

# **Low Cost 1W Isolated Power Supply Solution with TPS61085**

*Junwei Wu*
*PMP-DCDC Low Power Converters*

## **ABSTRACT**

This paper introduces a low cost 1 to approximately 2W isolated power supply solution with TPS61085. It is a useful solution in industry applications which need a low power isolated supply, such as the RS485 interface.

## **Contents**

1	Introduction .....	1
2	Flyback Circuit Design with TPS61085 .....	2
2.1	Power Specification .....	2
2.2	Reference Schematics .....	2
2.3	Frequency Selection .....	3
2.4	Transformer Design .....	3
2.5	Output Voltage Setting .....	4
2.6	Compensation Circuit .....	4
2.7	Input and Output Capacitors .....	4
3	Test Results for the Flyback Solution with TPS61085 .....	5
4	Conclusion .....	6
5	Reference .....	6

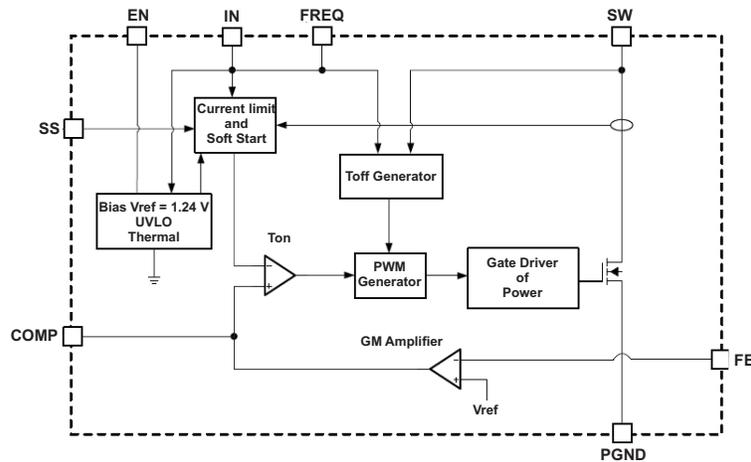
## **List of Figures**

1	Internal Block Diagram of TPS61085 .....	2
2	Schematic for 5V Isolated Power Supply with TPS61085 .....	2
3	Efficiency with 5V Input .....	5
4	Load Regulation with 5V Input .....	5
5	TPS61085 12V Isolated Solution with TL431 (Paper Design) .....	6

## **1 Introduction**

For industry applications, such as RS485 and isolated CAN transceivers, a mini power isolated power supply is required. The isolated flyback topology is suitable for these applications, due to its simple implementation and low cost.

It is possible to use a non-synchronous low voltage boost converter to build an isolated flyback power supply. This paper chooses TPS61085 as an example, which has an integrated 2A, 20V MOSFET, as shown in [Figure 1](#). The input voltage range of TPS61085 is 2.3V to approximately 6V. With the isolated solution with TPS61085, it is possible to get 5V with an isolation voltage of 2.5kV or 4kV (the isolation voltage is determined by the isolation transformer) from a 3.3V or 5V system.


**Figure 1. Internal Block Diagram of TPS61085**

## 2 Flyback Circuit Design with TPS61085

### 2.1 Power Specification

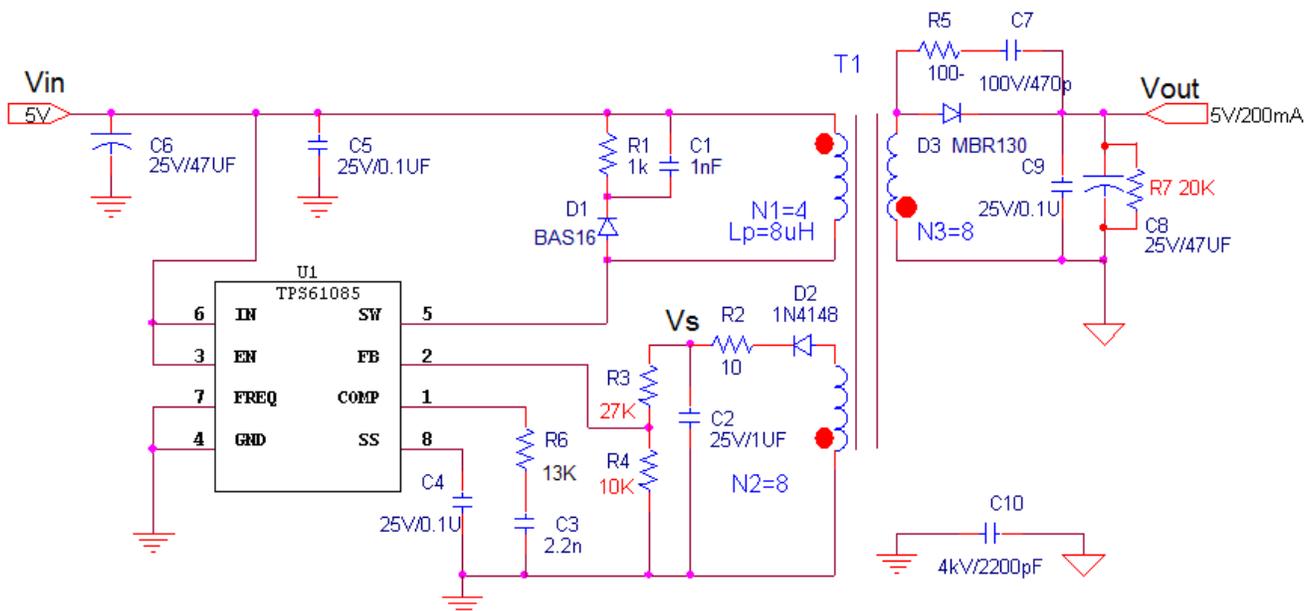
This paper gives a design example for an isolated power supply for a RS485 interface with TPS61085.

The specification in detail for the isolated RS485 application follows:

- Input voltage: 4.5V to approximately 5.5V
- Output voltage: 4.5V to approximately 5.5V (The voltage range is recommended in SN65HVD3082's data sheet, which is the RS-485 transceiver)
- Output current: 200mA.

### 2.2 Reference Schematics

Figure 2 is the schematics for the 5V -> 5V isolated power supply.


**Figure 2. Schematic for 5V Isolated Power Supply with TPS61085**

### 2.3 Frequency Selection

The TPS61085's frequency select pin, **FREQ**, allows to set the switching frequency of the device to 650 kHz (**FREQ** = low) or 1.2 MHz (**FREQ** = high). For this isolated power supply solution, the low frequency is preferred because higher switching frequencies cause more switching losses, EMI issues, and so on.

### 2.4 Transformer Design

There are two ways to design the transformer for the flyback converter. One is using the maximum duty cycle for the PWM controller; another is using the reflected voltage from the secondary-side.

TPS61085 has an integrated 20V MOSFET, thus the maximum drain-source voltage,  $V_{DS}$ , of the MOSFET is fixed and; therefore, the second method is used in this paper. Using 70% derating for the internal MOSFET, approximate the maximum allowed reflected secondary-side voltage of the MOSFET using [Equation 1](#):

$$V_{\text{reflect}} = 0.7 \times V_{DS} - V_L - V_{IN(\text{max})} = 0.7 \times 20 \text{ V} - 5.5 \text{ V} - 5.5 \text{ V} = 3 \text{ V} \quad (1)$$

where  $V_{DS}$  is the required drain to source voltage rating of the internal MOSFET.  $V_L$  is the voltage spike due to the leakage inductance of the transformer, estimated to be equal to  $V_{IN(\text{max})}$ .

The ratio of the transformer can be calculated by using [Equation 2](#):

$$N = \frac{N_P}{N_S} = \frac{V_{\text{reflect}}}{V_{\text{out}} + V_F} = \frac{3 \text{ V}}{5 \text{ V} + 0.6 \text{ V}} = 0.54 \approx 0.5 \quad (2)$$

$V_F$  is the forward voltage drop across the rectifier schottky diode, which is assumed to be 0.6V. To simplify the transformer ratio, we used  $N_P/N_S$  of 0.5 instead of 0.54.

The maximum duty cycle of the flyback converter is:

$$D_{\text{max}} = \frac{N \times (V_{\text{out}} + V_F)}{V_{\text{inmin}} + N \times (V_{\text{out}} + V_F)} = \frac{0.5 \times (5 \text{ V} + 0.6 \text{ V})}{4.5 \text{ V} + 0.5 \times (5 \text{ V} + 0.6 \text{ V})} = 0.36 \quad (3)$$

To calculate the primary inductance,  $\Delta I_L$  is set to half the primary current as an acceptable ripple current. For a CCM flyback design, the peak primary current is then calculated as:

$$I_{\text{peak}} = \frac{I_{O\text{max}}}{N(1 - D_{\text{max}})} + \frac{\Delta I_L}{2} \quad (4)$$

By replacing  $\Delta I_L$  with  $\frac{1}{2}(I_{\text{Peak}})$ ,  $I_{O\text{max}}$  with 0.2A,  $D_{\text{max}}$  with 0.36, and  $N$  with 0.5 which was calculated earlier, the peak primary current is calculated to be 0.625A and  $\Delta I_L$  calculates to 0.313A.

The inductance of the transformer's primary-side is calculated as follows:

$$L_P = V_{\text{in}(\text{min})} \times \frac{D_{\text{max}}}{f \times \Delta I_L} = 4.5 \text{ V} \times \frac{0.36}{650 \text{ kHz} \times 0.313 \text{ A}} = 8 \mu\text{H} \quad (5)$$

For the mini-power application, we can choose a small magnetic core, such as EE8. The  $A_e$  of the EE8 core is 7mm<sup>2</sup>.

$$N_P = \frac{V_{\text{inmin}} \times D_{\text{max}}}{A_e \times B_{\text{max}} \times f_{\text{min}}} = \frac{4.5 \text{ V} \times 0.36}{7 \text{ mm}^2 \times 0.15 \text{ T} \times 480 \text{ kHz}} = 3.2 \approx 4 \quad (6)$$

$$N_S = N_P / N = 4 / 0.5 = 8 \quad (7)$$

## 2.5 Output Voltage Setting

To reduce the cost, the circuit uses an auxiliary winding on the primary-side of the transformer, N2, which can save the cost for the optocoupler and a reference like TLV431 as the secondary-side control. As a result, the output load transition is not as good as with secondary-side control, but it is adequate for the RS485's power supply and some other applications.

Choose for N2 the same turns as for N3, the secondary side winding. The voltage at the point  $V_S$  (see [Figure 2](#)) is similar to  $V_{OUT}$ , because the turn ratio of N2:N3 = 1. R3 is chosen to be 10 k $\Omega$  (on the basis of experience), R4 can be calculated with [Equation 8](#):

$$R_4 = \frac{(V_S - V_{FB}) \times R_3}{V_{FB}} \quad (8)$$

$V_{FB}$  is given as 1.238V (the feedback voltage of TPS61085), and  $V_S$  is supposed to be 5V, which leads to a value of R4 of 30k $\Omega$ . For the actual circuit,  $V_S$  varies with the actual turns ratio of N2:N3 and the leakage inductance of the transformer. So R4 needs to be adopted in the actual circuit. In this case, R4 is finally set to 27 k $\Omega$ .

R7 is a dummy load, which can hold the output voltage in the range when there is no load at the output. Reducing the value of R7, can improve the load regulation, but, as a trade off, will increase the no load power dissipation.

## 2.6 Compensation Circuit

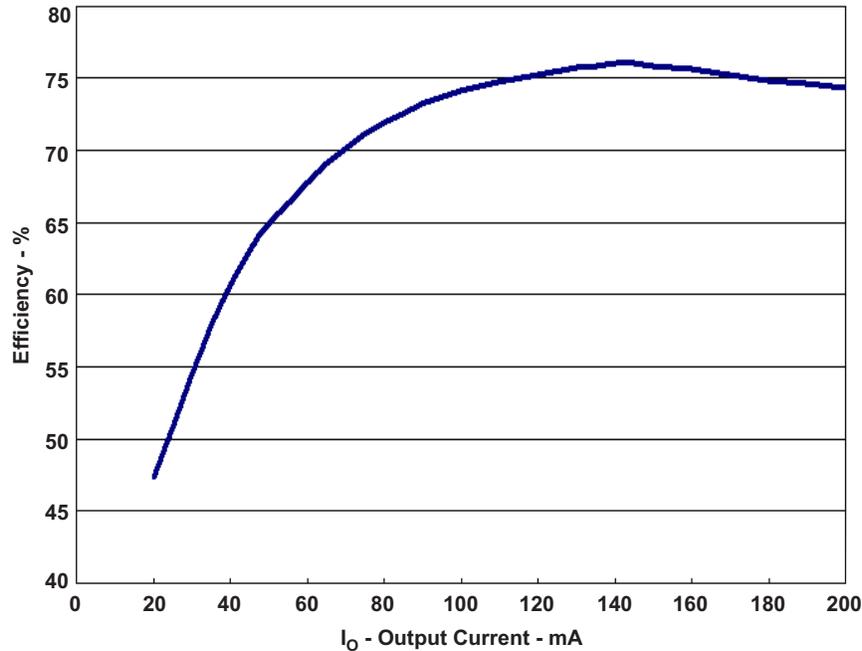
For  $C_{COMP}$ (C3), a value of 2.2nF or 3.3nF is sufficient for most applications.  $R_{COMP}$ (R6) is set as 13k $\Omega$  as recommended in the datasheet.

## 2.7 Input and Output Capacitors

For the input and output capacitors, it is recommended to use the low ESR ceramic capacitor with 10 $\mu$ F. For low cost applications, it is possible to use the capacitor combination of one 47 $\mu$ F electrolytic capacitor and one 0.1 $\mu$ F ceramic capacitor.

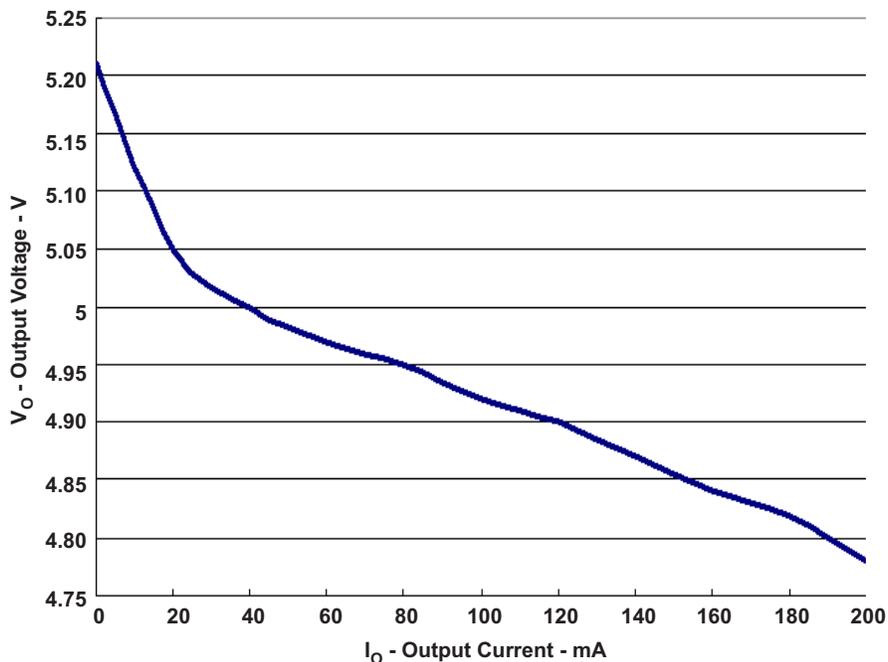
### 3 Test Results for the Flyback Solution with TPS61085

The efficiency for the TPS61085 isolated power solution with an input voltage of 5V is shown above in [Figure 3](#). The efficiency at full load is around 75%, the main power loss of the circuit are the conduction and switching losses of the MOSFET integrated into TPS61085, the conduction loss in the output diode D3, and the power dissipation in the transformer. For light load efficiency, the power dissipation on the dummy load can not be ignored.



**Figure 3. Efficiency with 5V Input**

[Figure 4](#) is the load regulation of this power solution at an input voltage of 5V. The total load regulation is limited to  $\pm 5\%$ , which meets the requirement of the RS485 application.

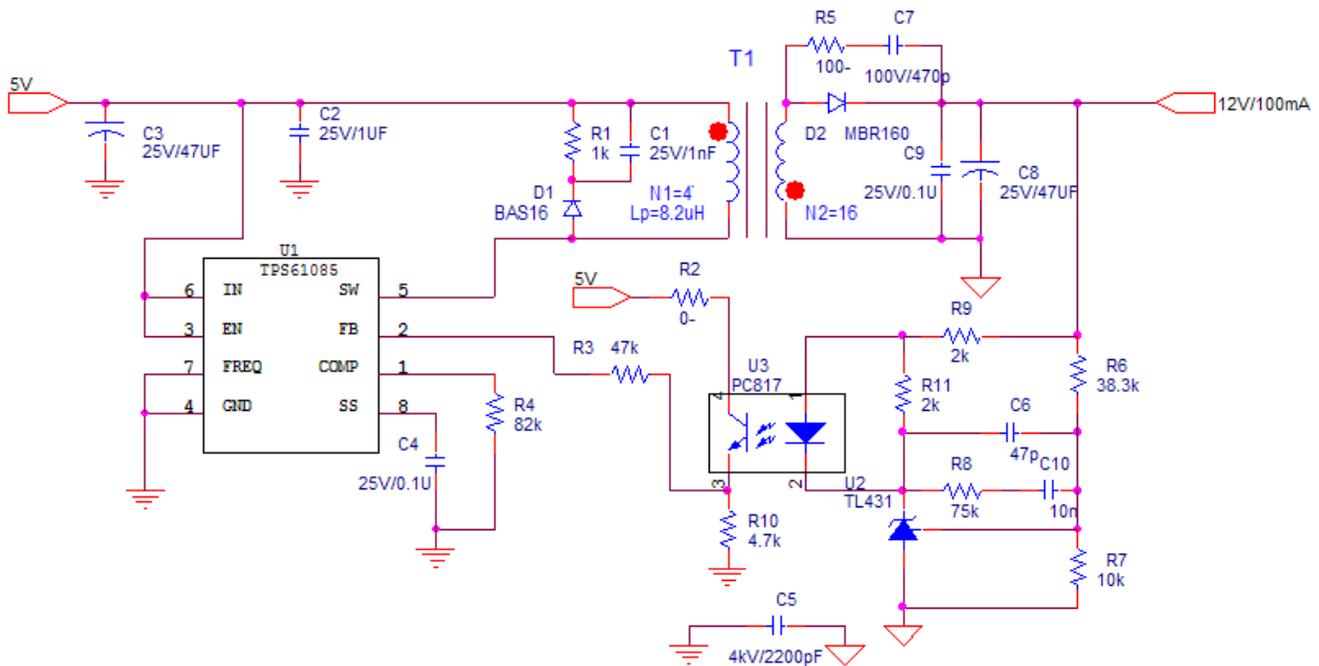


**Figure 4. Load Regulation with 5V Input**

## 4 Conclusion

The application report has introduced the isolated mini-power supply solution with TPS61085 and gives the design process for a 5V to 5V 1W isolated power supply.

In some applications, if a tighter load regulation is required, [Figure 5](#) provides another regulation possibility. It uses secondary side control with an optocoupler and the TL431. [Figure 5](#) demonstrates a solution with a tighter load regulation for a 12V output application. This is a paper design for the 12V output, and some components may require changes in an actual design.



**Figure 5. TPS61085 12V Isolated Solution with TL431 (Paper Design)**

## 5 Reference

U-165 ([SLUU096](#)) Reference Design: Isolated 50 Watt Flyback Converter Using the UCC3809 Primary Side Controller

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2012, Texas Instruments Incorporated