main TCR reactor is split into two halves, with the thyristor valve connected between the two halves. This protects the vulnerable thyristor valve from damage due to flashovers, lightning strikes etc.

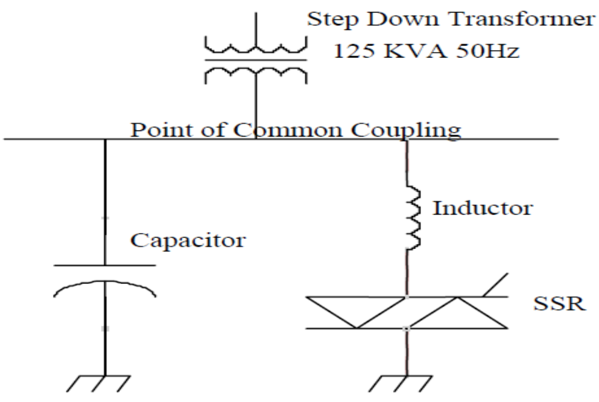


Fig. 2 FC-TCR Scheme

2) Thyristor Binary Compensation (TBC)

The simplest configuration for an advanced shunt compensator essentially consists of the thyristor switched capacitor bank with each capacitor step connected to the system through a thyristor switch. In the proposed paper capacitor bank step values are chosen in binary sequence weights to make the resolution small. An analysis of switching transients indicates that transient free switching can occur if the following two conditions are met.

a) The thyristor is fired at the negative/positive peak of voltage, and/or

b) Capacitor is pre-charged to the negative/positive peak voltage.

The configuration for five capacitor bank steps in binary sequence weight with thyristors switch is shown in Fig. 3.

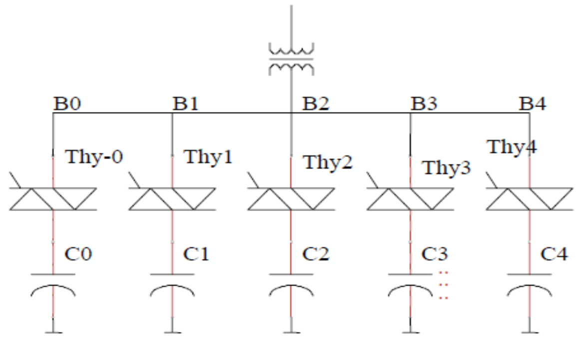


Fig. 3 Thyristor Binary Compensation Scheme (TBC)

III. HARDWARE IMPLEMENTATION

PIC MICROCONTROLLER

PIC (usually pronounced as "pick") is a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Peripheral Interface Controller. The first parts of the family were available in 1976; by 2013 the company had shipped more than twelve billion individual parts, used in a wide variety of embedded systems.

Early models of PIC had read-only memory (ROM) or field-programmable EPROM for program storage, some with provision for erasing memory. All current models use flash memory for program storage, and newer models allow the PIC to reprogram itself. Program memory and data memory are separated. Data memory is 8-bit, 16-bit, and, in latest models, 32-bit wide. Program instructions vary in bit-count by family of PIC, and may be 12, 14, 16, or 24 bits long. The instruction set also varies by model, with more powerful chips adding instructions for digital signal processing functions.

The hardware capabilities of PIC devices range from 6-pin SMD, 8-pin DIP chips up to 144-pin SMD chips, with discrete I/O pins, ADC and DAC modules, and communications ports such as UART, I2C, CAN, and even USB. Low-power and high-speed variations exist for many types.

The manufacturer supplies computer software for development known as MPLAB, assemblers and C/C++ compilers, and programmer/debugger hardware under the MPLAB and PICK it series. Third party and some open-source tools are also available. Some parts have in-circuit programming capability; low-cost development programmers are available as well as high-production programmers.

PIC devices are popular with both industrial developers and hobbyists due to their low cost, wide availability, large user base, extensive collection of application notes, and availability of low cost or free development tools, serial programming, and re-programmable Flash-memory capability.

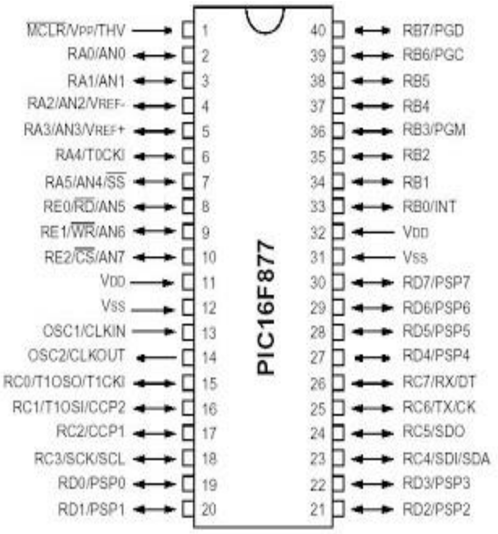


Fig. 4 Pin Diagram of PIC16F877

DESIGN OF POWER SUPPLY

Power supply is an integral parts a vital role in every electronic system and hence their design constitutes a major part in every application. In order to overcome mal-operation which results due to fluctuations in the load and discontinuity in the supply proper choice of power supply is necessary.

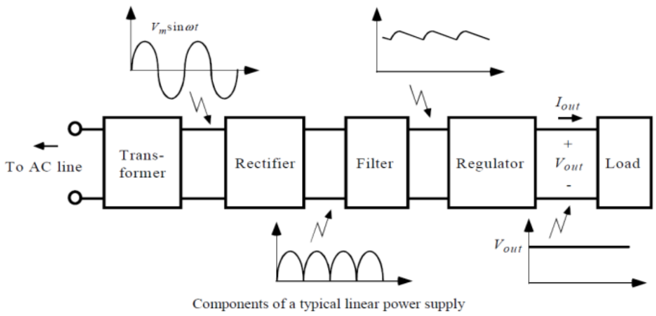


Fig.5 Block diagram of power supply

VOLTAGE REGULATOR

Voltage regulator is a device, which provides a stable and a constant D.C. voltage irrespective of the change in the load current. Stable and constant DC output voltage necessities the usage of voltage regulator in this power section.

The series 78 regulators provide fixed regulated voltages from 5 to 24 V. Figure shows how one such IC, a 7805, is connected to provide voltage regulation with output from this unit of +12V DC. An unregulated input voltage Vi is filtered by capacitor C1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated + 12V which is filtered by capacitor C2 (mostly for any high-frequency noise). These limitations are spelled out in the manufacturer's specification sheets.

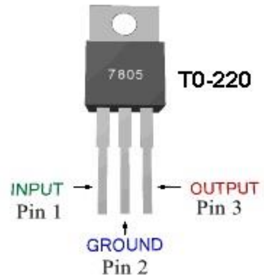


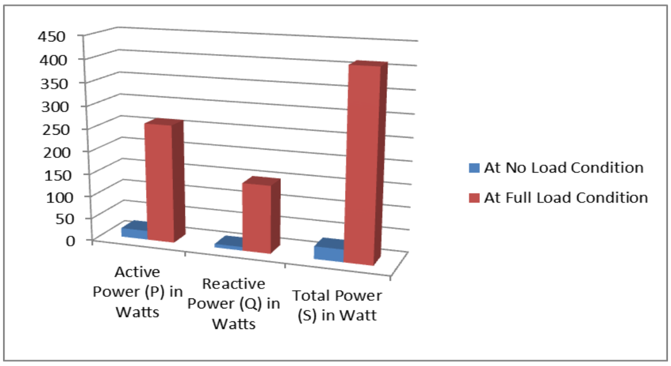
Fig. 6 Voltage Regulator 7805

IV. EXPERIMENTAL RESULTS

All the above components are fabricated, tested and implemented at power consumption calculation for a single phase, 1 kW capacitor start induction run (CSIR) induction motor at 270 volts. The load was increased from no load condition to full load condition. It is observed that without controller p.f. varies from 0.4 to 0.79 while with developed static Var compensator, it was in between 0.55 lag to 0.92 lag. The details of the system performance with and without SVC are given in the Table I and II also combine performance during the full load condition given in Graph III respectively.

Load Condition	V in Volt	I in Amp	Active Power (P) in Watts	Reactive Power (Q) in Watts	Total Power (S) in Watt	cosΦ
No Load	240	0.4	20	8	28	0.4
Full Load	226	1.47	262	150	412	0.79

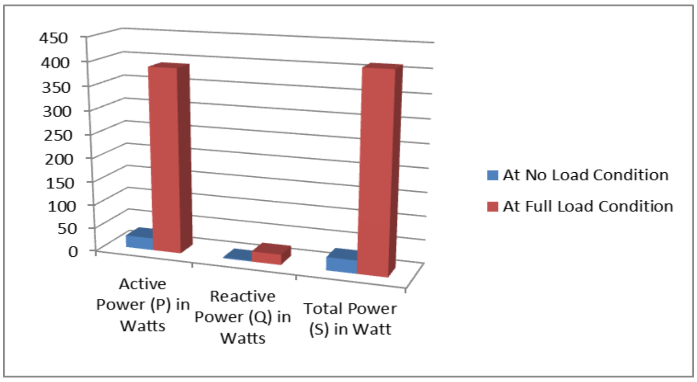
Table: - 1 Without Digital SVC Controller



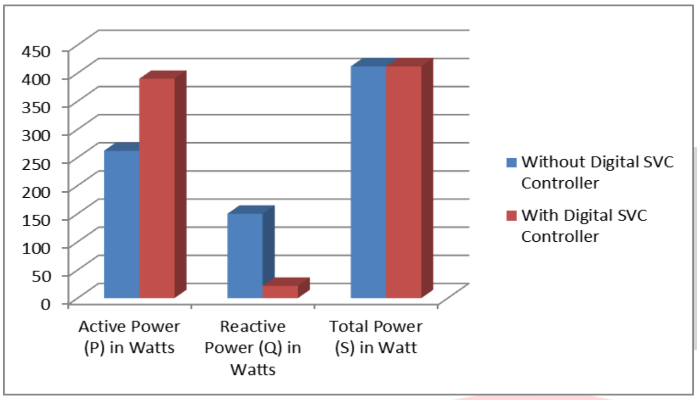
Graph: - 1 Without Digital SVC Controller

Load Condition	V in Volt	I in Amp	Active Power (P) in Watts	Reactive Power (Q) in Watts	Total Power (S) in Watt	cosΦ
No Load	240	0.4	26	2	28	0.55
Full Load	225	1.48	390	22	412	0.92

Table: - 2 With Digital SVC Controller



Graph: - 2 With Digital SVC Controller



Graph: - 3 Combine performance

ECONOMIC JUSTIFICATION:

In the college campus installation state electricity boards has been imposing penalties due to poor power factor and excessive maximum demand. The scheme that is proposed eliminates these penalties and college can avail the benefits of incentives by maintaining the power factor nearer to unity. On an average the college is paying the penalties to the tune of Rs. 8000/- per month. The overall installation cost of the proposed scheme is of around Rs. 0.8/- lakh. Monthly savings due to incentives offered by state electricity boards for improvement in the power factor from .96 to unity p.f. is of 5 to 6 % of the monthly bill. The average monthly bill is around 5 lakh. Hence straight way monthly incentives obtained are of around Rs. 17,000/-. Also incentives are obtained due to reduction in maximum demand charges approximately Rs. 3000/-.

Therefore the payback period comes out to be of 6 months for the system installed.

V. CONCLUSION

Power quality is totally depends upon reactive power. Also breakdown in Transmission and Distribution take place amount of reactive power. In this paper, reactive power compensation through conventional technics as well as application oriented technic with necessary hardware frame working is illustrated. The current digital SVC controller proves practically presence of reactive power and accordingly the technic to minimize it. The results were also mention, it is clear that the current technic is for improving power quality with reduction in reactive power accordingly power factor of the load is improving.

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