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Current mode proportional resonant controlled multi input–SEPIC-re-boost-system

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ABSTRACT

The intention of this paper is to identify a suitable controller for closed loop multi converter system for multiple input sources and to improve time response of high-gain-step up-converter. Closed-loop Multi Converter System (MCS) is utilized to regulate load-voltage. This effort recommends suitable-controller for closed-two loop-controlled-SEPIC-REBOOST Converter fed DC motor. The estimation of the yield in open-two loop and closed- two-loop-circuit has been done using MATLAB or Simulink. Closed-two loop-control of Multi Converter System with Propotional+Integral (PI)-Propotional+Integral (PI) and Proportional+Resonant (PR)–Proportional+Resonant (PR) Controllers are investigated and their responses are evaluated in conditions of rise time, peak time, settling time and steady state error. It is seen that current-mode PR-PR controlled MCS gives better time domain response in terms of motor speed. A Prototype of MCS has been fabricated in the laboratory and the experimental-results are authenticated with the simulation-results.

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1. INTRODUCTION

High Step-up Converter with three-winding coupled inductor for fuel cell energy source applications is given by Kuo. This paper presents a high step-up converter for fuel cell energy source applications. The proposed high step-up dc-dc converter is devised for boosting the voltage generated from fuel cell to be a 400-V dc-bus voltage. Through the three-winding coupled inductor and voltage doubler circuit, the proposed converter achieves high step-up voltage gain without large duty cycle. The passive lossless clamped technology not only recycles leakage energy to improve efficiency but also alleviates large voltage spike to limit the voltage stress [1].

A High Step-Up Converter with a voltage multiplier module for a photovoltaic system is presented by Shih. A novel high step-up converter is proposed for a front-end photovoltaic system. Through a voltage multiplier module, an asymmetrical interleaved high step-up converter obtains high step-up gain without operating at an extreme duty ratio. The voltage multiplier module is composed of a conventional boost converter and coupled inductors. An extra conventional boost converter is integrated into the first phase to achieve a considerably higher voltage conversion ratio [2].

An Isolated DC/DC converter using high-frequency unregulated LLC resonant converter for fuel cell applications is suggested by Han. This paper suggests an isolated dc/dc converter using an unregulated LLC converter for fuel cell applications. The LLC converter operates as an isolated voltage amplifier with a constant voltage gain, and a nonisolated converter installed in the input stage regulates the output voltage under a wide variation of fuel cell stack voltage. By separating the functions, the unregulated LLC converter can be operated at an optimal switching condition, and the high-frequency operation of 300 kHz can be accomplished without introducing an excessive switching loss [3].

A Cascaded High Step-Up DC–DC converter with single switch for Micro source applications is given by Jiann. The figuration of the proposed converter is a quadratic boost converter with the coupled inductor in the second boost converter. The converter achieves high step-up voltage gain with appropriate duty ratio and low voltage stress on the power switch. Additionally, the energy stored in the leakage inductor of the coupled inductor can be recycled to the output capacitor. The operating principles and steady-state analyses of continuous-conduction mode and boundary-conduction mode are discussed in detail [4].

An Interleaved Boost Converter with Zero-voltage transition is presented by Hsieh. This converter is able to turn on both the active power switches at zero voltage to reduce their switching losses and evidently raise the conversion efficiency. Since the two parallel-operated elementary boost units are identical, operation analysis and design for the converter module becomes quite simple. A laboratory test circuit is built, and the circuit operation shows satisfactory agreement with the theoretical analysis [5].

Comparison of PV based Embedded Z-source inverter fed three phase induction motor with PI controller and PID controller based closed loop systems is suggested by Malathi. EZSI is a good choice between PV and three phase loads since PV system can be easily split into two parts. This work proposes PV based EZSI fed three phase induction motor with PI and PID controller closed loop system. PI and PID controlled systems are designed and simulated using MATLAB. The principles of operation and simulation results are discussed [6].

A safety enhanced high step-up DC-DC converter for AC photovoltaic module application is given by Liang. Within the photovoltaic (PV) power-generation market, the ac PV module has shown obvious growth. However, a high voltage gain converter is essential for the module's grid connection through a dc-ac inverter. This paper proposes a converter that employs a floating active switch to isolate energy from the PV panel when the ac module is off; this particular design protects installers and users from electrical hazards. Without extreme duty ratios and the numerous turns-ratios of a coupled inductor, this converter achieves a high step-up voltage-conversion ratio; the leakage inductor energy of the coupled inductor is efficiently recycled to the load [7].

Interleaved converter with voltage multiplier cell for high step-up and high-efficiency conversion is presented by Zhao. A novel interleaved high step-up converter with voltage multiplier cell is proposed in this paper to avoid the extremely narrow turn-off period and to reduce the current ripple, which flows through the power devices compared with the conventional interleaved boost converter in high step-up applications. Interleaved structure is employed in the input side to distribute the input current, and the voltage multiplier cell is adopted in the output side to achieve a high step-up gain [8].

For sustainable energy applications, a high step-up-converter with voltage-multiplier modules was recommended by Huang. This work introduced a new-separated high stride-up-converter for sensible essential applications. Through an adjustable voltage-multiplier module, the introduced-converter achieved a high stride up get without utilizing either an expansive-obligation-proportion or a high turn's extent. The voltage-multiplier modules were made out of coupled-inductors and exchanged-capacitors. On account of the idle lossless fastened execution, spillage imperativeness was reused, which facilitated a gigantic voltage spike over the essential switches and upgrades capability [9].

Because of the indistinguishable course of action resistor of the boost-inductor, customary boost-converters were not prepared to surrender high voltage pick. A high-profitability high-stride up converter was proposed, with little voltage burden on control switch, control diodes and yield capacitors. The boost-converter filled in as a dynamic-brace-circuit to smother the voltage-spike on control turn in the midst of the kill-transient period. The key variables for sustainable-energy-power-conversion in modern applications were Efficiency, control quality, and unwavering quality. Du introduced a new plan to enhance exhibitions of high-voltage expansive limit photovoltaic power stations. Novel high-proficiency step-up converter was given by Tseng [10]. Examination of incorporated lift fly-back step-up converter was displayed by Liang. The working models, theoretical examination, and diagram arrangement of a high-capability wander up converter were shown. The coordinated Interleaved Boost Fly-back Converter (IBFC) used coupled-inductor methodologies to achieve high-step-up voltage with low commitment extent, and thusly the inclination-pay-circuit was discarded [11, 12].

Renewable-energy-systems with photovoltaic-power-generators, operation and-modeling were recommended by Bialasiewicz. A generous increment of photovoltaic (PV) power-generators establishments has occurred as of late, because of the expanding proficiency of sun-oriented cells and in addition the enhancements of assembling innovation of sun-oriented boards. These generators are both grid-associated and remain solitary applications. A hybrid fuel cell power system was proposed & it comprises of a fuel-cell, an isolated-unidirectional-converter, a bi-directional-converter, an-inverter and a-battery. A new unidirectional-converter, hybrid-full-bridge-LLC-resonant converter, was proposed and goes about as a unidirectional-converter in the system [13].

Design and analysis of stationary frame PR current controller for performance improvement of grid tied PV inverters is given by Mohanty. In this paper a single-phase grid connected photovoltaic (PV) system has been modeled and simulated using Matlab/Simulink. The PV generator is interfaced with the utility grid by a single-phase Voltage Source Inverter (VSI). A Maximum Power Point Tracking (MPPT) control algorithm is implemented to extract maximum power from the PV generator irrespective of operating conditions. The DC-DC boost converter placed in between PV generator and VSI performs MPPT and amplifies the output voltage from PV array to desired level. A control strategy to regulate the quality of power injected by the grid connected VSI is proposed. Two controllers are designed for the grid side DC-AC inverter one is the proportional integral (PI) voltage controller which regulates the DC link voltage, the other is the Proportional + Resonant (PR) current controller which maintains the current injected by the inverter into grid in phase with the grid voltage so that unity power factor can be achieved [14].

Design and analysis of stationary frame PR current controller for performance improvement of grid tied PV inverters is presented by Mohanty. The PV system is interfaced with the grid by a single-phase voltage source inverter (VSI). A Maximum Power Point Tracking (MPPT) controller is designed to draw maximum power from the PV array. The DC-DC boost converter carries out the task of MPP tracking and amplifies the output voltage of PV array to desired level. A control strategy to regulate the quality of power injected by the grid connected VSI is proposed. Two controllers are designed for the grid side VSI one is the proportional+ Integral (PI) voltage controller and the other is the Proportional and Resonant (PR) current controller which maintains the current injected by the inverter into grid in phase with the grid voltage [15].
Design analysis and simulation of a New current controller for wind power generation system using Proportional and Resonance (PR) Control is suggested by Bochuan [16]. Photovoltaic based proportional resonant controlled buck boost converter with coupled inductor by vanitha. This work deals with modeling and simulation of Buck Boost Converter with Coupled Inductor (BBCCI) system with Proportional +and Resonant (PR) controller. The objective of this work is to improve dynamic response of closed loop BBCCI system using PR controller. The closed loop controlled BBCCI systems with PI and PR controllers are modeled, simulated and the results are analyzed. The results indicate that the dynamic response is improved using PR controller. The proposed system has advantages like reduced THD, low settling time and steady state error [17]. In contrast to the quantity of switches utilized in the ordinary multilevel-inverter topologies, numerous topologies are with the count- falls exchanging gadgets [18, 12]. It is applicable that each switch delivers a misfortune in the framework amid ON and OFF tasks. On the off chance that the quantity of switching gadgets diminishes, the aggregate switching misfortunes in the inverter will likewise be radically decreased [23], [24]. The conduct of FLC is contrasted and the standard PI controller which is non-direct in nature. A PI controller is a generally accessible closed-loop input mechanism which is being utilized in significant applications to have a coveted and stable yield [25].

The above papers do not deal with combination of SEPIC-Re-boost converters for multiple sources at the input. This research suggests the combination of SEPIC and Re-boost converters. The above literature does not report current mode PR-PR controlled multi- input SEPIC- Re-boost system. This work proposes PR-PR controller for MISRCS.

2. SYSTEM DESCRIPTION

The Block-Diagram of Closed-two Loop-MCS with PR-Controller is exposed in Figure 1. Actual-speed is evaluated with the reference-speed and the ‘error is applied to PR. The output of PR is given to a comparator which evaluates saw-tooth with the output of PR. The PR system updates the width of pulse applied to the MOSFET of SEPIC& RBC.

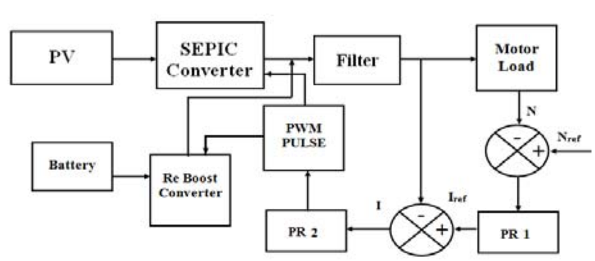

Figure 1. Block-diagram of closed-two Loop-MCS with PR-PR controller

3. SYSTEM ANALYSIS

Equivalent ‘L and C’ are expressed as follows:

$$L = \frac{V_i D}{f\,\Delta I} \quad (1)$$

$$C = \frac{D}{2fsR} \quad (2)$$

where, f_s- ‘Switching-frequency’
D- ‘Duty-ratio’
ΔI- ‘Ripple-current’
V_{i-} ‘Input-voltage’
R- ‘Load Resistance’
‘Output of PID’ is as follows:

$$V_o = K_1 e + K_2 \int e\, dt + K_3 de/dt \quad (3)$$

K_1- ‘Proportional-error-constant’
K_2- ‘Integral-error-constant’
K_{3-} ‘Derivative-error-constant’
‘Efficiency’ is calculated as follows:

$$\acute{\eta} = V_2 I_2 / V_1 I_1 \quad (4)$$

$V_{1\ -\ \text{‘Input}}$-Voltage’
V_2- ‘Output-Voltage’
I_1- ‘Input-Current’
I_2 – ‘Output-current’

4. RESULTS AND ANALYSIS

Multi-level inverter-system with multiple-input-sources of Open-loop system with disturbance is appeared in Figure 2. A step-change in input voltage is applied at the input.The input-voltage is delineated in Figure 3 and its value increases from 12 to 18V. The motor-speed is appeared in Figure 4 and its value is 800 RPM.The Torque-Response is appeared in Figure 5. The torque oscillates and settels at 1.9N-m.

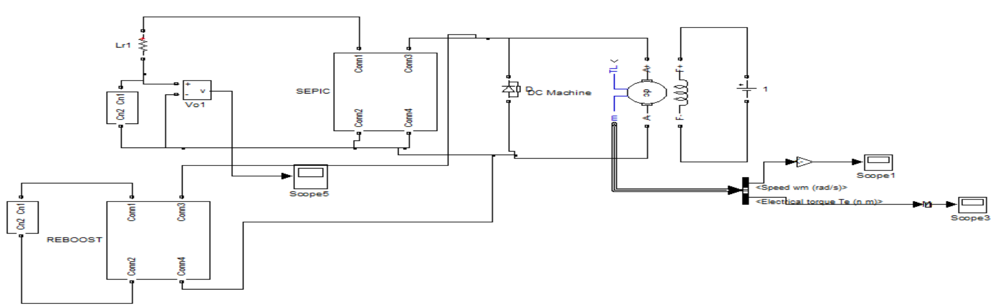

Figure 2. Open-loop-MCS system with step-rise in input voltage

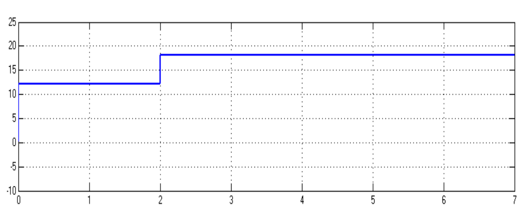

Figure 3. Input-voltage

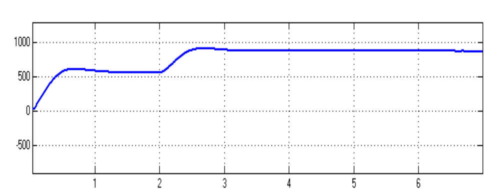

Figure 4. Motor-speed

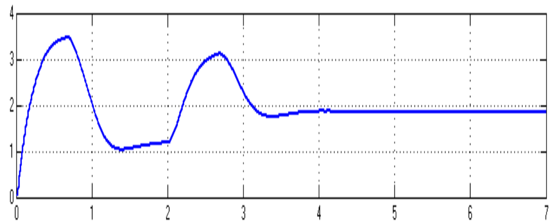

Figure 5. Torque-response

Multi level inverter system with multiple input sources of closed- loop-system with PI-PI controller is appeared in Figure 6.

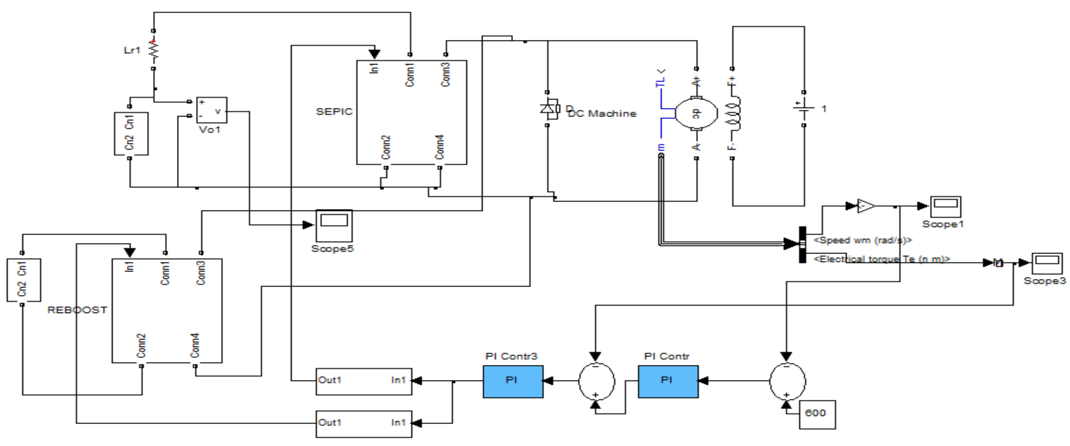

Figure 6. Closed-loop MCS with PI-PI controller

The input-voltage of MLIS-MIS is appeared in Figure 7 and its value 18 V. The Motor-speed of MLIS-MIS is appeared in Figure 8 and its value is 600 RPM. The Torque-Response of MLIS-MIS is appeared in Figure 9 and its value is 2.5 N-m. The Torque-Ripple of MLIS-MIS is appeared in Figure 10 and its value is 0.3 N-m.

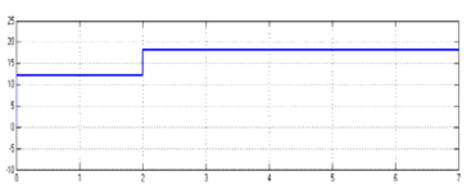

Figure 7. Input-voltage

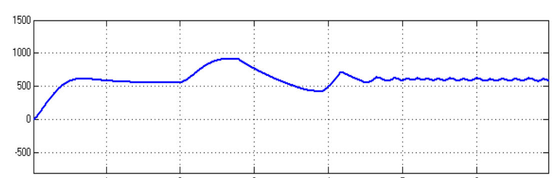

Figure 8. Motor-speeds

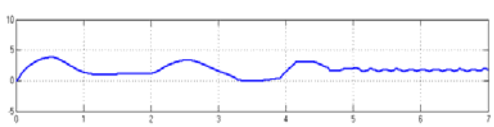

Figure 9. Torque response

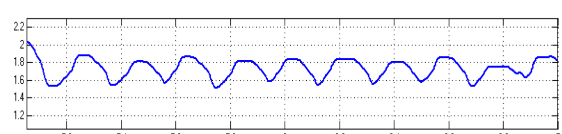

Figure 10. Torque-ripples

Multi level inverter system with multiple input sources of closed- loop-system with PR-PR controller is appeared in Figure 11. The input-voltage of MLIS-MIS is appeared in Figure 12 and its value 18 V. The Motor-speed of MLIS-MIS with PR-PR controller is appeared in Figure 13 and its value is 600 RPM. The Torque-Response of MLIS-MIS with PR-PR controller is appeared in Figure 14 and its value is 1.9 N-m. The Torque-Ripple of MLIS-MIS with PR-PR controller is appeared in Figure 15 and its value is 1.8 N-m.

The comparison of Time-domain-parameters is given in Table-1. By using-PR-PR-controller, the settling-time is decreased from 4.5 to 2.4 sec; the steady-state-error in speed is decreased from 6.3 to 3.8 Rpm ; the rise-time is reduced from 2.3 sec to 2.1 sec ; the peak-time is reduced from 2.7 to 2.6 seconds. Therefore the response with PR-PR controller is better-than-that of PI-PI controlled-MLIS-MIS system.

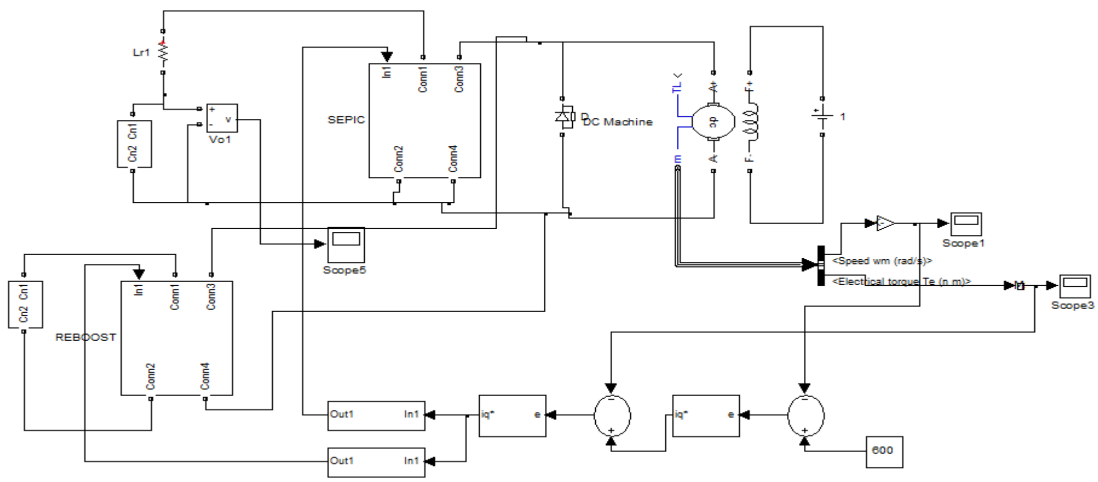

Figure 11. Closed-loop –MCS with PR-PR controller

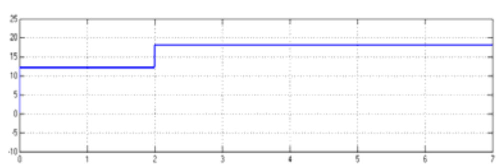

Figure 12. Input voltage

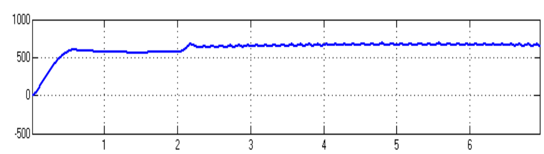

Figure 13. Motor speed with PR-PR controller

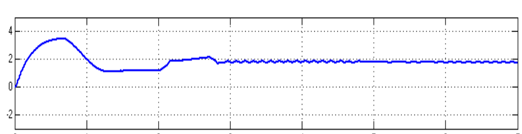

Figure 14. Torque response with PR-PR controller

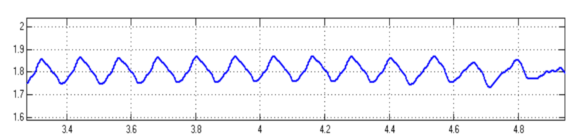

Figure 15. Torque-ripple with PR-PR controller

Table-1 Comparison of time domain parameters

Controllers	T_r (sec)	T_s (sec)	T_p (sec)	E_{ss} (Rpm)
PI	2.3	4.5	2.7	6.3
PR	2.1	2.4	2.3	3.8

5. HARDWARE RESULTS

Multi level inverter system with multiple input sources for hardware-snap shot is exposed in Figure 16. The Output-voltage of solar is appeared in Figure 17. The Output-voltage of battery is revealed in Figure 18. The output voltage of battery is free from ripple. The switching-pulses for Sepic and Re-boost converters are appeared in Figure 19. The output-voltage of Sepic& re-boost converter is revealed in Figure 20, and it is almost like pure DC.

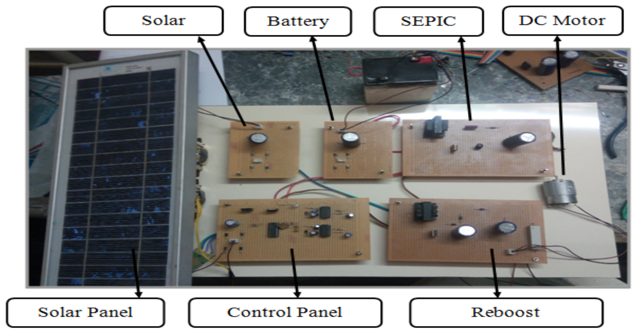

Figure 16. Hardware-Snap-Shot

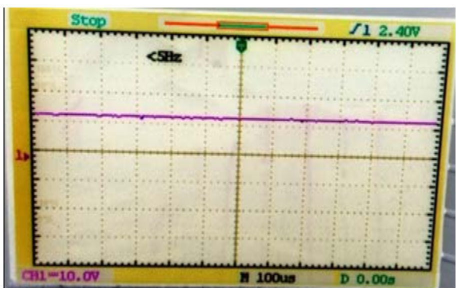

Figure 17. Output-voltage of Solar

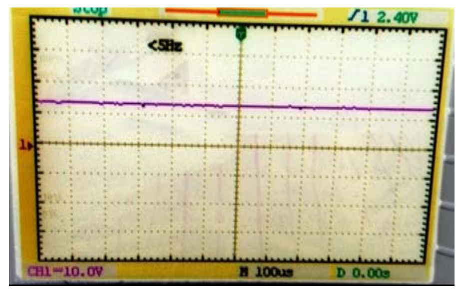

Figure 18. Output-voltage of battery

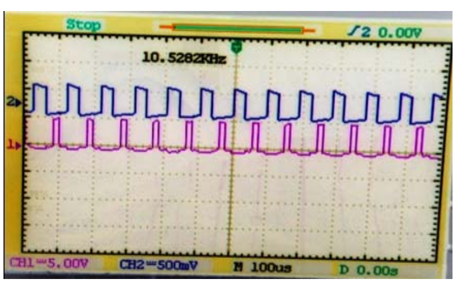

Figure 19. Switching-pulse for ‘sepic& re-boost-converter’

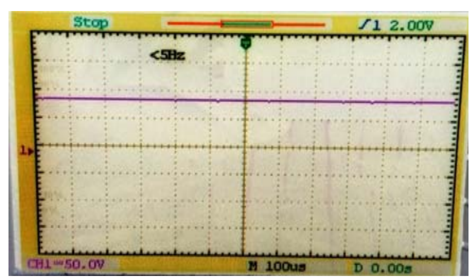

Figure 20. Output-voltage of sepic–re-boost-converter

6. CONCLUSION

The performance comparison of PI-PI and PR-PR controlled boost-converter and re-boost-converter is done in simulation using Simulink. Simulation-results are compared in terms of time domain parameters for speed. The results ensure that PR-PR based-Re-boost-converter produce better performance compared to the PI-PI controlled MCS. Prototype of MCS system is constructed and tested. The experimental-results are presented. The simulation-results indicated that the settling-time is as low as 2.6 sec using PR-PR. The steady-state-error in speed is 4.1Rpm using PR-PR. Therefore PR-PR controlled-MCS has better dynamic-response. The present-work deals with Closed-two loop-controlled-MCS with PI-PI and PR-PR controllers.

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