IDEC Chip Design Contest

Frequency Analysis of Conventional and 3-Level Buck Converter

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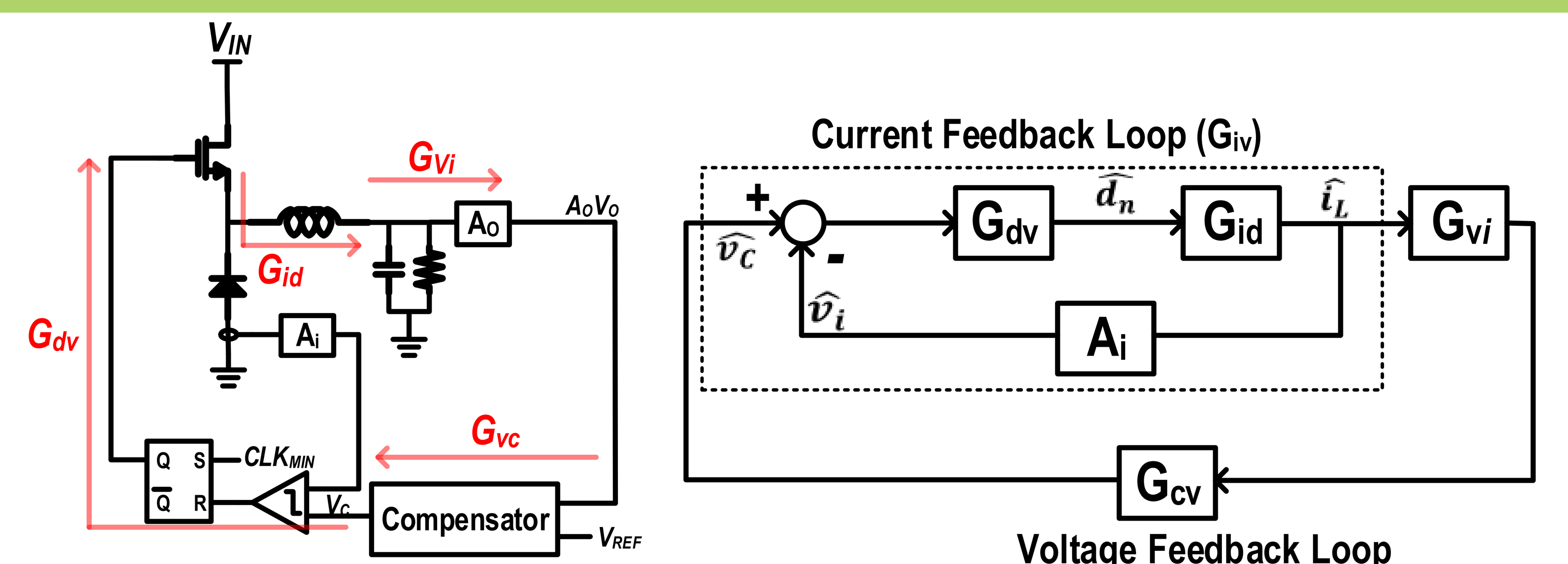
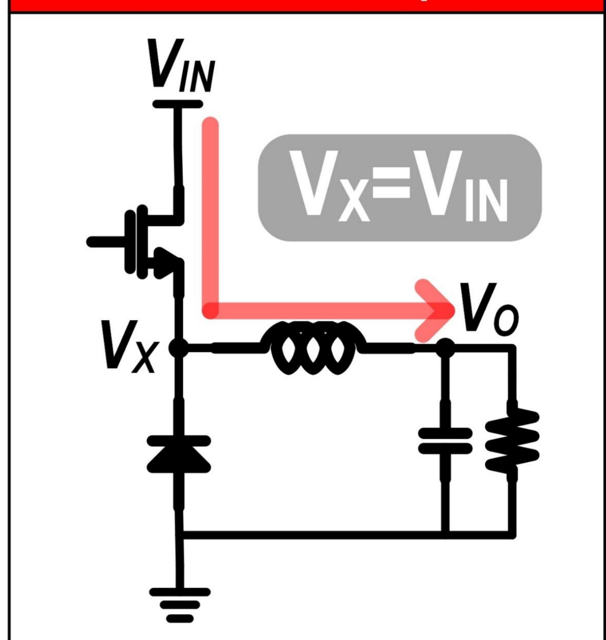
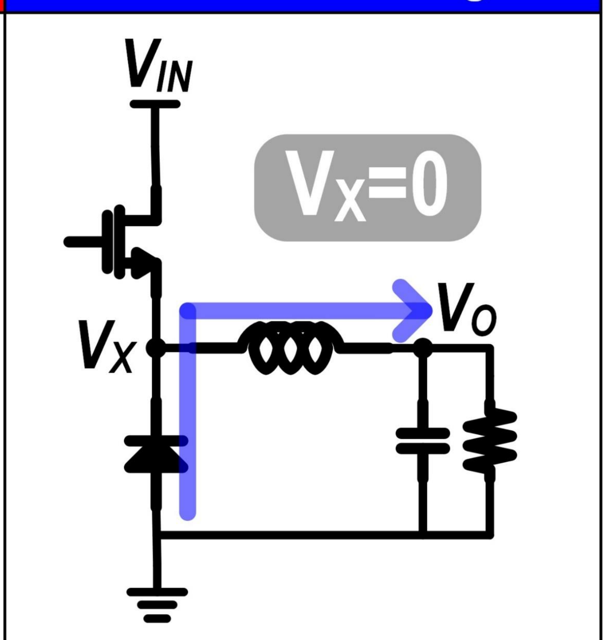
Introduction



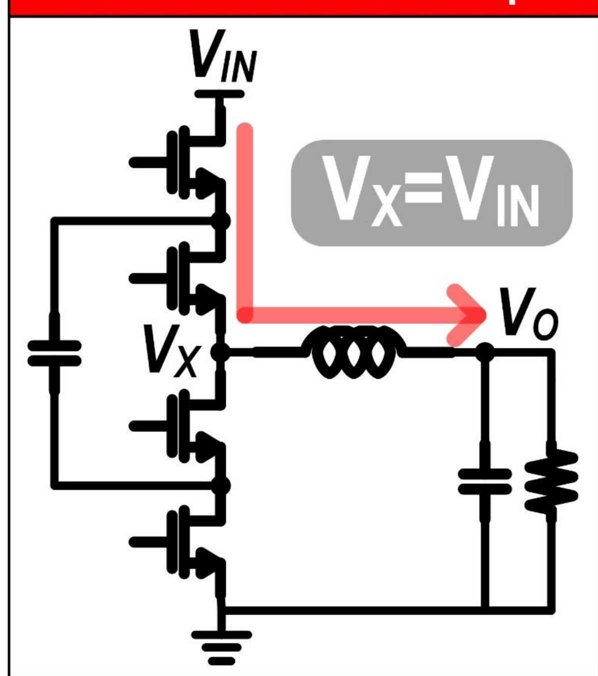
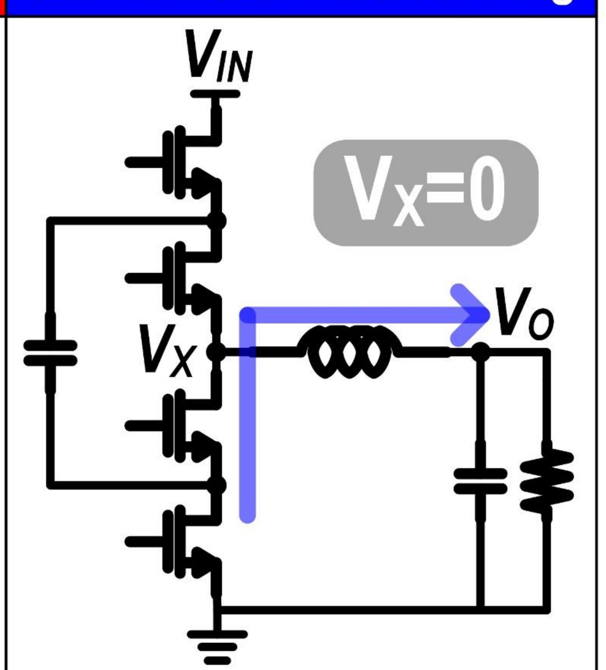
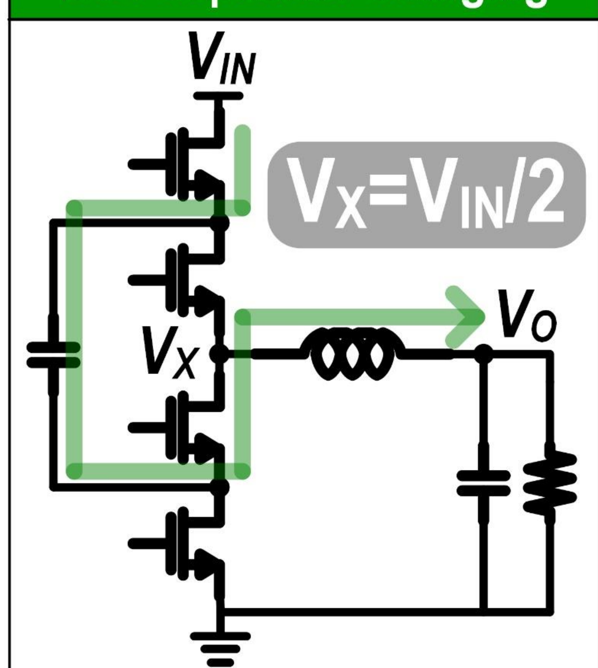
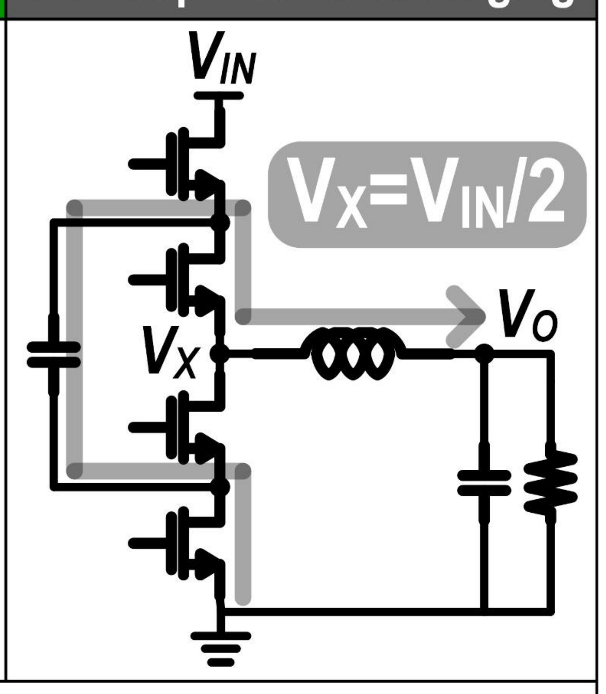
How can I control a 3-level converter?

State-Space Average Model

- Conventional Buck Converter (CBC)

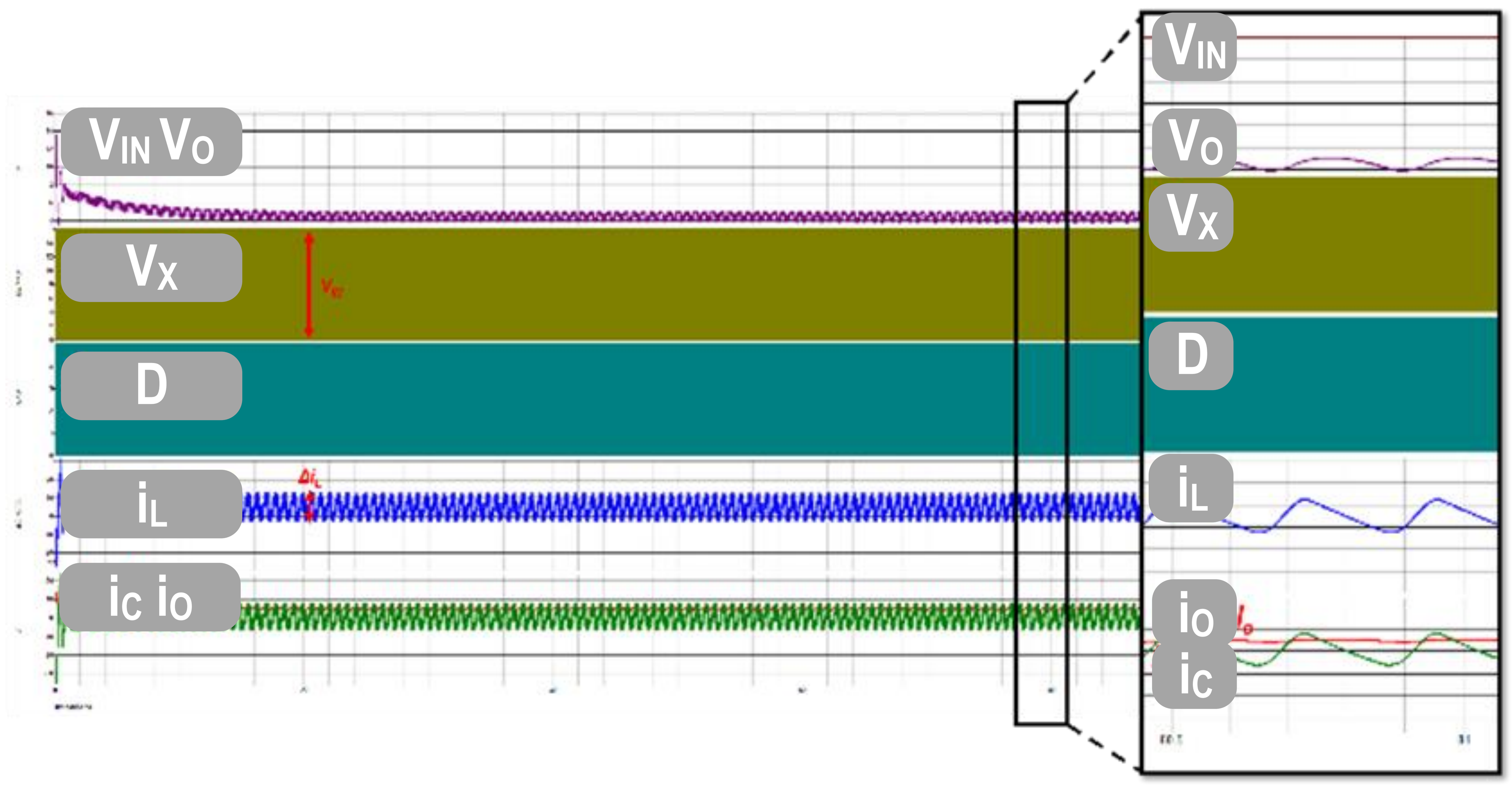
	Ø1 : Build-Up	Ø2 : Freewheeling
Operation		
L, C Equation	$\frac{di_L}{dt}=\frac{1}{L}v_{IN}-\frac{1}{L}v_C$, $\frac{dv_O}{dt}=\frac{1}{C}i_L-\frac{1}{RC}v_O$,	$\frac{di_L}{dt}=-\frac{1}{L}v_O$
State Equation	$A=\begin{bmatrix}0 & -\frac{1}{L}\\ \frac{1}{C} & -\frac{1}{RC}\end{bmatrix}$, $B=\begin{bmatrix}\frac{D}{L}\\ 0\end{bmatrix}$, $C=[0\quad 1]$	

- 3-Level Buck Converter

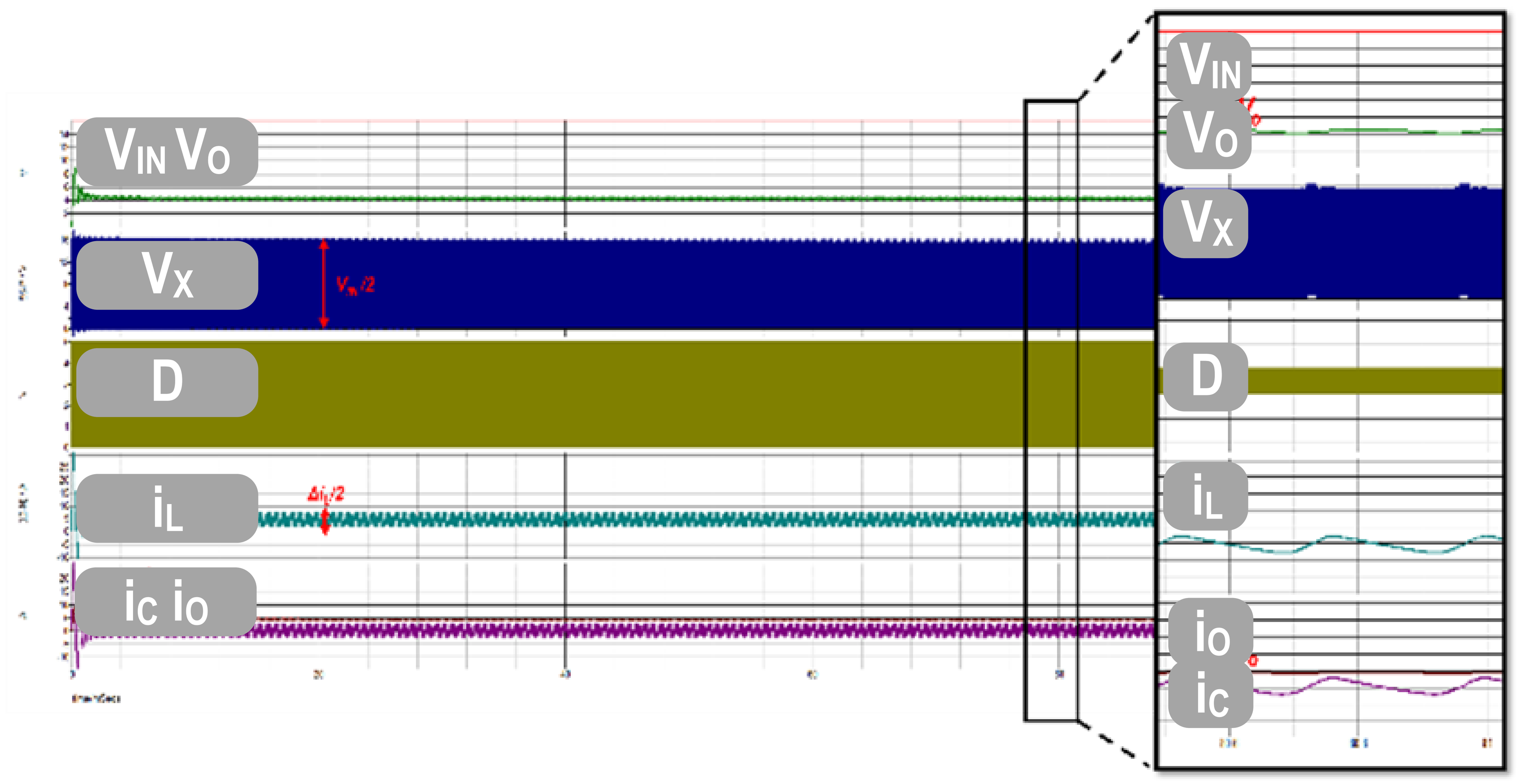
	Ø1 : Inductor Build-Up	Ø2 : Inductor Freewheeling
Operation		
	Ø3 : Capacitor Charging	**Ø4 : Capacitor Discharging**
		
L, C Equation	$\frac{di_L}{dt}=\frac{1}{2L}v_{IN}-\frac{1}{L}V_O$, $\frac{dv_O}{dt}=\frac{1}{C}i_L-\frac{1}{RC}v_O$,	$\frac{di_L}{dt}=-\frac{1}{L}v_O$, $\frac{di_L}{dt}=\frac{1}{L}v_{IN}-\frac{1}{L}v_O$
State Equation	$A=\begin{bmatrix}0 & -\frac{1}{L}\\ \frac{1}{C} & -\frac{1}{RC}\end{bmatrix}$, $B=\begin{bmatrix}\frac{D}{L}\\ 0\end{bmatrix}$, $C=[0\quad 1]$	

Simulation Results

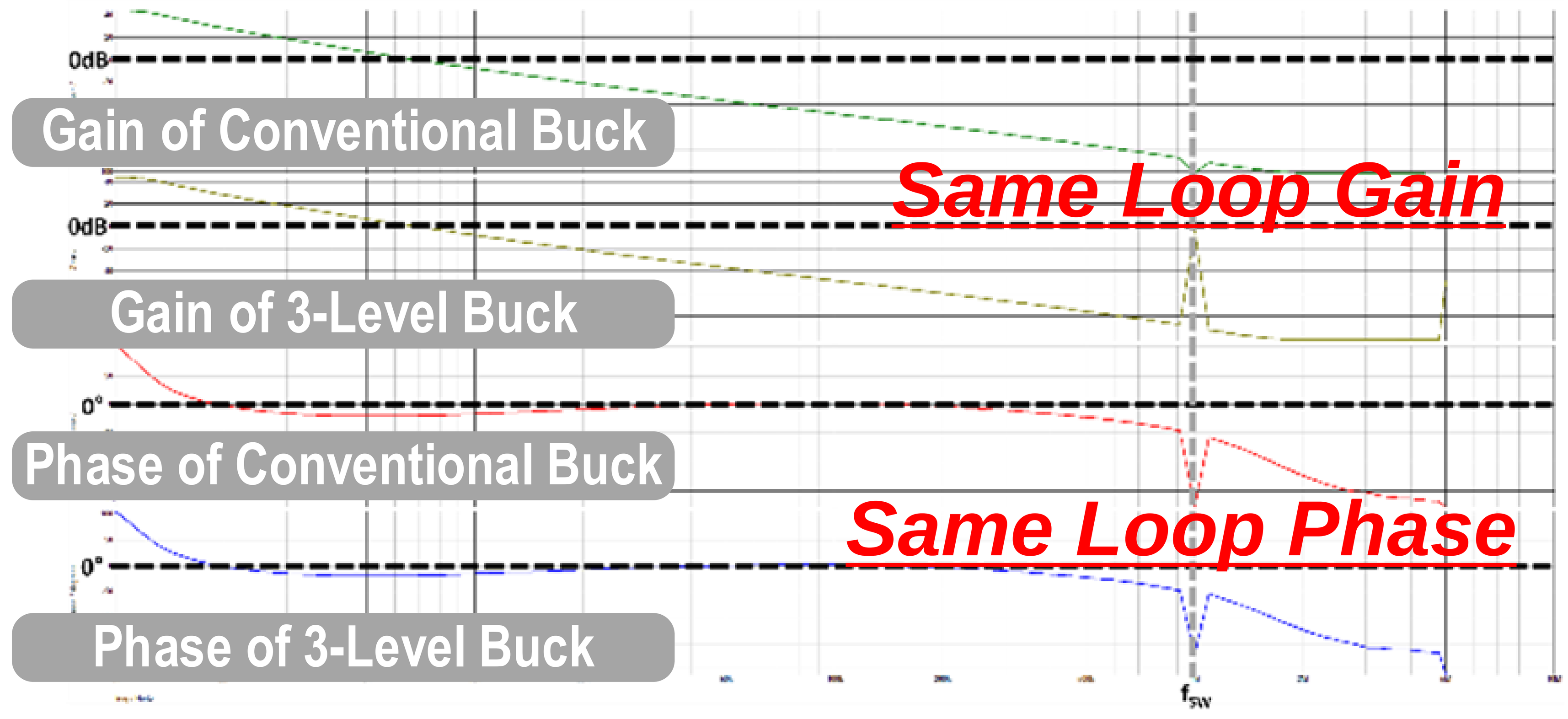
- Transient Response of CBC



- Transient Response of 3-Level Buck



- Comparison in Frequency Domain



Conclusion

- Frequency Domain

: Same Transfer Function

➔ Controller design is same with CBC

: No Effect of V_{CF}

- Comparison

	# of Switch	Extra Element	Voltage Stress	Switching Freq.
CBC	☺ 2	☺ No	☹ V_{IN}	☹ f_{SW}
3-Level Buck	☹ 4	☹ 1 C_F	☺ $V_{IN}/2$	☺ $2f_{SW}$

<Acknowledgement>
본 연구는 IDEC에서 MPW를 지원받아 수행하였습니다.

반도체설계교육센터 IC DESIGN EDUCATION CENTER