The Performance of DC motor using Improved Single-Stage Power Factor Correction Converter

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Abstract— **The power factor correction converters are used with either single stage or two stage topology. The two stage topology is commonly used but it will not produce the better output voltage than the single stage approach. To provide a better output voltage a new single stage three-level integrated ac–dc converter is presented. A single switch is used with two independent PID controllers. An input controller is used to perform power factor correction and the output controller is used to regulate the output voltage. This converter output is given to DC motor. The performance of the dc motor is obtained.**

Keywords— PID controller, DC-DC converter, single stage converter, Power factor correction.

I. INTRODUCTION

AC-DC converter plays an important role in power electronics. In order to get dc from the ac supply, the AC-DC converter is needed. There are many topologies available for high performance DC-DC power conversions. Among them, recent three level DC-DC converters are widely used for step-down DC-DC converter applications. Three level converters have more advantages such as wide voltage range, low voltage ripple and better efficiency.

Single Stage converters are widely used nowadays. The power factor correction is effective in these converters. These single stage converters are more efficient than two stage converters. Dylan Dah-Chuan Lu, *et.al.* presented their idea in converters a quasi-active power factor correction (PFC) scheme [1] and researchers like Gerry Moschopoulos, *et.al.* and Aslam Farhad *et.al.*also extended [1] their research in converter by implementing ideas such as removing harmonics by using PID controller in two stage converters [2][3]. Due to the drawbacks obtaining by implementing those ideas, to neglect that drawback they introduced new single-stage power factor correction (SSPFC) converter for the adapter application, which is composed of a flyback converter, novel single-stage high-power factor ac/dc converter with symmetrical topology, novel converter based on a quasi-active PFC scheme, flyback topology operating in discontinuous conduction mode (DCM) [4] to [6], [8]. Even though by using those techniques the performance of the converter is not increased efficiently. So Jung-Min Kwon, *et.al* and K.C.Dave, et.al.

Proposed new schemes like cost-effective plasma display panel (PDP) sustain power module and Ziegler Nichols method and loop shaping method in PI controller [10] [11]. due to those techniques the drawbacks in converters like presence of ripples and harmonic content not rectified properly. so researchers extended [10][11] ideas into several schemes like proposing AC–DC single-stage voltage-fed pulse width modulation(PWM) full-bridge converter , integrating a boost PFC converter with a two-switch clamped flyback converter into a single power stage circuit, fully integrated 3-level DC-DC converter, a hybrid of buck and switched-capacitor converters, implemented in 130 nm CMOS technology [13][14][15] . To neglect those drawbacks and increasing power efficiency, this paper is proposed. The main objectives of this paper are

- To improve the output voltage
- To regulate the dc bus voltage
- To increase the response time using controllers
- To drive the DC motor with the proposed converter.

Section II deals with the insight of block diagram and its explanation, where section III shows about the methodology and section IV gives detailed about results and discussion. Where section V gives conclusion about this paper and references gives information about references included.

II. SYSTEM ANALYSIS

A. *Closed loop system*

The AC supply is the readily available source, but there is a need of DC supply. The AC supply is converted into DC supply with the help of a diode bridge rectifier. The generated DC supply is filtered by the capacitor filter unit. This acts as the input to the three level DC-DC with input inductor which acting as a boost converter.

The use of a closed loop system helps to attain a better quality output with improved control features. A PID controller unit is chosen in order to realize the closed loop configuration. The voltage outputs from the proposed converter are fed back to the controller. The PID controller processes its available data, compares it with the preset reference value and calculates the deviation from the ideal working condition.

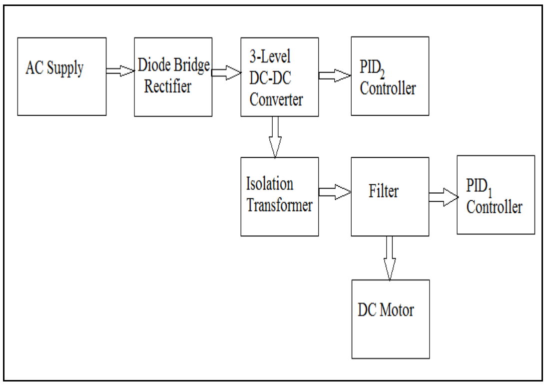

Fig. 1. Block Diagram

B. *PID controller*

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism. A PID controller calculates an error value as the difference between a measured process variable and a desired set point. PID controllers receive the voltage from three level DC-DC converter and from the isolation transformer. The output from PID controls the switching operation of the converter.

PID Control logic is widely used in the process control industry. PID controllers have traditionally been chosen by control system engineers due to their flexibility and reliability. A PID controller has proportional, integral and derivative terms that can be represented in transfer function is formed based on assumptions and system efficiency.

III. SYSTEM MODELLING

The proposed converter, which is shown in Fig.2, integrates an ac–dc boost PFC converter into a three-level dc–dc converter. The ac–dc boost section consists of an input diode bridge, boost inductor L1, boost diode D1, and switch S4, which is shared by the multilevel dc–dc section. When S4 is off, it means that no more energy can be captured by the boost inductor. In this case, diode D2 prevents input current from flowing to the midpoint of capacitors C1 and C2 and diode D1 conducts and helps to transfer the energy stored in the boost inductor Lin to the dc bus capacitor. Diode D3 bypasses D2 and makes a path for circulating current. Although there is only a single converter, it is operated with two independent controllers.

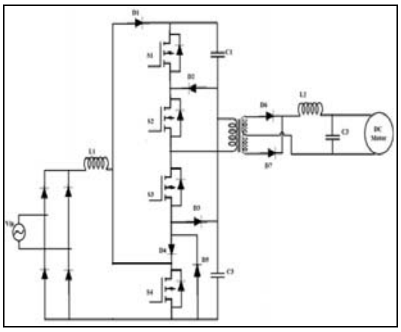

Fig .2. Figure showing Circuit Module
The value of inductors are taken from the reference[12]

A. *Controllers Operation*

One controller is used to perform PFC and regulate the voltage across the primary side dc-bus capacitors by sending appropriate gating signals to S4. The other controller is used to regulate the output voltage by sending appropriate gating signals to S1 to S4. It should be noted that the control of the input section is decoupled from the control of the dc–dc section and thus can be designed separately. The gating signal of S1, however, is dependent on that of S4, which is the output of the input controller. The gating signals for S2 and S3 are easier to generate as both switches are each ON for half a switching cycle, but are never ON at the same time.

TABLE 1. SWITCHING CHARACTERISTICS

S1	S2	S3	S4	Three level output
1	1	0	0	-V
1	1	0	1	-V
0	1	0	1	0
0	0	0	1	V
0	0	1	1	V
0	0	1	0	0
0	0	1	0	0
0	0	0	0	-V

B. MOSFET drivers

A gate driver is a power amplifier that accepts a low-power input from a controller IC and produces a high-current drive input for the gate of a high-power transistor such as an IGBT or power MOSFET. Gate drivers can be provided either on-chip or as a discrete module. In essence, a gate driver consists of a level shifter in combination with an amplifier. It is often stated that transistors such as MOSFETs with isolated gate electrodes can be driven without a power source, which is not correct. In contrast to bipolar transistors, MOSFETs do not require constant power input, as long as they are not being switched on or off. The isolated gate-electrode of the MOSFET forms a capacitor (gate capacitor), which must be charged or discharged each time when the MOSFET is switched on or off. As a transistor requires a particular gate voltage in order to switch on, the gate capacitor must be charged to at least the minimum required gate voltage for the transistor to be switched on.

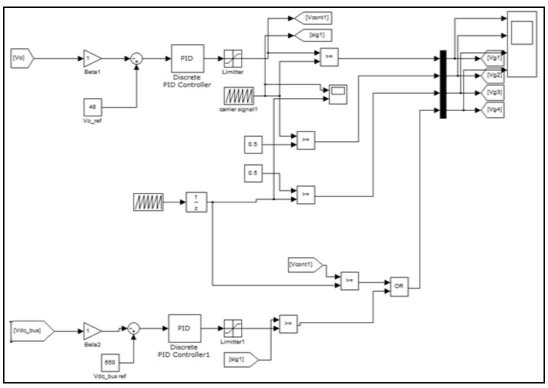

Fig 3. Simulation diagram of Controllers

Similarly, to switch the transistor off, this charge must be dissipated, i.e. the gate capacitor must be discharged. When a transistor is switched on or off, it does not immediately switch from a non-conducting to a conducting state; and may transiently support both a high voltage and conduct a high current.

Therefore, it is necessary to keep the switching time as short as possible, so as to minimize switching loss. Typical switching times are in the range of microseconds. Therefore, switching currents are often required in the range of several hundred mill amperes, or even in the range of amperes. For typical gate voltages of approximately (10-15) V, several watts of power may be required to drive the switch. When large currents are switched at high frequencies, multiple transistors are sometimes provided in parallel, so as to provide sufficiently high switching currents and switching power. The switching signal for a transistor is usually generated by a logic circuit or a microcontroller.

IV. RESULTS AND DISCUSSION

The proposed system was implemented using MATLAB Simulation. The proposed circuit was drawn in MATLAB and the output was obtained for the closed loop configuration using feedback control. The prescribed circuit consisted of four MOSFETS. Gating signals have to be provided to the MOSFETS for it to work.

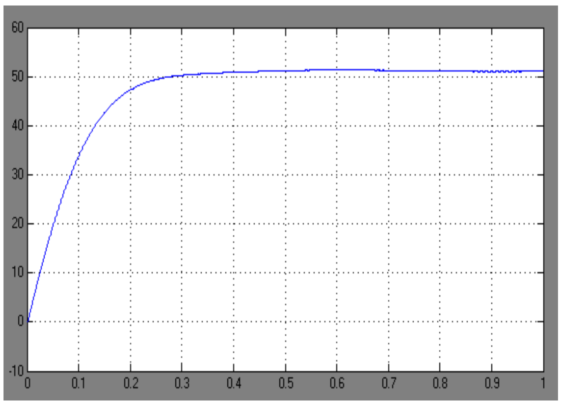

Fig 4. Figure showing output waveform converter

The gating signals of the switches are provided by feedback control method. The dc bus voltage and the output voltage are the inputs of the feedback loop. The voltage from the output is multiplied with a gain, the voltage output is compared with a reference voltage and the resulting error signal is fed to the PID controller. The output with peak value of 90V DC is obtained and attains the value of 50V which is used to drive the motor. The output voltage is given to the armature winding of the DC motor. The output voltage is measured using a voltage measurement unit connected across the load and the output voltage is displayed via a scope. The output voltage of the converter before the motor is connected to the converter is shown in Figure 4.

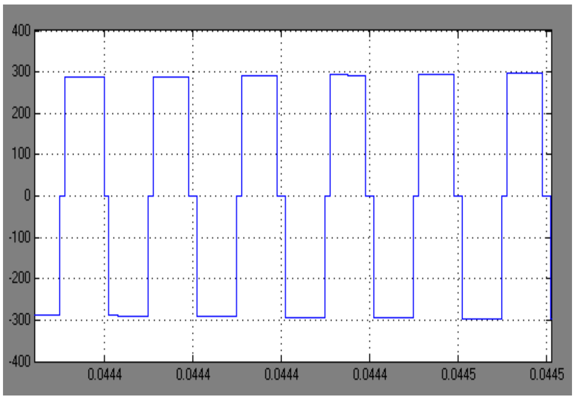

Fig 5. Figure showing Output of Three level Voltage

The bus voltage output should lies between 130-450V, because the wide bus voltage range makes most of the major components in the single-stage converter have a higher rating.

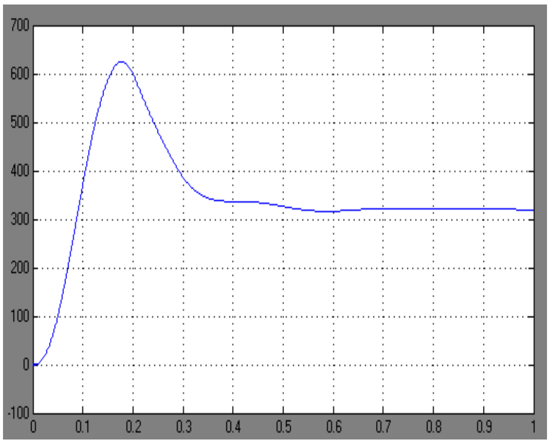

Fig 6. Speed waveform of the motor

The single stage three integrated AC-DC converter is fed to the DC motor. The proposed single stage converter produces the output voltage of 52V DC. This is given as input to the DC motor as armature voltage, the motor will run at 320rpm is shown in Figure 6. If the converter input is varied, the output voltage of the converter will be varied. This variable input is given to motor, then it will be driven variable speed.

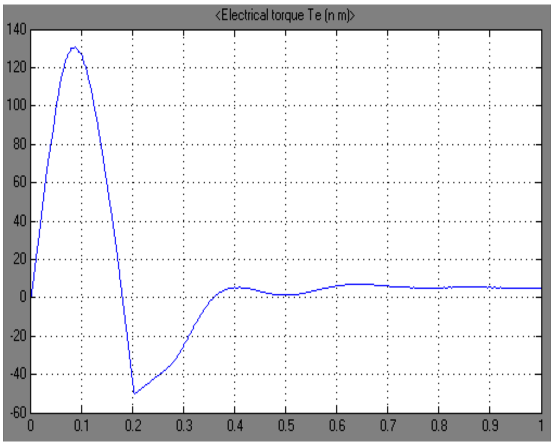

Fig 7. Torque output of the motor

The torque obtained from the motor after it is driven with the proposed converter is shown in Figure 7, the value of the obtained torque is 5N-m. This obtained torque is to start the DC motor.

V. CONCLUSION

The proposed Single stage three level integrated AC-DC converter fed DC motor drive involves the operation of input power factor correction, dc bus voltage regulation and improving the output voltage. This is a new multilevel single-stage ac–dc converter driving the DC motor. This converter is operated with two independent controllers. One of the controllers performs input PFC and other controller regulates the output voltage. The outstanding feature of this converter is that it combines the performance of two-stage converters with the reduction of cost of single-stage converters. This converter is fed to the DC motor.

The proposed converter is simulated with motor drive using MATLAB and the required output waveforms are obtained. The output voltage of the converter, the DC bus voltage of the converter, three level output voltage and the output voltages with motor drive, the speed and torque of the motor are obtained. In future it can be used with Fuzzy logic controller and the performance of the converter can be improved further.

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