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Design and Implmentation of Bi-Directional Power Converter for Electric Bike with Charging Feature

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Abstract:

This paper introduces a bi-directional converter connected in electric bicycle. The fundamental structure is a course buck-boost converter, which exchanges the vitality put away in battery for driving engine, and can reuse the vitality came about because of the back electromotive force (BEMF) to charge battery by changing the task mode. besides, the proposed converter can likewise fill in as a charger by interfacing with AC line specifically. Additionally, the single-chip DSP TMS320F2812 is embraced as a control center to deal with the exchanging practices of every mode and to identify the battery limit. In this paper, the identical models of every mode and finish plan contemplations are altogether point by point. All the test comes about are utilized to exhibit the attainability.

INTRODUCTION

As of late, keeping in mind the end goal to conform to the strategies of vitality sparing, carbon decrease, and natural rotection, the greater part of the electric types of gear and energies are asked for to fulfill the green request. Be that as it may, enormous fuel oil vehicles result in genuine air contamination and demolition condition. In this manner, the advancement of the electric vehicles (EV) or the half and half electric vehicles (HEV) are getting to be imperative approaches in numerous nations. The auxiliary batteries are the principle vitality wellsprings of the EV. Along these lines, vitality administration is the most critical key factor in EV or HEV outline. These days, bidirectional converter connected in electric vehicles can give vitality put away in battery to driving engine and offer battery charging or vitality recuperation. Numerous propelled strategies, inquire about outcomes or control methodology identified with the bi-directional converter are investigated in progression. In reference [1], the power administration and circuit topologies of single-stage and multi-stage bidirectional converters including non-confined write and detached compose are altogether nitty gritty. The non-confined converters can be classified into: buck, boost, and buck-boost writes, which are minimal effort, reduced size, without transformer, and simple to control due to having shared conviction. Be that as it may, a transformer is as yet basic in view of security contemplations, e.g. the voltage proportion wager ween the essential side and auxiliary side is sufficiently high or these two sides can't be grounded together. In addition, flyback type bi-directional converter is usually utilized as a part of numerous related applications [2]. The buck-boost write bidirectional converters not just have venture down and advance up capacities, yet additionally can control the vitality stream to accomplish vitality recuperation, which is likewise appropriate for some, EV plan [3-6]. In addition, there are a wide range of control techniques are proposed to control and deal with the buck-boost converter to enhance the framework productivity [7-8].

Directly, to give high power and high current yield attributes at moment for electric vehicles, numerous sorts of auxiliary batteries are fabricated. Among the current power batteries, lithium batteries have higher vitality thickness, lighter weight, and reduced size. Be that as it may, the lithium battery is as yet appropriate for bring down power applications because of mind-boggling expense, temperature rise, and lower yield current at moment. Then again, the lead-corrosive battery can offer higher quick yield present, minimal effort, and more wellbeing, despite the fact that its volume and weight are bad for highlight configuration incline.

Also, the electric limit of the battery will impact the continuance of electric vehicles. For the most part, a vitality administration component is critical for enhancing framework proficiency and broadening continuance. Along these lines, well plan charging methodologies consolidating estimation approaches for observing battery limit are enter f15eatures in vitality administration of EV or HEV. There are numerous normal utilized techniques with respect to battery charging, for example, steady voltage charging, consistent current charging, and heartbeat charging [9, 10]. Moreover, numerous current strategies of condition of charge (SOC) estimation are additionally proposed, for example, open-circuit voltage method [11-13], coulometric estimation strategy [11], impedance estimation technique [11, 14].

In this paper, the proposed bi-directional converter not just exchanges the vitality put away in battery for driving engine, yet additionally reuses the vitality came about because of the back electromotive force (BEMF) to charge battery. Additionally, the charger having SOC estimation work is likewise coordinated in the proposed bidirectional converter to conservative size and to lessen cost.

SYSTEM TOPOLOGY AND ANALYSIS OF EACH MODE

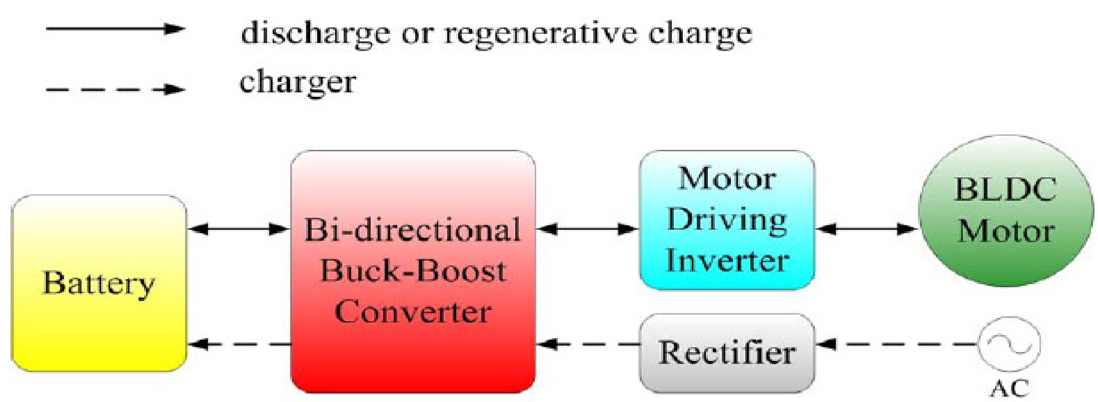

Figure 1: Block Diagram

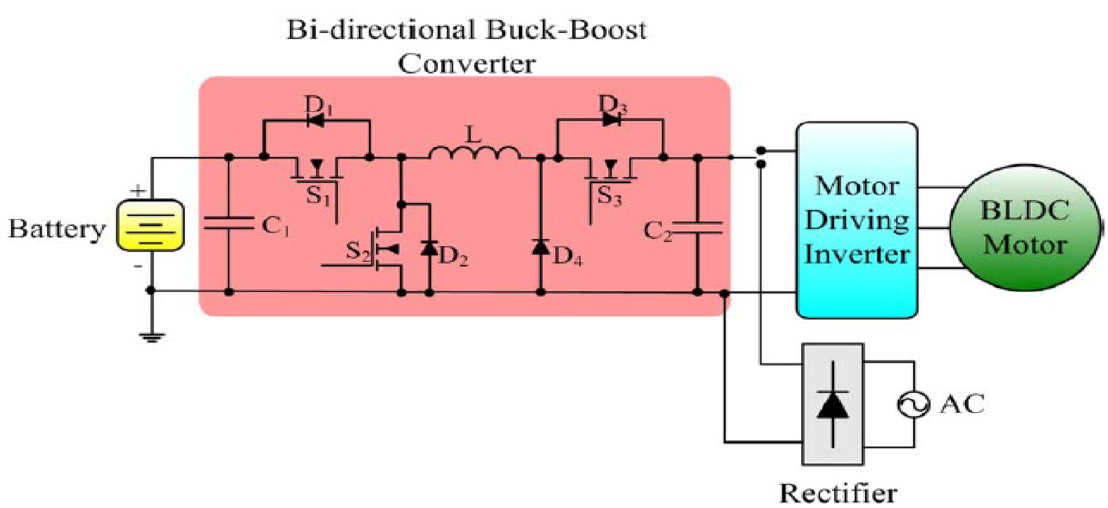

Figure 2: bi directional Buck Boost Converter

Fig. 1 demonstrates the framework square chart of the proposed bidirectional converter, which is utilized to interface a battery, an engine driving inverter and a rectifier. With this framework, the battery can give vitality to engine, and the BEMF created from engine can be moved to store in the battery. Plus, the bidirectional converter is likewise filled in as a charger, which changed over the amended voltage from AC source to charge the battery.

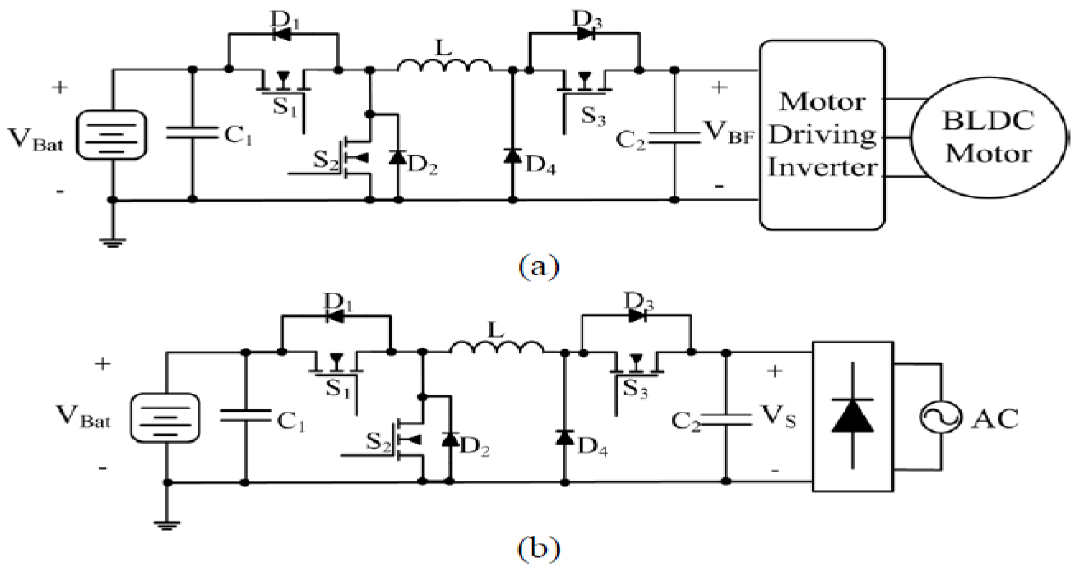

Figure 3: Equalent circuit for buck and boost converter a) motor driving mode b) Battery Charging Mode

Buck-boost converter is appeared as Fig. 2. The fundamental circuit structure of the proposed framework comprises of three switches and four diodes. Different capacities including bidirectional power stream control can be exchanged under various working mode. Fig. 3a demonstrates the comparable circuit in engine driving mode or vitality recuperation mode. In battery charging mode, the identical circuit is delineated as Fig. 3b. Every one of the working mode and the related numerical models are depicted and determined, separately, in the accompanying.

Mode I: Motor driving mode

Buck-boost converter is showed up as Fig. 2. The crucial circuit structure of the proposed system involves three switches and four diodes. Diverse limits including bidirectional power stream control can be traded under different working mode. Fig. 3a shows the similar circuit in motor driving mode or essentialness recovery mode. In battery charging mode, the indistinguishable circuit is depicted as Fig. 3b. Each one of the working mode the related numerical models are portrayed and decided, independently, in the going with.

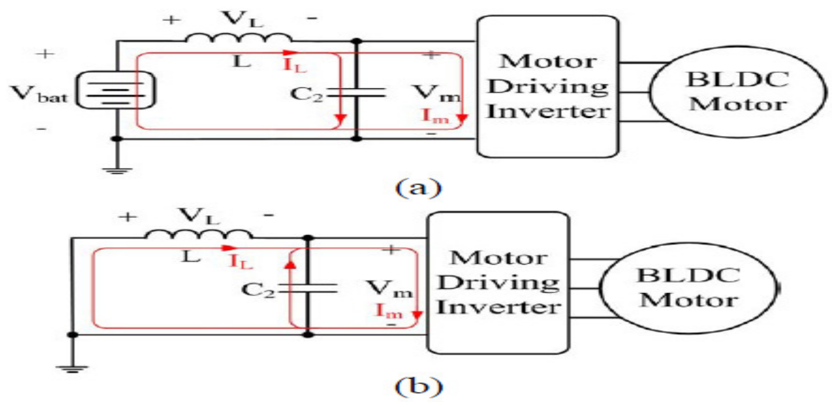

Figure 4 Current path of motor driving mode a) s1 on b) s1 off

Mode II: Battery charging mode

The comparable circuit of this mode is appeared as Fig. 3b, where the switch S1, S2, diode D2 and diode D3 keeps off, diode D1 is turned on consistently. The yield of AC source is corrected and sifted to give a consistent voltage source, at that point, we can venture down the dc voltage to charge battery by exchanging the switch S3 and diode D4. In spite of the fact that transforming the working heading of the proposed framework, it is likewise carries on as a buck converter with two states in a working period. In the principal express, the switch S3 is on and the freewheeling diode D4 is off, both the inductor L and capacitor C1 stockpiling vitality from the DC source, while the battery is additionally charged. In the wake of disentangling, the equal circuit can be delineated as appeared in Fig. 5a. At the following state, the turn S3 is killed and the freewheeling diode D4 is on, at that point the vitality put away in the inductor L and capacitor C1 will be utilized to charge the battery. The disentangled proportionate circuit is appeared as Fig. 5b.

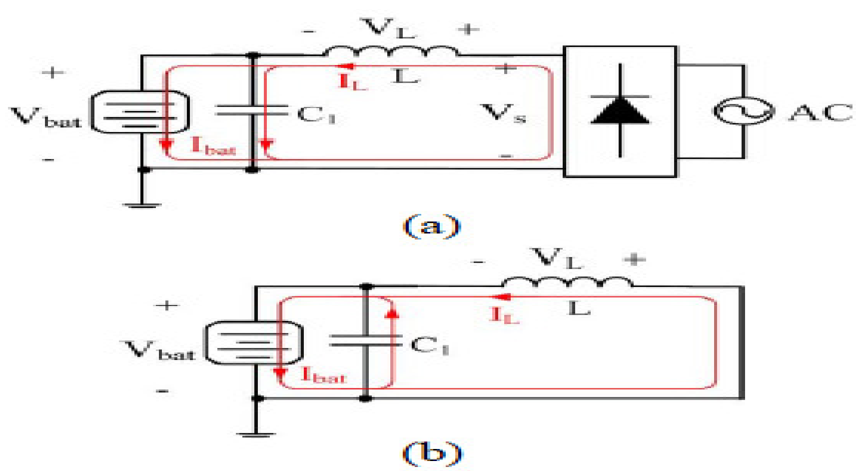

Figure 5 simplified circuit for battery charging a)s3 on b) s3 off

CONTROL STRATEGY

A solitary chip DSP TMS320F2812 gave by Texas Instruments was utilized to actualize a control center for the proposed bi-directional converter. This DSP has occasion chief and implanted control highlights, along these lines enabling a modern control calculation to be actualized for control changing over frameworks. There are numerous working mode in the proposed framework, including driving of BLDC, charging of battery, and location of the battery limit. Additionally, numerical activity ability and multi-I/O highlights are required. Along these lines, the DSP controller is utilized to diminish segment checks, to streamline controller structure, and enhance the framework unwavering quality. Fig. 6 demonstrates the stream diagram of the proposed framework, which is isolated into engine driving mode and battery charging mode.

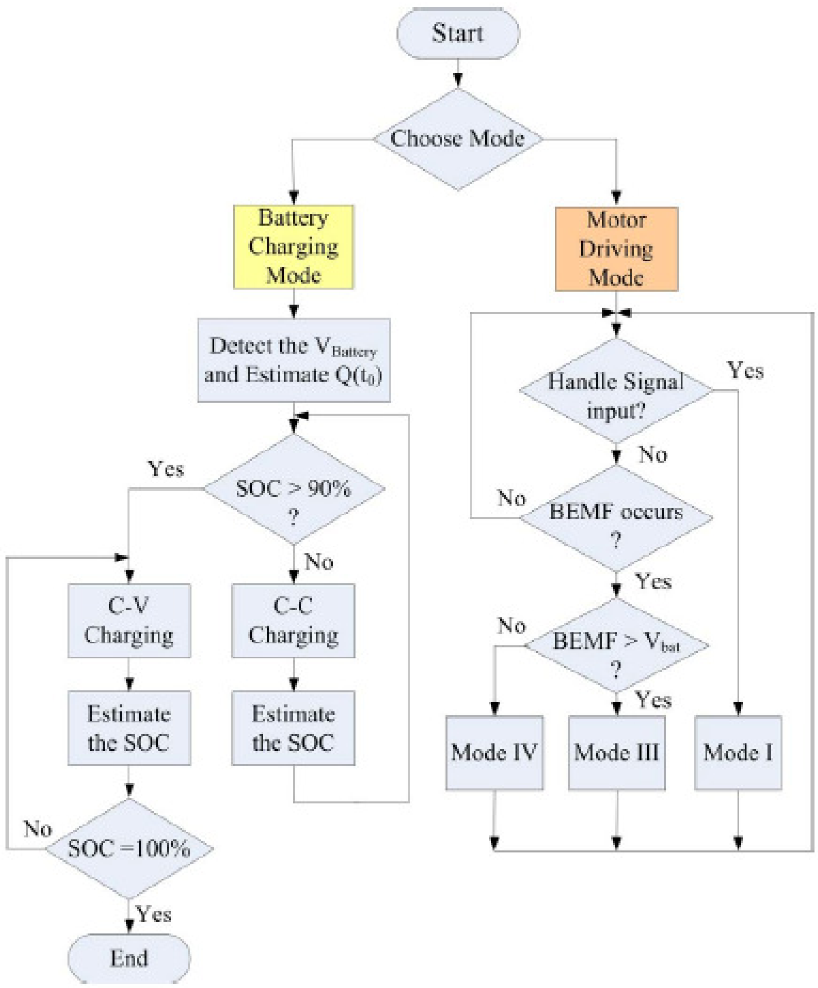

Figure 6: Flow chart of the proposed system

1. Motor driving mode:

While client chooses this mode, the handle flag, which is a customizable dc voltage, will be distinguished to control the obligation cycle of the engine driving inverter, further, to manage the engine speed. The bi-directional converter will enter Mode I when the handle flag is recognized, i.e., the battery offers vitality for driving engine. On the other hand, the framework will identify whether BEMF happens or not. If not, it speaks to framework sit without moving, and the program will come back to beginning state. Then again, the electric bicycle might be decelerated or in plunge state as the BEMF happens. And after that, the framework will naturally choose Mode III or Mode IV to reuse vitality to battery as indicated by whether the BEMF higher than battery voltage or not.

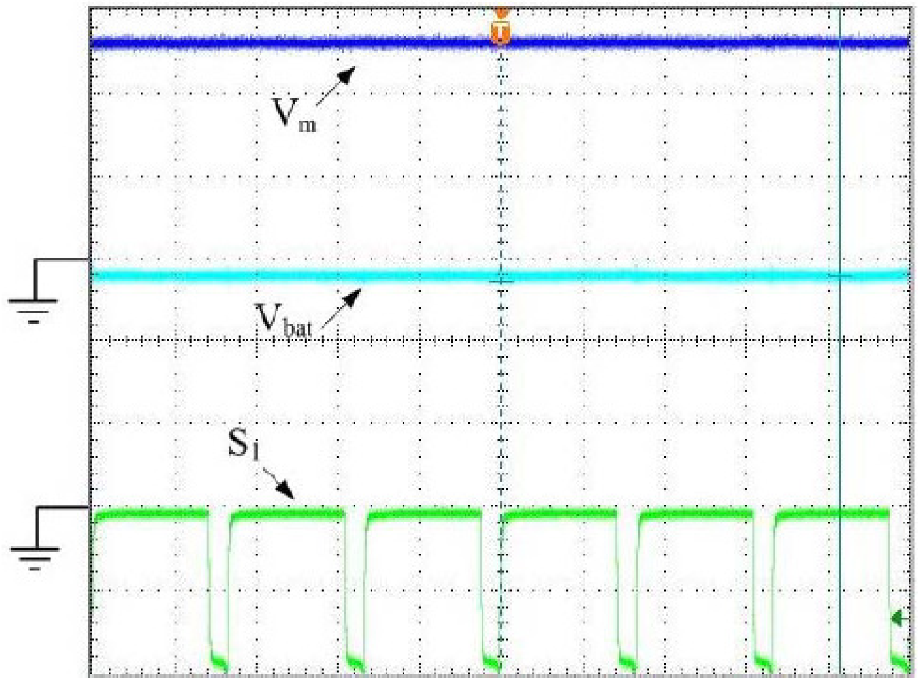

Figure 7: Measured waveforms of the mode I; Vm, Vbat, and S1. (Ver: 10V/div for Vm; 10V/div for Vbat; 10V/div for S1; Hor: 20s/div)

2. Battery charging mode:

The proposed bi-directional converter will carry on as a buck converter when this mode is utilized. Both having exact SOC estimation and reasonable control procedure are basic for an all around planned charger. By and large, the open-circuit voltage strategy is utilized to evaluate the underlying battery top acity under no heap. Plus, the coulometric estimation strategy can gives exact estimation in typical working state. In this paper, we consolidate the open-circuit voltage technique and the coulometric estimation strategy to appraise the battery limit.

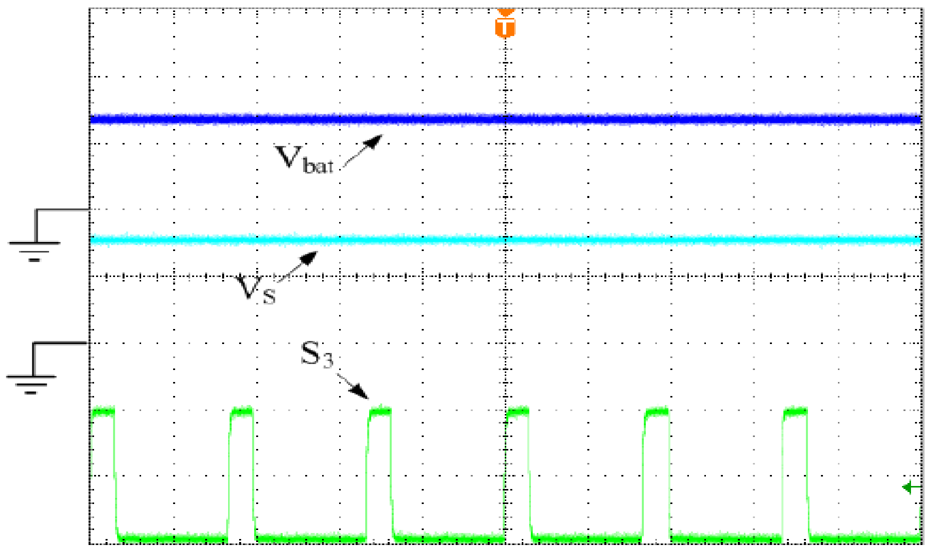

Figure 8: Measured waveforms of the mode II; Vbat, VS, and S3. (Ver: 20V/div for Vbat; 100V/div for VS ; 10V/div for S3; Hor: 20s/div)

CONCLUSION

The real target of this paper is to plan and to execute a bi-directional converter connected for electric bicycle. Three power switches are simply required in the proposed converter, which incorporates engine driver and battery charger, not just reuse vitality to battery to enhance framework execution, yet additionally decrease segment check to lessen the general cost. And after that, a driving, charging and electric limit estimation techniques are altogether implanted in proposed the framework to advance framework dependability.

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