AN-1670 LP38513TJ-ADJ Evaluation Board

1 Introduction

This board is designed to allow the evaluation of the LP38513TJ-ADJ voltage regulator. Each board is assembled and tested in the factory. This evaluation board has the TO-263 THIN 5-lead package mounted, and the output voltage is set to 1.20V.

2 General Description

The LP38513TJ-ADJ is an adjustable LDO linear regulator capable of suppling up to 3A of output current, and incorporates an Enable. The device has been designed to work with 10 µF input and output ceramic capacitors. Footprints areas for C_{IN} and C_{OUT} will allow for a variety of sizes.

3 Operation

The input voltage, applied between V_{IN} and GND, must be no less than 2.25V, which is the low end of the Operating Range voltage, no greater than 5.5V, which is the high end of the Operating Rating voltage.

The input voltage should also be at least 500 mV greater than the set V_{OUT}.

Loads can be connected to V_{OUT} with reference to GND.

V_{OUT} and V_{IN} test points are provided on the board to allow accurate measurements directly onto the input and output pins of the device, eliminating any voltage drop on the PCB traces or connecting wires to the load.

4 Setting V_{OUT}

The output voltage is set using the external resistive divider R1 and R2. The output voltage is given by the formula:

$$V_{OUT} = V_{ADJ} \times (1 + (R1 / R2)) \quad (1)$$

It is recommended that the values selected for R1 and R2 are such that the parallel value is less than 1.00 kΩ. This is to prevent internal parasitic capacitances on the ADJ pin from interfering with the F_Z pole set by R1 and C_{FF}.

$$((R1 \times R2) / (R1 + R2)) \leq 1.00\ k\Omega \quad (2)$$

Table 1 lists some suggested, best fit, standard ±1% resistor values for R1 and R2, and a standard ±10% capacitor values for C_{FF}, for a range of V_{OUT} values. Other values of R1, R2, and C_{FF} are available that will give similar results.

All trademarks are the property of their respective owners.

Copyright © 2009–2013, Texas Instruments Incorporated

Table 1. Resistor Tolerances

V_{OUT}	R1	R2	C_{FF}	F_Z
0.80V	1.07 kΩ	1.78 kΩ	4700 pF	31.6 kHz
1.00V	1.00 kΩ	1.00 kΩ	4700 pF	33.8 kHz
1.20V	1.40 kΩ	1.00 kΩ	3300 pF	34.4 kHz
1.50V	2.00 kΩ	1.00 kΩ	2700 pF	29.5 kHz
1.80V	2.94 kΩ	1.13 kΩ	1500 pF	36.1 kHz
2.00V	1.02 kΩ	340Ω	4700 pF	33.2 kHz
2.50V	1.02 kΩ	255Ω	4700 pF	33.2 kHz
3.00V	1.00 kΩ	200Ω	4700 pF	33.8 kHz
3.30V	2.00 kΩ	357Ω	2700 pF	29.5 kHz

Refer to *AN-1378 Method For Calculating Output Voltage Tolerances in Adjustable Regulators* (SNVA112) for additional information on how resistor tolerances affect the calculated V_{OUT} value.

The LP38513TJ-ADJ evaluation board is assembled with a 1.40 kΩ ±1% resistor for R1, and a 1.00 kΩ ±1% resistor for R2. This sets V_{OUT} to 1.20V.

$$V_{OUT} = 500\ mV \times (1 + (1.40\ k\Omega / 1.00\ k\Omega)) = 1.20V \quad (3)$$

5 Selecting C_{FF}

A capacitor placed across the gain resistor R1 will provide additional phase margin to improve load transient response of the device. This capacitor, C_{FF}, in parallel with R1, will form a zero in the loop response given by the formula:

$$F_Z = (1 / (2 \times \pi \times C_{FF} \times R1)) \quad (4)$$

The value for C_{FF} should be selected to set a zero frequency (F_Z) between 25 kHz and 50 kHz using the formula:

$$C_{FF} = 1 / (2 \times \pi \times F_Z \times R1) \quad (5)$$

The closest standard 10% value is adequate for C_{FF}.

The LP38513TJ-ADJ evaluation board is assembled with a 3300 pF capacitor for C_{FF}. This sets F_Z to approximately 34 kHz.

$$F_Z = (1 / (2 \times \pi \times 3300\ pF \times 1.40\ k\Omega)) = 34.4\ kHz \quad (6)$$

Copyright © 2009–2013, Texas Instruments Incorporated

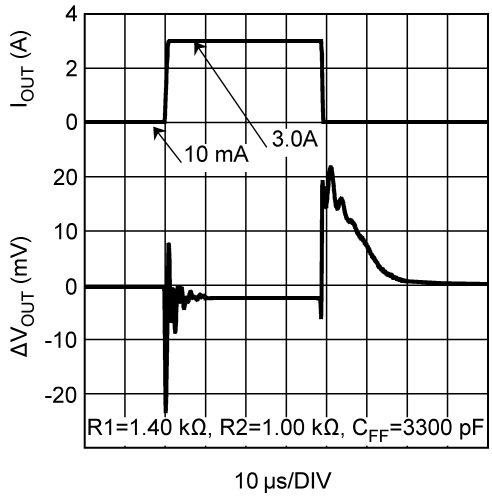


Figure 1. 10 mA to 3A Load Transient Response

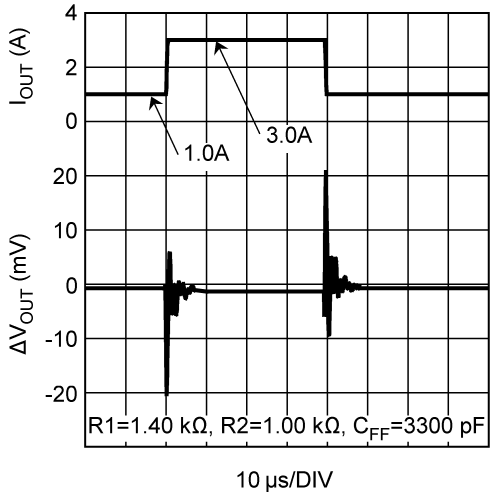


Figure 2. 1A to 3A Load Transient Response

6 Enable Function

ON/OFF control is provided by supplying a logic level signal to the Enable pin. A minimum V_{EN} value of 1.2V is typically required at this pin to enable the LDO output. The LDO output will be shutdown when the V_{EN} value is typically 0.6V or less. The V_{EN} threshold incorporates approximately 100 mV of hysteresis.

Copyright © 2009–2013, Texas Instruments Incorporated

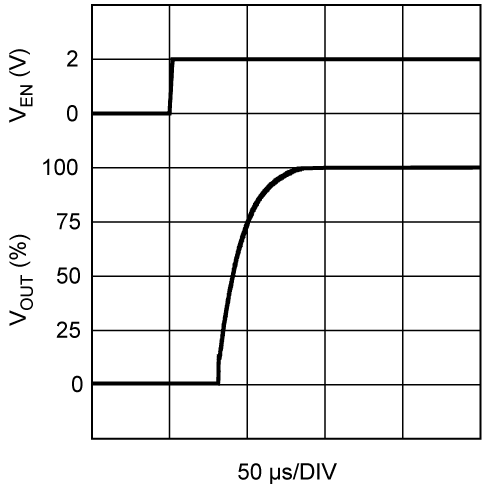


Figure 3. V_{OUT} vs V_{EN}

The Enable pin has no internal default bias and must not be left floating. The Enable pin must be actively driven to the appropriate voltage level. In applications where the LP38513TJ is operated continuously the Enable pin can be connected directly to V_{IN}. The LP38513TJ-ADJ Evaluation board is assembled with a 10 kΩ resistor (R3) to provide pull-up to V_{IN}.

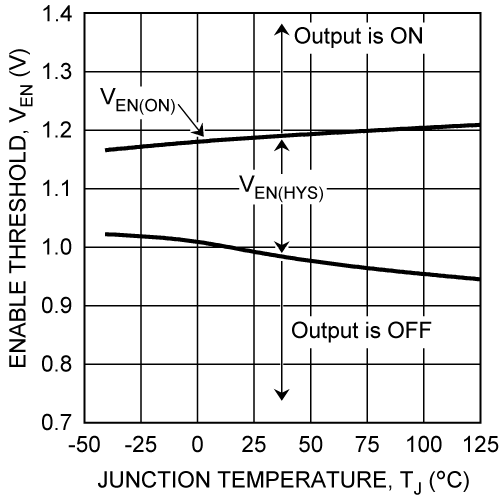


Figure 4. Enable Thresholds

7 Power Dissipation

The TO-263 THIN package alone has a junction to ambient thermal resistance (θ_{JA}) rating of 67°C/W. When mounted on the LP38513TJ-ADJ Evaluation Board the θ_{JA} rating is approximately 35°C/W.

Although there is only approximately 0.20 square inches (0.45in x 0.45in) of 1 ounce copper area immediately under the package body, the top copper surface area is extended to additional copper area on the bottom of the board by fifteen thermal vias.

With the 35°C/W thermal rating the LP38513TJ-ADJ evaluation board will dissipate a maximum of 2.8W with T_A = 25°C.

For a comparison of the TO-263 THIN package to the standard TO-263 package see *AN-1797 TO-263 THIN Package* (SNVA328).

Copyright © 2009–2013, Texas Instruments Incorporated

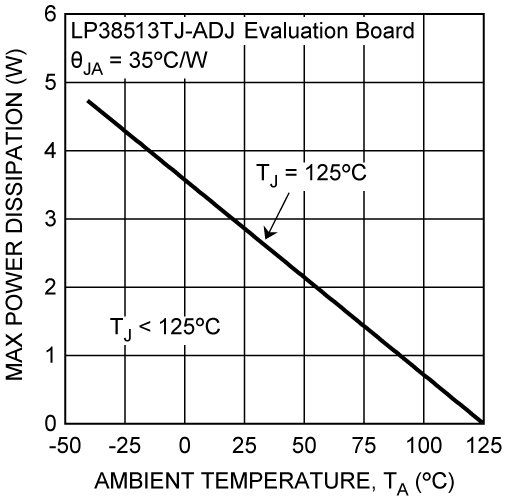
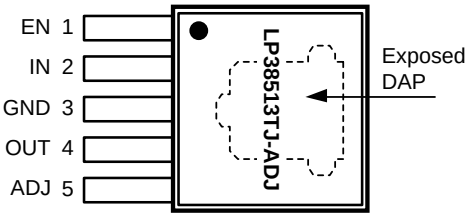


Figure 5. Maximum Power Dissipation vs Ambient Temperature



7.1 Schematic Diagram

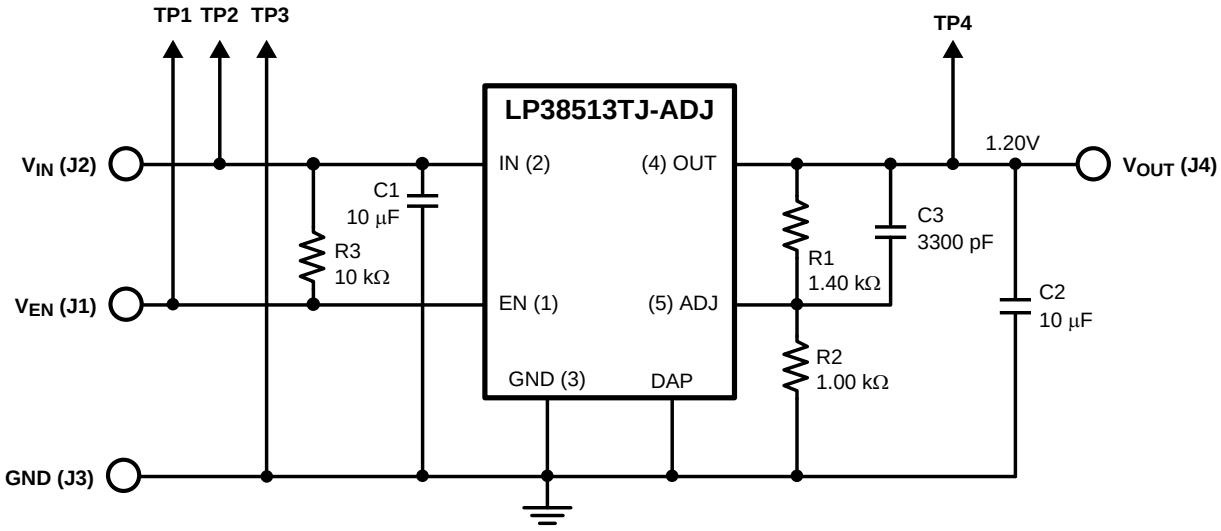


Figure 6. Evaluation Board Schematic.

Copyright © 2009–2013, Texas Instruments Incorporated

8 PCB Layout

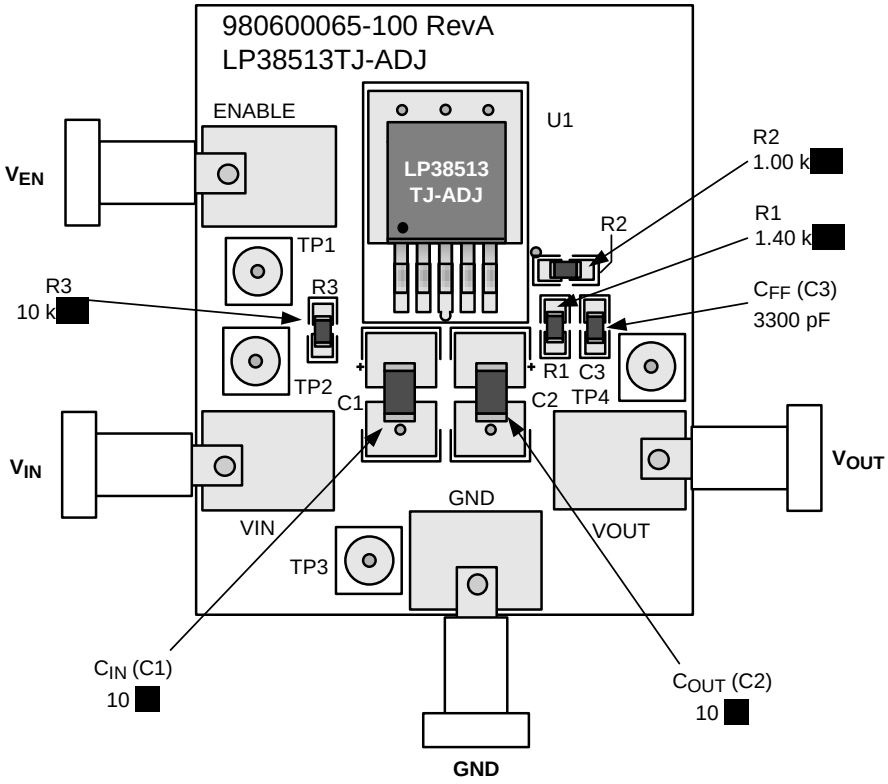


Figure 7. Evaluation Board Component and Pin Layout

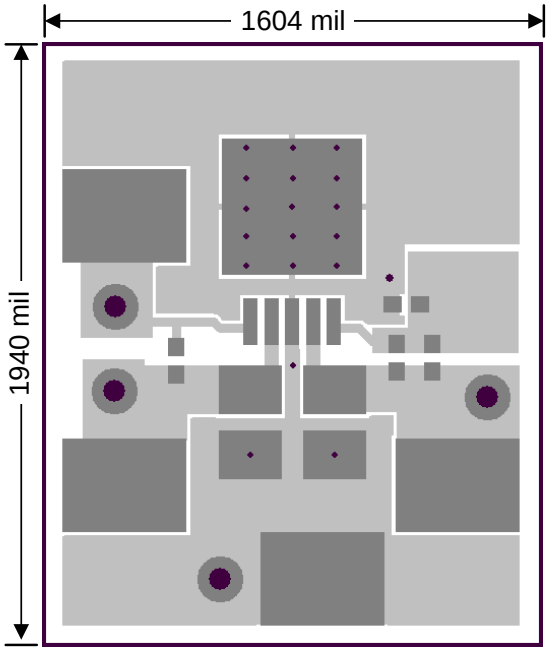


Figure 8. Top Side Copper Area

Copyright © 2009–2013, Texas Instruments Incorporated

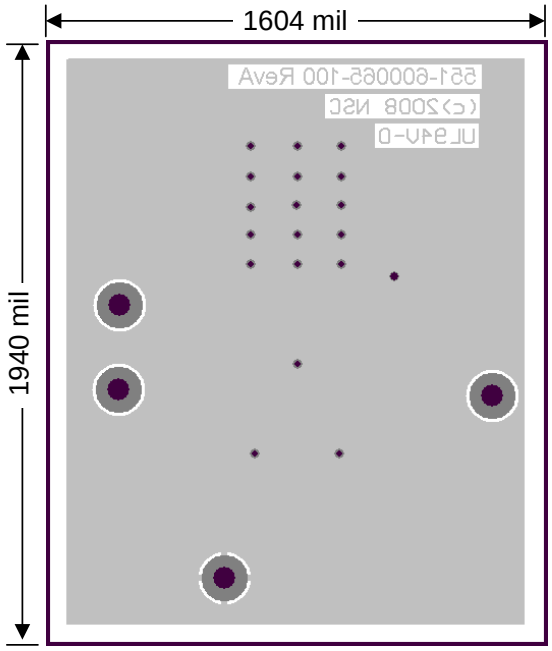


Figure 9. Bottom Side Copper Area

9 Bill of Materials

ID	Name	Description	Manufacturer	Part Number
PCB	PCB	Printed Circuit Board LP38513TJ-ADJ Evaluation Board	Texas Instruments	600065
U1	U1	LP38513	Texas Instruments	LP38513
C1	C_{IN}	Capacitor: 10 µF; ±10%; MLCC; 10V; X7R; 1210	AVX	1210ZC106KAT2A
C2	C_{OUT}	Capacitor: 10 µF;, ±10%; MLCC; 10V; X7R; 1210		1210ZC106KAT2A
C3	C_{FF}	Capacitor: 3300 pF;, ±10%; MLCC; 50V; X7R; 0805	KEMET	C0805C332K5RAC
J1	V_{EN}	Banana Jack : Insulated Solder Terminal; White	Johnson Components	108-0901-001
J2	V_{IN}	Banana Jack : Insulated Solder Terminal; Red		108-0902-001
J3	GND	Banana Jack : Insulated Solder Terminal; Black		108-0903-001
J4	V_{OUT}	Banana Jack : Insulated Solder Terminal; Orange		108-0906-001
R1	R1	Resistor: 1.40 kΩ, ±1%; Thick Film; 125 mW; ±100 ppm; 0805	VISHAY DALE	CRCW08051K40FK
R2	R2	Resistor: 1.00 kΩ, ±1%; Thick Film; 125 mW; ±100 ppm; 0805		CRCW08051K00FK
R3	R3	Resistor: 10.0 kΩ, ±1%; Thick Film; 125 mW; ±100 ppm; 0805		CRCW080510K0FK
TP1	TP_{EN}	Turret Terminal : Mounting Hole Diameter = 0.062”	Keystone	1593–2
TP2	TP_{IN}			
TP3	TP_{GND}			
TP4	TP_{OUT}			

Copyright © 2009–2013, Texas Instruments Incorporated

Copyright © 2009–2013, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2013, Texas Instruments Incorporated