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MODELLING OF SINGLE-PHASE OFF GRID INVERTER FOR SMALL STANDALONE SYSTEMS

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Abstract: This paper reports the modelling of off-grid inverter for small standalone system of single-phase applications. This off grid inverter consists of a high frequency DC-DC step up converter cascaded with a full bridge PI control voltage source inverter using SPWM modulation with LC filter to produce AC sine wave output. This off-grid inverter model is capable to produce AC sine wave output voltage at 230 V 50 Hz up to 1 kW power from a 48 V DC battery source. The AC sine wave output waveform achieved a voltage Total Harmonic Distortion (THD) of less than 1 % which is almost a pure sine wave. The conversion efficiency performance of the off-grid inverter achieved more than 94 %. The performance of the model is validated by real commercial off-grid inverter. The performance validation experiment shows that the off-grid inverter Simulink model conversion efficiency and THD performance are comparable to the commercial off-grid inverter. This model contributes to assist small to medium standalone system load.

Index terms: **Total harmonic distribution, LC filter, Pulse width modulation.**

Introduction: Uninterruptible Power Supplies (UPS) are important for various reasons, particularly in settings where a reliable and continuous power supply is crucial. UPS systems are important for maintaining the integrity and functionality of electronic equipment, preventing data loss, ensuring business continuity, and protecting critical infrastructure during power disturbances. It is important to note that while off-grid inverters can contribute to a UPS setup. Compatibility and Coordination between the off-grid inverter and the UPS are crucial to ensure a smooth and reliable power transition during outages. The conversion efficiency and Total harmonic distortion are two important parameters need to be considered while designing the inverter model.

Simulation method: The model is developed in MATLAB/Simulink platform using circuitry model. There are two steps in the entire model. The first step is modelling the Step-up DC-DC Converter with diode bridge rectifier while the second step is modelling of PI controlled full bridge inverter.

Simulation Modelling:

The first step of the simulation model enables the linear lead acid DC battery voltage to convert to square wave pulses of which the peak voltage equals to DC voltage. This is done by MOSFET switching devices which have high switching frequency. This pulsated DC square wave output is stepped up using a linear single-phase transformer having a frequency of 20Khz.

The high frequency transformer introduces a 90° phase shift which do not bother the pulsating square waveform. The output of single-phase high frequency transformer is sent to the full bridge diode rectifier system. The full bridge rectifier system converts the pulsating square wave transformer output to DC voltage back again. The rectifier system output contains many ripples in the output which gives distorted harmonic output. A capacitor filter is needed to reduce this ripple content in the output, which is connected across the rectifier output.

In the second step of modelling, PI controller is used for controlling the gate pulses for H-bridge inverter systems with MOSFET switching devices. The filtered output with reduced ripple content is connected to MOSFET H-bridge inverter. This output is further filtered with LC filter to reduce the ripple content and obtain a undistorted output voltage waveform.

This can be observed in percentage THD output. The output RMS values of current and voltage are obtained for R, RL, RC, RLC loads. The output RMS value of load voltage is compared with the reference voltage 230Volts, and this error is used to simulate pulse width modulation control with PI controller. The pulse width modulation controls the gate pulsing for H-bridge inverter systems which forms a closed loop control to reduce the harmonics of the output load RMS voltage.

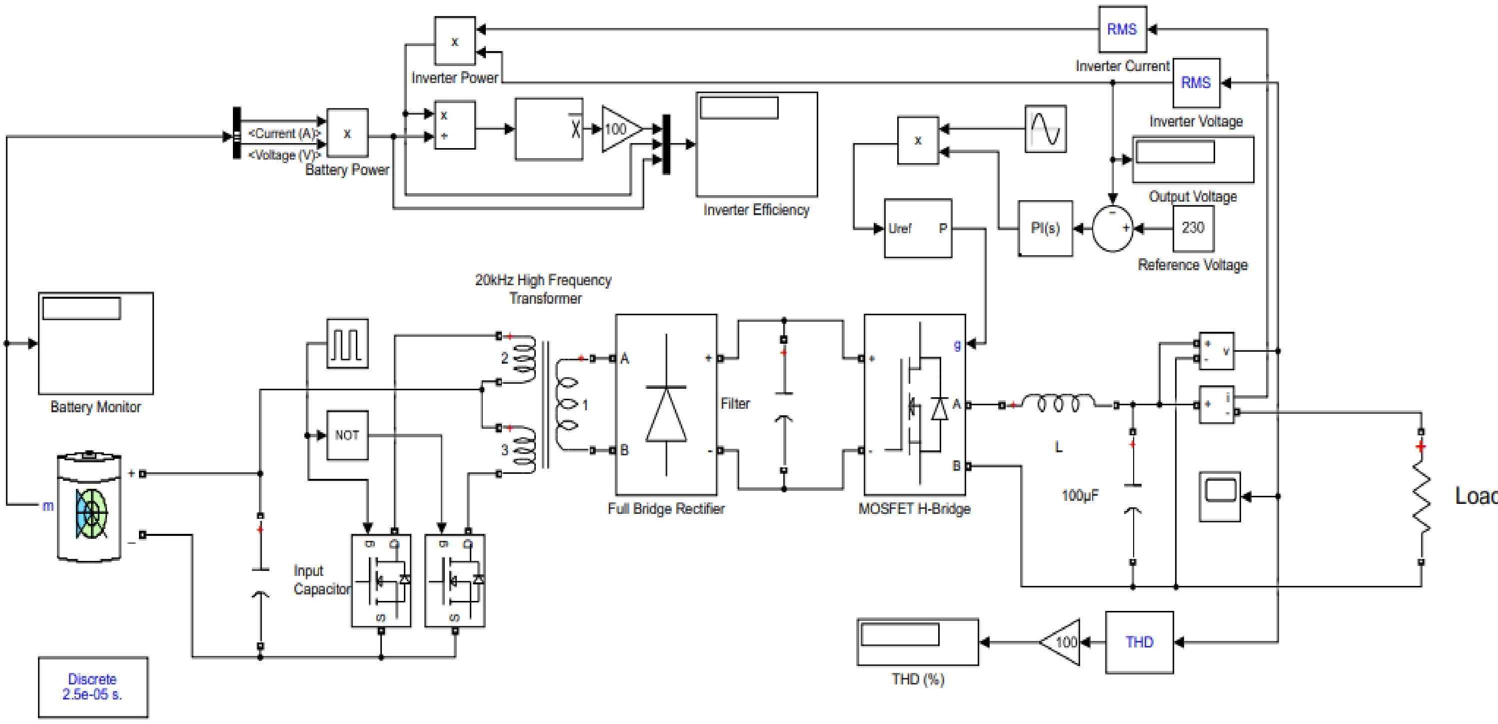

Fig - Simulation Model

Simulation results:

SIMULATION OF RESISTIVE LOAD

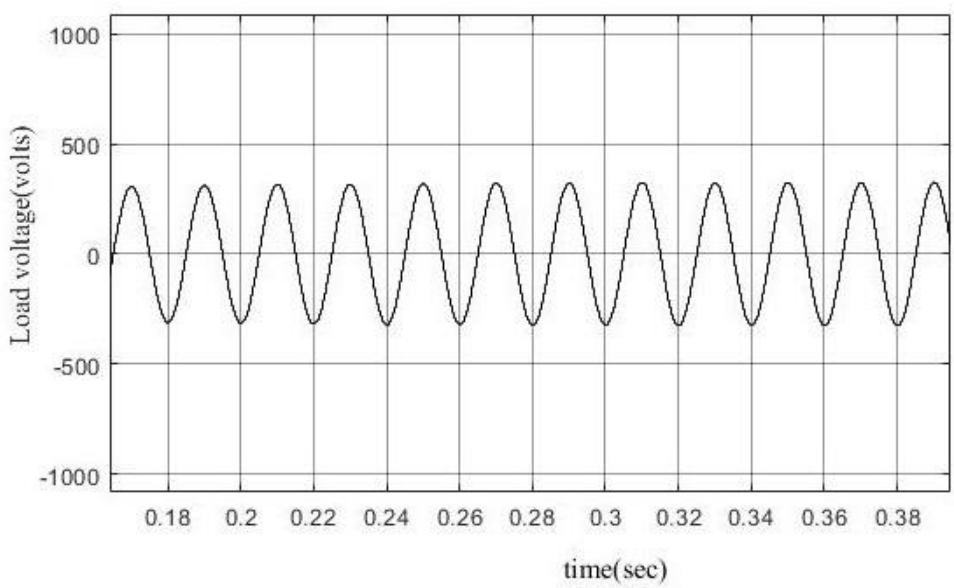

Fig - Load Voltage for R load

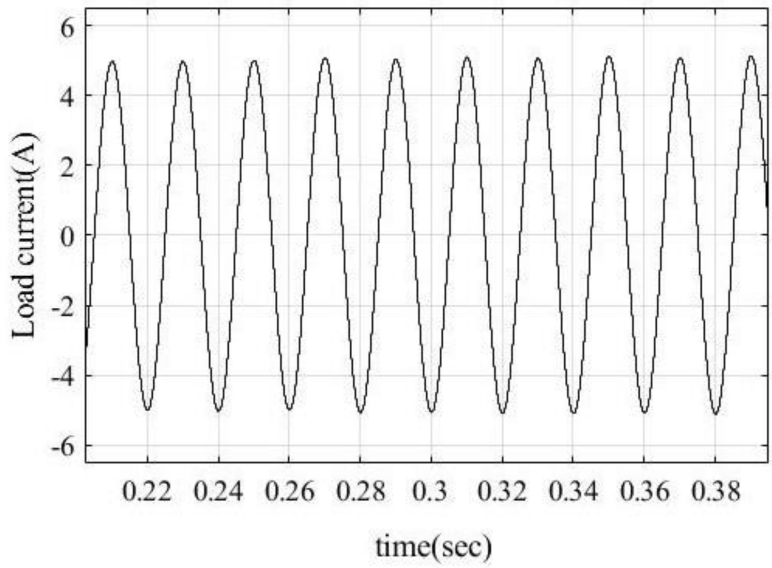

Fig - Load Current for R load

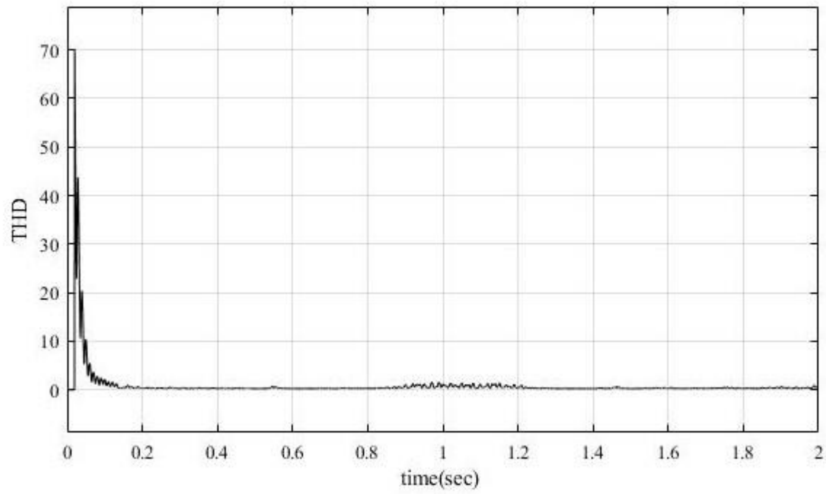

Fig - Total Harmonic Distortion for R load

SIMULATION OF INDUCTIVE LOAD

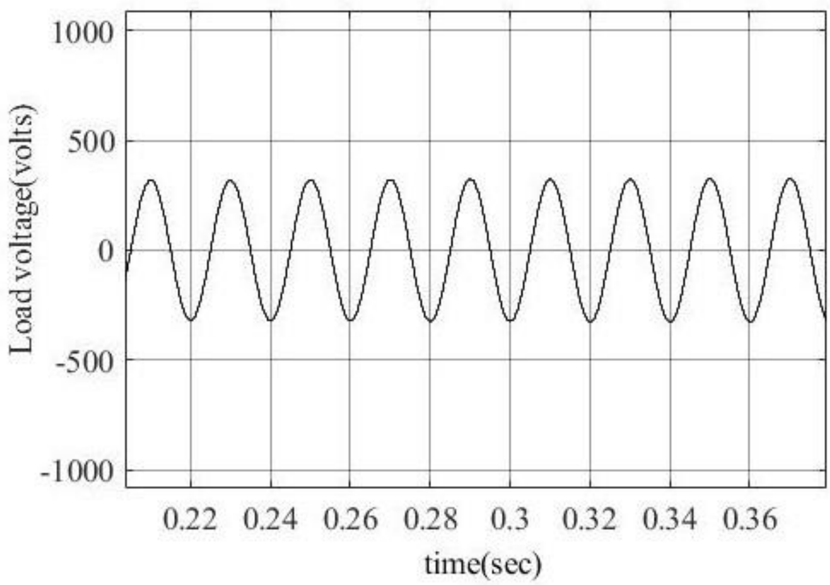

Fig - Load Voltage for RL load

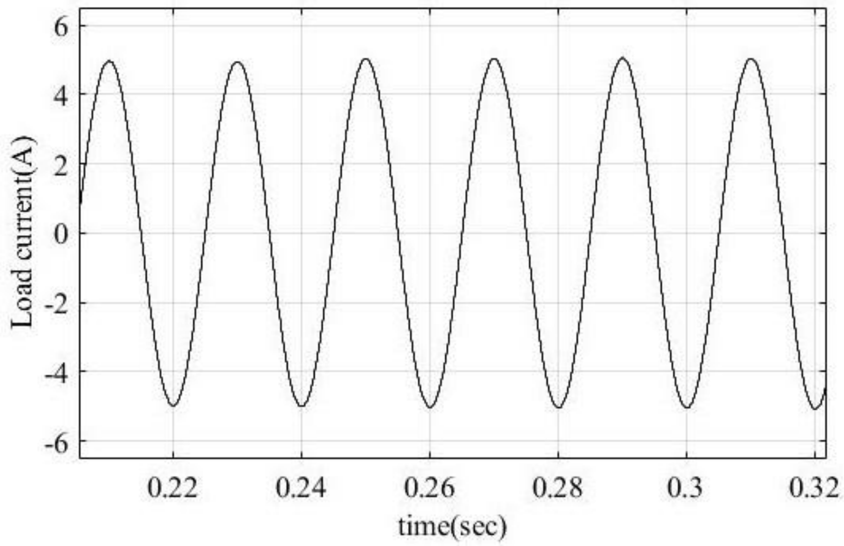

Fig - Load current for RL load

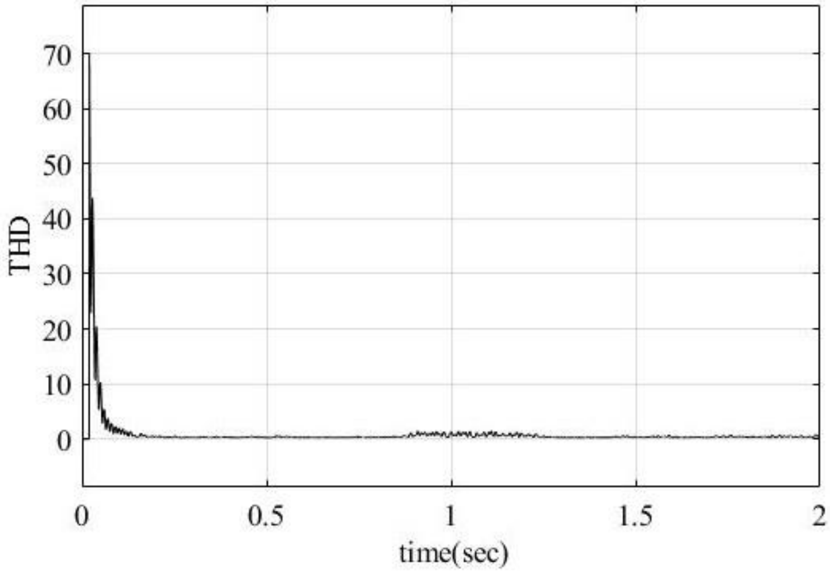

Fig - Total Harmonic Distortion for RL load

SIMULATION OF CAPACITIVE LOAD

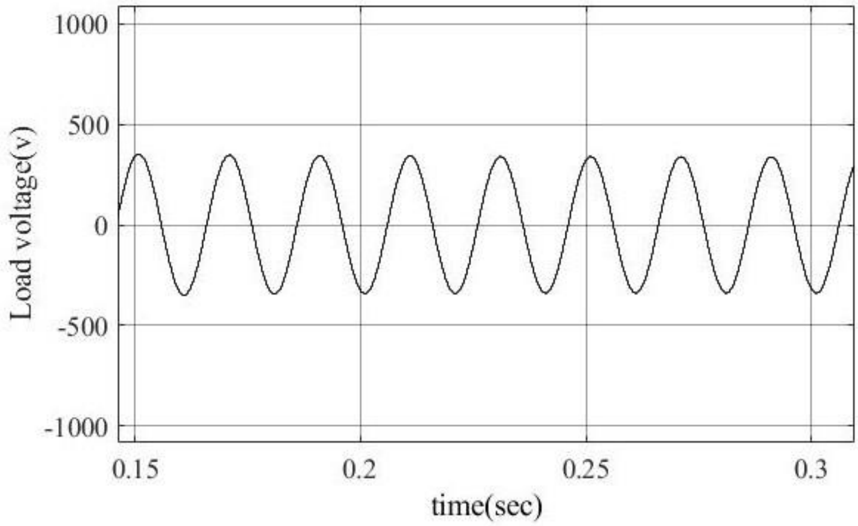

Fig – Load voltage for RC load

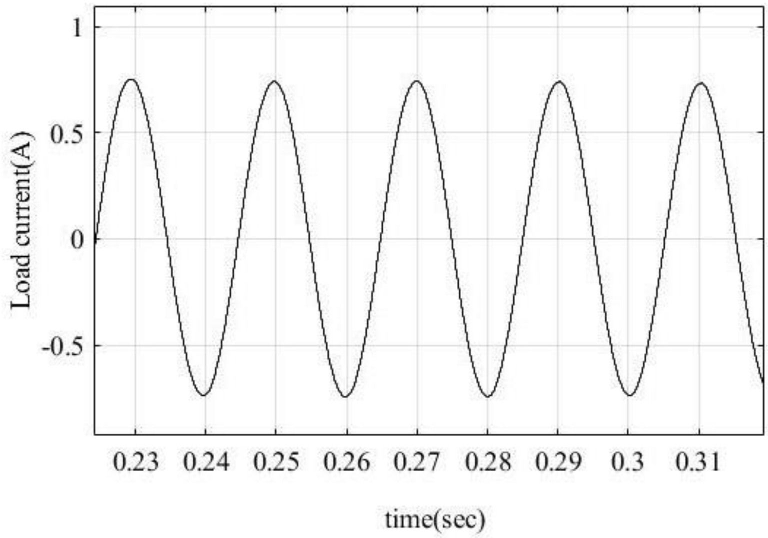

Fig – Load current for RC load

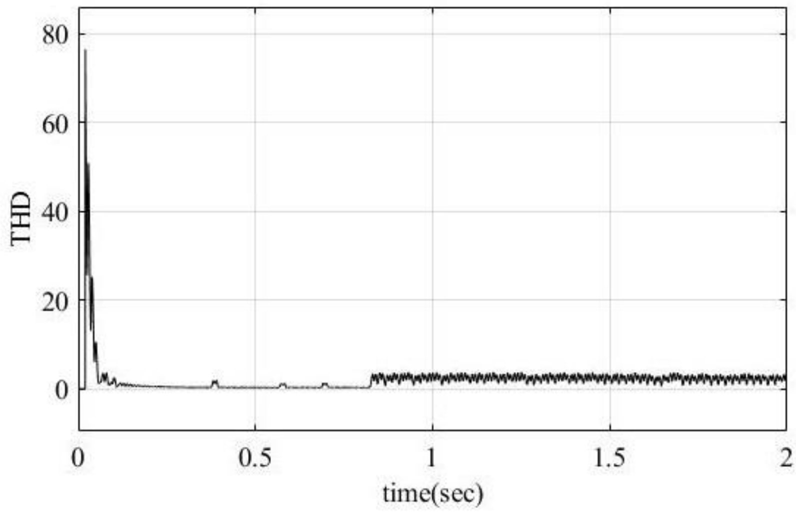

Fig – Total Harmonic distortion for RC load

SIMULATION OF COMBINED (R, L, C) LOAD

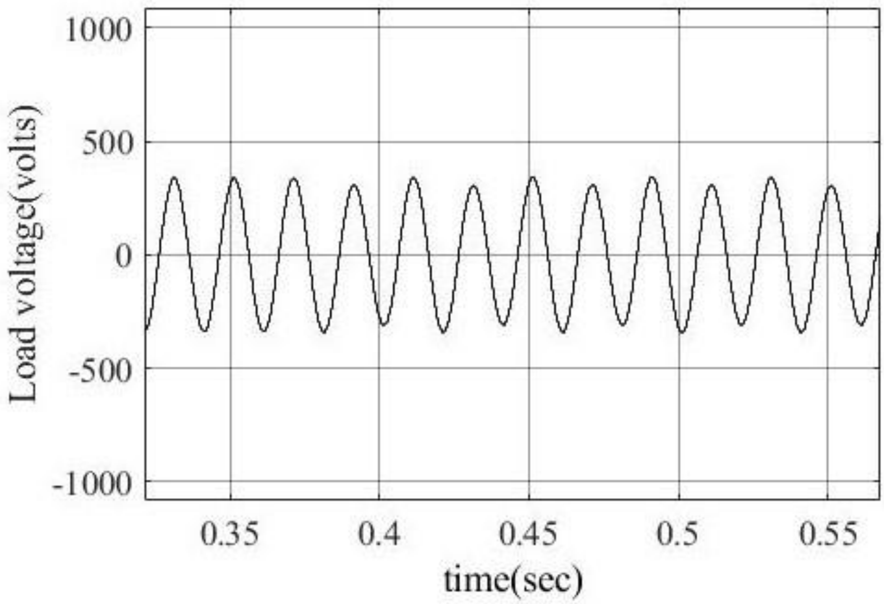

Fig – Load voltage for RLC load

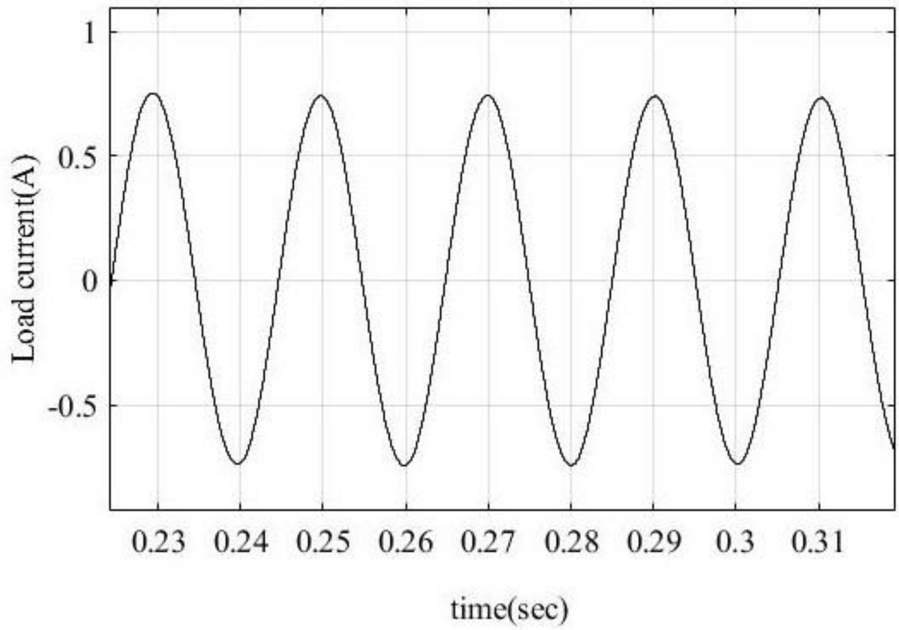

Fig – Load current for RLC load

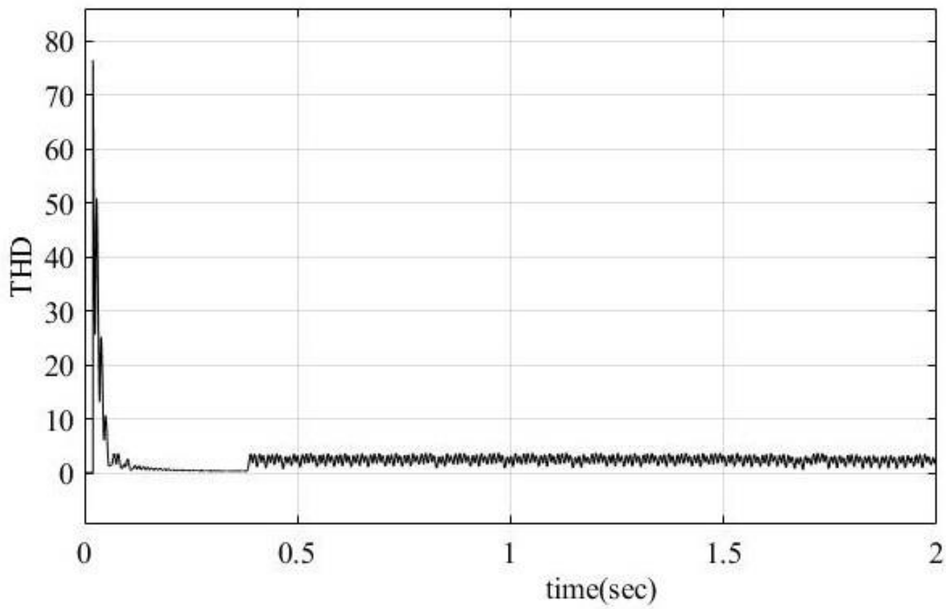

Fig – Total Harmonic Distortion for RLC load

Conclusions:

1. The off-grid inverter model is capable to convert a 48 V from a battery source to 230 V 50Hz up to a power rating of 1000 W. It achieved an average conversion efficiency of ≥94 % and produces sinewave output waveform with THD of less than 1 %.
2. Single PI Controller can be applicable for various loads. An off-grid inverter is majorly designed for single load alone as per the researchers, but we designed for multiple loads with a single controller.
3. The performance of the Simulink model is also validated with the commercial off-grid inverter. The Simulink model presented can be flexibly changed to meet the commercial inverter with similar topology.

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