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Paper Authors

D.RIHANA BEGUM, S.V.SIVANAGARAJU, G.N.S.VAIBHAV

PVKKIT, Anantapuramu

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MITIGATION OF VOLTAGE SAG USING AC–AC-CONVERTER-BASED TOPOLOGY

[1]D.RIHANA BEGUM, [2]S.V.SIVANAGARAJU, [3]G.N.S.VAIBHAV
[1]M.Tech student, Department of EEE, PVKKIT, Anantapuramu
[2]Associate Professor, Department of EEE, PVKKIT, Anantapuramu
[3]H.O.D., Department of EEE, PVKKIT, Anantapuramu

ABSTRACT: The customary voltage list compensator, which isdynamic voltage restorer (DVR) has many detriments, for example, need of vitality stockpiling gadgets, having dc connections and two phase control transformations. This expands its size, cost, control misfortunes and control many-sided quality. Additionally it isn't satisfactory for remunerating profound and long length voltage list. In this paper interphase AC topology is proposed for voltage list remuneration which suggeststhe thought of cross stage voltage infusion. In this, droop supporter is associated in each stage which draws the power from staying two stages. A solitary stage list supporter is acknowledged with two AC choppers and two transformers. The required infusing power is controlled by controlling the obligation cycle of every chopper. It doesn't require any vitality stockpiling gadget subsequently the size, cost, and related misfortunes are diminished. Detail reproduction alongside brings about MATLAB/Simulink for voltage list because of single line to ground blame is introduced in this paper.

KEYWORDS - Power quality, voltage hang, AC chopper

I. INTRODUCTION

The advanced electrical power framework is AC i.e. electricpower is produced, transmitted and circulated in the formof rotating current [1]. For solid and continuous flowof control frameworks, the age plant must create amplepower to meet buyer's requests, transmission framework musttransport mass control over long separations without overloadingsystem and appropriation framework must convey electric powerto every customer premises. Dispersion framework finds theend of energy framework and is associated with the consumerdirectly, so the power quality mostly relies upon distributionsystem. Power quality is portrayed as the variety of current,voltage and recurrence in a power framework [2], [3]. Among themthe voltage quality issue is vital and have thegreater rate. It incorporates voltage hang, swell, interruptionand music. Voltage list can be characterized as a brief term lessening inRMS voltage at control recurrence caused by flaws and startingof extensive burdens. Run of the mill span of voltage hang is 0.5 to 30cycles. Voltage droop is viewed as the most extreme since thesensitive hardware's utilized as a part of present day modern plants suchas process controllers, programmable rationale controllers (PLC),power apply autonomy, flexible speed drives are delicate to voltagesags and causes genuine financial misfortune due to

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malfunctionof the equipment's. Since it can happen even due to remotefaults in a power framework, it is more regularly than interruptionand can happen 20-30 times each year with a normal cost of50,000$ in every industry [4]. The primary driver of voltage sagis any brief span sort of shortcomings which might be symmetricor unsymmetrical in nature, because of beginning of acceptance motor,energization of transformer, operation of enclosures& circuitbreakers and so on. Voltage hang is portrayed by list magnitude,duration, stage bounce and three stage adjust. Voltage droop withlow voltage hang greatness is called profound list while with highvoltage size is called shallow list. Fig.1 shows thesingle-stage demonstrate for voltage hang at the purpose of commoncoupling.

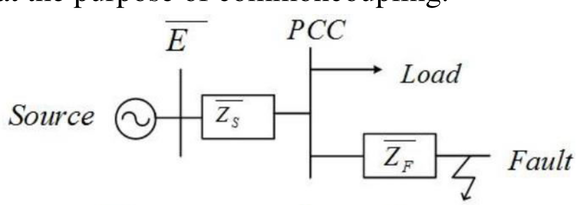

Fig.1. Single-phase model for voltage sag at the PCC

Studies show that voltage sag is accompanied with phase jump [5]. It occurs due to the difference in X/Rratio of the source(Zs) and feeder (Zf) impendences.

II. EXISTING SYSTEMS

For mitigating voltage sags different FACTs controllers areused. There are four types of FACTs controllers [6] 1) Series controllers 2) Shunt controllers 3) Combined series-series controller 4) Combined series-shunt controller Dynamic voltage restorer (DVR) & Unified power qualityconditioner(UPQC) are examples of series controllers whileDistribution static synchronous compensator (DSTATCOM) &Distribution static voltage compensator (DSVC) are examplesof shunt controllers. Out of these the most currently useddevice is DVR i.e. Dynamic voltage restorer. Basically DVR ispower electronic based converter connected in series to injectthe appropriate voltage for. It consists of voltage source converter(VSI) which will provide injection voltage corresponding to sag magnitude, injection transformer, dc link and energy storage device. Although DVR is a definitive solution towards compensation of voltage sag it suffers number of disadvantages such as it is not adequate for compensating deep and long duration voltage sag, requirement of energy storage devices for providing compensating voltage, it has dc link and two stage power conversions which increases the compensator size, cost, power losses and control complexity.

III. PROPOSED SYSTEM

To eliminate all the disadvantages of conventional topologies for mitigating the voltage sag a new topology without dc link utilizing direct AC-AC converters are preferable. This paper implements interphase AC-AC topology for compensating the voltage sag. Interphase AC-AC topology [7] suggests the idea of cross phase voltage injection. When the voltage sag occurs in any phase remaining two phases are used to inject the compensating voltage. The schematic diagram of the proposed topology with detailed phase-a sag supporter is shown in fig.2 It consist of three sag supporters connected in series with each phase. Each sag supporter consist of two AC choppers

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and two injection transformers. The main function of injection transformer is to isolate the chopper circuit from lines. When the voltage sag occurs at the point of common coupling (PCC) of any of the phase, the corresponding sag supporter injects appropriate voltage in series with the supply voltage to maintain the desired load voltage. The load voltage is the sum of respective phase voltage and injected voltage. The required injecting voltages are drawn from phase-b and phase-c with the help of individual AC choppers and connected to the primary of injection transformer. The injected voltage is vector sum oftwo AC choppers and injected in series with the line to compensate the voltage sag in phase-a. Similarly, for phase-b and phase-c sag supporters are realized.

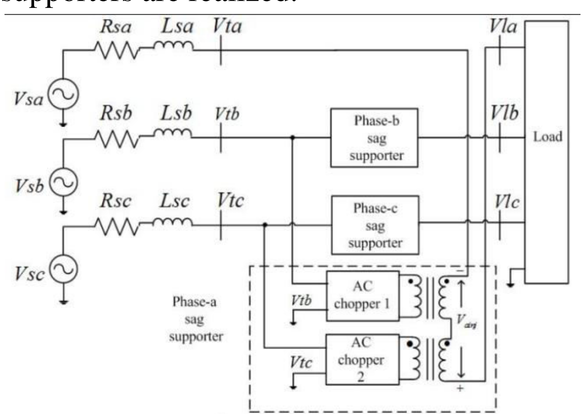

Fig.2. Interphase Ac-Ac converter topology

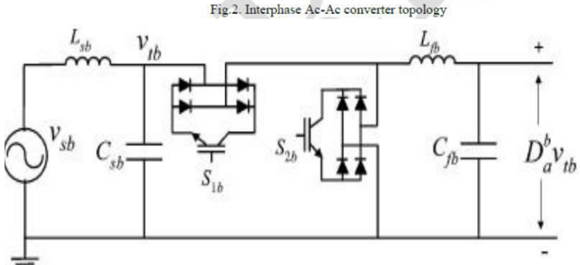
Fig.3. Ac-Ac chopper with input and output filters

Fig.3 shows the pulse width modulated (PWM) AC chopper with input and output filters placed across phase-b[4], [7], [8]. The chopper operates in buck mode. Each chopper consists of two switches. The bidirectional feature of switch is realized by using IGBT with Diode Bridge. The switching pulse T1 required to produce the desired output voltage is given to the series switch and the complementary switching pulse T1' is given to shunt switch for continuous flow of load current. Small LC filters are added at the input and output side to avoid propagation noise and to filter high-frequency components respectively. [9] Let the phase voltage-b voltage be,[7]

$$vtb=Vtbm\ cos\ \omega t-120°+\varphi b \quad (1)$$

where ω, φb and $Vtbm$are the angular frequency, phaseangle shift and peak value of the terminal voltage of phase-b respectively. When this voltage is chopped for constant duty cycle, the output voltage can be written as,

$$v_a^b = D_a^b V_{tbm} \cos(\omega t - 120° + \varphi_b) + \sum_{k=1}^{\infty} \frac{V_{tbm} \sin k D_a^b \pi}{k\pi} \cos(k\omega_s t \pm \omega)t \quad (2)$$

A similar chopper circuit is used for chopping phase-c voltagefor the phase-a sag supporter. Its output voltage is expressed as,

$$v_a^c = D_a^c V_{tcm} \cos(\omega t + 120° + \varphi_c) \quad (4)$$

The phase-a injected voltage (V_{ainj}) is the sum of voltages from phase-b and phase-c choppers. It is expressed as,

$$V_{ainj} = -(v_a^b + v_a^c) = -D_a^b V_{tbm} \cos(\omega t - 120° + \varphi_b) - D_a^c V_{tcm} \cos(\omega t + 120° + \varphi_c) \quad (5)$$

After arranging and expanding equation (5) we get,

$$V_{ainj} = \cos(\omega t)\left\{\frac{D_a^b V_{tbm}}{2}\cos(\varphi_b) + \frac{D_a^c V_{tcm}}{2}\cos(\varphi_c) - \sqrt{3}\frac{D_a^b V_{tbm}}{2}\sin(\varphi_b) + \sqrt{3}\frac{D_a^c V_{tcm}}{2}\sin(\varphi_c)\right\}$$
$$-\sin(\omega t)\left\{\frac{D_a^b V_{tbm}}{2}\sin(\varphi_b) + \frac{D_a^c V_{tcm}}{2}\sin(\varphi_c) + \sqrt{3}\frac{D_a^b V_{tbm}}{2}\cos - \sqrt{3}\frac{D_a^c V_{tcm}}{2}\cos(\varphi_c)\right\} \quad (6)$$

Equation (6) shows that it has two components in-phase and quadrature with respect to phase-a axis. If the quadrature component became zero then the resultant

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injected voltage lies on phase-a axis. This type of voltage injection is termed as in-phase voltage injection. With respect to value of quadrature component the resultant voltage leads/lags the phase-a axis. This type of method of voltage injection is termed as phase shifted voltage injection [7]. By controlling the duty cycle of each chopper in phase sag supporters, the magnitude and phase angle of the injected voltage can be realized. In this paper in phasevoltage injection method is used for compensating the voltage sag.

IV. SIMULATION CIRCUIT AND RESULTS

In this paper, the soundness of the proposed interphase AC AC topology is validated by simulation study conducted using MATLAB/Simulink.

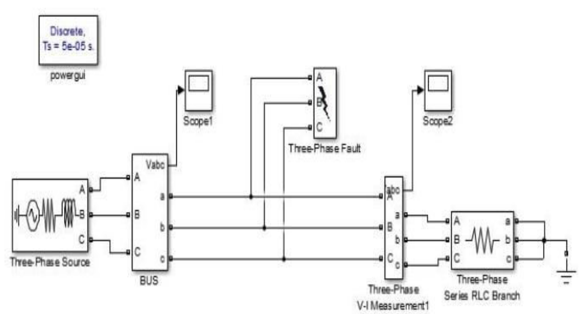

Fig.4. Simulation circuit for voltage sag without sag supporter

TABLE I
SYSTEM DETAILS

Parameters	Values	
Rated voltage and frequency	3-phase, 400 V, 50 Hz	
Load	100Ω	
Injection transformer	1:1, 500 V, 25MVA	
Sag duration	0.3 to 0.6 Sec	
AC chopper	Switching frequency	5 KHz
	Input inductance	0.9 mH
	Input capacitance	50 μF
	Filter inductance	0.25 mH
	Filter capacitance	180 μF

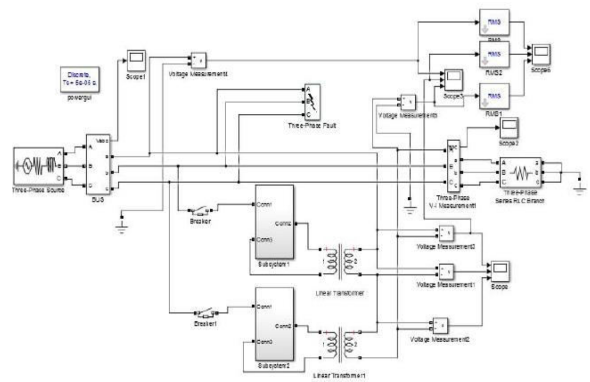

Fig.5. Simulation circuit for voltage sag with sag supporter

Simulation time for model is taken as 0.8 sec. In the begining simulation was done without creating any fault on the network. Fig.6 shows the load side voltage waveform without fault. X axis shows the simulation time and Y axis shows the voltage magnitude.

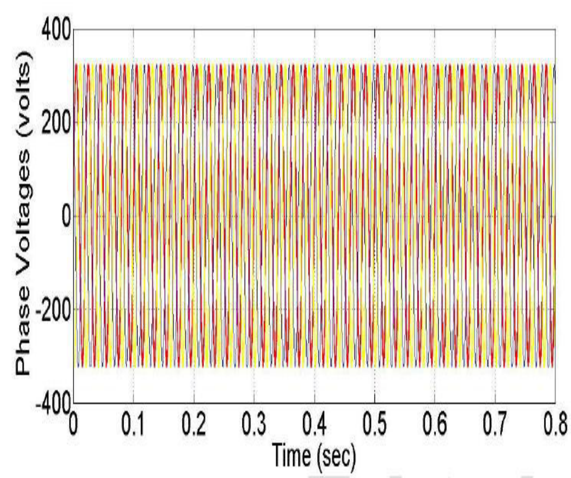

Fig.6. Load voltage without fault

Second simulation is done by creating single line to ground fault on the system with fault resistance of 0.1 Ω from 0.3 to 0.6 sec. The fault is created by using three phase shunt fault block from Simulink library. Fig.7 shows load voltage waveform during fault. From this waveform we can observelarge amount of voltage sag. Voltage drops to almost 90 %. This voltage drop is needed to be compensated by proposed topology.

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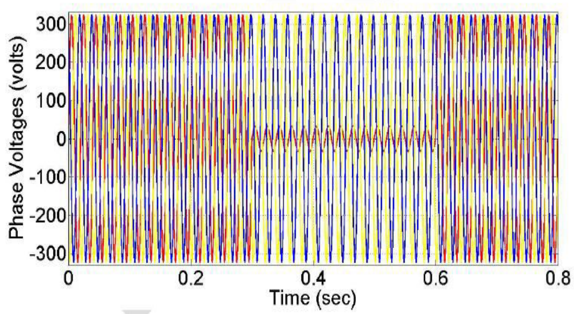

Fig.7. Load voltage during fault without sag supporter.

Third simulation is carried out by connecting sag supporter in phase-a for compensating the voltage sag occuring in the system mentioned above. Fig.7 and fig.8 shows the injected peak and RMS voltage respectively.

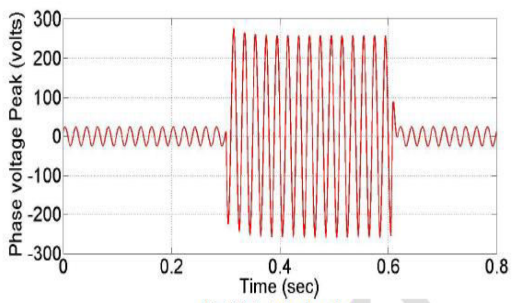

Fig.8. Injected peak voltage

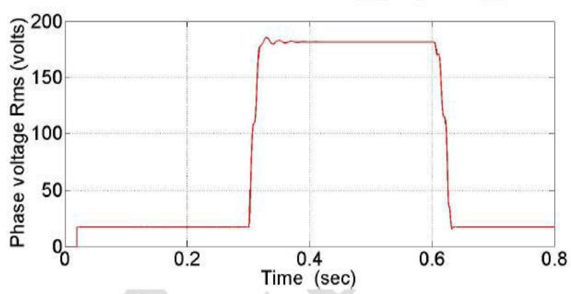

Fig.9. Injected RMS voltage.

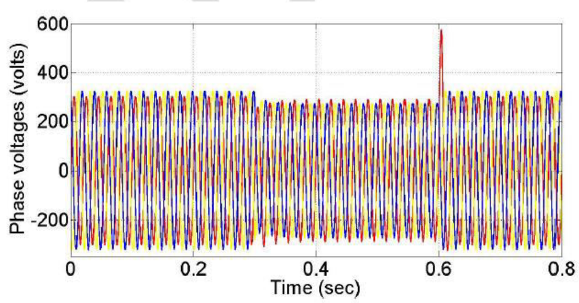

Fig.10. Load voltage with sag supporter

Fig.10 shows the load side waveform after connecting phase-a sag supporter for compensation. If we compare the waveform of load voltage with and without sag supporter we observed that when the sag supporter is in operation the voltage sag is compensated almost completely. From this waveform we can say that the proposed topology can compensate 96 to 98 % voltage sag magnitude. The sag supporter is designed to supply the sag voltage until fault isremoved from the system.

V. CONCLUSION

In this paper interphase AC-AC topology is used for voltage sag compensation. The proposed topology has number of advantages such as reduced size, cost and associated losses, no need of storage device, easy to implement. Control of compensation is achieved by providing proper duty cycle to AC choppers. From the detail analysis it can be seen that compensation achieved in case of single phase to ground fault is about 96 %.

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