Institute of Aeronautical Engineering

(Autonomous)

Department of Electrical and Electronics Engineering

A new structure of single-phase two-stage hybrid transformer less multilevel PV inverter

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Abstract

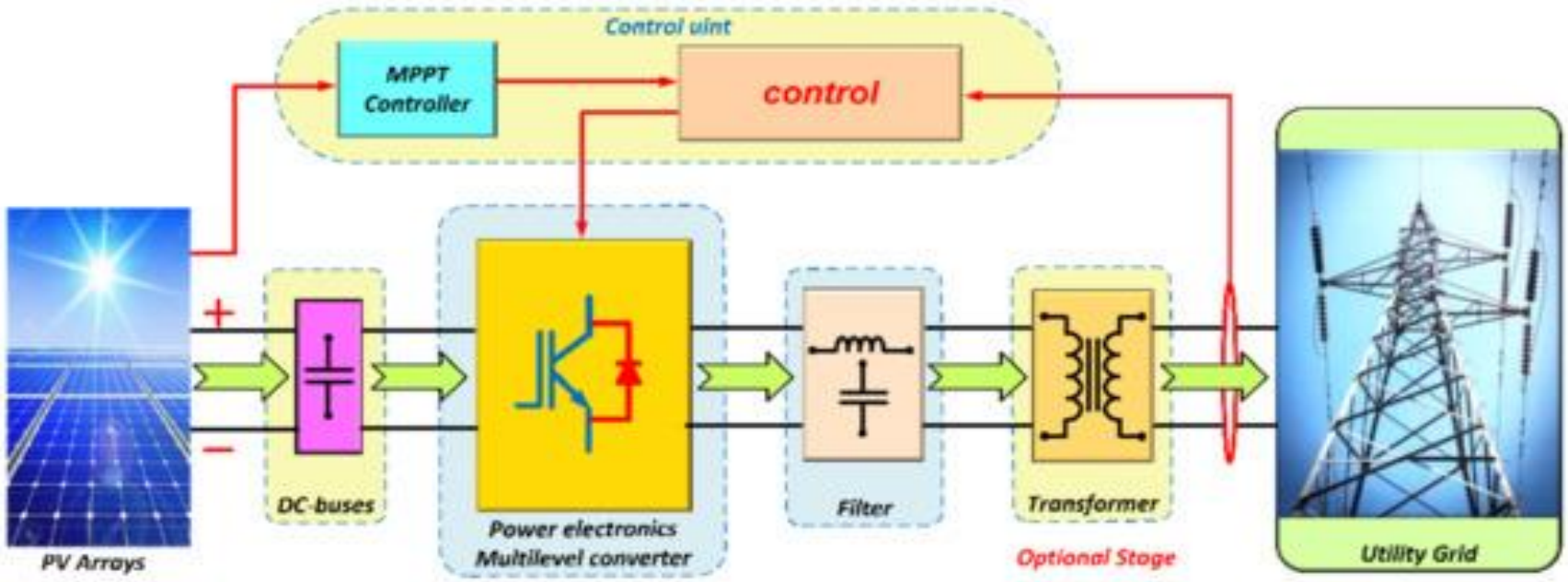
Transformer less inverters are becoming popular for grid-connected photovoltaic applications due to their simplicity, reduced size, weight, cost, and higher efficiency. In this paper, a two-stage hybrid transformer less multilevel inverter (MLI) for single-phase grid-connected photovoltaic power generation system (PVPGS) is presented. The proposed topology comprises a multilevel boost converter (MLBC) and a symmetrical hybrid MLI. MLBC combines the boosting and switched capacitor voltage functions to produce self-balanced multiple voltage levels. The proposed MLI is derived from a combination of bidirectional switches, a half bridge, and a diode-clamped branch, which can produce only two variations in the total common mode voltage and is capable of suppressing leakage current. It offers the advantages of scalability, reactive power capability, reduced total harmonic distortion, and filter size. The proposed hybrid transformer less seven-level inverter is simulated in MATLAB, and experimental setup is built to validate the effectiveness of the proposed configuration. Finally, a comprehensive comparison is made with other seven-level inverter topologies.

INTRODUCTION

Photovoltaic-based renewable energy sources (RES) have proved their potential, and so far, around 1000GW capacities of photovoltaic (PV) plants have been installed across the globe till 2021. This also effectively alleviates greenhouse gas emission and global warming associated with conventional fossil fuels. Leading to the design of compact, highly reliable, low cost of operations, and very efficient grid-connected photovoltaic power generation systems (PVPGS).

INTRODUCTION

Two-level single-stage grid- connected PV inverters are well commercialized in industries and residential applications due to the simple structure and higher efficiency. RES like PV are usually connected in series to meet the grid peak voltage in two-level single-stage inverter structures.



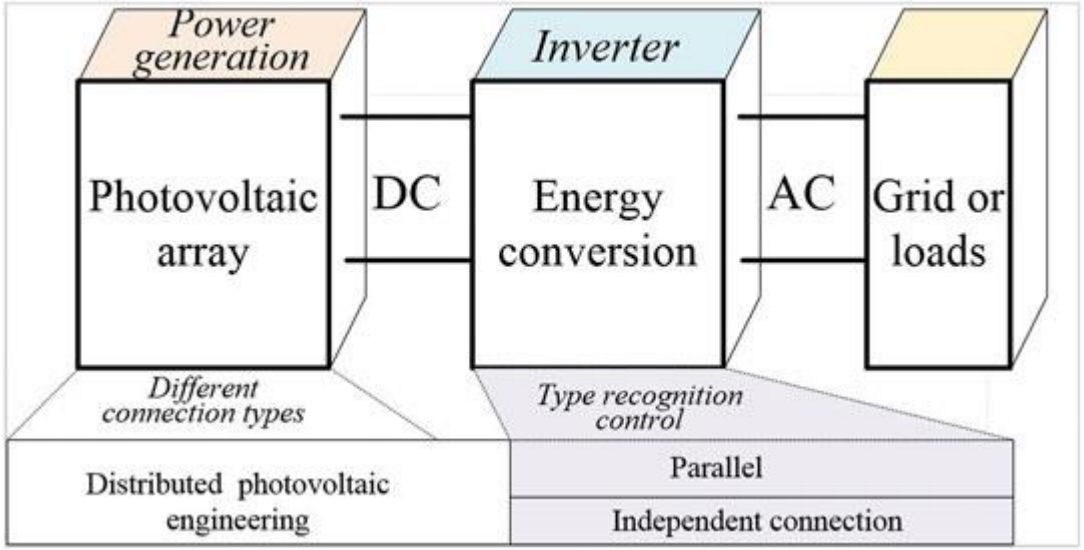
INTRODUCTION

However, these inverters have the following drawbacks: poor maximum power point tracking (MPPT), imbalance in power sharing due to partial shading that result in overheating of the nonshaded PV panel, and lower safety of operation. In addition, it requires high voltage–rated power semiconductor switches, and it has low quality of output power.

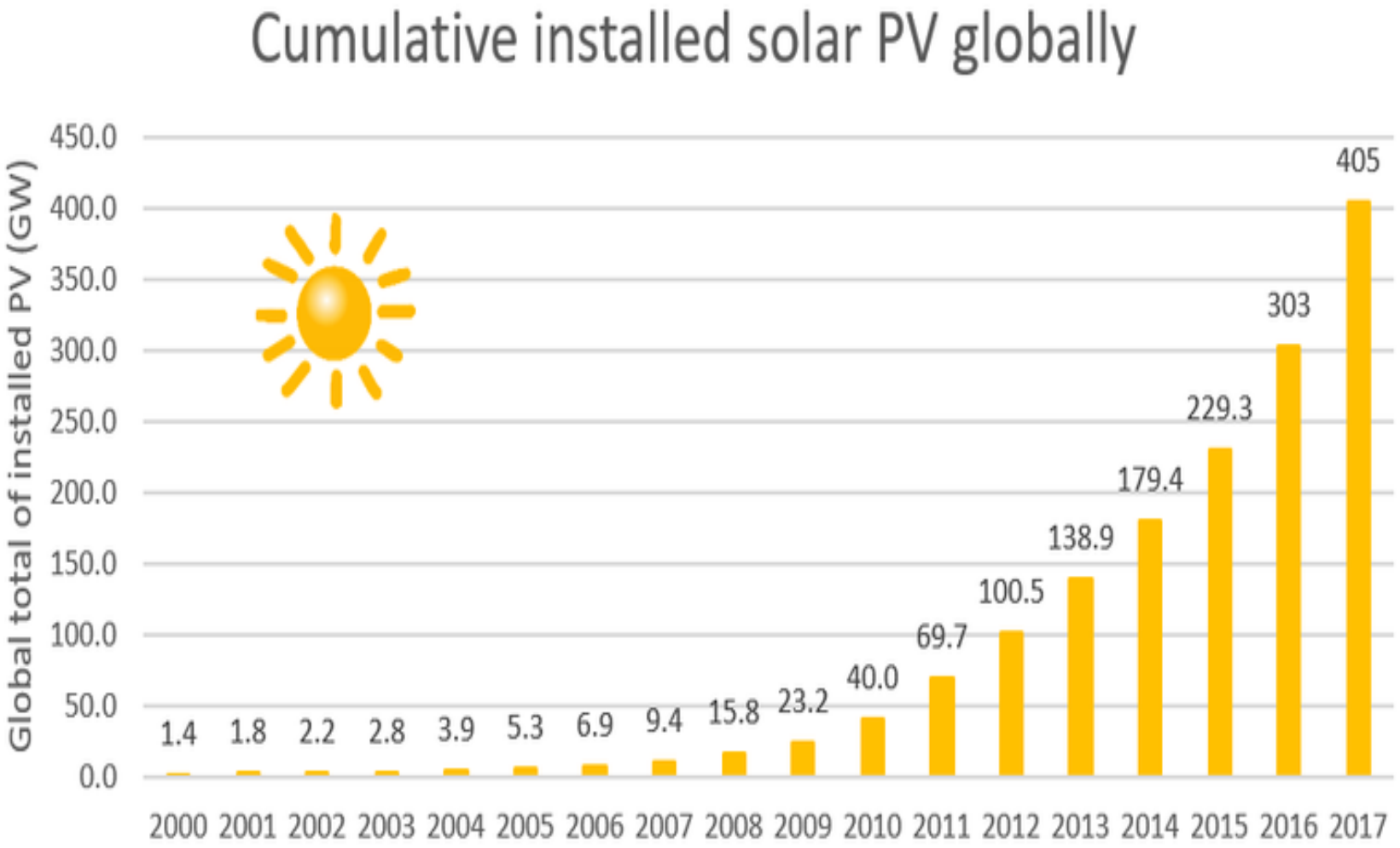
Therefore, two-stage power conversion has become more popular and is capable of overcoming the shortcomings of single-stage inverters by employing a front-end DC-DC converter stage. It boosts the lower PV voltage to higher DC-link voltage and then converts it to AC to meet the grid peak voltages. Moreover, lower number of series-connected PV panels and better MPPT performance are achieved in two-stage inverters in comparison with single-stage inverters. In general, two-stage inverters are built with either a line frequency transformer (LFT) or a high frequency transformer (HFT) to boost the voltage and also to provide galvanic isolation for leakage current flow from the grid to PV source. The size, cost, and efficiency of the overall two stages degrade with the use of transformer.

SCENERIOS

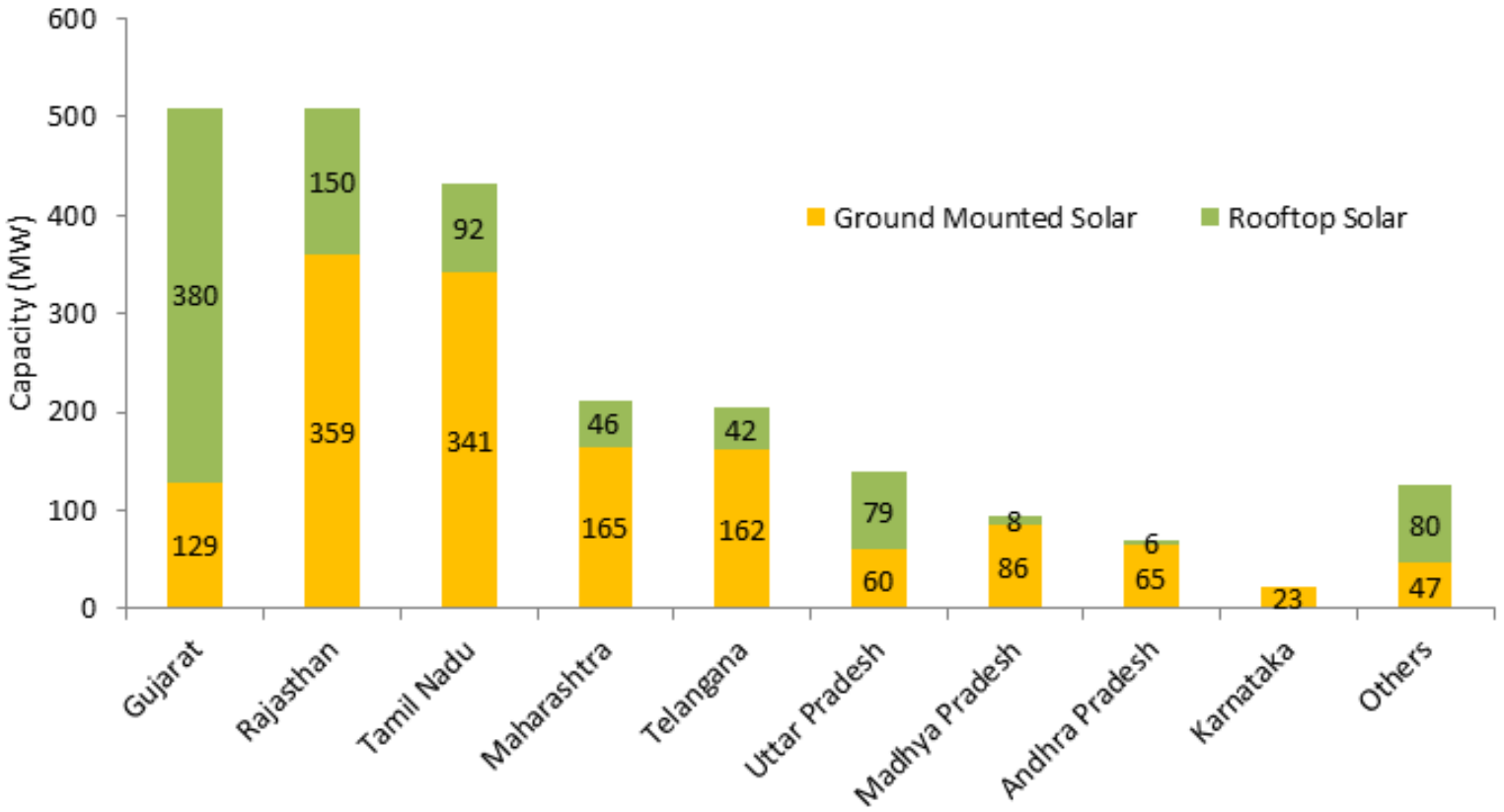
Many industries are focusing on transformer less inverter. Recently, multilevel inverters (MLIs) are emerging in the area of low-power grid-connected RES. MLIs are capable of synthesizing output waveform close to sinusoidal by connecting various DC sources in series. They are becoming popular due to the requirement of reduced device ratings, filter components, and good quality of output power from the perspective of harmonics. Hence, these are the better alternatives to limit the issues of two-level inverters.



FUTURE


Cumulative installed solar PV globally
Global total of installed PV (GW)
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1.4
1.8
2.2
2.8
3.9
5.3
6.9
9.4
15.8
23.2
40.0
69.7
100.5
138.9
179.4
229.3
303
405
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

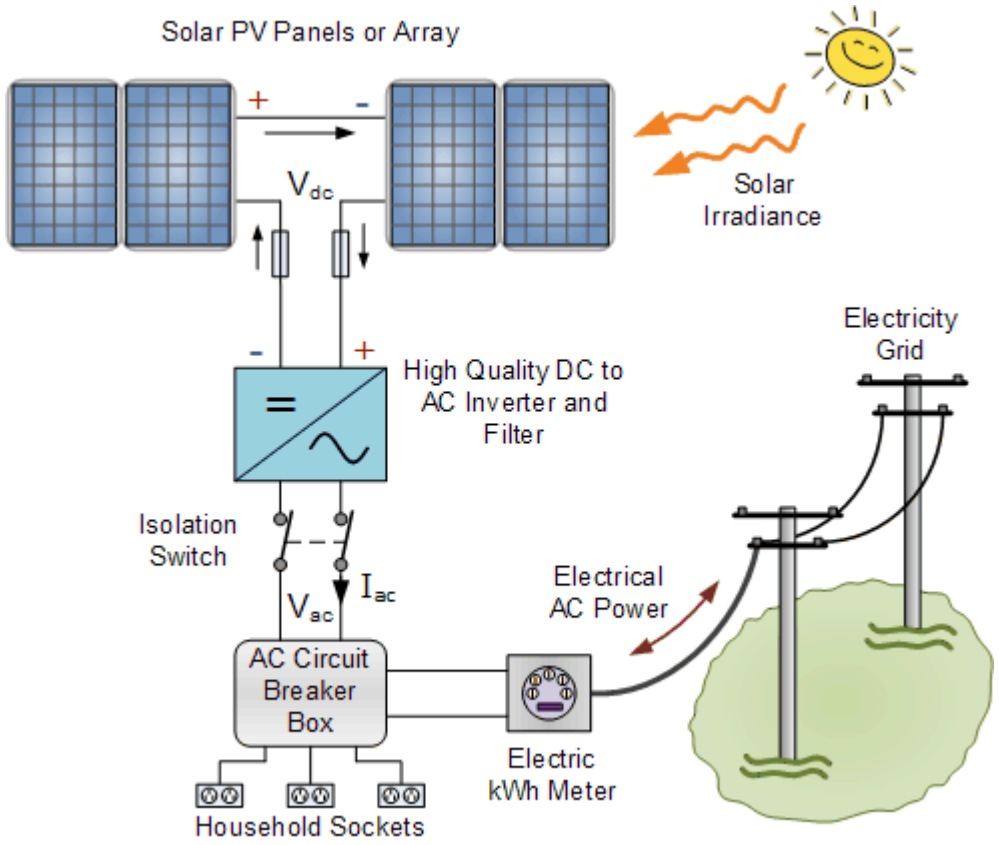
FUTURE

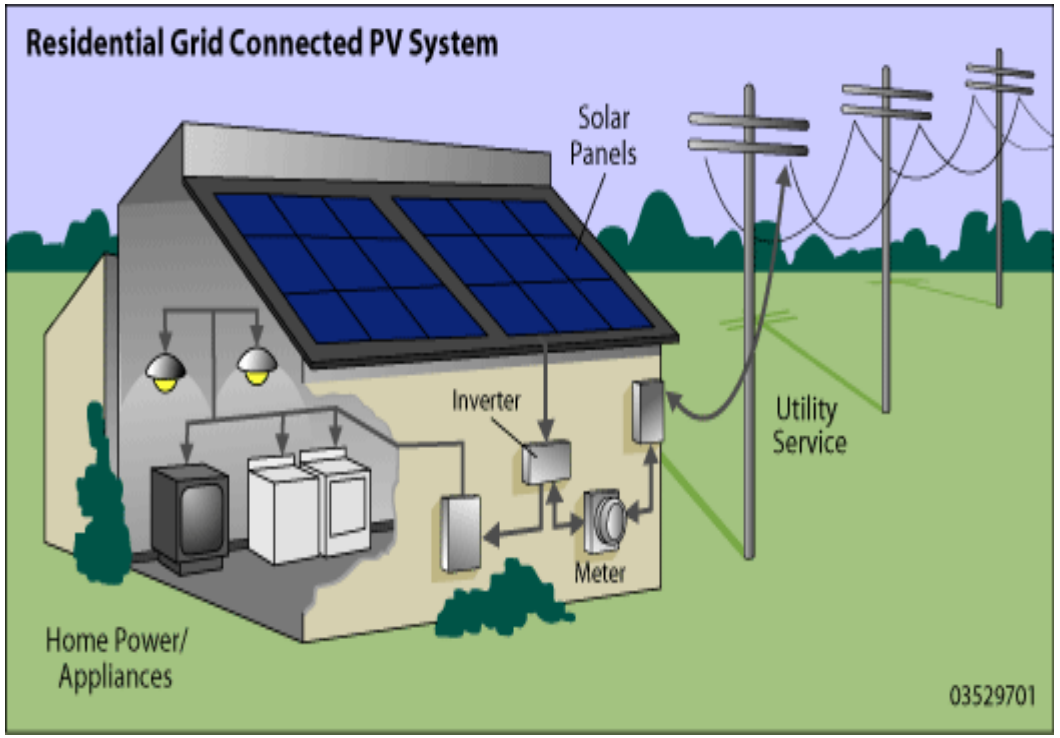


The demand for rooftop solar PV is soaring, driven by falling costs of the technology against energy crises that are gripping countries globally. But while an increasing number of households turn to solar to generate their own electricity, there is now a need for more specialist equipment, technologies and services to ensure the solar transition can reach as many customers as possible.

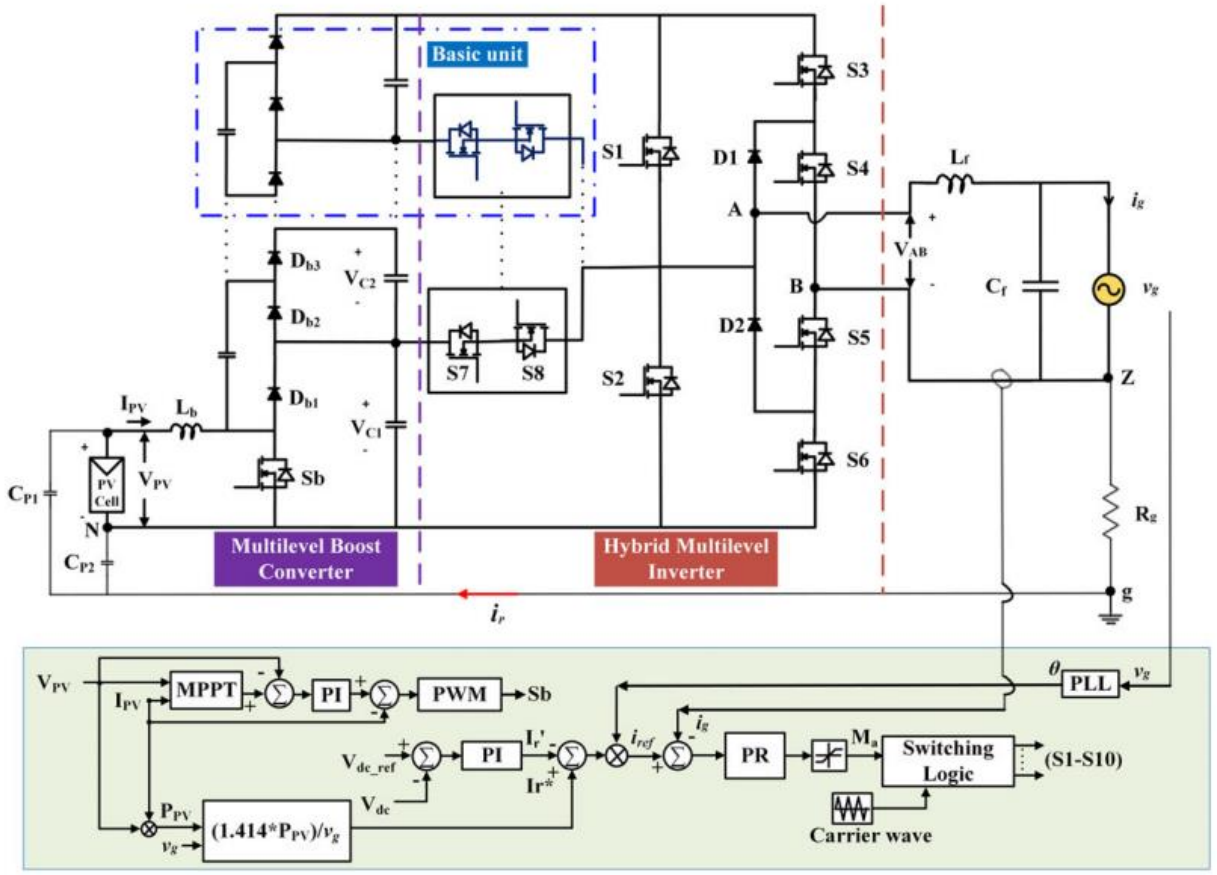
Delivering these is now a major challenge for rooftop solar installers. This webinar will analyze the characteristics of the rooftop solar market, discussing how the products, logistics, installation and servicing of solar systems has evolved in line with consumer demands.

REPRESENTATION

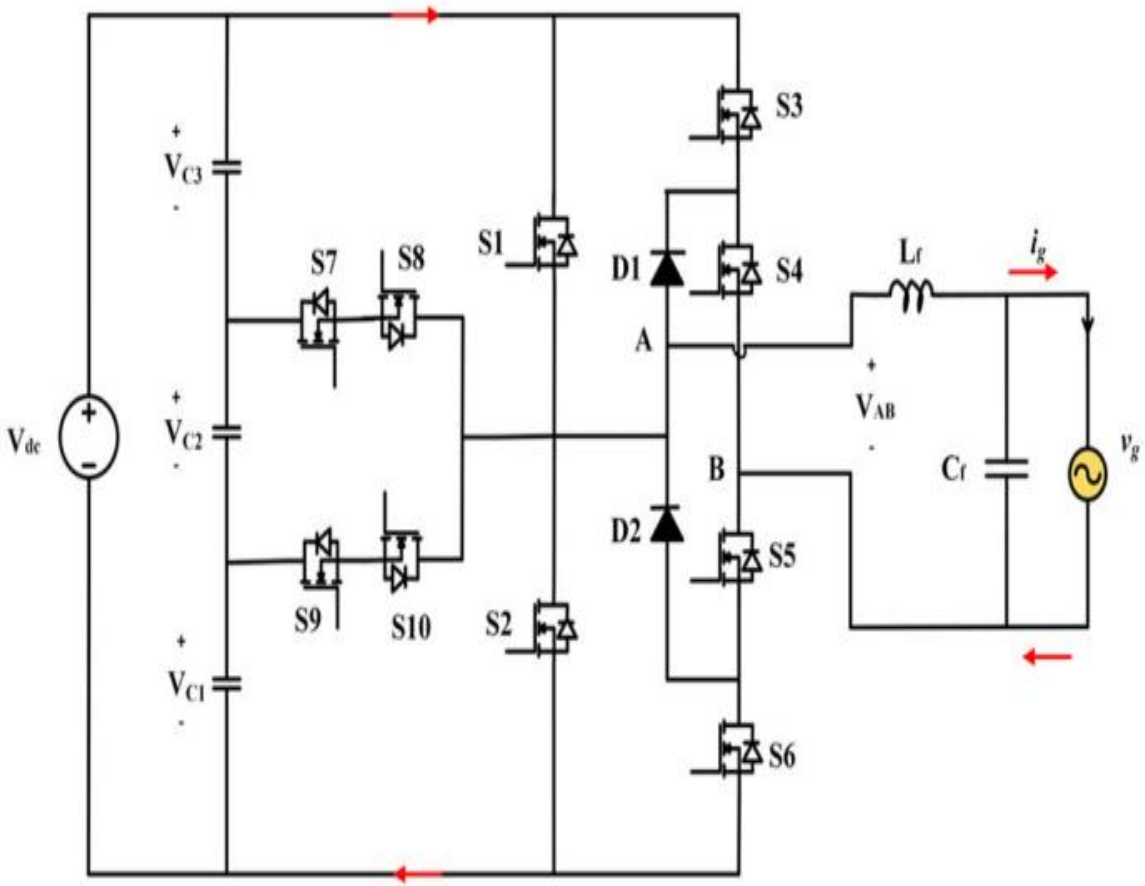




REPRESENTATION



Proposed two-stage grid-connected photovoltaic (PV) inverter



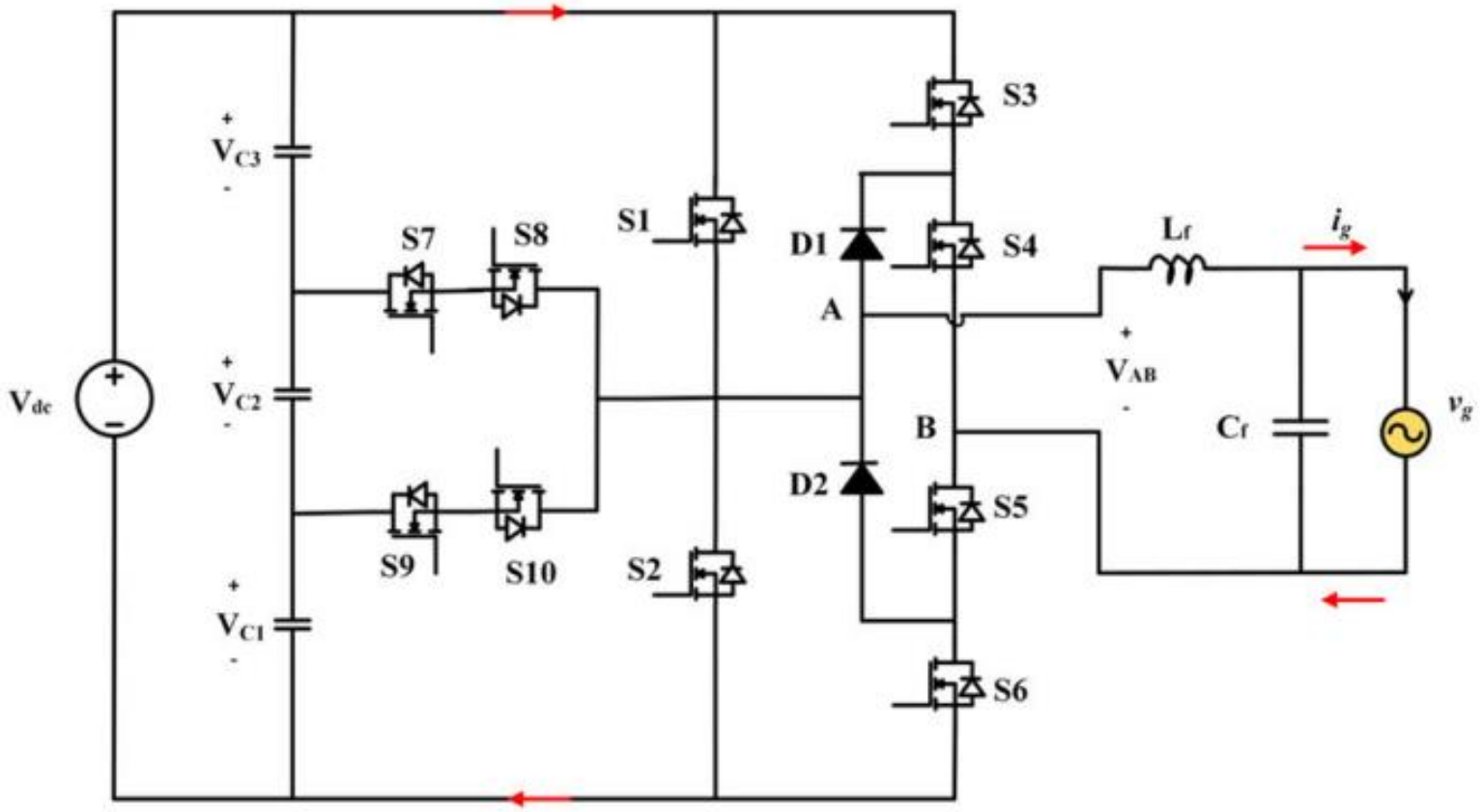
Proposed hybrid seven-level inverter topology

PROBLEM DEFINATION

Single – Stage inverters have the following drawbacks: poor maximum power point tracking (MPPT), imbalance in power sharing due to partial shading that result in overheating of the nonshaded PV panel, and lower safety of operation. In addition, it requires high voltage–rated power semiconductor switches, and it has low quality of output power.

There are several technical issues associated with grid connected systems like Power Quality Issues, Power and voltage fluctuations, Storage, Protection issues, Islanding. Power Quality issues are harmonics and voltage and frequency fluctuations.

METHODOLOGY



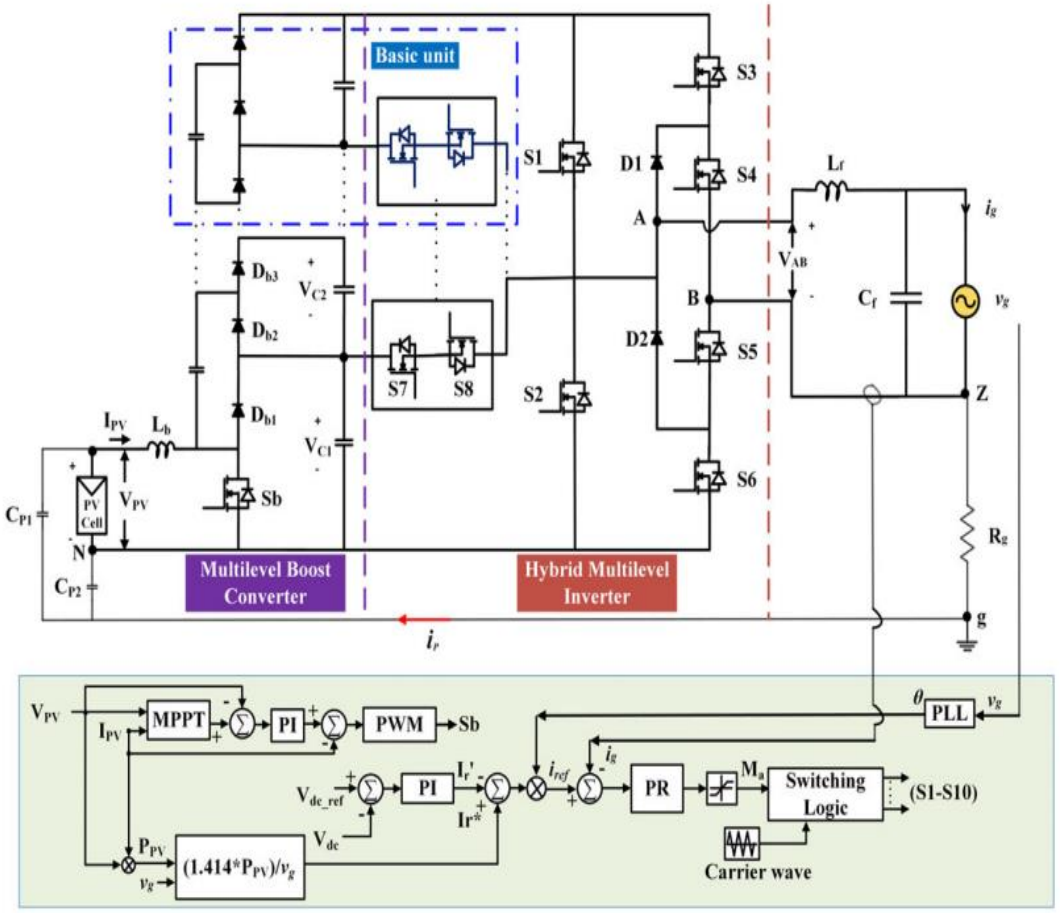
Proposed hybrid seven-level inverter topology

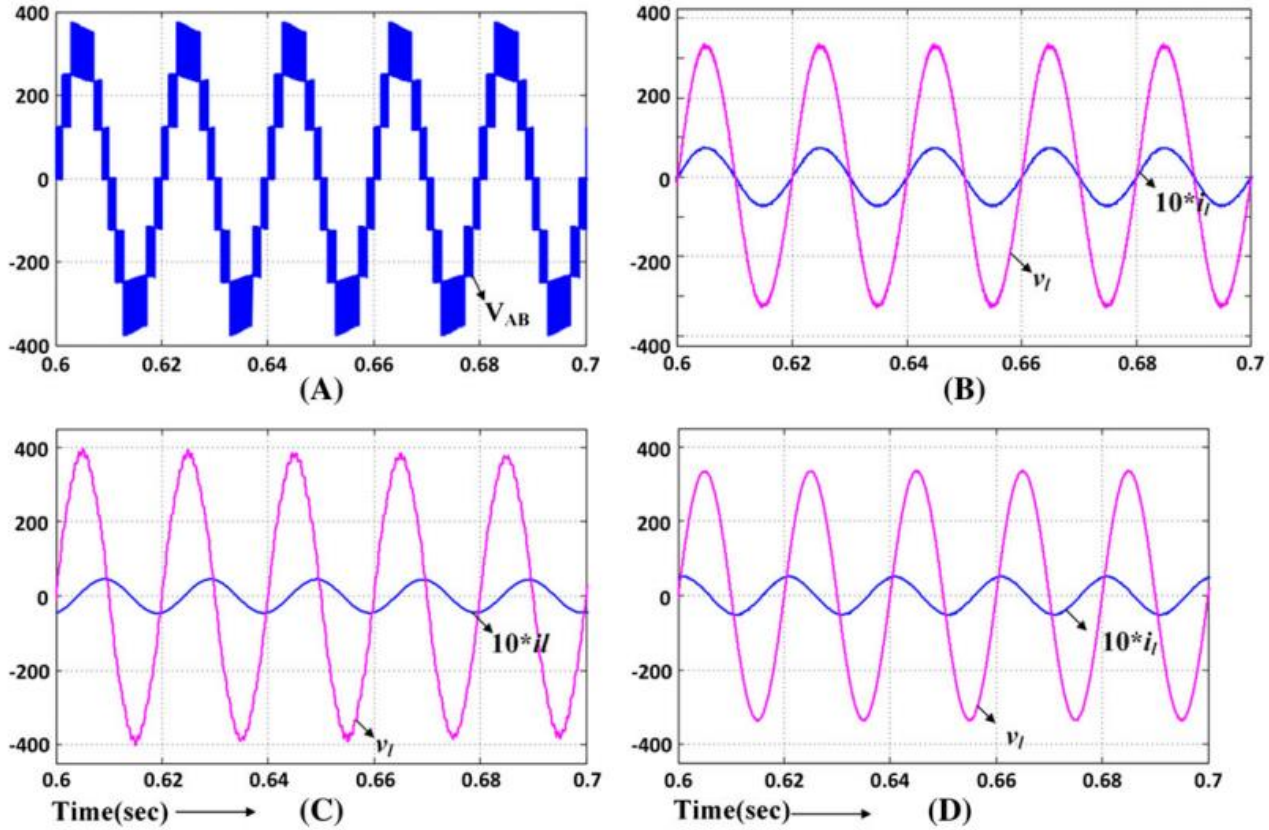
The proposed MLI is derived by combining common emitter bidirectional MOSFET branches and a hybrid-bridge three- level inverter. The hybrid-bridge inverter consists of half-bridge leg with S1 and S2 and an NPC leg with S3, S4, S5, S6, D1, and D2; this enables the polarity generation for the three-level DC voltages

APPROACH

- OPERATING STATES OF THE INVERTER IN DIFFERENT MODES
- MODIFIED SLS-PWM MODULATION TECHNIQUE WITH REACTIVE POWER CAPABILITY
- COMMON MODE VOLTAGE ANALYSIS
- DESIGN OF PASSIVE COMPONENTS
- BOOST INDUCTOR
- DC-LINK CAPACITORS
- SIMULATION RESULTS

APPROACH


Basic unit
S1
S2
S3
S4
S5
S6
S7
S8
D1
D2
A
B
Lf
Cf
VAB
ig
vg
Z
g
Rg
Db3
Db2
Db1
VC2
VC1
IPV
Lb
Sb
PV Cell
VPV
CP1
CP2
N
Multilevel Boost Converter
Hybrid Multilevel Inverter
ip
MPPT
PI
PWM
Sb
θ
PLL
Vdc_ref
Vdc
Ir'
Ir*
iref
PR
Ma
Switching Logic
(S1-S10)
Carrier wave
PPV
(1.414*PPV)/vg


400
200
0
-200
-400
0.6
0.62
0.64
0.66
0.68
0.7
VAB
(A)
10*il
vl
(B)
(C)
(D)
Time(sec)

APPROACH

A single-phase two-stage hybrid MLI for grid-connected PV applications is presented. The self-balanced capacitor voltage capability of the MLBC enables low control complexity and modularity for any level output of DC and also provides high boosting gain. The proposed MLI structure and its modulation technique provide the bidirectional path to the current in all modes of operation. In addition, reactive power control is also possible without affecting common mode voltage behavior and the output levels in the MLI. Thus, the proposed two-stage system provides high-quality output power and efficiency. The performance of the proposed two-stage system is validated by constructing a 200-W experimental prototype.

THANK YOU !