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AN INTELLIGENT CONTROL TECHNIQUE ANALYSIS FOR SENSORLESS PREDICTIVE CURRENT CONTROLLED DC–DC CONVERTER

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ABSTRACT

For a sensorless predictive current controlled boost dc–dc converter, its small-signal model that contains a number of parasitic parameters, is derived in this paper. This model indicates that the type of system becomes type 0 even with the correction of voltage loop proportional–integral controller, leading to the existence of output voltage steady-state error. Then a self-correction differential current observer (SDCO) is proposed to eliminate this steady-state error and gain high transient response speed. The self-correction part of the SDCO makes the system become type 1 to achieve no steady-state error for output voltage, whereas the differential part can guarantee that the intermediate calculation results do not overflow. By carrying out a series of simulation verifications, further investigation proves that the proposed algorithm has good robustness. A digital current-mode controller for dc-dc converters is introduced.The current control mode proposed current observer and PCC algorithm. It achieves the highest observation accuracy by compensating for all the known parasitic parameter. By employing the optimal current observer-based predictive current controller, a boost converter is implemented. The current-mode loop is sensorless, relying on constants and internal loop states. Fast current-mode control mechanism is implemented. This control scheme is that it facilitates the application of a low resolution PWM.

I.INTRODUCTION

In recent years, predictive current control (PCC) is a digital controlled DC-DC converters in continuous current mode (CCM) and it is a control mechanism. Therefore, it has been extensively studied by many researchers investigated a high performance PCC based on dead-beat control strategy, which shows a great advantage of low calculation complexity. However, the response is quite slow due to its current error elimination once every four switching cycles. A fast response PCC strategy is proposed by [2], whereby the disturbance of the inductance current can be eliminated in two switching cycles, whether in the valley, peak or average current control modes. Many PCC strategies have been proposed recently, but all the Strategies need to sample the inductor current using a current sensor. In current control mode, the compensation circuit slope is necessary to maintain system stability, when the pulse width modulation (PWM) duty ratio is higher than 50% [9]. In PCC mode, the next switching of the duty ratio can be calculated and next switching cycle of the inductor current can be predicted according to the reference current and predicted current. The precise current sampling is necessary for PCC of a boost converter system. The current sampling three types are shunt resistor, current mirror, and the last one is Hall

current sensor. The last one is the most accurate, but the Hall current sensors cost is relatively high, and itreduces system reliability. The sensorless current control should be estimated current by using current observer. The Fuzzy logic controller can be used in sensorless current control. The input voltage of the system is 12V

VOLUME-2 ISSUE-3
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and the output voltage is boosted 48V by using boost converter. The fuzzy controller should be used get a stable output voltage. The pulse width modulation technique would be used. This technique can be used to give a pulse signal to drive circuit.The aim of this research is mainly to eliminate the output voltage steady state error without using current sensor. The main objectives of this research can be summarized as:

1. To design and implement battery charger application, which are simple, reliable, low cost and high efficiency.

2. To predictive peak current control mode using Fuzzy controller.

IN RECENT years, the current mode controlled dc–dc converter has become a hot research topic [1]–[6]. Compared with voltage mode control, it has higher response speed and larger loop gain bandwidth. However, the extra current detecting module, which includes the current sensor, the voltage level shifting circuit, and the analog-to-digital converter (ADC), brings extra cost and unreliability. Thus, the sensorless current controlled dc–dc converter, which acts in current control mode with all the aforementioned advantages but without needing a current detecting module, has got great potentials in both academic and industrial applications. As an advanced current control strategy, the predictive current control (PCC) has the characteristics of high robustness and high response speed. It can be combined with the current observer to realize sensorless PCC (SPCC). Both the PCC and current observer technologies have been widely investigated. For the PCC, an algorithm was investigated in [7] to eliminate the inductor current disturbance in one switching cycle in peak, average, and valley current control modes. However, in order to maintain the current control loop stability, the specific combination of current control mode with pulsewidth modulation (PWM) modulation scheme should be obeyed, and it restrains the flexibility of system design. Lai and Yeh further investigated PCC-based peak current mode control in [8]. The effectiveness to eliminate the disturbance in limit cycle by PCC with leadingedge PWM modulation scheme was verified by theoretical derivation. Then, in [9], Lai *et al.* proposed a family of PCC methods to adapt leading-edge, trailing-edge, and triangular modulation schemes under boundary current mode control.

Although the zero-current detection and the high-frequency ADC can be eliminated from the system, an additional ADC is required for online inductance tuning. All the aforementioned PCC research work have already built solid basement for the research on SPCC.

II.BLOCK DIAGRAM

DC source is given to boost inductor to boost the voltage and the boosted voltage is filtered using filter. The input voltage and output voltage feedback is calculated using current calculation block and it is compared with the reference value which we set already. After that the output is given to fuzzy controller. This fuzzy controller is used to control the Gate driver circuit for driving the switches. This process is continued up to getting the correct peak current value. The input voltage of the converter is 12V and get the output voltage is 48V by using boost converter. It consists of the following sections are DC-DC converter, Fuzzy controller, and PWM driver circuit.The Proposed block diagram as shown in figure 1.

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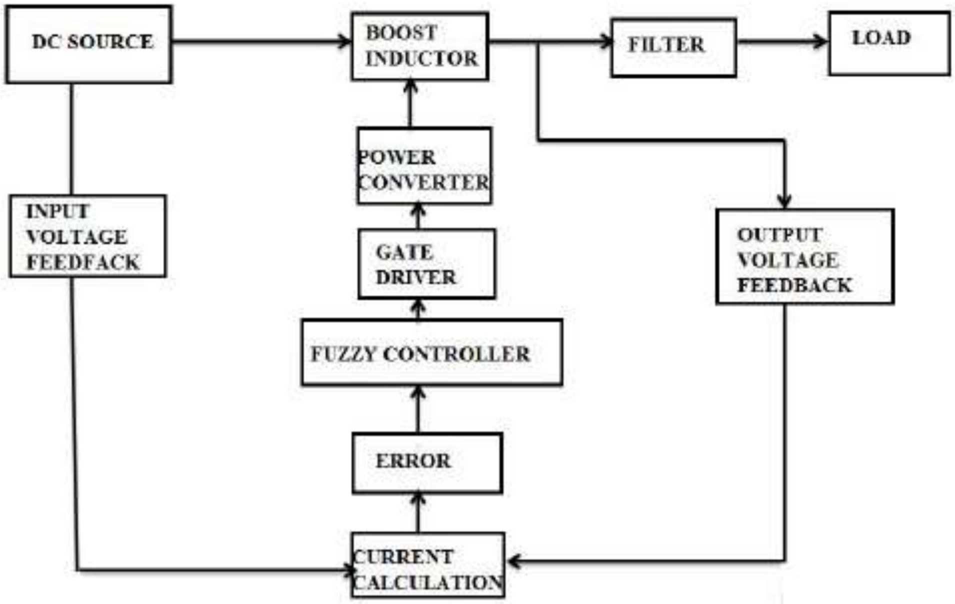

Fig.1. Block diagram forproposed system

A. Boost converter

A Boost Converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. It is a class of Switching-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple.

B. Fuzzy controller

It can be controlled one or more than one inputs and outputs are controlled. It can be implemented in both linear and

non-linear system.Fuzzy Logic provides a more efficient and resourceful way to solve Control Systems.Fuzzy logic

provides an alternative way to represent linguistic and subjective attributes of the real world in computing.It is able to be applied to control systems and other applications in order to improve the efficiency and simplicity of the design process. This controller must be used in more membership function. Here, mamdani Fuzzy interference system (FIS) shown in figure 2.

VOLUME-2 ISSUE-3
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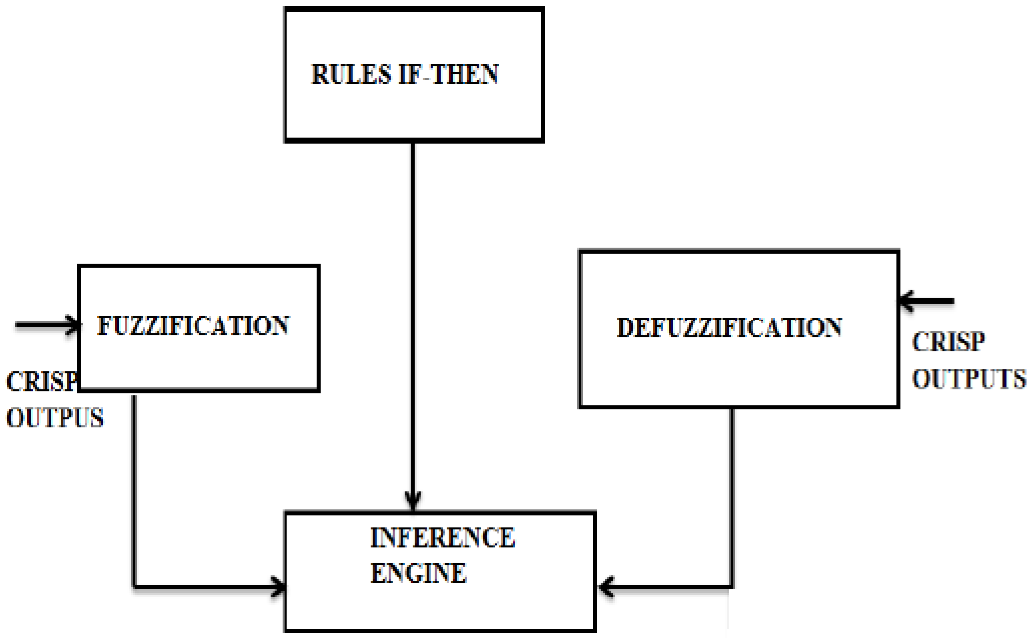

Fig.2. Basic diagram for Fuzzy controller

III. SENSORLESS PEAK CURRENT CONTROL

For PCC controllers with the basic current observer, the observed current will diverge due to the forward voltage of the diode and the parasitic resistors in the converter. More importantly, the divergence further induces steady state errors in the output voltage. The difference leads to the need for different mathematical modelling and controller optimization methods. By employing compensations for both the observed current and the sampled voltage, the CO-based PCC controller converges the observed current to the valley value of the inductor current, and eliminates the steady state error of the output voltage. The boost DC-DC converter with the current observer based PCC controller shown in figure 3. The input and output voltages are deduced inductor current and PWM duty cycle. It consists of two control loops.

The outer loop can be used Fuzzy control to control the voltage control loop. The inner loop used sensorless predictive current control mode to control the current control loop. Working in continuous current mode (CCM), without consideration of the parasitic parameters of inductor L and output capacitor *C*, using average inductor current

$$\frac{di_L(t)}{dt} = \frac{V_{IN}(t)}{L} - \frac{(1-D)V_o(t)}{L} \quad (1)$$

$$\frac{dV_o(t)}{dt} = \frac{(1-D)i_L(t)}{C} - \frac{V_o(t)}{RC} \quad (2)$$

VOLUME-2 ISSUE-3
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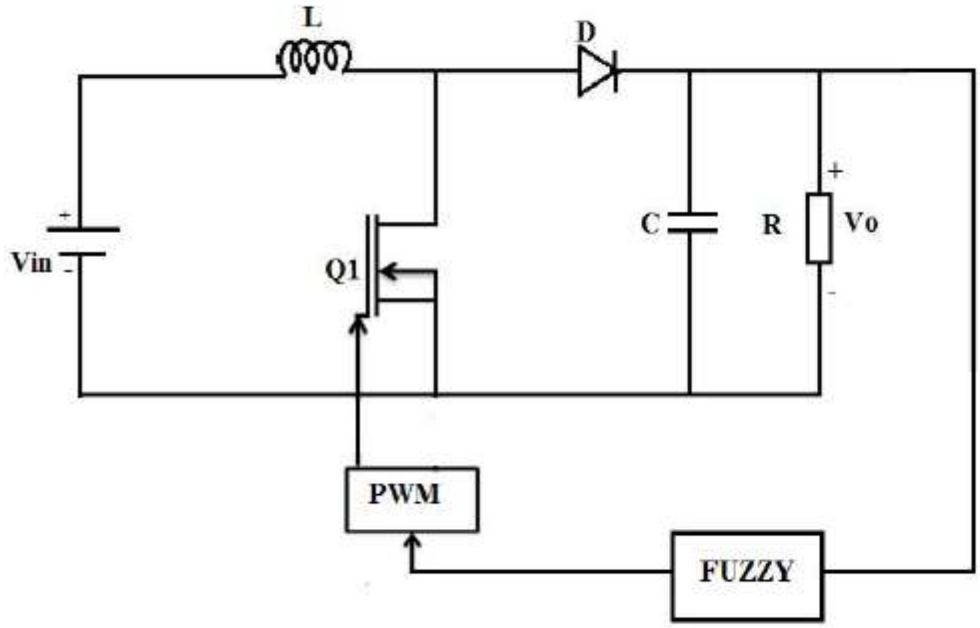

Fig. 5. Boost DC-DC converter with the fuzzy controller

Output voltage steady state error

For the PCC controller with the basic CO, the observed current will diverge due to the diode forward voltage and the parasitic resistors in the converter. The divergence of the observed current degrades the reliability of the converter, and will cause the steady state errors in the output voltage. In the following section, the relationship among the parasitic parameters, the convergence of the observed current and the steady state error of the output voltage will be studied in detail. For a current-mode-controlled boost converter with a current sensor, the voltage loop FUZZY controller is able to eliminate ΔVo, which is the steady-state error of the output voltage, by providing a pole at the origin. When there is no pole at the origin in the open-loop transfer function, the integration effect of the FUZZY controller is nullified, and hence, the output voltage may have a steady-state error.

CONCLUSION

The basic cause of output voltage steady-state error in a sensorless current controlled boost converter has been established in theory. On this basis, the system small-signal model, including the parasitic parameters, is constructed and analyzed. Then an SCDO is proposed. Simulation shows that the proposed algorithm is very robust. In addition, its computational complexity is low and easy to implement.With the proposed algorithm, the system ultimately achieves no voltage steady-state error with good transient performance despite parasitic parameters variation. Experimental results show that the control algorithm proposed in this paper is accurate and effective and has a good theoretical and practical application potential.

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VOLUME-2 ISSUE-3
ISSN : 2799-18

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