AUTOMOTIVE GRADE

CS8164

8V/5V Low Dropout Dual Regulator with ENABLE

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DEVICE NOT RECOMMENDED FOR NEW DESIGN

Description

The CS8164 is a low dropout, dual 8V/5V linear regulator. The secondary 5V/100mA output is used for powering systems with standby memory. Quiescent current drain is less than 2mA when supplying 10mA loads from the standby regulator.

In automotive applications, the CS8164 and all regulated circuits are protected from reverse battery installations, as well as high voltage transients. During line transients, such as a 60V load dump, the 750mA output will automatically shutdown to protect both internal circuits and the load, while the secondary regulator continues to power any standby load.

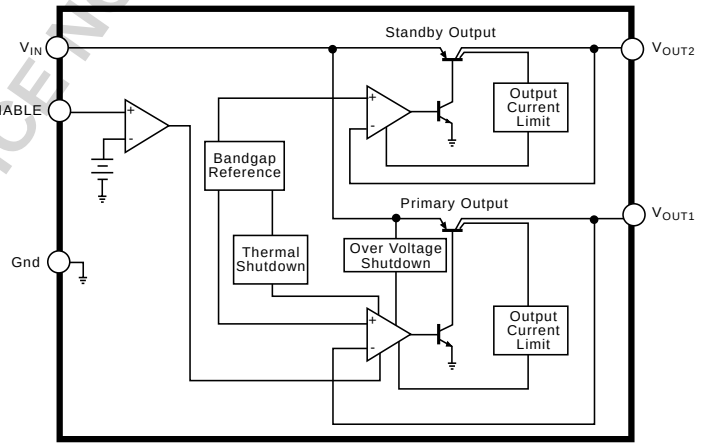
The on board ENABLE function controls the regulator's primary output. When ENABLE is in the low state, the regulator is placed in STANDBY mode where it draws 2mA (typ) quiescent current.

The CS8164 is packaged in a 5-lead TO-220, with copper tab for connection to a heat sink, if necessary.

Absolute Maximum Ratings

DC Input Voltage .....-0.5V to 26V
Transient Peak Voltage (46V Load Dump).....60V
Internal Power Dissipation .....Internally Limited
Operating Temperature Range.....-40°C to +125°C
Junction Temperature Range.....-40°C to +150°C
Storage Temperature Range .....-65°C to +150°C
Reverse Polarity V_{OUT1} Input Voltage, DC .....-18V
Reverse Polarity Input Voltage, Transient .....-50V
Lead Temperature Soldering
Wave Solder (through hole styles only).....10 sec. max, 260°C peak

Block Diagram

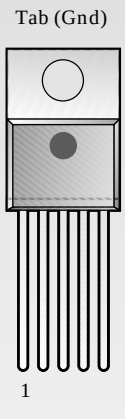


Features

- **Two Regulated Outputs**
  Primary Output
  8V ±5%; 750mA
  Secondary Output
  5V ±2%; 100mA
- **Low Dropout Voltage**
- **ON/OFF Control Option**
- **Standby Quiescent Drain (<2mA)**
- **Protection Features**
  Reverse Battery
  60V Peak Transient Voltage
  -50V Reverse Transient
  Short Circuit
  Thermal Shutdown

Package Options

5 Lead TO-220



1 V_{IN}
2 V_{OUT1}
3 Gnd
4 ENABLE
5 V_{OUT2}

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Electrical Characteristics for V_{OUT}: V_{IN} = 14V, I_{OUT} = 500mA, -40°C ≤ T_J ≤ +150°C unless otherwise specified

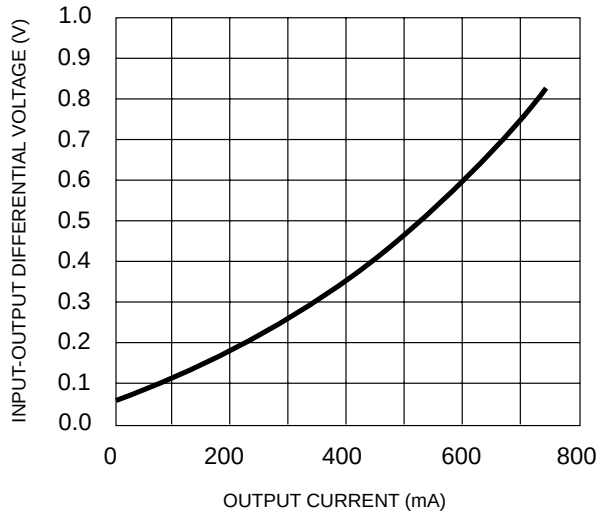
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
■ OUTPUT STAGE (V_{OUT1})					
Output Voltage, V_{OUT1}	13V ≤ V_{IN} ≤ 26V, I_{OUT1} ≤ 500mA, 13V ≤ V_{IN} ≤ 16V, I_{OUT1} ≤ 750mA	7.6 7.6	8.0 8.0	8.4 8.4	V V
Dropout Voltage	I_{OUT1} = 500mA			0.60	V
Line Regulation	13V ≤ V_{IN} ≤ 16V, I_{OUT1} = 5mA		15	80	mV
Load Regulation	5mA ≤ I_{OUT1} ≤ 500mA		15	80	mV
Quiescent Current	I_{OUT1} ≤ 10mA, No Load on Standby I_{OUT1} = 500mA, No Load on Standby I_{OUT1} = 750mA, No Load on Standby		3 40 90	7 100	mA mA mA
Ripple Rejection	f = 120Hz		53		dB
Current Limit		0.75	1.40	2.50	A
Long Term Stability			50		mV/khr
Output Impedance	500mA DC and 10mA rms, 100Hz - 10kHz		200		mΩ
Thermal Shutdown		150	190		°C
Overvoltage Shutdown		26	40		V
■ Standby Output (V_{OUT2})					
Output Voltage, (V_{OUT2})	6V ≤ V_{IN} ≤ 26V	4.75	5.00	5.25	V
Dropout Voltage	I_{OUT2} ≤ 100mA		0.55	0.70	V
Line Regulation	6V ≤ V_{IN} ≤ 26V		4	50	mV
Load Regulation	1mA ≤ I_{OUT2} ≤ 100mA		10	50	mV
Quiescent Current	I_{OUT2} ≤ 10mA, -40°C ≤ T_J ≤ +125°C V_{OUT1} OFF		2	3	mA
Ripple Rejection	f = 120Hz		66		dB
Current Limit			200		mA
Long Term Stability			20		mV/khr
Output Impedance	10mA DC and 1mA rms, 100Hz - 10kHz		1		Ω
■ ENABLE Function (ENABLE)					
Input ENABLE Threshold	V_{OUT1} Off V_{OUT1} On	 2.00	1.25 1.25	0.80	V V
Input ENABLE Current	V_{ENABLE} ≤ $V_{THRESHOLD}$	-10		10	µA

Package Lead Description

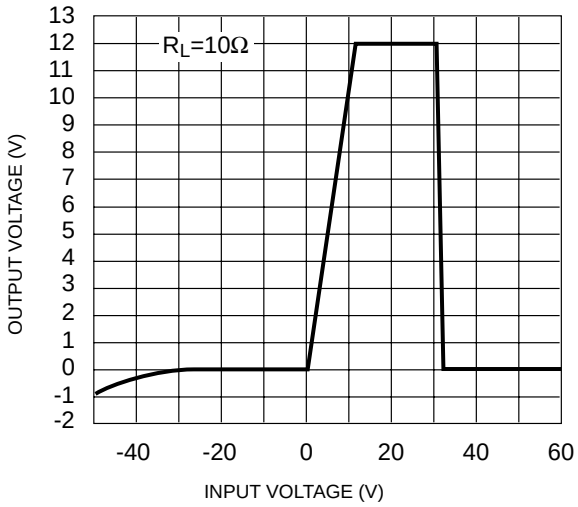
PACKAGE LEAD #	LEAD SYMBOL	FUNCTION
5 Lead TO-220		
1	V_{IN}	Supply voltage, usually direct from battery.
2	V_{OUT1}	Regulated output 8V, 750mA (typ).
3	Gnd	Ground connection.
4	ENABLE	CMOS compatible input lead; switches V_{OUT1} on and off. When ENABLE is high, V_{OUT1} is active.
5	V_{OUT2}	Standby output 5V, 100mA (typ); always on.

Typical Performance Characteristics

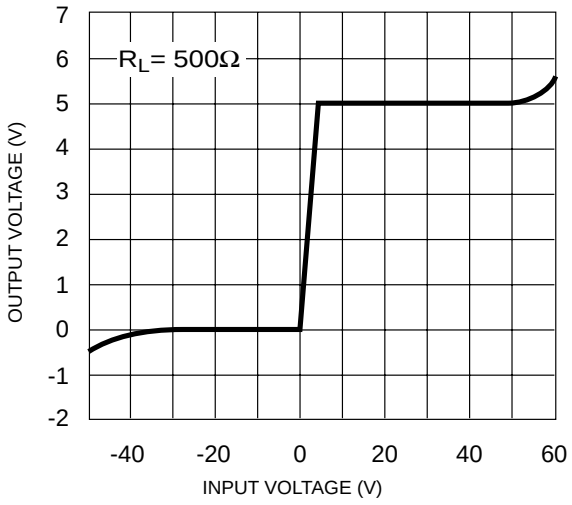
Dropout Voltage vs. Output Current



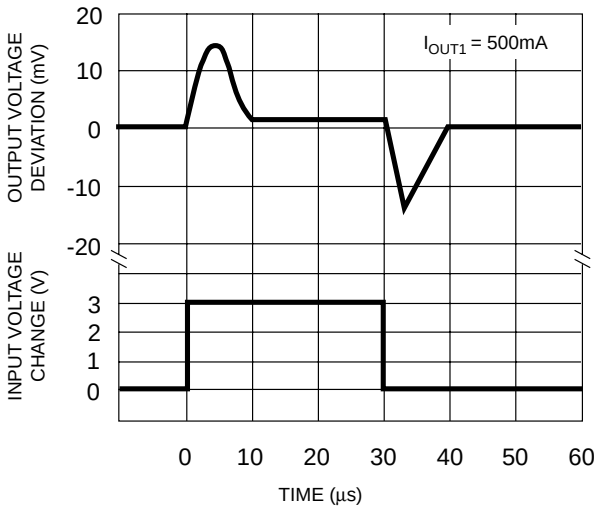
Output Voltage vs. Input Voltage



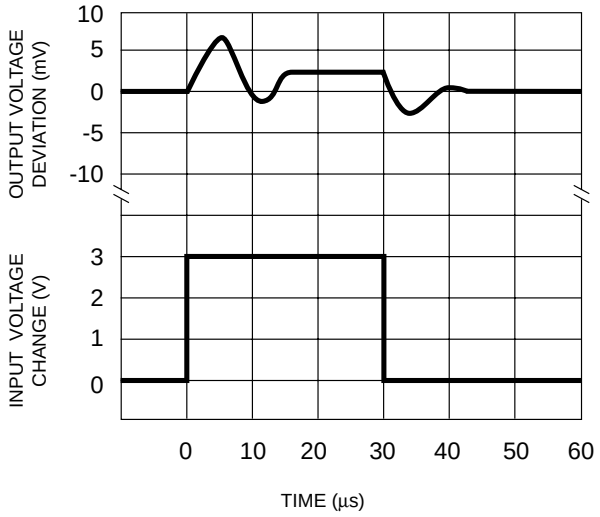
Standby Output Voltage vs. Input Voltage



Line Transient Response (V_{OUT1})

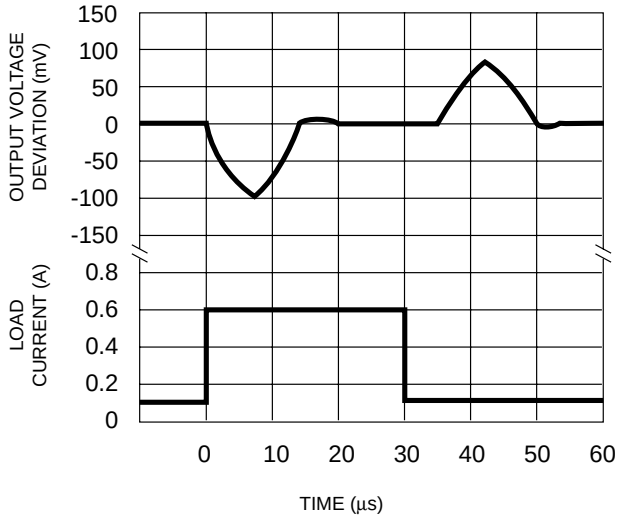


Line Transient Response (V_{OUT2})

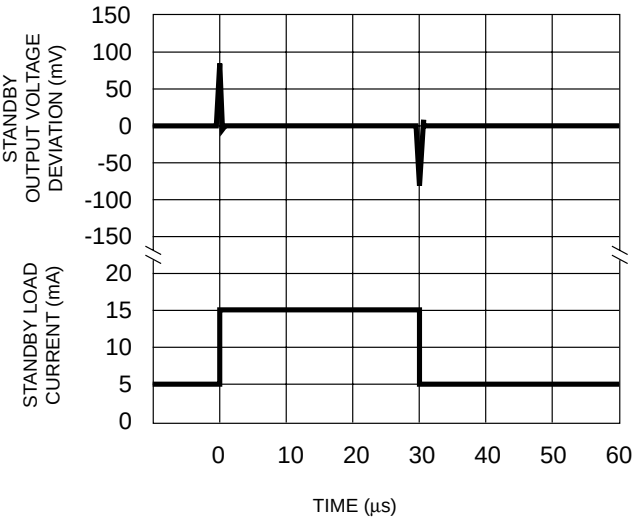


Typical Performance Characteristics: continued

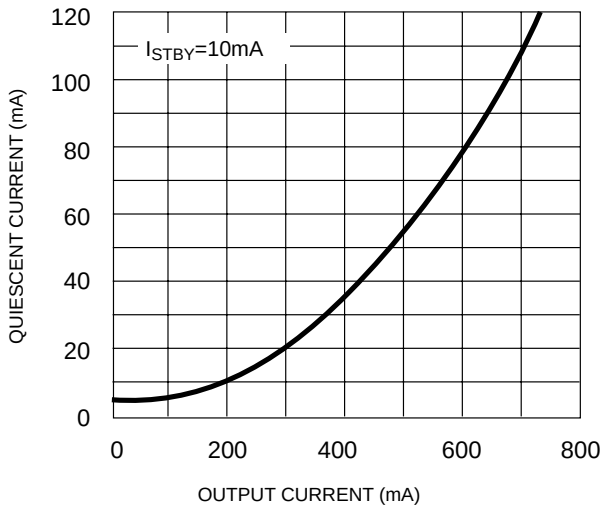
Load Transient Response (V_{OUT1})



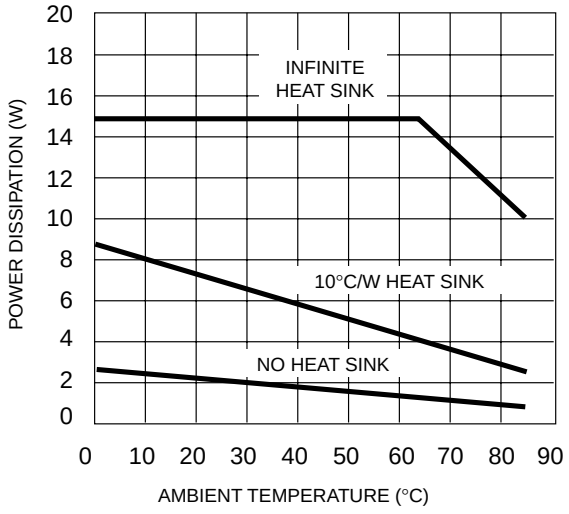
Load Transient Response (V_{OUT2})



Quiescent Current vs. Output Current



Maximum Power Dissipation (TO-220)



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.

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.

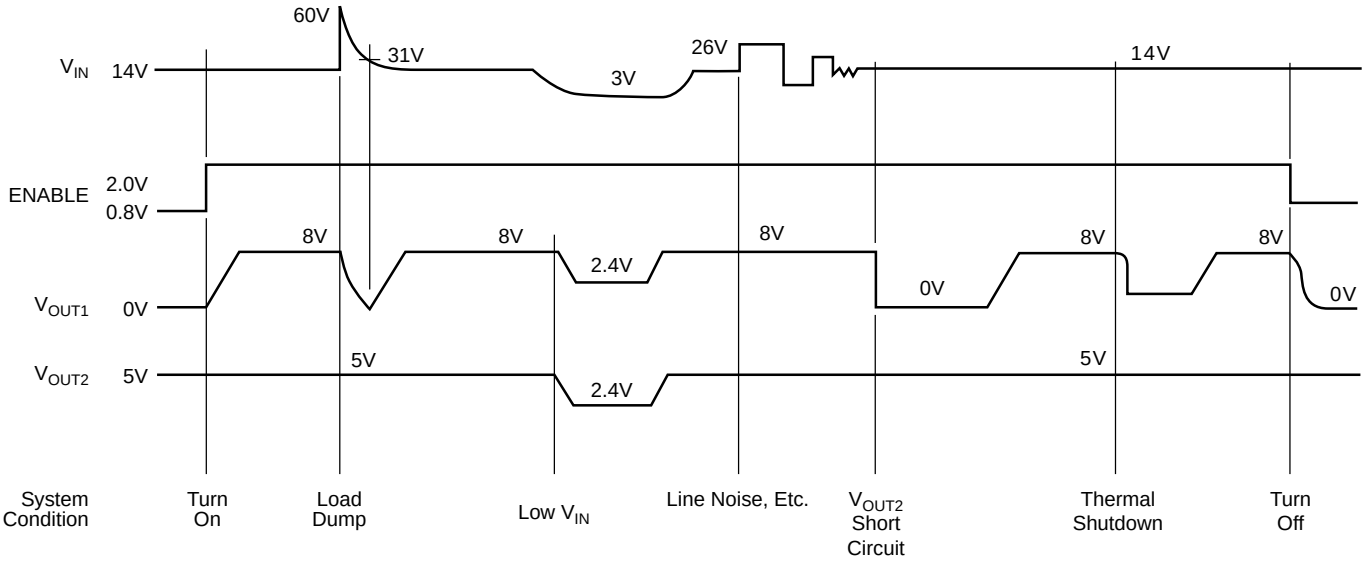
Quiescent Current
The part of the positive input current that does not contribute to the positive load current. i.e., the regulator ground lead current.

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.

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

Typical Circuit Waveform



Circuit Description

Standby Output

The CS8164 is equipped with two outputs. The second output is intended for use in systems requiring standby memory circuits. While the high current primary output can be controlled with the ENABLE lead described below, the standby output remains on under all conditions as long as sufficient input voltage is applied to the IC. Thus, memory and other circuits powered by this output remain unaffected by positive line transients, thermal shutdown, etc.

The standby regulator circuit is designed so that the quiescent current to the IC is very low (<2mA) when the other regulator output is off.

In applications where the standby output is not needed, it may be disabled by connecting a resistor from the standby output to the supply voltage. This eliminates the need for a capacitor on the output to prevent unwanted oscillations. The value of the resistor depends upon the minimum input voltage expected for a given system. Since the standby output is shunted with an internal 6.0V Zener, the current through the external resistor should be sufficient

Circuit Description: continued

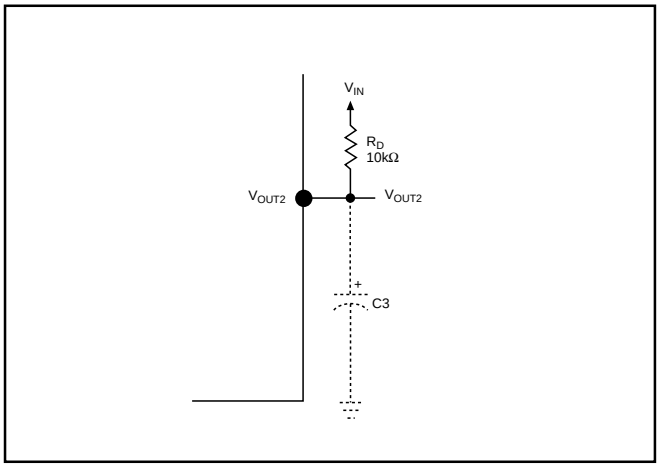
to bias V_{OUT2} up to this point. Approximately 60µA will suffice, resulting in a 10kΩ external resistor for most applications.

High Current Output

Unlike the standby regulated output, which must remain on whenever possible, the high current regulated output is fault protected against overvoltage and also incorporates thermal shutdown. If the input voltage rises above approximately 30V (e.g., load dump), this output will automatically shutdown. This protects the internal circuitry and enables the IC to survive higher voltage transients than would otherwise be expected. Thermal shutdown is effective against die overheating since the high current output is the dominant source of power dissipation in the IC.

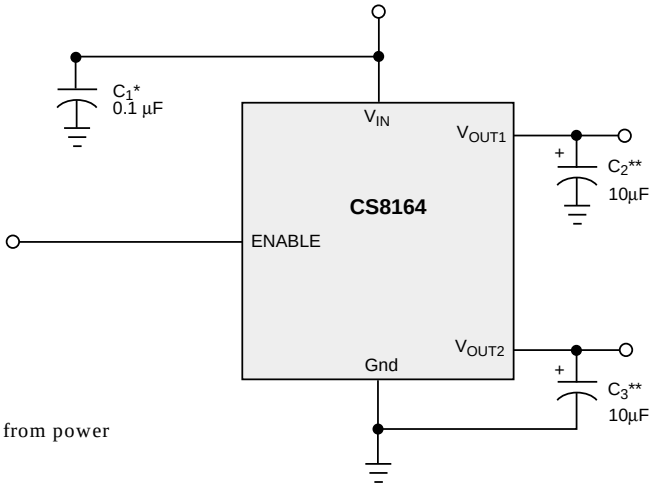
ENABLE

The enable function controls V_{OUT1} When ENABLE is high (5V), V_{OUT1} is on. When ENABLE is low, V_{OUT1} is off.



Disabling V_{OUT2} when it is not needed. C3 is no longer needed.

Test & Application Circuit



NOTES:

* C1 required if regulator is located far from power supply filter.

** C_2, C_3 required for stability.

Application Notes

Stability Considerations

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

The 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 provides this information.

The value for each output capacitor shown in the test and applications circuit should work for most applications, however it is not necessarily the optimized solution.

To determine acceptable values for C_2 and C_3 a particular application, start with a tantalum capacitor of the recommended value and work towards a less expensive alternative part for each output.

Step 1: Place the completed circuit with the tantalum capacitors of the recommended values in an environmental chamber at the lowest specified operating temperature and monitor the outputs with an oscilloscope. A decade box connected in series with the capacitor C_2 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 on the output under observation. look for oscillations on the output. 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 output 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 output 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 working 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 capacitor on the other output, C_3.

Calculating Power Dissipation in a Dual Output Linear Regulator

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

$$P_{D(max)} = \{V_{IN(max)} - V_{OUT1(min)}\}I_{OUT1(max)} + \{V_{IN(max)} - V_{OUT2(min)}\}I_{OUT2(max)} + V_{IN(max)}I_Q \quad (1)$$

where:

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

$V_{OUT1(min)}$ is the minimum output voltage from V_{OUT1},

$V_{OUT2(min)}$ is the minimum output voltage from V_{OUT2},

$I_{OUT1(max)}$ is the maximum output current for the application,

$I_{OUT2(max)}$ is the maximum output current for the application, and

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

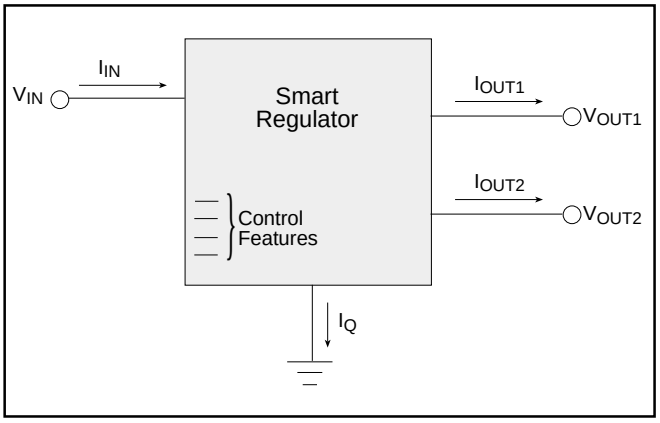


Figure 1: Dual output regulator with key performance parameters labeled.

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

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

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.

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:

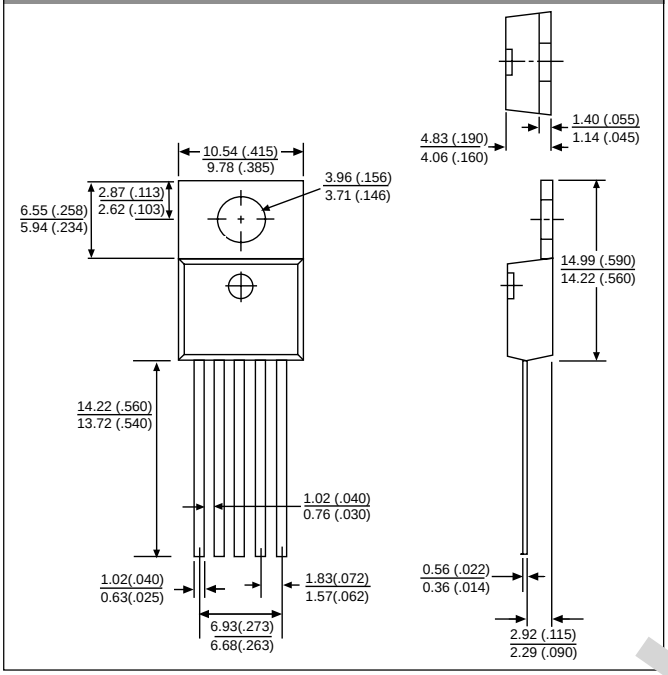
$R_{\Theta JC}$ = the junction-to-case thermal resistance,
$R_{\Theta CS}$ = the case-to-heatsink thermal resistance, and
$R_{\Theta SA}$ = the heatsink-to-ambient thermal resistance.

$R_{\Theta JC}$ 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.

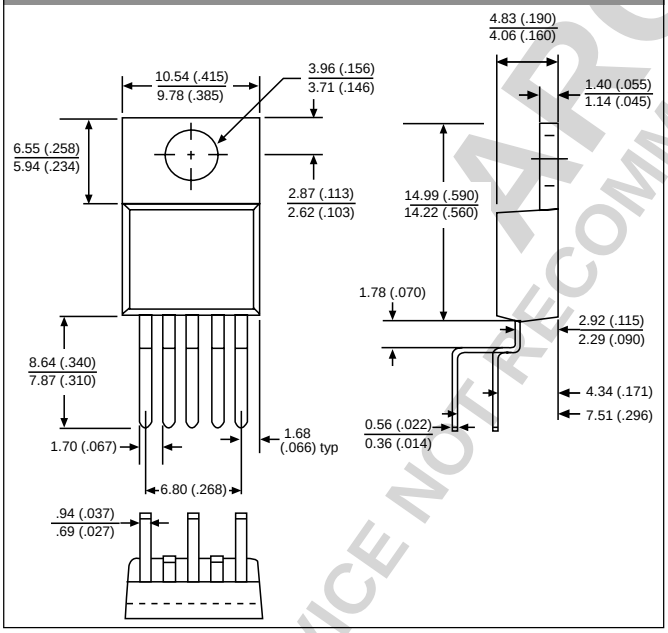
Package Specification

PACKAGE DIMENSIONS IN mm (INCHES)

5 Lead TO-220 (T) Straight



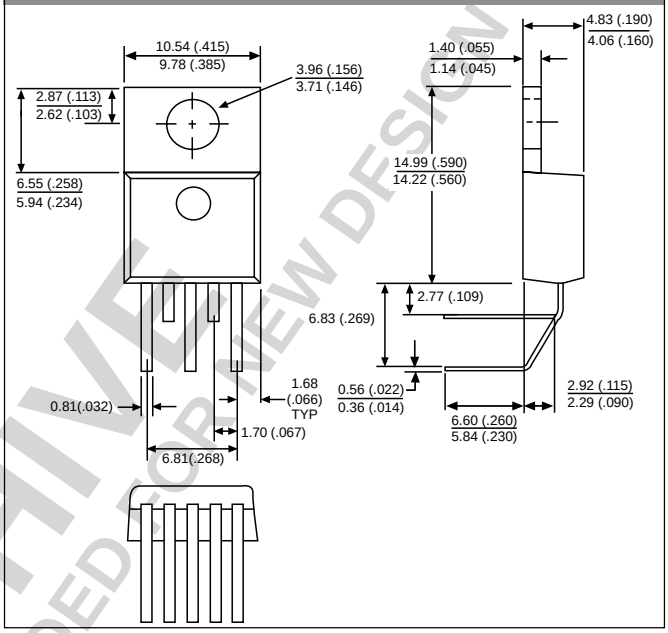
5 Lead TO-220 (TVA) Vertical



PACKAGE THERMAL DATA

Thermal Data		5 Lead TO-220	
$R_{\Theta JC}$	typ	2.0	°C / W
$R_{\Theta JA}$	typ	50	°C / W

5 Lead TO-220 (THA) Horizontal



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Ordering Information

Part Number	Description
CS8164YT5	5 Lead TO-220 Straight
CS8164YTVA5	5 Lead TO-220 Vertical
CS8164YTHA5	5 Lead TO-220 Horizontal

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