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Compensation of Sag and Swell Voltage by Using Dynamic Voltage Restorer

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Abstract: There is an introduction to the dynamic voltage restorer in this paper that discusses voltage sags and swell. Also, it is about the compensation of voltage sag and swells. The power quality requirement is one of the most important issues. The power quality problem includes voltage sag, swell, notch, spike, transient, etc. Voltage sags and swells are serious problems requiring immediate attention. In order to compensate for them, there are a number of methods to employ. One of the most effective methods of sag and swell compensation is DVR, which is used in low voltage and medium voltage applications. This paper deals with the compensation of sag and swell voltage. The sag and swell of voltage are compensated by using DVR.. Then the operation of hardware and elements in DVR is explained with their rating dynamic voltage restorer.
Keywords - Dynamic Voltage Restorer, Voltage Sag and Swell, Voltage Source Converter, Power Quality.

I. INTRODUCTION

Electrical is a simple and well-organized form of energy, that can easily transformed into other forms. Voltage sags are decrease of the normal voltage level between 10% to 90% of RMS voltage, for duration of 0.5 cycles to 1 min. Voltage swells are increases of the voltage beyond the normal voltage level with a duration of more than 1.1 and 1.8 pu. Voltages sag is due to sudden and voltage swell is due to single line to ground fault results in voltage rise of unfaulted phase. The quality of power has become a major concern for today's power industries and consumers. Power quality issues are caused by the increasing demand for electronic equipment and non-linear load.

The wide area solution are needed to reduce voltage sags and improve power quality. the basic operating principle is injecting the voltage missing voltage in series to the bus and defecting the voltage sag by zero-crossing detectors. DVRs are becoming a cost-effective means to protect nonlinear loads from voltage sags. Voltage sag can be effectively and efficiently corrected with a digital video recorder. The DVR is composed of a capacitor bank storage unit, a PWM inverter, and a filter and booster transformer.

Causes of Voltage sag

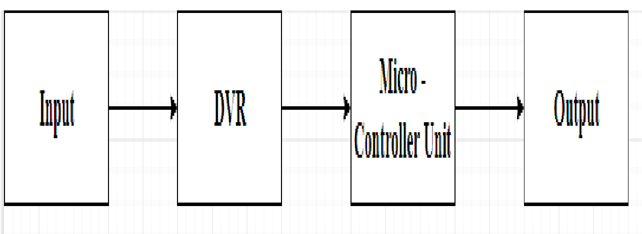
- Starting an electrical motor.
- Line-to-ground fault.
- Sudden load changed
- Transformer energizing

Causes of Voltage Swell

- In an ungrounded or floating delta system, where a sudden change in ground reference results in voltage rise.
- Due to de-energizing of a very large load.
- Energization of a large capacitor bank.

II. DYNAMIC VOLTAGE RESTORER

DVRs are connected devices. It is connected to a utility distribution feeder at a common coupling point. The main objective of DVR is to increase the power utilization capacity of a distribution feeder & protect the loads from voltage sad sag and swell coming from the network. DVR was first installed in North America in 1996 – a 12.47kV system located in Anderson, South Carolina. DVRs have been used to protect critical loads in utilities, semiconductors, and food processing ever since. The block diagram shows how dynamic voltage restorers read input and output when a supply input is provided.



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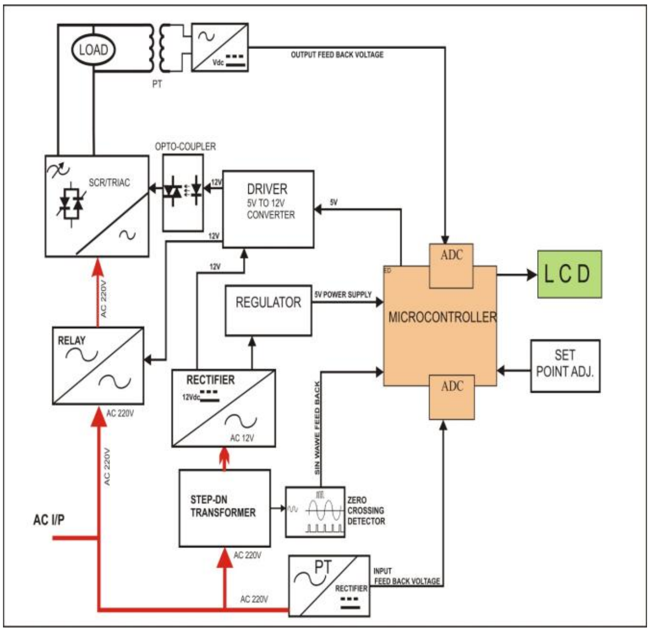
Microcontrollers are used to sense input and output supply. The micro-controller then sends the necessary commands to the dynamic voltage restorer, which results in improved output. The main function of DVR is the protection of non-linear load from voltage sag/swells expected from the network. The DVR is connected in series between the source voltage or grid of distribution and no-linear loads through a series injection transformer.

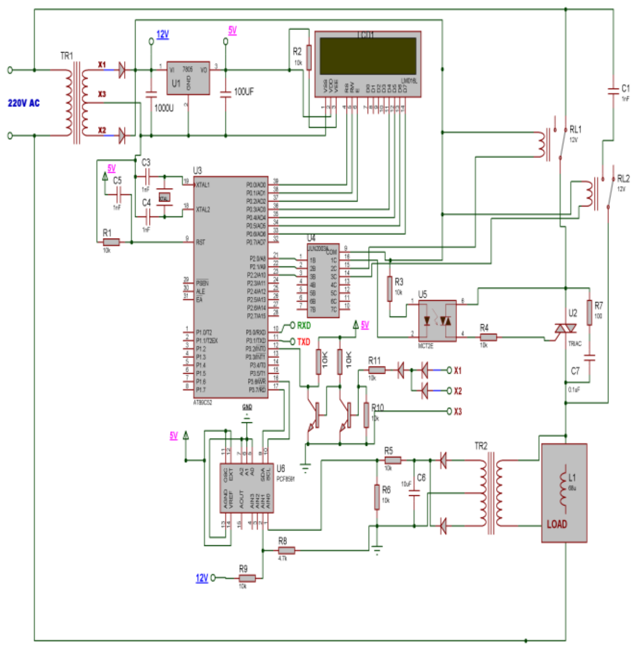
III. . EXPERIMENTAL SETUP



In the above block, the main purpose is to control and maintain voltage balance across the load. The controller first checks the incoming voltage from the line using the ADC (analog to digital converter) present inside the microcontroller. A firing angle control method is used to control the positive as well as the negative half cycle of incoming AC. The firing angle of any AC voltage can be controlled by monitoring every positive and negative half cycle, therefore in our project, a sine wave cycle monitor (Zero Crossing Detector) block is used. It informs the controller of the start of every cycle. Once the controller knows the voltage across the load and the sine wave cycle monitor signals, the controller calculates the firing angle and sends a firing pulse to the AC to AC converter, which is formed by an SCR/TRIAC static. A static switch can operate at high voltage and high frequency instead of a mechanical switch, like a relay. The output of AC to AC converter is further given to reactor which is nothing In the above block the main aim is to control and keep balance the voltage across the load. The output of the AC to AC converter is further given to the reactor which is nothing but a type of single-core step-up transformer. (220v to 300v transformer is used in our project), which gives a 220v output at 140v AC input. The output of 220v is further used by a various loads. The voltage across the load is measured by the controller with the help form a potential transformer (PT). Potential transformer is used to step down the voltage across the load to be measured and rectified to DC, because microcontroller can read a voltage upto5v dc only. Our project uses a relay to trip the input voltage in case of very high voltage or low voltage that are beyond control. Because the relay in our project is 12 volts and the controller can only provide 5 volts, it is necessary to amplify the 5 volts to 12 volts using a driver circuit.

A microcontroller requires 5v DC to work, which can be provided by a power supply consisting of a Step down transformer, rectifier, filter and regulator. Transformer step down the 220v AC to 12vAC, the rectifier and filter convert this 12v AC to 12v DC, and the regulator converts a 12v DC to a constant of 5v DC. The capacitor bank is an optional block that can be used if regulatory limits are exceeded.

IV. CIRCUIT DIAGRAM



The input supply is given to DVR through relay which operated on DV. The load is connected to the DVR output terminal. The DVR output is measured through P.T. The microcontroller requires DC, hence input AC is step down to AC to AC converted to DC with the help of full wave rectifier. Capacitor is used to get pure DC output.

The microcontroller requires constant DC. Hence this regulated supply given to regular IC7805 which gives constant DC to microcontroller. As input voltage varies, output voltage of IC7805 remains constant. This DC is given to microcontroller, LDC, this DC is given to microcontroller,

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LDC, opto-coupler, Driver & Zero Crossing Detector. The IC7805 is load and output of IC is reduced to then microcontroller will reset or restart. So that in such condition the current will not work properly.

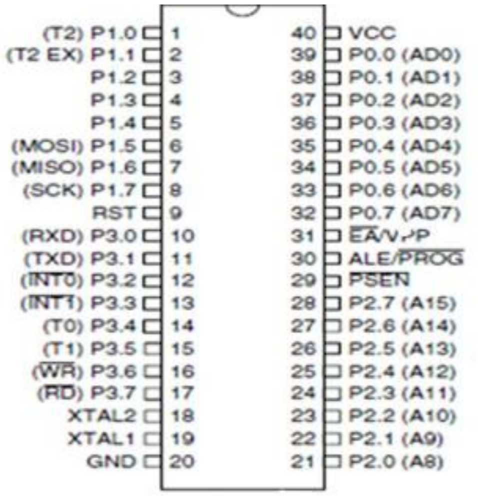
When capacitor is connected, it stores the charge, available in its potential. Capacitor provides charge when IC output is less than 5v. The output of this capacitor is fractional, i.e. 200 to 300 nF. The capacitor is electrolytic capacitor having polarity.

Two suppressor capacitors (C3& C4) are connected to crystal oscillator which maintain 50% duty cycle of crystal oscillator. It means ON time is equal to OFF time exactly 50% symmetrical output of frequency. The crystal oscillator is use to provide clock frequency to the microcontroller.

The microcontroller controls every positive and negative cycle of sine wave; hence zero crossing detector is used in our project. The zero crossing detectors consist of two NPN transistors and three diodes. The snubber circuit is used to suppress the rapid rise in voltage across the DVR.

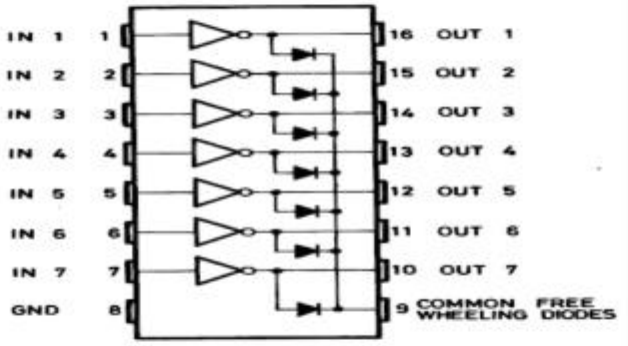
V. HARDWARE DESCRIPTION

AT89S52MicroController



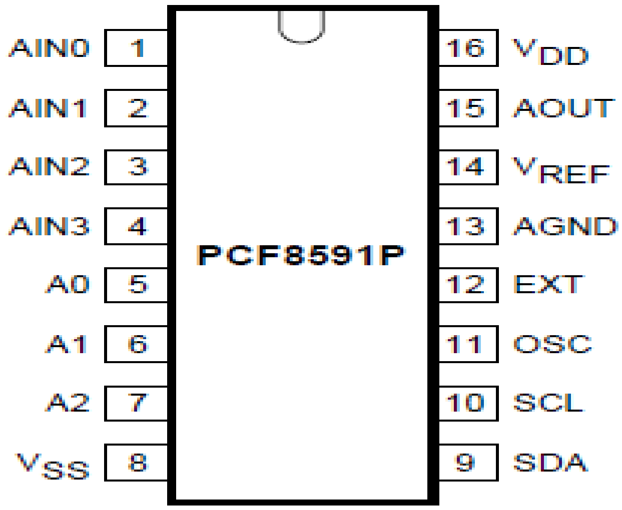
The AT889S52 is a low-power, high-performance COMS 8-bits microcontroller with 8K bytes of in-system programmable Flash memory. The device uses Atmel's high-density nonvolatile memory technology and is compatible with the 80C51 instruction set and pinout. With the on-chip Flash, the program memory can be reprogrammed in-system or by a nonvolatile memory programmer. Combining a multi-core 8-bit CPU and system-programmable Flash on a single chip, the Atmel AT89S52 is a low-power, highly-flexible and cost-effective microcontroller for embedded applications. The AT89S52 is also designed with static logic for operation down to zero frequency and supports two software-selectable power-saving modes. While the CPU is disabled, the RAM, timer/counter, serial port, and interrupt system continue functioning. The power-down modes saves the RAM contents but freezes the oscillator, disabling all other chip function until the next interrupt or hardware reset.

ULN 2003(Driver)

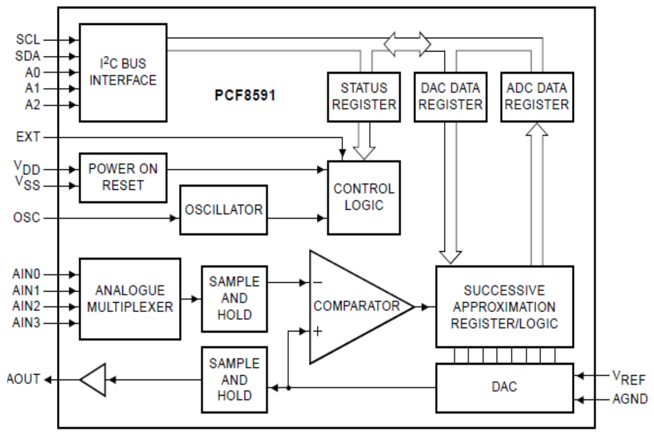


The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current each containing seven open collector Darlington pair with common emitters. Each pair rated at 500mA and input pins can be triggered by +5V. A suppression diode is used to drive inductive loads, and the inputs are pinned opposite the outputs to simplify the board layout. The devices can drive a wide range of loads, including solenoids, relays DC motors; LED displays filament lamps, thermal print-heads and high power buffers.

Analog to Digital Converter



The PCF8591 is an 8-bit CMOS data acquisition device with four analog inputs, one analog output, and a serial I2C bus interface. There are three address pins A0, A1 and A2 that are used to program the hardware address. Eight devices can be connected to the I2C-bus without additional hardware. Address, control and data are transmitted serially via the two-line bidirectional I2C-bus. In addition to analog input multiplexing and on-chip track and hold, the device also features eight-bit analog conversion and an eight-bit digital-to-analog conversion. Maximum conversion rate is detemined by the maximum speed of the I2C-bus.



LCD

An LDC with a 16x2 resolution can display 16 characters per line, and there are two lines. In this LCD, each character is displayed as a matrix of 5x7 pixel. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. The LDC receives a command that instructs it to perform a predefined task, such as initializing it, clearing its screen, setting the cursor position, controlling the display etc. This register stores the data that will be displayed on the LCD.

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

VI. COMPONENTS WITH THEIR RATING:

Sr. No.	Component	Rating
1	PIC Microcontroller	32-Bit
2	Series Inverter	1kV
3	Thyristor	0.5kV
4	Capacitor Bank	300kVAR
5	Potential Transformer	230/5V
6	Zero Crossing Detector	5V
7	Opto-coupler	12V
8	Regulator IC	5V
9	Line Frequency	50Hz
10	Filter Inductance	7mH
11	Filter Capacitance	10μF

VII. RESULT

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

VIII. CONCLUSION

In this paper, hardware model of DVR is setup. Voltage sags and voltage swells can be accurately identified by the proposed method. There has been only one switching per phase with the proposed method, which is easy to understand and reliable. The system is simple, easy to use, but requires energy storage devices in comparison to common DVR. The theoretical results verify the device's working performance and it is found satisfactory.

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