TLBO Based Controller for Grid Connected RES Systems

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Abstract:

Technology increases rapidly as the years goes forward. The present-day paper gives the Teaching and Learning Based Optimization (TLBO) Methodology for Grid Connected RES System. Every day a new algorithm came into existence for optimization problem. In the current work optimization based Tuned PI controller i.e Teaching and Learning Based Optimization (TLBO) Algorithm is used in the control technique for Grid Connected PV System for power quality improvement in a distribution system. The entire system is modelled in the MATLAB/SIMULINK environment. Finally, this paper shows the improvement in power quality by reduction of THD using TLBO tuned PI controller for a Grid Converter.

1. Introduction:

Now a day for the wellbeing of nations, power sector is the crucial constituent of organization also it is critical for economic growth. The most diversified sector in India is the power sector. In India the power generation sources mostly form conventional type of generations and also increasing demand in the Non-conventional type of generations. [1]- [5]

Due to this importance of power generation it is indeed to generate the quality power. But due to variety of loads there are several power quality issues. Hence the power quality is a challenging task for the power sector and power engineers. From the past days, various methods are implementing for the compensation of power quality. [6]- [10]

In this paper, Teaching and Learning Based Optimization (TLBO) based Grid Converter is used as a compensator for power quality improvement. For Grid Converter (STATCOM) is a shunt compensator where the input for a STATCOM is PV System. The paper shows the application Teaching and Learning Based Optimization (TLBO) Algorithm based control technique for Converter in Grid Tied PV System. In the control of STATCOM new optimization technique is proposed for the tuning of PI Controller. Finally, this paper shows the improvement in power quality by reduction of THD using Teaching and Learning Based Optimization (TLBO) tuned PI controller for a Grid Converter. [10]- [15]

2. Teaching and Learning Based Optimization (TLBO):

Teaching and Learning (T&L) inspired optimization process proposed by Rao et al. (2011, 2012), Rao and Savsani (2012) and Rao and Patel (2012) depends on Teacher and Learner Mechanism. The Teaching and Learning (T&L) based optimization is a meta-heuristic population-based search algorithm like HS, ACO, PSO and ABC. The Teaching and Learning (T&L) based optimization method is a simple mathematical model to solve different optimization problems.

In this work concentrates on a new optimization algorithm that is teaching and Learning (T&L) based optimization. The projected T&L based optimization algorithm over comes the drawbacks of the classical heuristic's problems like local optimal trapping, insufficient capability to find nearby extreme points, and lack of efficient mechanism to treat the constraints. According to our T&L based optimization algorithm a learner can gains knowledge in two ways: (i) by teacher (called teacher phase) and (ii) interacting with the neighbor learners (called learner phase). In this algorithm learners are called as population. Design variable are called as subjects of the learners. The best learner is treated as Teacher.

A. *Teacher Phase:*

Always learner learns the knowledge from the teacher. The teacher tries to increases the mean result of the class by his teaching. The best learner is that once knowledge is equal to the teachers knowledge means teacher make to learners to reach his knowledge. But practically is not possible because all learners are not cleverer. This follows as.

Let M_i = mean

T_i = teacher at any iteration i.

T_i Makes the mean M_i to move towards its own knowledge level, therefore T_i chosen as M_{new}. Hence the best learner is treated as teacher.

The difference of the current mean result of every subject and the corresponding result of the teacher for every subject is given by,

$$Difference = r*(M_{new} - T_F M_i) \qquad (1)$$

Where T_F = teaching factor.

It is given as follows:

$$T_F = round[1 + rand*(0,1)*(2-1)] \qquad (2)$$

This difference modifies the existing solution according to the following expression

$$X_{new,i} = X_{old,i} + difference \qquad (3)$$

Where $X_{new,i}$ is the updated value of $X_{old,i}$. Accept $X_{new,i}$.

B. *Learner phase:*

The input for the learner phase is the teacher in learner phase learner gains knowledge learner gains knowledge by two ways: one is gaining knowledge form teacher. And other is by sharing knowledge between learner's interactions.

The learner phase is shows as follows.

Randomly select two learners X_i and X_j where i≠j

$$X_{new,i} = X_{old,i} + r*(X_i - X_j) \text{ If } f(X_i) < f(X_j)$$

$$X_{new,i} = X_{old,i} + r*(X_j - X_i) \text{ If } f(X_i) > f(X_j) \quad (4)$$

Admit $X_{new,i}$ if it gives better function value.

3. TLBO Topology for Grid Converter:

In this paper Teaching and Learning Based Optimization (TLBO) Algorithm based control technique for Converter in Grid Tied PV System is proposed. In the control of STATCOM new optimization technique is proposed for the tuning of PI Controller. A 100 KW PV Grid system is simulated in the MATLAB. The Block Diagram is shown below.

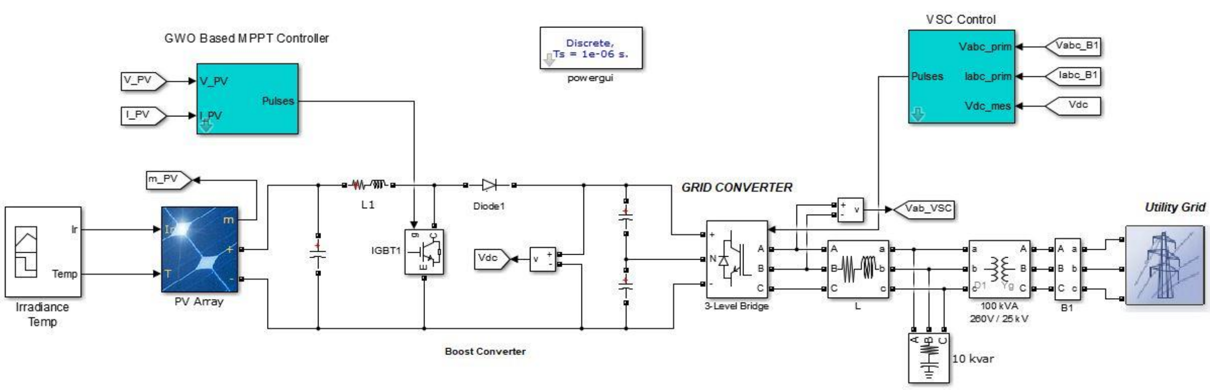

Fig: 1 Proposed Model of TLBO based grid converter

The structure of a Grid Converter is like three phase inverter. IGBT's are used as switches in the Grid Converter. Since IGBTS are fully controlled switches. Total six IGBT's are used i.e for each arm 2 switches are used, a total of 3 arms are there in a Grid Converter. [16]- [20]

In this model a 100 KW PV module is connected to 5 KHz 500 V Boost converter which boosts the PV Module Voltage to 500 V irrespective of changes it maintains the constant 500 V.

The boost converter is connected to the Grid tied Converter. In this model 3 level 500 V Voltage Source Converter is considered as a Grid converter. The Grid converter receives the constant 500 V DC voltage for the boost converter. The Grid converter is connected to the Utility Grid through 100 KVA Transformer.

4. Results and Discussion:

The proposed model in tested in Three Cases with Variable Irradiance and Temperature. The Tw0 different cases are shown below.

Case 1: PSO based Grid Converter.

Case 2: TLBO based Grid Converter.

All the two cases are tested with the variable Irradiance and Temperature i.e

- Pmpp @ 1000 W/m^2, 25 deg= 100.7 kW @ 273.5 V
- Pmpp @ 250 W/m^2, 25 deg= 24.4 kW @ 265.1 V
- Pmpp @ 1000 W/m^2, 50 deg= 92.9 kW @ 250.2 V

Case 1: PSO based Grid Converter:

In this case with the help of the PSO optimized algorithm the gain values of the PI controller are harnessed. With the help of the optimized gain value PI controller gives the optimized output, hence we can say the controller is tuned by the PSO algorithm since the gain values are tuned values for the PSO algorithm. The corresponding results are shown below.

The following figure shows the Variable Irradiance, Variable Temperature. Mean Power, Mean Voltage, Duty cycle. In the Mean Power, Mean Voltage and duty cycle oscillations exits. At 1000 W/m^2, 25 deg the Maximum power is 100.7 KW and in this condition the output power of the PV module is 273.5 V. At 250 W/m^2, 25 deg the Maximum power is 24.4 KW and in this condition the output power of the PV module is 265.1 V. At 1000 W/m^2, 50 deg the Maximum power is 92.9 KW and in this condition the output power of the PV module is 250.2 V.

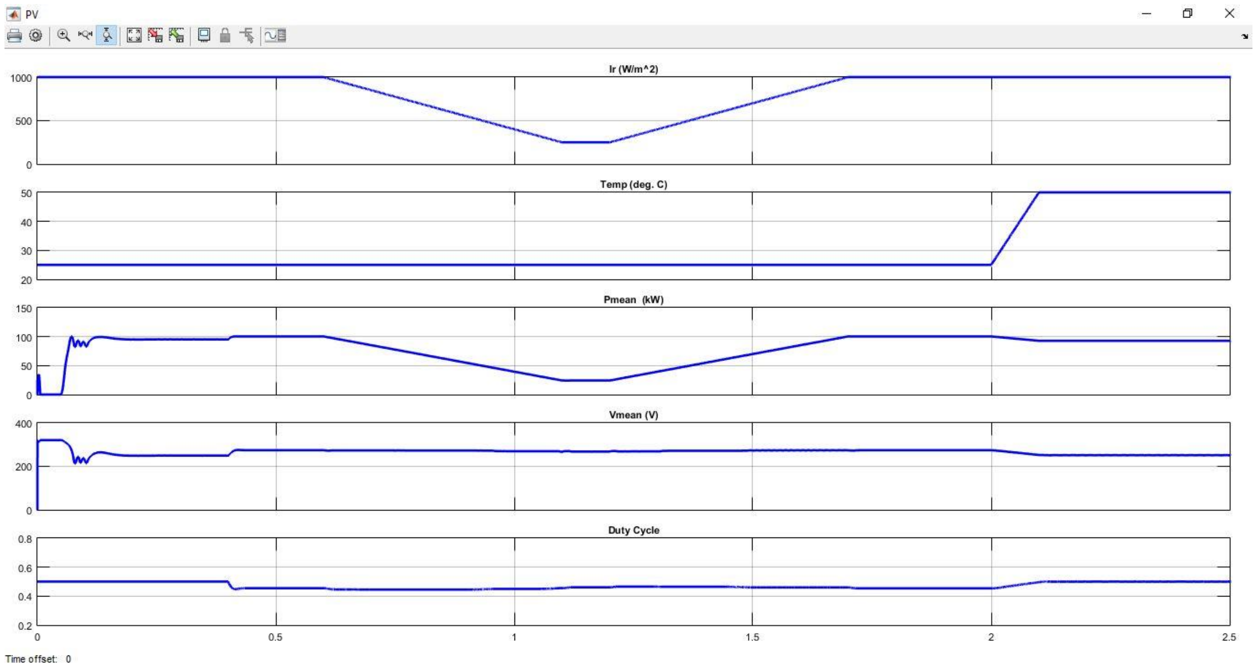

Fig: 2 Variable Irradiance, Variable Temperature. Mean Power, Mean Voltage, Duty cycle of proposed model

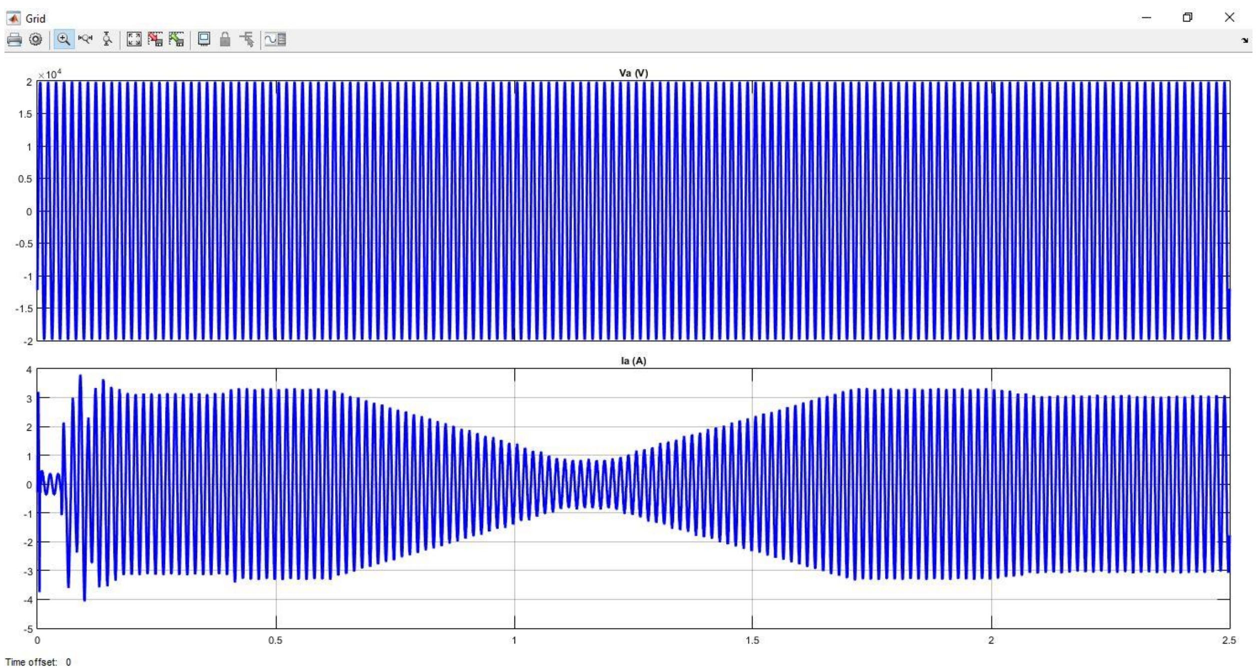

Fig: 3 Grid Voltage and Grid Current for the proposed model

The above figure shows that grid voltage is constant even though the variable Irradiance and Variable Temperature.

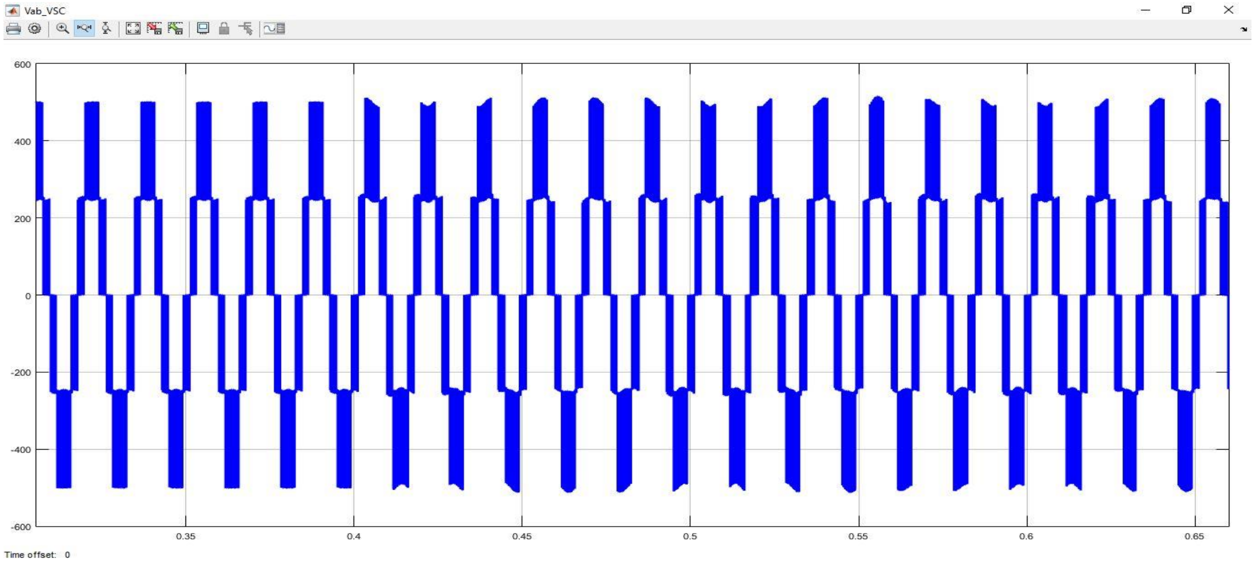

Fig: 4 Grid Converter Output Voltage

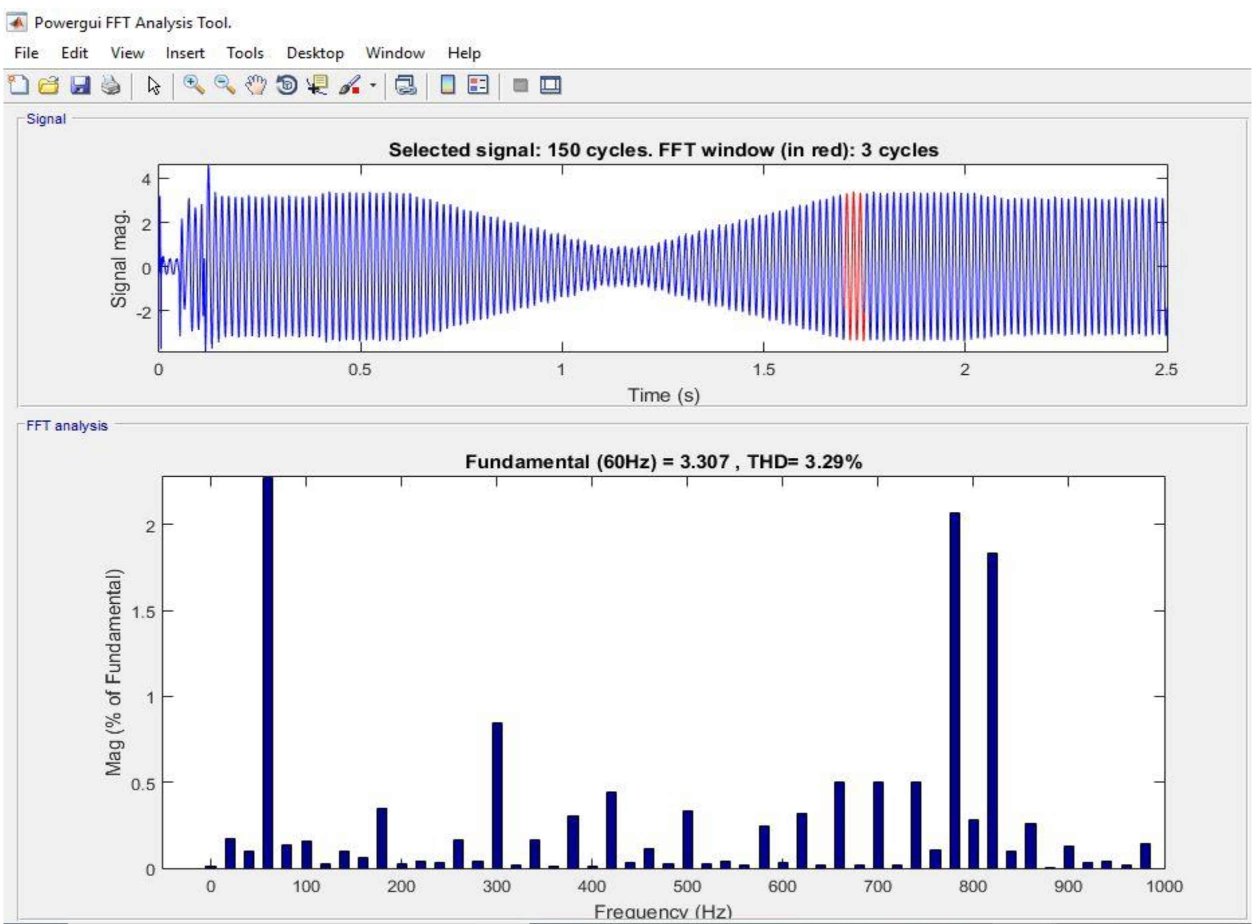

Fig: 5 THD analysis of PSO based Grid Converter.

The THD in this case is 3.29%.

Case 2: TLBO based Grid Converter:

In this case with the help of the Teaching and Learning Based Optimization (TLBO) optimized algorithm the gain values of the PI controller are harnessed. With the help of the optimized gain value PI controller gives the optimized output, hence we can say the controller is tuned by the Teaching and Learning Based Optimization (TLBO) algorithm since the gain values are tuned values for the PSO algorithm. The corresponding results are shown below.

The following figure shows the Variable Irradiance, Variable Temperature. Mean Power, Mean Voltage, Duty cycle. In the Mean Power, Mean Voltage and duty cycle oscillations exits. At 1000 W/m^2, 25 deg the Maximum power is 100.7 KW and in this condition the output power of the PV module is 273.5 V. At 250 W/m^2, 25 deg the Maximum power is 24.4 KW and in this condition the output power of the PV module is 265.1 V. At 1000 W/m^2, 50 deg the Maximum power is 92.9 KW and in this condition the output power of the PV module is 250.2 V.

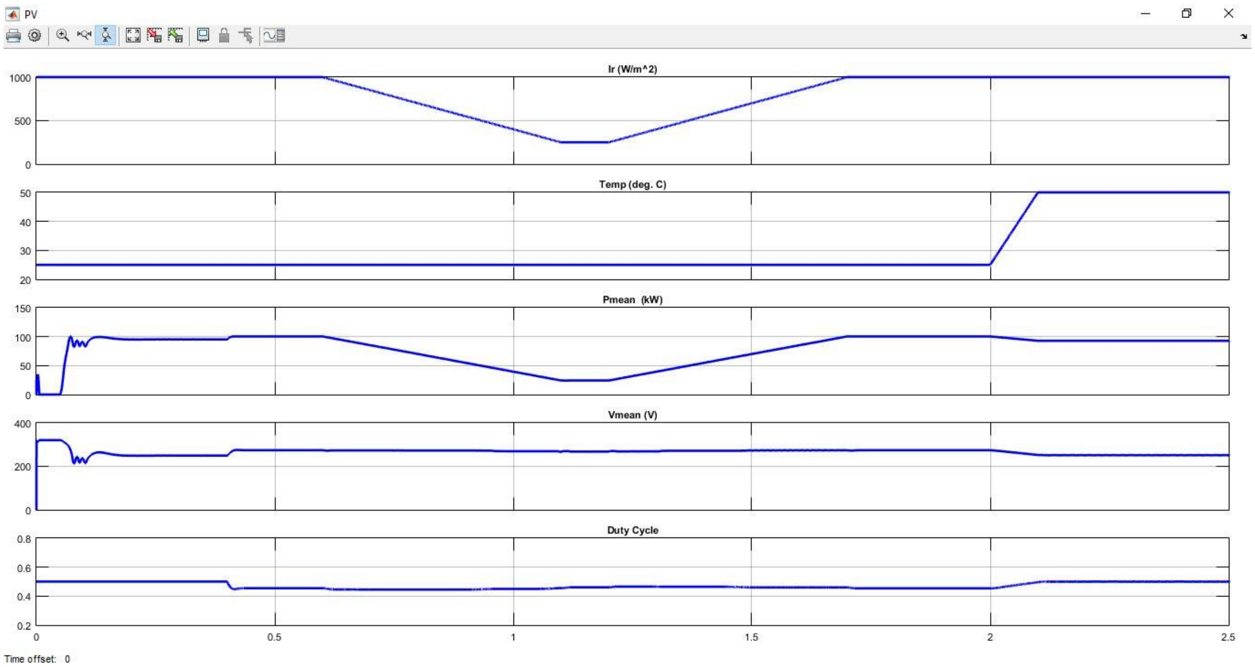

Fig: 6 Variable Irradiance, Variable Temperature. Mean Power, Mean Voltage, Duty cycle of proposed model

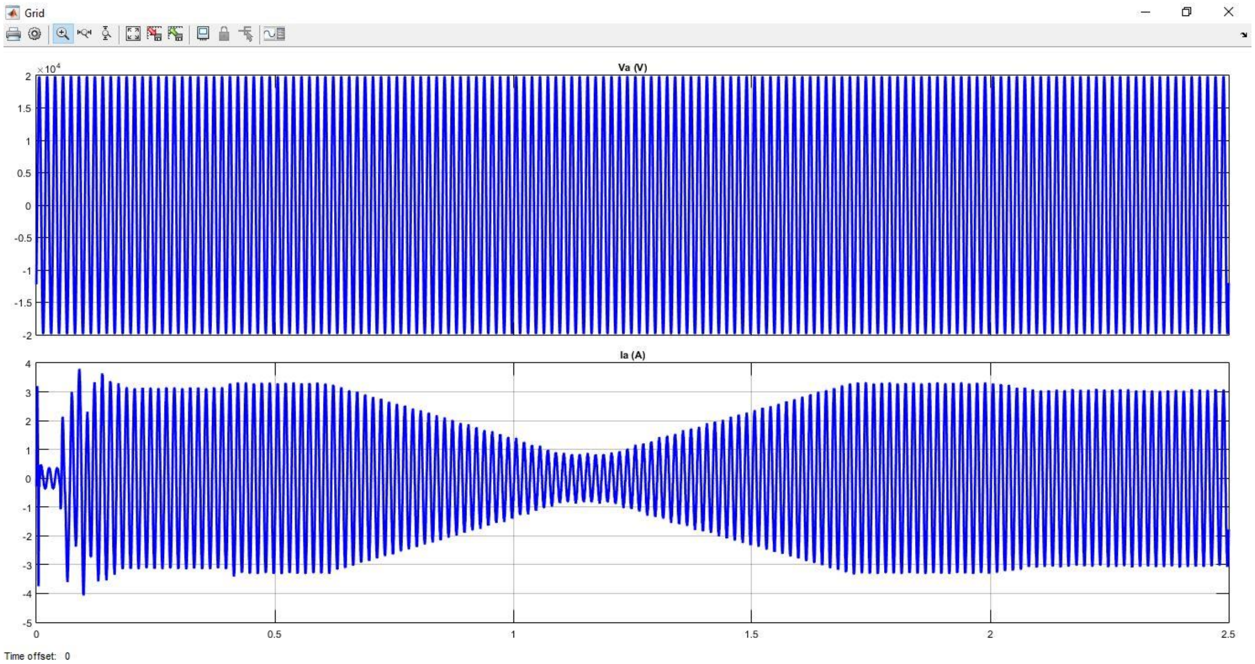

Fig: 7 Grid Voltage and Grid Current for the proposed model

The above figure shows that grid voltage is constant even though the variable Irradiance and Variable Temperature.

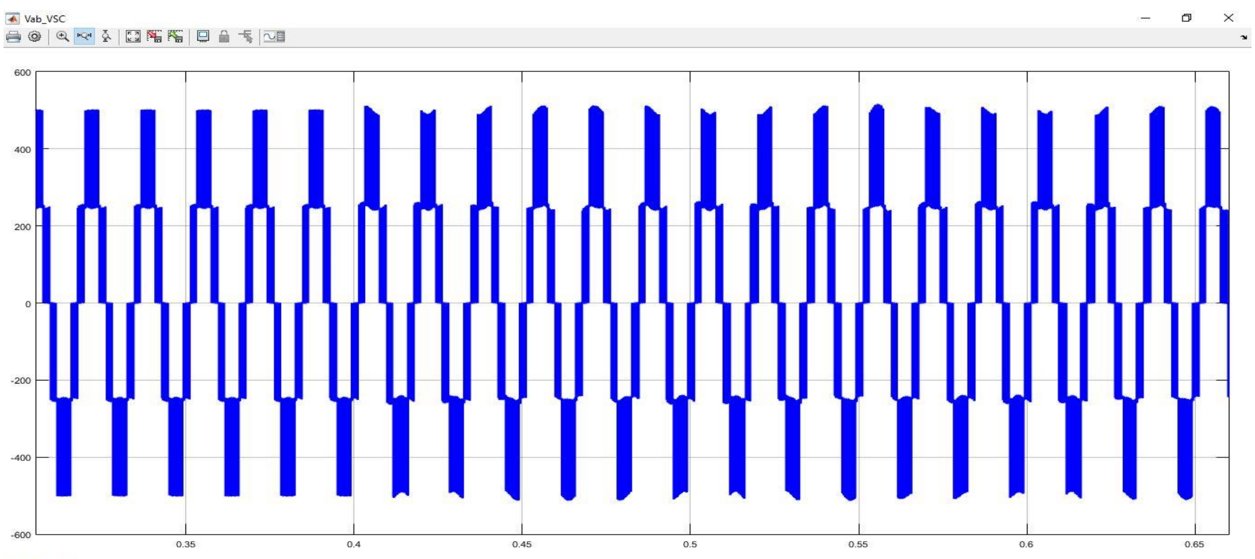

Fig: 8 Grid Converter Output Voltage

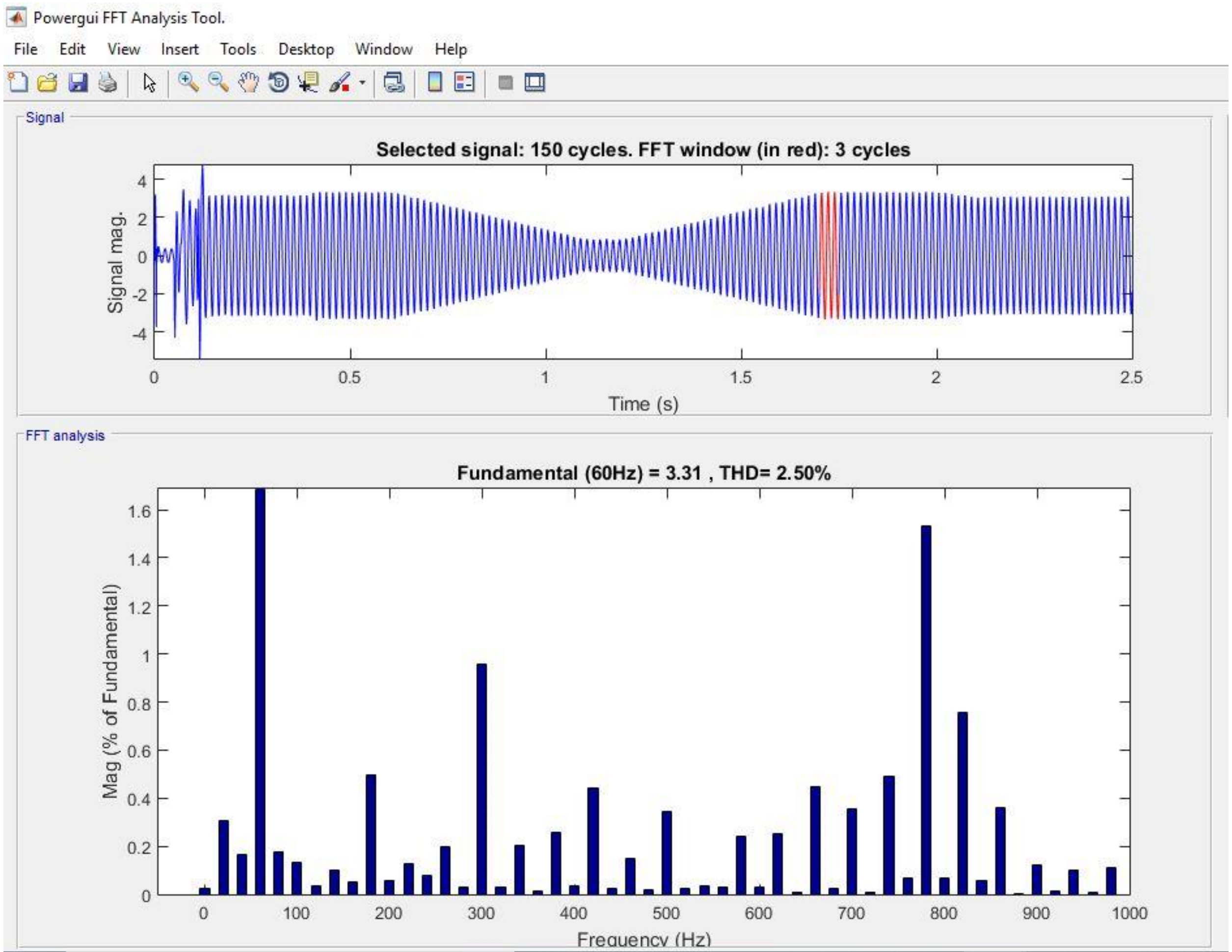

Fig: 9 THD analysis of TLBO based Grid Converter.

The THD in this case is 2.50%.

Comparison Table: I

Case	**Mode**	**THD**
1	PSO based Grid Converter	3.29 %
2	TLBO based Grid Converter	2.50 %

From the above comparison it is clear that a mark reduction in THD from 3.29 % to 2.50% is observed with the proposed Teaching and Learning Based Optimization (TLBO) based Grid Converter.

5. Conclusion:

The Teaching and Learning Based Optimization (TLBO) Tuned PI Controller based Grid Converter is modeled with the help of MATLAB/SIMULINK presented in this paper. The results show that Teaching and Learning Based Optimization (TLBO) Technique is the best Tuning Technique for the PI Controller. Form the THD analysis we can clearly observe that THD is decreased from 3.29 % to 2.50%. Hence improvement in power quality is achieved by reducing the THD using Teaching and Learning Based Optimization (TLBO) tuned PI controller for a Grid Converter.

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