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MICROCONTROLLER BASED CONVERSION OF SOLAR PV MODULE DC VOLTAGE TO AC USING OCTOCOUPLER DRIVING THE GATE CURRENT OF 3 PHASE INVERTER

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ABSTRACT

In this paper the total work is done experimentally in which Solar PV DC Voltage has been converted into AC. In this Proposed work Microcontroller Plays a very vital role as 3 Phase Inverter needs to be given pulses and for this we have used a 725mA 1ϕ Transformer and the Transformer output which is AC is Converted in DC and this DC is given to the Series Voltage Regulator LM7805 and then the output of this Voltage Regulator is Fed to Microcontroller. Now, the Microcontroller Output is given to TLP250, which is an Octocoupler which drives the Gate Current of 3ϕ Inverter and Pulses is given to the 3 Phase Inverter. Now connect the Solar PV Module to Input of Inverter in which gets Output of 3 Phase Inverter in 120° mode & the Phase Voltage obtained is in the form of Quasi Square Wave.

1. INTRODUCTION

Photovoltaic Module, through photoelectric experience, produce electricity in a nonstop electricity generation way. PV panels are completely silent, noise is not come on producing; as a result, they are a wonderful solution for city areas and for housing applications. Because of that solar power coincides within energy needs for cooling PV Modules can offer an useful solution to power demand peaks – specially in hot summer months where power insist is Peak.

A core of Processor, I/O programmable peripherals & Memory this are includes in a Microcontrollers. NOR flash is a Program Memo ry which is also frequently built-in on chip, as well as a characteristically tiny amount of RAM. Microcontrollers are designed fo r embedded applications, in dissimilarity to the microprocessors used in personal computers.

Microcontroller with Solar PV creates a vital role, Programming which is help to make pulses for Inverter means MOSFET, it is considered as a unipolar device and I n this implementation of experimental work uses N-Channel MOSFET because it gets electrons which is having high Mobility.

A. SYSTEM MODELLING

Transformer

According to the Proposed work here uses five Transformer having capacity of 725mA×1, 500mA×4. Transformer is a device which static by nature because of no rotating in it. So it is only work to transform Power from one circuit to another. In this case, 725mA is giving to Microcontroller for +5V supply and 500mA is applied for giving the supply to TLP250 Octocoupler.

Microcontroller

This is a low-power and having High-performance CMOS 8-bit microcontroller with 8K bytes of Flash programmable and erasable read one memory (PEROM). Atmel’s high-density nonvolatile memory technology is a technology which is used to construct this device and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out. The program memory to be reprogrammed in a system for that having permission from On-chip Flash, so the On-chip allows it.

Mosfet

It is a 14A, 500V, 0.4 Ohm, N-Channel Power MOSFET. This N-Channel enhancement mode silicon gate power field effect transistor is an advanced power MOSFET experimentally tested with designing also and guaranteed to survive in a particular level of power in the collapse avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, convertors of switching, drivers of Motor, drivers of relay, also with the drivers for high energy two way switching transistors having high Velocity and low gate drive power.

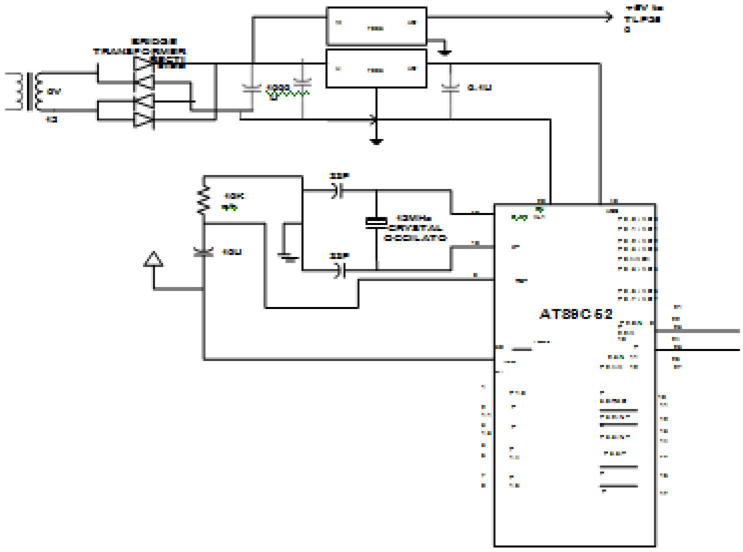
2. METHODOLOGY

For every Microcontroller whether it is AT89C51, AT89C52, whether it is AT89C20. For all the cases we need some standard condition, star connection at least power supply section which has been separately discuss where have a step down transformer and then gets 12V AC. 12V AC passes through a bridge rectifier and bridge rectifier gives pulsating DC. Pulsating DC is further filter, so getting a 12V DC here and 12V DC is passes through Voltage Regulator LM7805 and gets +5V DC supply here.

If it is to be operated directly from the battery then there is do not need to do supply as the Microcontroller needs +5V DC. Take 6V Battery and connected diode in series with solve the purpose of supplying +5V to the microcontroller 40 pins, 20 no. pin is always in negative(GND). The other connections are very standard where crystal which is connected at pin 19 & 18 and there is a 33pf capacitor 2 no. which are connected to the grounds. The RESET pin is necessary, to use the RESET pin with a capacitor which is connected to the positive terminal, the electrolytic capacitor positive terminal & negative terminal is goes to the RESET pin and negative terminal through a resistor is going to the Ground.

This circuit having a switch and call it a RESET switch & the functions are when the supply is switch on, that means whether through battery or through supply. When the supply is switch on, that capacitor from the positive supply starts conducting or charging so this point goes high initially.

After some times the charging current through the capacitor will stop because the charging will take place. The charging current will stop, once the charging current stop, then this point will remains at ground potential because this is in ground potential. So initially at the time of switch ON this point goes high after that is goes to ground that is negative, that is necessary for the program that is written here to starts from the beginning otherwise the program may starts from half. To ensure that the program starts from beginning this arrangement has been made, the RESET arrangement which is a very standard connection for all the microcontroller. Pin no. 31 is to be held that means it is connected to positive that is for the purpose if wish to program it while it is in the circuit then this particular pin use. Since programming it when it is externally when we take it out programming it bring it as per the manufacturer data sheet is required to be connected to positive point so pin 31 is connected to positive point so this are the standard connection.



In this proposed work the Solar PV DC Voltage is converted into AC by 3ϕ Inverter but the 3ϕ Inverter wants the pulses that is giving by TLP 250 which is an Octocoupler and its work is to drive the gate current of MOSFET. Proposed Hardware having 5 Transformer among them one is going to giving supply to Microcontroller and remaining 4 is giving supply to TLP250 circuit.

When the supply from 725mA step down Transformer step down capacity is 12V DC then by LM7805 regulator its convert it in +5V DC and this supply is going to the input of Microcontroller AT89C52 and another LM7805 regulator is giving to the TLP250 input for supply due to this inside on TLP250 LED is on and the photo transistor is on off. After that one 500mA×4 15V step down Transformer is giving the supply to 4 power supply capacitor.

After that among 4 power supply capacitor , three power supply capacitor which is passes through LM7815 and gets 15V DC at pin no. 8, and pin no.5 is ground and all 6 TLP250 getting +5V supply from LM7805 which is situated at Microcontroller and giving the symbol 'K' to pin no.2 applied to all 6 TLP250. Microcontrollers pin. no.21, 22, 23,24,25,26 is going to all 6 TLP250 at pin no.2 by 1KΩ resistor.

Among 5 transformers, one is for microcontroller, three is for three TLP250 and one Transformer is for three TLP250 because that remaining three TLP250 is common terminals for MOSFET.

Three TLP250's pin no. 6 and 7 is goes to A, B, & C of Power MOSFET with 1KΩ resistor and the remaining Three TLP250's pin no. which is a common because its pin no. 5 & 8 is gets common so only one transformer is sufficient to supply this remaining Three TLP250 and its output means pin no. 6& 7 is goes to the Common of MOSFET A', B' & C'.

So the Now that 4 Transformers for 4 Capacitor which is sufficient to giving supply to 6 TLP250 and now by LM7815 +15V DC output is having on TLP250 and TLP250 is capable to giving pulses to 3ϕ Inverter.

Finally, Solar PV module is giving input to 3ϕ Inverter and 3ϕ 120° mode output gets.

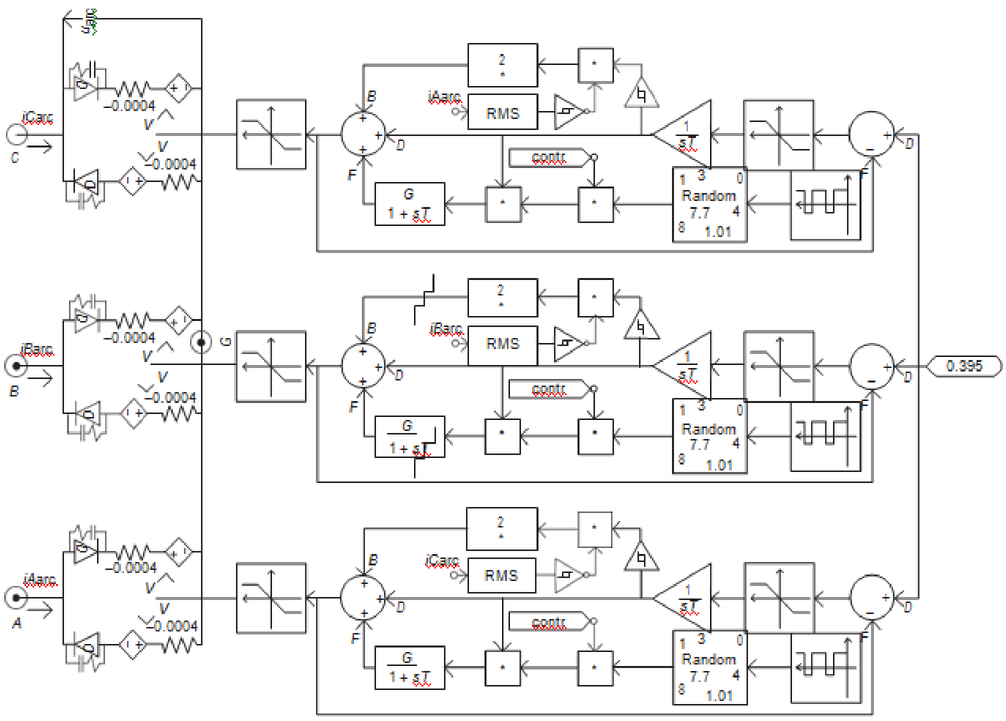


Fig. 2 Diagram of arc furnace model constructed using PSCAD components

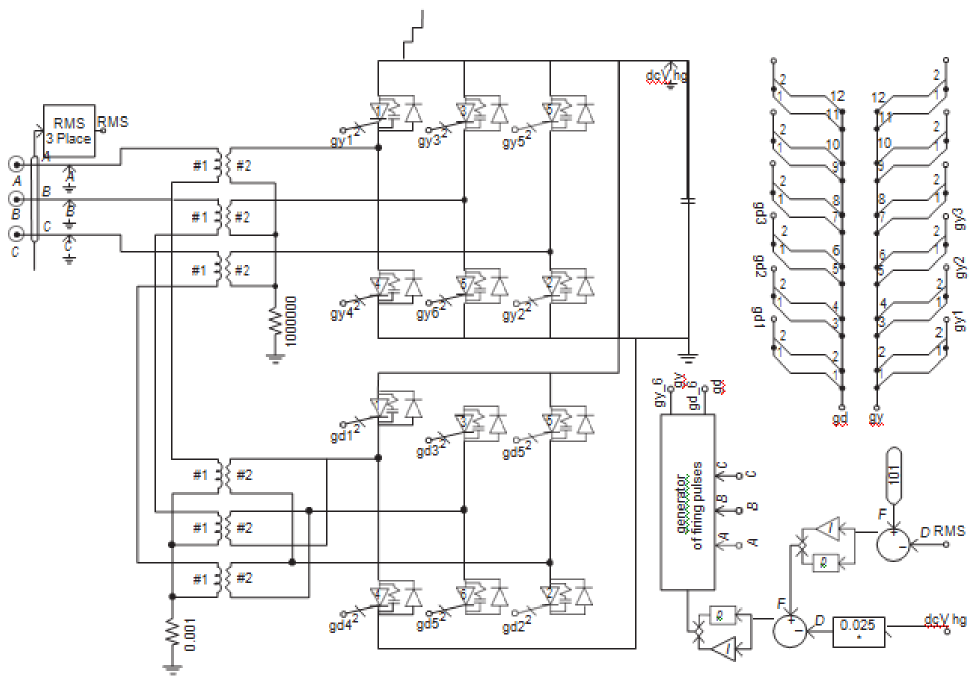


Fig. 3 12-pulse STATCOM diagram

For switching on and off. Synchronizing the valve switching to the AC system voltage was done using the PLL (three-phase PI-controlled phase-locked loop) element.

The control circuit was designed to control the magnitude of the inverter output voltages using the fundamental frequency switching method. Two signals are formed, which are then passed to the PI regulator: the first one comes from the capacitor voltage and the second one comes from the AC voltage measured at the PCC. With suitable parameters of PI regulators, this control enables both stabilization of voltage at the PCC and compensation of the negative sequence component of the voltage vector. The control circuit output is passed on to the firing block. The methods of control and firing pulses generation are the same in both types of STATCOM units, adjusted only to the appropriate number of thyristors.

The proposed structure of the control circuit is original and can be applied for compensation of any unbalanced and variable load.

Power quality assessment

As has already been mentioned, the STATCOM controller is designed to ensure the adequate power quality at the PCC. Both supply voltage level and waveform shape characterize the quality of supply. The quality assessment should be made according to international and native standards and regulations, which define voltage character-istics at the supply terminals, give their admissible values and specify a method for their measurement and evaluation.

The authors elaborated a special module for power quality assessment, based on the rules described in the standards . From the measured instantaneous voltage signals, the following power quality indexes are determined in it:

- voltage RMS,
- unbalance factor,
- THD factor and harmonic spectrum,
- IEC flicker meter signal.

The module consists of two blocks, including components from PSCAD library, which are shown in Figs. 4 and 5. In the first block, which is the voltage parameter meter, the on-line frequency scanner and harmonic calculator were used, both based on on-line fast Fourier transformation. The second block, called the IEC flicker meter, is the digital realization of the system described in details in the Standard. .Its first part is a voltage adaptor, which allows reduction of the influence of the very slow voltage variations on measurement results. The next part represents a combined reaction of the bulb–eye–brain channel to supply voltage fluctuations. The output signal of the flicker meter

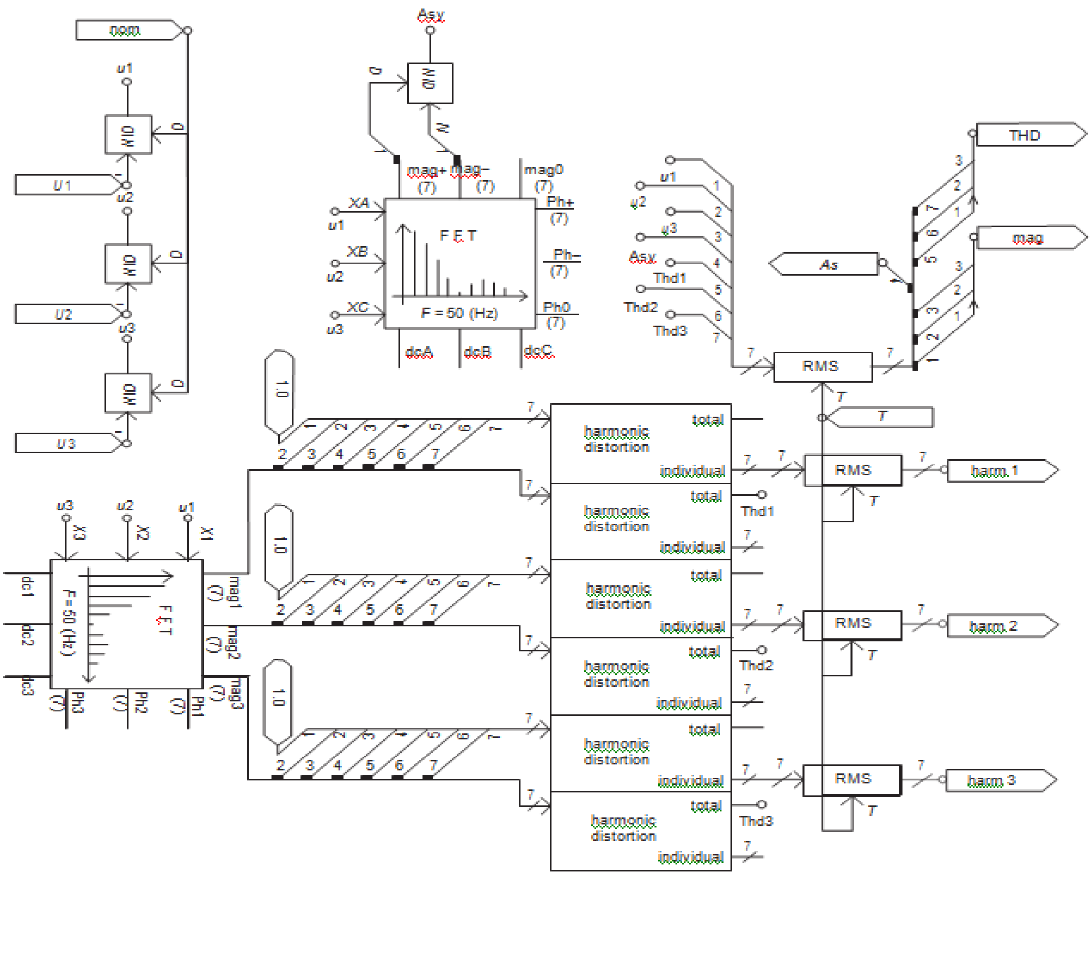


Fig. 4 Voltage parameter measurement module constructed using PSCAD components

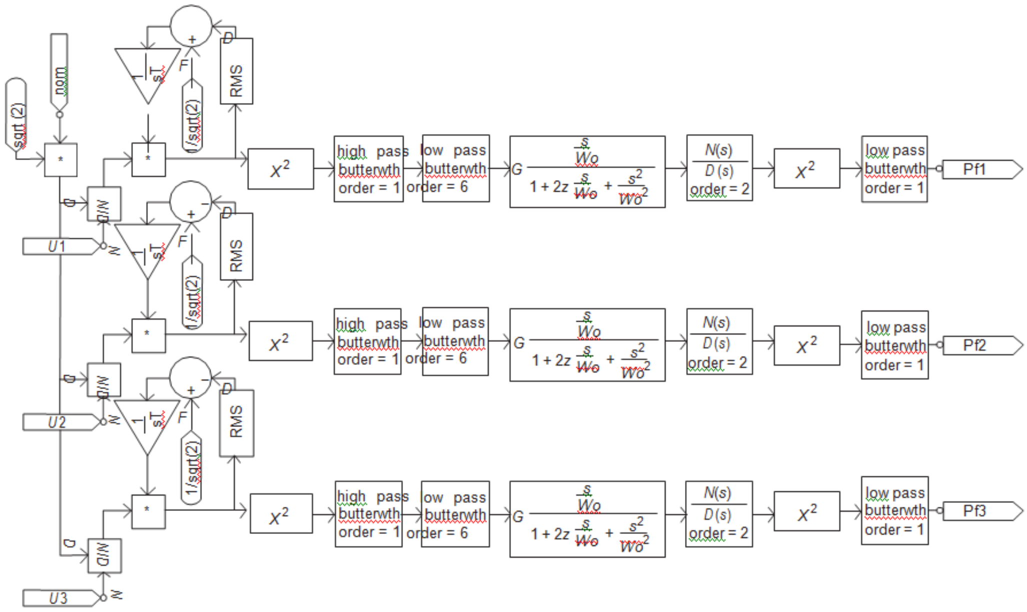


Fig. 5 Flicker meter block constructed using PSCAD components

blok is the basis for assessment of the flicker phenomena, asdescribed in .

3. SIMULATION

The effectiveness of compensation was investigated for anarc furnace of 80 MW connected to the 30 kV substation through the transformer of 120 MVA. The substation was supplied from the 220 kV grid through the distribution transformer of the following data: rated power of 120 MVA and positive sequence leakage reactance of 0.105 p.u. The short-circuit power at HV side of the transformer was 3800 MVA. Both phases of the arc operation: melting and refining, were taken into consideration. Selection of parameters of the STATCOM units and settings for their control circuit was done by simulation with the target function to obtain all power quality indexes in the permissible range at minimum compensator power for every load operation condition. This approach seems to bethe most effective for systems with dominating nonlinearelements.

In each simulation case the power quality indexes wereassessed. The assessment method was analogous to the onegiven in , but applied for the other timescale. Averagingtime was arbitrarily decreased from 10 min to 0.2 s and the measurement period from 1 week to 10s.

The following quantities were determined, averaged, andrecorded:

- voltage changes, according to the formula:

$$\Delta U = |U - 100\%| \quad (1)$$

where U is a percentage value of the voltage at the PCC,

- total harmonic distortion factor THD,
- Imbalance factor K_{2U}.

Moreover, the IEC flicker meter signal was recorded on-lineduring simulation to assess flicker phenomena.

The melting operation of the arc furnace was selected forpresentation, because this phase of work offers the worse working conditions for the STATCOM units.

Figures 6 and 7 show total active and reactive powers forboth the arc furnace and compensator and the resultant powers of the supplying network. Voltage changes at the PCC when the arc furnace operates uncompensated and forthe case of furnace operation compensated with the STATCOM system are presented in Fig. 8. Comparisonof operation of both 12-pulse and 24-pulse STATCOM units is shown in Fig. 9 in the form of systematic graphs. Similarly, Figs. 10 and 11, and also Figs. 12 and 13 allow comparison of disturbances produced by the load with and without the STATCOM compensation in terms of imbalance and flicker. The figures enumerated demonstrate

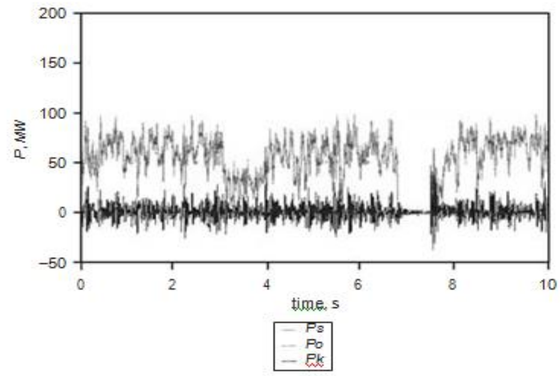


Fig. 6 Total active powers for arc furnace (Po), STATCOM controller Pk and network Ps

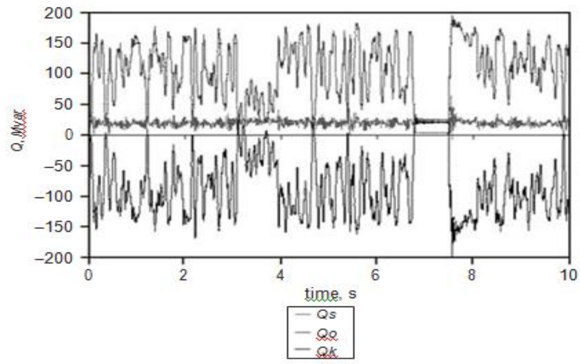


Fig. 7 Total reactive powers for arc furnace (Qo), STATCOM controller Qk and network Qs

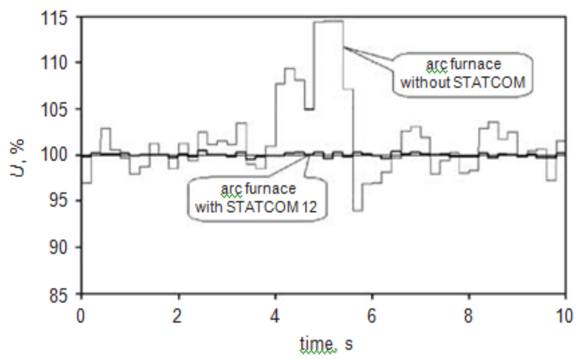


Fig. 8 Voltage changes at PCC

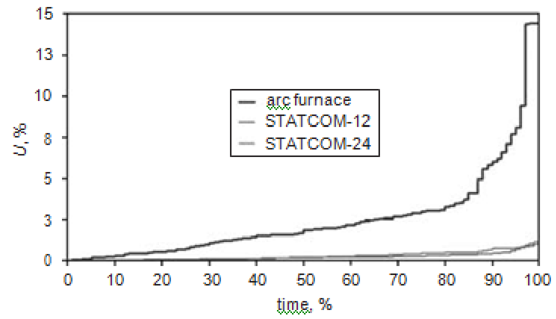


Fig. 9 Systematic graphs of voltage changes produced by arc furnace and compensated by STATCOM units

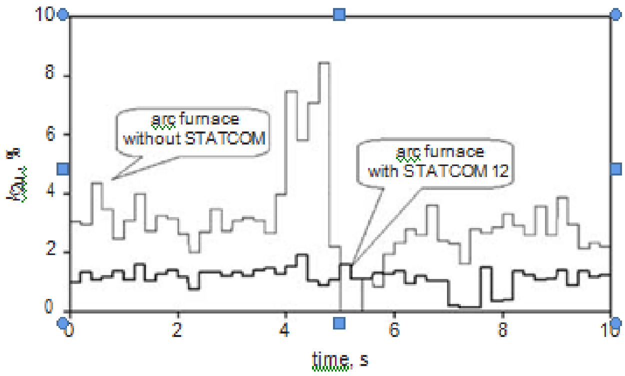


Fig. 10 Imbalance factor at PCC

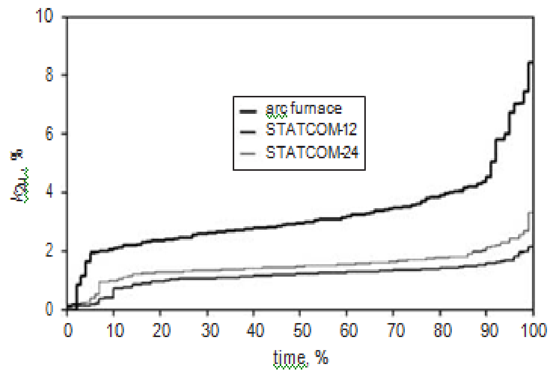


Fig. 11 Systematic graphs of unbalance factor during uncompen- sated furnace operation and operation compensated by STATCOMunits

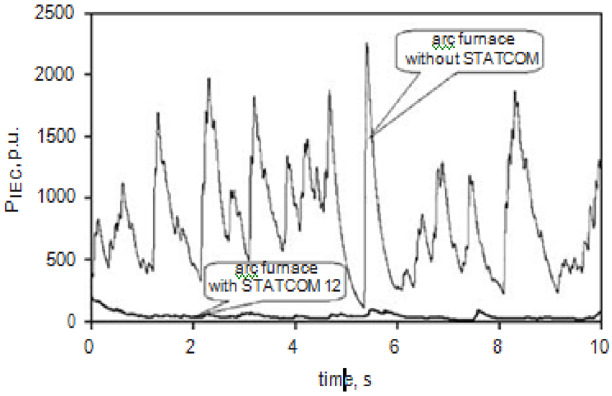


Fig. 12 Flicker meter signal at PCC

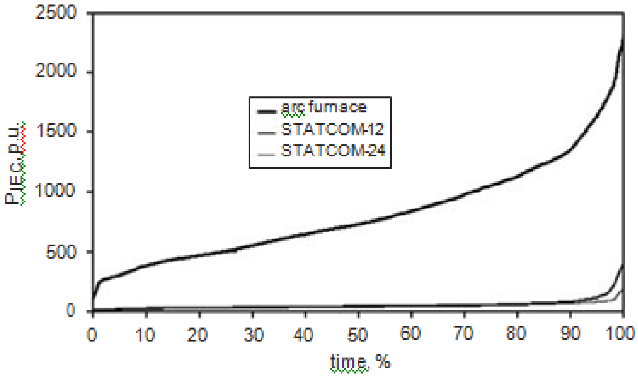


Fig. 13 Systematic graphs of flickermeter signal for case of uncompensated furnace operation and operation compensated by STATCOM units

the effectiveness of the proposed STATCOM control circuitin terms of compensation of voltage fluctuation and imbalance in the PCC. Figures 14 and 15 prove that the STATCOM units amplify the voltage distortion and therefore may require a special filtering on the AC side of

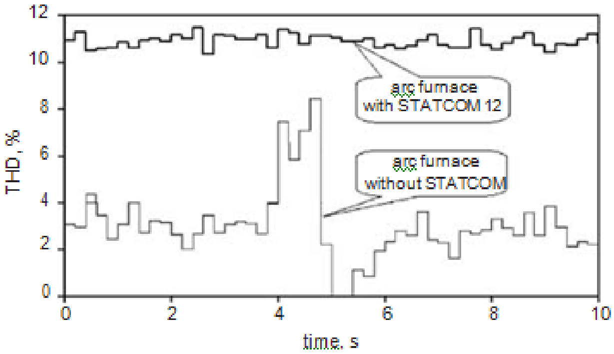


Fig. 14 THD factor at PCC

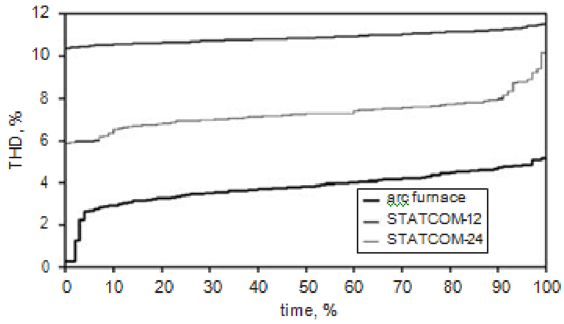


Fig. 15 Systematic graphs of THD factor for case of uncompensated furnace operation and operation compensated by STATCOM units

the converter transformer. Comparison of both STAT- COM unit controllers in terms of harmonics production isshown in Fig. 16. Another way of reducing harmonics may be by changing the control method, (e.g. using the PWM, pulse width modulation technique). These possibilities will be investigated in future.

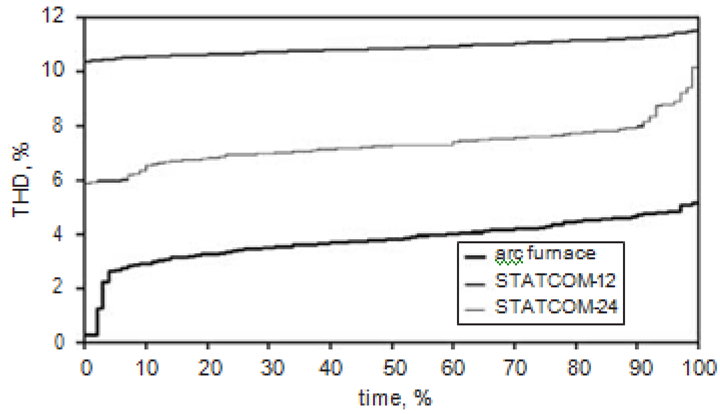


Fig. 15 Systematic graphs of THD factor for case of uncompen- sated furnace operation and operation compensated by STATCOMunits

4. CONCLUSIONS

The results presented in the paper prove that the STATCOM is an effective solution for reducing voltage fluctuations caused by disturbing loads and may be applied for power quality improvement. In particular, flicker reduction in this case is extremely good. However, the level of harmonics produced by the controllers is relatively high. Increasing the number of pulses in a multi-pulse configure- tion reduces the harmonics contents, as was proved in thispaper for the case of 12- and 24-pulse STATCOM units considered.

For examination of electrical power networks the methodof simulation can be applied effectively and PSCAD/ EMTDC has been recognized as a good tool. A model ofthe considered network was constructed using componentsthat are available in the program library. Some modules,especially the arc furnace, converter transformers for the 24-pulse unit, and the PQ assessment module, are original and were worked out by the authors. The simulator allows evaluation of the power quality at the PCC according to the EN 50160 Standard. It may also be useful for studies and transient analysis of power networks with nonlinear andunbalanced loads.

The authors applied the simulation method to selectingparameters and settings of the STATCOM controllers. With this approach it is possible to select the controller for agiven network environment, which will ensure power

quality indexes at the PCC at the required level forminimum compensator power. The simulation method is especially useful and convenient for nonlinear systems.

The STATCOM system requires self-commutated con-verters to be used. Up to the present day, they have been theGTO thyristors, rather expensive and inconvenient in practical applications. These disadvantages have been overcome in IGCT technology. IGCT are characterised by short switching time, small losses, and high reliability.They do not need snubbers. Their ratings are in the range of

4.5 kV peak and 4.0 kA turn-off , which make it possibleto construct systems of up to a few hundred MVA over the full range of MV. It should be mentioned that the design of STATCOM systems is more compact, which eventually leads to a significant reduction in equipment size and installation costs. It is assessed that the costs of power electronic equipment using the IGCT technology may be reduced by approximately 35%. Good switching abilities makes it useful for applying the PWM control. These favourable features of IGCT thyristors allow the assumption that the STATCOM compensator will becomea good solution for power quality improvement, commonlyused in practice.

ACKNOWLEDGMENT

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