Comparison of continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM) in Omni wheel Robot Power Supply

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Abstract

Nowadays many robot approaches to robust control problems are applicable only to linear systems for nonlinear systems; we may not be able to easily compute the solution to the optimal control problem as analytical solutions may not be available, problem is that statically-stable wheeled mobile robots can easily become dynamically unstable. If the center of gravity is too high, or the robot accelerates/decelerates too rapidly, or is on a sloping surface, so the power supply are necessary for input to actuator robot. This paper presents mode control solutions in power supply for support Omni mobile robot. The performance compare between Continuous Conduction Mode (CCM) and Discontinuous Conduction Mode (DCM) in Power supply. The experiment on the 5V/50W 100 KHZ prototype CCM and DCM converter, which have been designed and builted with similar circuit layouts and component. Aspects to be compared are stability voltage and ripple factor. The both operation mode are discussed based on the simulation and experimental result.

Keywords: Omi robot, Continuous Conduction Mode (CCM), Discontinuous Conduction Mode (DCM)

1. Introduction

Omni-drive systems operate by having individual wheels apply torque in one direction in the same way as a regular wheel. The key advantage of Omni-drive systems is that translational and rotational motion are decoupled for simple motion. However, consider the fastest possible motion. In this paper, we review and design Power Supply designs in Omni wheel robot

A buck-boost converter is a switching power supply topology widely used in applications that require power below 100W. Due to its low part the buck-boost converter is compact for off-line operation. Various aspects of the buck-boost converter have already been studing, whether they are the design issues, control techniques or simulation and modeling. One of the very first challenges, when designing a buck-boost converter, is decision on the circuit's mode of operation. It is known that performance of the CCM and DCM buck-boost converters differ significantly in terms of voltage regulation and efficiency. However, there are not been a comprehensive performance comparison between the two modes of operation.

This paper presents performance comparison of the CCM and DCM buck-boost converters. The comparison is carried out experimentally on the 12V/200W, 100 kHz prototype CCM and DCM buck-boost converters, which have been designed and built with similar circuit layouts, components, and power ratings. Aspects to be compared stability voltage and ripple factor

2. Omni wheel Robot

2.1 Omni wheel

The basis of the most common Omni-drive transport systems are wheels

that allow free motion in a direction that is not parallel to the wheel's drive direction. By combining a number of such wheels, each is able to apply a force on the centre of mass of the transport system, and as each wheel has some axis along which it can freely rotate, a velocity can be induced by the other wheels in this direction. The well-known the figure 1 show general Omni wheel

Fig. 1 Omni wheel

Fig. 2 Transport patients.

Fig. 3 Service robot.

Omni-directional can be move many direction, it a good choice for transport systems separated into two basic classes: orthogonal wheels (pairs of near-spherical wheels), and universal wheels (wheels with rollers).

Fig. 4 The fork lifts industry.

The figure 2, 3, and 4 review example widely uses Omni-directional ground transport systems before examining a particular class of Omni-drive vehicles, orthogonal universal wheel-based systems, in more detail. Finally, we look at the Power Supply imply to electric motor actuator motion of Omni-drive systems for curved paths. We find that, theoretically, electric power supply designs systems can travel between points faster for certain component stress, output voltage drop and voltage regulation

3. Power Supply
3.1. CCM and DCM

In CCM we have only two portions of the duty cycle: D_2 which give rise to two circuit topologies during the cycle. D_1 is actively set by the control circuitry, defaulting value of $D_2 = 1-D_1$.

In DCM one or more additional circuit conditions are met that result

a) Unipolar diode conduction in one of the switches

b) Low $I_{o\,(DC)}$ and high ripple i_L in the current waveform

With both are present then DCM of operation can occur with three circuit topologies present over the switch cycle.
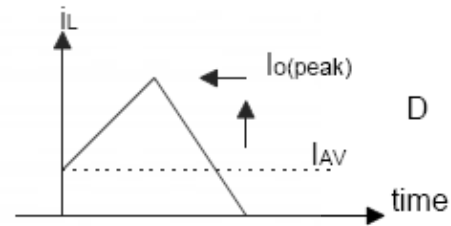

Fig. 5 current output signal

Whenever I_O (peak) > I_{AV} and unidirectional switches present DCM operation occurs with its mixed desirable and undesirable features both on a DC and AC basis follow by figure 5 and 6
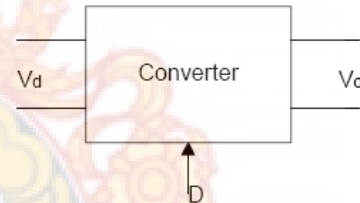

Fig. 6 Block diagram converter power supply

Hence, when the duty cycle, D, is such that $I_{O\,(peak)} = I_{AV}$ we have a transition or border region mapped out between DCM and CCM of operation. This will be unique for each circuit topology. In short when the ratio at CCM boundary occurs. Often in applications we require V_O = constant for a converter while V_g (raw DC input) and D (duty cycle) are adjusted accordingly to achieve this, usually by output driven feedback loops. From our period work on equilibrium conditions, lossless CCM of operation has an ideal output V source characteristic with I_O not effecting V_O.

That is V_O is constant for all I_O. $V_O = M_{(D)}V_{in}$ only, with no I_O dependence. We will contrast this with the DCM of operation which has a non-ideal V_O source with I_o effecting V_O. Since for DCM, $V_O = M_{(D, RL)} V_{O(DCM)}$ usually exceeds V_O (CCM) for a fixed duty cycle.

3.2 Buck-Boost Topology

Review of CCM V_0 /V_d Transfer Functions and Inductor Waveforms The basic buck-boost circuit with switches is shown Figure 7(a), (b)
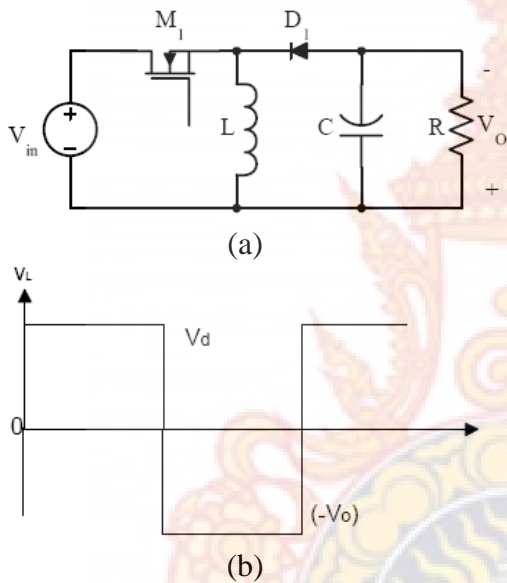

(a)

(b)

Fig. 7 The basic buck-boost circuit with switches
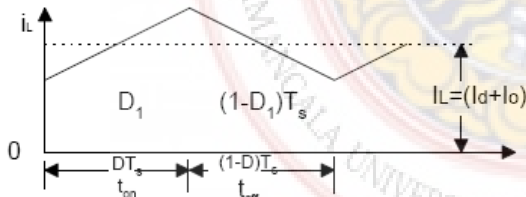
Fig. 8 In the CCM of operation the V_L and I_L waveforms for buck boost

Figure 8 and 9 Presents CCM and DCM Boundary the inductor current, i_L, just reaches zero and tries to go negative but the circuit diodes will not allow it. We now write expressions for the inductor current

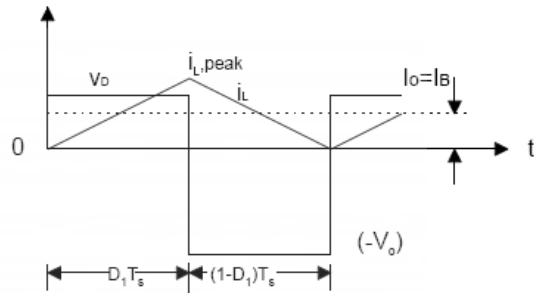average, I_{AV}(boundary), versus V_d and D as well as versus V_O and D.

Fig. 9 In the DCM of operation the VL and IL waveforms for buck boost

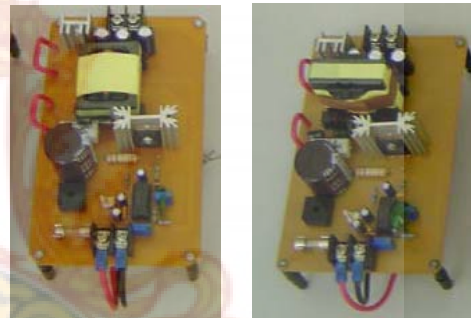## 4. Experimental Result

4.1 Prototype

Fig. 10 Buck boost converter prototype

Firstly, the prototype CCM and DCM buck boost converters are tested to compare their details are as follows. By figure 10
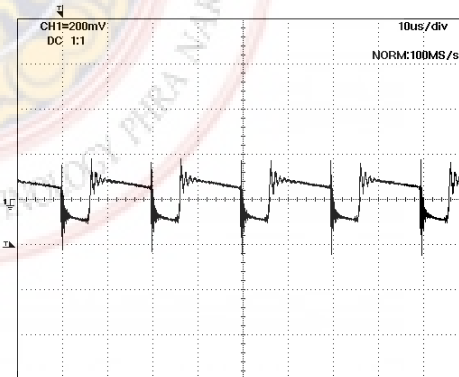

Fig. 11 Output Voltage CCM mode in Buck boost converter

A measured output voltage of the prototype CCM and DCM buck boost converters when take load currents. The measurement is made It can be seen that the output voltage in both circuits drops only slightly when the load current is increased from minimum to maximum values. The output voltage defined as the difference between a voltage at minimum load current and a voltage at maximum load current divided by a voltage for both circuits. The good voltage is attributed to will that the feedback compensation
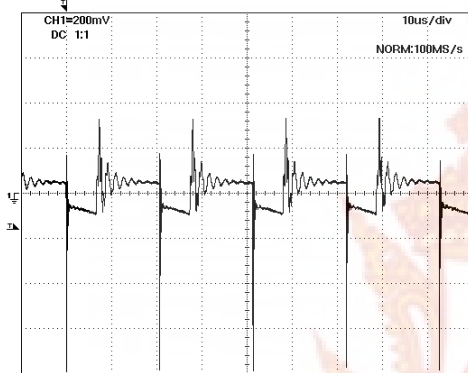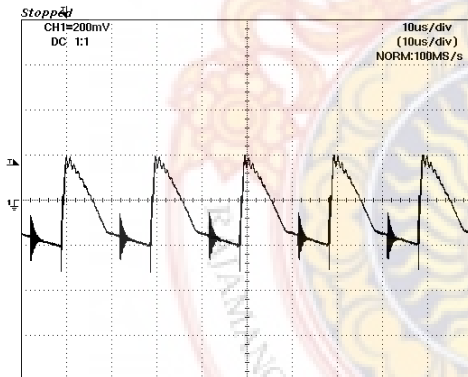

Fig. 12 Ripple CCM mode in Buck boost converter

Fig. 13 Output Voltage DCM mode in Buck boost converter

Figure 11 and 12 shows the output voltage and ripple factor of the prototype CCM buck boost converters, when the load current 5A. It can be seen that the output voltage response of the CCM circuit is very well.
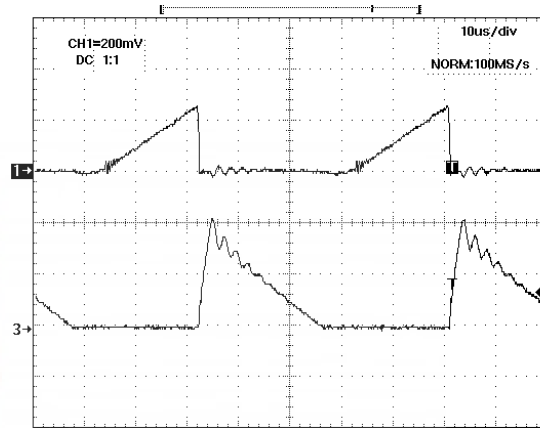

Fig. 14 Ripple DCM mode in Buck boost converter

Figure 13 and 14 shows the output voltage and ripple factor of the prototype DCM buck boost converters, when the load current 5A. It can be seen that the output voltage response of the DCM circuit
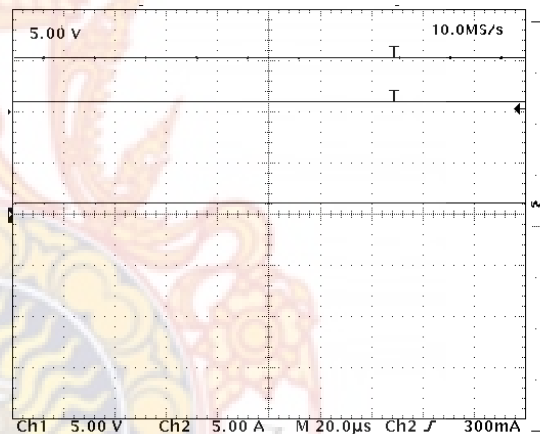

Fig. 15 Output voltage of CCM, DCM

Figure 15 shows the output voltage of the prototype CCM and DCM buck boost converters, when the load current 5A.

5. Conclusions

Comparison of a CCM and DCM buck boost converters for Omni wheel robot has been presented in this paper. As for output voltage performance, both CCM and DCM buck boost converters perform equally well in terms of output voltage. The conduction and switching losses are nearly expected that the findings from this study provide for selecting mode of

operation of a buck boost converter, the decision of which a power designer to make early in the design process.

5. Acknowledgements

6. References

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