Enabling Multiple TPS4019x Devices

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ABSTRACT

The TPS4019x (TPS40190, TPS40192, TPS40193, TPS40195, TPS40197) family of DC/DC synchronous buck controllers have an internal structure on the Enable input that is somewhat uncommon and requires care when connecting multiple enable pins together. This application report discusses specific solutions which address this issue so a single control signal can reliably drive the ENABLE pins of multiple TPS4019x devices.

The TPS4019x (TPS40190, TPS40192, TPS40193, TPS40195, TPS40197) family of DC/DC synchronous buck controllers have an internal structure on the Enable input that is somewhat uncommon and requires care when connecting multiple enable pins together. As shown in Figure 1, the structure of the Enable input of the TPS4019x family has a Darlington transistor followed by a diode in parallel with a 1kΩ pull-down resistor through an N-channel MOSFET. Once the Enable threshold has been achieved, the voltage on the ENABLE pin will be self-clamped. When that happens, one controller can meet its Enable V_{IH} requirement before the other(s), and it clamps the voltage on the common Enable node. This pulls the Enable voltage on the other part(s) below their respective Enable thresholds and can prevent them from turning on.

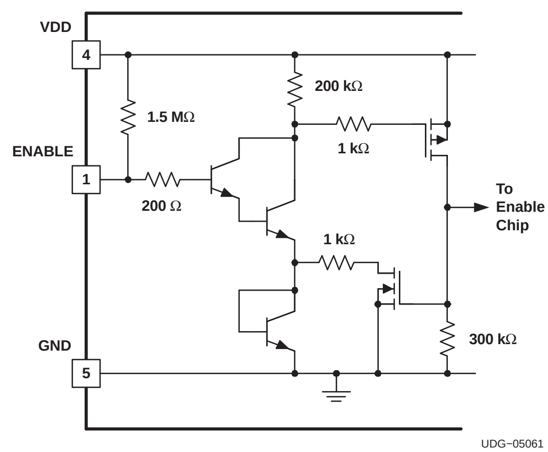

Figure 1. TPS4019x Enable Input Structure

Initially, the ENABLE pin voltage will be clamped to the three V_{be} forward voltages in series; this subsequently turns on the lower MOSFET pulling down the 1kΩ resistor, clamping the ENABLE pin to its steady-state voltage. The Enable voltage waveform is shown in Figure 2. The conditions for this waveform are the same as described in the Discrete Small Signal Transistor Method section, see Figure 3.

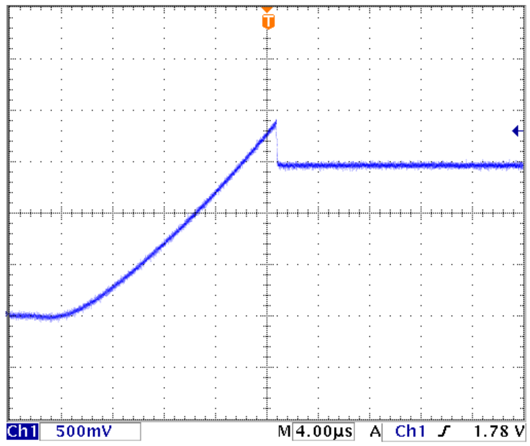

Figure 2. Voltage on the ENABLE Pin of a TPS4019x Device

There are a variety of solutions to this problem, all of which are relatively easy to implement and are very low in cost. The main idea of each solution should be to isolate/buffer the clamped voltage on the ENABLE pin of a given device from the ENABLE pins on subsequent TPS4019x controllers. The following are a few ideas which may benefit a designer in ensuring reliable turn-on of multiple TPS4019x controllers from a single enable control signal.

Discrete Small Signal Transistor Method

Using a single discreet small signal transistor is one alternative that is a low cost and effective means of buffering the ENABLE pin. This option could be configured as shown in the data sheet and as shown in Figure 3. Note that there is an internal 1.5MΩ pull-up resistor (see Figure 1) which satisfies the need for a pull-up resistor. Of course, the base/gates of the individual transistors could be tied together to enable multiple TPS4019x controllers with a single enable signal.

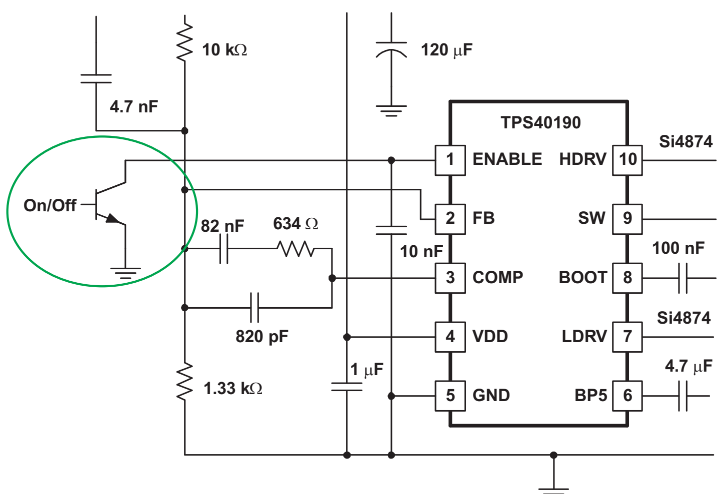

Figure 3. Discrete Transistor Buffer

An open drain buffer/driver like the SN74LVC2G07 could be used in place of the discrete transistor shown in Figure 3. Again the internal 1.5MΩ pull-up resistor could be used as noted previously. However, if an external pull-up resistor is required, the current into the ENABLE pin must be limited to less than 500µA. Therefore, it is important to correctly select the pull-up resistor on the open drain output of the buffer. The steady-state current into the ENABLE pin will simply be:

$$I_{enable} = (V_{cc} - V_{enable}) / R_{pullup} \quad (1)$$

V_{cc} is the supply voltage to pull up Enable. For V_{enable}, use V_{IL} (min) 0.6V from the datasheet.

Resistive Divider Method

Yet another option for isolating the ENABLE pins of multiple TPS4019x controllers is a resistive divider method as shown in Figure 4.

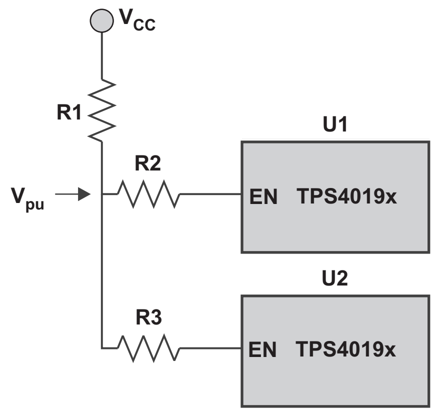

Figure 4. Block Diagram for Resistive Divider Method

In this case a designer selects the resistor values such that:

1. The current into the ENABLE pin is limited to less than 500µA
2. V_{pu} is high enough to enable both parts; though one before the other

The nodal equation for the enable circuit in Figure 4 is as follows:

$$\frac{V_{cc} - V_{pu}}{R1} + \frac{V_{IL} - V_{pu}}{R2} - \frac{V_{dd} - V_{IH}}{1.5M\Omega} = 0 \quad (2)$$

Example:

Calculate the V_{pu} level using values in the TPS40190 datasheet for the values of V_{IL} and V_{IH} and selecting values for V_{cc} and V_{dd} based on a given design.

V_{IL} = 0.6V (worst case clamped enable voltage on first TPS40190 enabled)

V_{IH} = 2.8V (worst case threshold to enable the second TPS40190, use Table 1 based on selected device)

Table 1. Enable V_{IH} Max Values of TPS4019x Devices

Device	TPS40190	TPS40192	TPS40193	TPS40195	TPS40197
Enable V_{IH} max (V)	2.8	3.0	3.0	3.0	3.0

Let R1 = 4.9kΩ, R2 = R3 = 24.9 kΩ, V_{cc} = 3.3V, V_{dd} = 12V

Solving for V_{pu}:

$$V_{pu} = \frac{V_{cc} \times R2 + V_{IL} \times R1}{R2 + R1} - \frac{(V_{dd} - V_{IH})(R1 \times R2)}{1.5M\Omega(R2 + R1)} \quad (3)$$

V_{pu} = 2.83V

Since V_{pu} is higher than V_{IH}, the second TPS40190 also can be turned on. The current into both ENABLE pins is limited to less than 500µA.

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