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Introduction

The LM5171 is a dual-channel, bidirectional, average-current-mode controller. Average current mode control enables precise regulation of the inductor current. Constant current operation can be achieved by controlling the ISET1 and ISET2 (ISETx) voltages.

The LM5171 has two operating modes: Forced PWM (FPWM) mode and diode emulation (DEM) mode. In FPWM mode, the gate drive signal of the synchronous FET is complementary to that of the control FET at all times. Reverse current is allowed in FPWM mode. In DEM mode, the current through the synchronous FET is monitored and the FET turns off when the current drops to zero. Therefore, there is no reverse current in DEM mode.

The FPWM mode exhibits better load transient behavior, while the DEM mode exhibits better light-load efficiency.

Bidirectional Operation by Toggling DIRx

Figure 1 shows how to switch between buck mode and boost mode by toggling the DIR1 and DIR2 (DIRx) pins in DEM mode. The channel operates in the buck region when the DIRx pin is pulled above 2V (DIRx=1), the current flows from the HV-Port to the LV-Port; the channel operates in the boost region when the DIRx pin is pulled below 1V (DIRx=0), the current flows from the LV-Port to the HV-Port.

V_{CS} is the voltage across the current sense resistor R_{CS} . The converter operates in the buck region when $V_{CS} > 0$ and in the boost region when $V_{CS} < 0$. The voltage applied to ISETx is V_{ISET} .

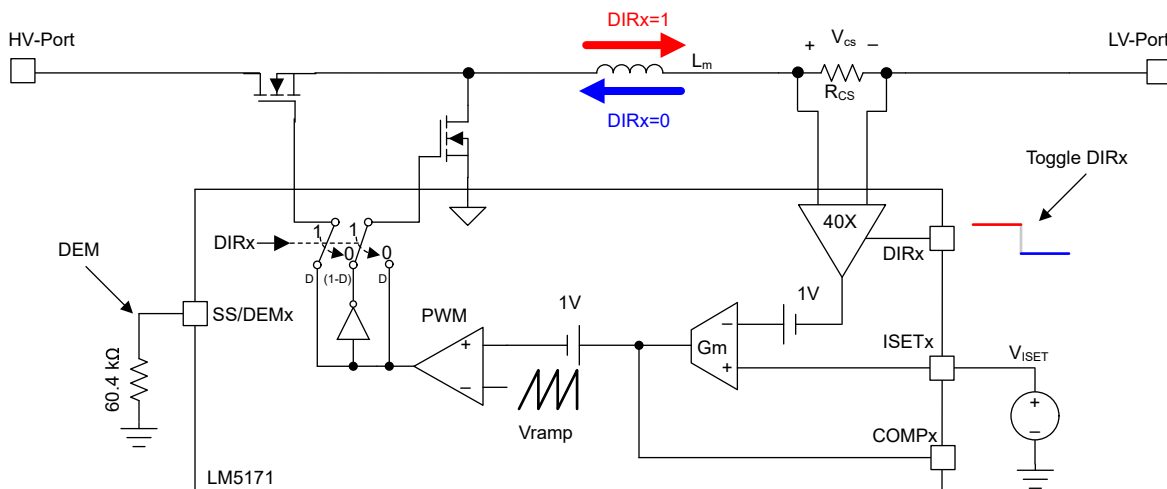


Figure 1. Bidirectional Operation by Toggling DIRx

In DEM mode, when $V_{ISET} > 1V$, V_{CS} is given by,

$$V_{CS} = \begin{cases} \frac{V_{ISET} - 1V}{40}, & DIRx = 1 \\ -\frac{V_{ISET} - 1V}{40}, & DIRx = 0 \end{cases} \quad (1)$$

In DEM mode, when $V_{ISET} \leq 1V$, $V_{CS} = 0$.

Figure 2 shows the relationship between V_{CS} and V_{ISET} in DEM mode.

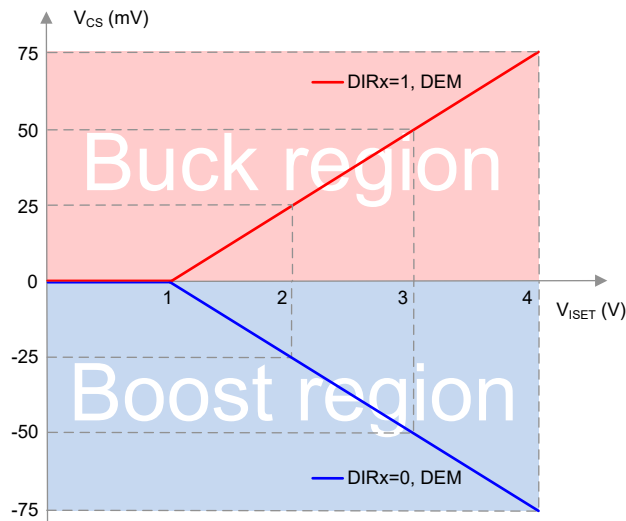


Figure 2. V_{CS} and V_{ISET} in DEM Mode

When the DIRx toggles, the SS/DEMx pin first discharges and then undergoes a new soft start process. The soft start time is determined by the capacitor on the SS/DEMx pin.

Bidirectional Operation by Adjusting ISETx Voltage

In FPWM mode, Equation 1 holds true for $0V \leq V_{ISET} \leq 4V$. Figure 3 illustrates the relationship between V_{CS} and V_{ISET} in FPWM mode.

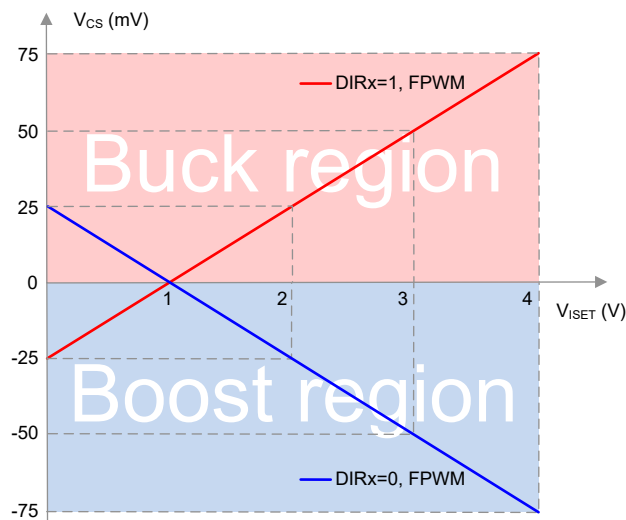


Figure 3. V_{CS} and V_{ISET} in FPWM Mode

Bidirectional Operation with Voltage Loops

Figure 6 shows how to regulate the HV-Port voltage in boost mode and the LV-Port voltage in buck mode in DEM mode. The LM5171 integrates two internal error amplifiers, and DIR1 determines the active error amplifier.

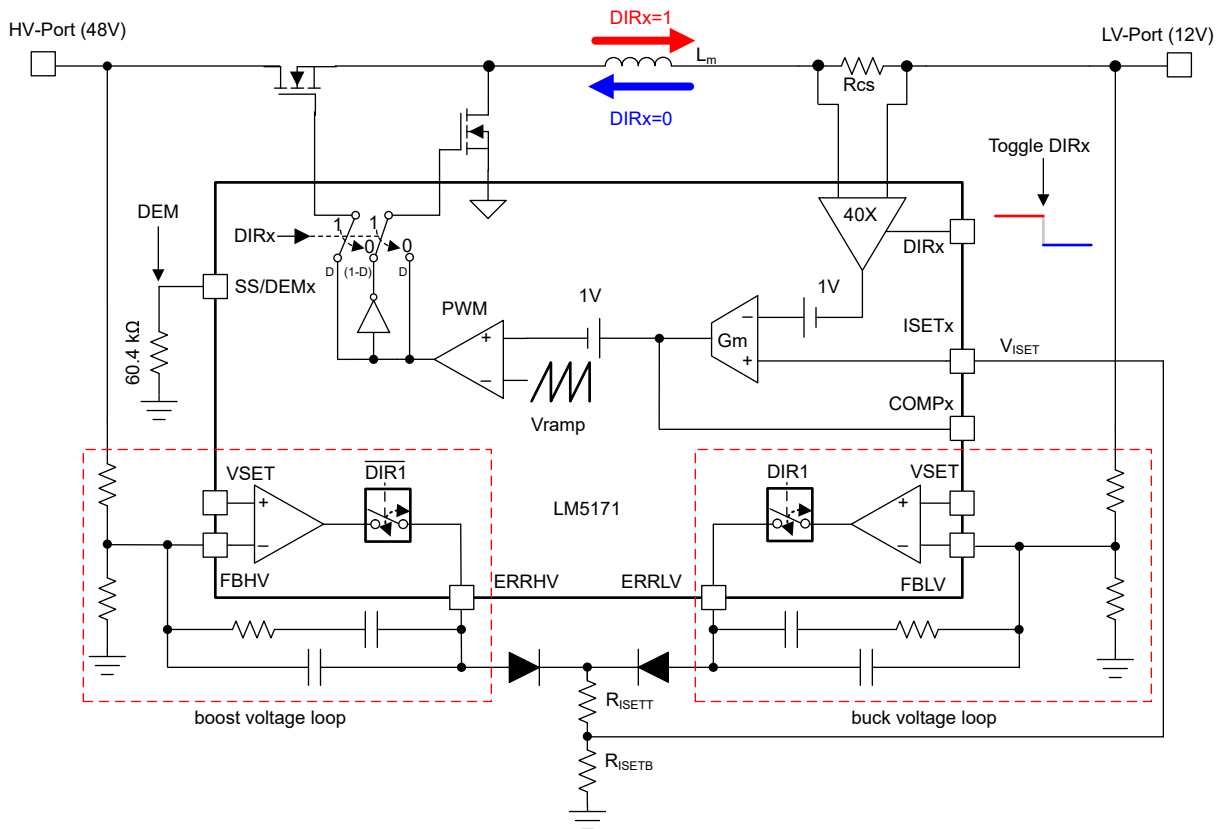


Figure 6. Bidirectional Operation with Two Voltage Loops

Figure 7 shows a diagram with a single voltage loop in FPWM mode. In this example, boost mode (DIR=0) is selected. As mentioned above, the LM5171 does not switch at startup until the COMPx rises above 1V. Therefore, if the HV-port voltage is higher than the target regulation voltage, the ERRHV voltage is zero and then the COMPx voltage is zero, the LM5171 does not switch. Conversely, if the output voltage is lower than the target regulation voltage, the ERRHV voltage rises and then the COMPx voltage rises. The LM5171 starts switching once the COMPx rises above 1V. Once the LM5171 has starts switching, seamless bidirectional operation is allowed. The internal error amplifier adjusts the ERRHV/ISETx voltage to maintain a regulated HV voltage. The current crosses 0A when V_{ISET} crosses 1V as shown in Figure 3. The HV-Port can both sink and source current to maintain a regulated HV voltage.

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