DYNAMIC VOLTAGE RESTORER (DVR) FOR VOLTAGE SAGS AND SWELLS COMPENSATION - AN OVERVIEW

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Abstract

Power Quality is an essential concern in the modern power system that can affect consumers and utility. The integration of renewable energy sources, smart grid systems and extensive use of power electronics equipment caused myriad problems in the modern electric power system. Current and voltage harmonics, voltage sag, and swell can damage the sensitive equipment. These devices are susceptible to input voltage variations created by interference with other parts of the system. Hence, in the modern age, with an increase in sensitive and expensive electronic equipment, power quality is essential for the power system's reliable and safe operation. Dynamic Voltage Restorer (DVR) is a potential Distribution Flexible AC Transmission System (D-FACTS) device widely adopted to surmount the problems of non-standard voltage,current, or frequency in the distribution grid. It injects voltages in the distribution line to maintain the voltageprofile and assures constant load voltage. The simulations were conducted in MATLAB/Simulink to show the DVR-based proposed strategy's effectiveness to smooth the distorted voltage due to harmonics. A power system model with a programmable power source is used to include 3rd and 5th harmonics. The systems' response for load voltage is evaluated for with and without DVR scenarios. It has been noted that the proposed DVR based strategy has effectively managed the voltage distortion, and a smooth compensated load voltage was achieved. The load voltage THD percentage was approximately 18% and 23% with insertion 3^{rd} and 5^{th} harmonics in the supply voltage, respectively. The inclusion of the proposed DVR has reduced THD aroundless than 4% in both cases.

INTRODUCTION

The quality of electric power becomes an important issue because the electricity that is channeled to the consumer must be really good quality. Disturbances to the electrical system can occur at any time and can't be avoided. The disturbances can come from both internal and external of the power plant system and can cause the problem of voltage drop. Voltage drop can impact the power quality of the power system.

Power quality problems are: voltage drop, flicker, voltage imbalance, disconnection and harmonic problem. Sensitive equipment such as computers, releases, programmable logic controllers (PLC), electric motor drivers and so on, are extremely sensitive to voltage changes caused by interference with other parts of the system[3]. The voltage drop is defined as a decrease in the rms value of the voltage that can occur from 10 ms to 1 min with the depth of the falling voltage of 0.9 pu to 0.1 pu of a nominal pu based on the IEEE standard 1159-1995 .

In the electrical system of PT. DSS power plant, often there is a decrease of voltage andone of the causal factor is a short circuit that resulted in the performance of motor drivers on the mills in generator unit 6. In this research will be modeling three-phase system that experienced a decrease in voltage, from the results modeling will be analyzed the voltage drop recovery that occurs with the sensitive load to be protected by the DVR

from the effect of the voltage drop, so that a large pattern of DC PWM inverter voltage required by the DVR in accordance with the needs of sensitive load to be protected.

Objectives of the work

For an economic operation of power system power quality should be maintained properly. Voltage sag/swell has been concerned as major power quality issue. The main objectives of this project are:-

1. Detection of voltage sag/swell in the power system network.
2. To mitigate the power quality issue using DVR and its behavioural study.
3. To select the best suitable control technique for DVR.
4. To control the device in order to obtain desired performance.

Voltage sag/dip:

The voltage sag or dip can be stated as decrease in nominal voltage level by 10-90% for short duration for half cycle to one minute as shown in fig. 1. Sometime, voltage sag last for long duration such prolonged low voltage profile referred as 'under-voltage'. Voltage sag is further divided in three categories: instantaneous, momentary and temporary sags respectively.

Voltage sag are mainly caused due to occurrence of faults in power system, overloading of the electrical network and starting current drawn by heavy electrical loads like motors and refrigerators.

Voltage sag in power system network results in failure of relays and contactor, dim light and fluctuating power.

Voltage Swell:

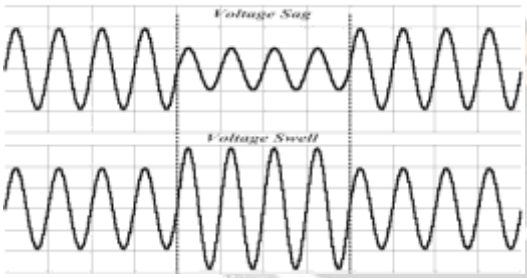
Voltage swell can be stated as voltage rise by 10-80% of normal value for duration of half cycle to one minute as shown in fig.2. Likewise voltage sag, prolonged high voltage profile is referred as 'over-voltage'. Voltage swell is subdivided as:

i. Instantaneous swell

ii. Momentary swell

iii. Temporary swell

Fig. 1



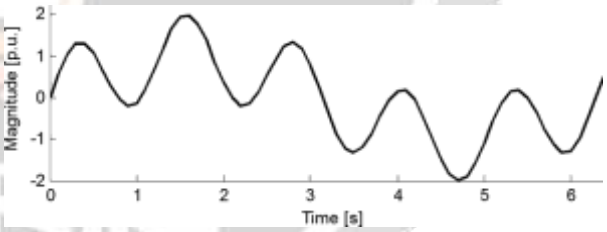


Fig. 2

DVR

DVR is a power electronic switching device which is connected in series
to the load voltagebus to inject a dynamically controlled voltage. This voltage can eliminate effects of fault of voltage bus on a sensitive load.

DVR is equipment used to recover a voltage or improve the voltage quality on the load side and its position is mounted in series between the source and the load. DVRs are coupled in series with distribution systems to protect sensitive equipment against the occurrence of voltage drops. The basic function of the DVR is to detect the occurrence of voltage drops that occur on the power system channel, and then inject the voltage to compensate for the voltage drop that occurs. Therefore the DVR is placed close to the sensitive load that is protected.

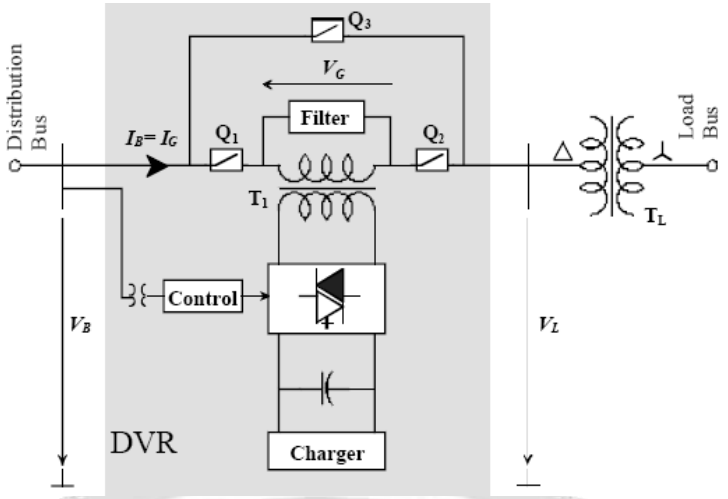


Fig.3

The DVR works depending on the type of interference or an event occurring in the system, generating the injected voltage obtained from the DC energy storage unit and then converted to AC voltage by the voltage source inverter (VSI) . To set the controller on the DVR is used dq0 transformation or Park transformation. The dq0 method will provide information on the depth of the voltage drop and the phase shift with the starting point and end point of the voltage drop. The transformation process from three phase system to dq0 system is shows at Equation

BLOCK DIAGRAM

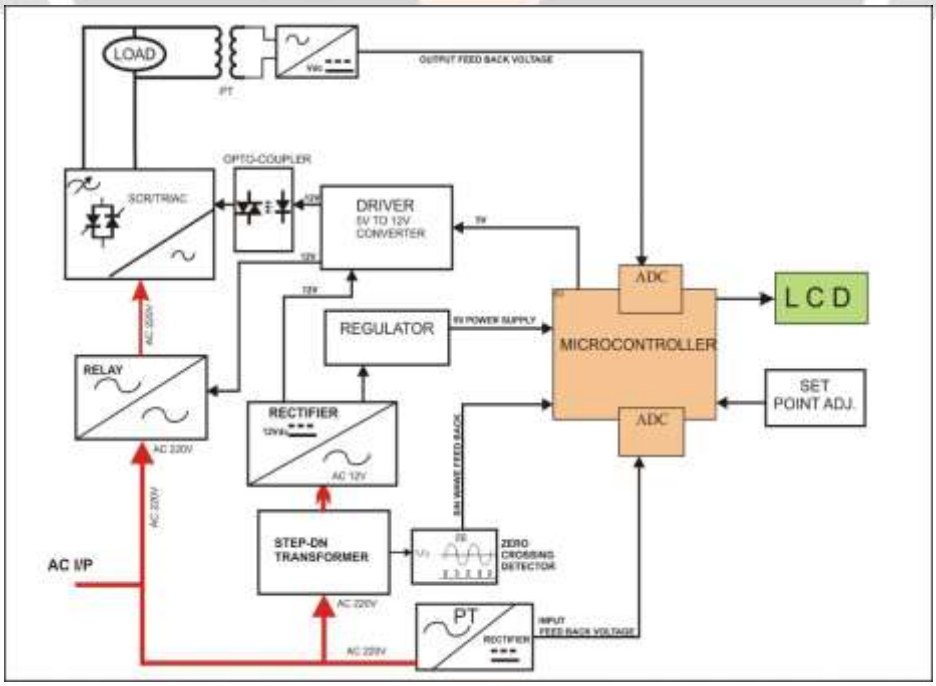


Fig 4

Detail of Components

AT89s52 micro-controller

The whole processing of the device is done by a microcontroller. The micro-controller 89s52 is a small but powerful micro-controller from Microchip .The AT89S52 is a low-power, high performance CMOS 8-bit microcontroller with 8Kbytes of in-system
programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pinout. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory
programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful micro-controller which provides a highly-flexible and costeffective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector twolevel interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Powerdown mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

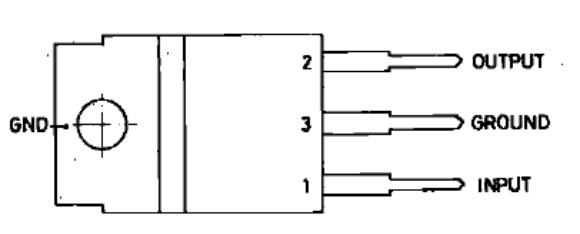


Fig. 5

Power supply circuit

The entire electronics component such transistor, integrated circuits, etc generally requires DC for their operation. So AC supply is then stepped down. Now this stepped down AC is converted to DC supply by rectification process .there may be some ripples coming out of Power supply circuit The entire electronics component such transistor, integrated circuits, etc generally requires DC for their operation. So AC supply is then stepped down. Now this stepped down AC is converted to DC supply by rectification process .there may be some ripples coming out of rectifying unit is bypassed by connecting the capacitor in parallel. Then 12v supply given to the LM7805 regulator. Now as microcontroller, LCD module, relays and other certain ICs requires 5V DC supply for their operation we need a regulated uninterrupted 5V DC supply. This block involves production of 5V DC supply for whole circuit.

Every circuit requires power for its operation. Here we require +5v dc to operate Micro-controller, Relays, and certain ICs. The supply voltage of 230v ac is step downed to 12v by using the step-down Transformers. As the circuit requires only the dc supply the in fed ac is converted to dc by using the rectifying unit. The rectifying unit consists of bridge rectifiers comprising diodes for rectification Purpose. Any of the ripples coming out of the rectifying unit is bye passed by connecting the Capacitor in parallel. As the microcontroller circuit requires only +5v dc supply, the outputs is further diminished by the regulator (LM7805) for accurate +5v to the micro-controller circuit. The capacitor is connected in parallel for suppressing the ripples.

ZERO CROSSING DETECTOR

This is used to generate a sync pulse related to the AC voltage phase angle often used in power control circuits. Fig. 6 shows the relationship of a zero-crossing pulse to a sine wave.

The pulse occurs at 0, 180, and 360 degrees.

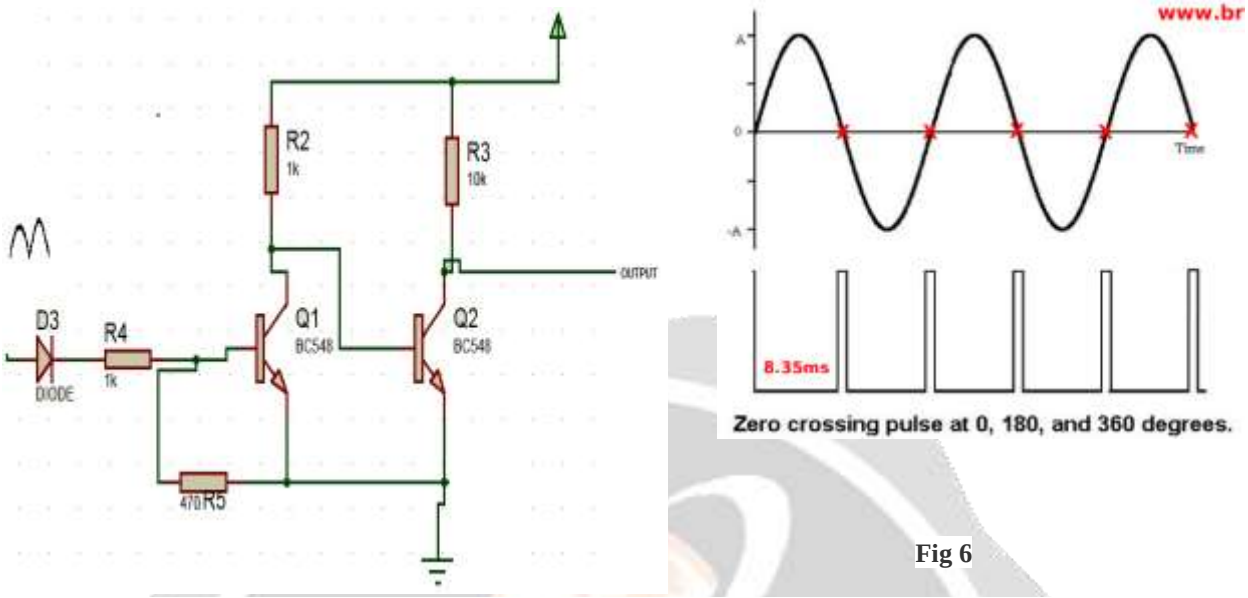


Fig 6

The regulated 5V is also used as biasing voltage for both transistors (Q1 and Q2) and the control section. A pulsating DC voltage is applied to the base of transistor Q1 through diode D3 and resistors R4 and R5. When the pulsating voltage goes to zero, the collector of transistor Q1 goes high. This is used for detecting the pulse when the voltage is zero. Finally, the detected pulse from 'OUTPUT' is fed to the microcontroller of the control section.

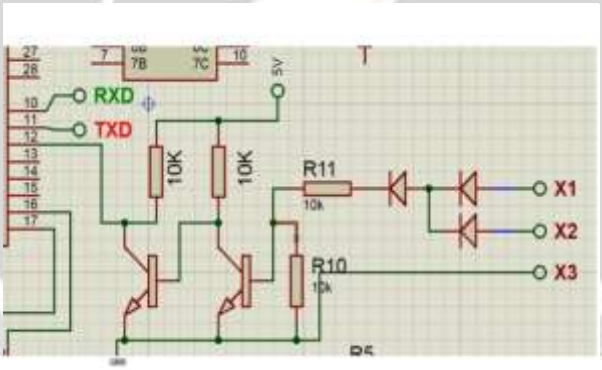


Fig 7

ANALOG TO DIGITAL CONVERTER

The PCF8591 is a single-chip, single-supply low power 8-bit CMOS data acquisition device with four analog inputs, one analog output and a serial I2C-bus interface. Three address pins A0, A1 and A2 are used for programming the hardware address, allowing the use of up to eight devices connected to the I2C-bus without additional hardware.

Address, control and data to and from the device are transferred serially via the two-line bidirectional I2C-bus. The functions of the device include analog input multiplexing, on-chip track and hold function, 8-bit analog-to-digital conversion and an 8-bit digital-to-analog conversion. The maximum conversion rate is given by the maximum speed of the I2C-bus.

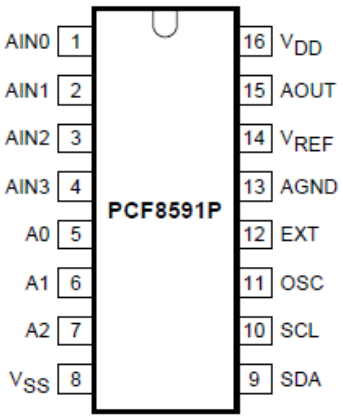


Fig 8

LCD (LIQUID CRYSTAL DISPLAY)

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.
The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.
The data is the ASCII value of the character to be displayed on the LCD.

Working Model

Fig 9

Result

Input Voltage	Output Voltage
234	221
245	225
250	227
260	234
200	219
190	222
180	223

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