

current-programmed boost converter when it operates in CCM with  $d(t) > 0.5$ . The addition of this ramp causes  $\langle i_g(t) \rangle_{T_s}$  to differ from  $i_c(t)$ . Additional deviation is introduced by the inductor current ripple. Both mechanisms are most pronounced when the inductor current is small, near the zero-crossings of the ac line waveforms.

The static input characteristics, that is, the average input current vs. the input voltage, of the current-programmed boost converter are given by

$$\langle i_g(t) \rangle_{T_s} = \begin{cases} v_g(t) \frac{Li_c^2(t)f_s V}{2(V - v_g(t))(v_g(t) + m_a L)^2} & \text{in DCM} \\ i_c(t) - \left(1 - \frac{v_g(t)}{V}\right) \left(m_a + \frac{v_g(t)}{2L}\right) T_s & \text{in CCM} \end{cases} \quad (18.57)$$

The converter operates in the continuous conduction mode when

$$\langle i_g(t) \rangle_{T_s} > \frac{T_s V}{2L} \frac{v_g(t)}{V} \left(1 - \frac{v_g(t)}{V}\right) \quad (18.58)$$

In terms of the control current  $i_c(t)$ , the condition for operation in CCM can be expressed

$$i_c(t) > \frac{T_s V}{L} \left(\frac{m_a L}{V} + \frac{v_g(t)}{V}\right) \left(1 - \frac{v_g(t)}{V}\right) \quad (18.59)$$

In the conventional current-programmed rectifier control scheme, the control current  $i_c(t)$  is simply proportional to the ac input voltage:

$$i_c(t) = \frac{v_g(t)}{R_e} \quad (18.60)$$

where  $R_e$  is the emulated resistance that would be obtained if the average input current exactly followed the reference current  $i_c(t)$ . The static input characteristics given by Eqs. (18.57) to (18.60) are plotted in Fig. 18.17. The average input current  $\langle i_g(t) \rangle_{T_s}$  is plotted as a function of the applied input voltage  $v_g(t)$ , for several values of emulated resistance  $R_e$ . The region near the CCM–DCM boundary is shown. The curves are plotted for a fixed artificial ramp having slope

$$m_a = \frac{V}{2L} \quad (18.61)$$

This is the minimum value of artificial ramp that stabilizes the boost current-programmed controller at all static operating points. Decreasing  $m_a$  below this value leads to instability at operating points in the continuous conduction mode at low  $v_g(t)/V$ .

To obtain resistor emulation, it is desired that the static input characteristics be linear and pass through the origin. It can be seen from Fig. 18.17 that this is not the case: the curves are reasonably linear in the continuous conduction mode, but exhibit significant curvature as the CCM–DCM boundary is approached. The resulting average current waveforms are summarized in Fig. 18.8.

To minimize the line current THD, it is apparent that the converter should be designed to operate deeply in the continuous conduction mode for most of the ac line cycle. This is accomplished with emulated resistances  $R_e$  that are much smaller than  $R_{base} = 2L/T_s$ . In addition, the artificial ramp slope  $m_a$