Evaluation Board User Guide

RHP50000-CSL Evaluation Board

Evaluates: RHP50000-CSL

Description

EVAL-RHP50000-CSLZ features the RHP50000-CSL 12.5A, low voltage, synchronous step-down Silent Switcher® 2 for commercial space operating as a 2MHz 3.3V to 1.2V, 12.5A buck regulator. The RHP50000-CSL supports output voltages from 0.5V to V_{IN} with operating frequencies from 500kHz up to 5MHz. The RHP50000-CSL is a compact, ultralow emission, high efficiency, and high speed synchronous monolithic step-down switching regulator. The integrated bypass capacitors optimize all the fast current loops and make it easier to minimize electromagnetic interference (EMI) by reducing layout sensitivity. Fast minimum on-time of 35ns enables high V_{IN} to low V_{OUT} conversion at high frequency. The RHP50000-CSL is total ionizing dose (TID) assured up to 30krad(Si). It is single-event latch-up (SEL) free up to 47.0 MeV·cm^2/mg at $V_{IN} \leq 3.6V$.

EVAL-RHP50000-CSLZ is set up to run in forced continuous mode with a 2MHz switching frequency but can be configured to pulse skip mode or different switching frequencies. RT is connected to V_{IN} which sets the MODE/SYNC pin as an input and allows the RHP50000-CSL to sync from an external clock. Connecting the MODE/SYNC pin to V_{IN} sets the mode to pulse skip mode and connecting the MODE/SYNC pin to GND sets the mode to forced continuous mode.

The RHP50000-CSL data sheet gives a complete description of the part, operation, and application information. The data sheet must be read in conjunction with this evaluation board. The RHP50000-CSL is assembled in a 3mm × 3mm LQFN package with exposed pads for low thermal resistance. The layout recommendations for low EMI operation and maximum thermal performance are available in the data sheet.

EVAL-RHP50000-CSLZ is intended only for electrical evaluation purposes. Design files and ordering information for this circuit board are available at *www.analog.com*.

Performance Summary

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		2.25		5.5	V
V_{OUT} Voltage Range*		1.176	1.2	1.224	V
Output Current	V_{IN} > 3V			12.5	A
Switching Frequency		1.8		2.2	MHz
Minimum On-Time			35	60	ns

*With 1% feedback resistors. Accuracy will improve to within 1% using 0.1% FB resistors.

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Quick Start Procedure

EVAL-RHP50000-CSLZ is easy to set up and evaluate the performance of the RHP50000-CSL. See *Figure 1* for proper measurement equipment setup and follow the procedure below.

NOTE: For accurate V_{IN}, V_{OUT} and efficiency measurements, measure V_{IN} at the VIN SNSE and GND SNSE turrets and V_{OUT} at the VOUT SNSE and GND SNSE turrets as illustrated as VM1 and VM2 in *Figure 1*. When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the output voltage ripple by touching the probe tip directly across the output turrets as shown in *Figure 2*.

1. Set the J1 Jumper to the HI position.
2. With power off, connect the input power supply (PS1) to V_{IN} and GND.
3. Slowly increase PS1 to 1V. If AM1 reads less than 20mA, increase PS1 to 3.3V. Verify that VM1 reads 3.3V and VM2 reads 1.2V. Record VM1, VM2, VM3, AM1, and AM2. Connect an oscilloscope voltage probe as shown in *Figure 2*. Set Channel to AC-coupled, voltage scale to 20mV and time base to 10µs. Record V_{OUT} ripple voltage. Verify that PGOOD voltage is above 3V. Calculate die temperature using formula below:

$$T_J(°C) = \frac{V_{SSTT}}{4mV} - 273$$

4. Increase the load by 1A intervals up to 12A and observe the voltage output regulation, ripple voltage, and the voltage on the SSTT turret. Observe the switching waveform by contacting a second voltage probe, set to 1V scale, to the SW node of UI pins 6, 7, 8, and 9 as shown in *Figure 1*.
5. If pulse skip mode is desired, set PS1 to 0V. Install a 100k resistor in the R3 location and remove R6 or short the MODE/SYNC turret to V_{IN}. Repeat steps 1 through 4. In step 4, observe that the switching waveform is now operating in pulse skip mode at low currents.
6. To change the frequency, remove R4 and R6 if installed. Install the desired RT resistor in the R7 location. Note, the MODE/SYNC pin is an output when R4 is installed and the MODE/SYNC pin should have high impedance to GND and V_{IN}. Size the inductor, output capacitors and compensation components to provide the desired inductor ripple and a stable output. Refer to the RHP50000-CSL data sheet for more information on choosing the required components.
7. Turn off PS1 and Load. Remove all connections to the evaluation board.

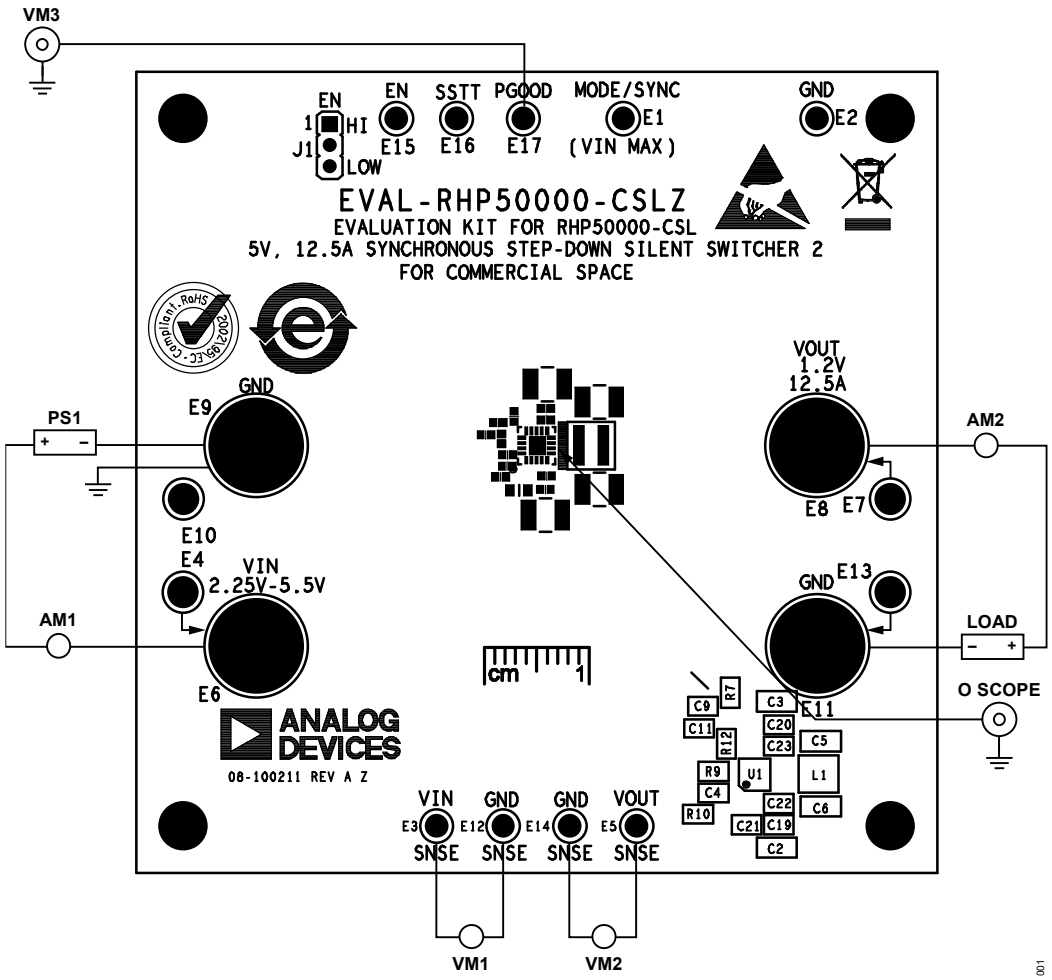


Figure 1. Test Setup for the EVAL-RHP50000-CSLZ Evaluation Board

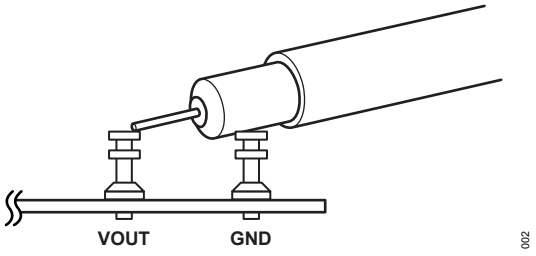


Figure 2. Technique for Measuring Output Ripple

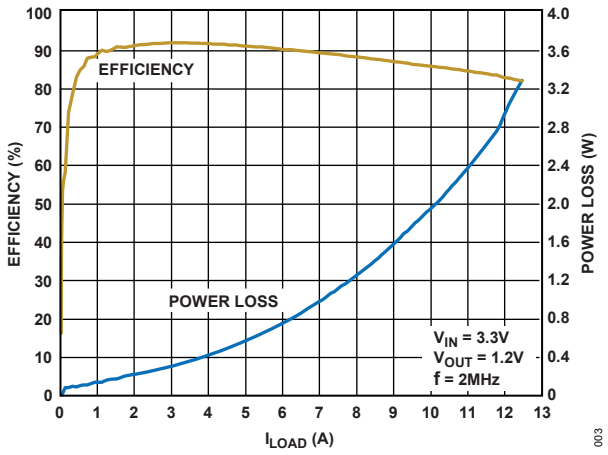


Figure 3. Efficiency vs. Load Current

Theory Of Operation

Introduction to the EVAL-RHP50000-CSLZ

The EVAL-RHP50000-CSLZ evaluation board circuit features the RHP50000-CSL, a low voltage synchronous step-down silent switcher for commercial space applications. The RHP50000-CSL is a monolithic, constant frequency, current mode step-down DC/DC converter. An oscillator, with frequency set using a resistor on the RT pin, turns on the internal top power switch at the beginning of each clock cycle. Current in the inductor then increases until the top switch comparator trips and turns off the top power switch. The peak inductor current at which the top switch turns off is controlled by the voltage on the internal ITH node. The error amplifier servos the ITH node by comparing the voltage on the VFB pin with an internal 500mV reference. When the load current increases, it causes a reduction in the feedback voltage relative to the reference leading the error amplifier to raise the ITH voltage until the average inductor current matches the new load current. When the top switch turns off, the synchronous power switch turns on until the next clock cycle begins or the inductor current falls to zero. If overload conditions result in excessive current flowing through the bottom switch, the next clock cycle will be delayed until the switch current returns to a safe level.

If the EN pin is low, the RHP50000-CSL is in shutdown and in a low quiescent current state. When the EN pin is above its threshold, the switching regulator will be enabled.

The MODE/SYNC pin synchronizes the switching frequency to an external clock, is a clock output or sets the PWM mode. The PWM modes of operation are either pulse-skipping or forced continuous. Refer to the RHP50000-CSL data sheet for more detailed information.

The maximum allowable operating frequency is influenced by the minimum on time of the top switch, the ratio of V_{OUT} to V_{IN} and the available inductor values. The maximum allowable operating frequency may be calculated using a minimum t_{ON} of 35ns in the formula below.

$$f_{SW(MAX)} = \frac{V_{OUT}}{V_{IN(MAX)} \bullet t_{ON(MIN)}}$$

Select an operating switching frequency below $f_{SW(MAX)}$. Typically, it is desired to obtain an inductor current of 30% of the maximum RHP50000-CSL operating load, 12.5A. Use the equations below to calculate the inductor value to obtain a 30% (3.75A) inductor ripple for the operating frequency.

$$L \geq \frac{V_{OUT}}{3.75A \bullet f_{SW}} \bullet \left(1 - \frac{V_{OUT}}{V_{IN(MAX)}}\right) \text{for } \frac{V_{OUT}}{V_{IN(MAX)}} \leq 0.5$$

$$L \geq \frac{0.25 \bullet V_{IN(MAX)}}{3.75A \bullet f_{SW}} \text{ for } \frac{V_{OUT}}{V_{IN(MAX)}} > 0.5$$

When determining the compensation components, C4, C11 and R12, controlling the loop stability and transient response are the two main considerations. The RHP50000-CSL has been designed to operate at a high bandwidth for fast transient response capabilities. This reduces output capacitance required to meet the desired transient response.

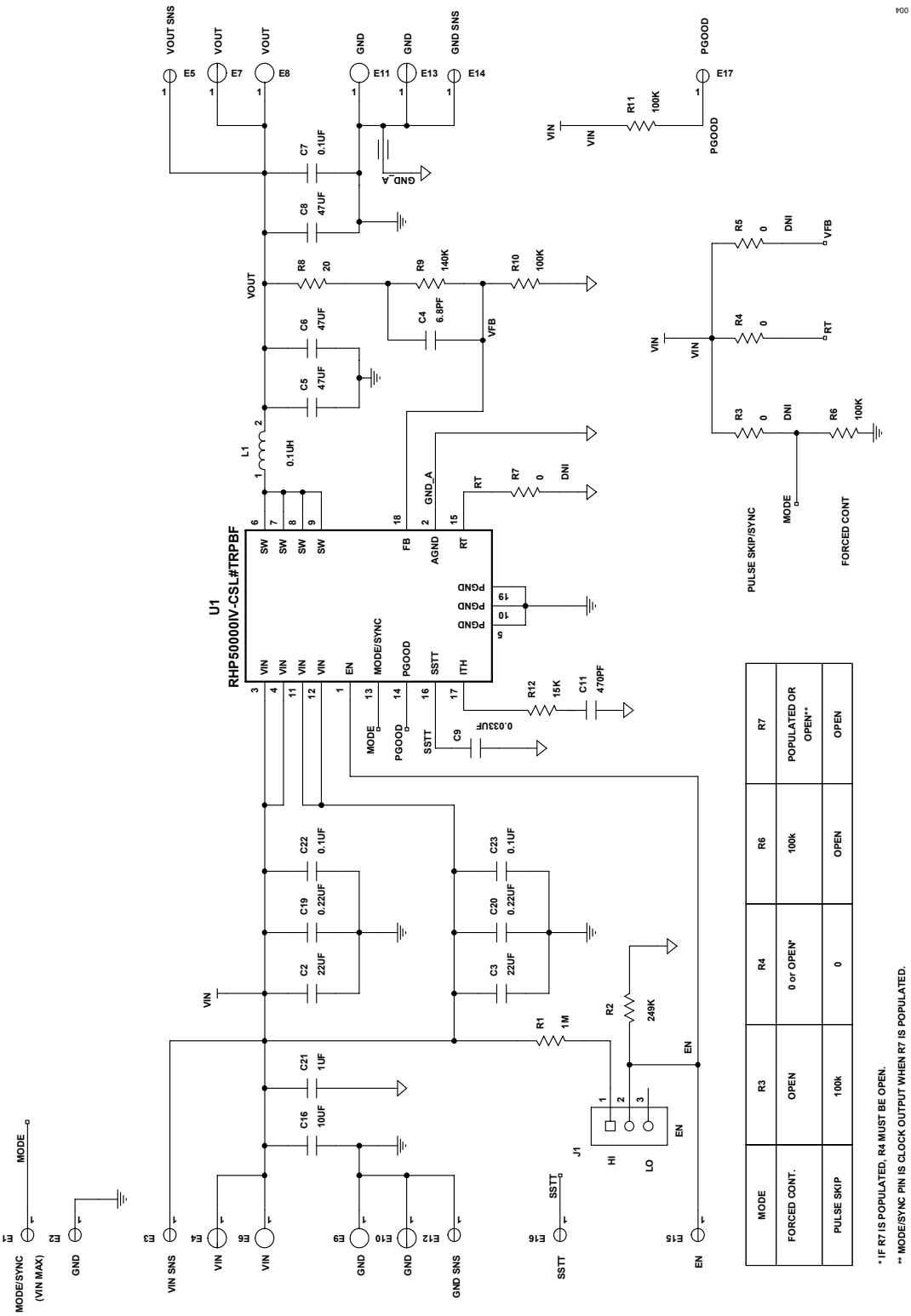
Loop stability is generally measured using the bode plot method of plotting loop gain in dB and phase in degrees. The 0dB crossover frequency should be less than 1/6 of the operating frequency to reduce the effects of added phase shift of the modulator. The control loop phase margin goal should be 45° or greater and a gain margin goal of 8dB or greater.

Parts List

ITEM	QTY	REFERENCE DESIGNATOR	PART DESCRIPTION	MANUFACTURER/ PART NUMBER
Required Items				
1	1	N/A	PCB	
2	1	C11	CAP, SMT (0402), 470pF, 5%, 50V, C0G, CERAMIC	MURATA GCM1555C1H471JA16
3	1	C16	CAP, SMT (0805), 10µF, 20%, 16V, X7R, CERAMIC	TAIYO YUDEN EMK212BB7106MG
4	2	C19, C20	CAP, SMT (0402), 0.22µF, 10%, 16V, X7R, CERAMIC	MURATA GRM155R71C224KA12
5	2	C2, C3	CAP, SMT (1210), 22µF, 20%, 25V, X7R, CERAMIC	MURATA GRM32ER71E226M
6	1	C21	CAP, SMT (0603), 1µF, 10%, 16V, X7R, CERAMIC	MURATA GCM188R71C105KA64
7	3	C7, C22, C23	CAP, SMT (0402), 0.1µF, 10%, 25V, X7R, CERAMIC	MURATA GRM155R71E104KE14
8	1	C4	CAP CER, 6.8pF, 50V, 0.1pF, C0G 0402	MURATA GJM1555C1H6R8BB01D
9	3	C5, C6, C8	CAP, SMT (1210), 47µF, 20%, 6.3V, X7R, CERAMIC	MURATA GRM32ER70J476ME20
10	1	C9	CAP, SMT (0402), 0.033µF, 10%, 25V, X7R, CERAMIC	MURATA GRM155R71E333KA88
11	9	E1, E2, E3, E5, E12, E14, E15, E16, E17	CONN-PCB SOLDER TERMINAL TURRETS FOR CLIP LEADS	MILL-MAX 2308-2-00-80-00-00-07-0
12	4	E4, E7, E10, E13	CONN-PCB SOLDER TERMINAL TEST POINT TURRET 0.094 MTG. HOLE PCB 0.062” THK	MILL-MAX 2501-2-00-80-00-00-07-0
13	4	E6, E8, E9, E11	CONN-PCB BANANA JACK	KEYSTONE ELECTRONICS 575-4
14	1	J1	CONNECTOR, MALE, THROUGH HOLE, WR-PHD THT STRAIGHT SINGLE PIN HEADER, STRAIGHT, 3PINS	WURTH ELECTRONICS 62000311121

15	1	L1	IND SHIELDED POWER, 0.0018Ω, DCR, 25.8A, AEC-Q200	COILCRAFT INC. XEL4030-101MEC
16	1	R1	RES; SMT (0402), 1M, 1%, ±100PPM/DEGC, 0.0630W	VISHAY DALE CRCW04021M00FK
17	3	R6, R10, R11	RES SMD 100KΩ, 1%, 1/16W, 0402, AEC-Q200	VISHAY CRCW0402100KFKED
18	1	R12	RES SMD 15KΩ, 1%, 1/16W, 0402, AEC-Q200	VISHAY CRCW040215K0FKED
19	1	R2	RES, SMT (0402), 249K, 1%, ±100PPM/DEGC, 0.0630W	VISHAY CRCW0402249KFK
20	1	R4	RES, SMD 0Ω, JUMPER, 1/5W 0402, AEC-Q200	VISHAY CRCW04020000Z0EDHP
21	1	R8	RES, SMT (0402), 20, 1%, ±100PPM/DEGC, 0.0630W	VISHAY DALE CRCW040220R0FK
22	1	R9	RES, SMD, 140KΩ, 1%, 1/16W, 0402, AEC-Q200	VISHAY CRCW0402140KFKED
23	1	U1	IC; 5V, 12.5A, SYNCRONOUS STEP-DOWN SILENT SWITCHER 2 FOR COMMERCIAL SPACE	ANALOG DEVICES RHP50000IV-CSL#TRPBF
Mechanical Items				
1	1	N/A	SHUNT, 2POS, 2MM PITCH, BLACK	SAMTEC INC 2SN-BK-G
2	4	MECH1, MECH2, MECH3, MECH4	STANDOFF, BRD SUPPORT SNAP LOCK/SCREW MOUNT NYLON 15MM LONG, 6.6 OD, 3.2 ID	KEYSTONE 9032
Items Not Installed				
1	3	R3, R5, R7	RES, SMD 0Ω, 0402	

Schematic Diagram



MODE	R3	R4	R6	R7
FORCED CONT.	OPEN	0 or OPEN*	100k	POPULATED OR OPEN**
PULSE SKIP	100k	0	OPEN	OPEN

Notes