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INTERNAL MODEL CONTROLLER BASED ISSBC DC TO DC CONVERTER FOR ELECTRICAL VEHICLE APPLICATIONS

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Abstract:

The most fundamental DC to DC converter, the ISSBC (interleaved soft switching boost converter), reduces ripple on both the input and output sides. An electrical power switch, a string of diodes, and a filter capacitor make up ISSBC converters. Designing a suitable control system is challenging due to the rise in nonlinear features and the quantity of energy storage elements. The transfers' forward and backward directions MATLAB SIMULINK is used to assess the relationship between the controlled parameter, voltage at output, and the manipulated parameter, duty cycle.. After that, the internal model controller (IMC) is created.

Key Words: Electrical power switch, diodes, and a filter capacitor, ISSBC converters

Introduction:

The ISSBC converter is a boost DC to DC converter with interleaving feature. ISSBC converters are commonly employed in low-power applications with well-defined size limits and a diverse variety of applications like photovoltaic and Electrical vehicle [1]. ISSBC converters are used in a variety of applications in addition to these. Small size and low power handling capability characterize ISSBC converters, which result in high power loss and low efficiency[2].

Non linear components such as power electronic switches and coupling diodes are used in ISSBC converters. The ISSBC converter is a nonlinear system due to the use of a power electronic switch and diodes[3]. The claimed to be practical nonlinearity contributes to the ISSBC converter's overall nonlinear nature, posing issues when creating a suitable control system. [4].

According to the literature review, traditionally used controllers are the PI and PID controllers. attempted repeatedly on the ISSBC converter. Later, soft computing control methods like Fuzzy Logic Controllers (FLC) and Artificial Neural Networks (ANN) (FLC) [5,6] were developed and put into use.

PID controllers were utilized for the operation of the ISSBC converter have also been used for tuning thanks to developments in Techniques for heuristic search algorithms, specifically the Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) [7,8]. Improvements in semiconductor technology and contributions to the development are responsible for the success of the ISSBC converters and their current position in the application field. The ISSBC converters can now be operated at switching frequencies of several hundred kilo hertz An IMC based controller is used for controlling the duty cycle of the proposed converter.

ISSBC converter

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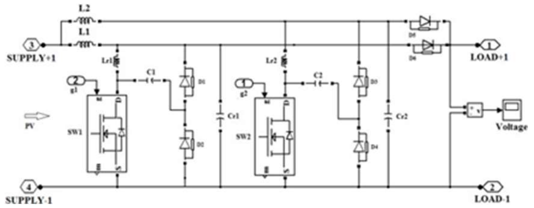

Figure 1 Circuit diagram of ISSBC converter

We have adopted two control systems, one of which uses the conventional PI controller and the other of which is the internal model controller. system with closed loop controls is crucial. Normally, the DC source, inductor, and one switch are connected in series to control the ISSBC converter. [12]. Applying a duty cycle to the power control switch can be changed to alter the output voltage. The converter typically has three regions of disturbance and one degree of control. The disturbances induced by parametric changes introduced by circuit components or parts as a result of heating and ageing include source side disturbances, load side disturbances, and disturbances caused by trouble. The controller strives to keep electricity at the output desired constant value under these three disturbances.

The ISSBC converters' wide array of uses includes charging devices for cameras, laptops, and cell phones. Even though power handling capacity is often low, smaller size and lighter weight are the main requirements. High switching frequency is therefore used. The ISSBC converter's efficiency is poor due to the usage of high frequency switching. The ISSBC converter is very nonlinear because it is made up of nonlinear components like switches and diodes , because of practical nonlinearity. As a result, the PI controller's traditional tuning process becomes quite challenging.

PI Controller

The ISSBC converter is subject to disturbances on the source and load sides, as was previously stated. The controller's primary responsibility is to keep the voltage produced stable and within the specified range. It is the PI controller that most basic of the controllers since it is simple to build in an embedded system utilizing a microcontroller with integrated ADCs and PWM operations. A PI controller adjustment is required. Tuning the controller involves choosing the proper values for Ki, the integral constant, and Kp, the proportional constant. PI controllers are often calibrated using the Zeigler Nicholas method.

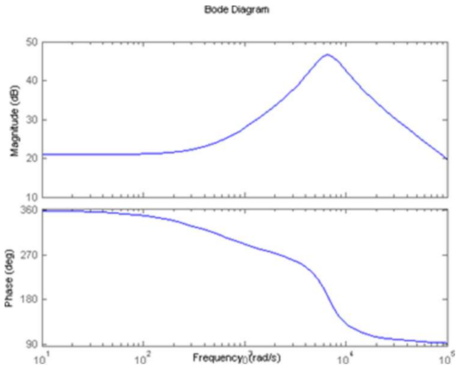

Figure 2. Bode plot for PI controller (ISE) using PI method

Internal Model Controller

Using both the physical system and the transfer operations of the vehicle's forward and reverse of the controlled plant, internal model control is a sort of direct feedback control [13]. To simulate the actual physical system, Matlab software with SIMULINK uses a circuit model made up of components from the MATLAB SIMULINK library. Figure 4 displays the IMC's block diagram.

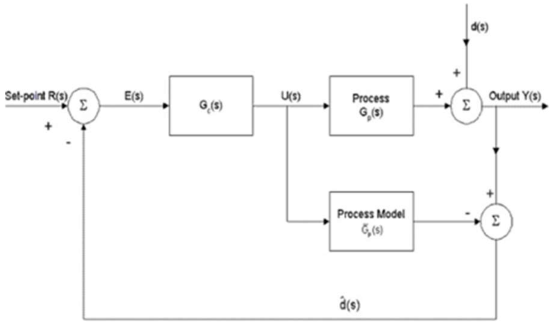

Figure 4. Block diagram of the IMC

The system's forward and reverse transfer mechanisms in command must first be assessed prior to designing the IMC. The ISSBC converter can be said to have two modes of operation based on the layout of its circuit. Closed is the power control switch. in the first mode. principal current dramatically rises during this time. As a result, the circuit experiences a reverse voltage, and the output side of the circuit is considered to be open.

The power control switch is left unlocked in the second mode of operation, allowing a forward voltage to be induced to power the converter circuit. For the bulk of the circuit in the first mode, the primary inductor and leakage inductance are linked across the DC main power source. As a result, every element in the circuit is linear.

The switch on the source side is open in the second operating mode. The only components of the circuit remaining required when the diode is closed are the inductance, output capacitor, and load resistor. As a result, the circuit is entirely made up of linear components in both modes. The switch on the source side is open in the second operating mode. The output and inductance The only components of the circuit that are still required with the diode closed are the capacitor and the load resistor. As a result, the circuit is entirely made up of linear components in both modes. This is only plausible in an ideal circuit with no losses and ideal switches and diodes.

Use the MATLAB functions "id data" and "Tfest" to gain access to the plant's transfer function in this instance, the ISSBC converter. Because The controlled variable is the output voltage, and the manipulated variable is the duty cycle. when operating the ISSBC converter, a transfer function between the two variables is created. A sufficient amount of time is spent operating the system for it to achieve equilibrium at the specified 240 V DC voltage level and 0.6 duty ratio.
S = id data(V_out, duty_cycle, 0.00001) where 0.0001 is the sampling period.
Stf = tfest(S,2)

where 2 denotes the transfer function's necessary order.

The obtained transfer function was
G(s) = $1.531e03+7.15e05s$
$s2+546.2s+1.41e04$

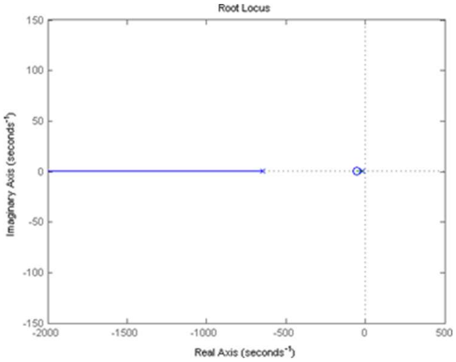

Figure 5 Root locus of forward transfer function

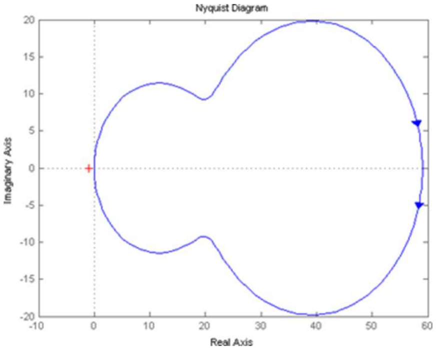

Figure 6 Nyquist plot of forward transfer function

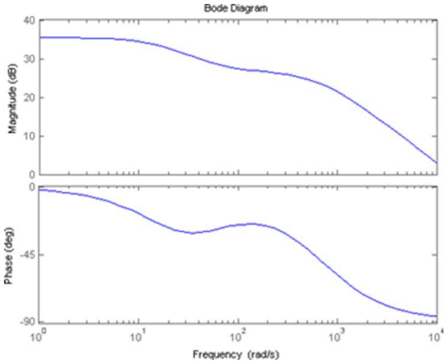

Figure 7 Bode plot of forward transfer function

The identical set of data for "Vout" and "duty" were used to build the reverse transfer function in the same manner as the forward transfer function. The order of the Vout and duty components is only altered by the call to the 'iddata' function, as indicated.
SR= iddata (duty_cycle,V_out, 0.0001).

The reverse transfer function is as follows.
R(s) = 0.18126s+17.49
s2+75.18s+755.3 (2)

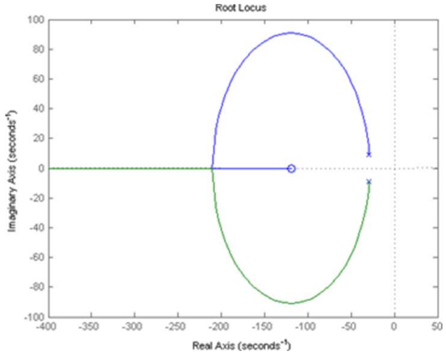

Figure 8 Root locus of reverse transfer function

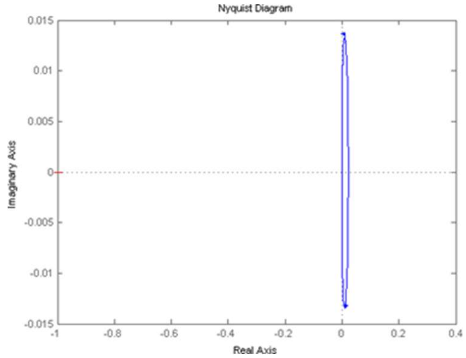

Figure 9 Nyquist plot of reverse transfer function

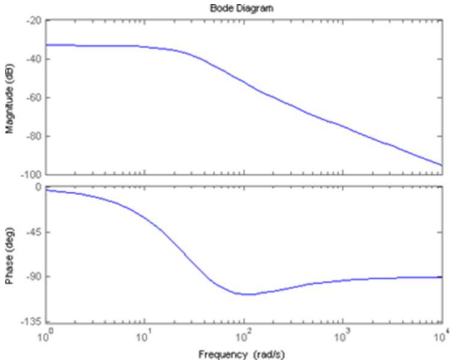

Figure 10 bode plot of reverse transfer function

The stability of the forward and reverse transfer functions is individually assessed using the MATLAB functions rlocus, nyquist, and bode. Figures 3–8 illustrate the outcomes of the rlocus, nyquist, and bode operations carried out on the forward and reverse transfer functions, and they don't reveal any signs of instability. The idea that an IMC can use the under control system without encountering instability is supported by these results. After it was established that the forward and reverse transfer functions were both independently stable, these two transfer functions were added to the IMC, as shown by the block diagram in figure 4.

Simulation of MATLAB SIMULINK

The PI controller with ISSBC converter and the sub systems of the ISSBC converter with the IMC are shown in figures 11-12.

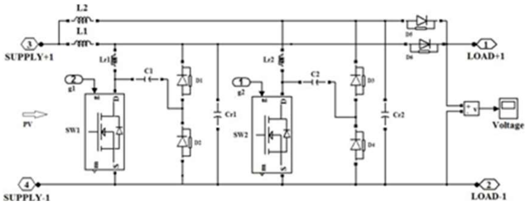

Figure 11 Simulink diagram of ISSBC converter tuned with PI

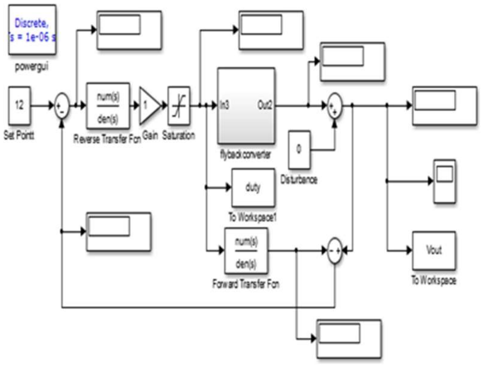

Figure 12 Simulink diagram of ISSBC converter tuned IMC

The switch is PWM-operated with a 20 KHz carrier in both control schemes. The carrier, a train of triangle pulses, is compared to a reference signal generated by the PI controller or, in the case of the IMC, the reverse transfer function. Two different disturbances were produced in order to compare the performance of the two control systems. The voltage of the source was raised from 220 to 260 volts. The resistance of the load was decreased from 36 to 24 ohms. At the output DC voltage, both control systems displayed the integrated square error, peak overshoot, steady state error, and ripple contents.

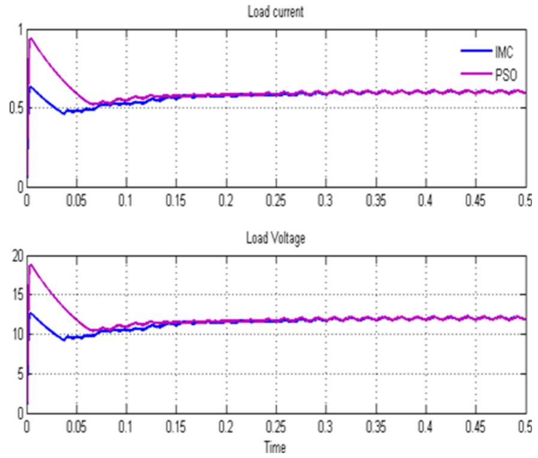

Figure 14 Simulink diagram of ISSBC converter tuned IMC

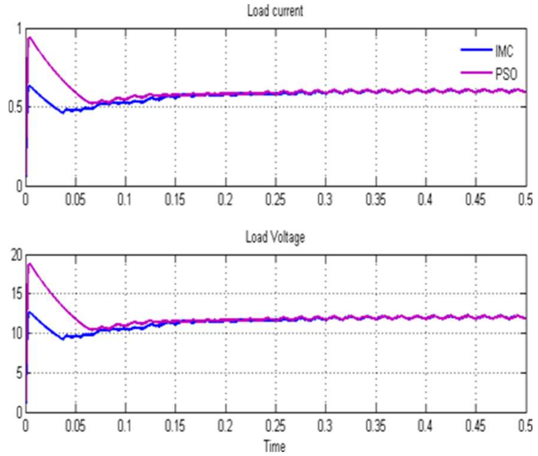

Figure 14 Simulink diagram of ISSBC converter tuned IMC Table 1 Comparison of controllers

Controller	Steady State Error	Peak Over Shoot	Integral Square Error	Settling Time
IMC	0.13	17.2	123.1	0.19 sec
PI	0. 20	14.2	132.2	0.25 sec

Conclusion

A Internal model controller and PI controller for the operation of the ISSBC converter suitable for low power applications have been created in this study using a step-by-step process. Simulations based on MATLAB SIMULINK have been used to validate the proposed system. The IMC has been proven to be superior to the PI controller in terms of performance. It was suggested that we evaluate the results of the IMC-based control system to that of a well tuned PI controller, and for that we employed the PI controller. The simulation and experimental verification results reveal that the IMC outperforms the PI controller, but the PI controller is still appropriate.

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