6.6220 HW9 Solutions*

9.1 Compensating Ramp in Peak Current Control

First, we derive the inductor current change rates (M_1, $-M_2$) for the buck converter.

When the switch is on for DT,

$$M_1 = \frac{di_L}{dt} = \frac{V_{in} - V_{out}}{L}$$

and when the switch is off for (1-D)T

$$-M_2 = \frac{di_L}{dt} = \frac{-V_{out}}{L}$$

and for a continuous conduction mode buck converter, $D = \frac{V_{out}}{V_{in}}$.

The inductor current waveform in peak current mode control is shown in Fig. 1, where if the initial current difference for the nth period is ΔI_n, with the compensating ramp, the current difference at the start of the (n+1)th period will be ΔI_{n+1}. From geometric relationships, we have

$$\frac{\Delta I_{n+1}}{\Delta I_n} = -\frac{M_2 - M_c}{M_1 + M_c}$$

where M_1, M_2 and M_c are all defined to be positive. Hence to achieve ripple stability (no sub-harmonic oscillations), we need

$$-\frac{M_2 - M_c}{M_1 + M_c} < 1$$

$$\implies M_c > \frac{M_2 - M_1}{2} = \frac{2V_{out} - V_{in}}{2L}$$

Since V_{out} is regulated at $V_{out,ref}$ =10 V and V_{in} is in the range of 15 V to 30 V, the smallest M_c that can guarantee stable ripple dynamics occurs across the entire input voltage range is when V_{in} =15 V. Plugging in numbers, we have

$$M_c > \frac{2 * 10\,\text{V} - 15\,\text{V}}{2 * 6.8\,\mu\text{H}} = 368\,\text{kA/s}$$

Note that the equations imply that if $V_{in} > 2V_{out}$ for a CCM buck converter, then ripple stability is guaranteed and no compensating ramp is needed. The condition, of course, would vary with input voltage specs and circuit topologies.

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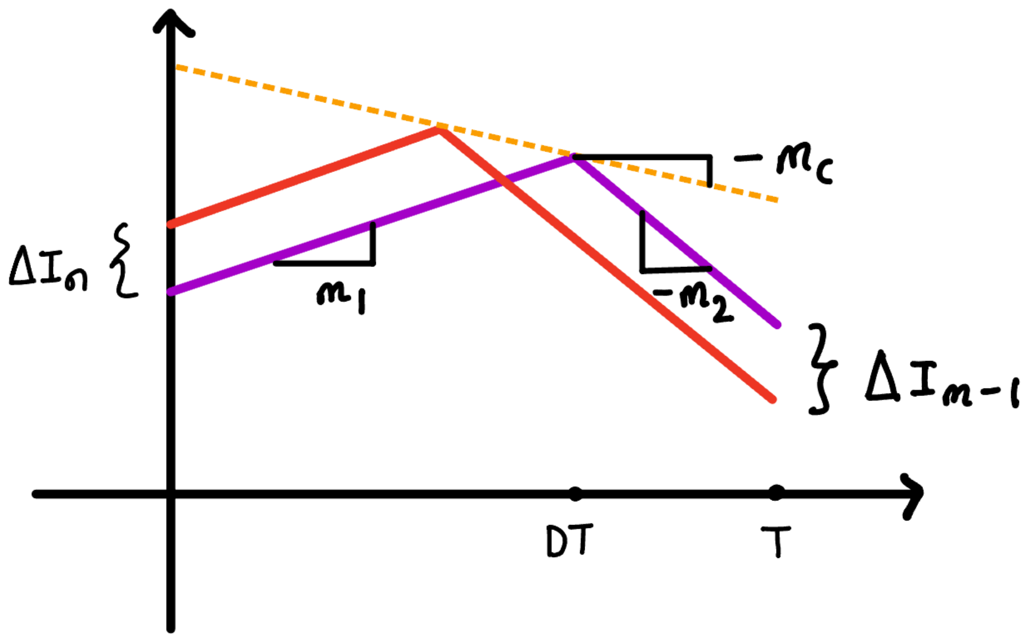

Figure 1: Current Waveforms with Peak Current Mode Control