

# Voltage Regulator VRG8691/92

7.5 Amp LDO Adjustable Positive Voltage Regulators

Released Datasheet

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March 24, 2016

# COBHAM

The most important thing we build is trust

## FEATURES

- ❑ Radiation performance
  - Total dose: 100 krad(Si),  
Dose rate = 50-300 rad(Si)/s
- ❑ Output voltage adjustable: 1.0V to 3.3V
- ❑ Output current: 7.5A
- ❑ Dropout voltage: 0.5V at 7.5Amps
- ❑ Voltage reference: 1.0V  $\pm$ 0.5%
- ❑ Load regulation: 0.5% max
- ❑ Line regulation: 0.2% max
- ❑ Ripple rejection: >80dB
- ❑ Enable Input - TTL / CMOS Compatible
- ❑ Slow Start capability
- ❑ Stable with multiple ceramic output capacitors
- ❑ Packaging – Hermetic metal
  - Thru-hole or Surface mount
  - 12 Leads, 0.900"L x 1.000"W x .205"Ht
  - Power package
  - Weight - 18 gm max
- ❑ Designed for aerospace and high reliability space applications

❑ **Radiation Hardness Assurance Plan: DLA Certified to MIL-PRF-38534, Appendix G.**

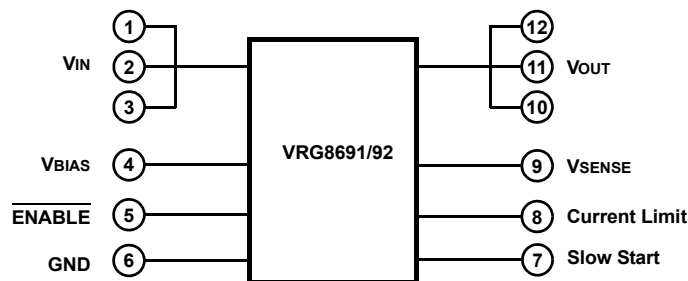
## DESCRIPTION

The VRG8691/92 is capable of supplying in excess of 7.5Amps over the output voltage range as defined under recommended operating conditions. The regulator is exceptionally easy to set-up, requiring only 2 external resistors to set the output voltage. The module design has been optimized for excellent regulation and low drop-out voltage. Figures 2 through 5 illustrate setting output voltage, setting current limits and choosing a slow start capacitor. The VRG8691/92 serves a wide variety of applications including local on-card regulation, programmable output voltage regulation or precision current regulation.

The VRG8691/92 has been specifically designed to meet exposure to radiation environments. The VRG8691 is configured for a Thru-Hole 12 lead metal power package and the VRG8692 is configured for a Surface Mount 12 lead metal power package. It is guaranteed operational from -55°C to +125°C. Available screened to MIL-STD-883, the VRG8691/92 is ideal for demanding military and space applications.

## CURRENT LIMIT (ICL)

The VRG8691/92 features internal current limiting making them virtually blowout-proof against overloads. The limit is nominally 11.5A @  $V_{in} = 5V$  (see Table 2), but may be increased or decreased with the addition of one external resistor (see Application Note 2).



**FIGURE 1 – BLOCK DIAGRAM / SCHEMATIC**

## ABSOLUTE MAXIMUM RATINGS

PARAMETER	RANGE	UNITS
Operating (Junction) Temperature Range	-55 to +150	°C
Lead Temperature (soldering, 10 sec)	300	°C
Storage Temperature Range	-65 to +150	°C
VBIAS, VIN	7	V
Thermal Resistance (Junction to case $\theta_{JC}$ )	1	°C/W
Power	25 <sup>1/</sup>	W

<sup>1/</sup> Based on pass transistor limitations of  $(V_{IN} - V_O) \times I_O$  and  $\theta_{JC} < 1^\circ\text{C/W}$  with  $25^\circ\text{C}$  max  $T_J$  rise and  $T_C = +125^\circ\text{C}$ .

NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only; functional operation beyond the "Operation Conditions" is not recommended and extended exposure beyond the "Operation Conditions" may effect device reliability.

## RECOMMENDED OPERATING CONDITIONS

PARAMETER	RANGE	UNITS
Output Voltage Range	1.0 to 3.3	V <sub>DC</sub>
Case Operating Temperature Range	-55 to +125	°C
Output Current	0 to 7.5	A
VBIAS	3.3 to 5.5 <sup>1/</sup>	V <sub>DC</sub>
VIN	1.8 to 5.5 <sup>2/</sup>	V <sub>DC</sub>

<sup>1/</sup> VBIAS must maintain a level equal or above VIN but not fall below 3.3V

<sup>2/</sup> Depending upon V<sub>OUT</sub> setting.

## ELECTRICAL PERFORMANCE CHARACTERISTICS <sup>1/</sup>

PARAMETER	SYM	CONDITIONS	MIN	MAX	UNITS
Reference Voltage	V <sub>REF</sub>	V <sub>IN</sub> = V <sub>BIAS</sub> = 5V, $\overline{\text{ENABLE}} = 0$ , $0A \leq I_{OUT} \leq 7.5A$	0.985	1.015	V
Line Regulation	$\frac{\Delta V_{OUT}}{\Delta V_{IN}}$	$2V \leq V_{IN} \leq 3V$ , $V_{OUT} = 1.0V$ , $C_{IN} \geq 47\mu F$ , $4.3V \leq V_{IN} \leq 5.3V$ , $V_{OUT} = 3.3V$ , $C_{OUT} \geq 47\mu F$ ,	-	0.2	%/V
Load Regulation	$\frac{\Delta V_{OUT}}{\Delta I_{OUT}}$	$0A \leq I_{OUT} \leq 7.5A$ , $C_{IN} \geq 47\mu F$ , $C_{OUT} \geq 47\mu F$ ,	-	0.5	%
Ripple Rejection Ratio		$f = 120\text{Hz}$ , $C_{LOAD} = 47\mu F$ , $V_{IN} + V_{RIP} \geq V_{OUT} + V_{DROP(MAX)}$ @ 5A, $V_{IN} = 4.3V$ , $V_{RIP} = 1V_{P-P}$ , $V_{OUT} = 3.3V$	80	-	dB
Dropout Voltage	V <sub>DROP</sub>	@ $\Delta V_{OUT} = 1\%$ , $0A \leq I_{OUT} \leq 7.5A$	-	0.5	V
Adjustment Pin Current	I <sub>ADJ</sub>		-	100	pA
Minimum Load Current	I <sub>MIN</sub>		-	0	mA
Current Limit <sup>2/</sup>	I <sub>CL</sub>		9.5	13.5	A
Long Term Stability <sup>3/</sup>	$\frac{\Delta V_{OUT}}{\Delta \text{TIME}}$		-	1	%
Supply Current (VBIAS)	I <sub>BIAS</sub>		-	15	mA

Notes:

<sup>1/</sup> Unless otherwise specified, these specifications apply for post radiation: V<sub>BIAS</sub> = V<sub>IN</sub> = 5V, V<sub>OUT</sub> = 3.3V, I<sub>OUT</sub> = 7.5A and  $-55^\circ\text{C} < T_C < +125^\circ\text{C}$ , Min Input/Output capacity of 47 $\mu F$  Tant with 1 $\mu F$  ceramic in parallel.

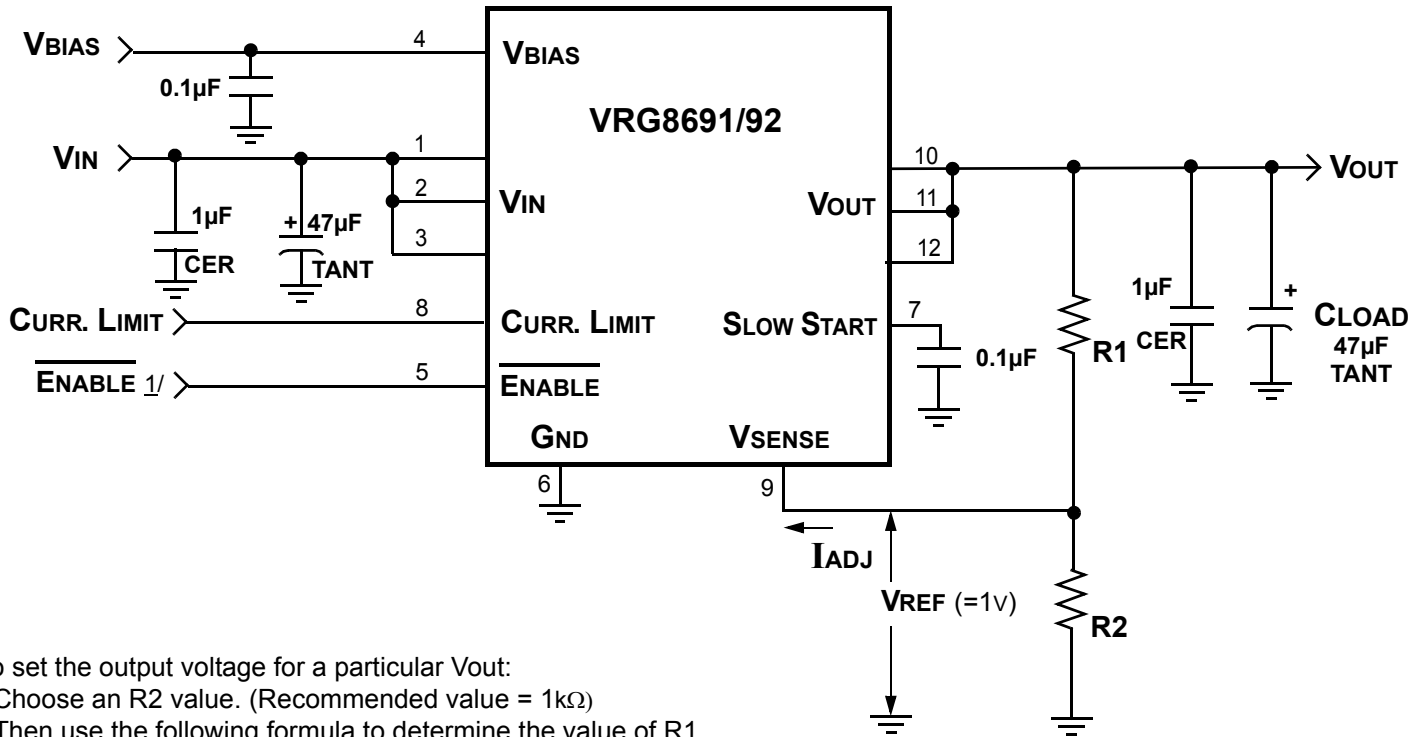
<sup>2/</sup> Current Limit is adjustable as shown in Application Note 2, Figures 3 and 4.

<sup>3/</sup> Not tested. Shall be guaranteed to the specified limits after 1000hr life test.

# APPLICATION NOTE 1

## BASIC SET-UP

Setting the output voltage (V<sub>OUT</sub>):



To set the output voltage for a particular V<sub>OUT</sub>:

- Choose an R<sub>2</sub> value. (Recommended value = 1kΩ)
- Then use the following formula to determine the value of R<sub>1</sub>.

$$R_1 = R_2 \times \frac{V_{OUT} - V_{REF}}{(R_2 \times I_{ADJ}) + V_{REF}}, \text{ where } V_{REF} = 1\text{V}, I_{ADJ} \text{ typ} = 10\text{pA}$$

Table 1 shows example values for R<sub>1</sub> and R<sub>2</sub> to achieve some standard voltages.  
 Table 2 shows the nominal current limit settings if the 'CURR. LIMIT' function (pin 8) is left open.

Table 1  
Example R<sub>1</sub> & R<sub>2</sub> for typical V<sub>OUT</sub>

V <sub>OUT</sub>	R <sub>2</sub>	R <sub>1</sub>
3.3V	1kΩ	2.3kΩ
2.5V	1kΩ	1.5kΩ
1.8V	1kΩ	800Ω
1.0V	1kΩ	0Ω

Table 2  
2/

V <sub>IN</sub>	I <sub>CL</sub> NOM
5V	11.5A
3.3V	7.5A
2.5V	5.7A
1.8V	4.1A

Notes:

1/ ENABLE should be asserted after both V<sub>IN</sub> and V<sub>BIAS</sub> are applied.  
 (See Application Note 3, Figure 5 for the configuration where a separate ENABLE control line is NOT required).

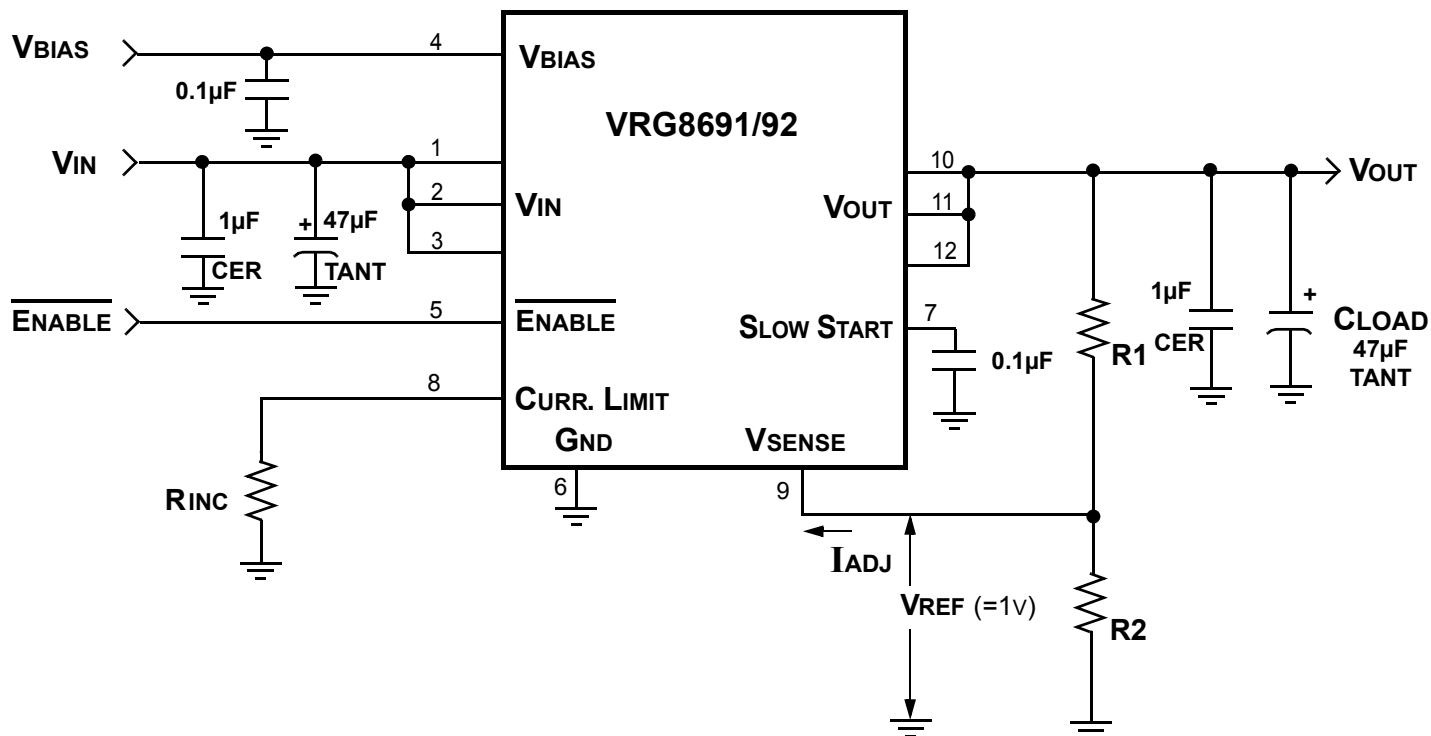
2/ I<sub>CL</sub> varies directly with V<sub>IN</sub>.  
 (See Application Note 2 for adjusting the Current Limit, I<sub>CL</sub>).

**FIGURE 2 –SETTING OUTPUT VOLTAGE**

## APPLICATION NOTE 2

### SETTING THE CURRENT LIMIT

To Increase the Current Limit (ICL):



- If the 'CURR. LIMIT' function (pin 8) is left open, the ICL decreases from 11.5 A(NOM) as VIN is decreased from 5V (Table 3).

Table 3

VIN	RINC	ICL NOM
5V	Open	11.5 A
3.3V	Open	7.5 A
2.5V	Open	5.7 A
1.8V	Open	4.1 A

- To increase the current limit above the nominal setting for any VIN and ICL combination, use the following formula:

$$RINC(K-OHMS) = \frac{30 \times V_{IN}}{\left(\frac{30 \times I_{CL}}{69}\right) - V_{IN}}$$

- To maintain ICL at the 11.5 A setting, for commonly found VIN voltages, apply RINC value found in Table 4.

Table 4

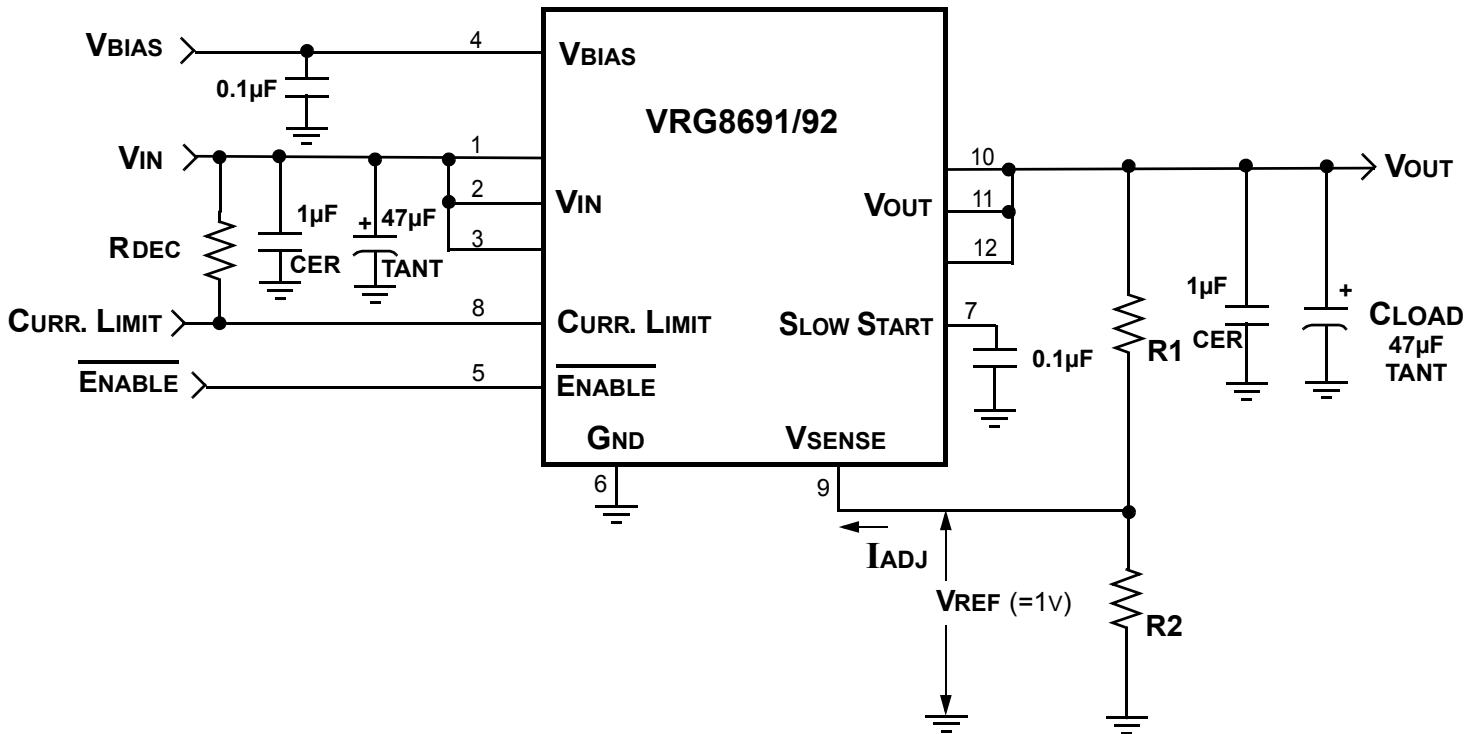
VIN	RINC	ICL NOM
5V	Open	11.5 A
3.3V	56kΩ	11.5 A
2.5V	30kΩ	11.5 A
1.8V	16kΩ	11.5 A

**FIGURE 3 – INCREASING THE CURRENT LIMIT (ICL)**

## APPLICATION NOTE 2 (CONTINUED)

### SETTING THE CURRENT LIMIT

To Decrease the Current Limit (ICL):



- As shown in Table 3, if the 'CURR. LIMIT' function (pin 8) is left open, the ICL decreases from 11.5 A(NOM) as VIN is decreased from 5V.

- To achieve any ICL, less than nominal, use RDEC which can be calculated using the following formula:

$$RDEC(K-OHMS) = \frac{31 \times V_{IN}}{\left(\frac{69 \times V_{IN}}{30}\right) - I_{CL}}$$

**FIGURE 4 – DECREASING THE CURRENT LIMIT (ICL)**

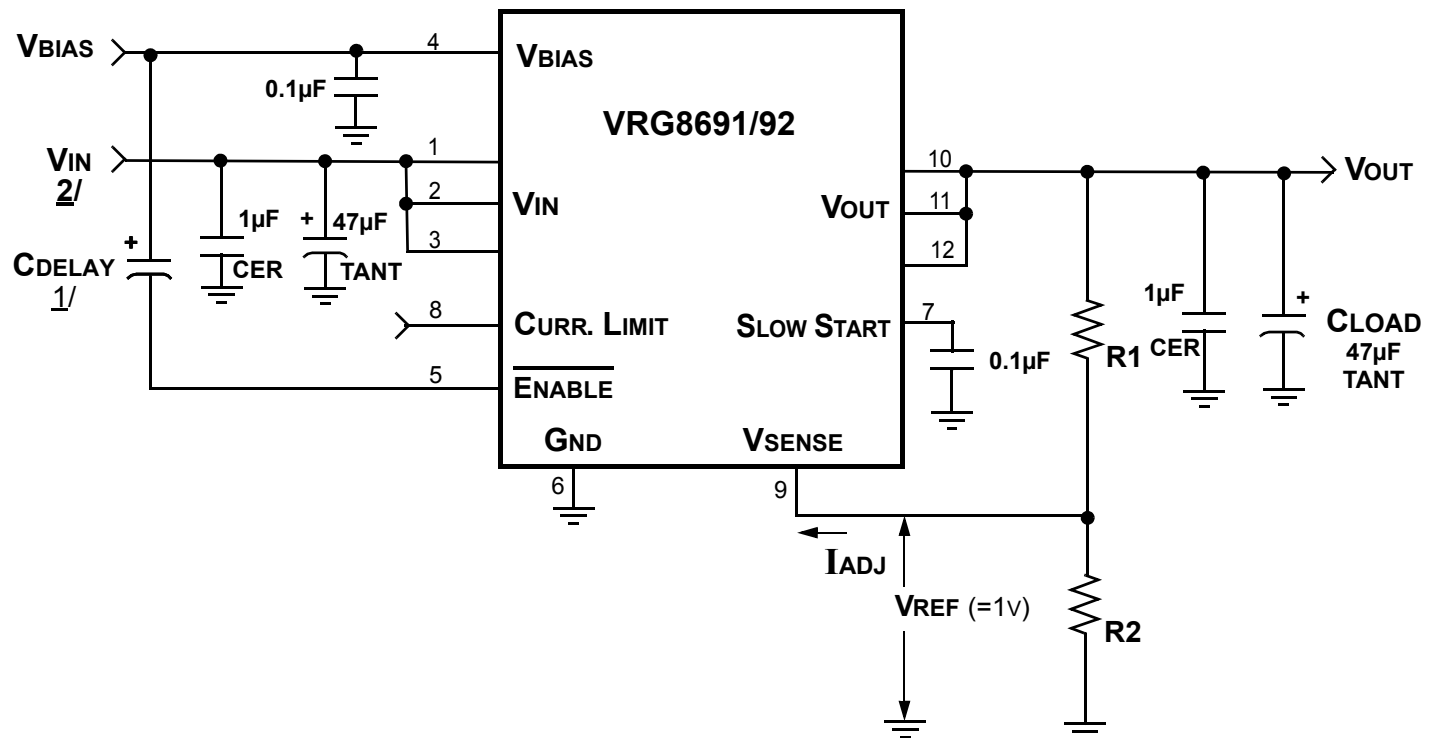
## APPLICATION NOTE 3

### START UP SEQUENCE

#### Recommended Power Supply Sequencing Options:

- OPTION 1: Controlling the  $\overline{\text{ENABLE}}$  line with a Digital signal (TTL / CMOS compatible).
  - Prior to applying power, disable the regulator by setting the  $\overline{\text{ENABLE}}$  control line to a HIGH state.
  - Apply  $V_{\text{IN}}$  and  $V_{\text{BIAS}}$ . 1/
  - Wait until both  $V_{\text{IN}}$  and  $V_{\text{BIAS}}$  supplies have reached their operating levels.
  - Toggle the  $\overline{\text{ENABLE}}$  control line to a LOW state to turn on  $V_{\text{OUT}}$  of the regulator.
- OPTION 2: Controlling the  $\overline{\text{ENABLE}}$  line using the CDELAY feature.
  - Connect a CDELAY capacitor between  $V_{\text{BIAS}}$  and the  $\overline{\text{ENABLE}}$  as shown in Figure 5 below. 2/
  - Apply  $V_{\text{IN}}$  and  $V_{\text{BIAS}}$ . 1/
  - CDELAY causes the regulator to self-enable after  $V_{\text{BIAS}}$  has reached operating level.

NOTE: The  $\overline{\text{ENABLE}}$  should always be asserted AFTER  $V_{\text{IN}}$  and  $V_{\text{BIAS}}$  have reached operating level.



#### NOTES:

- 1/  $V_{\text{IN}}$  should be applied before  $V_{\text{BIAS}}$  if the Slow Start feature is used.
- 2/ CDELAY capacitor of 10µF is adequate for  $V_{\text{BIAS}}$  rise times of up to 50ms.

FIGURE 5 – DELAYED ENABLE

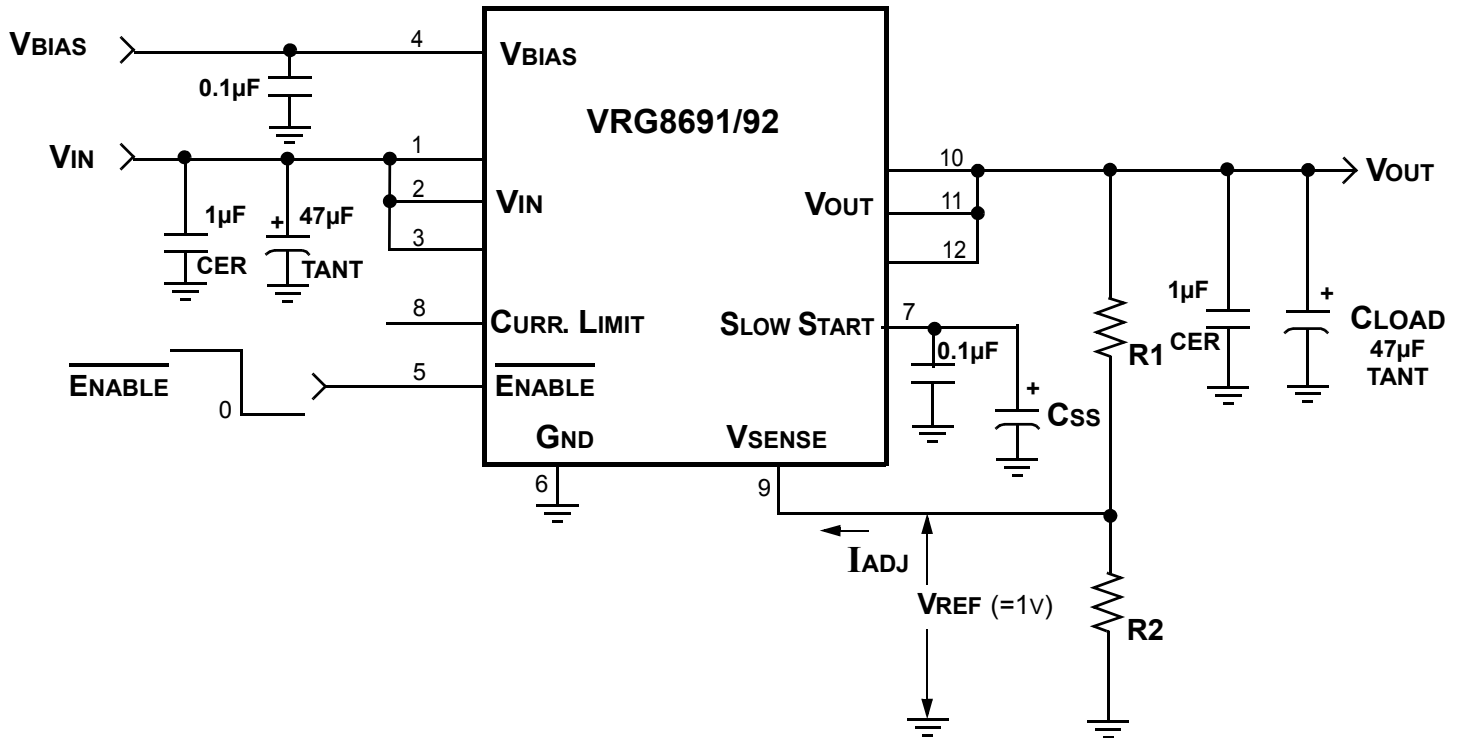
## APPLICATION NOTE 4

### VOUT START UP RISE TIME CONTROL

#### Utilizing the Slow Start option:

When the VRG8691/92 is first powered up, using the Slow Start function controls the rate at which VOUT rises to the required voltage set by R1 and R2.

Note: VIN should be applied before VBIAS when the Slow Start feature is used.



If it is desirable to control the output rise time, a capacitor (CSS) can be asserted on the Slow Start pin to adjust the rise time for the following:

- A. Large load capacitance will cause high surge currents which will trip the current limit circuitry.  
The use of CSS will allow the output voltage to rise slowly thus mitigate the surge current phenomenon.

$$\frac{C_{SS}}{C_{LOAD}} > \frac{V_{OUT\ NOM}}{I_{CL} - I_{LOAD\ NOM}} \times (0.4 \times 0.0014)$$

- B. CSS may be used solely to control VOUT RISE TIME (Tr), when CLOAD is not an issue.

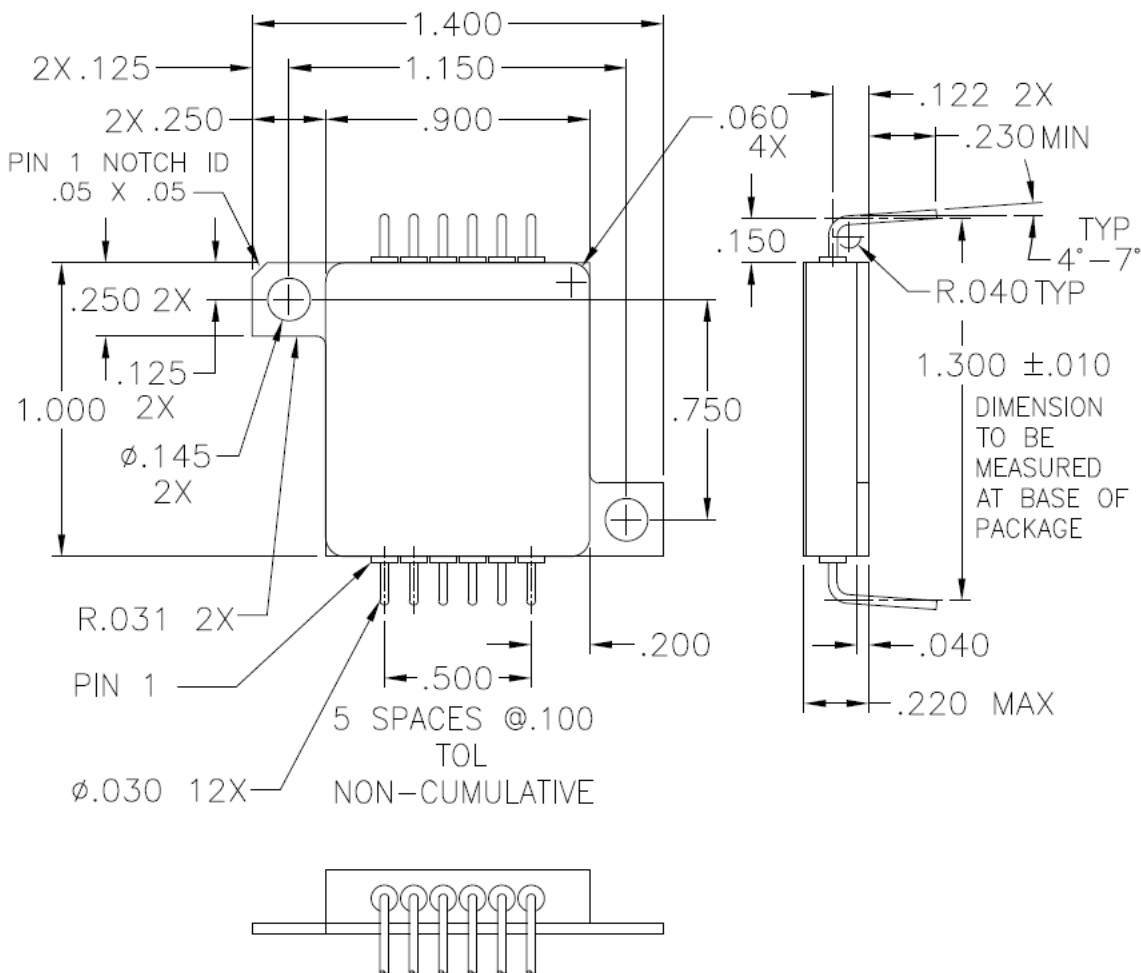
$$T_R = \left( \frac{C_{SS} \times 2.5}{0.0014} \right) \quad \text{Note: } C_{SS} \text{ in Farads and } T_R \text{ in seconds.}$$

- C. CSS is effective only when VIN is applied prior to VBIAS or  $\overline{ENABLE}$ .

**FIGURE 6 – SLOW START**

## PIN NUMBERS vs FUNCTION

PIN	FUNCTION	PIN	FUNCTION
1	VIN	7	Slow Start
2	VIN	8	Current Limit
3	VIN	9	VSENSE
4	VBIAS	10	VOUT
5	$\overline{\text{ENABLE}}$	11	VOUT
6	GROUND	12	VOUT



### Notes:

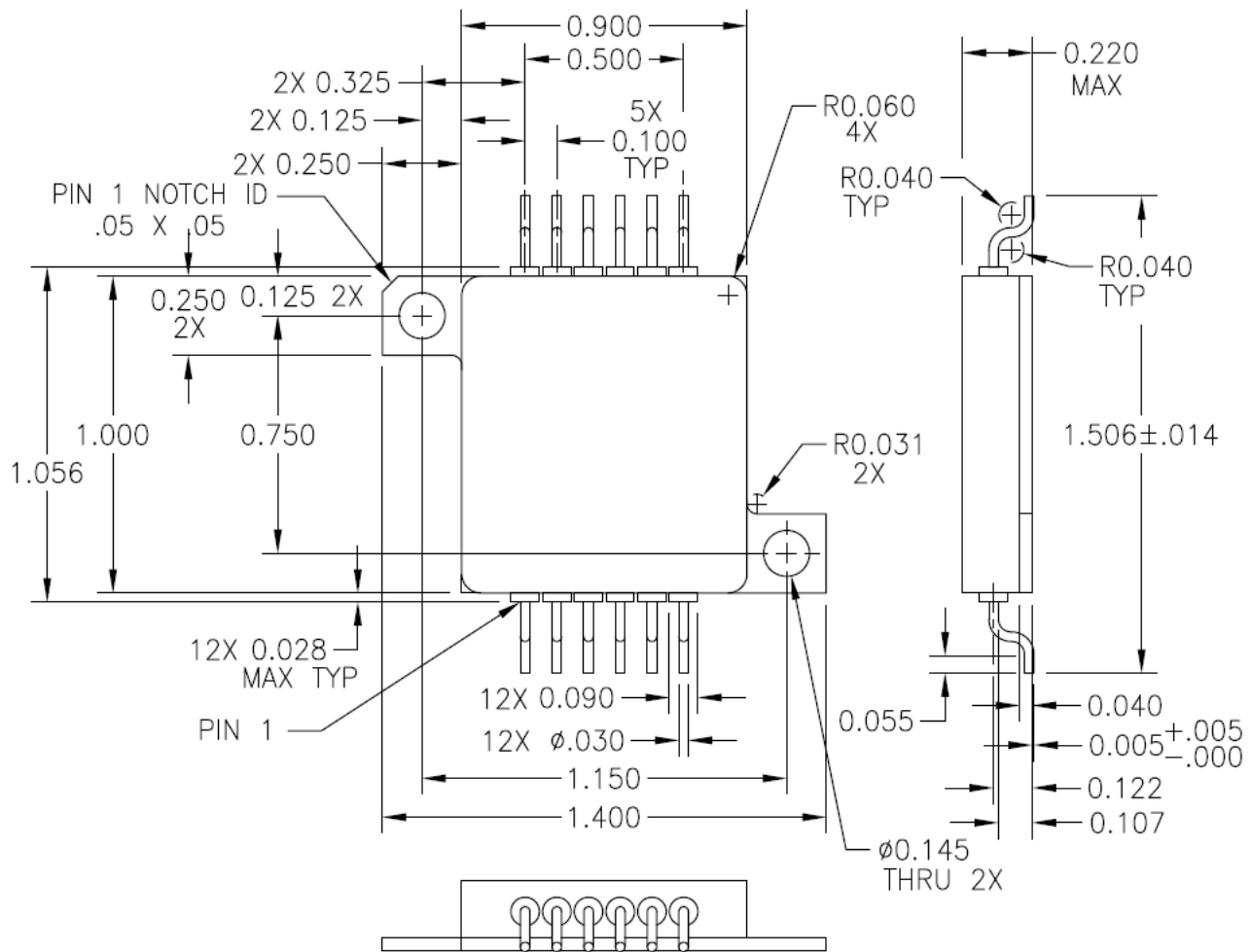
1. Dimension Tolerance:  $\pm .005$  inches
2. Package contains BeO substrate
3. Case electrically isolated

**FIGURE 7- PACKAGE OUTLINE — VRG8691 THRU-HOLE POWER PACKAGE**



## PIN NUMBERS vs FUNCTION

PIN	FUNCTION	PIN	FUNCTION
1	V <sub>IN</sub>	7	Slow Start
2	V <sub>IN</sub>	8	Current Limit
3	V <sub>IN</sub>	9	V <sub>SENSE</sub>
4	V <sub>BIAS</sub>	10	V <sub>OUT</sub>
5	$\overline{\text{ENABLE}}$	11	V <sub>OUT</sub>
6	GROUND	12	V <sub>OUT</sub>



**Notes:**

1. Dimension Tolerance:  $\pm 0.005$  inches
2. Package contains BeO substrate
3. Case electrically isolated

**FIGURE 8— PACKAGE OUTLINE — VRG8692 SURFACE MOUNT POWER PACKAGE**

## ORDERING INFORMATION

MODEL	DLA SMD #	SCREENING	PACKAGE
VRG8691-7	-	Commercial Flow, +25°C testing only	12 Lead Thru-Hole Power Pkg
VRG8691-S	-	Military Temperature, -55°C to +125°C Screened in accordance with the individual Test Methods of MIL-STD-883 for Space Applications	
VRG8691-201-1S	5962-0923701KXC	In accordance with DLA SMD	
VRG8691-201-2S	5962-0923701KXA		
VRG8691-901-1S	5962R0923701KXC	In accordance with DLA Certified RHA Program Plan to RHA Level "R", 100 krad(Si)	
VRG8691-901-2S	5962R0923701KXA		
VRG8692-7	-	Commercial Flow, +25°C testing only	12 Lead Surface Mount Power Pkg
VRG8692-S	-	Military Temperature, -55°C to +125°C Screened in accordance with the individual Test Methods of MIL-STD-883 for Space Applications	
VRG8692-201-1S	5962-0923701KYC	In accordance with DLA SMD	
VRG8692-201-2S	5962-0923701KYA		
VRG8692-901-1S	5962R0923701KYC	In accordance with DLA Certified RHA Program Plan to RHA Level "R", 100 krad(Si)	
VRG8692-901-2S	5962R0923701KYA		

## REVISION HISTORY

Date	Revision	Change Description
03/24/2016	J	Import into Cobham format

## *Datasheet Definition*

**Advanced Datasheet - Product In Development**

**Preliminary Datasheet - Shipping Prototype**

**Datasheet - Shipping QML & Reduced Hi-Rel**



### **EXPORT CONTROL:**

*This product is controlled for export under the Export Administration Regulations (EAR), 15 CFR Parts 730-774. A license from the Department of Commerce may be required prior to the export of this product from the United States.*

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