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Multi-Phase Multi-level Inverter with Grid Integration for PV Applications

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ABSTRACT: The increasing in population though out the world parley increases the high stipulate for the electricity along with the decreasing of the fossil fuel resources, so as in the search for the alternation most of the countries all over the world run out for the renewable energy sources like wind, tidal and solar for the electric generation. Encompassing all among the renewable sources the research for solar photovoltaic PV systems as a vacillation sources for power generation has gained global contemplation. With the most imperative facets that should be well thought-out for the applications of PV system is by utilizing the grid integration multi level inverter (MLI). This paper work, focuses on the 3-phase grid connected multilevel inverter (MLI) is anticipated for the integration power to the grid from the (RES). The anticipated inverter is competent of integrating to the grid with the low total harmonic distortion (THD). The inverter is allied from PV array through a Dc-Dc boost converter.

KEYWORDS: 3-Phase; Multi level Inverter (MLI); Total Harmonic Distortion (THD); Grid Integration; Photo Voltaic (PV) system; Renewable Energy Sources RES's.

I. INTRODUCTION

In present Technical scenario the power obtained from the sun light along with other renewable resources are become very vital in the power generation. The extracted power from the any kind of renewable energy sources won't be directly utilized by the load or grid. As the power electronic interfaces such as converters like DC-DC converter and DC-AC inverter especially MLI's are being placed for the interfacing among them. With the lesser harmonics a pure sinusoidal wave or voltage/Current will be fed to the grid. It is necessary for matching of the grid frequency with the injected frequency signal [1]. MLI is incorporated with the LC filter for obtaining the low harmonic sinusoidal three phase voltage current. The convectional MLIs are begins with the three phase levels outputs as 0V-Vdc -0V. Furthermore there were numerous number of harmonic profile improvement. Another step further advantage of MLIs with higher and greater efficiency, were the reduced dV/dt stresses on load. The MLs DC input voltage source can be derived from the one of the renewable energy sources as the Photo Voltaic array with DC to DC converter, induction generator generator/Synchronous generator fed wind turbine with rectifier configuration and fuel cell with DC-DC converter [2]. There are so many techniques available for adopting the waveform such as hysteresis current control MLI for H-bridge cascaded inverter, etc… for improving the harmonic profile of voltage and current [3][4]. The 1Soltech 1STH-215-P with 4parall strings with the 27 series connected module per string.

The proposed work is focused on the arrangement of the 3-phase with the multi levels of inversions with three single phases with a DC source and switches. With the help of voltage source inverter, at this time of work for controlling current injection amount to the grid synchronous reference frame control i.e d-q frame control technique is adjacent to the PWM technique. Grid connected techniques are discussed in many number of phases [3-6]. Subsequently, to coordinate with the grid frequency and phase, Phase Locked Loop (PLL) method is executed. It is additionally insightful to utilize a LC filter and a transformer after inverter to eliminate high harmonics and to give galvanic isolation appropriately. To decrease the harmonic in the output voltage, appropriate value of three phase transformer spillage inductance is chosen [5]. THD of the output waveform is dissected with the utilization of MATLAB simulink/FFT block.

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II. SYSTEM MODELLING FOR THE 3-PHASE SYSTEM:

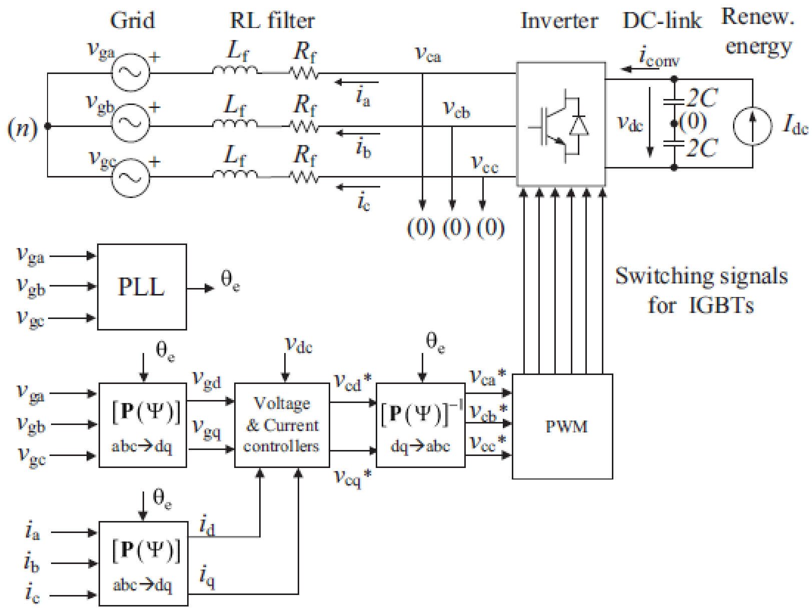

Fig: 1. Proposed design for Renewable Energy system

In according to the Fig: 1, as shown above, the system is configured in three diverse subsystems: as DC-side as one side of the system inverter in middle and AC-side on other. The individual parameters are discussed as following:

A. DC-side

In the Dc-side of the proposed system is made up of the renewable energy as the solar power along with the DC-link. The RES system is designed and modeled as the constant current source as I_{dc}, which the value is consequent to the active power which preferred to be delivered to the grid with the assumption of zero power losses in the RES systems.

$I_{dc} = P^* / V^*_{dc}$ (1)

Where,

P* = active power reference value

V_{dc} = of the DC-link voltage reference value.

In the modelling of DC-link the mathematical expression is expressed in way of DC voltage stored in the capacitor, v_{dc}, in accordance of figure: 1.

$V_{dc} = \int 1/C \, (I_{dc} - i_{conv})$

Where,

C is Dc-link capacitance

I_{dc} is the current injected by RES (1)

i_{conv} is the current injected from DC-link to the inverter.

B. Inverter

In the design of inverter system contains a VSI, a LC filter and a transformer. The design of system is under the accordance of IEEE1547 standards as current and voltage harmonics under 5% for the smooth operation of the system. The controlled VSI with the amplitude modulation index (Ma) is in range of 0.7 and 0.8 with the switching frequency of 5 kHz. The power operation as on and off simultaneously for varying the voltage in range of $-v_{dc}$ to $+v_{dc}$ as output of the converter. The output is independent of load and depends on switch status and input voltage only.

The analytical expression for the voltage at the power converter output (v_{ac}, v_{db} and v_{cc}) are:

$V_{ca} = (s_a - 1/2) v_{dc}$

$V_{cb} = (s_b - 1/2) v_{dc}$

$V_{cc} = (s_c - 1/2) v_{dc}$

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Where,
V_{dc} is the DC-link Voltage, S_a ,S_b, S_c are the Boolean switching signals.

C. AC-side

The combination of RL filter with grid is on the AC side. The mathematical expression for the three phase inverter injects to the grid (i_a, i_b and i_c) are:

$i_a = \int 1/L\ (V_{ca} - R_f i_a - v_{ga})$;
$ib = \int 1/L\ (V_{cb} - R_f i_a - v_{gb})$
$ic = \int 1/L\ (V_{cc} - R_f i_a - v_{gc})$

$$v_{ga} = \sqrt{2} V_{ga} \cos(\omega_g t + \varphi_V); v_{gb} = \sqrt{2} V_{gb} \cos\left(\omega_g t + \varphi_V - \frac{2\pi}{3}\right)$$

$$v_{gc} = \sqrt{2} V_{gc} \cos\left(\omega_g t + \varphi_V + \frac{2\pi}{3}\right)$$

Where,
V_{ca}, V_{cb}, V_{cc} are the three phase voltages at the output
R_f :Resistance of the filter
L_f :Inductance of the filter.
V_{ga}, V_{gb} and V_{gc} are three phase grid voltages.

I. PV system Modelling

The modules of PV cell are connected in series and parallel arrangement. The modelling of solar cell can be done by using a diode and two resistors. The mathematical modelling was bring into in [6] [7].The PV model is mathematically designed in the MATLAB with the standard value of certain variables were taken into consideration as below table.

Sl.No	Parameters	Symbols	STH-P
1)	Short Circuit Current	I_{sc} (A)	7.84
2)	Open Circuit Voltage	V_{oc} (V)	36.6
3)	Voltage at MPPP	V_{mpp} (V)	29
4)	Current at MPP	I_{mpp} (A)	7.35
5)	Voltage Temp. Coefficient	K_v (mV/C)	-0.36099
6)	Current Temp. Coefficient	K_i (mA/C)	0.102
7)	Cells in Number	N_s	27

Table: I PV system Specifications

Parameters	Symbols	Value
Grid Line Voltage	V_{L-L}(V)	412
Grid Phase Voltage	V_{ph}(V)	220
DC Source Voltage	V_{dc} (V)	414
Output Power from Inverter	P_i (W)	10000
Grid Frequency	f(Hz)	50
Switching Frequency	f_s(KHz)	5

Table: II parameters for the designed system

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a) Implementation of PV system for above proposed system:

In the control of the proposed multi level inverter with the grid tied with PV system. The control method consists of two PI controllers, the first PI controller is for the proposed inverter that controls the grid currents, and second PI controller is for charging the capacitors voltage in reference values which are connect to PV panels. In the proposed control method the control method doesn't use a conventional DC/DC converter for boost of capacitors. It uses a maximum power point tracking (MPPT) strategy based on incremental conductance method to generate a reference current and voltage to obtain the error between measured DC capacitor voltages and currents with reference values [8],[9].

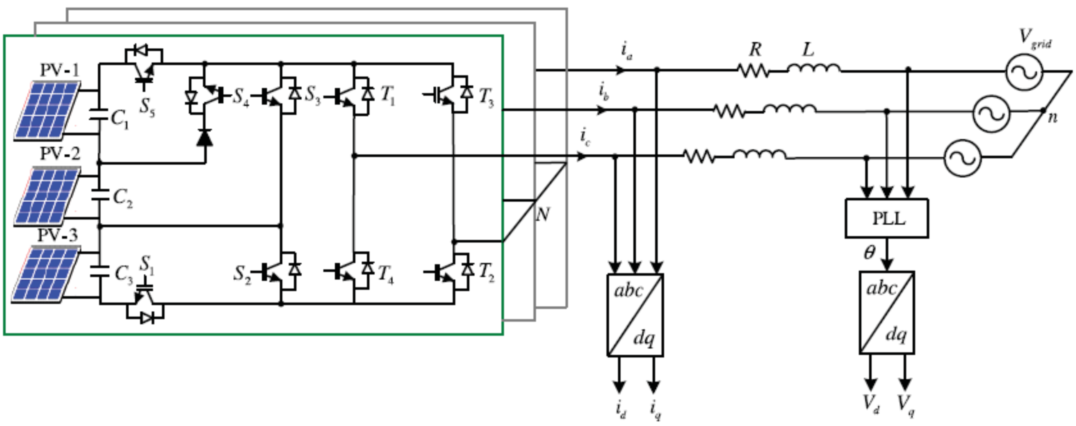

Fig: 2. Assembling of PV system with the 3-phase system for the grid.

Grid synchronizations plays important role for grid connected systems. A PLL technique causes one signal to track another one. It keeps the output signal synchronized with the reference input signal in frequency and phase. Designing of PLL is mentioned in [10], [11]. In MATLAB three phase PLL block is directly available.

II. RESULTS AND DISCUSSIONS

In this section the simulation results in the proposed focus on the 3-phase grid connected MLI is anticipated along with the integration with the power to the grid from the RES. The proposed inverter and discussions had done with the low total harmonic distortions (THD). The inverter is aligned with a converter with the PID controller had implemented and simulated in the Matlab/Simulink Software.

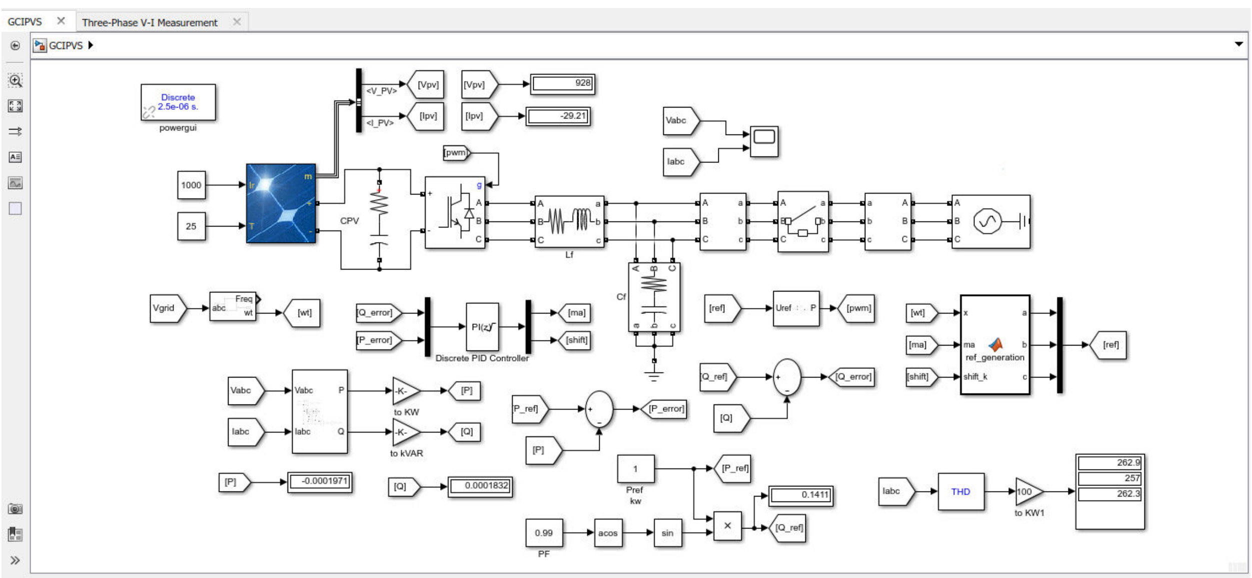

Fig: 3. Simulink implementation for proposed MLI for PV systems

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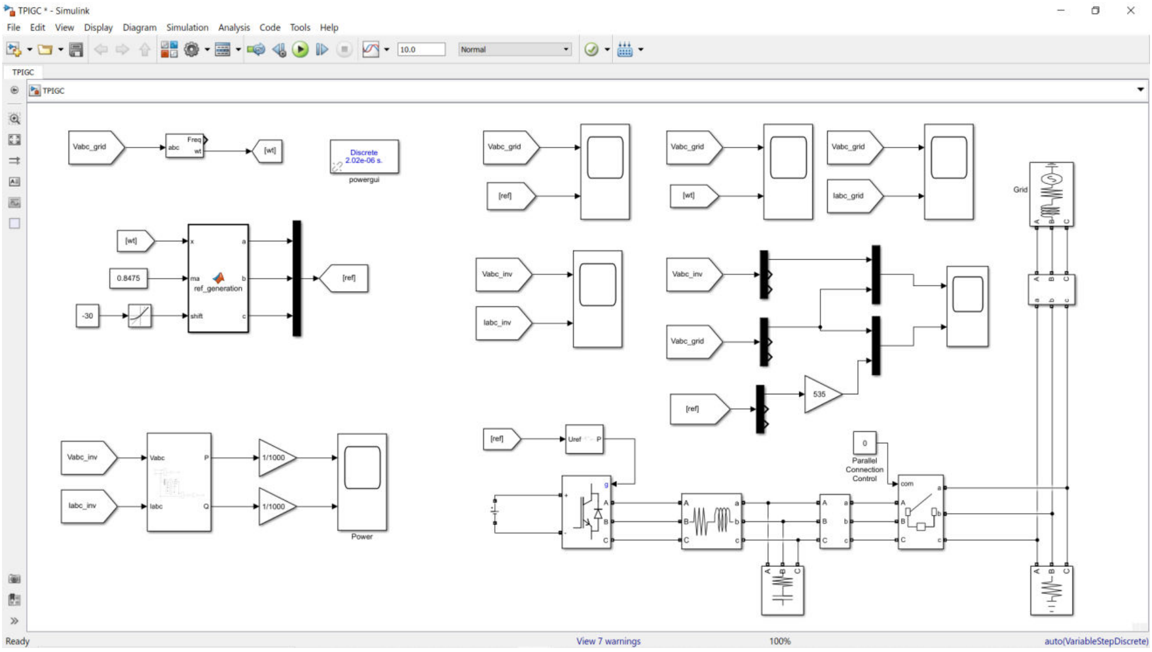

Fig: 4. Three phase inverter for grid connection

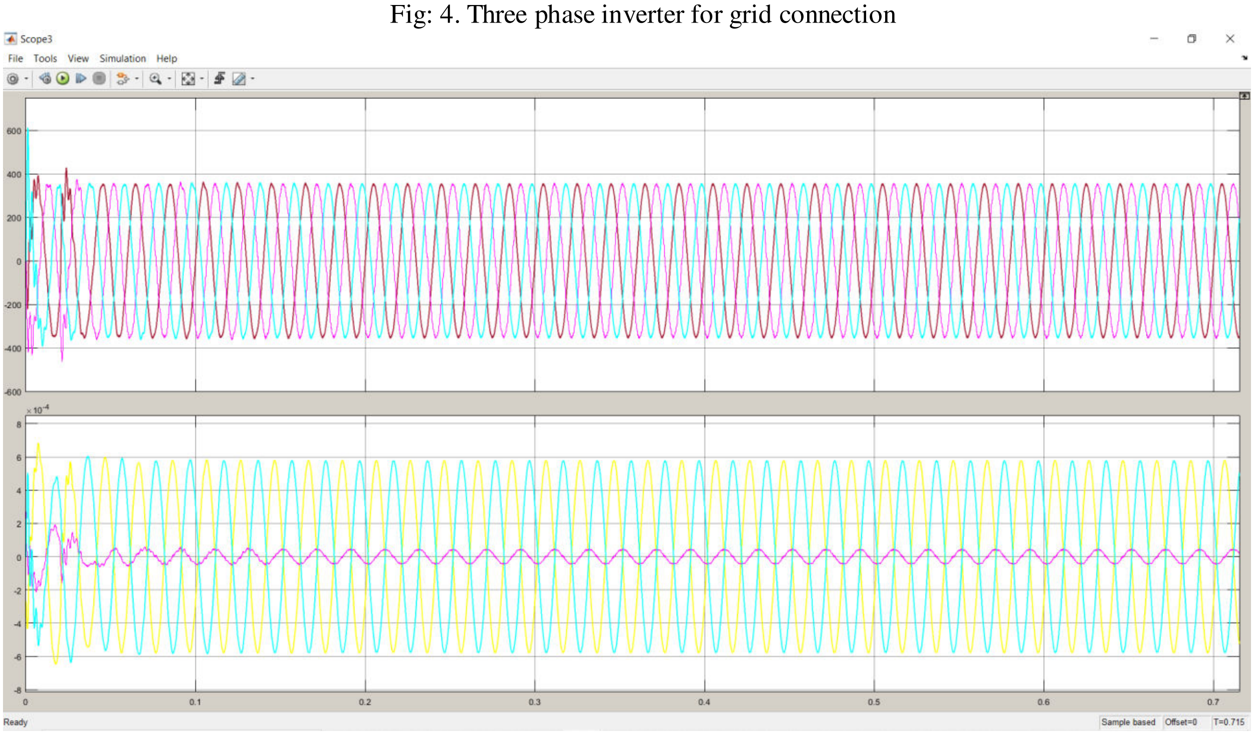

Fig: 5. Voltage outputs for Grid side.

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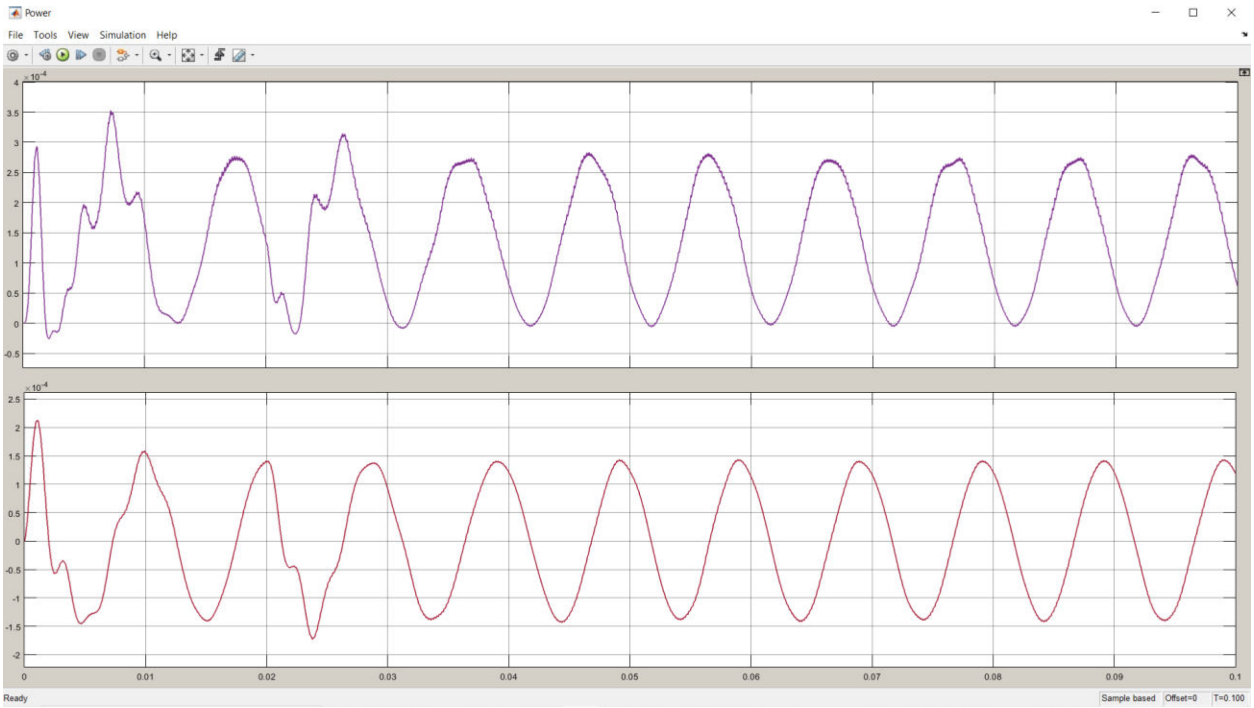

Fig: 6. out power for the change in constants

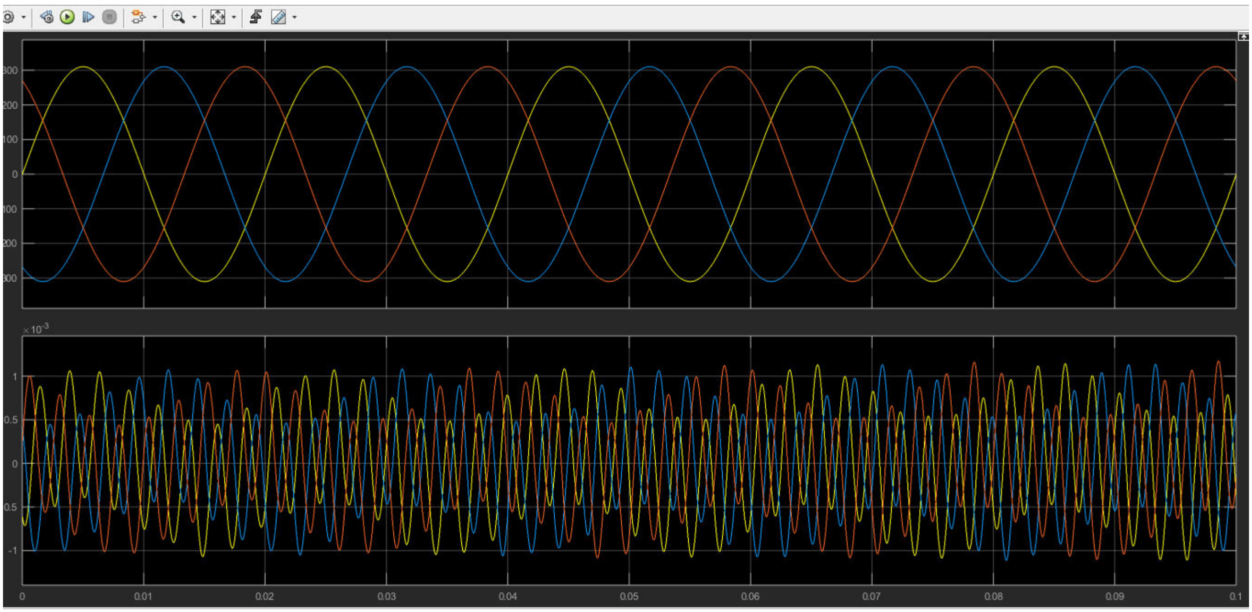

Fig: 6.Three Phase Integration with Grid Voltage.

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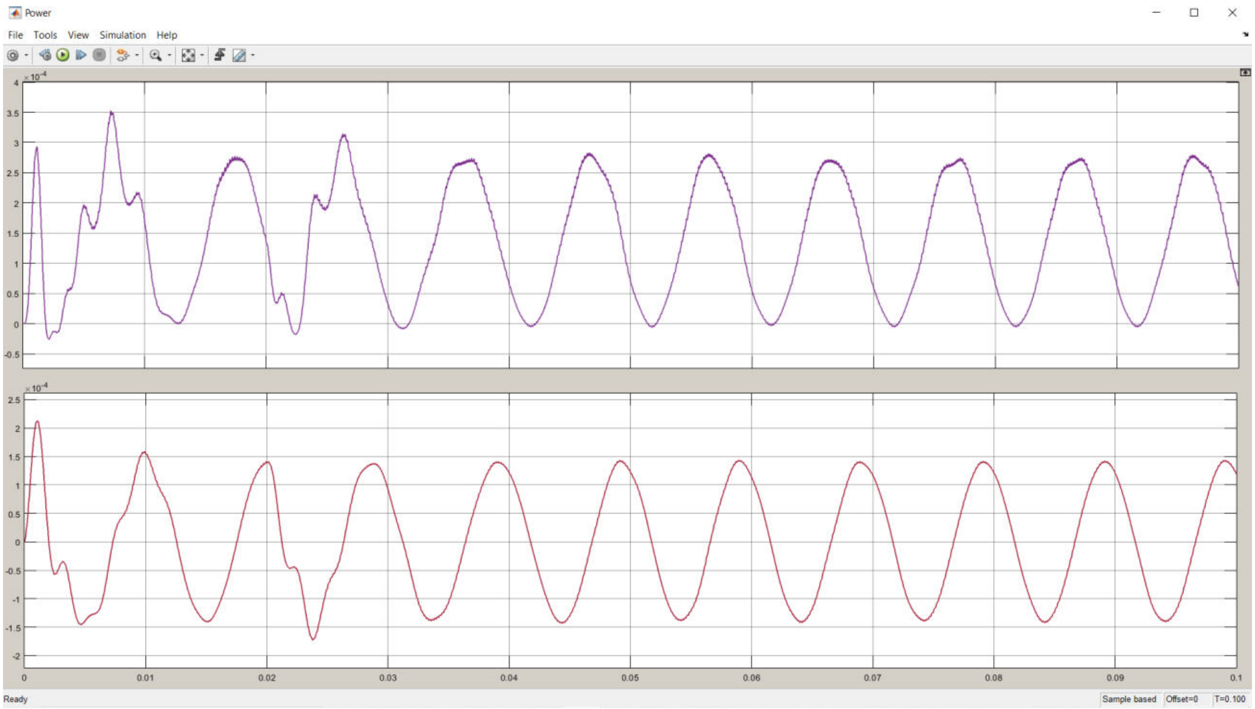

Fig: 7.Power out of the Inverter

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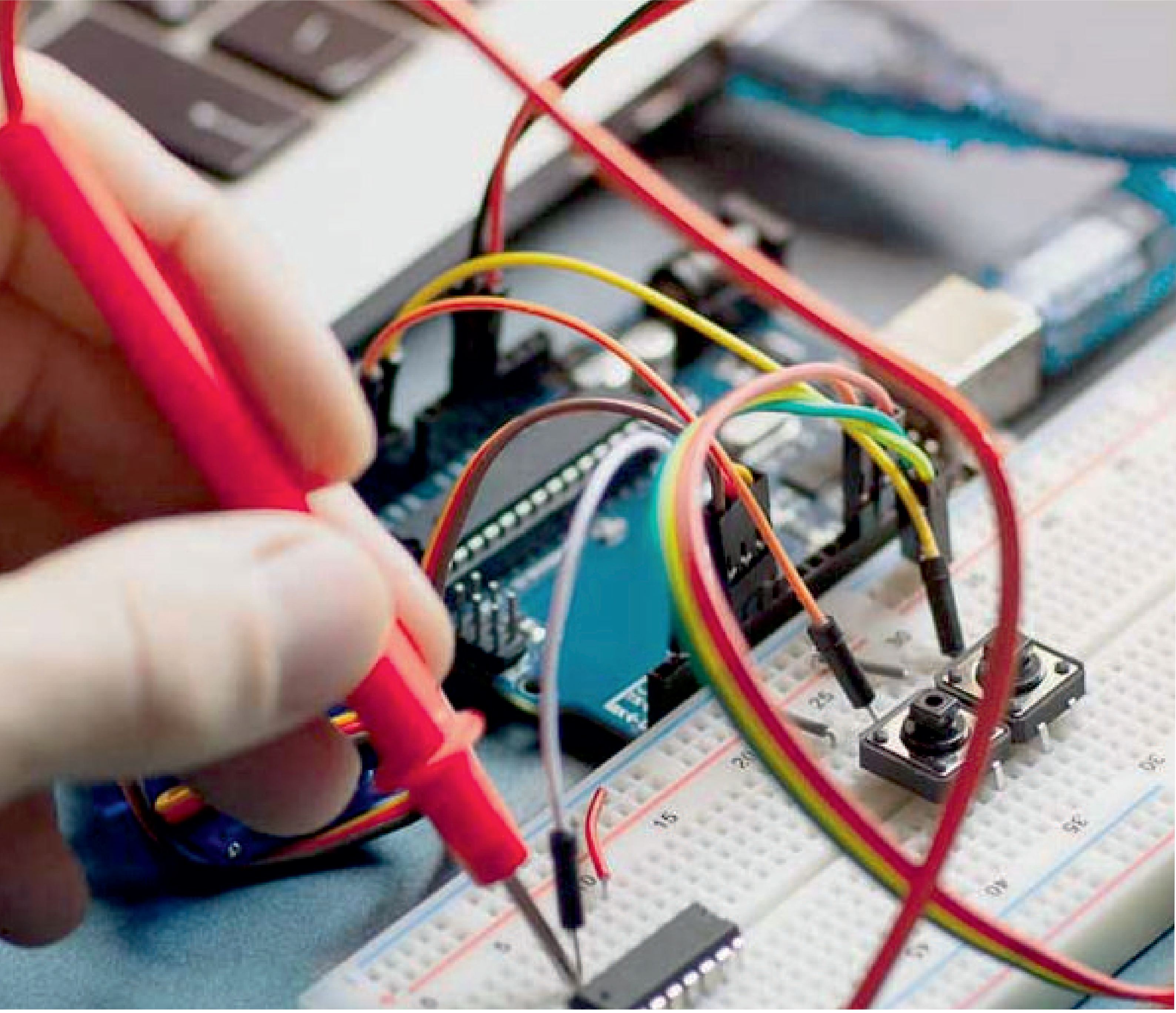

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