Particle Swarm Optimization and Grid Integration of Hybrid Renewable Energy System IUPQC Performance for Multi-Feeder Systems

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ABSTRACT

"Specific power devices" based on power electronics reduce power quality issues and give tailored solutions. Modern power quality conditioners solve load-related issues and supply voltage issues (UPQC). Shunt and Series Compensation solve many power quality issues. Shunt compensators improve series compensators' current and voltage profiles. Custom feeding systems use the premise that the neighboring healthy feeder can compensate for the current feeding unit's issues. These devices outperform individual feeder bespoke power supplies. Interline proprietary power devices include IDVR, IVOLCON, IUPQC, and two VSCs. A new IUPQC topology with multi-bus/multi-feeder PI controller may simultaneously improve energy quality in voltage and current defects. Conventional approaches include hexagonal coordinate system space vector pulse width modulation and four multi-tier voltage source converters (VSC). PI controllers improve power quality and eliminate status errors. PI controllers are unstable, slow to react to rapid disorder, and sensitive. Particle Formation Optimization improves power quality with PI controller installation (PFO). IUPQC with PFO stabilises voltage and current discrepancies for power quality enhancement in the multi-bus/multi-feeder system. A shared capacitor transmits voltage from healthy feeds to neighbouring feeders to balance voltage changes in a recommended controller. Two hybrid renewable energy feeders use the researchers' method. MATLAB/SIMLUNIK tested IUPQC.

INTRODUCTION

In today's power systems, a major problem is having power that is both reliable and of good quality. It may give rise to a number of difficulties, including malfunction, instability, shortened lifespan, and the like. Since both problems and remedies are required, the ability to recognize and correct power quality issues is critical. Power system equipment often experiences transient problems, which are among the issues with power quality because they are active and have the capacity to react quickly, Active Power Filters (APFs) are a better option than passive filters for power quality problems. Series APF power quality compensation mainly deals with voltage sag, swell, and harmonics. On the other hand, the APF helps correct for difficulties like low power factor, imbalance, and harmonics that are related to load current. UPQC is a series of back-to-back connected APFs with a common DC link capacitor that are coupled in a shunt fashion. By implementing UPQC, which combines the benefits of both shunt and series APF, most power quality issues are compensated. In this paper, multi converter configurations for PQ improvement in adjacent feeders are discussed. The inter line unified power-quality conditioner(IUPQC), which is the extension of the IPFC concept at the distribution level, has been proposed .The IUPQC consists of one series and one shunt converter. Hence, two feeders are considered as two isolated sources based on the fault level at point of common coupling. In IUPQC [11] with two VSCs, one converter is connected in shunt with one feeder and another converter in series with another feeder. In this configuration, current profile of the first feeder and the voltage profile of the second feeder are improved. In this connection, many other possibilities are explored by the addition of third converter with different nomenclature such as UPQS [13], DS-UniCon [12] and MC-UPQC with 3 VSCs. A new topology of unified power-quality conditioning system, IUPQC with four VSCs is proposed in this paper. This IUPQC is able to improve voltage and current profiles in multi-bus/multi-feeder systems simultaneously. The proposed IUPQC is implemented between grid and the HRES [17]. This paper presents a new connection for a UPQC called interline UPQC (IUPQC). The single-line diagram of an IUPQC connected distribution system is shown in Fig. 1. Two feeders, Feeder-1 and Feeder-2, which are connected to two different substations, supply the system loads L-1 and L-2. The supply voltages are denoted by vs1 and vs2(from HRES). It is assumed that the IUPQC is connected to two buses B-1 and B-2, the voltages of which are denoted by vt1andvt2, respectively. Further two feeder currents are denoted by Is1 and Is2 while the load cur- rents are denoted by IL1 and IL2The load L-2 voltage is denoted by VL2

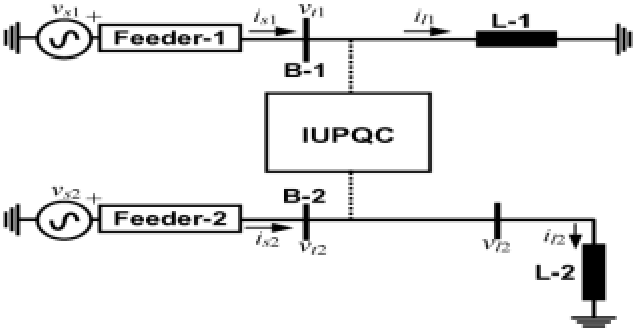


Fig 1 Single line diagram of IUPQC

The purpose of the IUPQC is to hold the voltages vt1and vt2 constant against voltage sag/swell, temporary interruption in either of the two feeders. It has been demonstrated that the IUPQC can absorb power from one feeder (say Feeder-1) to holdVl2constant in case of a sag in the voltage. This can be accomplished as the two VSCs are supplied by a common dc capacitor. The dc capacitor voltage control has been discussed here along with voltagereference generation strategy. Also, the limits of achievable performance have been computed. The performance of the IUPQC has been evaluated through simulation studies using MATLAB.

II. STRUCTURE AND CONTROL

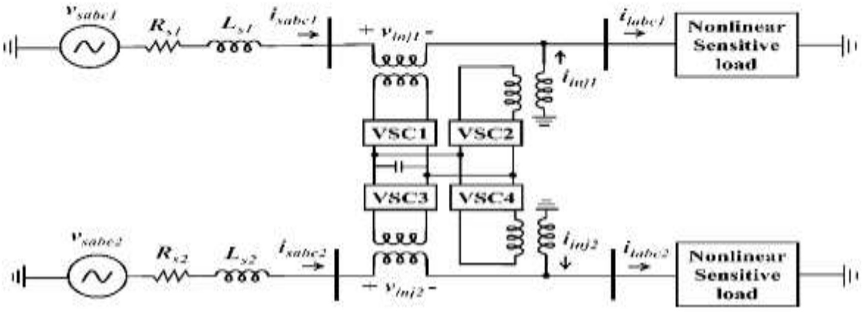


Fig 2 Single line diagram of four converter topology for multi-feeder system.

Interline Unified Power Quality Conditioner (IUPQC) is a relatively new member of the custom power device. It is a combination of shunt and series compensators. Generally power quality problems arise either because of supply voltage distortion or because of load current distortion. Since a UPQC has both series and shunt compensators, it can handle supply voltage and load current problem simultaneously when installed at the point of common coupling. It can protect sensitive loads from power quality events arising from the utility side and at the same time can stop the disturbance being injected in to the utility from load side. To improve the quality of power for non-linear and voltage sensitive load UPQC is one of the best solution.

Series inverter control Sag/ swell detection, voltage reference generation, voltage injection strategies and methods for generating of gating signals.

Shunt inverter control Current reference generation, methods for generating of gating signals and capacitor voltage control.

ControlStrategyforShuntand SeriesVSCConverters

TheswitchingcontrolstrategyforseriesVSCsand the shunt VSC are selected to be sinusoidal pulse widthmodulation (SPWM) voltage control and hysteresis currentcontrol,respectively.

Shunt-VSCFunctionsoftheshunt-VSCare

✓ tocompensateforthereactivecomponentofloadL1current;
✓ tocompensatefortheharmoniccomponentsofloadL1current;
✓ to regulate the voltage of the common dc-link capacitor.Fig. 3 shows the control block diagram for the shunt VSC.Themeasuredloadcurrent(il_abc)istransformedintothesynchronousreferenceframe(dq0).

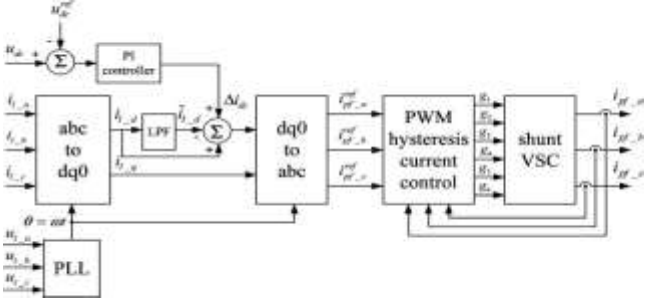


Fig.3PWMhysteresiscurrentcontrolblockdiagramfortheshuntVSC

Bythistransform,thefundamentalpositive-sequencecomponent,whichistransformedintodcquantitiesinthe and axes, can be easily extracted by low-pass filters (LPFs).Also,allharmoniccomponentsaretransformedintoacquantitieswitha fundamentalfrequencyshift. Switchinglossescausethedc-linkcapacitorvoltage to decrease. Other disturbances, such as the suddenvariation of load, can also affect the dc link. In order toregulatethedc-linkcapacitorvoltage,aproportional–integral (PI) controller is used as shown in Fig.3. The inputof the PI controller is the error between the actual capacitorvoltage and its reference value. By using PWM hysteresiscurrent control, the output-compensating currents in eachphaseare obtained.

Series-VSC FunctionsoftheseriesVSCsineachfeederare

- ✓ Tomitigatevoltagesagandswell;
- ✓ Tocompensate forvoltagedistortions,suchasharmonics;
- ✓ Tocompensate forinterruptions.

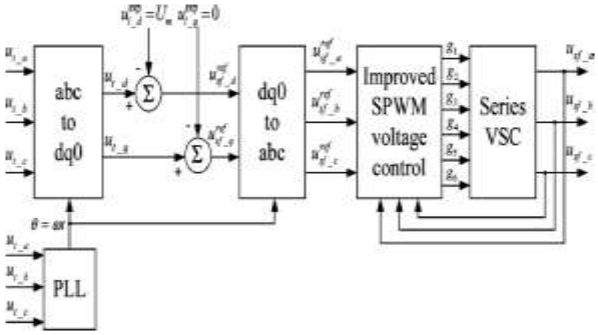


Fig. 4 Improved SPWM Voltage Control block diagram for the seriesVSC

The control block diagram of each series VSC isshown in Fig.4. The bus voltage is detectedandthentransformedintothesynchronousreferenceframe(dq0).ByusinganimprovedSPWMvoltagecontroltechnique(sinePWMcontrolwithminorloopfeedback)[3], the output compensation voltage of the seriesVSCcanbeobtained. The multilevel converters are employed in the proposed system to transform the VSC's power supply three-phase converters are employed for three-level power supplies. A number of multilayer converter (MLC) techniques, including sinusoidal triangular comparison, selective harmonic elimination, and hysteresis, are available, along with SVPWM. It's advantageous since it reduces common mode distortion.

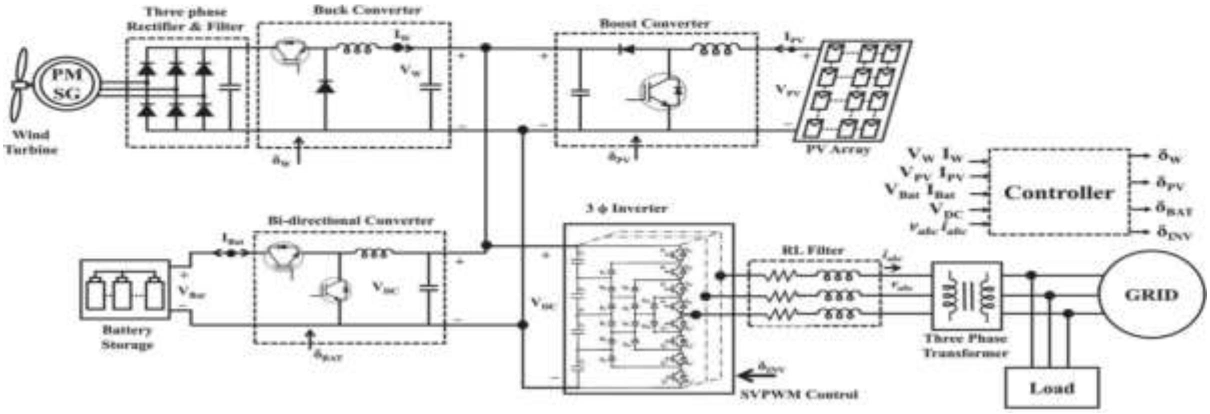


Fig5Schematic diagram of HRES.

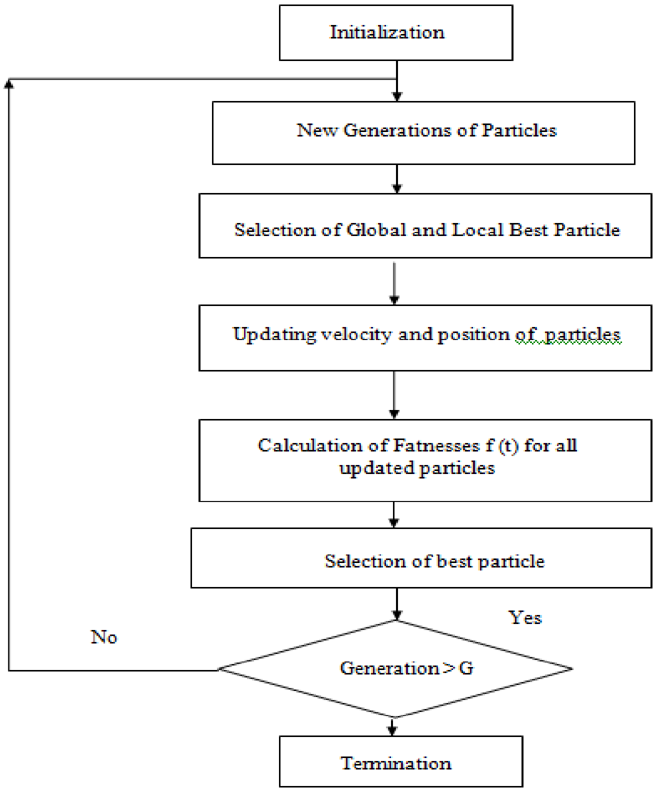
A novel topology of IUPQC with PI controller for multi-bus/multi-feeder systems, capable of compensating both voltage and current imperfections simultaneously for power quality improvement. In Conventional method, four Voltage-Source Converters (VSC) with multilevel configuration are considered and space vector pulse width modulation is used in hexagonal coordinate system. PI controller reduces steady state error and improves power quality improvement. The main drawback of PI controllers reduces stability, slow response to sudden disturbances, and sensitivity to controller gains. Instead of PI controller, Particle Formation Optimization (PFO) are used for further improvement in power quality. The IUPQC with Particle Formation Optimization (PFO) for multi-bus/multi-feeder systems, stability of compensating both voltage and current difference continuously for power quality improvement.

III. PARTICLESWARMOPTIMIZATIONMETHOD

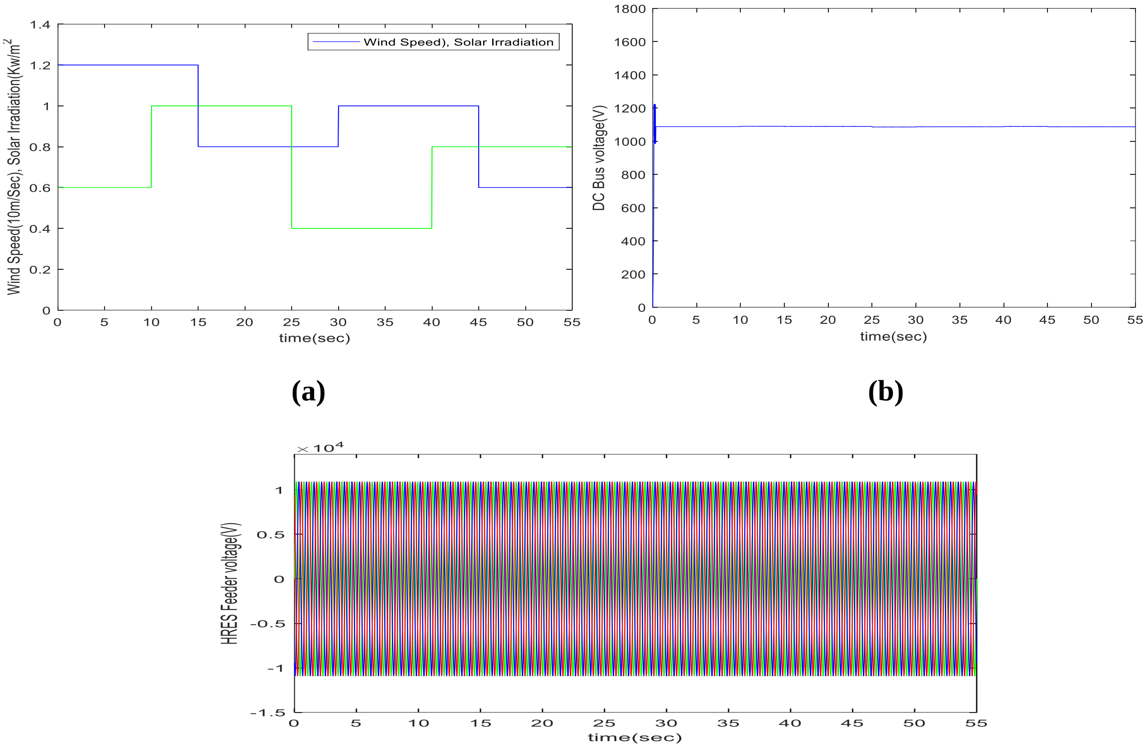
Optimization via population-based technique. This is influenced by group-oriented behaviours. The group is made up of fish and birds. Particles are also known as search agents. They are generated randomly at the start, with information on the optimization variables included. Velocity coordinates the particle's position for the following instant. The particles are updated to pbest and gbest.

Consider Vel_{ij}^{t+1}	the velocity of the particle in $(t+1)_{th}$ iteration
k	Constriction factor
c1, c2	the learning constants
$random_1$ and $random_2$	random numbers in the range [0 -1]
X_{ij}^{t}	Position of the particle in the t_{th} iteration
w	Inertia weight
$pbest_{ij}^{t}$	Personal best of the particle
$gbest_{j}^{t}$	Global best of the particle
T	Maximum iterations
t	Current iteration

In particular when compared to genetic algorithms, PSO is not widely used in the scheduling environment (GA). Nonetheless, its results are highly classified in general comparisons with all optimizationstrategies, in particular for single-mode resource-constrained project scheduling problems (SRCPSPs).



IV. Simulation results using PSO:



(a) **(b)**

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FIGURE 6. (a) Solar irradiance and wind speed levels.(b) DC Bus voltage.(c) HRES feeder voltage

From fig 6 (a) the solar irradiance and wind speeds are varied for different combinations of wind and solar conditions in order to test the performance of the HRES. Even with different variations in wind velocity and solar radiation, dc bus tension is maintained at 1kV. This is achieved by the BEES and the voltage remains constant at the dc bus. The voltage at the output of the secondary transformer is illustrated in Fig. c and is constant at 11kV because of a constant dc bus voltage. The HRES technology offers a stable constant voltage and frequency to be loaded.

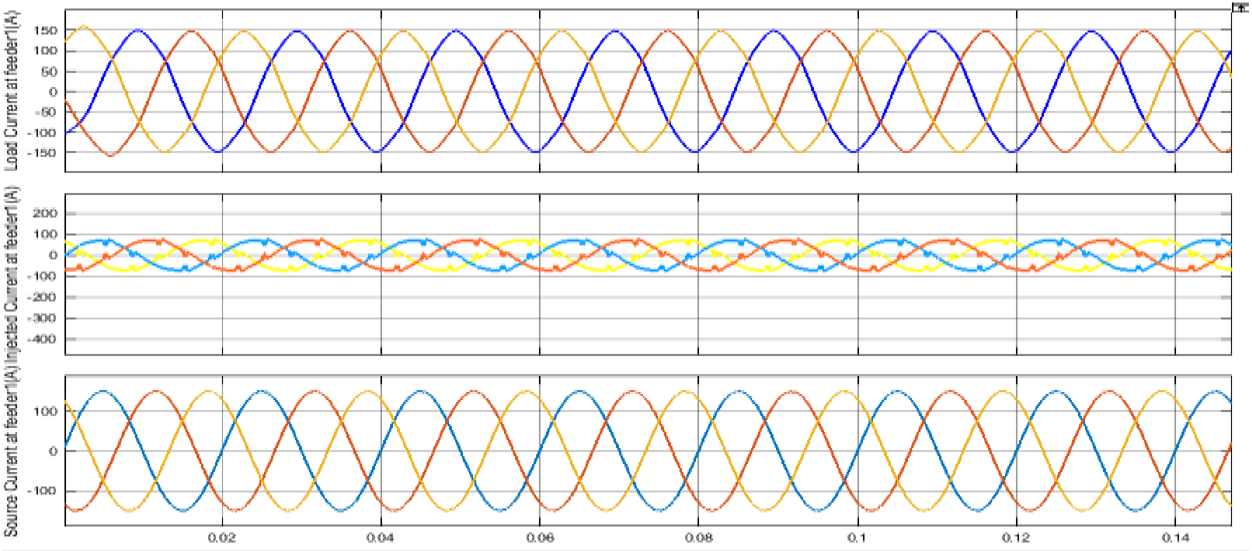


FIG 7. Voltages and currents at feeder 1.

A comprehensive case study has tested the proposed IUPQC topology for two feeders system and control systems. The two-phase, three-wire 11kV and 50-Hz power system are evaluated. IUPQC's performance is discussed and results offered. A variety of power quality problems are considered as various scenarios and the performance of IUPQC is provided. These are current harmonics owing to non-linear loading and voltage flaws such slant/slope and voltage harmonics.

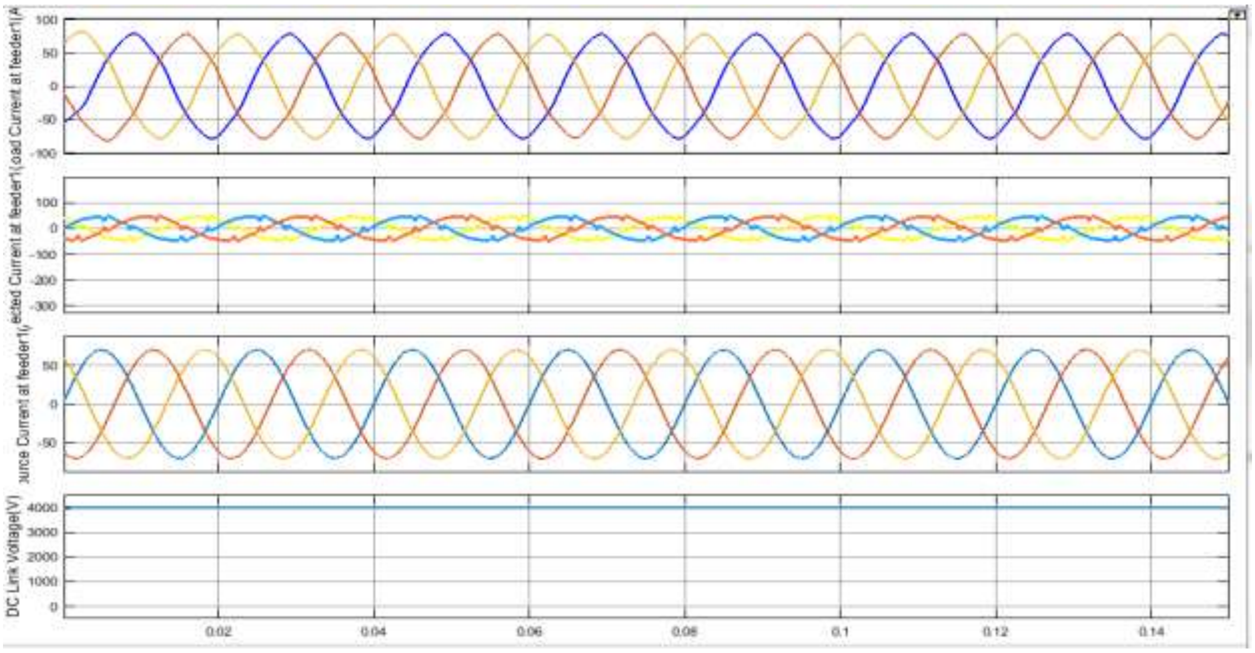
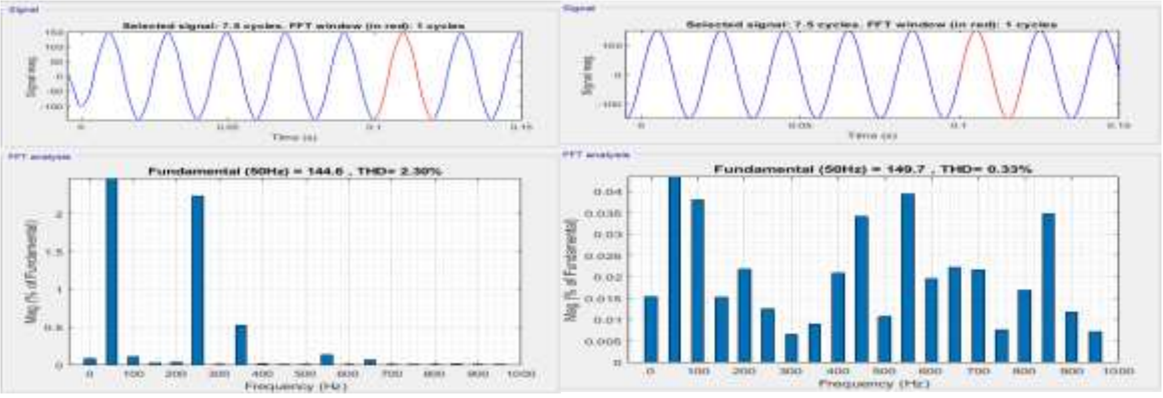


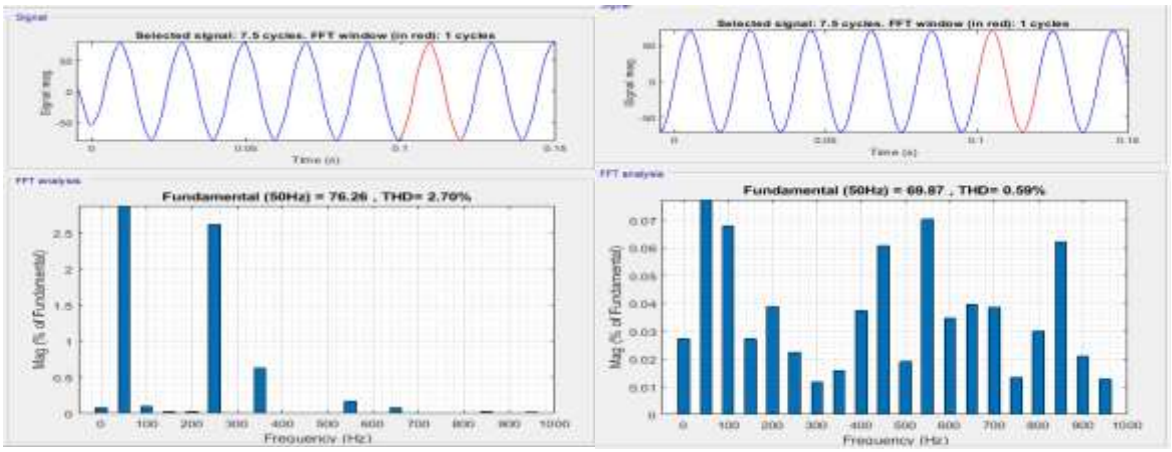
FIGURE 8. Voltages and currents at feeder 2, DC link voltage.

Feeders 1 and 2 supply 100 ohms and 140 ohms of resistive load through diode bridge rectifier to nonlinear loads. Fig. 11 and Fig. 12 show that, due to non-linear loads and source currents, the load currents contain harmonious content. The THD of the first feeding system is lowered from 2.03 percent to 0.33 percent from load current to source current, and that of the second feeder from 2.70 to 2.59 percent. Fig.9 and Fig. 10 demonstrate FFT analysis using THD values.



Load current at feeder1 Source current at feeder 1

Fig 9 FFT analysis of feeder1



Load current at feeder2 Source current at feeder 2

Fig 10 FFT analysis of feeder1

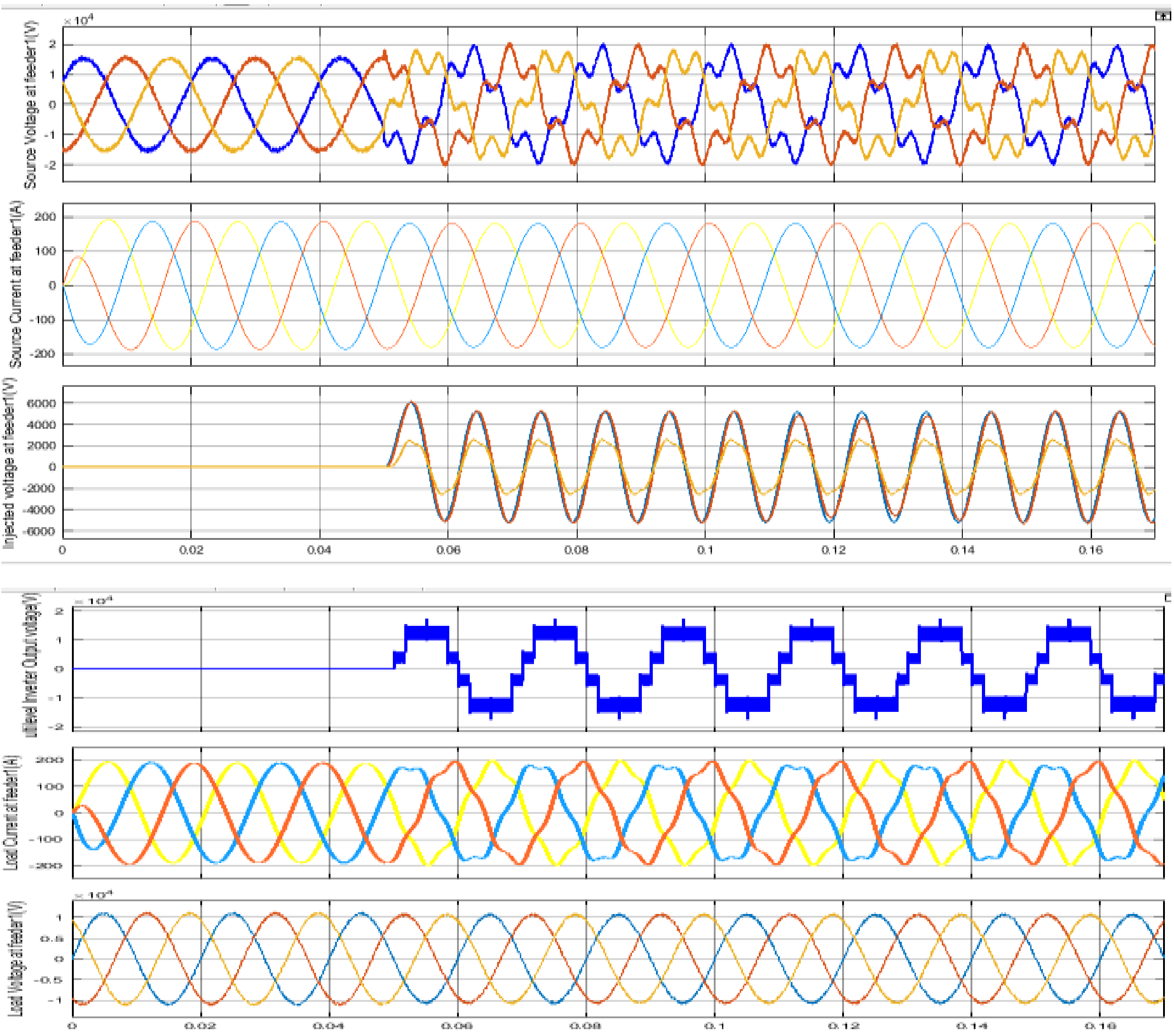


FIG11. Voltages and currents at feeder 1.

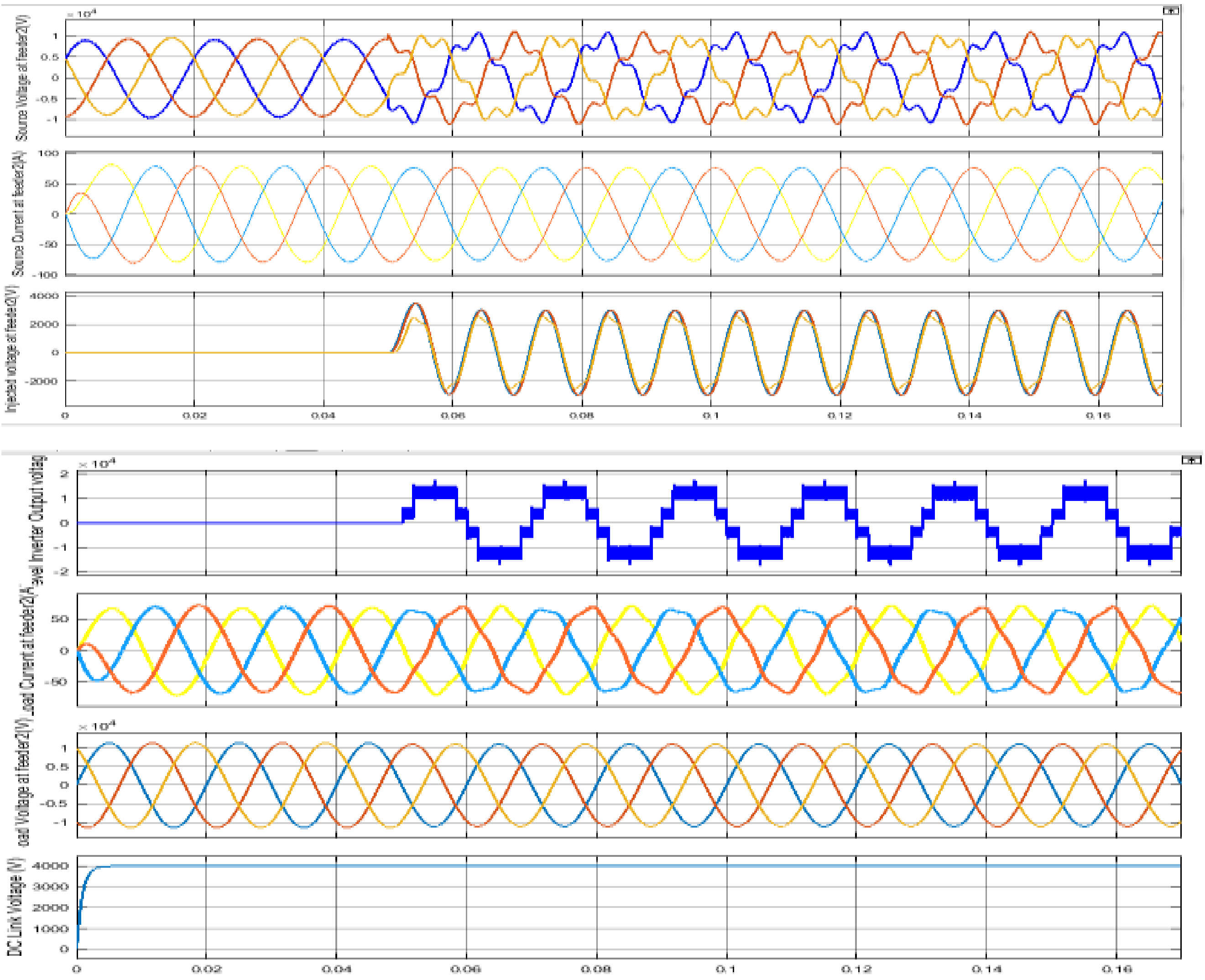
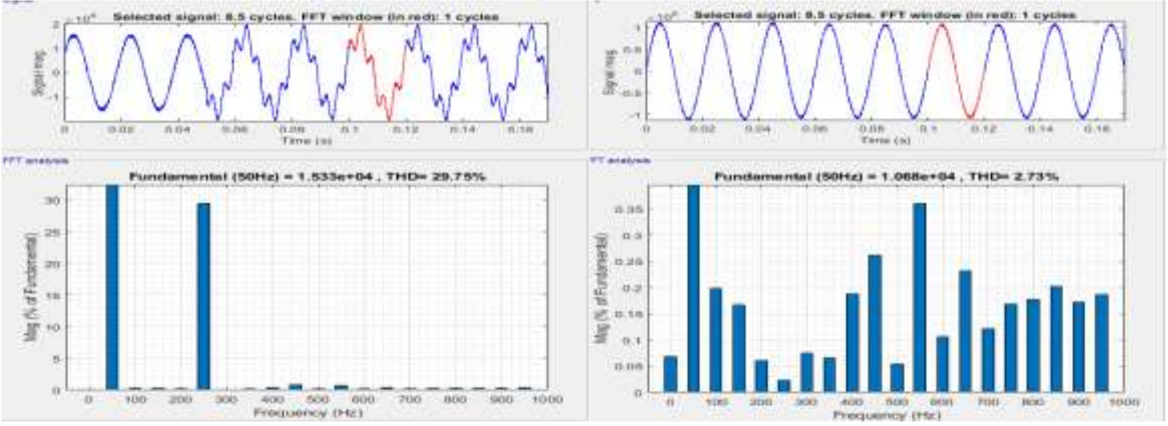


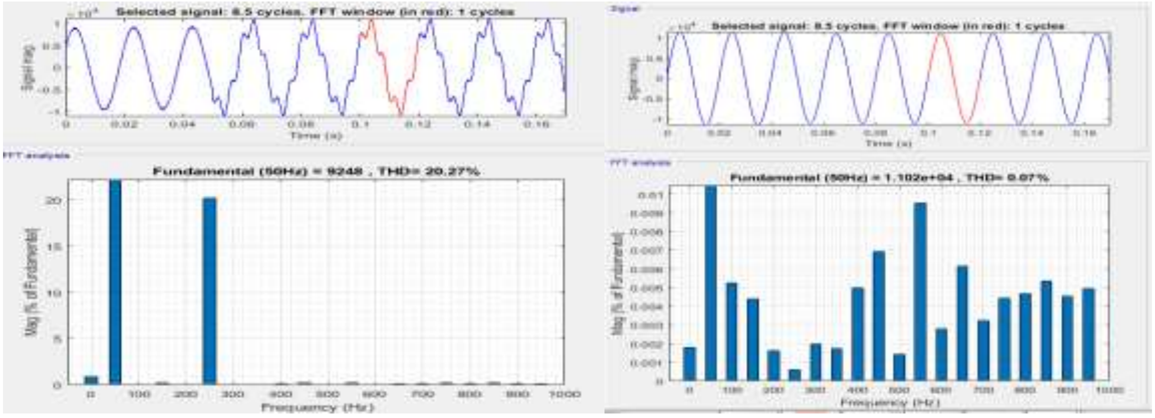
FIG 12. Voltages and currents at feeder 2**.**

Bother feeders are displayed in Fig. 11 and Fig. 12 as source voltages, load voltages, spring currents, load currents and injected voltages and multi-level converter voltages. Fig. 13 and Fig. 14 demonstrate FFT analysis with THD values. We note that the THD of Feeder 1 has improved by 4.63% to 2.73%, and feeder 2 has improved by 2.59% to 0.07% on the load side.



Source voltage 1 Load voltage 1

FIG 13. FFT analysis at feeder 1.



Source voltage 2 Load voltage 2

FIG 14. FFT analysis at feeder 2.

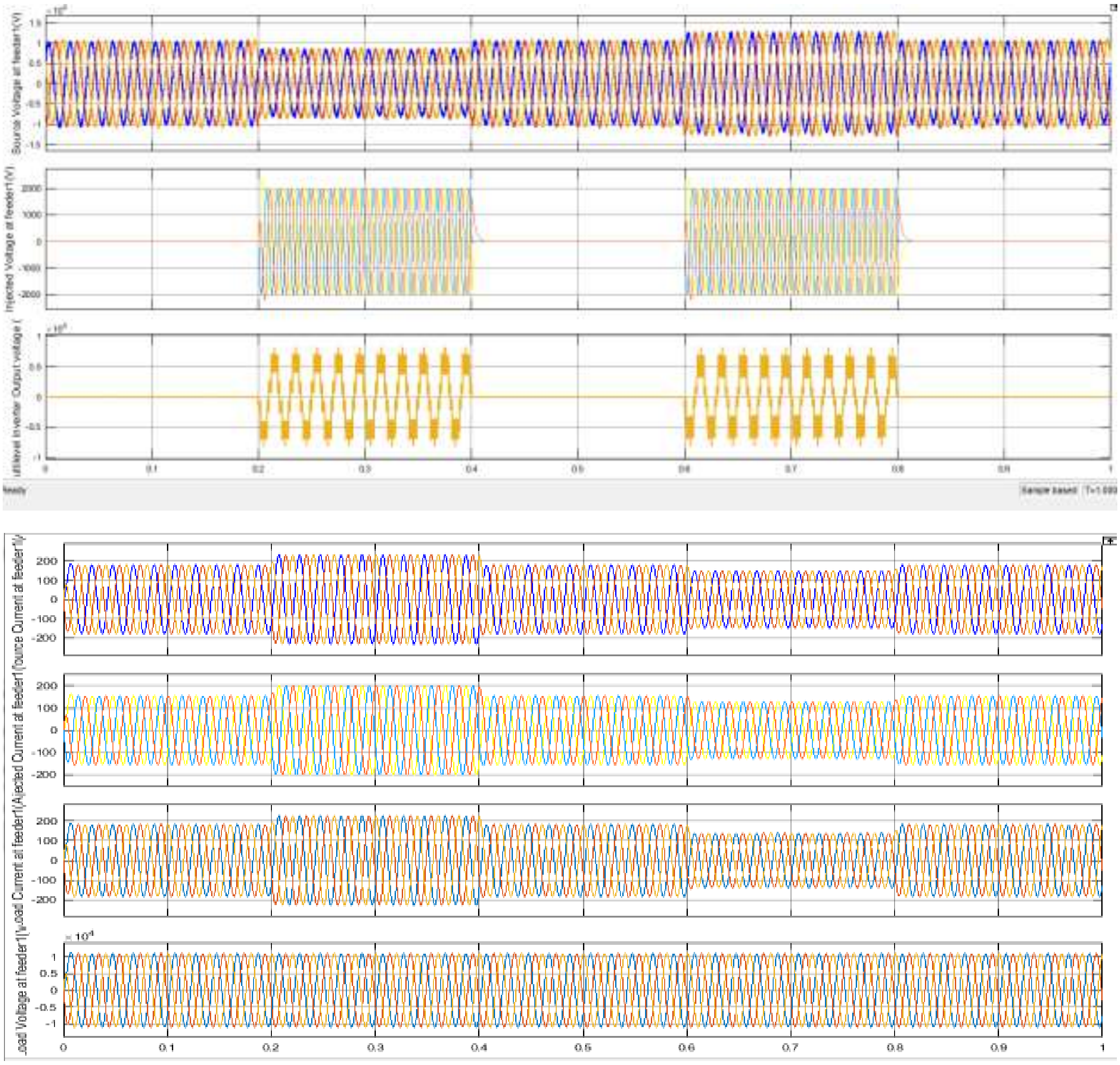


FIG15. Voltages and currents at feeder 1.

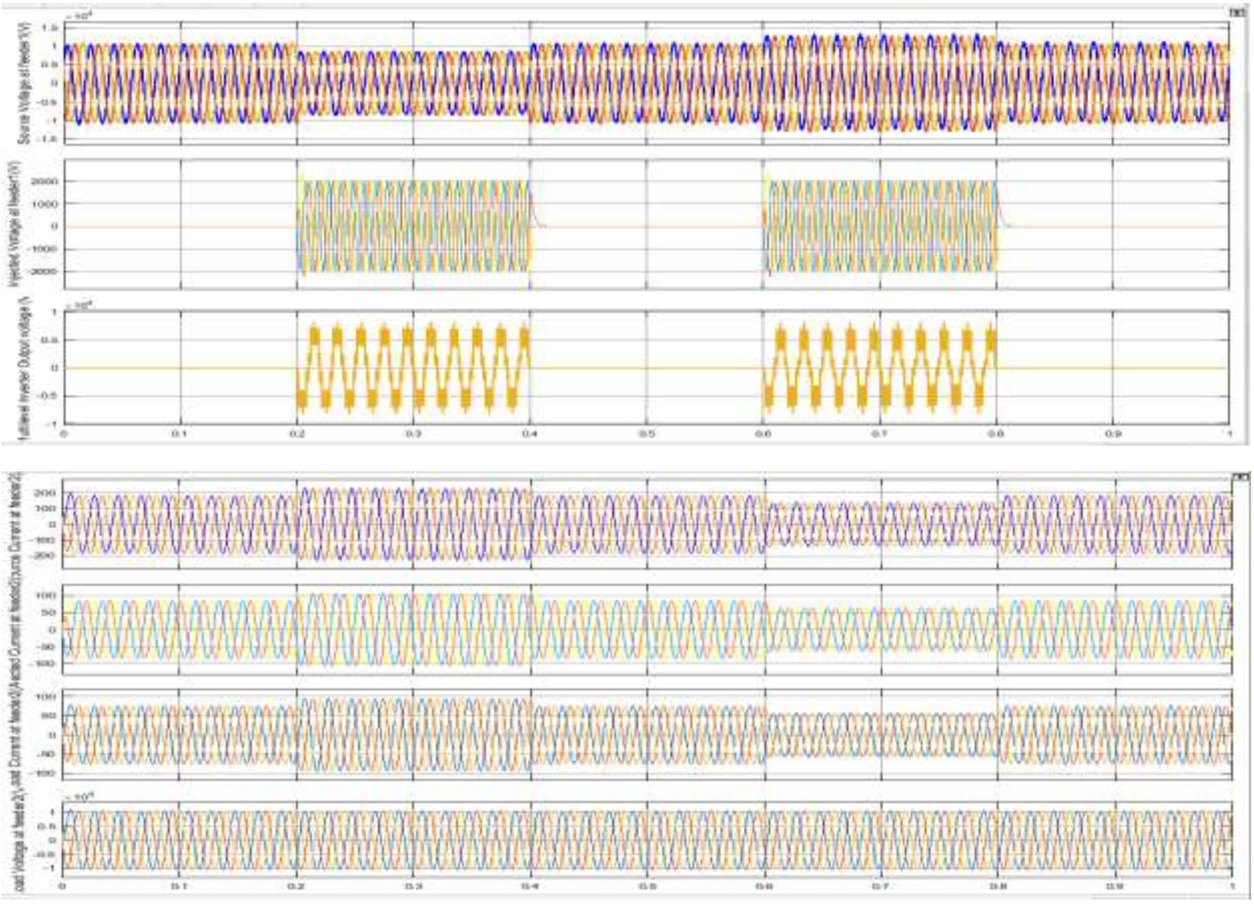


FIG16. Voltages and currents at feeder 2.

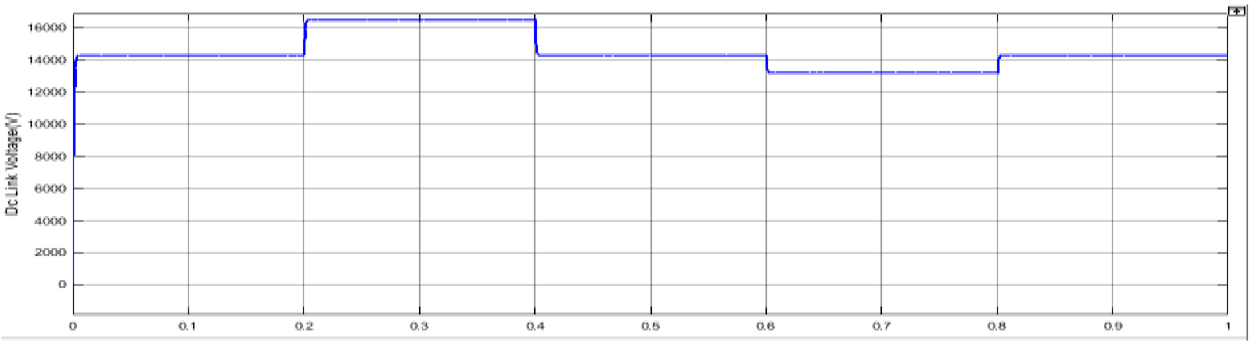


FIG17. DC link voltage**.**

First feeder supplies RL of 50Ωand 100mH and second feeder supplies RL load of 100Ωand 140mH. Source voltages, source currents, load voltages,load currents, injected voltages and multilevelconverter volt ages of both the feeders are shown in Fig. 15 and Fig. 16.It can be observed that source voltages are compensated atthe loads of both the feeders. DC link capacitor voltage canbe observed from Fig. 17.PSO plays major role in reducing the errors using PI controller in voltage regulation.

CONCLUSION:

The hybrid renewable energy system is built and implemented for several variations in the results demonstrating that the IUPQC may be satisfactorily applied for grid integration of HRES. In order to safeguard loads against tensile disturbances in the system, IUPQC is able to control load voltages. It also offsets the nonlinear load currents in reactive and harmonic components. For adjustment of slope/swell and current/voltage harmonics, power from healthy feeding to nearby feeders can be transferred. In multi-feeder systems, IUPQC can be a superior way of solving numerous power quality problems.

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