IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 5, May 2016

Flyback DCM High Efficiency Utility Interactive Inverter using MPPT for Solar Energy Applications

Mrs. Abjhasree S S[1], Abhishek D S[2], Abitha B Nair[3], Adarsh Babu T[4], Navin Francis[5], Rifas M[6]

Assistant Professor in College of Engineering, Pathanapuram[1]

B.Tech Student, Electrical and Electronics Engineering Dept., College of Engineering, Pathanapuram[2,3,4,5,6]

Abstract: This paper proposes a topology of inverter without center tapping which improves the wave shape of the load voltage. By avoiding Centre tapping of the Fly back transformer, a more symmetrical waveform without any dc component in the output is obtained. This further improves Transformer Utilization Factor (TUF) and the voltage stress across various components is also reduced. The presence of fly back Transformer further avoids the problems of TCO corrosion in solar panel and the leakage current by providing double grounding on the PV panel side and ac neutral. Due to unfolding type inverter, switching losses are also reduced since only one switch is operated at high frequency during the entire operation and the losses are reduced since it works under MPPT technique. DCM operation is preferred due distortion of current waveform in CCM mode which in turn requires an additional inner current shaping loop and also voltage spikes in the transformer winding. Its operation design and analysis is discussed in this paper.

Keywords: fly back Inverter; CCM and DCM Operation modes; Maximum power point tracking (MPPT)

I.INTRODUCTION

Today's world is more and more worried with fossil fuel exhaustion and environmental impacts, hence renewable energy sources such as wind energy, solar power, thermal gradients, biomass energy, etc. has become the hub of the present generation for energy extraction. Green energy sources flourish in our surroundings. Among the diverse ambient energy sources, solar energy has become the most popular one since it is clean, inexhaustible and free.

Even if the availability of solar energy depends on the climatic conditions, it has higher power density compared to supplementary renewable energy sources which makes it more popular. Numerous methods are there for extracting solar energy. Many conventional methods include a dc-dc converter followed by an inverter for ac voltage applications [3]. Two major trends are noted in this type of converter topologies.

The first is the use of transformer less inverters which has the advantage of reduced size and cost and high efficiency. But the required voltage boosting is not obtained for universal grid voltage range (85-265Vac) applications. Also the problem of grounding the solar cell side is a serious problem in case of transformer less topologies.

The second one uses an isolated scheme which consists of one or more dc voltage boosting stages and an inverter with proper isolation using a line frequency or high frequency transformer. The problem of sufficient voltage boosting and grounding of the PV panel is avoided in this topology. Also the problem of leakage current caused by the earth parasitic capacitance is avoided using isolation transformer. Because of the large volume, weight and cost of the line frequency transformer, high frequency transformers are preferred. The high frequency transformer is incorporated in dc-dc converter.

Another feature introduced was the maximum power point tracking technique. The system will operate at maximum power obtained. There will not be any mechanical tracking, it works at the point where the maximum power obtain, by measuring the voltage and current from the PV panel and finding out the operating point using incremental conductance technique.

The operating point is fixed in particular intervals by measuring the output of the PV panel (both the current and voltage) and giving that to the input of the microcontroller. Here, PIC16F877A microcontroller is used for the programming.

A flyback inverter with centre tapped secondary, Practically centre tapped flyback inverter can cause asymmetrical waveforms in both half cycles due to slight variations in the centre tapping point. So we go for an inverter with single primary and single secondary. This of course improves the transformer utilization factor (TUF) and the voltage stress across the inverter switches is halved.

A photovoltaic generation system with a pseudo dc link, where a modulated dc-dc converter or a combination of modulated and non-modulated dc-dc converter is used to convert the dc to rectified sinusoidal voltage on the dc link which is followed by an unfolding type inverter. Many topologies have been proposed based on this configuration. [1]-[4]. A new topology using a Flyback transformer is discussed in detail in this paper.

2 .PROPOSED CIRCUIT DIAGRAM

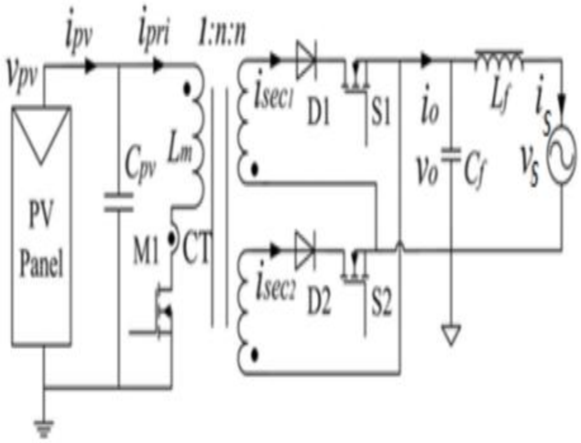

Fig 1. Proposed circuit diagram

Figure shows the circuit configuration of proposed flyback dc-ac converter with a single primary and secondary. Basic idea of flyback current source inverter is to modify the current source whose voltage depends on grid voltage. PV panel acts as current source. An input capacitor is placed at the output of the PV panel to avoid the input voltage fluctuation due to high frequency operation of the Flyback converter switch. Also the mismatch between PV power output and the pulsating input power of the flyback inverter is handled by this capacitor. The flyback converter switch M1 is operated at high frequency employing sine PWM so that the average output current of the flyback converter is shaped as half sinusoid at line frequency. Switches S1, S2, S3 and S4 are operated to unfold this waveform to obtain a sinusoidal current waveform. The presence of Flyback transformer provides necessary isolation and the problems of TCO corrosion and leakage current is avoided by double grounding. Moreover the unfolding arrangement reduces switching stresses and losses and hence efficiency is also improved.[1]

Even though the number of switches in the inverter side increases, since all the switches are operated at ZVS and ZCS, there are no switching losses. Figure 2 shows the switching pattern for different power electronic switches. Flyback converter switch is operated at high frequency to follow sine PWM so that dM1=D sin wt. And the switches S1 and S2 are kept ON during positive half cycle and S3 and S4 during negative half cycle. Since only one switch is operated at high frequency switching losses can be reduced and all other switches are operated at ZCS and ZVS.

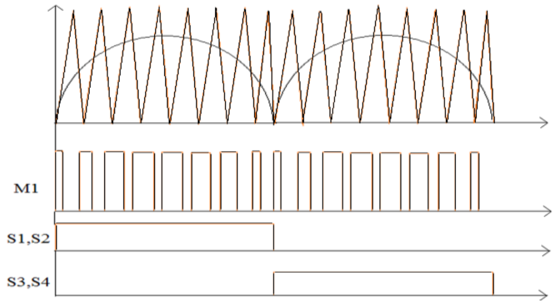

Fig 2. Switching pattern for M1,S1, S2, S3 and S4

The circuit operation of the converter is explained in different modes. During positive half cycle of the ac output voltage, S1 and S2 are kept ON and M1 is operated. All other switches are kept OFF.

Mode 1: The current path is shown in figure 3 When M1 is turned ON, primary is connected directly to the PV panel, current flows from the PV panel and energy is stored in the primary of the flyback converter. The induced voltage in the secondary makes the diode D1 reverse biased and the load is supplied by the dc capacitor at the output side.

Mode 2: The current path is shown in figure 8. When M1 is turned OFF, there is no current path in the primary of the flyback converter. Diode D1 is forward biased and the energy stored in the secondary of the transformer during previous mode supplies the load through S1 and S2. Since M1 is at high frequency switching, these two modes repeats many times for half of the line period.

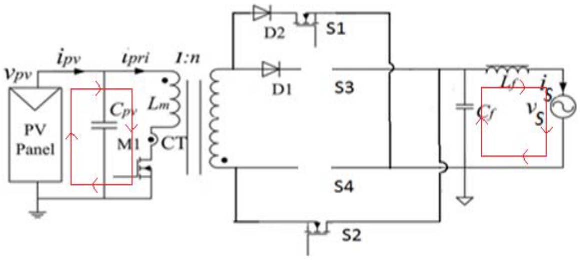

Fig 3. Current direction during positive half cycle when M1 is ON.

During negative half cycle of the ac output voltage, S3 and S4 are kept ON and M1 is operated. All other switches are kept OFF.

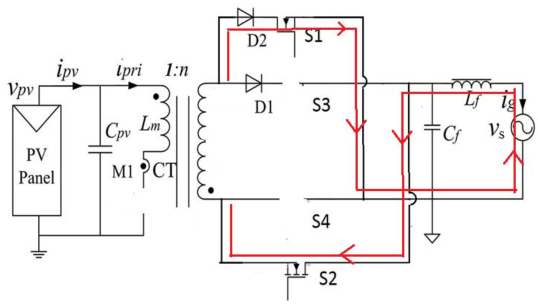

Fig 4. Current direction during positive half cycle, When M1 is OFF

Mode 3: The current path is shown in figure 9. When M1 is turned ON, primary is connected directly to the PV panel, current flows from the PV panel and energy is stored in the primary of the flyback converter. The induced voltage in the secondary makes the diode D2 reverse biased and the dc capacitor at the output supplies the load.

Mode 4: The current path is shown in figure 10. When M1 is turned OFF, there is no current path through the primary of the flyback converter. Diode D2 is forward biased and the energy stored in the secondary in the previous mode supplies the load through S3 and S4. These two modes repeat many times for next half cycle of the line period

DOI 10.17148/IJIREEICE.2016.4502

and an ac waveform is obtained.[3]

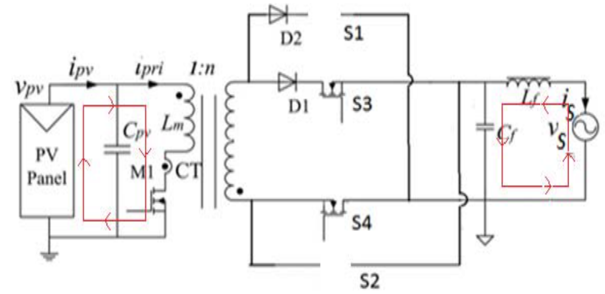

Fig 5. Current direction during negative half cycle when M1 is on.

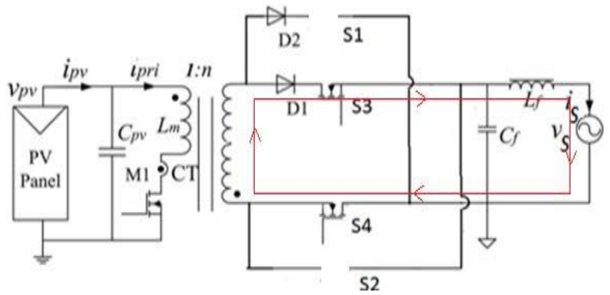

Fig 6. current direction during negative half cycle when M1 is off.

3. APPLICATION OF MPPT IN SWITCHING

MPPT:- Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of.
MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different.

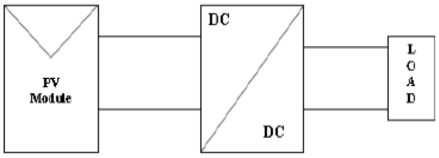

Fig. 7 Block diagram of typical mppt system.

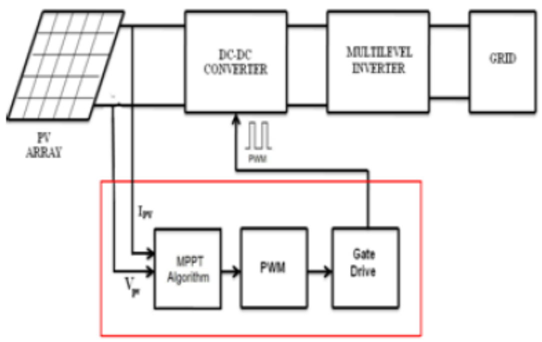

Fig.8 System configuration of the PV system.

The current and voltage from the panel side is taken out and used to generate the PWM block which is used as a gate driving pulse. The pulse generated is used here to switch the mosfet with the high frequency transformer.[2]

4. IC MPPT TECHNIQUE

The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC(Incremental conductance) method . The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dl/dV and –I/V This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P and O.

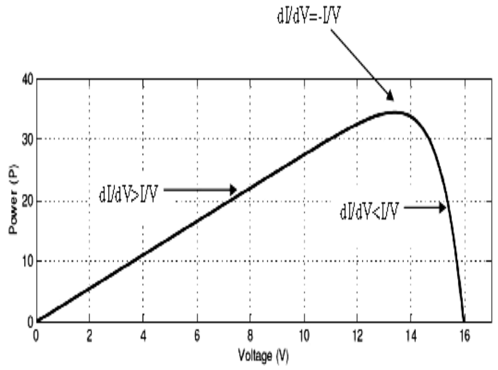

Fig 9. graph of power versus voltage for IC algorithm

Fig-9 shows that the slope of the P-V array power curve is zero at the MPPT, increasing on the left of the MPPT and decreasing on the Right hand side of the MPPT. The basic equations of this method are as follows.

di/dv= -(i/v) at Maximum ………………..(1)

di/dv> -(i/v) left of MPP…………………...(2)

di/dv< -(i/v) right of MPP………………….(3)

This method exploits the assumption of the ratio of change in output conductance is equal to the negative output Conductance Instantaneous conductance. We have,

$$P = VI$$

Applying the chain rule for the derivative of products yields to

$$\partial P/\partial V = [\partial (VI)]/ \partial V$$

At MPPT, it will be equals to zero. The above equation could be written in terms of array voltage V and array current I as

$$\partial I/\partial V = - I/V$$

DOI 10.17148/IJIREEICE.2016.4502

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 5, May 2016

The MPPT regulates the PWM control signal of the dc – to – dc boost converter until the condition: $(\partial I/\partial V) + (I/V) = 0$ is satisfied. In this method the peak power of the module lies at above 98% of its incremental conductance. The Flow chart of incremental conductance MPPT is shown below.[2]

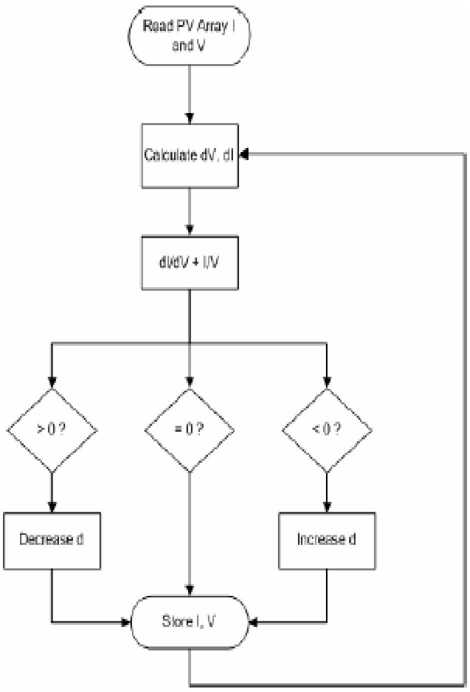

Fig 10. Flowchart based on MPPT

5. PROPOSED CIRCUIT WITH THE MPPT CONTROL

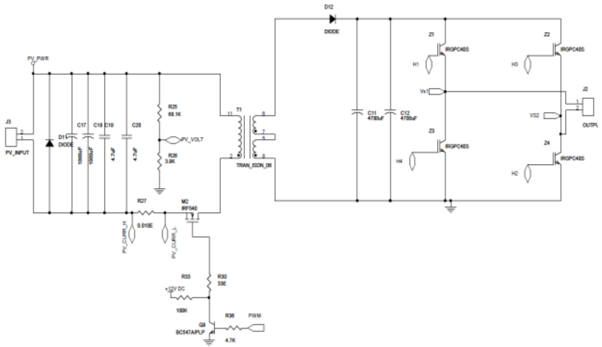

Fig 11.Total power circuit

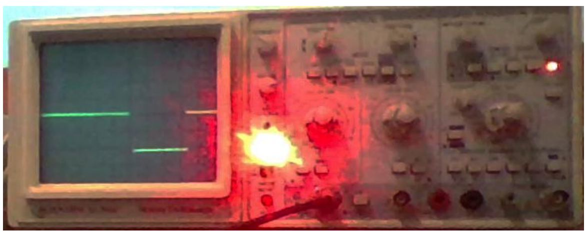

Fig12. Generation of PWM according to INC logic

The PWM block is generated by the PIC16F877A micro controller using the voltage and current inputs which are the output of the PV module. The voltage is taken from the power circuit through a voltage divider and the current is taken from the circuit across a standard resistance. These two are given to a LM324 IC for measurement and then the PWM block is generated. The duty cycle of the PWM is varied in accordance with the incremental conductance logic.

The microcontroller and switching process requires regulated 5v and 12v respectively. These are generated either using LM7812 and LM317 or LM723.

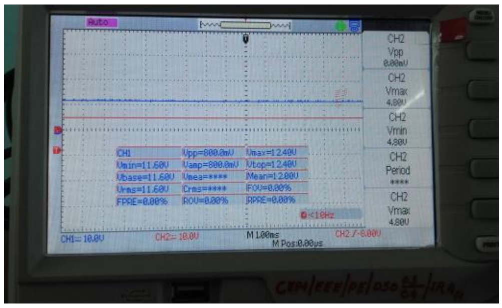

Figure.13 5v regulator output.

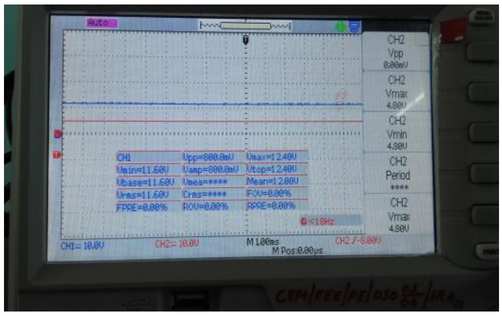

Figure 14. 12 v regulator output

6. COMPARISON

PRESENT INVERTERS

- MPPT technique not employed.
- Non-isolated scheme reduce the size of the inverter and cost but voltage boosting is not possible.
- Life span , less than the proposed one
- Non symmetric output due to center tapping.
- Paracitic capacitance and leakage current

PROPOSED INVERTER

- Mppt technique is employed-increased efficiency.
- High freequency transformer of low cost and small size.
- Protection against lightning and surges, so increased life span.
- Symmetric output wave forms.

Paracitic capacitance and leakage current can be avoided.

7. CONCLUSION

A Flyback dc-ac converter for low power PV applications is proposed. The presence of Flyback transformer provides necessary isolation and the problems of TCO corrosion and leakage current is avoided by double grounding. Since single primary and secondary is used in the Flyback transformer, Transformer Utilization Factor (TUF) is improved as well as the MPPT technique will help the inverter to work at the maximum power obtaining point which varies according to the amount of sunlight exposed to the panel, which increases its efficiency. Moreover the voltage stresses of the inverter switches are halved compared to the centre tapped circuit configuration. Due to unfolding type arrangement only one switch is operated at high frequency during the entire operating range and hence switching losses are also reduced. Also a better symmetrical waveform is obtained in both half cycles of load voltage.

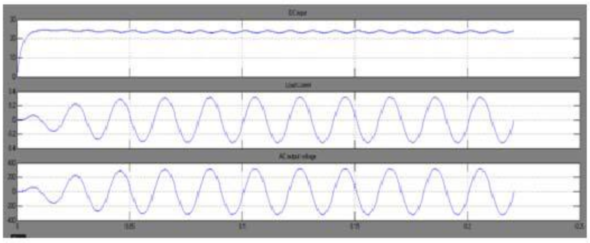

Fig15. output voltage of PV panel load current and load voltage

Even though the number of switches in the inverter side increases, since all of them is operated at ZVS and ZCS, there is no switching loss. But the presence of transformer makes the circuit bulky. However the advantageous mentioned above have made the circuit with isolation more popular compared to transformer less topologies. This converter can be used for local loads as well as grid interfacing and also suitable for ac module applications.

REFERENCES

[1] Lallu mol K Johny, Jose Sebastian T.K, " A flyback DCM DC-AC high converter for PV applications." International Conference on Microelectronics , Communication and Renewable Energy (ICMiCR-2013).

[2] Srushti R. Chafle, Uttam B. Vaidya "Incremental conductance MPPT technique for PV system." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering *Vol. 2, Issue 6, June 2011.*

[3] Toshihisa Shimizu, Keiji Wada, and Naoki Nakamura "Flyback-Type Single-Phase Utility Interactive Inverter With Power Pulsation Decoupling on the DC Input for an AC Photovoltaic Module System" *IEEE transactions on power electronics, vol. 21, no. 5, september 2006.*

[4] Quan Li, and Peter Wolfs "A Review of the Single Phase Photovoltaic Module Integrated Converter Topologies With Three Different DC Link Configurations" *IEEE transactions on power electronics, vol. 23, no. 3, may 2008*

[5] Jia-Min Shen, Hurng-Liahng Jou, and Jinn-Chang Wu ''Novel Transformerless Grid-Connected Power Converter With Negative Grounding for Photovoltaic Generation System" IEEE transactions on power electronics, vol. 27, no. 4, april 2012.

[6] T. Shimizu, K. Wada, and N. Nakamura, "A flyback-type single phase utility interactive inverter with low-frequency ripple current reduction on the DC input for an AC photovoltaic module system," in *Proc. IEEE PESC*, 2002, pp. 1483–1488

[7] Jia-Min Shen, Hurng-Liahng Jou, and Jinn-Chang Wu ''Novel Transformerless Grid-Connected Power Converter With Negative Grounding for Photovoltaic Generation System" IEEE transactions on power electronics, vol. 27, no. 4, april 2012

[8] S. Mekhilef, N. A. Rahim, and A. M. Omar, "A new solar energy conversion scheme implemented using grid-tied single phase inverter," in Proc. IEEE Tencon, 2000, pp. 524–527

[9] E. Achille, T. Martiré, C. Glaize, and C. Joubert, "Optimized dc–ac boost converters for modular photovoltaic grid-connected generators," in *Proc. IEEE ISIE*, 2004, pp. 1005–1010

[10] A. Ch. KyritsisE. C. Tatakis, and N. P. Papanikolaou "Optimum Design of the Current-Source Flyback Inverter for Decentralized Grid- Connected Photovoltaic Systems" IEEE transactions on energy conversion, vol. 23, no. 1, march 2008.

BIOGRAPHIES

Mrs.Abjhasree S S, received Masters of Engineering in Industrial drives and control from RIT Kottayam affiliated to MG university in 2008. She completed the Bachelors of Technology in Electrical and Electronics Engineering from RIT Kottayam in 2005. Now she is working as an Assistant Professor in College of Engineering Pathanapuram, affiliated to Cochin University of Science And Technology, Kerala. She has a teaching experience of 9 years and interested in Power electronics and drives.

Abhishek D S, B.Tech student, doing his graduation in electrical and electronics engineering, at college of engineering Pathanapuram, having an area of interest in power electronics and control system engineering.

Abitha B Nair, B.Tech student doing her graduation in electrical and electronics engineering, at college of engineering Pathanapuram. Her area of interest is in power syatem analysis.

Adarsh Babu T, B.Tech student, doing his graduation in electrical and electronics engineering, at college of engineering Pathanapuram, having an area of interest in control system engineering and conventional energy sources.

Navin Francis, B.Tech student, doing his graduation in electrical and electronics engineering, at college of engineering Pathanapuram, having an area of interest in circuit theory, power electronics drives and control.

Rifas M, B.Tech student, doing his graduation in electrical and electronics engineering, at college of engineering Pathanapuram, having an area of interest in non-conventional energy sources.