Low Voltage (0V–5.5V) Hot-Swap Application Using TPS2300/2301

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ABSTRACT

This application note illustrates the use of the TPS2300/2301 for low voltage applications. The TPS2300/2301/2310/2311/2320/2321 are dual-channel hot-swap controllers that eliminate high frequency hot-plug or hot-removal transients, reduce inrush current, and provide overcurrent protection. The TPS2300/2301/2310/2311/2320/2321 can be easily configured for low voltage applications and are capable of operating with input supply voltages all the way down to zero volts. The low voltage operating range of 0 V–5.5 V makes the TPS2300/2301/2310/2311/2320/2321 useful for numerous digital and signaling applications.

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Introduction

With the rapid growth of DSP applications, more systems are employing low supply voltages. In the portable computing area, operating voltages are projected to decrease from 1.5 V in 2001 to 0.3 V in 2014. Furthermore, future microprocessors are expected to require lower voltages, probably about 1 V. Since recent electronic systems often operate on less than 3 V, hot-swap controllers for low voltages are already needed, and their importance will increase with time.

To assist designers in the evaluation of the hot-swap controllers for low voltage applications, an application circuit using TPS2300/2301 has been developed. This application note describes the circuit and presents test results.

Description

Both the TPS2300 and TPS2301 are dual-channel hot-swap controllers that use external N-channel MOSFETs as high-side switches. These devices integrate features such as overcurrent protection, inrush current control, output-power status reporting, and separation of load transients from actual increases in load current. The TPS2300 and TPS2301 differ only in the polarity of the enable pin. For a detailed description of functions and characteristics of the TPS2300 and TPS2301, refer to the data sheet (literature number SLVS265A). The minimum number of external parts for each channel is four: an N-channel MOSFET, a current-sense resistor, a current-limit-setting resistor, and a timing capacitor. The data sheet describes how to select appropriate values for these components.

For low voltage applications, the following factors must be considered:

1. UVLO

   TPS2300/2301 includes an undervoltage lockout (UVLO) that monitors the voltage present on the VREG pin. Since VREG is fed from Vi1 through a low-dropout voltage regulator, the voltage on VREG will track the voltage on Vi1. This connection precludes operation with Vi1 less than 3.0 V. The UVLO does not sense Vi2, so this channel can operate at voltages below 3.0 V.

2. Power Good Signals

   Vsense1 and Vsense2 are used to detect output undervoltage conditions. When Vsense1 senses a voltage below approximately 1.23 V, PWGD1 is pulled down. Similarly, a voltage less than 1.23 V on Vsense2 causes PWRGD2 to be pulled low. The power good feature cannot be used if the output voltage is below 1.23 V. However, the voltages applied to the Vsense1 and Vsense2 pins in no way affect the operation of the MOSFET switches. Thus, for applications involving voltages of less than roughly 1.3 V, the power good feature is left unused.

Figure 1 shows a simplified circuit diagram using TPS2300 for low voltage applications.

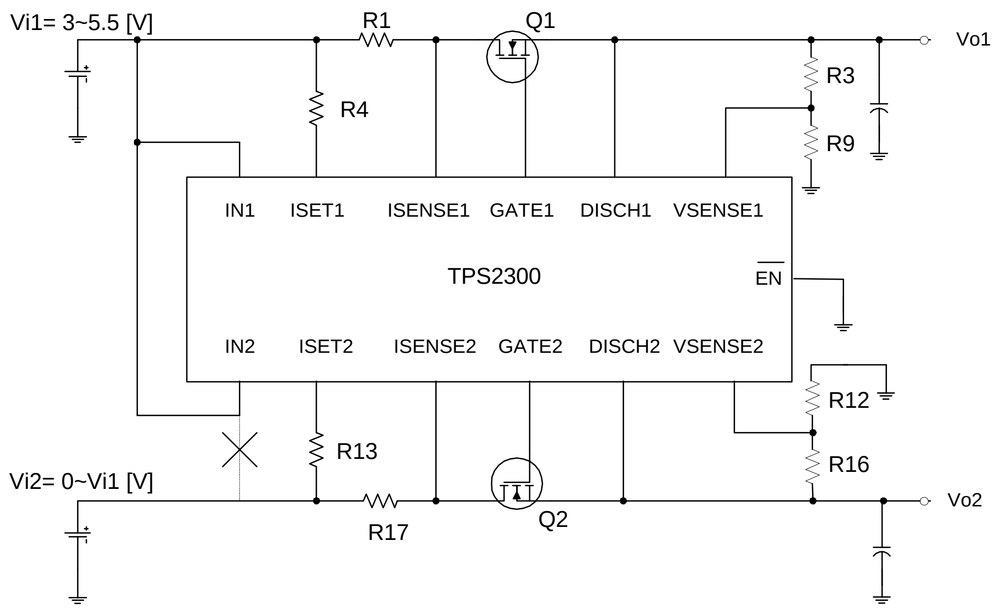

Figure 1. Simplified Circuit Diagram for Low Voltage Applications

The TPS2300/2301 was designed to operate with the IN1 and IN2 pins connected to the input voltages fed to the respective channels. For proper operation, the voltages on both these pins (IN1, IN2) should not fall below 3 V. For low voltage applications, the IN2 pin is connected to the supply for channel 1 (Vi1) rather than to the supply for channel 2 (Vi2) to ensure adequate operating voltage. When the device is configured in this manner, Vi2 must always be less than or equal to Vi1. The current limit thresholds remain user-configurable; see data sheet for details.

Table 1. Operating Specifications for Figure 1

Channel	Input Voltage Range [V]	Output Voltage Range [V]
1	Vi1=3–5.5	Vo1=3–5.5
2	Vi2=0–Vi1	Vo2=0–Vi1

This application circuit can be used for any pair of TI DSP supply voltages (such as 0.9V/3.3 V, 1.2/3.3 V, 1.5/3.3 V, 1.6/3.3 V, 1.8/3.3 V, 1.9/3.3 V, 2.5/3.3 V, 3.3/3.3 V, 3.3/5 V, 5/5 V, and others). It is also suitable for many other applications.

Power Good Signal

Vsense1 and Vsense2 are used to detect output under-voltage conditions. When Vsense1 senses a voltage below approximately 1.23 V, PWGD1 is pulled down. Similarly, a voltage less than 1.23 V on Vsense2 causes PWRGD2 to be pulled low. These pins are used to sense a threshold voltage greater than 1.23 V by connecting an external resistor divider from Vout to ground. The resistor values are derived with the following equations:

$$R3 = \frac{R9(V_{o1\_\min} - V_{ref})}{V_{ref}}$$ for channel 1 and $$R16 = \frac{R12(V_{o2\_\min} - V_{ref})}{V_{ref}}$$ for channel 2

where V_{o1_min} and V_{o2_min} are the minimum required output voltages, and V_{ref} is an internal voltage reference (1.225V $\pm 2\%$). For applications where Vo2<1.3V, the channel 2 power-good circuit should be disabled by connecting its input, Vsense2, to ground through a 47 kΩ resistor.

Table 2 shows the list of recommended resistor values for Power Good signals.

Table 2. Resistor Selection for Power Good Signals

Output Voltage [Vo]	Channel 1		Channel 2	
	R9[Ω]	R3[Ω]	R12[Ω]	R16[Ω]
5	49.9 k	158 k	49.9 k	158 k
3.3	43 k	75.25 k	43 k	75.25 k
2.5			47 k	51 k
1.9			47 k	27.4 k
1.8			41.2 k	20.5 k
1.6			41.2 k	13.7 k
1.5			47 k	11.8 k
1.2			47 k	†
0.9			47 k	†
0.8			47 k	†
↓			47 k	†
0			47 k	†

†Below 1.3 V omit this resistor. The PWRGD2 pin may then be left unconnected.

Schematic and Bill of Materials

Figure 2 shows the schematic for a low voltage application circuit. Switch S1 is used for easy selection between two input modes; one is normal input mode and the other is low voltage input mode Table 3 shows the corresponding voltage ranges of each mode. Table 4 lists the bill of materials (BOM).

Table 3. Mode Selection Switch

Mode (S1)	Channel	Input Voltage Range [V]	Output Voltage Range [V]
Low voltage input	1	Vi1=3–5.5	Vo1=3–5.5
	2	Vi2=0–Vi1	Vo2=0–Vi1
Normal input	1	Vi1=3–13	Vo1=3–13
	2	Vi2=3–5.5	Vo2=3–5.5

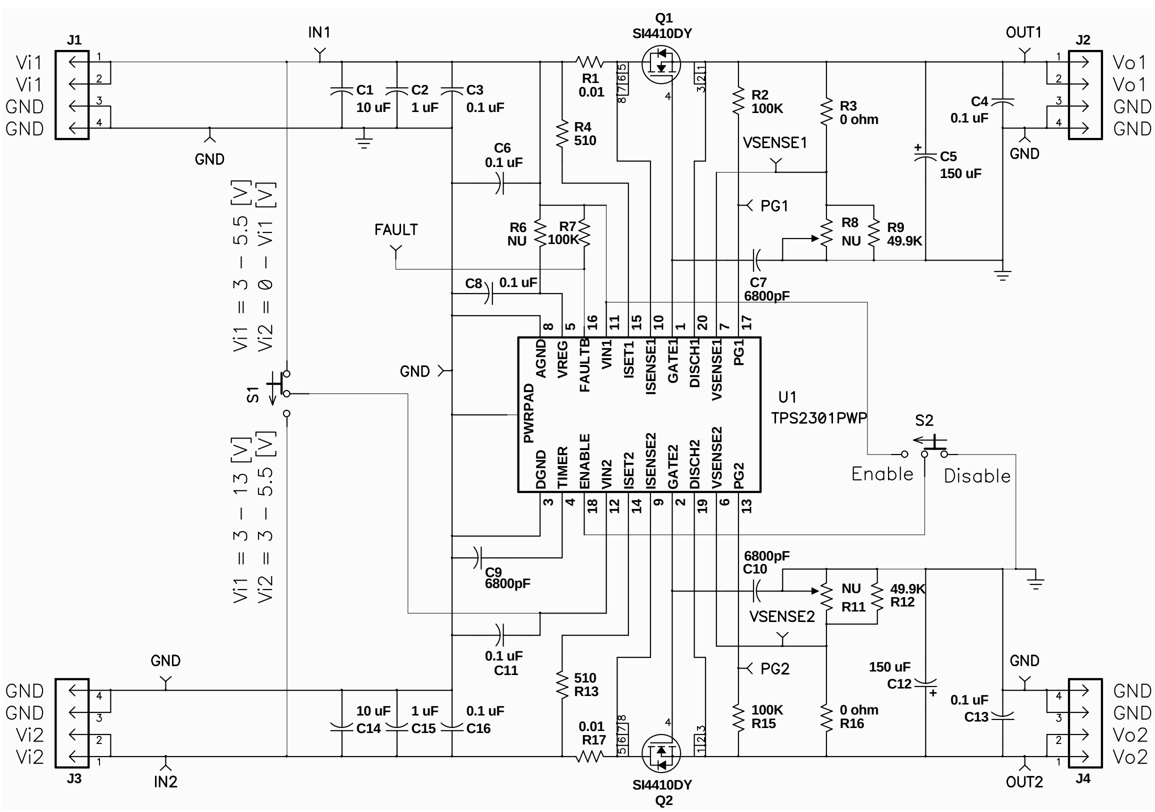

Figure 2. TPS2301 Schematic for Low Voltage Applications

Table 4. Bill of Materials for Figure 2

Reference Designator	Qty	Part Number	Description	Mfg	Size
C1, C14	2	GRM235Y5V106Z016A	Capacitor, ceramic, 10 µF, 16 V, +80%-20%, Y5V	TDK	1210
C2, C15	2	ECJ-2VF1C105Z	Capacitor, ceramic, 1.0 µF, 16 V, +80%-20%, Y5V	Panasonic	805
C3, C4, C6, C8, C11, C13, C16	7	ECJ-2VB1E104K	Capacitor, ceramic, 0.1 µF, 25 V, 10%, X7R	Murata	805
C5, C12	2	TPSD157M016R150	Capacitor, tantalum 150 µF, 16 V, 150 mΩ, 20%	AVX	D Case
C7, C9, C10	3	ECJ-2VB2A682K	Capacitor, ceramic, 6800 pF, 50 V, 10%, X7R	Murata	805
J1, J2, J3, J4	4	PTC36SAAN	Header, single row, straight, 4 pin, 0.100 in. x 25 mil	Sullins	0.1 in.
Q1, Q2	2	Si4410DY	MOSFET, N-chan, 30 V, 10 A, 13 mΩ	Siliconix	SO-8
R1, R17	2	WSL-2512 0R01 1%	Resistor, chip, 0.010 Ω, 1 W, 1%	Vishay	2512
R2, R7, R15	3	ERJ-8GEYJ104V	Resistor, chip, 100 kΩ, 1/8 W, 1%	Panasonic	1206
R3, R16	2	ERJ-8GEY0R00V	Resistor, chip, 0 Ω, 1/8 W, 1%	Panasonic	1206
R4, R13	2	ERJ-8GEYJ511V	Resistor, chip, 510 Ω, 1/8 W, 1%	Panasonic	1206
R6, R8, R11	0		NU		
R9, R12	2	ERJ-8ENF4992V	Resistor, chip, 49.9 kΩ, 1/8 W, 1%	Panasonic	1206
TP1, TP2, TP5, TP6, TP7, TP9, TP10, TP13, TP14	9	240-345	Test point, red, 1 mm	Farnell	1 mm
TP3, TP4, TP8, TP11, TP12	5	240-333	Test point, black, 1 mm	Farnell	1 mm
S1, S2	2	09-03201-02	Slide switch	EAO	500 mA
U1	1	TPS2301PWP	IC, dual hot swap controller	TI	

Test Results

Figure 3 through Figure 6 show the test results for low voltage applications.

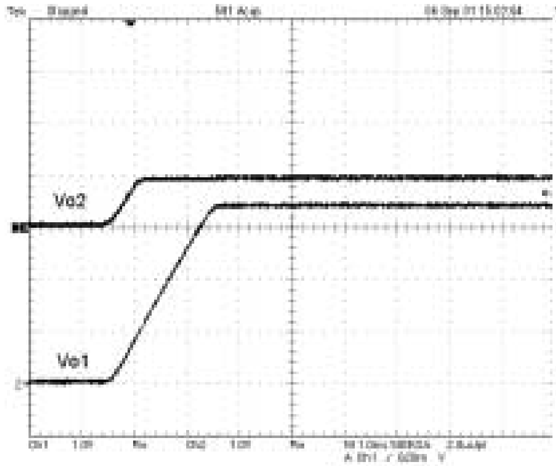

Figure 3. Hot Swap (Vo1=3.3 V, Vo2=0.9 V)

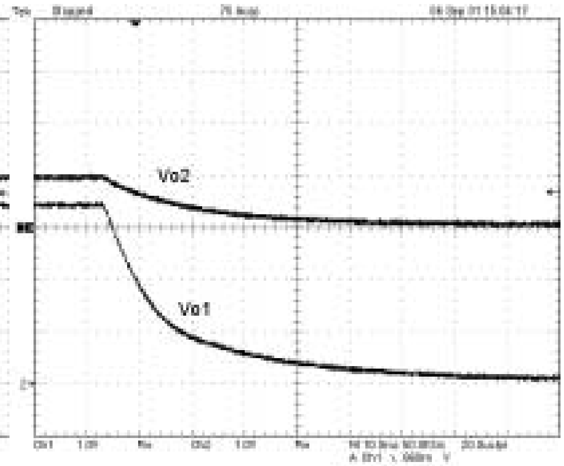

Figure 4. Hot Removal (Vo1=3.3 V, Vo2=0.9 V)

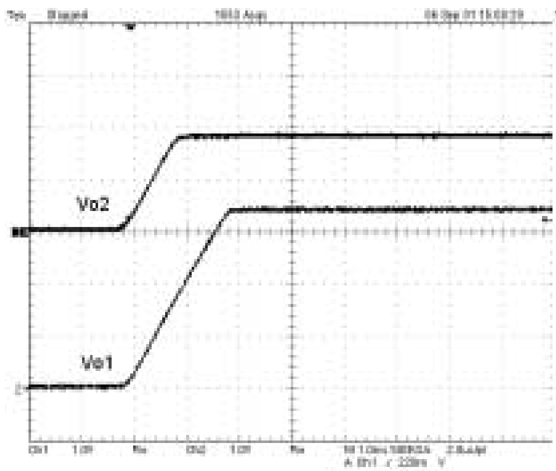

Figure 5. Hot Swap (Vo1=3.3 V, Vo2=1.8 V)

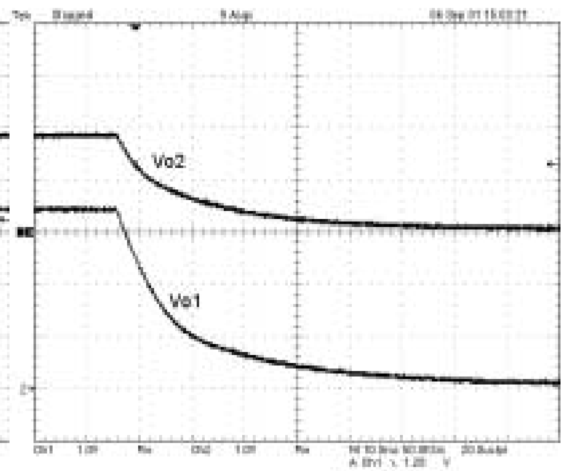

Figure 6. Hot Removal (Vo1=3.3 V, Vo2=1.8 V)

Conclusion

The application circuit of TPS2300/2301 has been developed, and the test results show that the low operating voltage range of the TPS2300/2301 hot-swap controllers make them suitable for numerous low voltage digital and signaling applications. The application circuit can be applied to TPS2310/11 and TPS2320/2321.

Reference

1. TPS2300 (hot swap controller) data sheet, Texas Instruments literature number SLVS265A.

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