Compensation of Sags And Swells Voltage Using Dynamic Voltage Restorer (Dvr) During Single Line To Ground And Three-Phase Faults – An Overview

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ABSTRACT

The issue of voltage sags and Swells and its severe impact on load is well-known. To unravel this issue, custom power devices are used. One among those devices is that the Dynamic Voltage Restorer (DVR), that is one of the foremost economical and effective trendy custom power devices utilized in power distribution networks. This paper described DVR principles and voltage correction strategies for balanced and/or unbalanced voltage sags and swells during a distribution system. This paper describes the effectiveness of using dynamic voltage restorer (DVR) in order to mitigate voltage sags and swells in low voltage distribution systems. A dynamic voltage restorer based on the dqo algorithm is discussed. The proposed control scheme is very effective to detect any disturbance in low voltage distribution systems. Simulation results using Matlab/Simulink are presented to verify the effectiveness of the proposed scheme.

Keywords: low voltage, dynamic voltage restorer, voltage sags, voltage swells.

1. INTRODUCTION

Power quality phenomena or power quality disturbance can be defined as the deviation of the voltage and the current from its ideal waveform voltage and the current its ideal waveform.

Voltage sags last until network faults are cleared and typically range from a few milliseconds to several seconds . Voltage swell, on the other hand, is defined asa *swell* is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 min. typical magnitudes are between 1.1 and 1.8 up. Swell magnitude is also is also described by its remaining voltage, in this case, always greater than 1.0.

Voltage swells are not as important as voltage sags because they are less common in distribution systems. Voltage sag and swell can cause sensitive equipment (suchas found in semiconductor or chemical plants) to fail, or shutdown, as well as create a large current unbalance that could blow fuses or trip breakers. These effects can bevery expensive for the customer, ranging from minor quality variations to production downtime and equipment damage .

This paper Introduces Dynamic Voltage Restorer (DVR) and its operating principle. Then, analyses of the voltage compensation methods are presented. At the end, simulation results using MATLAB/SIMULINK are illustrated and discussed.

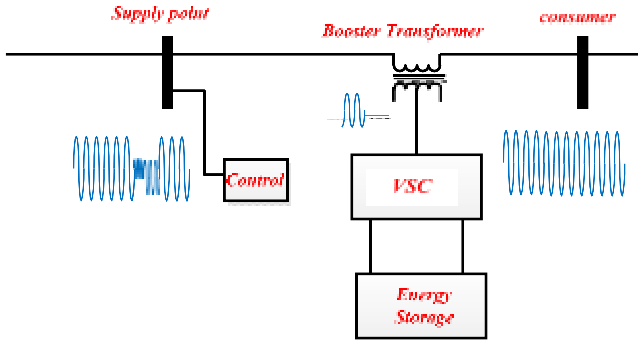


Figure 1. Basic DVR topology

I. Voltage sag and swell

Voltage sags/swells caused by unsymmetrical line-to-line, single line to ground (SLG), double-line-to-ground and symmetrical three phase faults effects on sensitive loads, the DVR injects the independent voltages to restore and maintained sensitive to its nominal value The injection power of the DVR with zero or minimum power for compensation purposes can be achieved by choosing an appropriate amplitude and phase angle.Voltage sags can occur at any instant of time, with amplitudes ranging from 10-90% and a duration lasting0 for half a cycle to one minute. Voltage swell, on the other hand, is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 minute. Typical magnitudes are between 1.1 and 1.8 up. Swell magnitude is also described by its remaining voltage, in this case, always greater than 1.0.. IEEE 519-1992 and IEEE 1159-1995 describe the voltage sags/swells as shown in Figure 2.

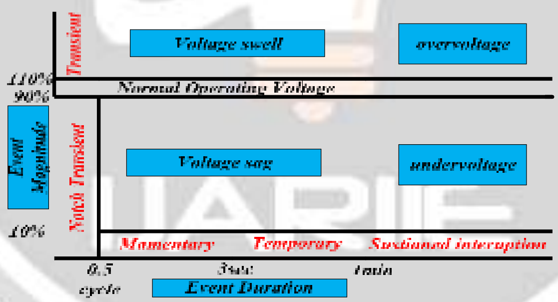
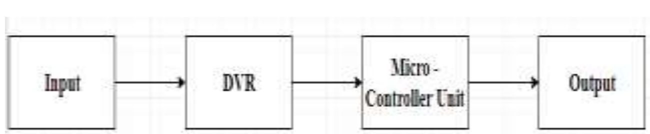


Figure 2. Voltage reduction standard of IEEE 1159-1995

Due to the fact that voltage swells are less common in distribution systems, they are not as important as voltage sags. Voltage sag and swell can cause sensitive equipment (such as found in semiconductor or chemical plants) to fail, or shutdown, as well as create a large current unbalance that could blow fuses or trip breakers. These effects can be very expensive for customers, ranging from minor quality variations to produce downtime and equipment damage.

METHODOLOGY



Block diagram of the role of dynamic voltagerestorer in improving power quality.

Basic Configuration:

Some of the basic elements of a DVR are as follows:

- Converter
- L&C filter
- Booster transformer DC-link and paper capacitorstorage unit
- DC-link and energy storage
- By-pass equipment
- Disconnecting equipment

COMPENSATION METHODS OF DVR

The type of the compensation technique mainly depends upon the specified factors such as DVR power ratings, various conditions of load, voltage sag type & swell.
Some loads are non-linear towards phase angle l jump and some are sensitive towards change in magnitude and others are tolerant to these.
Therefore, the control strategies mainly depend upon the type of load characteristics; there are three different methods of DVR series voltage injection which are:

(a) Pre-sag compensation
(b) In-phase compensation
(C) Voltage tolerance method with minimum energyinjection

[A] Pre-Sag/Dip Compensation Method:

The pre-sag method detects the supply voltage continuously and if it detects any disturbances in supply voltage by micro- controller it will inject the difference voltage between the sag and pre-fault condition, so that the load voltage can be restored by back to the pre-fault condition. Compensation of voltage sags in both phase angle and amplitude.
Non-linear loads would be achieved by pre-sag compensation method. In this technique the series injected real power cannot be controlled and it is calculated by external conditions such asthe type of faults and load conditions.
The voltage of DVR isgiven below:

VDVR = V pre fault – V sag

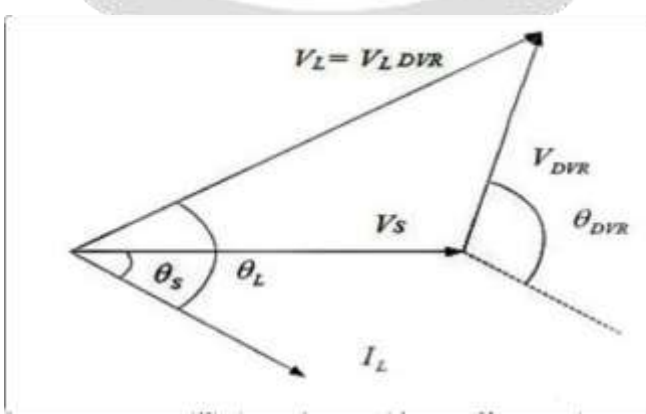


Fig -: Phasor diagram of pre-sag/dip method

[B] In-Phase Compensation Method:

In this method the injected voltage is in phase with the supply side voltage regardless of the load current and pre- fault voltage.
The phase angles of the pre-sag and load voltage are not similar but the vital criteria for power quality that is the constant magnitude of load voltage are fulfilled.
The load voltage is given below:

|VL| = |V pre-fault|

One of the advantages of this technique is that the amplitude of DVR injection voltage is minimum for some voltage sag in comparison with different strategies.
Practical application of this technique is in non-sensitive loads to phase angle jump.

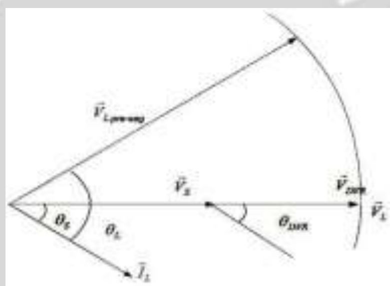


Fig -6.1.2: Phasor diagram of in phase method

[C] Voltage Tolerance Method with Minimum Energy Injection:

A small jump in phase angle and a small drop in voltage canbe tolerated by the load itself.
If the phase angle variations between 5% -10% of nominal state and voltage magnitude lies between 90%-110% of nominal state that will not disturb the operational features of loads. Both phase and magnitude are the control parameter for this method and can be achieved by small energy injection. In this technique, the magnitude and phase angle of corrected load voltage inside the area of load voltage tolerance are changed. The phase angle jump and voltage drop on load can be accepted by load itself. The delicacy of loads to voltage magnitude and phase angle jump is different.

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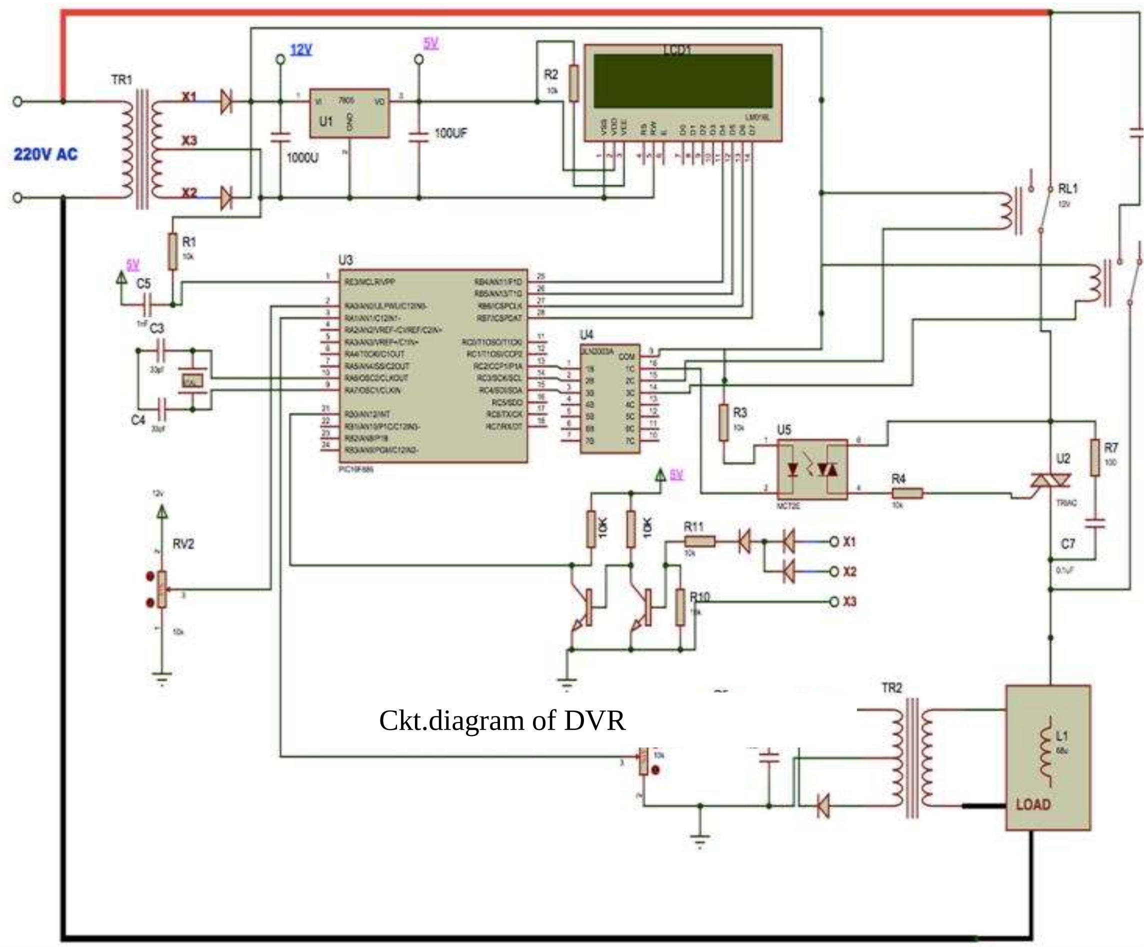


Ckt.diagram of DVR

HARDWARE PARTS DESCRIPTION

AT89S52 Micro-Controller

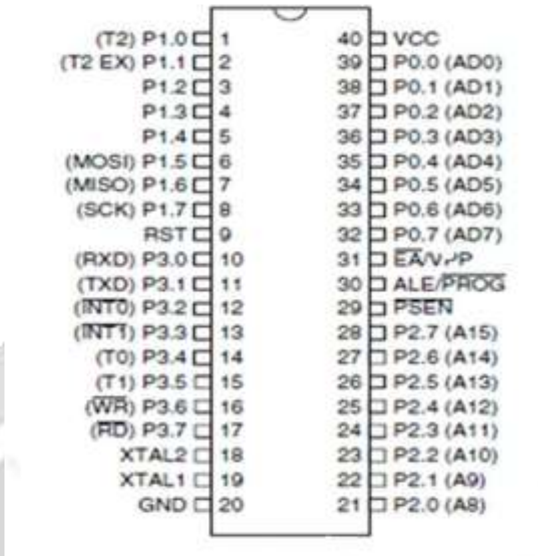


Fig -5.1: Pin Diagram of AT89S52 Micro-Controller

The whole processing of the device is done by a microcontroller. The micro-controller 89s52 is a small but powerful micro-controller. TheAT89S52 is a low-power, highperformance 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 pin out. The on-chip Flash allows the program memory to be reprogrammed in- system or by a conventional nonvolatile memory programmer. In addition, the AT89S52is designed with staticlogic for operation down to zero frequency and supports twosoftware selectable power saving modes. The idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupts system to continue functioning. The Power down mode saves the RAM contents but freezes theoscillator, disabling all other chip functions until the next interrupt or hardware reset.

ULN 2003 (Driver)

The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current darlington arrays each containing seven open collector darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA.Suppression diodes are included for inductive load driving and the inputs are pinned opposite theoutputs to simplify board layout. These versatile devices areuseful for driving a wide range of loads including solenoids,relays DC motors; LED displays filament lamps, thermal print-heads and high power buffers.

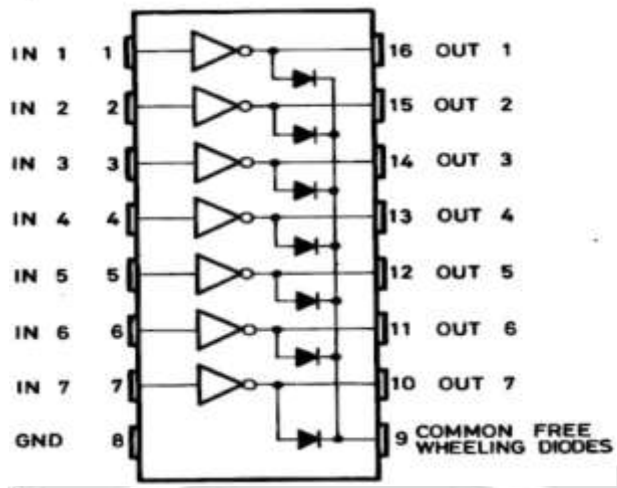


Fig -5.1: Internal Structure of IC ULN2003

Power Supply Circuit

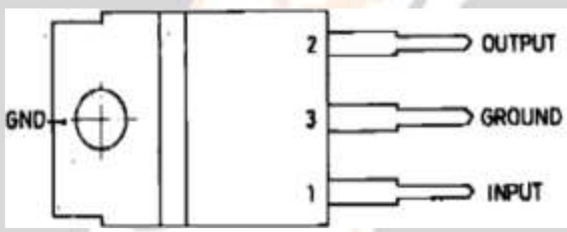
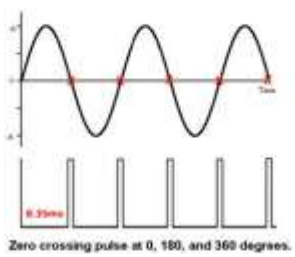


Fig -5.4: Regulator IC LM7805

The entire electronics component such transistor, IC's etc generally requires DC for their operation. So AC supply is then stepped down. Now this stepped down AC is convertedto DC supply by rectification process .there may be some ripples coming out of Power supply circuit. The 12V supplygiven to the LM7805 regulator. Now as microcontroller, LCD module, relays and other certain ICs requires 5VDC supply for their operation we need a regulated uninterrupted 5VDCsupply. This block involves production of 5V DC supply for whole circuit.

Zero Crossing Detectors

The regulated 5V is also used as biasing voltage for both transistors (Q_1 and Q_2) and the control section. A pulsatingDC voltage is applied to the base of transistor Q_1 through diode D_3 and resistors R_4 and R_5. When the pulsating voltagegoes to zero, the collector of transistor Q_1 goes high. This isused for detecting the pulse when the voltage is zero. Finally, the detected pulse from 'OUTPUT' is fed to the microcontroller of the control section.



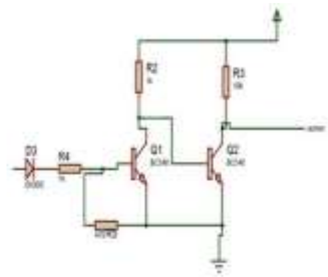


Fig : Output and circuit of zero crossing detectors

1.1 LCD (Liquid Crystal Display)

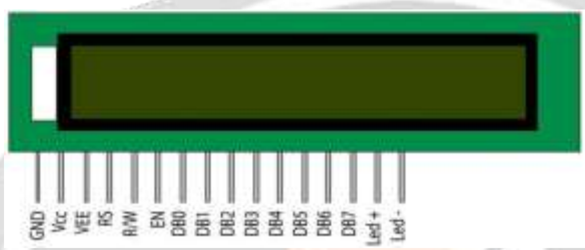


Fig -: Liquid Crystal Display

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.

Relay

Fig -: Relay

A relay is an electrically operated switch. Many relays used are electromagnet, but others are also used, such as solid- state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re- transmitted it on another circuit.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called "protective relays".

Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands.

TRIAC

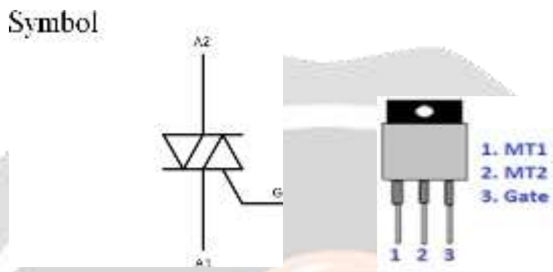


Fig -: TRIAC

TRIAC, its formal name is bidirectional triode thyristor or bilateral triode thyristor. A thyristor is analogous to a relay. TRIACs are a subset of thyristors and are related to silicon controlled rectifiers (SCRs). TRIACs differ from SCRs in that they allow current flow in both directions, whereas an SCR can only conduct current in a single direction. Most TRIACs can be triggered by applying either a positive or negative voltage to the gate (an SCR requires a positive voltage). Once triggered, SCRs and TRIACs continue to conduct, even if the gate current ceases, until the main current drops below a certain level called the holding current.

Resistors

Fig -: Resistor

A resistor is passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High- power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Opto-couplers

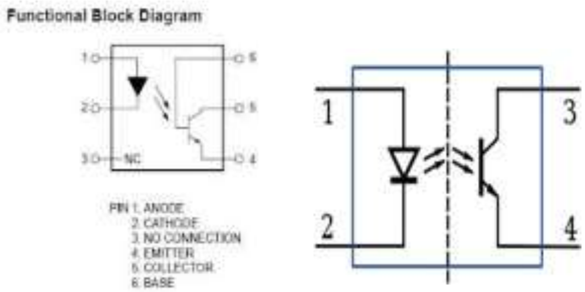


Fig -: Circuit and pin diagram of opto-coupler

In electronics, an opto-isolator, also calledan optocoupler, photocoupler, or optical isolator, is a component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal Commercially available opto-isolators withstand input-to-output voltages up to 10 kV and voltage transientswith speeds up to 10 kV/μs.A common type of opto-isolator consists of an LED and a phototransistor in the same opaque package. Other types of source-sensor combinations include LED-photodiode, LED-LASCR and lamp-photoresistor pairs. An opto-isolator contains a source (emitter) of light, almostalways a near infrared light-emitting diode (LED), thatconverts electrical input signal into light, a closed optical channel (also called dialectical channel), and a photo sensor, which detects incoming light and either generates electric energy directly, or modulates electric current flowing from an external power supply. The sensorcan be a photoresistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a TRIAC.

Capacitors

Fig -: Capacitor

A capacitor is a passive two terminal electrical component that stores electrical energy in an electric field. The effect of a capacitor is known as capacitance. While capacitance exists between any two electrical conductors of a circuit in sufficiently close proximity, a capacitor is specifically designed to provide and enhance this effect for a variety of practical applications by consideration of size, shape, and positioning of closely spaced conductors, and the intervening dielectric material. A capacitor was therefore historically first known as an electric condenser.

Conclusion

REFERENCES

[1] N. Khan, S. Dilshad, R. Khalid, A. R. Kalair, and N. Abas, ‘‘Review of energy storage and transportation of energy,’’ *Energy Storage*, vol. 1, no. 3,Jun. 2019, doi: 10.1002/est2.49.

[2] M. A. Basit, S. Dilshad, R. Badar, and S. M. S. ur Rehman, ‘‘Limitations, challenges, and solution approaches in grid-connected renewable energy systems,’’ *Int. J. Energy Res.*, vol.

44, no. 6, pp. 4132–4162, May 2020, doi: 10.1002/er.5033.

[3] A. Kalair, N. Abas, A. R. Kalair, Z. Saleem, and N. Khan, ‘‘Review of harmonic analysis, modeling and mitigation techniques,’’ *Renew. Sustain. Energy Rev.*, vol. 78, pp. 1152–1187, Oct. 2017, doi: 10.1016/j.rser.2017.04.121.

[4] F. H. Gandoman, A. Ahmadi, A. M. Sharaf, P. Siano, J. Pou, B. Hredzak, and V. G. Agelidis, ‘‘Review of FACTS technologies and applications for power quality in smart grids with renewable energy sys- tems,’’ *Renew. Sustain. Energy Rev.*, vol. 82, pp. 502–514, Feb. 2018, doi: 10.1016/j.rser.2017.09.062.

[5] A. M. Sharaf and A. A. Abdelsalamy, ‘‘A novel facts based dynamic voltage compensation scheme for smart electric grid stabilization and efficient utilization,’’ in *Proc. 24th Can. Conf. Electr. Comput. Eng. (CCECE)*, May 2011, pp. 000042–000047, doi: 10.1109/CCECE.2011.6030405.

[6] A. R. Kalair, N. Abas, A. Kalair, Q. U. Hasan, and N. Khan, ‘‘Impact of FACTS devices on transmission and distribution system,’’ *J. Active Passiv. Electron. Devices*, vol. 14, no. 4, pp. 287–305, 2019.

[7] M. Büyük, M. Inci, and M. Tümay, ‘‘Performance comparison of voltage sag/swell detection methods implemented in custom power devices,’’ *Rev. Roum Sci. Techn.-Électrotechn. Énerg*, vol. 62, no. 2, pp. 129–133, 2017.

[8] Y. W. Li and J. He, ‘‘Distribution system harmonic compensation methods: An overview of DG-interfacing inverters,’’ *IEEE Ind. Electron. Mag.*, vol. 8, no. 4, pp. 18–31, Dec. 2014, doi: 10.1109/MIE.2013.2295421.

[9] N. G. Hingorani and L. Gyugyi, *Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems*. New York, NY, USA: Wiley, 2000.

[10] Y.-H. Song and A. Johns, *Flexible ac Transmission Systems (FACTS)*, no. 30. Edison, NJ, USA: IET, 1999.

[11] K. Habur and D. O’Leary, ‘‘FACTS-flexible alternating current trans- mission systems: For cost effective and reliable transmission of electrical energy,’’ Siemens-World Bank Doc., Erlangen, Germany, Draft Rep., 2004, p. 46. [Online]. Available: http://www.academia.edu/ download/41305916/facts_siemens.pdf

[12] W. Frangieh and M. B. Najjar, ‘‘Active control for power quality improvement in hybrid power systems,’’ in *Proc. 3rd Int. Conf. Technol. Adv. Electr., Electron. Comput. Eng. (TAEECE)*, Apr. 2015, pp. 218–223, doi: 10.1109/TAEECE.2015.7113630.