TPS6211x Driving EN and SYNC Pins

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ABSTRACT

The TPS6211x high-input-voltage buck converters operate over a wide, input-voltage range. The control and input signal can also be controlled from 1.8-V logic levels up to maximum input voltage.

One characteristic of the EN and SYNC control circuits is the increase in leakage current when these pins are driven by a voltage level less that 4 V.

In this application report, the difference in the two leakage current specifications is explained, when they apply, and the impact on drive circuits.

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1 Background

The requirement to operate over a wide voltage range and wide range of control signal voltage drove the need for a more complicated Enable (EN) and Synchronization (SYNC) input circuit. One of the characteristics of this circuit is a high-leakage current of possibly 20 µA for signals of less than 4 V, but for greater than 4 V, a leakage current of 0.2 µA. The reason for this is related to the behavior of a body diode on the input circuit of each of these pins.

In the following electrical characteristics table (Table 1), the *EN input leakage current* specifies current out of the EN pin for a $V_{(EN)}$ of less that 0.6 V or greater than 4 V and with V_I or operating voltage at 12 V. This is the low-current condition with leakage current of 0.2 µA maximum. The higher current condition of 20 µA maximum is specified as *EN input current* where $V_{(EN)}$ is between 0.6 V and 4 V with V_I of 12 V.

The SYNC pin has similar specifications of *SYNC input leakage current* and *SYNC input current* (Table 2).

Table 1. Enable Pin Electrical Characteristics

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ENABLE						
V_{IH}	EN high-level input voltage		1.3			V
V_{IL}	EN LOW-level input voltage				0.3	V
	EN trip-point hysteresis			170		mV
I_{IKG}	EN input leakage current	EN = GND or V_I, V_I = 12 V		0.01	0.2	µA
$I_{(EN)}$	EN input current	0.6 V ≤ $V_{(EN)}$ ≤ 4 V		10	20	µA
$V_{(UVLO)}$	Undervoltage lockout threshold	Input voltage falling	2.8	3	3.1	V
	Undervoltage lockout hysteresis			250	300	mV

Table 2. Synchronization Pin Electrical Characteristics

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SYNCHRONIZATION						
I_{IKG}	SYNC input leakage current	SYNC = GND or VIN		0.01	0.2	µA
	SYNC trip-point hysteresis			170		mV
	SYNC input current	0.6 V ≤ $V_{(SYNC)}$ ≤ 4 V		10	20	µA
	Duty cycle of external click signal		30%		90%	

2 Impact on Drive Circuit

Often the EN pin or the SYNC pin is connected to V_I or ground; in either of these conditions, the lower leakage current specification of 0.2 µA applies.

When a control signal of less that 4 V is used, the current out of the EN and SYNC pins increases to up to 20 µA. This can present a problem for the turnoff circuit that is trying to pull these pins low. If the impedance of the pulldown circuit is significant, then the low-level voltage requirement may not be met.

For a circuit that has an impedance of 50 kΩ to ground:

V_signal = input current × impedance = 20 µA × 50 kΩ = 1 V

This is above the minimum low-level threshold for a low of 0.3 V, and the TPS6211X does not turn off. To meet the 0.3-V threshold, the signal impedance to ground needs to be less that 15 kΩ to ground.

3 Equivalent Circuit

The additional current is caused by current flow through the forward-biased body diode in the control circuit. This body diode then connects an internal current source to the EN pin. Figure 1 represents the equivalent circuit for leakage current but should not be considered an accurate representation of the control circuit.

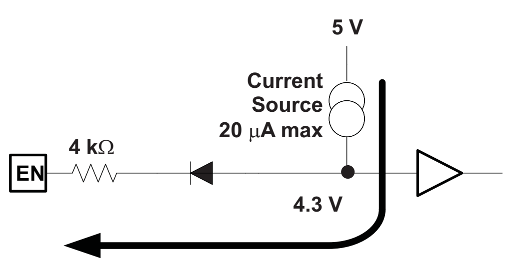

Figure 1. EN Pin Leakage Current Path

4 Test Results

The problem appears as the EN pin is pulled low. If the impedance to ground is low, there is no problem. But impedance in the ground path results in a voltage. If this voltage is high enough, the device does not turn off. The following test results are with an impedance of 200 kΩ. In Figure 2 and in Table 3, V Control is voltage applied to the 200-kΩ resistor and V-EN is voltage at the EN pin 4 .

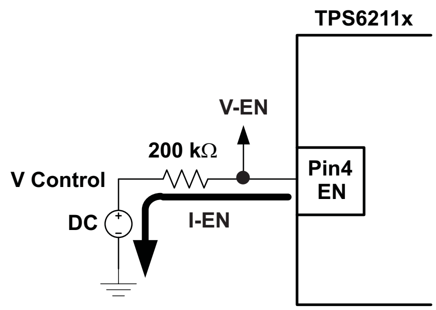

Figure 2. Test Circuit

Table 3. Test Results

V Control	V-EN	I-EN, µA
0	1.098	5.46
1	2.126	5.34
2	2.994	4.88
3	3.867	3.93
4	4.62	2.67
5	5.28	1.3
6	5.92	0.586

Note that with the control voltage at 0 V, the EN pin voltage is ~1.1 V above the 0.3 V required for turn off. Current out of the EN pin for this device is ~5.5 µA, which is below the maximum specification of 20 µA. As V control is increased, it can be seen that the body diode is reverse biased by 6 V and the leakage current is less that 1 µA.

5 Drive Circuit

Figure 3 shows a circuit with potential problems; the pulldown resistor presents too much impedance for the leakage current and prevents the device from turning off.

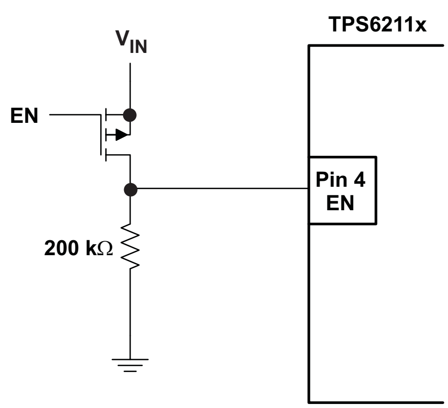

Figure 3. Circuit With Potential Turnoff Problems

Figure 4 shows the recommended drive circuit and its performance.

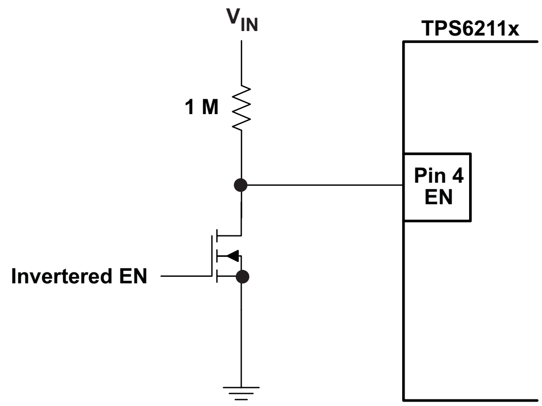

Figure 4. Drive Circuit Example 1