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Simulink based model of solar-wind hybrid power system with tracking of MPP using Incremental Conductance Method

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***Abstract*—Electric power in modern time becomes one of the most important requirements in the world. There are several sources of electricity such as oil, nuclear power, waterfalls and some natural resources such as wind and solar energy. In the past decade, due to many restrictions on natural sources of energy input in pollution and environmental damage, scarcity of resources, there is a need to use renewable energy sources. In India, petroleum is the main and natural supplier of electric power. But the traditional energy crisis has forced the world to prepare for the solar and wind system. As the source of solar, wind energy is unaffected by their utilization and available throughout the world, it became obvious and prime topic of research for scholars from last three decades.**

In this proposed work maximum power point of solar wind hybrid system is tracked by using Incremental Conductance method at different temperature and irradiation for PV module and with different speed for wind turbine. A PMSG based stand-alone solar wind hybrid generation system MPPT tracker is designed, modeled and simulated with MATLAB & SIMULINK.

Keywords*— *Wind Energy, PV module, Maximum Power Point (MPP), Permanent Magnet Synchronous Generator

INTRODUCTION

There are two types of energy sources in the world: renewable sources of energy and non renewable energy sources. Renewable energy is the type of abundant energy from the earth. Wind energy, solar energy, geothermal energy and biomass are different types of renewable energy sources. These resources are inexhaustible. The known benefits of renewable energy sources are their own nature, rich in quantity and above all ecological, as opposed to non-renewable energy sources. Today, more research is being done to improve the technology for the efficient conversion of renewable energy sources into useful sources of electricity. Although the literal conversion efficiency of renewable energy sources is lower than that of a conventional energy source, technology is being developed and improvised daily to improve its efficiency by over 90%. due to its low cost. Now, for future energy consumption, renewable energy is essential. These sources are also widely used because of their ecological compatibility and unrestricted availability. Wind and solar energy are considered to superior to most of the renewable resources.

It is expected that from the total electricity consumption of 36,346 TWh (compared to 15,578 TWh in 2001, IEA), renewable energy will cover 29,808 TWh, with solar power dominating to a large extent. (Source: EREC) [3]. The Renewable Energy Sources Report 2016 states that "renewable energy sources have grown significantly, with the largest global additions to date, although problems remain, especially beyond the electricity sector in 2015. The World Bank Group has signed an agreement with the International Solar Alliance (ISA), which is made up of 121 countries led by India, to work together to increase the use of solar energy around the world to mobilize investments of 1 trillion δ Larry 2030 "[1]. This initiative certainly opens new doors for specialists to focus on this technology.

The projected increase in wind and solar energy from the previous year has been higher among other renewable energy sources. Continuous growth in these two areas determines the better future of R & D in the sector as well.

I. ANALYSIS OF SOLAR AND WIND ENERGY

Wind Energy system

The wind is the movement of gaseous masses produced by the irregular heating of the surface of the earth by the sun. To compensate for the overall temperature, this heating difference causes the masses of the air to move. As we know, the wind varies regularly, sometimes too slow and sometimes with sharp explosions. The main advantages of wind power are that wind generated electricity does not contaminate water, air or soil. It does not contribute to global warming. It does not consume much water for other sources of energy. There are several elements of a SWECS, the most important of which is the type of generator used. There are various types of generators that are used such as the Self Excited Induction Generator (SEIG), Doubly feed Induction Generator (DFIG), and Permanent Magnet Synchronous Generator (PMSG). Among these generators, PMSG has several advantages that make it very useful for WECS. It does not require additional

DC power for the excitation circuit. By eliminating excitation, a 20% energy savings can be achieved simply by using magnets. It does not use slip rings, so it's simpler and does not require maintenance. Condensers are not required to maintain the power factor, unlike the induction generator. It is also advantageous compared to the IG-driven segment system. The induction generator requires leading reactive power to build up terminal voltage. DFIG, on the other hand, has a lower operating range, as opposed to PMSG.

Previously, wind turbines were used as constant speed turbines using a squirrel cage induction generator with capacitors bank. Generally used wind turbines were at constant speed due to their cost and ease. The characteristics of the wind turbine clearly mean that the energy to be utilized to the maximum, the speed of the rotor of the machine must vary depending on the wind speed. This can be done using the latest electronic power converters to operate the machine at adjustable speeds. These unregulated wind turbines can improve wind power generation. Thousands of wind turbines operate around the world, with a total capacity of 59,322 MW. In 2007, the power generated by wind turbines was about 94.1 GW, or about 1% of total world production. Worldwide, the long-term technical potential of wind power is estimated at 5 times the current global energy consumption or 40 times the demand for electricity. This would require covering 12.7% of all land with wind turbines. This land must be covered with 6 large wind turbines per square kilometer. About 80% of the world's wind energy market is now concentrated in only four countries, reflecting the failure of most other countries to adopt favorable policies for renewable energy. Future market growth will largely depend on the fact that new countries are moving away from renewable energy sources as a reform of the electricity industry.

A report in 2016 of Installed capacity of wind system in different countries is listed below;

Table 1- Countries with installed capacity [3]

Sr.No.	Country	Installed capacity (in MW)
1	Germany	18,428
2	Spain	10,027
3	U.S.A	9,149
4	India	4,430
5	Denmark	3,122

Solar energy system

The solar photovoltaic module is a combination of photovoltaic modules or a combination of cells. Basically, a photovoltaic cell is a structural deposition of semiconductor materials to make a diode-like structure that converts solar energy into electricity. It works based on the principle of the photoelectric effect. The light energy (nhf) falls on the surface of the photovoltaic cell and the frequency of the incident photons is quite large, the electrons leave their atoms and are released from their movements. With the implementation of a potential, these load carriers are aligned in a particular direction to generate current. The accumulation of such cells in a serial or parallel combination provides enough current to produce electricity to be stored or disposed of for real-time applications.

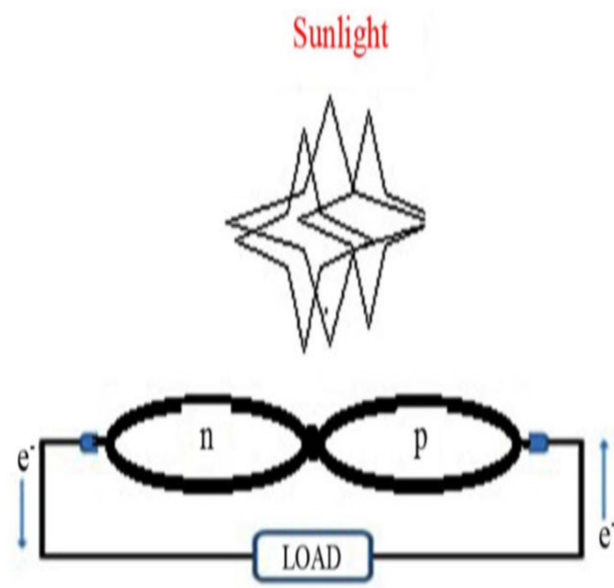


Fig. 1.Semiconductor pn-junction solar cell with load [5]

As technology evolves, it is easier to design and test a prototype hardware unit using simulation tools and analyze it. MATLAB is one of the tools whose library and technology sub-sectors are used to design and test the proposed study. The project was divided into several stages, such as modeling of the photovoltaic unit called "photovoltaic unit", and wind energy unit with testing, observing the characteristics and tracking of MPP using artificial neural network (ANN). The task guarantees the best possible algorithm that can be used in real-world applications. It offers superior performance and less delay means proper adjustment or polarization of the unit.

A report in 2016 of Installed capacity of solar system in different countries is listed below;

Table 2- Countries with installed capacity [6]

Sr. No.	**Country**	**Installed capacity (in GW)**
1	China	130.4
2	United States	85.3
3	Japan	63.3

4	India	57.4
5	Germany	48.4

II. MAXIMUM POWER POINT TRACKING

MPP is defined as a point where the solar module provides maximum power. The current and the voltage corresponding to this point (Impp and Vmpp) are called current and maximum voltage respectively. The solar panel does not deliver its maximum power during normal operation. To achieve maximum conversion efficiency, it is desirable to apply a smart algorithm. In addition, it is also important to connect the module to the load so that maximum load power is available. To this end, a number of DC-DC converters have been proposed in recent years. The block diagram of the MPPT algorithm [28] is presented in fig. 3.1 below

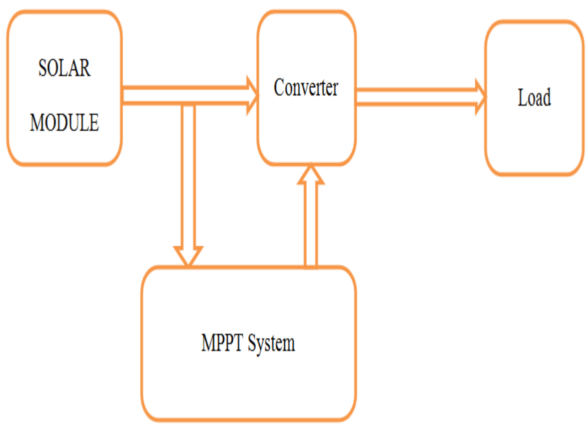


Fig. 2 Block Diagram of MPP tracking system

I-V and P-V Curve of Photovoltaic Cell

The I-V curve of Solar Cells indicate the current and voltage (I-V) characteristics of a photovoltaic cell, module or array (PV), describing in detail its capacity and efficiency of energy conversion solar. Knowledge of the electrical characteristics of the I-V (most important Pmax) of a solar cell or panel is essential for determining the output performance and solar efficiency of the unit.

The main electrical characteristics are summarized in a PV cell or module in the relationship between the current and the voltage produced on a typical I-V solar characteristic curve. The intensity of the solar radiation that strikes the cell is the current (I), and the increases in the temperature of the solar cell decrease to reach the voltage (V).

Solar cells produce direct current (DC) electricity and current hours are power, which allows the creation of I-V solar curves representing the current as a function of voltage for a photovoltaic device.

The following figure shows a combined I-V and P-V curve for a solar module with a maximum power point (MPP);

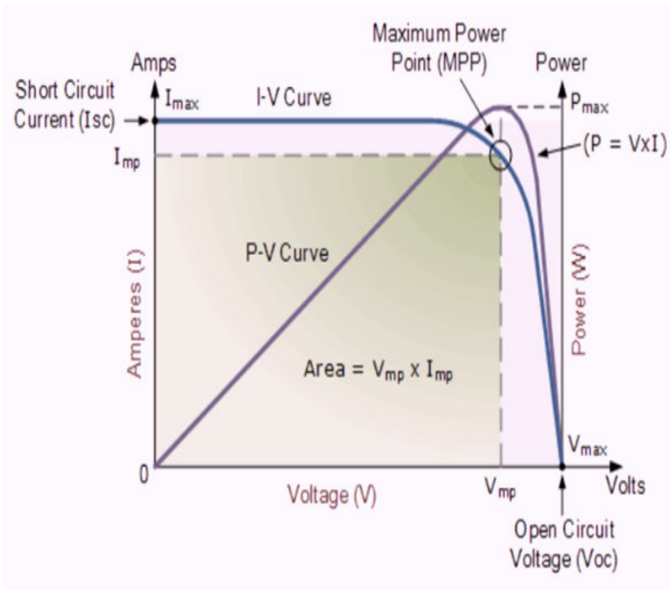


Fig.3 Combined I-V and P-V Curve of PV Module

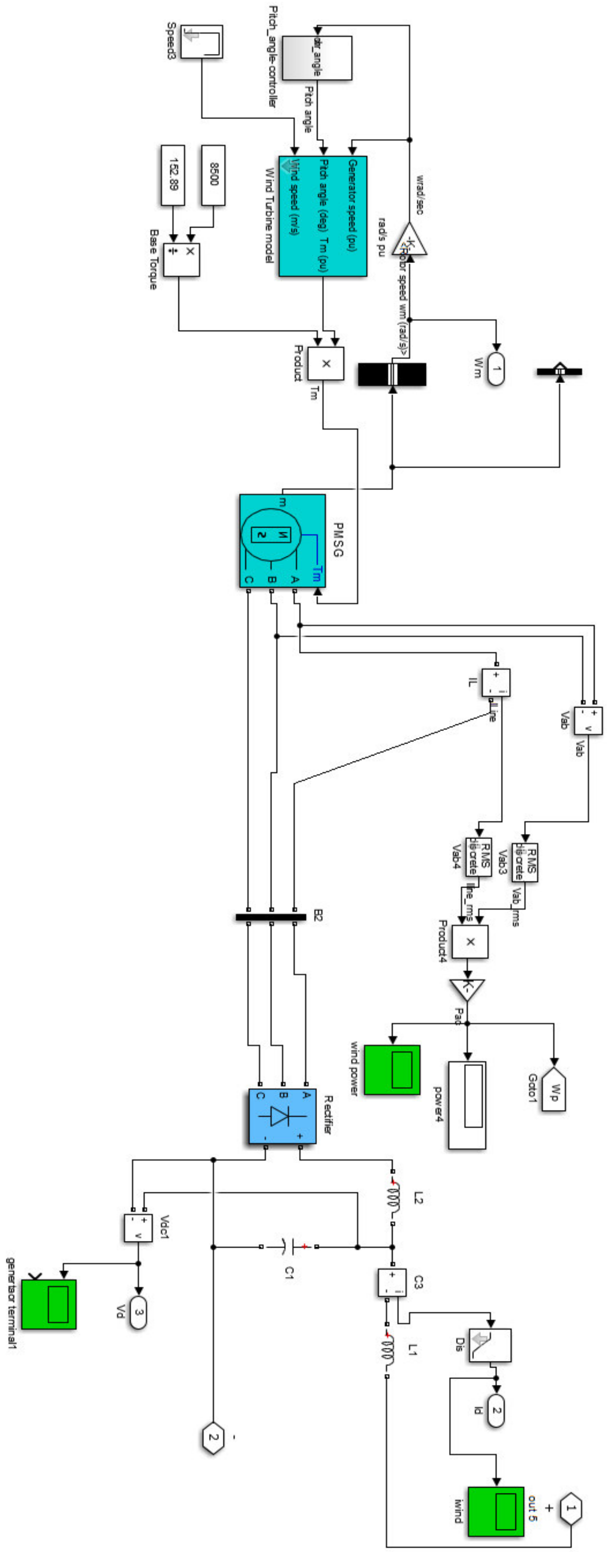
III. ARTIFICIAL NEURAL NETWORK

In this work feed forward artificial neural network is used

Feed Forward ANN

In this ANN, the information flow is unidirectional. A unit sends information to other unit from which it does not receive any information. There are no feedback loops. They are used in pattern generation/recognition/classification. They have fixed inputs and outputs.

IV. SIMULATION AND MODELING



V. RESULTS

In this chapter, we have shown the tracking of MPP of grid connected solar-wind hybrid power system by using Incremental Conductance method and artificial neural network algorithm using MATLAB through simulation. The obtained results by Incremental Conductance method is compared with the results obtained by artificial neural network.

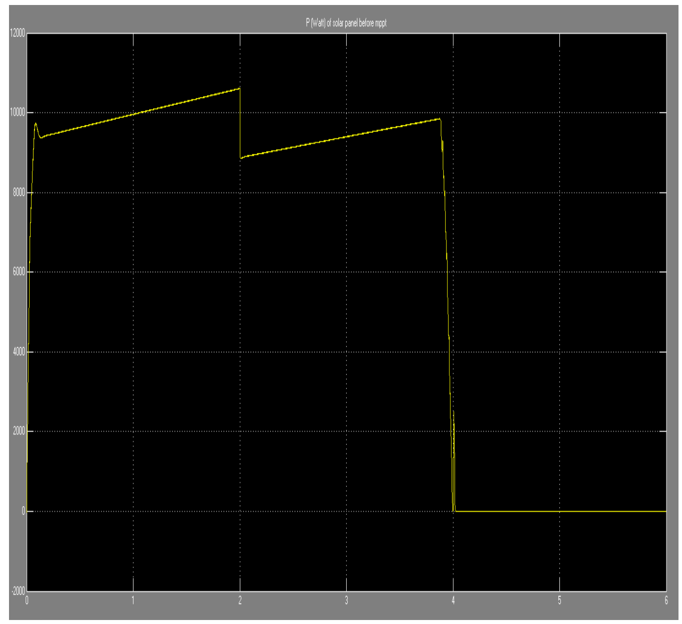


Fig. 7.1 Output Power curve of solar module before MPPT

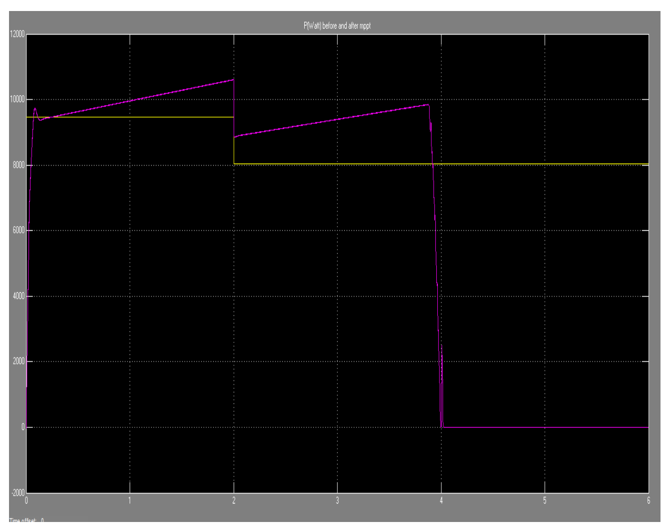


Fig. 7.2 Tracking of MPP in Power curve of solar module after MPPT

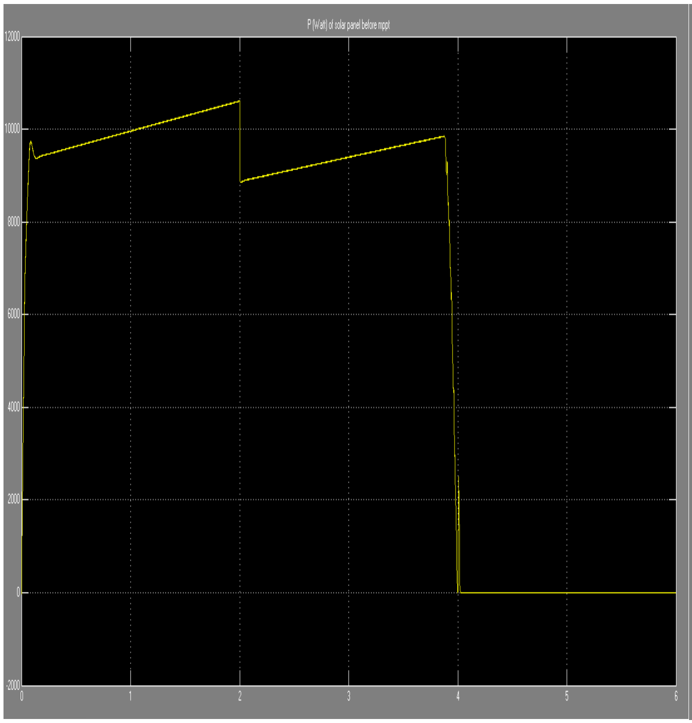


Fig. 7.3 Output Voltage curve of solar module before MPPT

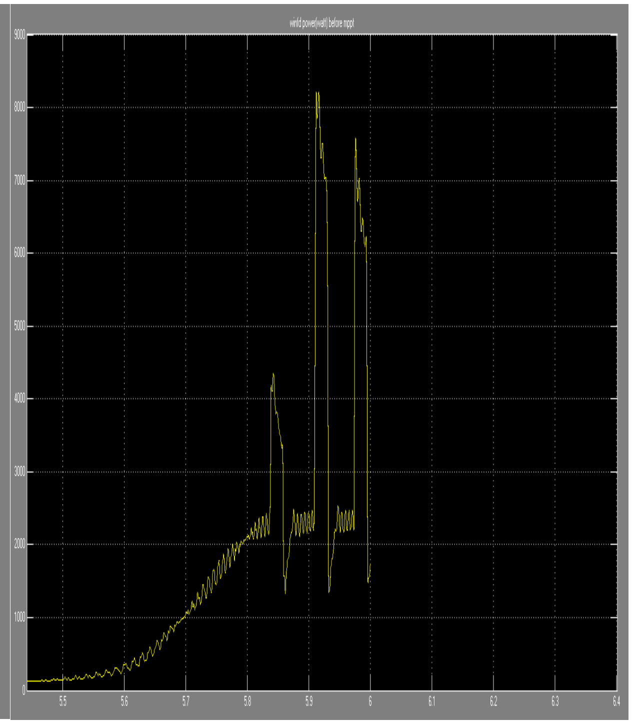


Fig. 7.5 Output of wind generation system before MPPT

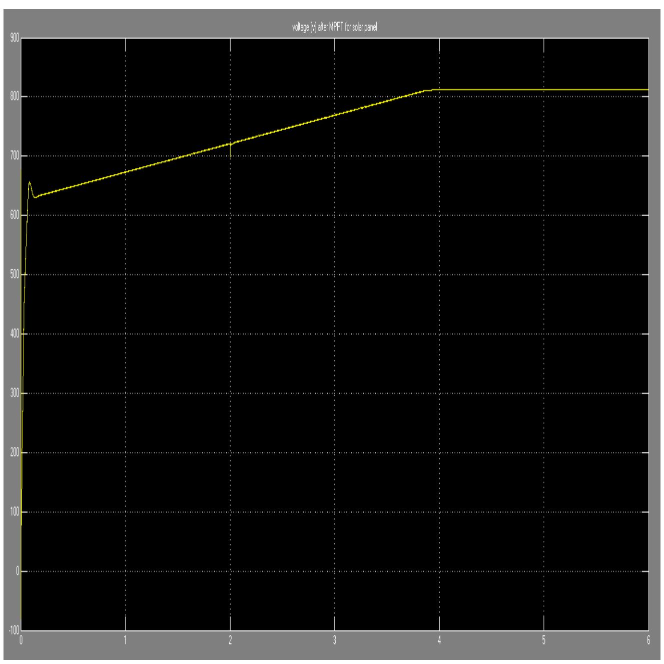


Fig. 7.4 Output Voltage curve of solar module after MPPT

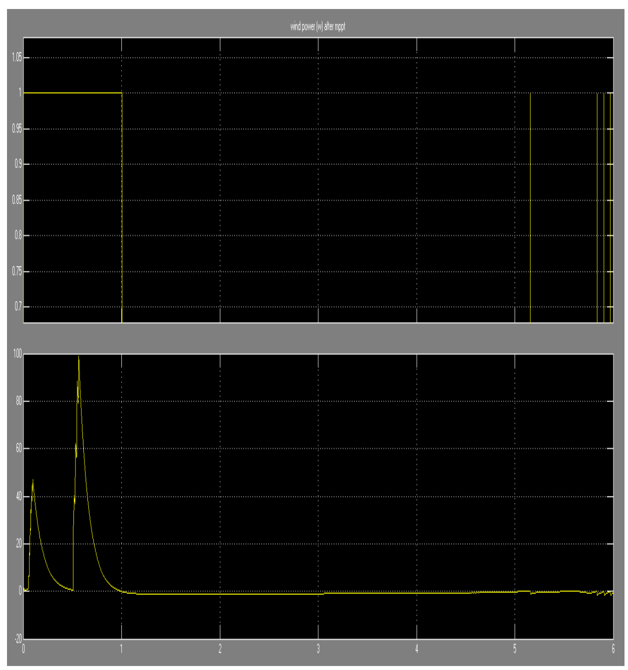


Fig. 7.6 Output of wind generation system after MPPT

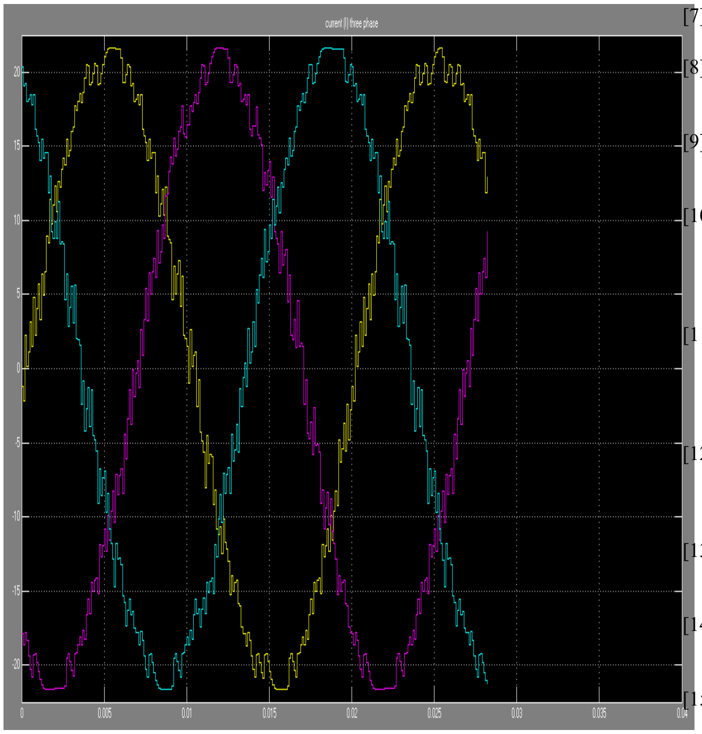


Fig. 7.7 Three phase output current curve

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