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Simulation Modeling and Analysis of Multi Mode Operation for PV Power System with Low Voltage Ride through Capability

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ABSTRACT:

This paper presents a multi-mode operation for the three-phase PV power system with low-voltage ride-through (LVRT) capability is proposed. With the proposed multi-mode control strategy, the active power from the PV arrays can be continuously extracted by the interleaved boost converter during LVRT while the maximum power point tracking (MPPT) operation can be quickly achieved after the grid fault clearance. Also, the multichannel boost converter with interleaved operation can increase power conversion efficiency while decreasing the input current ripple. On the other hand, the maximum current limitation control (MCLC) of the three-phase inverter can provide maximum reactive power under rated current amplitude during the voltage sag period as well as output the demanded reactive/rated current ratio to meet different LVRT codes. A three-phase 5kVA simulation model of PV converter has been built and tested to verify the performance of the proposed multi-mode operation strategy and the LVRT capability.

Index Terms:

MPPT, Interleaved converters, LVRT, Multimode operations.

I. INTRODUCTION:

In the present day power framework the nontraditional vitality sources, for example, PV power framework and wind era framework are the more ideal frameworks for the spotless force era [1]. The PV power framework has been quickly created keeping in mind the end goal to reduction utilization of routine sources [2].

In electric force uses the PV power framework confronting numerous difficulties because of un-expectable natural changes, for example, low illumination condition the yield of the PV exhibit will be low, the yield of the 3-stage inverter will likewise be low amid this condition the framework will fall. Amid high light condition we have a voltage of the PV exhibit is behind the normal worth it might make harm the PV cluster or circuit or any of the gadgets due to overvoltage. The natural condition is not same at constantly. The primary target of the PV power framework is to give the persistent force supply to the network even under low illumination condition and high light condition. With the advancement of PV force framework the idea of multimode operation is presented for the nonstop power era under all conditions so as to take care of the electrical force demand.

II. WORKING PRINCIPLE:

The below fig , demonstrates the circuit outline of the PV power framework comprises of a PV exhibit ,network, multimode controller , DC transport sensor, interleaved help converter with the Maximum Power Point Tracking capacity and a 3-stage inverter with the Maximum Current Limitation Control procedure and so forth. The three-line interleaved support converter worked by lesser info current swell gives the great MPPT results furthermore gives the most extreme aggregate yield force of the PV frameworks. Under lesser sun based radiation condition, maybe a couple lines can be changed off to anticipate superfluous force misfortunes at lesser PV influence yield.

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Amid the potential drop condition, the three-stage inverter gives most extreme accessible receptive force by receiving the MCLC procedure. the passable greatest yield dynamic force of the three-stage inverter, $P_{inv,max}$, amid the matrix hang period ought to be resolved as in condition (1) . Where Sinv,max speaks to the evaluated complex force of the three stage inverter, Irated is the appraised present and Ireactive is the necessary receptive 'I' of the 3-stage inverter.

$$P_{inv,max} = S_{inv,max} \times \cos(\tan^{-1}\frac{I_{reactive}}{\sqrt{I_{rated}^2 - I_{reactive}^2}}); \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

MODES OF OPERATION:

(A) MPPT Mode

In the event that the voltage of the air conditioner mains is somewhere around 90% and half of its ordinary esteem yet the present dynamic yield force of the three-stage inverter is lower than the reasonable most extreme quality, $P_{inv,\ max}$, as given in (1), the interleaved support converter can remain its MPPT operation to gather the greatest force from the PV exhibit. Therefore, enter reference current charge, Ipv, ref, of interleaved help converter stays unaltered and is equivalent to its greatest force point (MPP) .

$$I_{pv,ref} = I_{mpp} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Esteem, I_{mpp}, under ordinary operation On the other hand, the perturbation and observation (P&O) is embraced to accomplish the MPPT highlight. Albeit annoying the PV voltage is the most well-known methodology for the P&O calculation, the PV current is irritated rather than the PV voltage in this paper. It is on account of that the support converter is actualized with the interleaved highlight, so the info current for every channel ought to have the capacity to be controlled freely to accomplish the present sharing ability In the in the interim, the dynamic force charge, P_{cmd}, of the three-stage inverter is equivalent to the one for MPPT operation P_{mpp}, under typical operation.

$$P_{cmd} = P_{mp} \quad \ldots\ldots\ldots(3)$$

$$Q_{cmd} = \sqrt{S_{inv,max}^2 - P_{mpp}} \quad \ldots\ldots\ldots(4)$$

$$\text{If } V_{dc} > V_{dc,high}, \text{then } I_{d,ref}(n) = I_{d,ref}(n-1) + \Delta I_d \quad \ldots\ldots\ldots\ldots(5)$$

$$\text{Else if } V_{dc} < V_{dc,low}, \text{ then } I_{d,ref}(n) = I_{d,ref}(n-1) - \Delta I_d \quad \ldots\ldots\ldots\ldots(6)$$

$$\text{Otherwise, } I_{d,ref}(n) = I_{d,ref}(n-1) \ldots\ldots\ldots\ldots\ldots(7)$$

(B) The CPC Mode

When the three-stage inverter's available yield force is higher than the admissible most extreme worth, $P_{inv,max}$, the MPPT capacity of the interleaved help converter ought to be deserted. Under this condition, the most straightforward route is to kill the knobs of the interleaved support converter and cripple the vitality gathering from PV clusters. Nonetheless, with a specific end goal to constantly convey the sun based vitality to the matrix and in addition to abbreviate the MPPT reaction time after the network flaw is cleared, the CPC Mode is proposed. Amid this operation, the dc-join voltage ought to be controlled by the front-end interleaved support converter and the information reference current charge is decreased to keep up adjusted force stream. Therefore, a current reference, Ipv,ref, of the interleaved boost converter can be derived as:

$$Ipv,ref = Ipv\ x \frac{Pinv,max}{Ppv} \ldots\ldots\ldots\ldots(8)$$

$$\text{If } V_{dc} > V_{dc,high},$$

$$\text{then } I_{pv,ref}' = I_{pv,ref} - \Delta I_{pv} \ldots.\ (9)$$

$$\text{Else if } V_{dc} < V_{dc,low},$$

$$\text{then } I_{pv,ref}' = I_{pv,ref} + \Delta I_{PV} \ldots\ldots\ldots\ldots(10)$$

$$\text{Otherwise } I_{pv,ref}' = I_{pv,ref} \quad \ldots\ldots\ldots\ldots(11)$$

On the other hand, the active power command of the three- phase inverter should be limited to its allowable maximum value, as shown in (12). Eventually, the reactive power command can be calculated as (13).

$$P_{cmd} = P_{inv,max} \quad \ldots\ldots\ldots\ldots \quad (12)$$

$$Q_{cmd} = \sqrt{Sin_{inv,max}^2 - P_{inv,max}^2} \ldots \quad (13)$$

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(C) The SCC Mode

The extreme voltage list happens and the voltage of the air conditioner mains is lower than half of its typical worth, the PV inverter needs to infuse 100% responsive. At the end of the day, the PV power framework ought to cripple the vitality reaping from the PV exhibit and yield responsive power as it were. Under this condition, the least complex route is to kill the switches of the interleaved support converter and the operation point is situated at point B, the open-circuit voltage point. With a specific end goal to expand the MPPT speed after lattice issue is cleared, the SCC Mode is proposed.

$$I_{pv,ref} = I_{sc} \quad \ldots\ldots\ldots \qquad (14)$$

command of the three-phase inverter is equal to zero while the reactive power command is equal to the rated apparent power of the inverter, as shown in (15) and (16), respectively.

$$Pcmd = 0 \quad \ldots\ldots\ldots \qquad (15)$$

$$Qcmd = Sin_{inv,max} \quad \ldots\ldots \qquad (16)$$

III. EXPERIMENTAL RESULTS

The above simulink square outline demonstrates the proposed work, which developed utilizing simulink. A 5kVA PV power framework comprises of a three channel interleaved support converter and a three-stage inverter with details as said with info force is 80V~265V, and network voltage is 3 stage 220v and 60Hz, DC transport voltage will be around 380V~420V, DC transport capacitance will be 2880µF and the inductance will be 760µH, inductance of the inverter is 2mH. Determination which is specified in the table-l l is worked to confirm the execution of the proposed multi mode operation framework. The proposed multi-mode operation and the MCLC system are acknowledged through the DSP. The PV cluster is built with details, for example, Maximum yield power, Pmpp is 1kW, the most extreme yield voltage Vmpp is 110V, maximum yield current Impp is 9.09A, open circuit voltage Vcc is 130v and the short out current Icc is 10A The PV cluster will gather the dynamic energy to the framework up to 1kW.In this part we are going to talk about the attributes of MPPT, MCLC.

TABLE- I: Specifications of the PV power system model

Sl.no	Parameters	Value
1	Rated power	5KVA
2	Input power	80V-265V
3	Grid voltage	3-ph, 220V,60Hz
4	DC- Bus voltage	380v-420v
5	DC-Bus capacitance	2880µF
6	Switches of boost converters	47N60C3
7	Inductance of boost converters	760µH
8	Diodes of boost converters	15D60BG
9	Switches of the three-phase inverter	CM100DY-24NF
10	Inductance of the three-phase converter	2mH

TABLE-II: Specifications of the Agilent e4360 solar array simulators

Sl.no	Parameters	Value
1	Maximum output power, P_{mpp}	1KW
2	Maximum output voltage, V_{mpp}	110V
3	Maximum output current, I_{mpp}	9.09A
4	Open circuit voltage, V_{oc}	130V
5	Short circuit current, I_{sc}	10A

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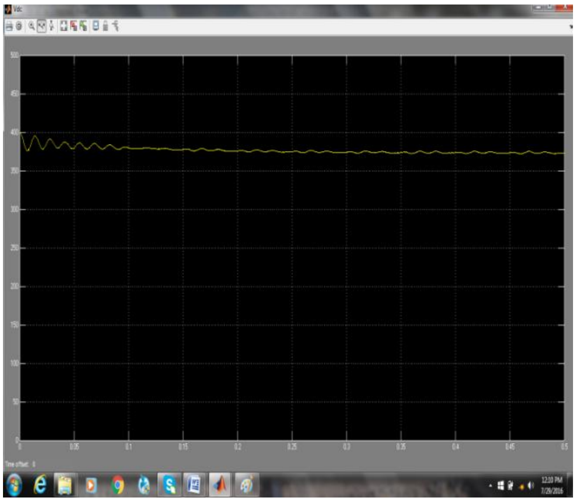

Fig 1: V_{dc} DC bus voltage with MPPT

The Dc bus voltage Vdc of the range 380v to 420V,Vdc low is 380V and Vdc high is 420V.

Fig 2: interleaved inductor currents and total input currents with MPPT.

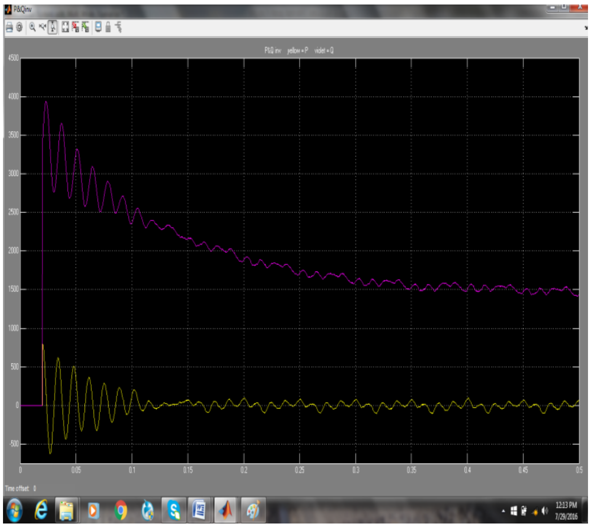

Fig 3: Key waveforms of the boost converter under MPPT operation

Fig 2 and 3 appeared above demonstrates the waveforms of MPPT operation.

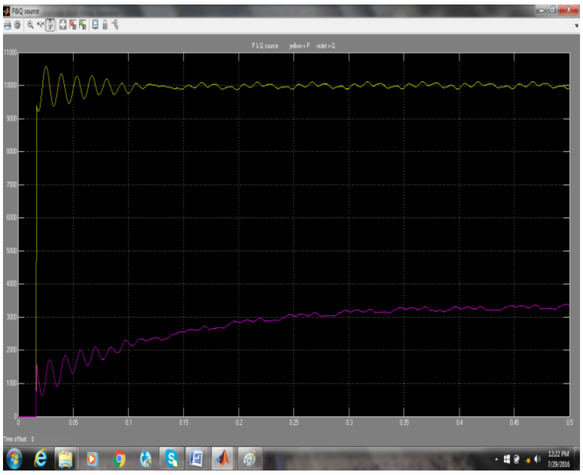

Fig 4: active and reactive power of source with MPPT

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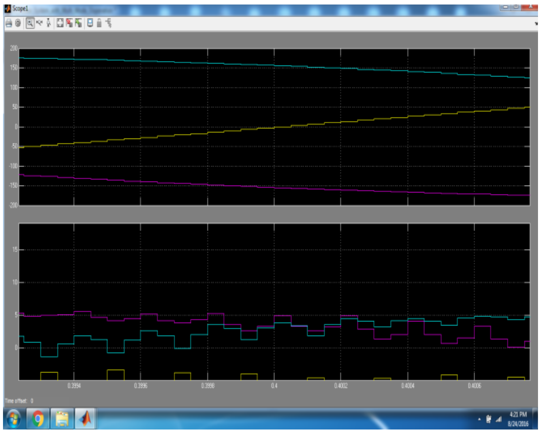

Fig 5: scope 1 waveform with MPPT

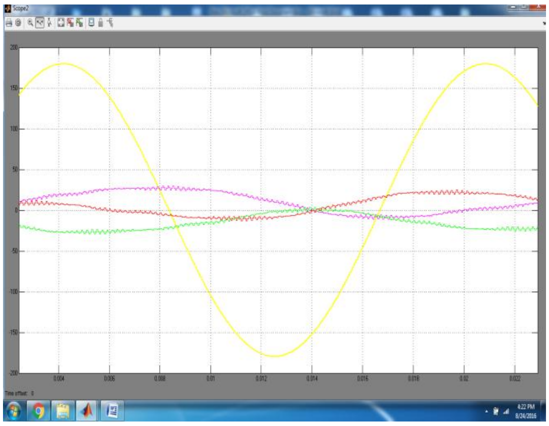

Fig 6: scope 2 waveform with MPPT

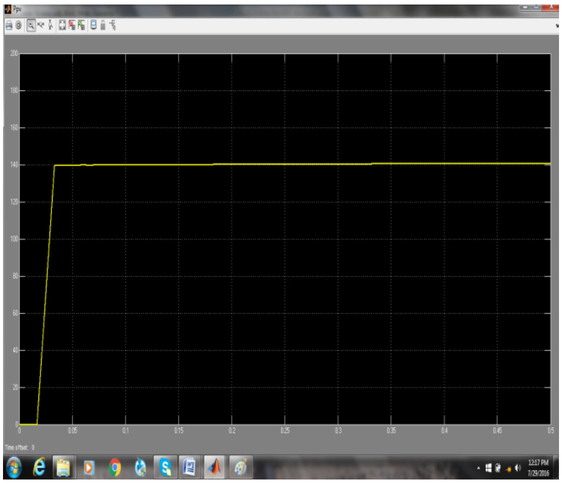

Fig 7: maximum output power P_{pv} with MPPT

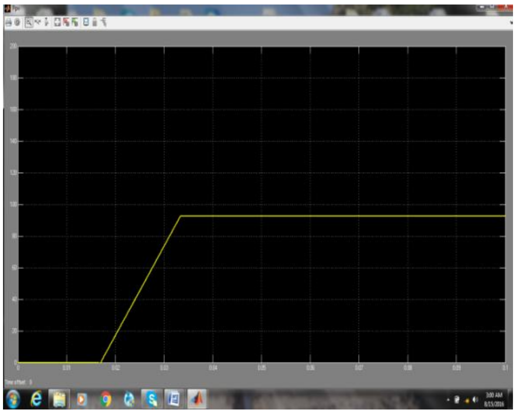

Fig 8: maximum output power P_{pv} without MPPT when switch 1 OFF

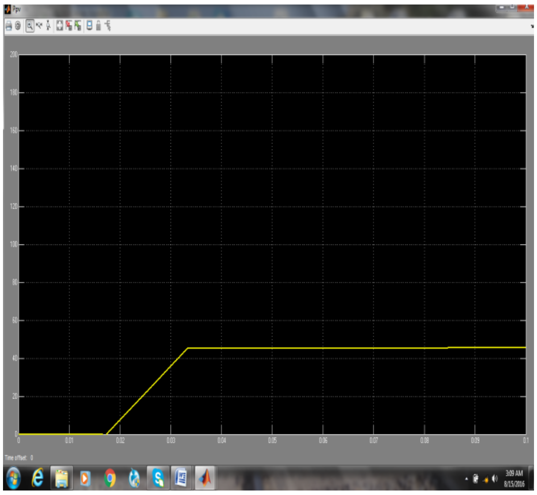

Fig 9: Maximum output power P_{pv} without MPPT when switch 1 & 2 OFF

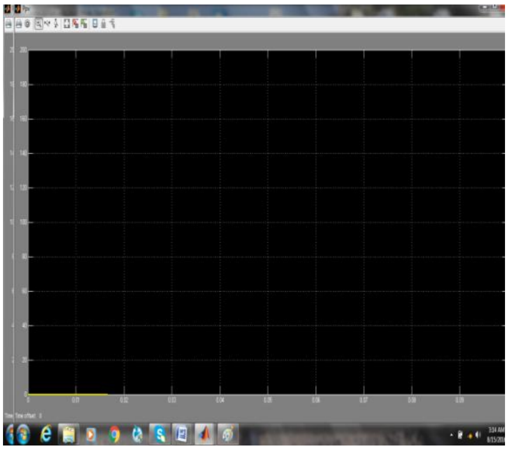

Fig 10: maximum output power P_{pv} without MPPT when switch 1 , 2 & 3 OFF

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Table-III Simulink output power variation with change in input voltage

V_{in}	R_L	V_{out}	P_{out}
150V	5KW	400V	140W
140V	5KW	400V	122W
130V	5KW	400V	106W
120V	5KW	400V	90W
110V	5KW	400V	74W

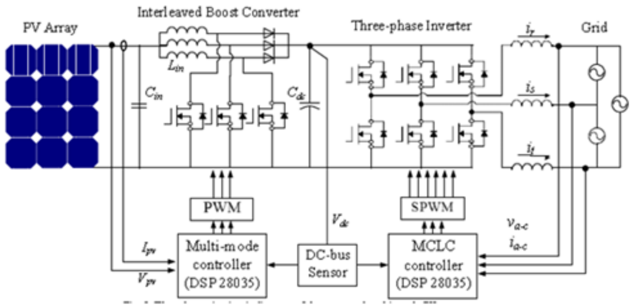

Fig. 11. The schematic circuit diagram of the proposed multi-mode PV power system.

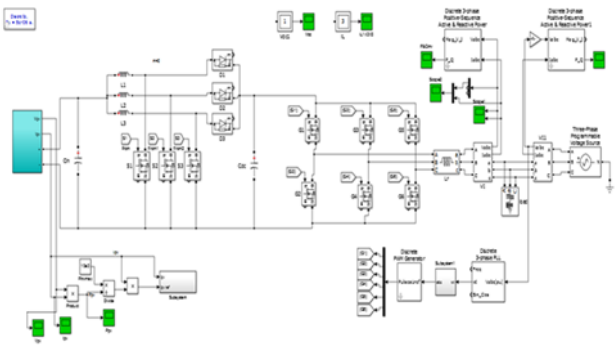

Fig 12: Proposed Simulink Module

Features of Proposed System:

1) The CB model can be further executed in SVPWM procedure rather than PWM method since space vector adjustment (SVM) system has turned into the imperative PWM strategy for 3-stage voltage source inverters.
2) The space vector regulation strategy uses DC transport voltage all the more successfully and creates less symphonious mutilation when contrasted and sinusoidal PWM system. So that its proficiency is higher than SPWM.

IV. CONCLUSION:

An enhanced multi-mode control technique for the three-stage PV power framework with LVRT ability is proposed in this paper. In light of various voltage droop levels, the proposed PV power framework can work in the MPPT Mode, the CPC Mode and the SSC Mode to accomplish better execution. Under typical condition, the PV converter works in the MPPT Mode. Amid the slight voltage list, the PV converter works in the CPC Mode can persistently separate dynamic force without impairing the vitality gathering from the PV exhibit. Likewise, the PV converter can work in the SCC Mode to diminish the season of accomplishing MPPT capacity after the extreme framework deficiency is cleared.

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