AUTOMOTIVE GRADE

CS8271

Adjustable Micropower Low Dropout Linear Regulator with $\overline{\text{ENABLE}}$

Description

The CS8271 is an adjustable micropower voltage regulator with very low quiescent current (60μA typical at 100μA load). The output supplies 100mA of load current with a maximum dropout voltage of only 600mV. Control logic includes $\overline{\text{ENABLE}}$. The combination of low quiescent current, outstanding regulator performance and control logic makes the CS8271 ideal for any battery operated equipment.

The logic level compatible $\overline{\text{ENABLE}}$ pin allows the user to put the regulator into a shutdown mode where it draws only 50μA of quiescent current.

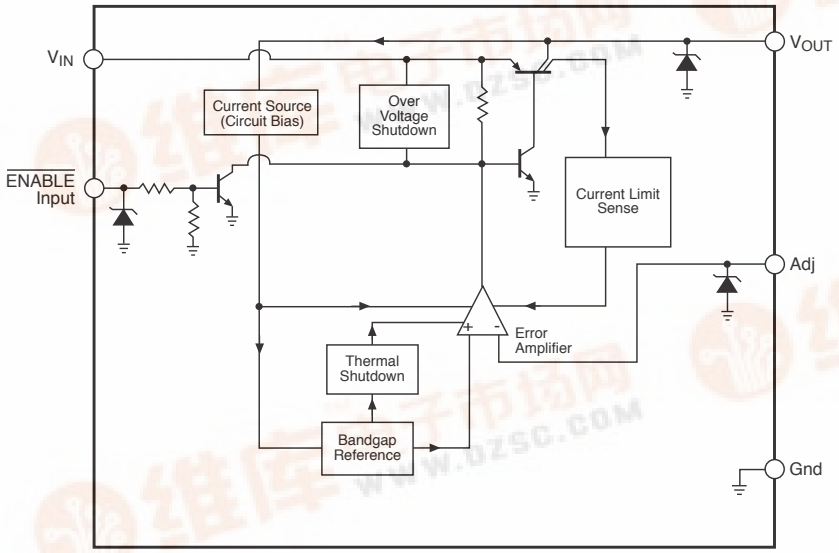
The regulator is protected against reverse battery, short circuit, over voltage, and over temperature conditions. The device can withstand 60V load dump transients making it suitable for use in automotive environments.

The CS8271 is pin compatible with the National Semiconductor LM2931.

Features

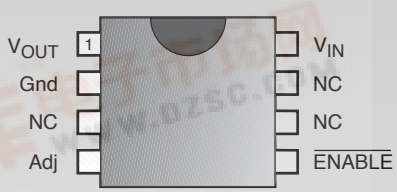
- Low Quiescent Current
- Adjustable Output: 5V to 12V
- $\overline{\text{ENABLE}}$ for Sleep Mode Control
- 100mA Output Current Capability
- Fault Protection
  - +60V Load Dump
  - -15V Reverse Voltage
  - Short Circuit
  - Thermal Shutdown
- Low Reverse Current (Output to Input)

Block Diagram



Package Options

8L SOIC & PDIP



Other Packages: Consult factory for 16L SO Batwing, 5L TO-220 and D^{2}PAK.

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Absolute Maximum Ratings

Power Dissipation ..... Internally Limited
Transient Input Voltage ..... -50V, 60V
Reverse Battery ..... -15V
Output Current ..... Internally Limited
ESD Susceptibility (Human Body Model) 2kV
Junction Temperature ..... -40°C to 150°C
Storage Temperature ..... -55°C to 150°C
Lead Temperature Soldering
- Wave Solder (through hole styles only) ..... 10 sec. max, 260°C peak
- Reflow (SMD styles only) ..... 60 sec. max above 183°C, 230°C peak

Adj and Enable Output ..... -0.3V, 10V
V_{OUT} ..... -0.3V, 20V

Electrical Characteristics: V_{OUT} + 1V ≤ V_{IN} ≤ 30V, 5V ≤ V_{OUT} ≤ 12V, I_{OUT} = 10mA, -40° ≤ T_A ≤ 125°, -40° ≤ T_J ≤ 150°, V_{ENABLE} = 0V; unless otherwise specified.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
■ Output Voltage					
Dropout Voltage	I_{OUT} = 100µA, V_{DROP} = (V_{IN} – V_{OUT}) I_{OUT} = 100mA, V_{DROP} = (V_{IN} – V_{OUT})		100 400	150 600	mV mV
Load Regulation	Measure V_{OUT} when I_{OUT} = 100µA, 100mA. LD_{REG} = ABS (ΔV_{OUT})		0.1	1.0	%V_{OUT}
Line Regulation	I_{OUT} = 1mA. Measure V_{OUT} when V_{IN} = V_{OUT} + 1V, 30V. LN_{REG} = ABS (ΔV_{OUT})		0.1	0.5	%V_{OUT}
Quiescent Current, (I_Q) Active Mode	V_{IN} = 6V, I_{OUT} = 100µA, V_{OUT} setup for 5V. I_Q = IV_{IN} - I_{OUT}		55	120	µA
	V_{IN} = 13V, I_{OUT} = 100µA, V_{OUT} setup for 12V. I_Q = IV_{IN} - 100µA		130	200	µA
	V_{IN} = 30V, I_{OUT} = 100µA, V_{OUT} setup for 5V, I_Q = IV_{IN} - 100µA		150	450	µA
	V_{IN} = 30V, I_{OUT} = 100µA, V_{OUT} setup for 12V, I_Q = IV_{IN} - 100µA		200	500	µA
	I_{OUT} = 50mA, I_Q = IV_{IN} - 50mA		4	7	mA
	I_{OUT} = 100mA, I_Q = IV_{IN} - 100mA		12	21	mA
Quiescent Current, (I_Q) Sleep Mode	V_{IN} = 6V, ENABLE = 2.5V, I_{QSLEEP} = IV_{IN}		20	50	µA
	V_{IN} = 30V, ENABLE = 2.5V, I_{QSLEEP} = IV_{IN}		75	350	µA
Ripple Rejection	*f*=120Hz, (Note 1)	60	75		dB
Current Limit	V_{OUT} = V_{OUT} - 500mV, I_{LIM} = IV_{OUT}	105	200	300	mA
Short Circuit Output Current	V_{OUT}=0V, I_{SHRT} = IV_{OUT}	15	100	215	mA
Thermal Limit	(Note 1)	150	180	210	°C
Overvoltage Shutdown	Adjust V_{IN} from 28V to 40V until V_{OUT} ≤ 1V	30	34	38	V
Reverse Current	V_{IN}=0V, I_{REV} = IV_{OUT}, V_{OUT} = 13.2V		100	200	µA

Electrical Characteristics: V_{OUT} + 1V ≤ V_{IN} ≤ 30V, 5V ≤ V_{OUT} ≤ 12V, I_{OUT} = 10mA, -40° ≤ T_A ≤ 125°, -40° ≤ T_J ≤ 150°, V_{ENABLE} = 0V; unless otherwise specified.

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
■ $\overline{\text{ENABLE}}$					
Enable Threshold		1.15	2.0	2.6	V
Enable Input Current	V_{ENABLE} = 2.6V V_{ENABLE} = 5V		10 35	20 50	μA μA
■ **Adjustment Pin**	**R1: Feedback resistor between V_{OUT} and Adjust, R2: Adjust resistor to ground.**				
Reference Voltage	100μA ≤ I_{OUT} ≤ 100mA	1.246	1.272	1.297	V
Adjustment Pin Current	$I_{Adj} = \frac{V_{REF}}{R2} - \frac{(V_{OUT} - V_{REF})}{R1}$		20	500	nA

Note 1: Guaranteed by design, not 100% tested in production.

Package Pin Description

PACKAGE PIN #	PIN SYMBOL	FUNCTION
8L SOIC & PDIP		
1	V_{OUT}	100mA output; adjustable from 5V to 12V.
2	Gnd	Ground.
3, 6, 7	NC	No Connection.
4	Adj	Resistor divider from V_{OUT} to Adj, sets output voltage.
5	$\overline{\text{ENABLE}}$	Logic level switch, when HIGH, regulator is in sleep mode.
8	V_{IN}	Input voltage.

Circuit Description

Output Voltage Adjustment

The output voltage of the CS8271 is adjustable to any value between the reference voltage on the Adj pin, (1.272V Typ.) and the maximum input voltage minus the dropout voltage. To adjust the output voltage, a pair of external resistors R1 and R2 are connected as shown in Figure 1.

The equation for the output voltage is

$$V_{OUT} = V_{REF} \times \left(\frac{R1 + R2}{R2}\right) + I_{Adj} \times R1$$

where V_{ref} is the typical reference voltage and I_{Adj} is the adjust pin bias current. This is usually 500nA maximum.

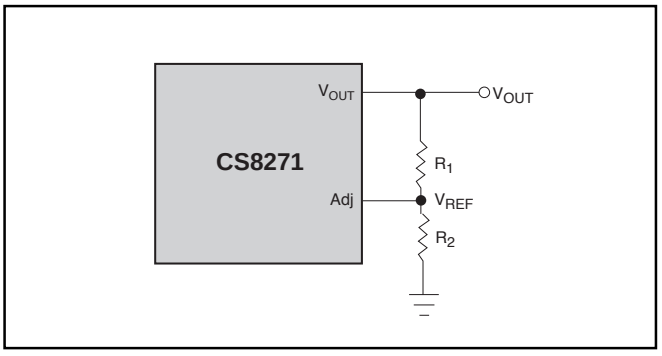


Figure 1: Output Voltage Adjustment.

Circuit Description: continued

Output Stage Protection

The output stage is protected against overvoltage, short circuit and thermal runaway conditions (Figure 2).

If the input voltage rises above 30V (e.g. load dump), the output shuts down. This response protects the internal circuitry and enables the IC to survive unexpected voltage transients up to 60V in magnitude.

Short circuit protection limits the amount of current the output transistor can supply. In the case of a CS8271 under a short circuit condition, the output transistor current is limited to 100mA.

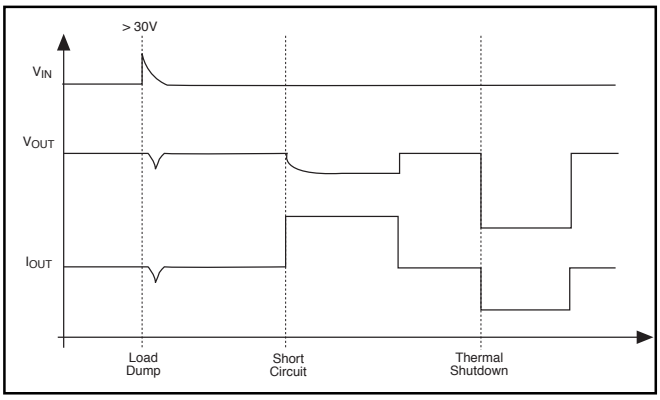


Figure 2: Typical Circuit Waveforms for Output Stage Protection.

Should the junction temperature of the power device exceed 180˚C (typ) the power transistor is turned off. Thermal shutdown is an effective means to prevent die overheating since the power transistor is the principle heat source in the IC.

$\overline{\text{ENABLE}}$

The $\overline{\text{ENABLE}}$ switches the output transistor. When the voltage on the $\overline{\text{ENABLE}}$ pin exceeds 2.0V typ, the output pass transistor turns off, leaving a high impedance facing the load. The IC will remain in Sleep mode, drawing only 20μA (typ), until the voltage on the $\overline{\text{ENABLE}}$ pin drops below the $\overline{\text{ENABLE}}$ threshold.

Application Notes

Selecting the Right Capacitor Value

The output compensation capacitor C_{OUT}, determines three main characteristics of a linear regulator: start-up delay, load transient response and loop stability.

The selection of a capacitor value and type should be based on cost, availability, size and temperature constraints. A tantalum or aluminum electrolytic capacitor is best, since a film or ceramic capacitor with almost zero ESR, can cause instability. The aluminum electrolytic capacitor is the least expensive solution, but, if the circuit operates at low temperatures (-25°C to -40°C), both the value and ESR of the capacitor will vary considerably. The capacitor manufacturers data sheet usually provide this information.

The value for the output compensation capacitor C_{OUT} shown in Figure 3 should work for most applications, but it is not necessarily the least expensive or the optimal solution.

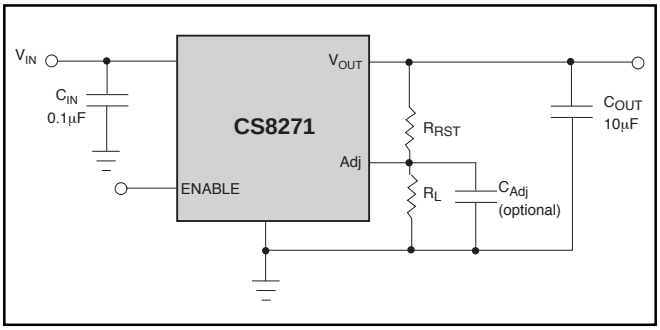


Figure 3: Test and application circuit showing an output compensation capacitor.

To determine an acceptable value for C_{OUT} for a particular application, start with a tantalum capacitor of the recommended value and work towards a less expensive alternative part.

Step 1: Place the completed circuit with a tantalum capacitor of the recommended value in an environmental chamber at the lowest specified operating temperature. Monitor the outputs on the oscilloscope. A decade box connected in series with the capacitor will simulate the higher ESR of an aluminum capacitor. (Leave the decade box outside the chamber, the small resistance added by the longer leads is negligible)

Step 2: With the input voltage at its maximum value, increase the load current slowly from zero to full load while observing the output for any oscillations. If no oscillations are observed, the capacitor is large enough to ensure a stable design under steady state conditions.

Step 3: Increase the ESR of the capacitor from zero using the decade box and vary the load current until oscillations appear. Record the values of load current and ESR that cause the greatest oscillation. This represents the worst case load conditions for the regulator at low temperature.

Step 4: Maintain the worst case load conditions set in step 3 and vary the input voltage until the oscillations increase. This point represents the worst case input voltage conditions.

Step 5: If the capacitor is adequate, repeat steps 3 and 4 with the next smaller valued capacitor. (A smaller capacitor will usually cost less and occupy less board space.) If the capacitor oscillates within the range of expected operating conditions, repeat steps 3 and 4 with the next larger standard capacitor value.

Application Notes: continued

Step 6: Test the load transient response by switching in various loads at several frequencies to simulate its real work environment. Vary the ESR to reduce ringing.

Step 7: Remove the unit from the environmental chamber and heat the IC with a heat gun. Vary the load current as instructed in step 5 to test for any oscillations.

Once the minimum capacitor value with the maximum ESR is found, a safety factor should be added to allow for the tolerance of the capacitor and any variations in regulator performance. Most good quality aluminum electrolytic capacitors have a tolerance of ±20% so the minimum value found should be increased by at least 50% to allow for this tolerance plus the variation which will occur at low temperatures. The ESR of the capacitor should be less than 50% of the maximum allowable ESR found in step 3 above.

Capacitance on the Adjust pin combined with the feedback resistors R1 and R2 can affect loop stability and should also be considered. The CS8271 internal circuitry produces about 5pF to Ground on the Adjust pin. This capacitance, plus any additional external capacitance on the Adjust pin will create a pole when combined with the resistive feedback network. The effect can be significant when using large values for the feedback resistors to minimize quiescent current.

A capacitor connected from the Adjust pin to Ground provides additional means to compensate the regulator by creating a pole. Alternately, a capacitor can be connected from the Adjust pin to V_{OUT} to create a zero.

Calculating Power Dissipation in a Single Output Linear Regulator

The maximum power dissipation for a single output regulator (Figure 4) is

$$P_{D(max)}=\{V_{IN(max)}-V_{OUT(min)}\}I_{OUT(max)}+V_{IN(max)}I_Q \qquad (1)$$

where

$V_{IN(max)}$ is the maximum input voltage,

$V_{OUT(min)}$ is the minimum output voltage,

$I_{OUT(max)}$ is the maximum output current, for the application

I_Q is the quiescent current the regulator consumes at $I_{OUT(max)}$.

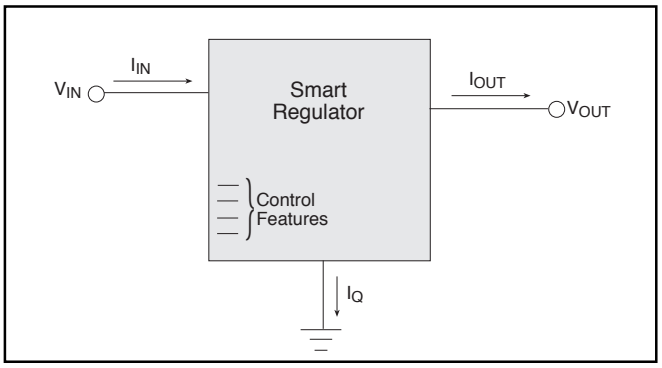


Figure 4: Single output regulator with key performance parameters labeled.

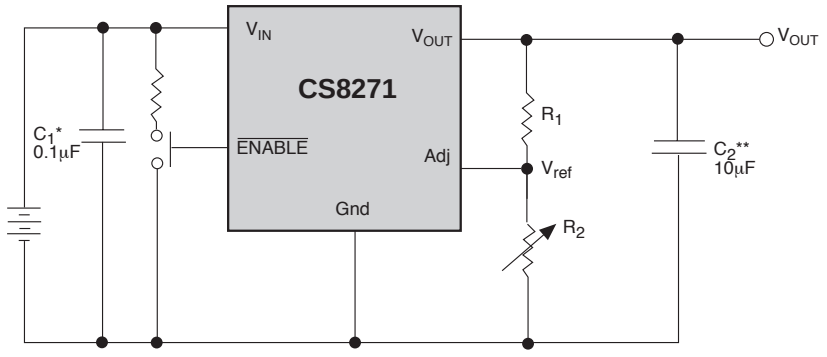
Once the value of $P_{D(max)}$ is known, the maximum permissible value of $R_{\Theta JA}$ can be calculated:

$$R_{\Theta JA} = \frac{150°C - T_A}{P_D} \qquad (2)$$

The value of $R_{\Theta JA}$ can then be compared with those in the package section of the data sheet. Those packages with $R_{\Theta JA}$'s less than the calculated value in equation 2 will keep the die temperature below 150°C.

In some cases, none of the packages will be sufficient to dissipate the heat generated by the IC, and an external heatsink will be required.

Application Diagram



C_1* Required if regulator is away from power supply filter.

C_2** Required for output stability.

$$V_{OUT} = V_{ref} \times \left(\frac{R1 + R2}{R2}\right) + I_{Adj} \times R1$$

Package Specification

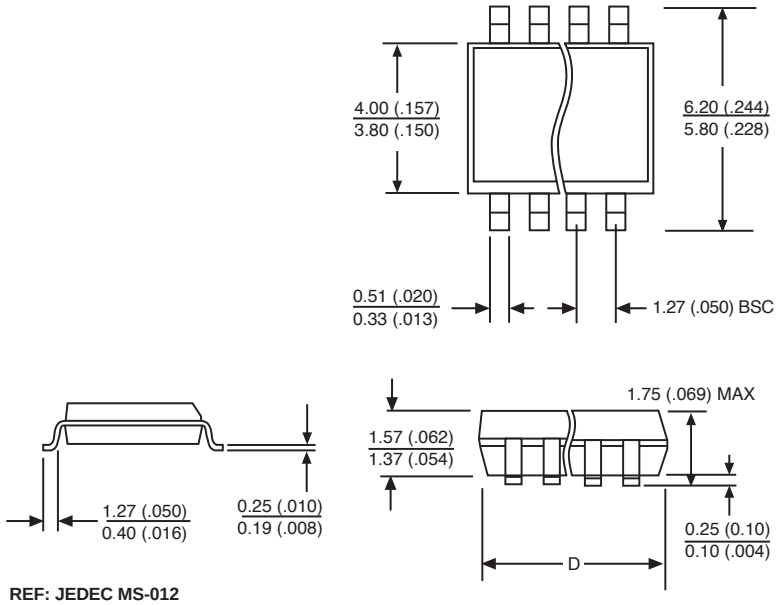
PACKAGE DIMENSIONS IN mm (INCHES)

Lead Count	D			
	Metric		English	
	Max	Min	Max	Min
8L SOIC	5.00	4.80	.197	.189
8L PDIP	10.16	9.02	.400	.355

PACKAGE THERMAL DATA

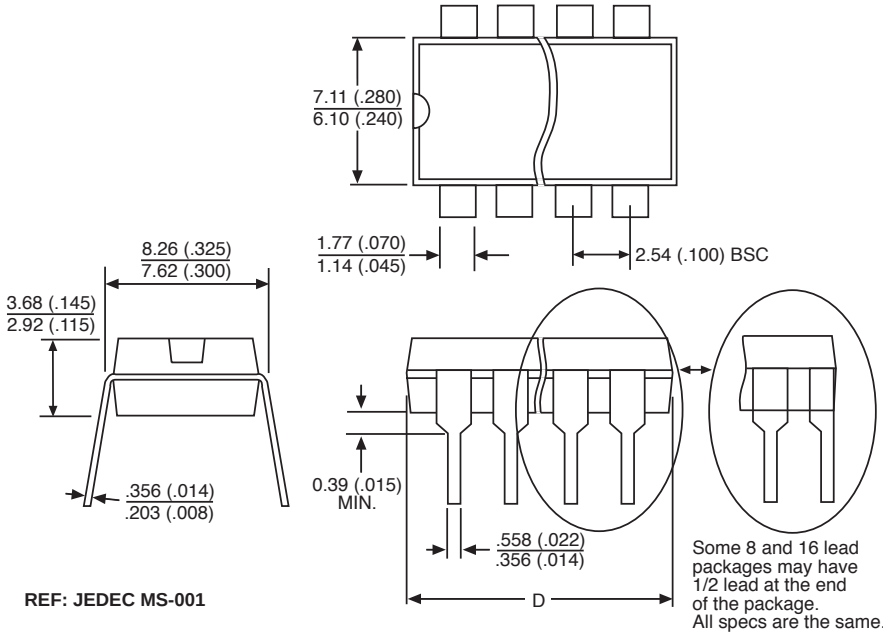
Thermal Data		8L SOIC	8L PDIP	
$R_{\Theta JC}$	typ	45	52	°C/W
$R_{\Theta JA}$	typ	165	100	°C/W

Surface Mount Narrow Body (D); 150 mil wide



REF: JEDEC MS-012

Plastic DIP (N); 300 mil wide



REF: JEDEC MS-001

Ordering Information

Part Number	Description
CS8271YD8	8L SOIC
CS8271YDR8	8L SOIC *(tape & reel)*
CS8271YN8	8L PDIP

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