ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

A New Hybrid Power Conditioner for Suppressing Harmonics and Neutral-Line Current in Three-Phase Four-Wire Distribution Power Systems



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ABSTRACT

A new hybrid power conditioner for solving the problems of harmonic currents and neutral-line current in three-phase four wire distribution power systems is proposed in this paper. This hybrid power conditioner is configured by a neutral-line current attenuator and a hybrid power filter. The hybrid power filter, configured by a three-phase power converter and a three phase tuned power filter, is utilized to filter the nonzero-sequence harmonic currents in the three-phase four-wire distribution power system. The neutral-line current suppressor is connected between the power capacitors of the three-phase tuned power filter and the neutral line to attenuate the neutral-line current in the three-phase four-wire distribution power system. The proposed hybrid power conditioner can effectively reduce the power rating of passive and active elements. A simulation results is developed to verify the performance of the proposed hybrid power conditioner.

Index Terms—***Harmonic, neutral-line current, power converter.***

INTRODUCTION

Power conditioner

A power conditioner (also known as a line conditioner or power line conditioner) is a device intended to improve the quality of the power that is delivered to electrical load equipment. While there is no official definition of a power conditioner, the term most often refers to a device that acts in one or more ways to deliver a voltage of the proper level and characteristics to enable load equipment to function properly. In some uses, power conditioner refers to a voltage regulator with at least one other function to improve power quality (e.g. power factor correction, noise suppression, transient impulse protection, etc.)Conditioners specifically work to smooth the sinusoidal A.C wave form and maintain a constant voltage over varying loads.

Neutral-line current

As the neutral point of an electrical supply system is often connected to earth ground, ground and neutral are closely related. Neutral is a circuit conductor that carries current in normal operation, which is connected to ground (or earth).Current carried on a grounding conductor can result in objectionable or dangerous voltages appearing on equipment enclosures, so the installation of grounding conductors and neutral conductors is carefully defined in electrical regulations. Where a neutral conductor is used also to connect equipment enclosures to earth, care must be taken that the neutral conductor never rises to a high voltage with respect to local ground.

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The task of a power converter is to process and control the flow of electric energy by supplying voltages and currents in a form that is optimally suited for the user loads. Energy was initially converted in electromechanical converters. Today, with the development and the mass production of power semi conductors; static power converters find applications in numerous domains and especially in particle accelerators. They are smaller and lighter and their static and dynamic performances are better.

A static converter is a meshed network of electrical components that acts as a linking, adapting or transforming stage between two sources, generally between a generator and a load.

PROPOSED SYSTEM

II. THREE-PHASE FOUR-WIRE HYBRID POWER FILTER

The zig-zag transformer, connected to the load in parallel, hasbeen employed to attenuate the neutral-line current [1], [3], [4].However, the attenuation of neutral-line current is dependent on the ratio between the impedance of the utility system and thezig-zag transformer. Furthermore, the zig-zag transformer alsohas a low impedance path for zero-sequence voltage of the unbalanced utility, which will further cause a significant neutralline current [4]. A single-phase power converter can be combined with the zig-zag transformer to advance the performance of the neutral-line current suppression [5], [6]. The single-phase power converter is inserted at the neutral line between the loadand the utility, thus causing fluctuation in the ground voltage ofthe load. A neutral-current suppression scheme, configured by a-Y transformer and a single-phase power converter connectedin series, is connected to the load in parallel to suppress the neutral-line current [7]. The neutral line of the load is directly connected to that of the utility, and the fluctuation in ground voltage of the load can thus be avoided. A series of active power filters connected to the neutral line between the utility and the load can suppress the neutral-line current, thus eliminating the needof the transformer for a zero current path [8]. However, there is fluctuation in ground voltage of the load because the neutral lines of the load and utility are separated.

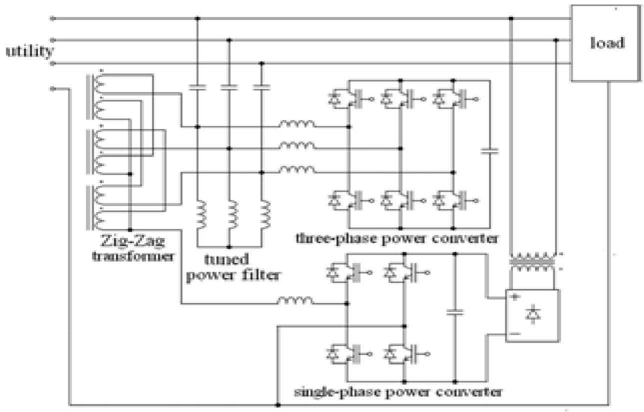

Fig. 1. System configuration of the proposed hybrid power conditioner

A new hybrid power conditioner for solving the problems of harmonic currents and neutral-line current in three-phase fourwire distribution power systems is proposed in this paper. This hybrid power conditioner is configured by a neutral-line currentattenuator and a hybrid power filter. The hybrid powerfilter, configured by a three-phase power converter and a threephase tuned power filter, is utilized to filter the nonzero-sequence harmonic currents in the three-phase four-wire distribution power system. The neutral-line current suppressor is connected between the power capacitors of the three-phase tuned power filter and the neutral line to attenuate the neutral-line current in the three-phase four-wire distribution power system. The proposed hybrid power conditioner can effectively reduce thepower rating of passive and active elements.

CONTROL STRATEGY

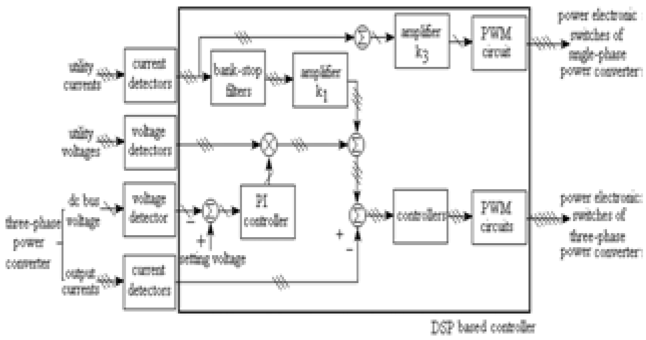

Fig. 3. Control block diagram of the three-phase and single-phase power converters.

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Fig. 3shows the control block diagram of three-phase and single-phase power converters. The three-phase power converter adopts the current-mode control. The current referencesshould be calculated first. The current references should beequal to (1)–(3), and they contain a fundamental signal and a harmonic signal. The detected three-phase utility currents are sent to the bandstop filters to extract their harmonic components.

The outputs of the bandstop filters are sent to the amplifier with gain , and the harmonic signals of the currentreferences are then obtained. The detected dc bus voltage ofthe three-phase power converter is compared with the settingvoltage, and the compared result is sent to a proportional-integral(PI) controller. The output of the PI controller is.

Both the outputs of the PI controller and the detected three-phaseutility voltages are sent to the multipliers so that the fundamental signals of the current references are obtained. Thecurrent references are obtained by summing up the harmonicsignals and the fundamental signals. The detected output currentsof the three-phase power converter are compared with thecurrent references, and the compared results are then sent to thecontrollers. The outputs of the controllers are sent to the PWM circuits to generate the driver signals of the power-electronic switches for the three-phase power converter.

The feed forward control is employed to control the singlephase power converter. The neutral-line current of the utility can be obtained by summing up the detected three-phase utility currents and is then sent to an amplifier of gain . The output of the amplifier is sent to the PWM circuit to serve as the modulation signal. The PWM circuit adopts unipolar PWM to generate four PWMsignals for the power-electronic switches of the single-phase power converter.

IV.SIMULATION RESULTS

BALANCED LOAD CIRCUIT AND WAVEFORMS

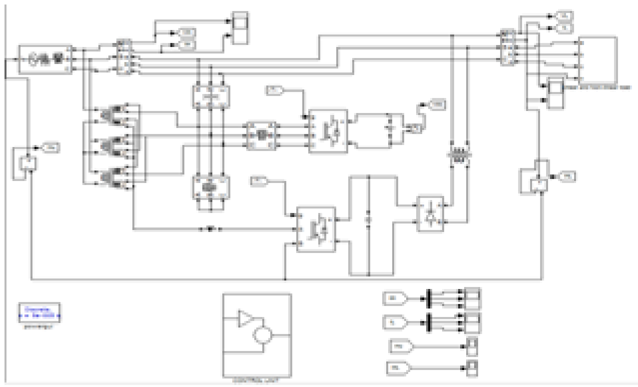

Fig.4.Balanced load circuit

LOAD CURRENT

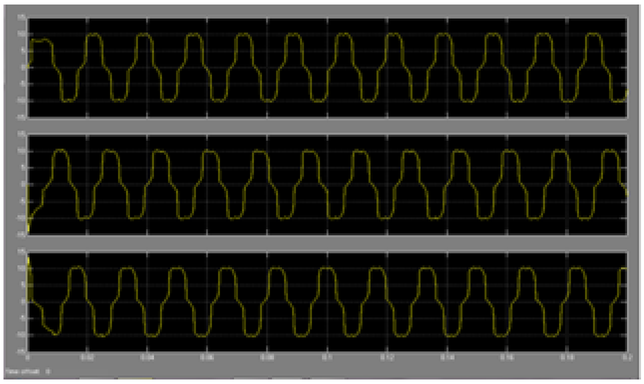

Fig.5 Waveforms of the balanced three-phase load: (a) phase a load current, (b) phase b load current, (c) phase c load current

UTILITY CURRENT

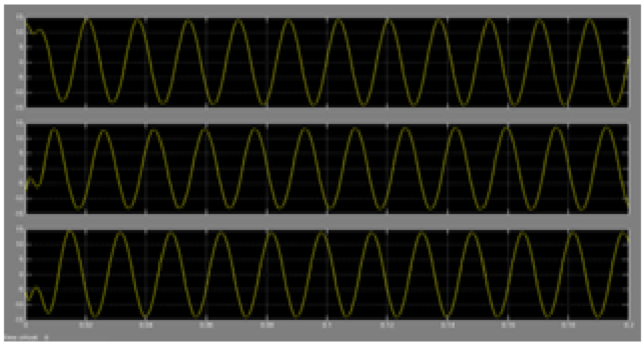

Fig. 6 Waveforms of the hybrid power conditioner under the balanced three-phase load: (a) phase a utility current, (b) phase b utility current,(c) phase c utility current

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LOAD NEUTRAL CURRENT

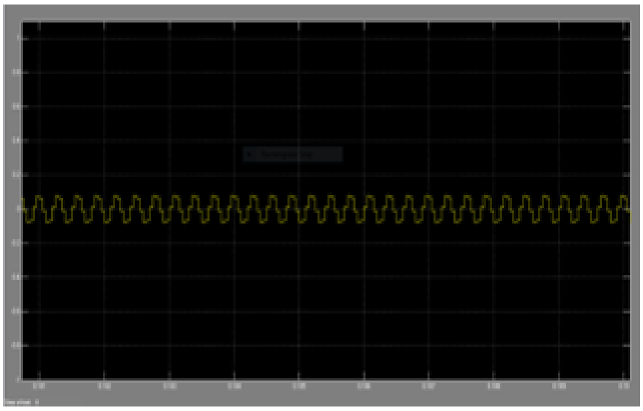

Fig 7 waveform for neutral current at load

UTILITY NEUTRAL CURRENT

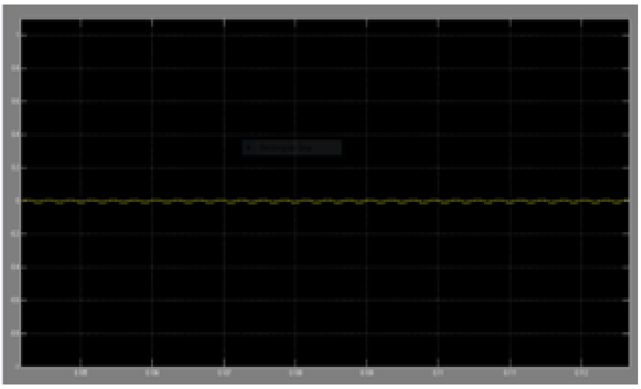

Fig.8 Wave form for neutral line current of utility.

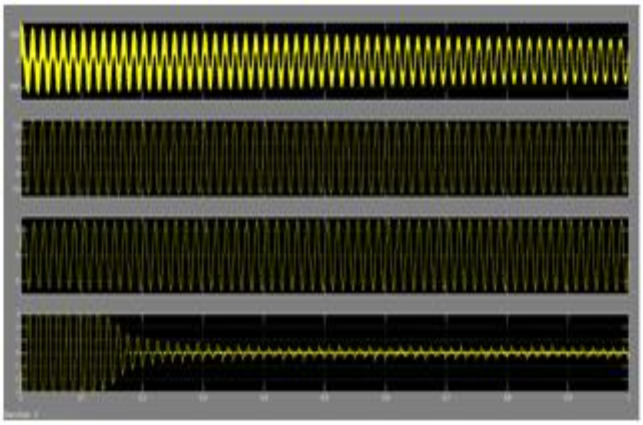

Fig.9 Waveforms of three phase four-wire hybrid power conditioner under the transient of applying the neutral-line current attenuator (a)Phase a utility voltage(b) phase a utility current (c)phase a load current (d)neutral line current line current of the utility

UNBALANCED LOAD CIRCUIT AND WAVEFORMS

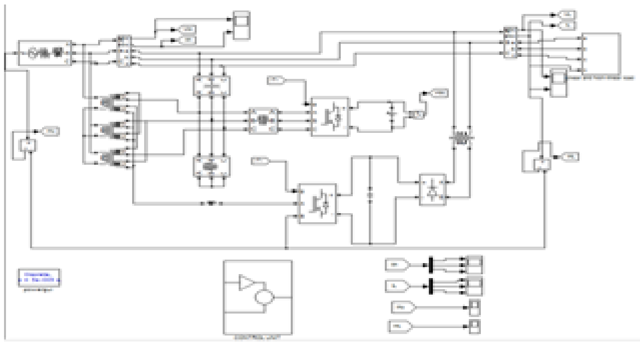

Fig 10. Unbalanced load circuit

UTILITY CURRENTS

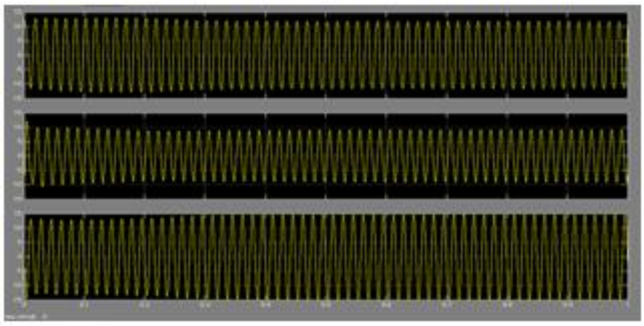

Fig. 11 Wave forms of the hybrid power conditioner under the unbalanced three-phase load: (a) phase a utility current, (b) phase b utility current,(c) phase c utility current

LOAD CURRENTS

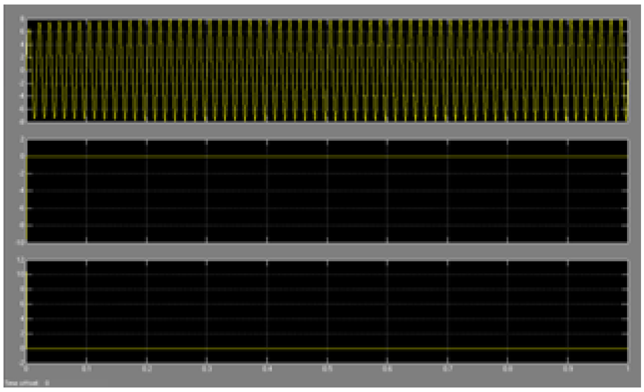

Fig. 12Waveforms of the unbalanced three-phase load, (a) phase a load current, (b) phase b load current, (c) phase c load current

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LOAD NEUTRAL CURRENT

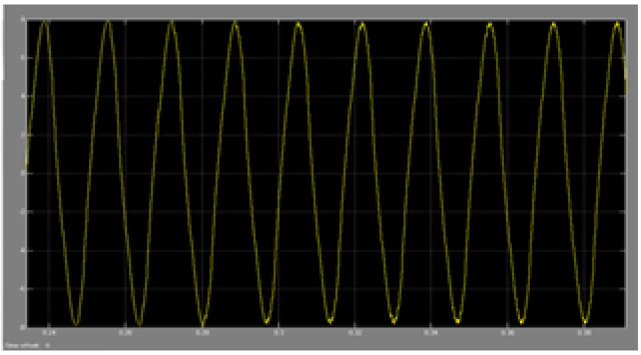

Fig. 13 Waveform of the neutral line current of the load.

UTILITY NEUTRAL CURRENT

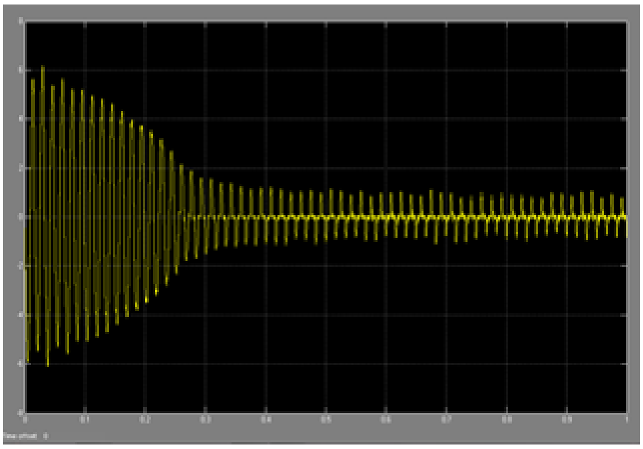

Fig. 14 Wave forms of neutral line current of the utility.

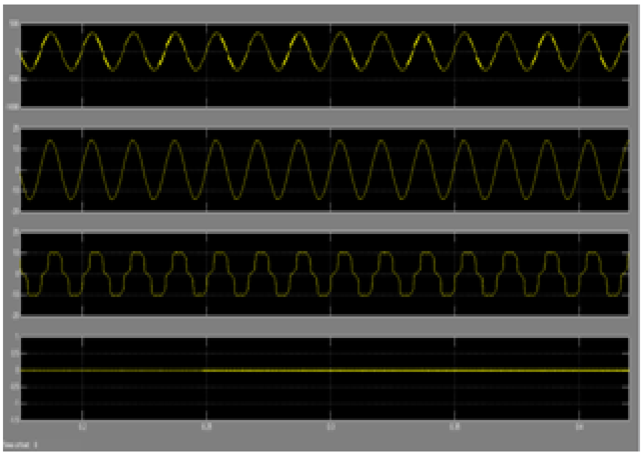

Fig.15waveforms of hybrid power conditioner under the transient of increasing load (a) phase a utility voltage (b) phase a utility current (c) phase a load current (d) neutral line current of the utility

V. CONCLUSION

A new hybrid power conditioner for solving the problems of harmonic currents and neutral-line current in three-phase four wire distribution power systems is proposed in this paper. This hybrid power conditioner is configured by a neutral-line current attenuator and a hybrid power filter. The hybrid power filter, configured by a three-phase power converter and a three phase tuned power filter, is utilized to filter the nonzero-sequence harmonic currents in the three-phase four-wire distribution power system.

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