1A Very Low Dropout Voltage Regulator   LM2941

FEATURES

• Guaranteed Output Current of 1.0A
• Very Low Dropout Voltage
• Accurate 1% Initial Tolerance
• Very Low Quiescent Current
• Good Line and Load Regulation
• Extremely Fast Transient Response
• Reverse-Battery/ Load-Dump Protection
• Adjustable Output Voltage up to 25V
• TTL/CMOS Compatible Enable Logic
• Over-Temperature/Over-Current Protection
• Available in TO-263-5L Package
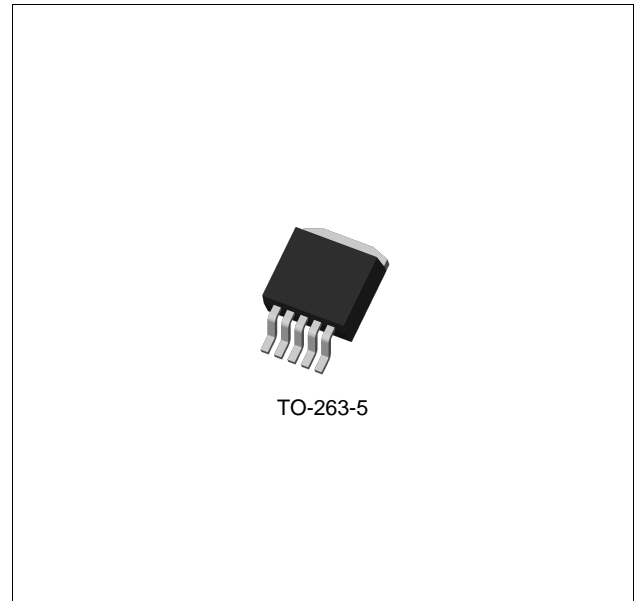• Moisture Sensitivity Level 3

APPLICATIONS

• Battery Powered Equipment
• Automotive Electronics
• High Efficiency Linear Power Supplies
• High Efficiency Post Regulator for Switching Supply

TO-263-5

ORDERING INFORMATION

Device	Package
LM2941R	TO-263-5L

DESCRIPTION

The LM2941 is a high current, high accuracy, and low-dropout voltage regulator. Using process with a PNP pass element, these regulators feature 400mV (full load) dropout voltages and very low ground current. These devices also find applications in lower current, low dropout-critical systems, where their tiny dropout voltage and ground current values are important attributes.

The LM2941 is fully protected against over current faults, reversed input polarity, reversed lead insertion, over temperature operation, and positive and negative transient voltage spikes. LM2941 features logic level enable control and an error flag which signals whenever the output falls out of regulation. The EN pin may be tied to VIN if it is not required for On/Off control.

ABSOLUTE MAXIMUM RATINGS (Note 1)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Input Supply Voltage (Survival)	V_{IN}	−20	30	V
Enable Input Voltage (Survival)	V_{EN}	−20	30	V
Output Voltage (Survival)	V_{OUT}	−0.3	$V_{IN} + 0.3$	V
Storage Temperature Range	T_{STG}	−65	150	°C
Package Thermal Resistance*	$\Theta_{JA\text{-}TO\text{-}263}$	80		°C/W

* No Heat Sink, No Air Flow, No Adjacent Heat Source, 20 mm^2 Copper Area (T_A = 25°C)

RECOMMENDED OPERATING RATINGS (Note 3)

CHARACTERISTIC	SYMBOL	MIN	MAX	UNIT
Input Supply Voltage	V_{IN}	2.3	26	V
Enable Input Voltage	V_{EN}	0	26	V
Operating Junction Temperature Range	T_{JOPR}	−40	125	°C

ORDERING INFORMATION

Package	Order No.	Description	Supplied As	Status
TO-263-5L	LM2941R	1.0A, Adjustable, Enable	Tape & Reel	Active

PIN CONFIGURATION

TO-263-5
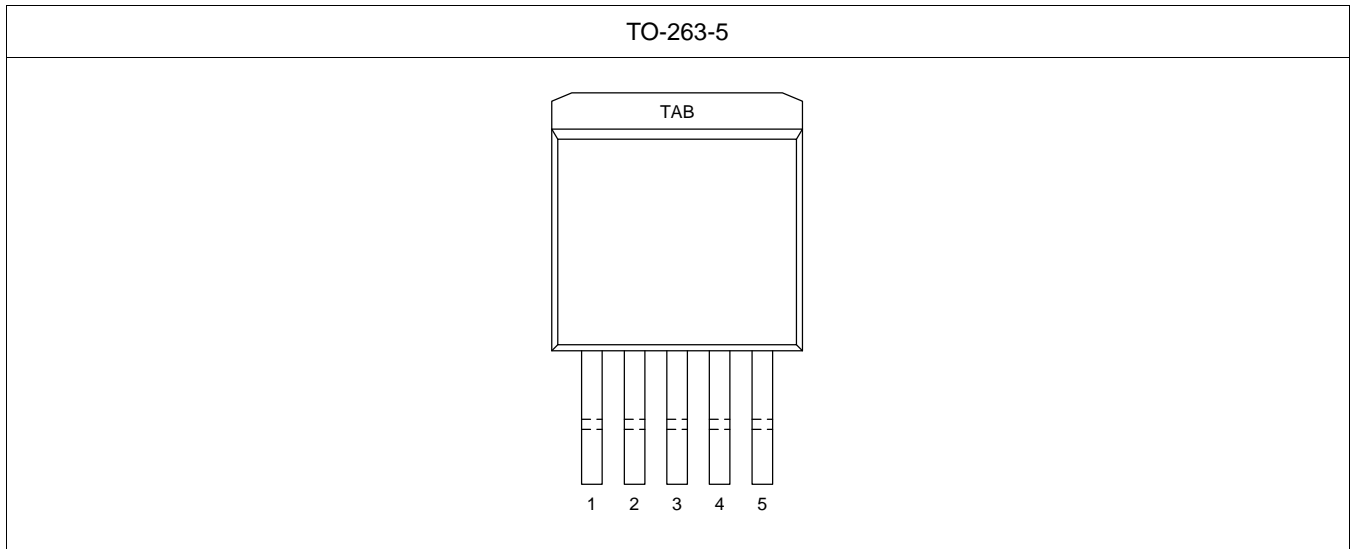
PIN DESCRIPTION

Pin No.	Pin Name	Pin Function
1	ADJ	Output Voltage Adjust Input. Connect an external voltage divider to determine the output voltage.
2	EN (ON/OFF)	Chip Enable. Do not float. Logic high will turn on the device.
3	GND	Ground.
4	IN	Input Supply.
5	OUT	Output Voltage.
TAB	GND	Connect to GND. Put a copper plane connected to this pin as a thermal relief.

BLOCK DIAGRAM
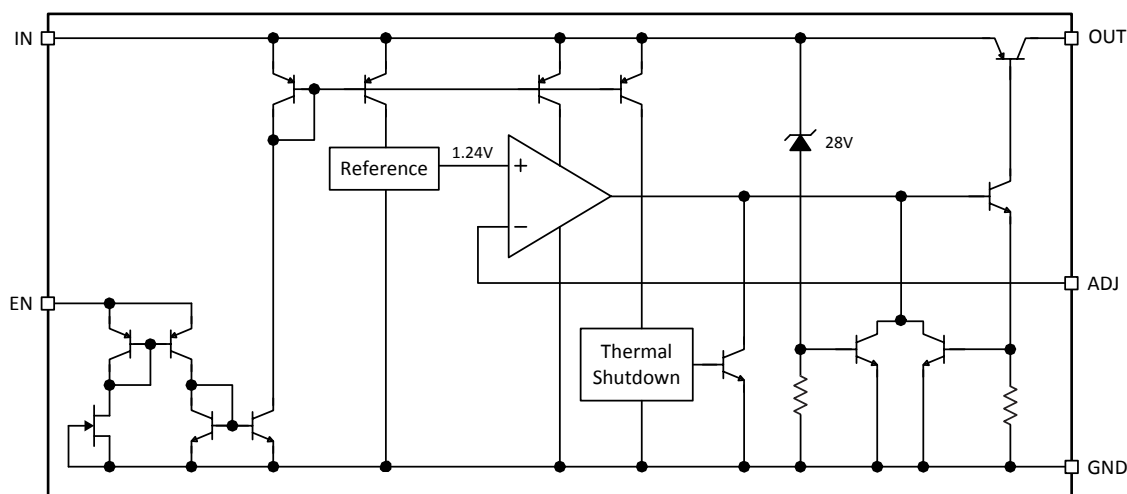
TYPICAL APPLICATION CIRCUIT
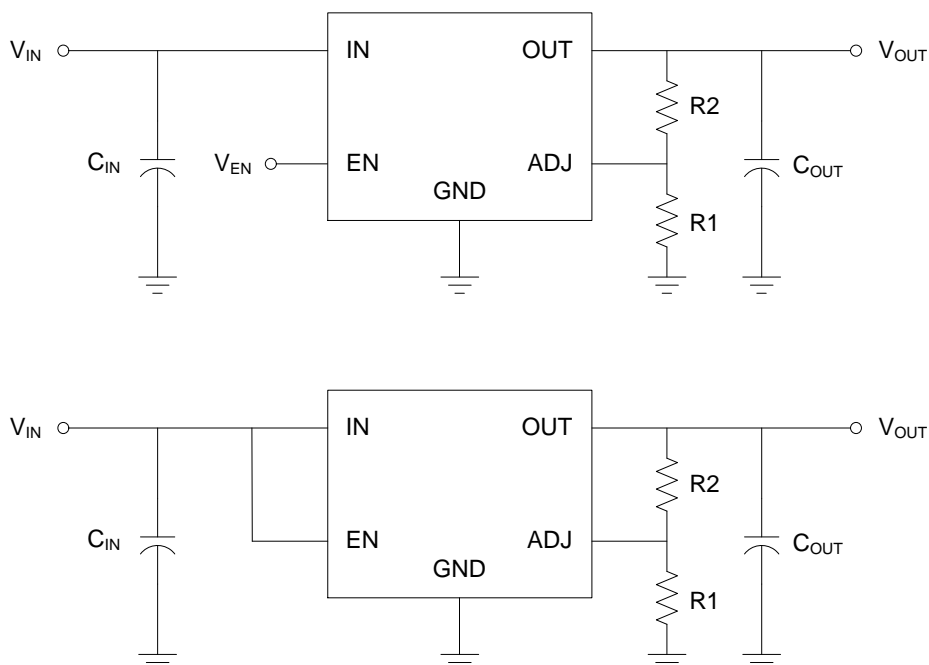
* For the details, refer to the Application Information.

ELECTRICAL CHARACTERISTICS

Limits in standard typeface are for T_J = 25⁰C, and limits in **boldface type** apply over the **full operating temperature range**. Unless otherwise specified: $V_{IN} = V_{OUT(NOM)}$ + 1.0 V [Note 2], V_{EN} = 2.3 V, V_{OUT} is programmed to 5.0 V.

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ADJ Pin Voltage [Note 3]	V_{ADJ}	I_{OUT} = 5.0 mA	1.228 **1.215**	1.24	1.252 **1.265**	V
		5.0 mA ≤ I_{OUT} ≤ 1.0 A, 2.3 V ≤ V_{IN} ≤ 26 V	**1.203**	-	**1.277**	
Line Regulation	LNR	I_{OUT} = 5.0 mA, V_{OUT} +1.0 V ≤ V_{IN} ≤ 26 V	-	0.06	0.5	%
Load Regulation	LDR	$V_{IN} = V_{OUT}$ +5.0 V, 5.0 mA ≤ I_{OUT} ≤ 1.0 A	-	0.2	1.0	%
ADJ Voltage Temperature Coefficient [Note 4]	$\Delta V_{ADJ}/\Delta T$		-	-	100	ppm/°C
ADJ Pin Bias Current	I_{ADJ}		-	20	40 **60**	nA
ADJ Pin Bias Current Temperature Coefficient	$\Delta I_{ADJ}/\Delta T$		-	0.1	-	nA/°C
Dropout Voltage [Note 5]	V_{DROP}	I_{OUT} = 5.0 mA	-	60	**180**	mV
		I_{OUT} = 100 mA	-	170	-	
		I_{OUT} = 1.0 A	-	400	**630**	
Ground Pin Current [Note 6]	I_{GND}	I_{OUT} = 5.0 mA	-	250	**500**	µA
		I_{OUT} = 1.0 A	-	16	**25**	mA
		$V_{IN} ≤ V_{OUT(NOM)}$ − 0.5 V, I_{OUT} = 10 mA	-	1.0	-	
Current Limit	I_{CL}	V_{OUT} = 0 V	-	1.5	**2.5**	A
Enable Input Voltage	V_{ENL}	Logic Low (Output Low)	-	-	**0.8**	V
	V_{ENH}	Logic High (Output High)	**2.3**	-	-	V
Enable Input Current	I_{ENL}	V_{EN} = 26 V	-	20	60 **75**	µA
	I_{ENH}	V_{EN} = 0.8 V	-	-	2.5 **5.0**	µA
Shutdown Output Current	I_{SHDN}	V_{IN} ≤ 8.0 V, V_{EN} ≤ 0.8 V, V_{OUT} = 0 V	-	10	**500**	µA

Note 1. Exceeding the Absolute Maximum Ratings may damage the device.

Note 2. The device is not guaranteed to function outside its Operating Ratings.

Note 3. $V_{ADJ} ≤ V_{OUT} ≤ (V_{IN}$ − 1.0 V)

Note 4. The thermal regulation is defined as the change in the output voltage at a time T after a change in power dissipation is applied, excluding the load regulation or line regulation effects. The specifications are for a 200 mA pulse at V_{IN} = 20V (at 4 watt pulse) for t = 10 ms.

Note 5. The dropout voltage is defined as the input-to-output differential when the output voltage drops to 99% of its nominal value with VOUT to VIN.

Note 6. Ground current, or quiescent current, is the difference between input and output currents. It's defined by $I_{GND} = I_{IN}$ − I_{OUT} under the given loading condition.

Note 7. When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground.

TYPICAL OPERATING CHARACTERISTICS

T.B.D.

APPLICATION INFORMATION

INTRODUCTION

The LM2941 is a high performance low-dropout voltage regulator suitable for all moderate to high current voltage regulator applications. Its 400mV dropout voltage at full load makes them especially valuable in battery powered systems and as high efficiency noise filters in post-regulator applications. Unlike older NPN-pass transistor designs, dropout performance of the PNP output of these devices is limited merely by the low V_{CE} saturation voltage.

The LM2941 regulator is fully protected from damage due to fault conditions. Current limiting is provided. This limiting is linear; output current under overload conditions is constant. Thermal shutdown disables the device when the die temperature exceeds the 125°C maximum safe operating temperature. Transient protection allows device survival even when the input voltage spikes between −20V and +30V. When the input voltage exceeds about 35V to 40V, the over voltage sensor temporarily disables the regulator.

INPUT CAPACITOR

An input capacitor of 1.0 µF or greater is recommended when the device is more than 4 inches away from the bulk and is used as a supply capacitance, or when the supply is a battery. Larger values will help to improve ripple rejection by bypassing the input to the regulator, further improving the integrity of the output voltage.

Where the regulator is powered from a source with high AC impedance, a 0.1 µF capacitor connected between input and ground is recommended. This capacitor should have good characteristics to above 250 kHz. Small, surface-mount, ceramic chip capacitors can be used for the bypassing.

OUTPUT CAPACITOR

The LM2941 requires an output capacitor to maintain stability and improve transient response. Proper capacitor selection is important to ensure proper operation. The value of this capacitor is dependent upon the output current; lower currents allow smaller capacitors. LM2941 regulator is stable with the 10 µF minimum capacitor values at full load. Higher capacitance values help to improve transient response and ripple rejection and reduce output noise.

Very low ESR capacitors, such as ceramic chip capacitors may promote instability. These very low ESR levels may cause an oscillation and/or under damped transient response. A low-ESR solid tantalum capacitor works extremely well and provides good transient response and stability over temperature. Aluminum electrolytic can also be used, as long as the ESR of the capacitor is less than 1.0 Ohm.

MINIMUM LOAD CURRENT

The LM2941 regulator is specified to operate between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. A 5.0 mA minimum load current is necessary for proper regulation.

ENABLE INPUT

The LM2941 features an enable (EN) input for ON/OFF control of the device. Its shutdown state draws "zero" current drain when the device is disabled (only microamperes of the leakage current). The EN input has TTL/CMOS compatible thresholds for simple interfacing with the logic, or may be connected to up to its maximum

voltage. Enabling the regulator requires approximately 20 µA of current.

TRANSIENT RESPONSE

The LM2941 has excellent transient response to variations in input voltage and load current. The device has been designed to respond quickly to load current variations and input voltage variations. Large output capacitors are not required to obtain this performance. A standard 10 µF output capacitor, preferably tantalum, is all that is required. Larger values help to improve performance even further.

OUTPUT ADJUSTMENT

The LM2941 allows programming the output voltage any-where between 1.24V and the 25V. Two resistors are used. Resistors can be quite large, up to hundreds of thousands of Ohms, because of the very high input impedance and low bias current of the sense comparator. These resistor values are calculated by:

$$R2 = R1 \left(\frac{V_{OUT}}{1.24} - 1 \right)$$

Where V_{OUT} is desired output voltage. Figure 1 shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation (see below).

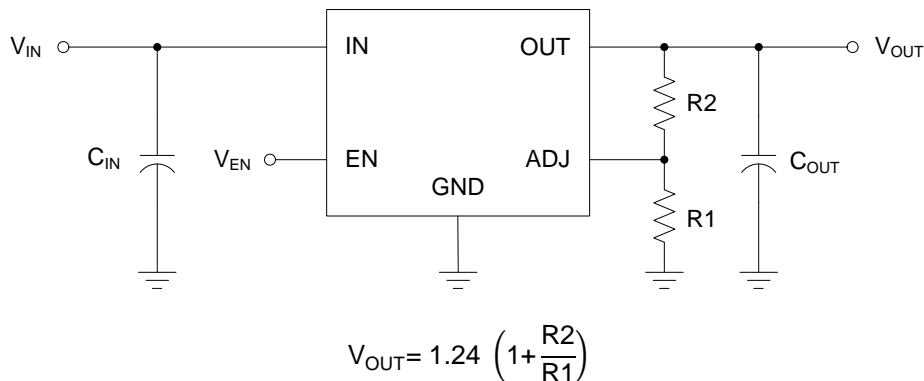$$V_{OUT} = 1.24 \left(1 + \frac{R2}{R1} \right)$$

Fig. 1. Application for Adjustable Output Voltage

MAXIMUM OUPUT CURRENT CAPABILITY

The LM2941 can deliver a continuous current of 1.0A over the full operating junction temperature range. However, the output current is limited by the restriction of power dissipation of package. A heat sink may be required depending on the maximum power dissipation and maximum ambient temperature of application. With respect to the applied package, the maximum output current of 1.0A may be still undeliverable due to the restriction of the power dissipation of LM2941. Under all possible conditions, the junction temperature must be within the range specified under operating conditions.

The temperatures over the device are given by:

$$T_C = T_A + P_D \times \theta_{CA}$$
$$T_J = T_C + P_D \times \theta_{JC}$$
$$T_J = T_A + P_D \times \theta_{JA}$$

where T_J is the junction temperature, T_C is the case temperature, T_A is the ambient temperature, P_D is the total power dissipation of the device, θ_{CA} is the thermal resistance of case-to-ambient, θ_{JC} is the thermal resistance of junction-to-case, and θ_{JA} is the thermal resistance of junction to ambient.

The total power dissipation of the device is given by:

$$P_D = P_{IN} - P_{OUT} = (V_{IN} \times I_{IN}) - (V_{OUT} \times I_{OUT})$$
$$= (V_{IN} \times (I_{OUT} + I_{GND})) - (V_{OUT} \times I_{OUT}) = (V_{IN} - V_{OUT}) \times I_{OUT} + V_{IN} \times I_{GND}$$

where I_{GND} is the operating ground current of the device which is specified at the Electrical Characteristics. The maximum allowable temperature rise (T_{Rmax}) depends on the maximum ambient temperature (T_{Amax}) of the application, and the maximum allowable junction temperature (T_{Jmax}):

$$T_{Rmax} = T_{Jmax} - T_{Amax}$$

The maximum allowable value for junction-to-ambient thermal resistance, θ_{JA}, can be calculated using the formula:

$$\theta_{JA} = T_{Rmax} / P_D$$

If proper cooling solution such as copper plane area, heat sink or air flow is applied, the maximum allowable power dissipation could be increased. However, if the ambient temperature is increased, the allowable power dissipation would be decreased.

REVISION NOTICE

The description in this datasheet is subject to change without any notice to describe its electrical characteristics properly.