AUTOMOTIVE GRADE

CS8251

10V/5V Low Dropout Dual Regulator with Independent Output Enables

Description

The CS8251 is a 10V / 5V dual output linear regulator. The 10V ±5% output sources 1A, while the 5V ±5% output sources 250mA. Each output is controlled by its own ENABLE pin. Setting the ENABLE input high turns on the associated regulator output. Holding both ENABLE inputs low puts the IC into sleep mode where current consumption is less than 50µA.

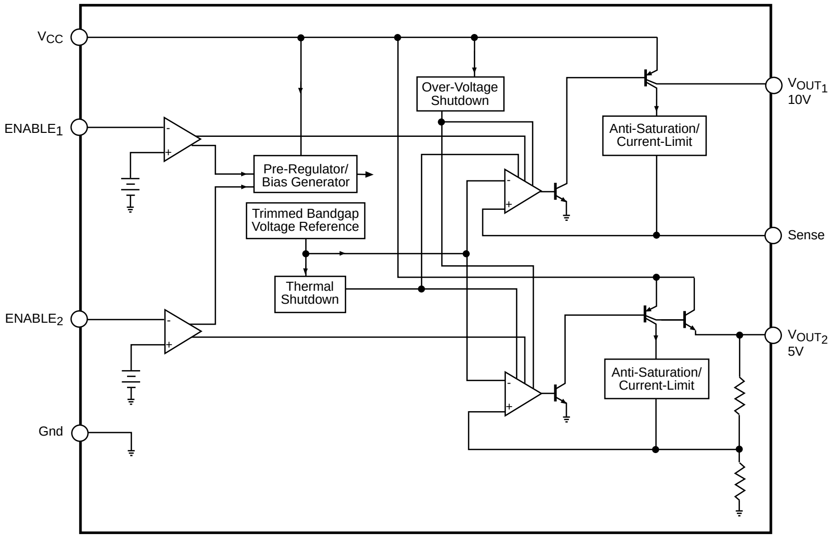
The regulator is protected against overvoltage, short-circuit and thermal runaway conditions.

The CS8251 is available in a 7 lead TO-220 package with copper tab. The tab can be connected to a heat sink if necessary.

Absolute Maximum Ratings

Supply Voltage Operating Range	-0.6V to +24V
ENABLE Input Voltage Range	-0.6V to +10.0V
Peak Transient Voltage (60V Load Dump @ V_{CC} = 14V)	74V
Storage Temperature Range	-65°C to +150°C
Junction Temperature Range	-40°C to +150°C
Lead Temperature Soldering:	
Wave Solder (through hole styles only)	10 Sec. max 260°C Peak
ESD Human Body Model	2kV

Block Diagram

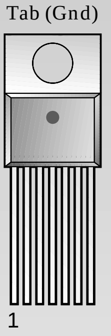


Features

- **Two Regulated Outputs**
  - **10V ± 5%, 1A**
  - **5V ± 5%, 250mA**
- **Independent ENABLE for each Output**
- **Separate Sense Feedback Pin for 10V Output**
- **50µA Sleep Mode Current**
- **Fault Protection**
  - **Overvoltage Shutdown**
  - **74V Peak Transient**
  - **Short Circuit**
  - **Thermal Shutdown**
- **CMOS Compatible, Low-Current ENABLE Inputs**

Package Options

TO-220 7 Lead



1 ENABLE$_1$
2 ENABLE$_2$
3 V_{OUT_2}
4 Gnd
5 Sense
6 V_{CC}
7 V_{OUT_1}

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June, 1999 - Rev. 4

Electrical Characteristics: -40°C ≤ T_A ≤ +85°C, 11.0V ≤ V_{CC} ≤ 16.0V, $ENABLE_1$ = $ENABLE_2$ = 5.0V, I_{OUT_1} = I_{OUT_2} = 5.0mA, unless otherwise specified

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
■ **Primary Output (V_{OUT_1})**					
Output Voltage	I_{OUT_1} = 1.0A, 11.1V ≤ V_{CC} ≤ 16V	9.5	10.0	10.5	V
Line Regulation	11.1V ≤ V_{CC} ≤ 26V			50	mV
Load Regulation	5mA ≤ I_{OUT_1} ≤ 1.0A			150	mV
Sleep Mode Quiescent Current	V_{CC} = 14V, $ENABLE_1$=$ENABLE_2$ = 0V			50	µA
Quiescent Current	V_{CC} = 14V, I_{OUT_1} = 1.0A, I_{OUT_2} = 250mA			208	mA
Dropout Voltage	I_{OUT_1} = 5.0mA			300	mV
	I_{OUT_1} = 1.0A			900	mV
Quiescent Bias Current	I_{OUT_1} = 5mA, $ENABLE_2$ = 0V, V_{CC} = 14V, I_Q = I_{CC} - I_{OUT_1}			10	mA
	I_{OUT_1} = 1.0A, $ENABLE_2$ = 0V, V_{CC} = 14V, I_Q=I_{CC} - I_{OUT_1}			200	mA
Ripple Rejection	f = 120Hz, V_{CC} = 14V with 1.0V_{pp} AC		54		db
Current Limit	11.1V ≤ V_{CC} ≤ 26V	1.3		2.5	A
■ **Secondary Output (V_{OUT_2})**					
Output Voltage	I_{OUT_2} = 250mA	4.75	5.0	5.25	V
	V_{CC} = 50V transient			6	V
Line Regulation	7V ≤ V_{CC} ≤ 26V			40	mV
Load Regulation	5mA ≤ I_{OUT_2} ≤ 250mA			100	mV
Dropout Voltage	I_{OUT_2} = 5.0mA			1.2	V
	I_{OUT_2} = 250mA			1.8	V
Quiescent Bias Current	I_{OUT_2} = 5mA, $ENABLE_1$ = 0V, V_{CC} = 14V, I_Q = I_{CC} - I_{OUT_2}			5	mA
	I_{OUT_2} = 250mA, $ENABLE_1$ = 0V, V_{CC} = 14V, I_Q = I_{CC} - I_{OUT_2}			8	mA
Ripple Rejection	f = 120Hz, V_{CC} = 14V with 1.0 V_{pp} AC		54		db
Current Limit	7V ≤ V_{CC} ≤ 26V	300		600	mA
■ **ENABLE Function (ENABLE)**					
Input Current	V_{CC} = 14V, 0V ≤ ENABLE ≤ 5.5V	-150		150	µA
Input Voltage	Low	0		0.8	V
	High	2.0		5.0	V
■ **Protection Circuitry**					
Overvoltage Shutdown		24		32	V
Thermal Shutdown			180		°C
Thermal Hysteresis			30		°C

Package Pin Description

PACKAGE PIN #	PIN SYMBOL	FUNCTION
7 Lead TO-220		
1	$ENABLE_1$	ENABLE control for the 10V, 1A output
2	$ENABLE_2$	ENABLE control for the 5V, 250mA output
3	V_{OUT_2}	5V ±5%, 250mA regulated output
4	Gnd	Ground
5	Sense	Sense feedback for the primary 10V output
6	V_{CC}	Supply voltage, usually from battery
7	V_{OUT_1}	10V ±5%, 1A regulated output

Definition of Terms

Dropout voltage: The input-output voltage differential at which the circuit ceases to regulate against further reduction in input voltage. Measured when the output voltage has dropped 100mV from the nominal value obtained at 14V input, dropout voltage is dependent upon load current and junction temperature.

Current Limit: Peak current that can be delivered to the output.

Input Voltage: The DC voltage applied to the input terminals with respect to ground.

Input Output Differential: The voltage difference between the unregulated input voltage and the regulated output voltage for which the regulator will operate.

Line Regulation: The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Load Regulation: The change in output voltage for a change in load current at constant chip temperature.

Long Term Stability: Output voltage stability under accelerated life-test conditions after 1000 hours with maximum rated voltage and junction temperature.

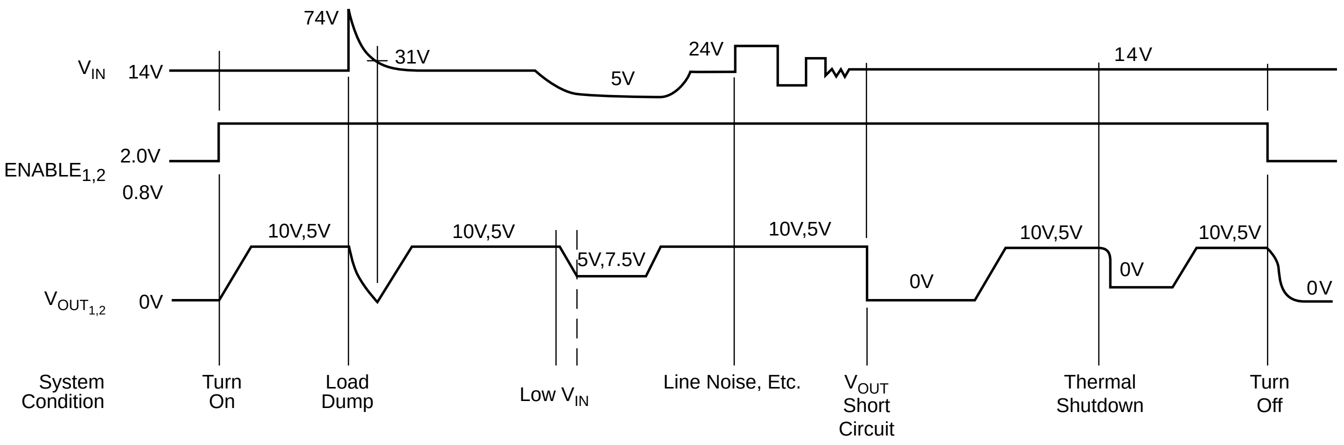
Output Noise Voltage: The rms AC voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

Quiescent Current: The part of the positive input current that does not contribute to the positive load current. The regulator ground lead current.

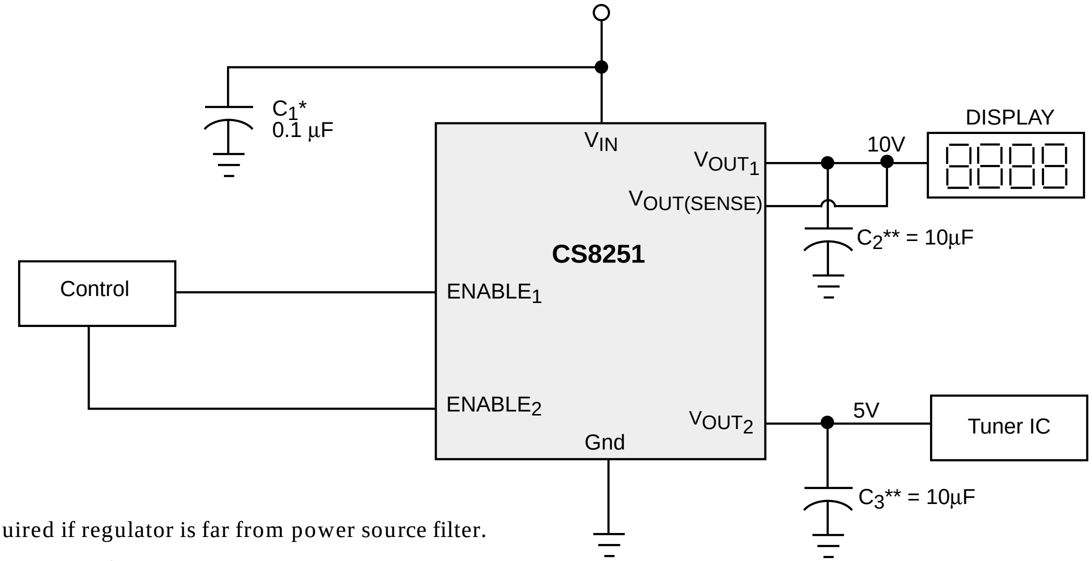
Ripple Rejection: The ratio of the peak-to-peak input ripple voltage to the peak-to-peak output ripple voltage.

Temperature Stability of V_{OUT}: The percentage change in output voltage for a thermal variation from room temperature to either temperature extreme.

Typical Circuit Waveform



Applications Circuit



*C_1 is required if regulator is far from power source filter.

**C_2, C_3 is required for stability

Application Notes

With separate control of each output channel, the CS8251 is ideal for applications where each load must be switched independently. In an automotive radio, the 10V output drives the displays and tape drive motors while the 5V output supplies the Tuner IC and memory.

Stability Considerations

The output or compensation capacitors determine three main characteristics of a linear regulator: start-up delay, load transient response and loop stability.

The capacitor values and types 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.

To determine acceptable values for the compensation capacitors in a particular application, start with tantalum capacitors of the recommended value and work towards a less expensive alternative part on each output in turn.

Step 1: Place the completed circuit with tantalum capacitors of the recommended values in an environmental chamber at the lowest specified operating temperature and monitor the outputs on the oscilloscope. A decade box connected in series with one of the capacitors C_2 or C_3 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 circuit oscillates within the range of expected operating conditions, repeat steps 3 and 4 with the next larger standard capacitor value.

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 for each output, 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 capacitors should be less than 50% of the maximum allowable ESR found in step 3 above.

Repeat steps 1 through 7 with the second output leaving a large tantalum on the first output for stability.

Calculating Power Dissipation in a Dual Output Linear Regulator

The maximum power dissipation for a dual output regulator (Figure 1) is

$$P_{D(max)} = \{V_{IN(max)}–V_{OUT1(min)}\}I_{OUT_1(max)}+ \{V_{IN(max)}–V_{OUT_2(min)}\}I_{OUT_2(max)}+V_{IN(max)}IQ \quad (1)$$

Where

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

$V_{OUT_1(min)}$ is the minimum output voltage from V_{OUT_1},

$V_{OUT_2(min)}$ is the minimum output voltage from V_{OUT_2},

$I_{OUT_1(max)}$ is the maximum output current, for the application

$I_{OUT_2(max)}$ is the maximum output current, for the application

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

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

$$R\Theta_{JA} = \frac{150°C - T_A}{P_D} \quad (2)$$

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.

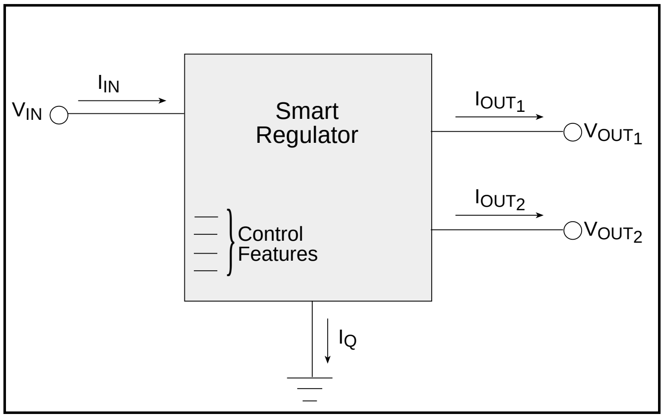


Figure 1: Dual output regulator with key performance parameters labeled.

Heat Sinks

A heat sink effectively increases the surface area of the package to improve the flow of heat away from the IC and into the surrounding air.

Each material in the heat flow path between the IC and the outside environment will have a thermal resistance. Like series electrical resistances, these resistances are summed to determine the value of $R\Theta_{JA}$.

$$R\Theta_{JA} = R\Theta_{JC} + R\Theta_{CS} + R\Theta_{SA} \quad (3)$$

where

$R\Theta_{JC}$ = the junction–to–case thermal resistance,
$R\Theta_{CS}$ = the case–to–heatsink thermal resistance, and
$R\Theta_{SA}$ = the heatsink–to–ambient thermal resistance.

$R\Theta_{JC}$ appears in the package section of the data sheet. Like $R\Theta_{JA}$, it too is a function of package type. $R\Theta_{CS}$ and $R\Theta_{SA}$ are functions of the package type, heatsink and the interface between them. These values appear in heat sink data sheets of heat sink manufacturers.

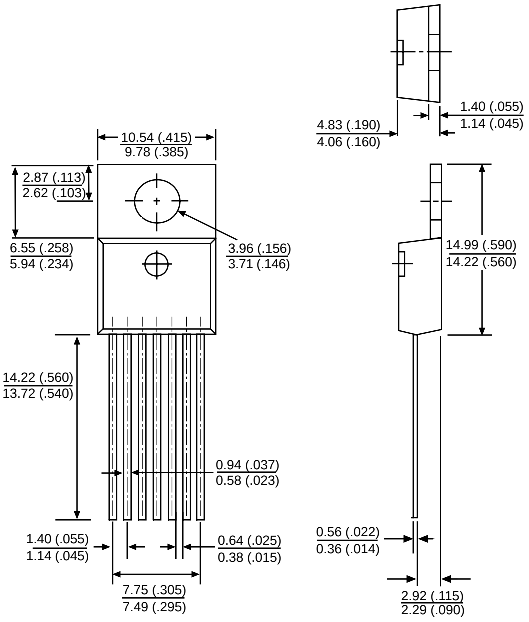
Package Specification

PACKAGE DIMENSIONS IN mm (INCHES)

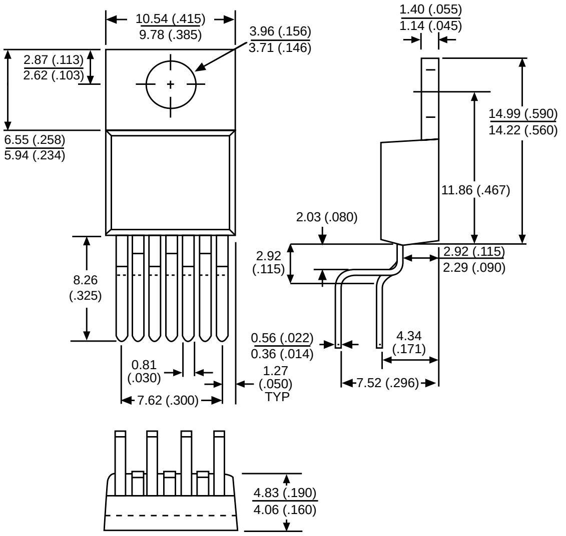
PACKAGE THERMAL DATA

Thermal Data		TO-220	
RΘ$_{JC}$	typ	3.5	°C / W
RΘ$_{JA}$	typ	50	°C / W

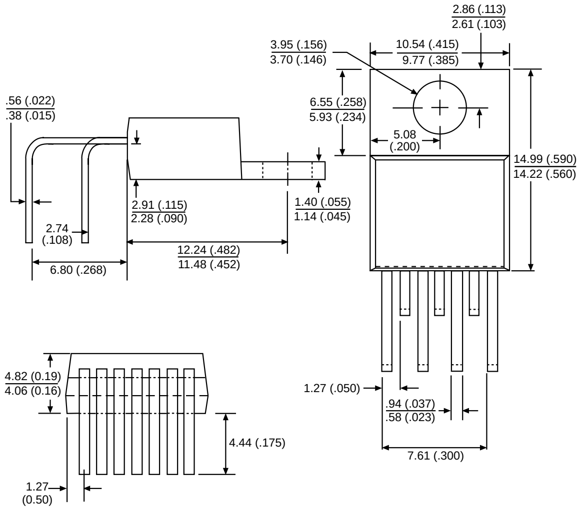
7 Lead TO-220 (T) Straight



7 Lead TO-220 (TVA) Vertical



7 Lead TO-220 (THA) Horizontal



Note:
Leads maintain a right angle with respect to the package body to within +/- .020.

Ordering Information

Part Number	Description
CS8251ET7	7 Lead TO-220 Straight
CS8251ETVA7	7 Lead TO-220 Vertical
CS8251ETHA7	7 Lead TO-220 Horizontal

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Notes

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