부적합한 전원이 연결된 전류제어 승압형 변환기와 전류제어 강압형 동특성

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Dynamics of the Current-Mode Controlled Boost and Buck Converters Connected to an Ill-Conditioned Source

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ABSTRACT

This paper presents the dynamics of the current mode controlled buck and boost converters, which are both connected to an ill conditioned source. This paper investigates the origin of potential instability and demonstrates internal/external dynamics of the converters under adverse interactions with the source.

1. Introduction

Dc to dc converters are often powered from a non ideal voltage source, which presents a finite source impedance[1]. Although properly designed for an ideal voltage source, the converters could become unstable when combined with a non ideal voltage[2]. Such destabilizing effects could occur when the magnitude of the source impedance of the non ideal voltage source exceeds the low frequency asymptote of the input impedance of the downstream converter. This instability is referred to the source induced instability.

This paper demonstrates that the pattern of the source induced instability could develop very differently depending on the converter topology and control scheme. For the current mode controlled boost converter, the source induced instability affects all the small signal and time domain performance, thereby clearly showing the impact of the ill conditioned source. For the buck converter, by contrast, the source induced instability is totally hidden in the loop gain and output impedance of the converter. This paper investigates this intriguing dynamics of the boost and buck with an ill conditioned source.

2. Performance analysis of two converter cases

2.1 A Current-mode controlled boost converter with an unsuitable source

The source impedance is passing through the input impedance of the current mode controlled boost converter around $1.11kHz$ as shown in Fig.1(b). Hence this converter becomes unstable in Fig. 1(c). Fig. 1(d) and (e) show that the loop gain and output impedance is changed around $1.11\,kHz$. Especially phase margin of a converter is less than -180°.

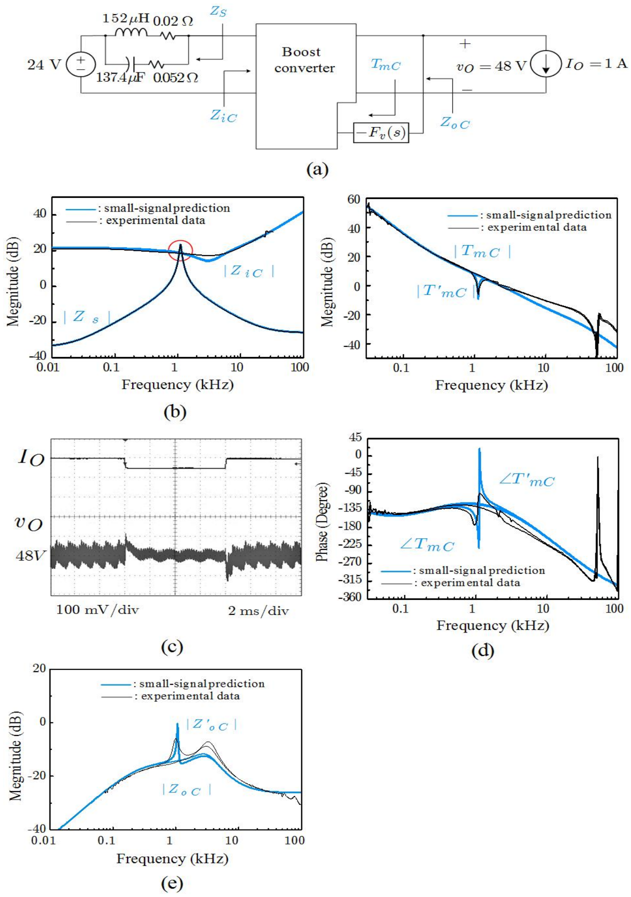

Figure 1. Comparison performance between uncoupled converter and detrimental source coupled converter. (a) Circuit diagram. (b) Source impedance and input impedance overlap. (c) Step-load response. (d) Loop gain. (e) Output impedance.

2.2 A Current-mode controlled buck converter with an unsuitable source

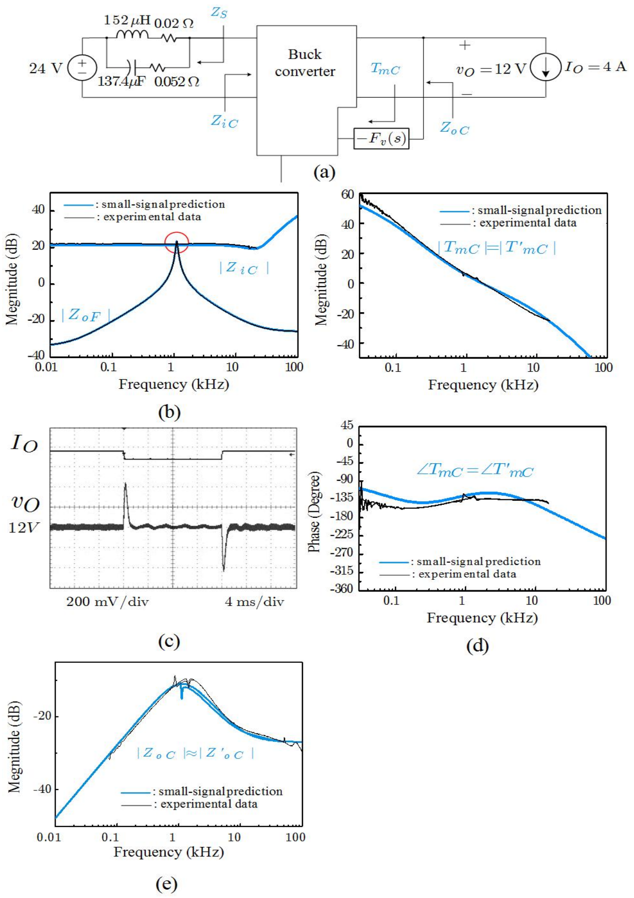

Figure 2. Comparison performance between uncoupled converter and detrimental source coupled converter. (a) Circuit diagram. (b) Source impedance and input impedance overlap. (c) Step-load response. (d) Loop gain. (e) Output impedance.

As shown in Fig. 2(b), the source impedance is going through the input impedance of the current mode controlled buck converter and Fig. 2(c) displays this phenomenon makes this converter unstable as same as the boost converter case. However dynamic performances in Fig. 2(d) and Fig. 2(e) is not changed unlike the boost converter although an inadequate converter is connected.

2.3 The reasons why this different occurrence happened between two converters

Table 1 Performance criteria for PWM converter with source subsystem[3]

Transfer functions	$T'_{mC}=T_{mC}\dfrac{1+\dfrac{Z_{oF}}{Z''_i}}{1+\dfrac{Z_{oF}}{Z'''_i}}$		$Z'_{oC}=Z_{oC}\dfrac{1+\dfrac{Z_{oF}}{Z'_i}}{1+\dfrac{Z_{oF}}{Z_{iC}}}$	
Multiplication factors	$1+\dfrac{Z_{oF}}{Z''_i}$	$1+\dfrac{Z_{oF}}{Z'''_i}$	$1+\dfrac{Z_{oF}}{Z'_i}$	$1+\dfrac{Z_{oF}}{Z_{iC}}$

The two transfer functions listed in Table 1[3]. In the current mode controlled boost converter case, These conditions, $1\gg Z_{oF}/Z'_i$ and $1\gg Z_{oF}/Z'''_i$, are satisfied for all frequencies as presented Fig. 3(a), T'_{mC} and Z'_{oC} of a current mode controlled boost converter can be abbreviated like $T'_{mC}=T_{mC}\cdot(1+Z_{oF}/Z''_i)$ and $Z'_{oC}=Z_{oC}/(1+Z_{oF}/Z_{iC})$. Because of two multiplication factors, $1+Z_{oF}/Z''_i$ and $1+Z_{oF}/Z_{iC}$, T'_{mC} and Z'_{oC} can be changed.

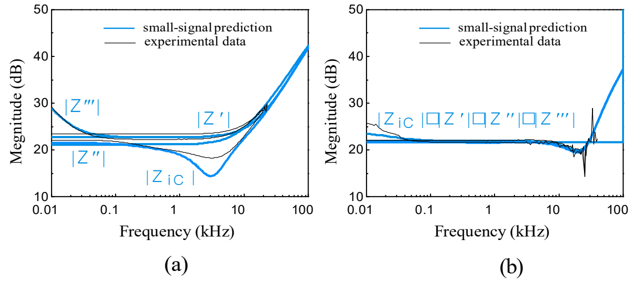

Figure 3. Driving point input impedance. (a) A boost converter case. (b) A buck converter case.

However, all the multiplication factors can be vanished in the case of a current mode controlled buck converter since $Z_{oF}/Z'_i\approx Z_{oF}/Z''_i\approx Z_{oF}/Z'''_i\approx Z_{oF}/Z_{iC}$ is assured at all frequencies as displayed Fig. 3(b). As a result, both of the transfer functions are not reform unlike the current mode boost converter.

3. Conclusion

This paper has described how the ill conditioned source affects to a current mode controlled boost converter and current mode controlled buck converter. Especially the paper has specified transfer functions variation with the reasons.

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