# Three Port Flyback MicroInverter to Interface Renewable Energy Sources

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## ABSTRACT
The proposed photovoltaic Micro Inverter is based on three port flyback with one port dedicated to power decoupling function so the decoupling capacitance is reduced and hence the long lifetime film capacitor is used. One of the two transformers and one capacitor is used for decoupling function. The decoupling capacitor functions as energy storage as well as snubber capacitor to recycle the transformers leakage energy. A diode is involved to prevent the reverse current from power decoupling capacitor to PV panel.

## Keywords
Three Port Flyback, Microinverter, Decoupling Capacitor, Photo Voltaic (PV)

## 1. INTRODUCTION
With the depletion of fossil fuels, renewable sources, generated from natural resources, have caught the eyes in recent years from both the industries and governments all over the world due to their environmental friendliness. Among renewable sources, the photovoltaic (PV) has witnessed the unprecedented growth. The PV market grew by almost 15% in 2009 compared to that in 2008, reaching 7.2-GW capacity, and the accumulative PV power installed in the world raised by 45%up to 22.9GW [1-2].

Currently, the inverter for the PV system can be categorized into three types: centralized inverter, string inverter, and ac module. Recently, the ac module has attracted the attention of both the researchers and industry due to its numerous advantages:1) higher energy harvest, 2) higher system efficiency,3) reduced installation costs, 4) plug-N-play operation, and 5) enhanced flexibility and modularity. Moreover, ac module is designed with mass production in mind, which will lead to competitive cost [6]. With these advantages, the ac module has become the trend for future PV system development. However, low cost, high efficiency, long life expectancy, low profile, and multi functions are the challenges that still need to be addressed.

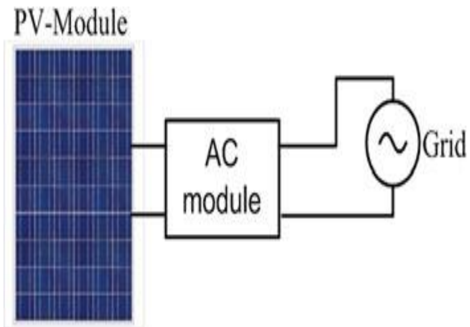


**Fig 1: AC-module PV system.**

Fig. 1 shows a typical microinverter-based PV system, where the microinverter is integrated to the PV panel, and feeds the collected solar power directly into the utility grid. Usually, for safety purposes and leakage current in grid-connected applications, a high-frequency transformer is embedded in the ac module due to the reasons of low cost and small size [5]. AC module with a high-frequency transformer can be further grouped into three architectures based on the dc-link configurations: dc link, pseudo-dc link and high-frequency ac. Among these three basic implementations, the architecture with the pseudo ac link, featuring only one power conversion stage compared to other two implementations, has the potential to achieve the highest efficiency [10].

Typically, the micro inverter is connected to a single PV panel, which requires that the microinverter has a lifespan matching the PV panel's ones, namely 25 years, and thus long life components have to be used to ensure ac module's long lifespan [11]. However, ac module with single-phase grid connection has the disadvantage that the power flow to the grid is time varying, while the power of the Photo Voltaic panel must be constant for maximizing energy harvest.

## 2. CONVENTIONAL SYSTEM
Fig. 2 shows the circuit configuration of the proposed single stage microinverter.

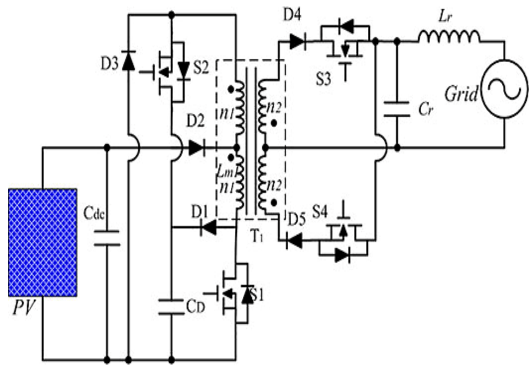


**Fig 2: Conventional system.**

This topology is basically derived from a conventional flyback by adding additional switch S2 , and another transformer winding at primary side to implement power decoupling function. The power decoupling capacitor CD is configured to function as both an energy storage element and a snubber capacitor to recycle the transformer's leakage energy.

## 3. OPERATION PRINCIPLE

The operation of the proposed topology is divided into four different circuit stages in each switching cycle. Each stage shown in Fig. 5 will be explained in details as follows.

### 3.1.1 Modes of Operation

*A. Mode 1 (Ppv> Pac)*

This mode occurs whenever the generated PV power is greater than the output ac power. The switching period Tsis divided into four intervals.

*Stage1*

During this stage, as seen in Fig. 5(a), switch S1 is turned ON. Then, the magnetizing current in transformer ramps up from zero to iL1-peak11.

*Stage 2*

This stage starts when the main switch S1 is turned OFF, while the switches in the secondary side are still OFF, at this instant, the magnetizing current starts charging the decoupling capacitor CD throughD1 and D3.

*Stage 3*

During this stage, the current i2 is released through one of the secondary windings and the corresponding ac switch, either S3 or S4, The grid voltage during one switching period uac can be assumed to be constant; as the current I reach to zero.

*Stage 4*

As the current i2 decreases to zero, this stage starts where all the switches are turned OFF. The capacitor Cr and inductor Lr keep pumping energy to the grid, while the flux in the flyback transformer is reset.

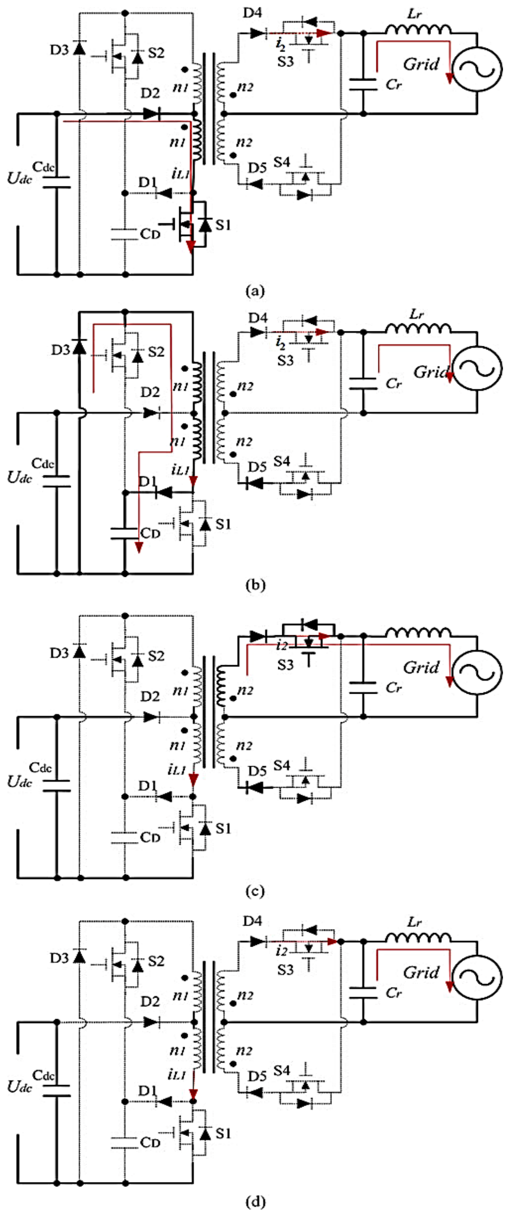


**Fig 3: Detailed circuit operation stages during mode-I.(a)Stage1[t0–t1],(b)Stage2[t1t2],(c) Stage3 [t2–t3], and(d) Stage4[t3–t4]**

*B. Mode II (Ppv<Pac )*

*Stage 1*

This stage is quite similar to stage 1 in mode I. S1 is turned ON, and the magnetizing inductance stores energy from PV panel throughD1 , T1 , and S1 , The magnetizing current ramps up linearly until it reaches iL –peak.

To maintain constant power from PV panel, the peak current in this stage should be fixed as the input voltage from PV panel is assumed to be constant in the steady state.

*Stage 2*

This mode starts when the magnetizing current reaches iL - peak21. At that instant S2 is turned ON, and all the diodes at the primary side are reversed biased,. As the magnetizing current in one primary winding is coupled into another primary winding during this stage, the magnetizing current iL-peak21 will be halved. The energy stored in the decoupling capacitor CD continues charging the new inductor with two windings in series.

The new magnetizing current ramps up linearly until it reaches iL-peak22, where the energy stored in the magnetizing inductance equals the required energy to be pumped into the ac side on the average basis of one switching period.

### *Stage 3*

Once S1 and S2 are turned OFF simultaneously at t3 , the current at secondary side i2 (t) is released through one of the secondary side. Since the voltage ripple across the capacitor Cr during one switching period is negligible.

### *Stage 4*

This stage is the same as stage 4 in mode I. No current flows through transformer windings, and the transformer is in magnetizing reset state. The output current is maintained by Cr and grid-tied inductor Lr.

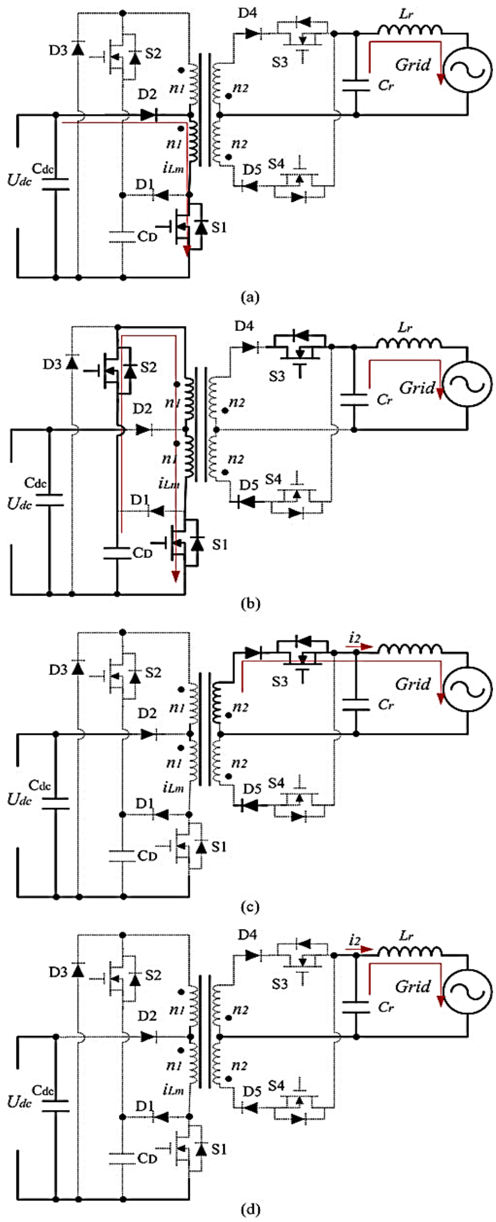

**Fig 4: Detailed circuit operation stages during mode II. (a)Stage 1[t0 –t1], (b) Stage 2[t1 –t2], (c) Stage 3[t2 –t3], and (d) Stage 4[t3 –t4].**

## 4. PROPOSED SYSTEM

The proposed system is the three port flyback micro inverter like conventional system but the output of the proposed system is three phase. This system contains battery instead of decoupling capacitor which presented in the conventional system.

The transformer is isolated transformer which has higher efficiency with less loss. This battery backup provides the supply to the transformer when the input system fails.

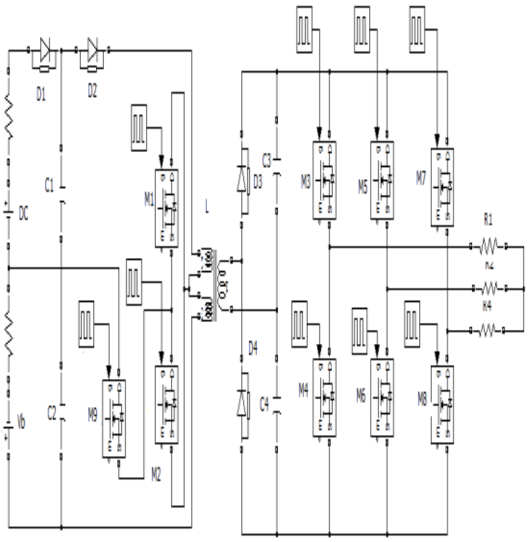


**Fig 5: Proposed Technology**

## 4.1.1 Mode of Operations

### *A. Normal Mode*

The input supply Vdc is supplying the load by turning on the switches M1, M9, and the diodes D1 and D2 are conducting. On the secondary capacitor C4 and diode D3 is conducting and the switches M3, M6 and M7 are turned on connecting the load for the three phase mode.

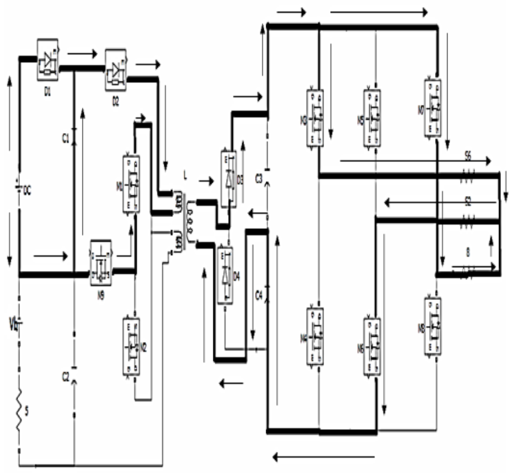

**Fig 6: Normal operation of proposed circuit**

### *B. Battery Charging Mode*

The input $V_{dc}$ is supplying the load through the diodes D1, D2, D3 and the switches M3, M6 and M7 are turned on by connecting the load.

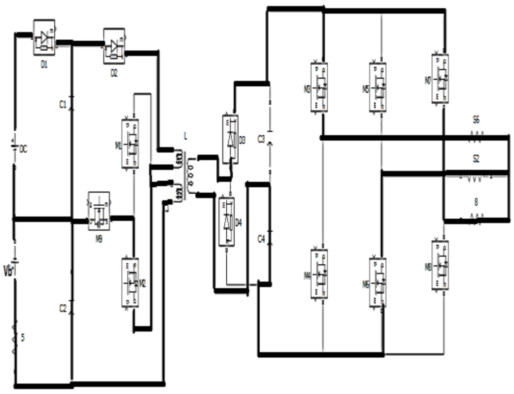

**Fig 7: Battery charging mode**

The battery (Vb) is charged by turning on the switches M9 and M2

### *C. Battery Supplying Mode*

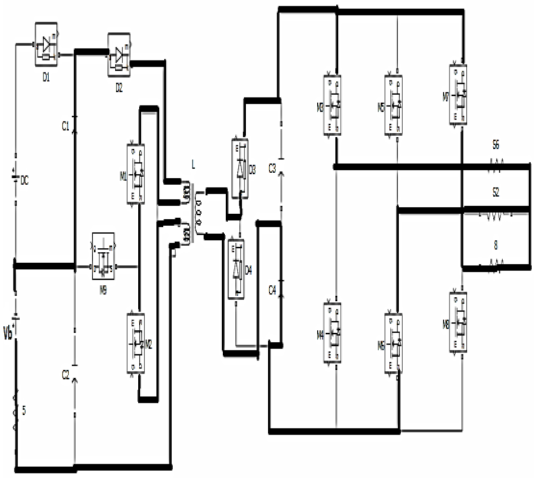

**Fig 8: Battery supplying mode**

The battery voltage Vb is supplying the load through the diode D2, capacitor C1, C4 and diode D3 and the switches M1, M2, M3, M6, and M7 are turned on.

## 5. Experimental Results

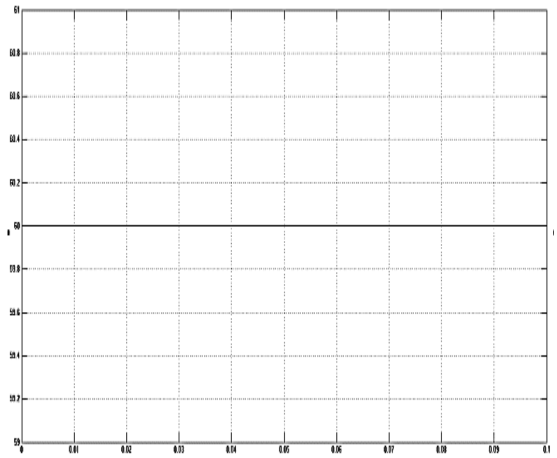

**Fig 9: Input waveform of the conventional model**

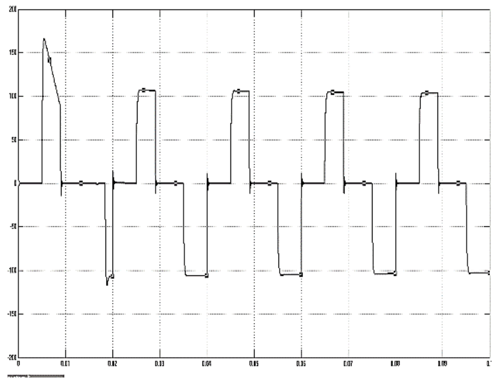

**Fig 10: Output waveform of the conventional system (Normal Mode)**

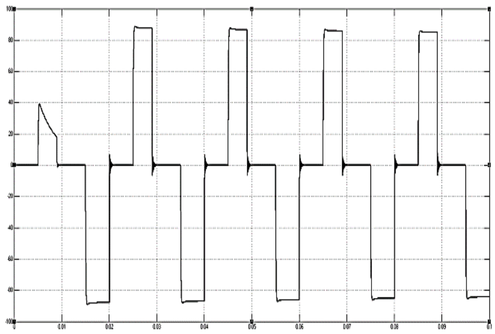

**Fig 11: Output waveform of the conventional system (Backup Mode)**

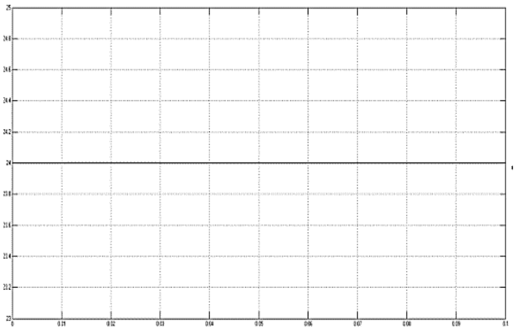

**Fig 12: Input waveform of the proposed model**

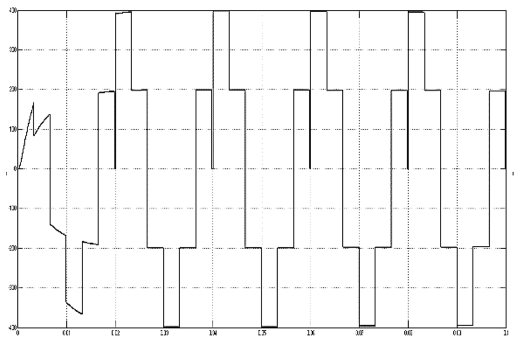

**Fig 13: Three phase output wave form of the proposed model.**

# 6. CONCLUSION

A new microinverter topology is proposed. It primarily aims for the ac-module PV systems.The proposed topology employs a new battery backup technique and it is easily replacable if the battery failure. Hence, it will have a long life span comparable to the PV Panel.The Isolated high frequency transformer is used in this model so there is no leakage current in the primary side of the transformer.So the efficiency will be high and the final output of the proposed model is three phase output.

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