5A 2-4 Cell Buck-Boost Switching Battery Charger Evaluation Board

General Description

The Evaluation Board demonstrates that the RT9492GQVF(2) is designed for a highly-integrated 5A Buck-Boost switch mode battery charge management and system power path management device for 2-4 cell Li-Ion and Li-polymer batteries. The low impedance power path optimizes switch-mode operation efficiency, reduces battery charging time, and extends battery life during the discharging phase. The I^2C serial interface with charging and system settings makes the device a truly flexible solution.

Table of Contents

Performance Specification Summary

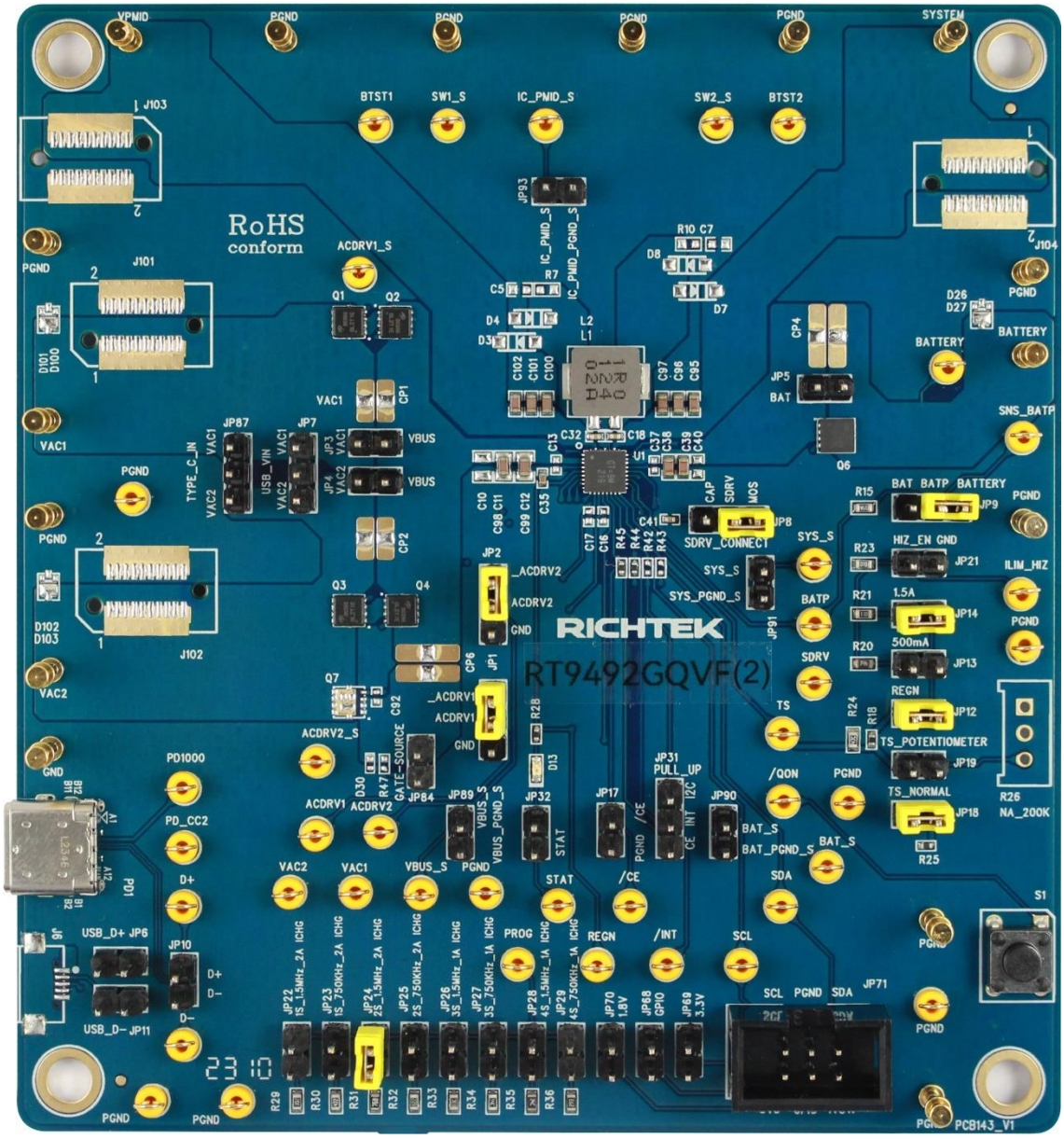
Summary of the RT9492GQVF(2) Evaluation Board performance specification is provided in Table 1. The ambient temperature is 25°C.

Table 1. RT9492GQVF(2) Evaluation Board Performance Specification Summary

Specification	Test Conditions	Min	Typ	Max	Unit
Supply Input Voltage Range		3.6	--	24	V
Maximum Input Current		--	--	3.3	A
Maximum OTG Current	OTG mode	--	--	3.32	A
Maximum Output Current	(SW2), ISYS	--	--	5	A
Maximum Battery Voltage		--	--	18.8	V
Maximum Charge Current		--	--	5	A
Maximum Discharge Current		--	--	10	A

Detailed Description of Hardware

Headers Description and Placement



Carefully inspect all the components used in the EVB according to the following Bill of Materials table, and then make sure all the components are undamaged and correctly installed. If there is any missing or damaged component, which may occur during transportation, please contact our distributors or e-mail us at evb_service@richtek.com.

Test Points

The EVB is provided with the test points and pin names listed in the table below.

Test Point/ Pin Name	Function
VAC1	Input voltage for VAC1.
PGND	Ground.
VAC2	Input voltage for VAC2.
SYSTEM	Output voltage for sys.
BATTERY	Battery connection point.
SNS_BATP	External battery positive sense
PD1	USB TYPE-C port.
JP87	TYPE-C USB BUS tied to VAC1 or VAC2 jumper.
JP8	SDRV tied to SHIPFET or 1nF capacitor.
JP31	Pull up for I2C/INT/CE.
JP1	ACDRV1 tied to AC-RBFET1 or GND.
JP2	ACDRV2 tied to AC-RBFET2 or GND.
JP3	VAC1-VBUS short jumper.
JP4	VAC2-VBUS short jumper.
JP5	BAT-BATTERY short jumper.
JP9	BATP tied to BATTERY or BAT.
JP12	REGN for TS circuit pull high jumper.
JP13	Test resistence jumper with 500mA for ILIM_HZ function.
JP14	Test resistence jumper with 1.5A for ILIM_HZ function.
JP17	CE pull low jumper.
JP18	Test resistence jumper with TS_NORMAL for JEITA.
JP19	Test resistence jumper with TS_POTENTIOMETER for JEITA.
JP21	Test resistence jumper for ILIM_HZ function.
JP22	This header is for the part number RT9492S.
JP23	This header is for the part number RT9492S.
JP24	PROG resistence jumper for default set 2S_1.5MHz_2A ICHG.
JP25	PROG resistence jumper for default set 2S_750KHz_2A ICHG.
JP26	PROG resistence jumper for default set 3S_1.5MHz_1A ICHG.
JP27	PROG resistence jumper for default set 3S_750KHz_1A ICHG.
JP28	PROG resistence jumper for default set 4S_1.5MHz_1A ICHG.
JP29	PROG resistence jumper for default set 4S_750KHz_1A ICHG.
JP32	STAT_LED enable jumper.
CP1	VAC1-VBUS short pad.
CP2	VAC2-VBUS short pad.
CP4	BAT-BATTERY short pad.
S1	Button for exit ship mode or system reset.

Default Jumper Setting on EVB

Jumper	Description
JP1	Short ACDRV1 to _acdrv1.
JP2	Short ACDRV2 to _acdrv2.
JP8	Short SDRV to MOS.
JP9	Short BATP to BATTERY.
JP12	Short REGN to TS pull-up resistor.
JP18	Short TS to normal temperature resistor.
JP14	Short ILIM for 1.5A.
JP24	For 2 cell/1.5MHz setting.

Quick Start Procedure

Suggestion Required Equipments

- RT9492GQVF(2) Evaluation Board
- DC power supply capable of 24V, 3.3A
- Battery simulator capable of 18.8V, 10A
- Electronic load capable of 10A
- Oscilloscope

Evaluation Board Jumper Setup

The Evaluation Board is fully assembled and tested. Follow the steps below to verify board operation. Do not turn on supplies until all connections are made. When measuring the 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 and ground ring directly across the last output capacitor.

1. Use jumpers on JP24 to JP29 to set battery cells and switching frequency for default charging profile.

Battery Cell (s)	Switching Frequency	Jumper No.
2S	1.5MHz	JP24
	750kHz	JP25
3S	1.5MHz	JP26
	750kHz	JP27
4S	1.5MHz	JP28
	750kHz	JP29

2. Use jumpers on JP1 and JP2 to connect ACDRV1 and ACDRV2 to the gate driver output from IC. If the external AC-RBFETs are not needed, use jumpers on JP3 and JP4 to bypass them and JP1 and JP2 should be used to connect ACDRV1 and ACDRV2 to GND.
3. Use a jumper on JP8 with Mid-Right side to connect SDRV to the gate driver output from IC. If the external ship FET is not needed, use a jumper on JP5 to bypass it and use JP8 with Mid-Left side to connect SDRV to the capacitor.
4. Use a jumper on JP18 (TS_NORMAL) or JP19 (TS_POTENTIOMETER) for setting TS pin configuration and JP12 for connecting to REGN as pull-up voltage.
5. Use a jumper on JP13 (500mA) or JP14 (1.5A) for ILIM setting and JP21 for controlling HIZ_EN.
6. Use a jumper on JP9 with Mid-Right side to connect BATTERY to BATP when the external Ship FET is adopted. If the external Ship FET is not needed, use a jumper on JP9 with Mid-Left side to connect BATP to VBAT.
7. Use a jumper on JP87 for connecting Type_C_IN on VAC1 or VAC2.

Proper measurement equipment setup and follow the procedure below.

1. With power off, connect input power and ground to VIN1 or VIN2 and PGND respectively.
2. With load off, connect electronic load to SYSTEM and PGND respectively.

3. With power off, connect power and ground to BATTERY and PGND respectively. Turn on battery simulator, then the device is powered up.
4. Use I^2C to set registers for charging function and proper protection level. Richtek also provides designers GUI software tool to read or write registers. The details are shown in the next chapter ” Evaluation GUI Software Tool Installation and Introduction”.
5. Turn on the input power supply to start charging. Make sure that the power supply voltage is under OVP level.
6. Check the output charging current using a current meter.
7. Once the proper charging current is established observe the output voltage regulation, ripple voltage, efficiency and other performance.
8. For testing SYS load, turns on the electronic load and adjusts SYS current.

Evaluation GUI Software Tool Installation and Introduction

The function settings of the RT9492 are not only hardware pins but also software register settings. The RT9492 register is set via I^2C communication. To test evaluation board conveniently, Richtek provides GUI tool and users can use it to read and write the register. Follow the below steps to install the relative software tools.

1. Richtek Bridgeboard Utilities Installation

Get the Richtek Bridgeboard Utilities, user manual and purchase the bridge board from the website.

https://www.richtek.com/Design%20Support/Reference%20Design/RD0001-01?sc_lang=en

Please follow the user manual to install the Richtek Bridgeboard Utilities.

Title	Last Update	Share	Download
User Manual	2022/08/25		
Richtek Bridgeboard Utilities	2023/03/21		

2. Download the GUI

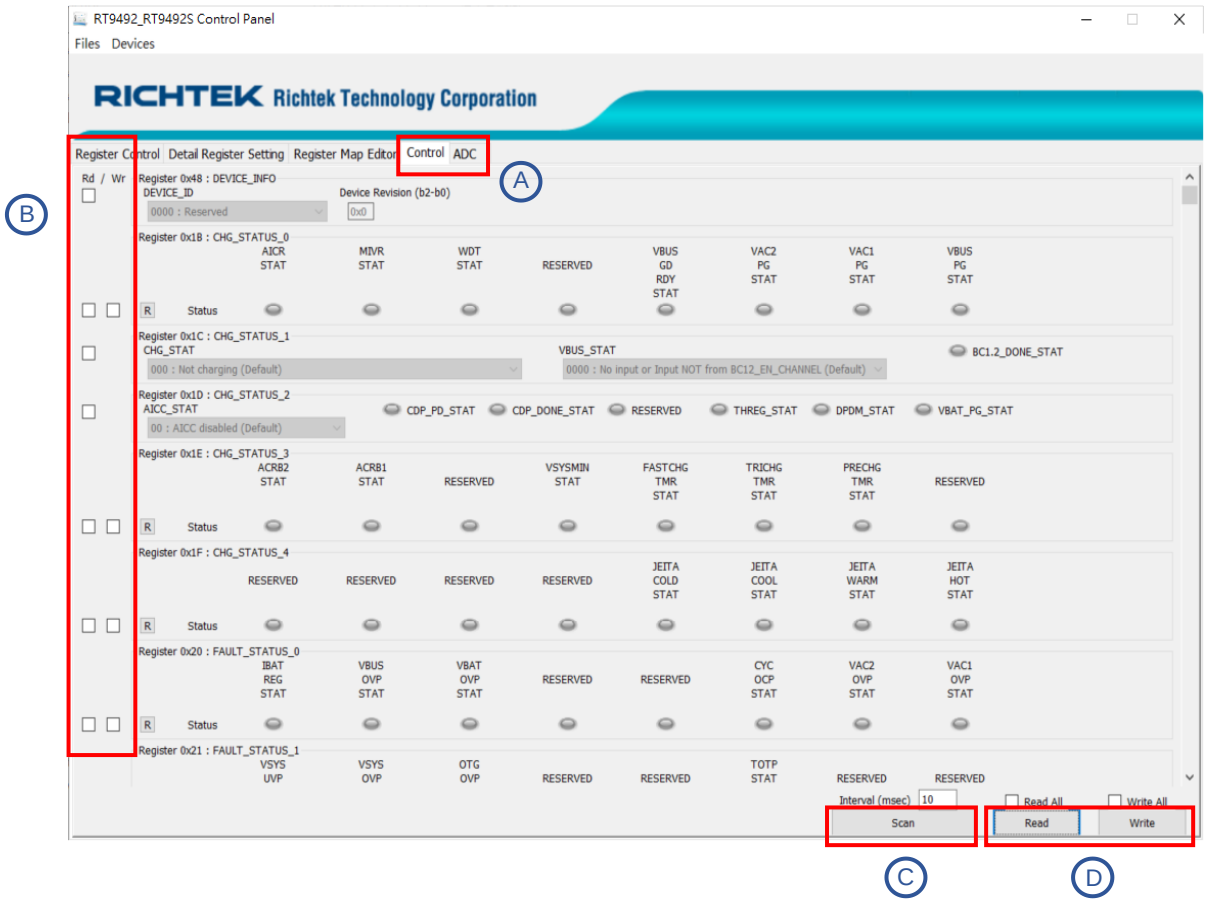
Get the RT9492 GUI from website.

https://www.richtek.com/Design%20Support/Reference%20Design/UG9492GQVF2?sc_lang=en

Overview | Design Resources | Related Product | Ordering Info

Title	Last Update	Share	Download
Evaluation Board User Guide	2023/08/16		
Bill of Materials	2023/08/16		
Schematic	2023/08/16		
Gerber File	2023/08/16		
RT9492 GUI Control Panel	2024/02/02		

3. The introduction of GUI interface is as below.



A:

All registers can be read/written in these pages.

B:

You can select which byte you want to read/write in this column.

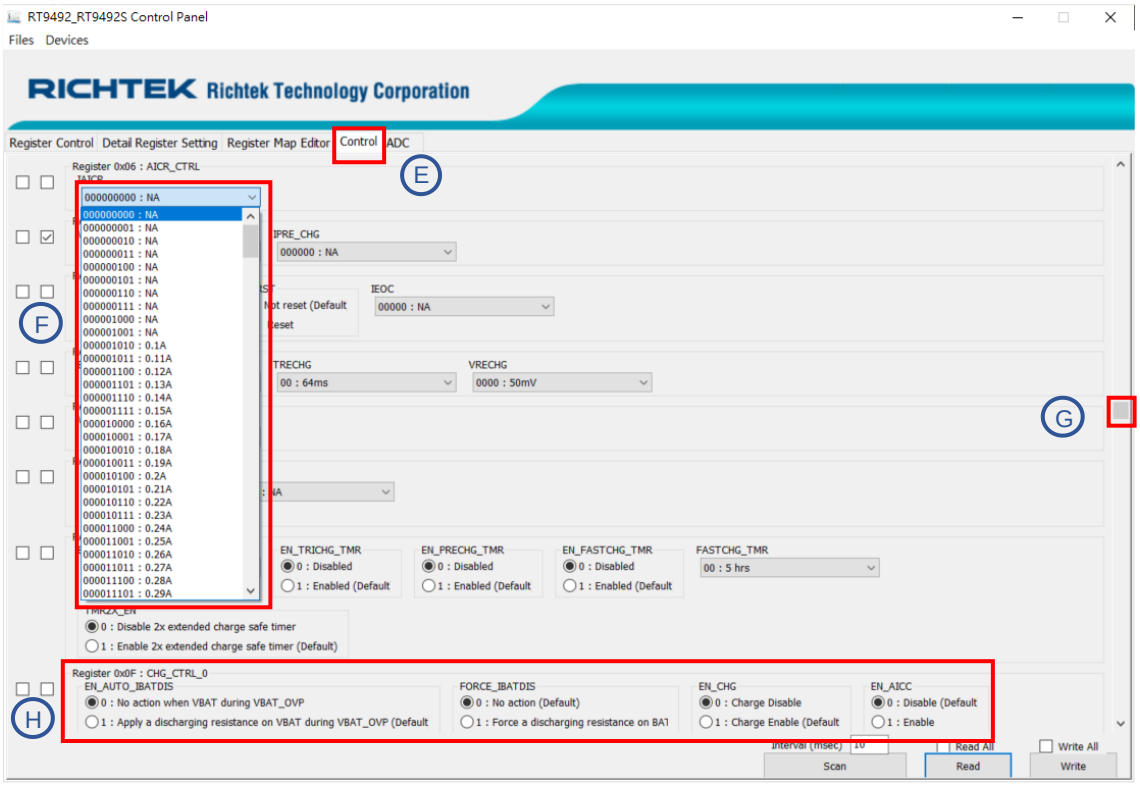
C:

The selected register will continue to be read after click the scan button.

D:

Write: The selected register will be written to the device after click the write button.

Read: The selected register will be updated after click the read button.



E:

This page is for charging behavior setting.

F:

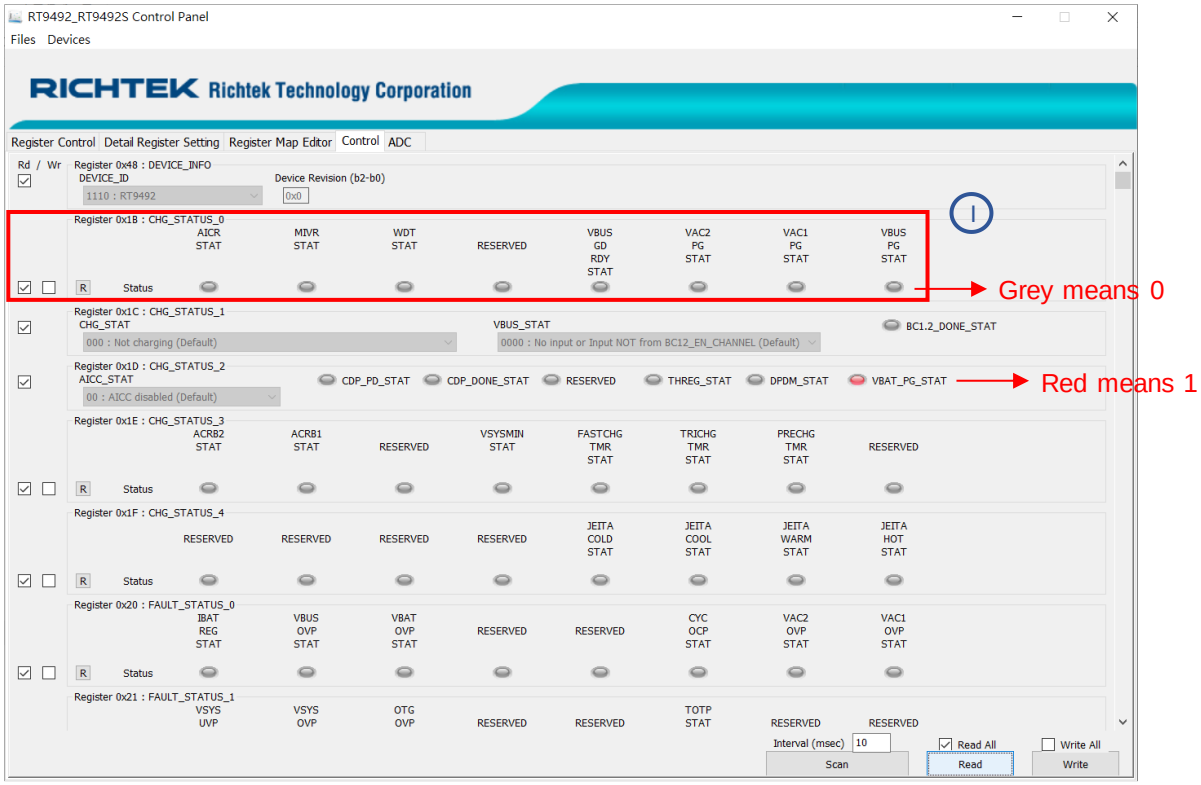
This type of dropdown menu allows you to select the setting you need.

G:

You can scroll down/up to select the register setting.

H:

This type of menu allows you to select the bit setting you need. A solid fill indicates your selection.



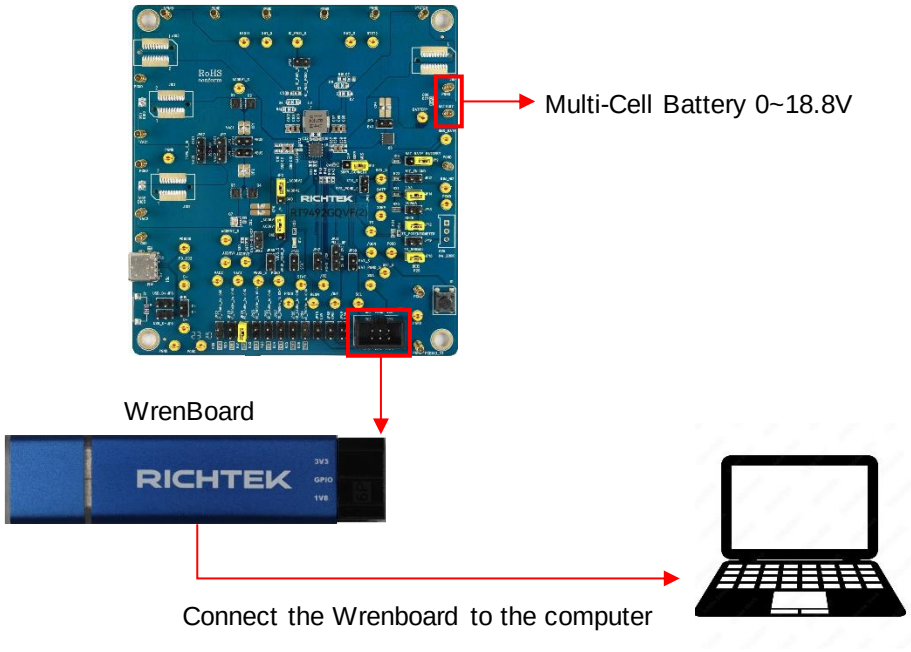
I:

These lamp icon are STATUS type of register.

Test Procedure

Hardware Initial Settings

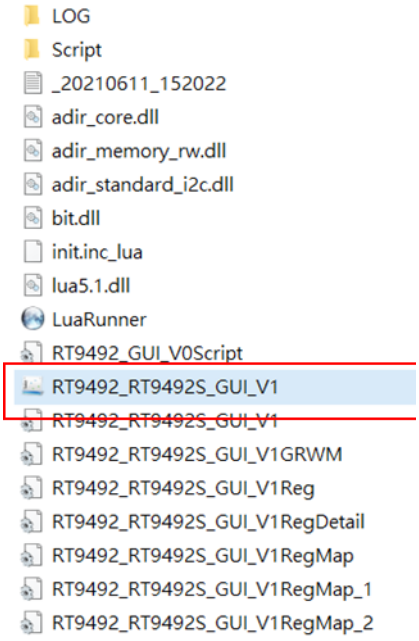
1. Follow the section “Evaluation Board Jumper Setup” to set the board jumper.
2. Use a battery simulator or a real battery to power up the RT9492 at the BATTERY pin. The voltage should be within the application range. For example, in 2-cell application, users can initially provide 8V to the BATTERY pin.



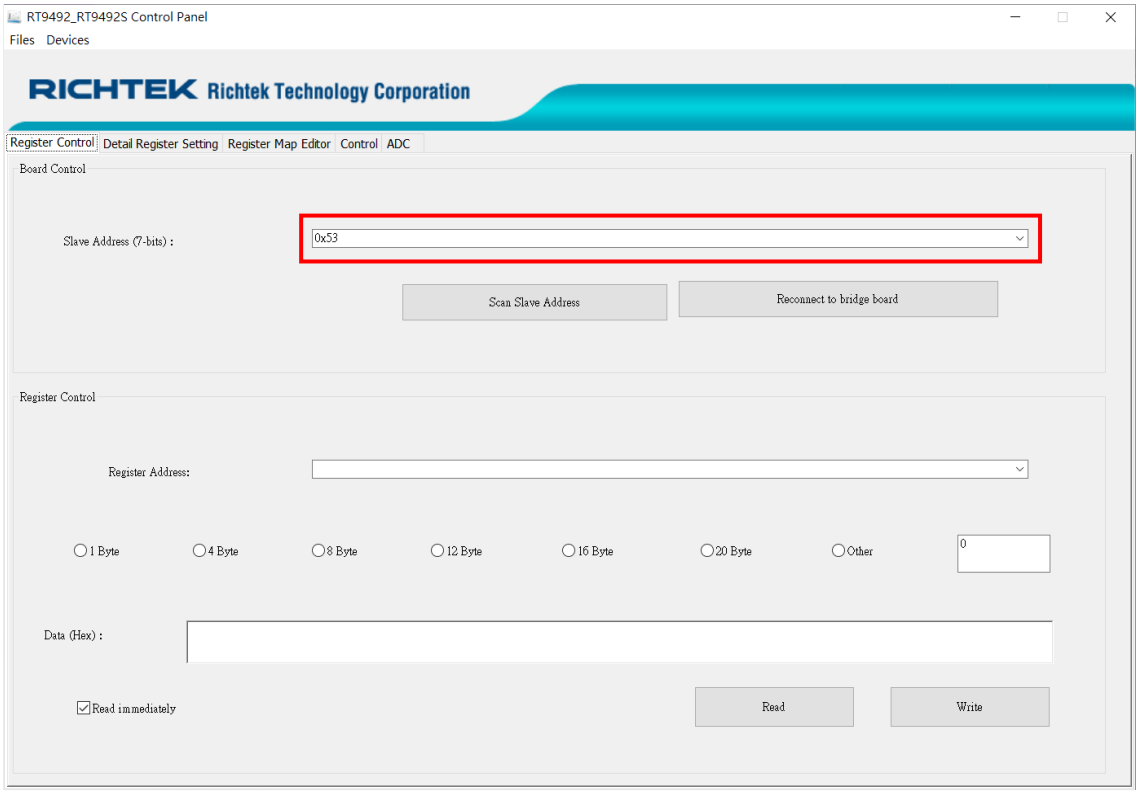
GUI Setup

1. Follow the section” Evaluation GUI Software Tool Installation” to Install the GUI tool.
2. Connect Richtek Wrenboard to evaluation board through JP71 SCL/SDA/PGND pin.
3. Connect Richtek Wrenboard to the computer.

4. After providing power to the Evaluation Board, run the RT9492_RT9492S_GUI_V1.exe.

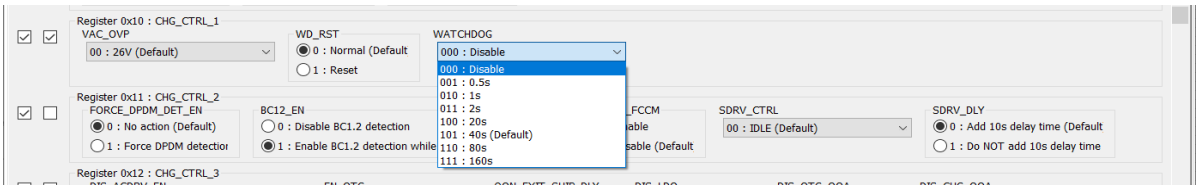


5. If GUI connection is successful, the slave address ID will show 0x53.

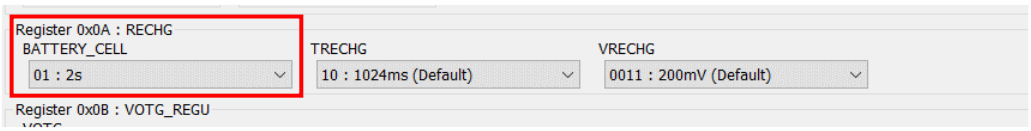


Register Initial Setting

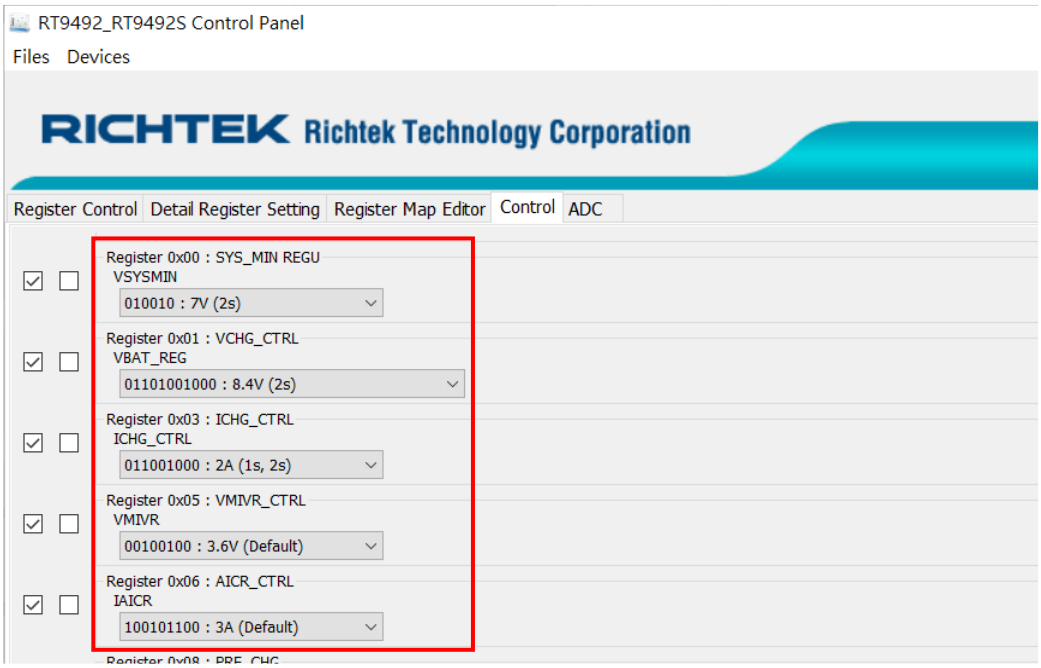
1. For board evaluation, disable watchdog initially if don't want to verify watchdog function.



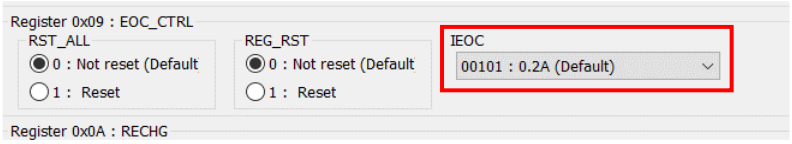
2. Check whether BATTERY_CELL setting is the same as PROG pin setting. This register can also be changed after powered up.



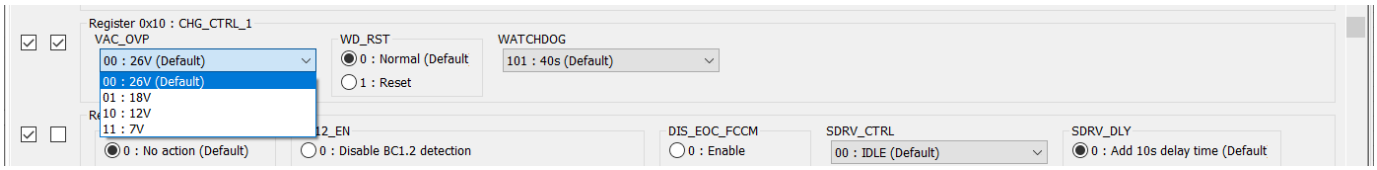
3. Set VSYSMIN for Buck-Boost sys pin minimum regulation level. Set it as minimum system voltage.
4. Set VBAT_REG for battery full charged level.
5. Set ICHG_CTRL for fast charge current level.
6. Set VMIVR for input voltage limitation level. Set it lower than test input voltage.
7. Set IAICR for input current limitation level. Set it lower than test input source current limit.



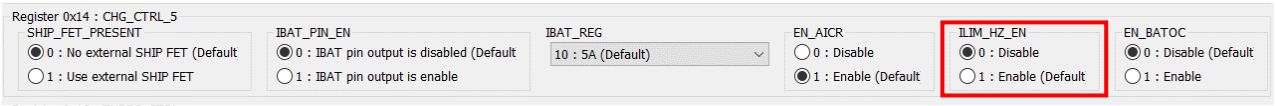
8. Set the IEOC for charging termination level.



9. Check whether VAC_OVP level is large enough. It should bigger than VBUS input voltage.

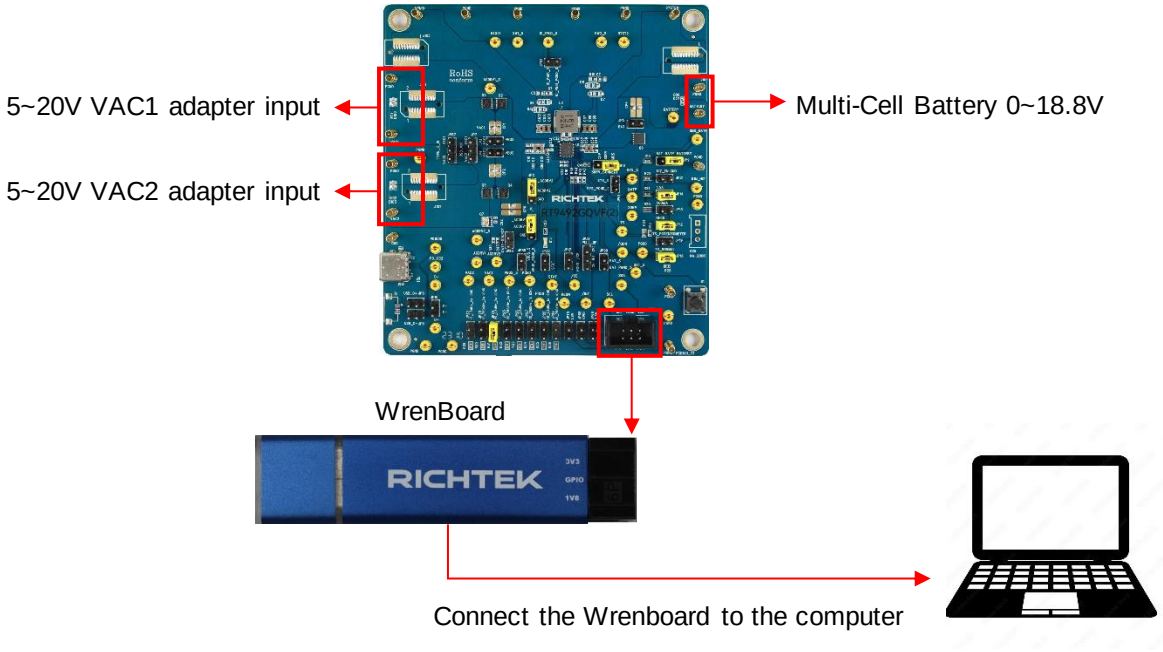


10. The charger input current limit is decided by the minimum value between AICR and ILIM. If do not want to verify the ILIM_HZ function, disabled ILIM_HZ function.

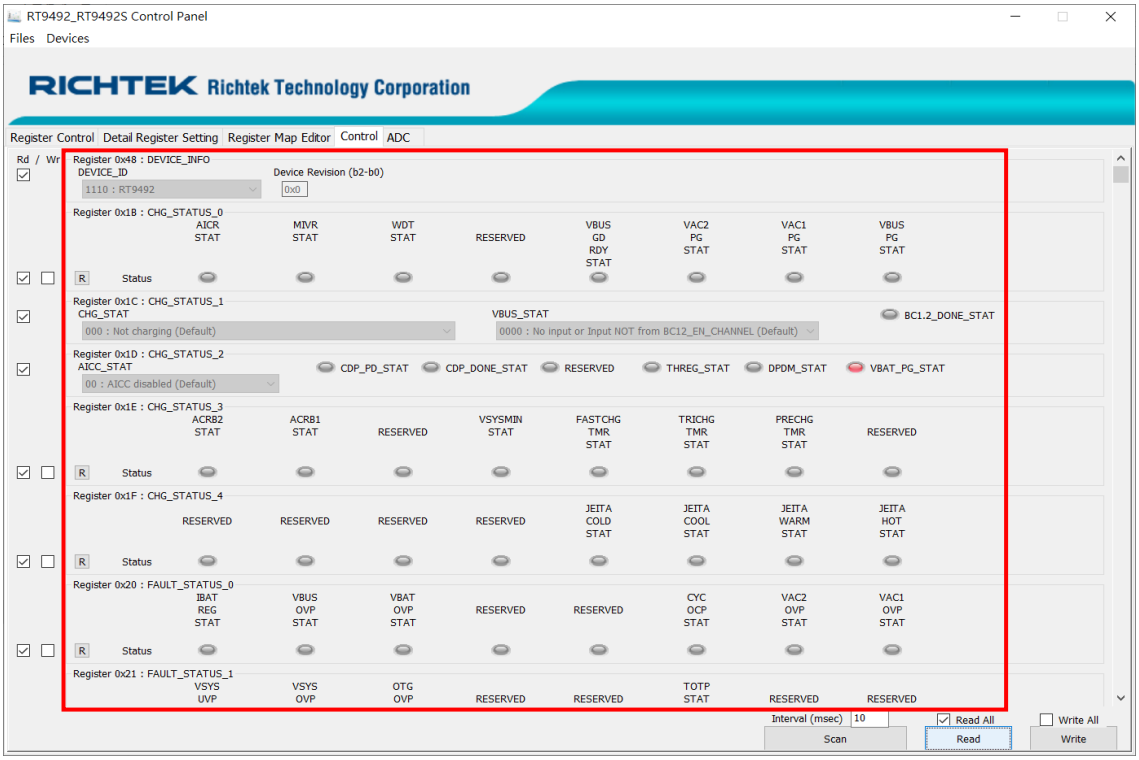


Charger Function Test

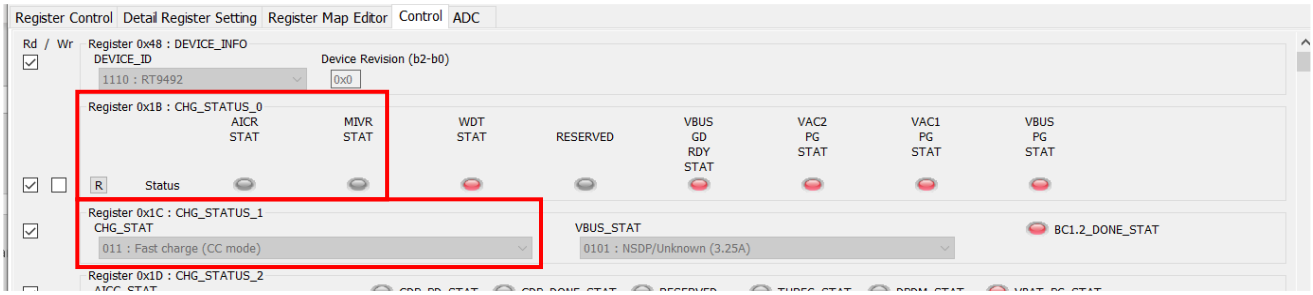
1. After finishing register initial setting, give VAC1 or VAC2 pin input power to start charger. For example, give it 15V.



2. Check whether it triggers AICR_STAT, MIVR_STAT, or other protections.

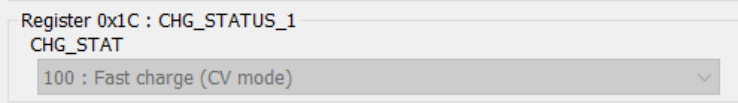


3. If it triggers AICR_STAT, it means that the input current is near limitation level. Increase input voltage or reduce ICHG_CTRL setting to leave AICR_STAT.
4. If it triggers MIVR_STAT, it means that the input power is not enough and input source voltage drops. Increase input power ability or reduce ICHG_CTRL setting to leave MIVR_STAT.
5. Check the CHG_STAT. In CC mode, the charging current will be regulated as register ICHG_CTRL if it doesn't have AICR_STAT and MIVR_STAT.

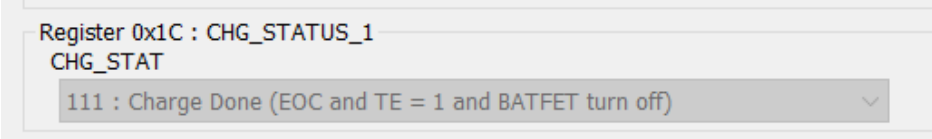


6. Measure the BAT pin output current to verify the fast charge current.
7. Gradully increase battery simulator voltage to simulate battery charging.
8. Measure the charging current and the BATP pin voltage as the battery voltage increases. Once the charging current starts to fall down, verify that the voltage remains at the VBAT_REG level (IR drop + VBAT = VBAT_REG level).

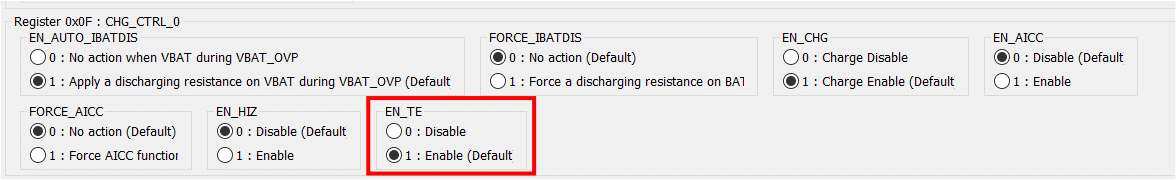
9. Check that CHG_STAT is into CV mode.



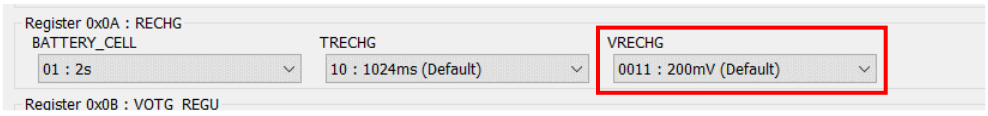
10. Continue increasing the battery voltage. Check that the BAT charging current is gradually down in CV mode.
11. After BAT charging current is below IEOC level, the RT9492 will stop charging.
12. CHG_STAT will show Charge_done at this full-charged stage.



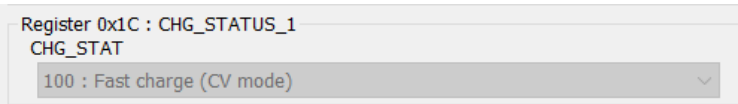
13. If EN_TE is disabled at initial setting, the IEOC function will not work at this stage. The RT9492 will not stop charging and will continue charging until the current decreases to 0A.



14. To verify the recharge function, load the SYS pin to discharge the battery or reduce the voltage of the battery simulator.
15. The recharge level is determined by the VRECHG register.



16. Afrer battery voltage is below (VBAT_REG-VRECHG), the RT9492 will start to charge again. For example, VBAT_REG is 8.4V, VRECHG is 200mV and the recharge level will be 8.2V.

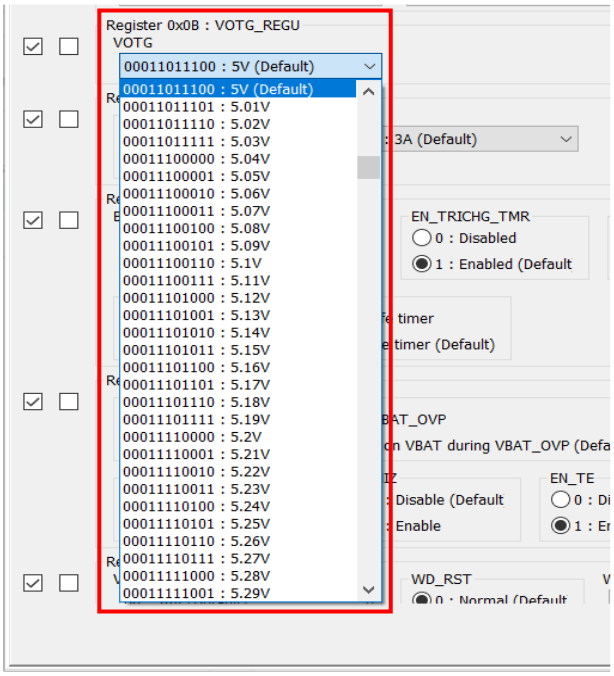


17. Plug out the VAC input power. RT9492 will stop charging.

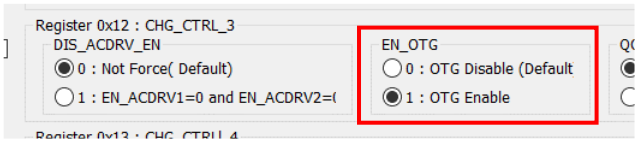
OTG Function Test

1. Finish register initial setting as section" Register initial setting" .
2. Make sure the battery voltage is above VOTG_LBP (typ. 2.7V). For example, provide it 8V.

3. Set the OTG voltage level.

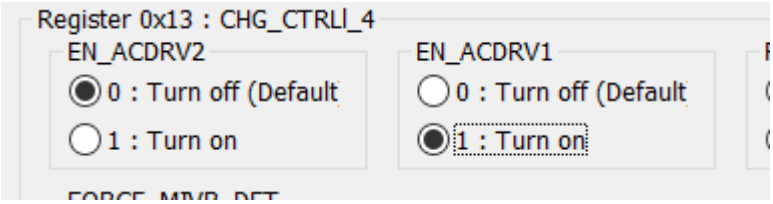


4. Enable EN_OTG. The RT9492 will start to output voltage at the VBUS pin.



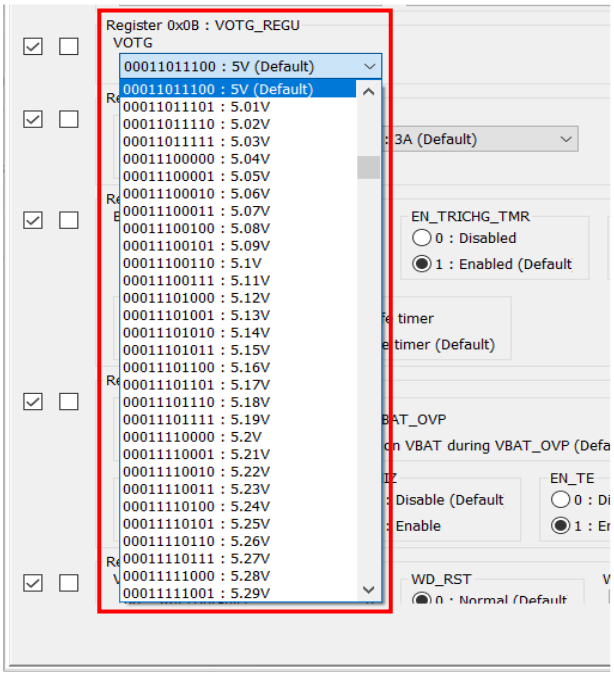
5. On the RT9492 evaluation board, there are mounted AC-RBFETs already. If AC-RBFET is used by jumper setting(see the details in the section" Evaluation Board Jumper Setup"), OTG only starts after the choosed AC-RBFET is turned on.

   For example, if VAC1 RBFET is used, EN_ACDRV1 should be enabled. The RT9492 starts to output OTG voltage after register EN_ACDRV1 is set to 1.



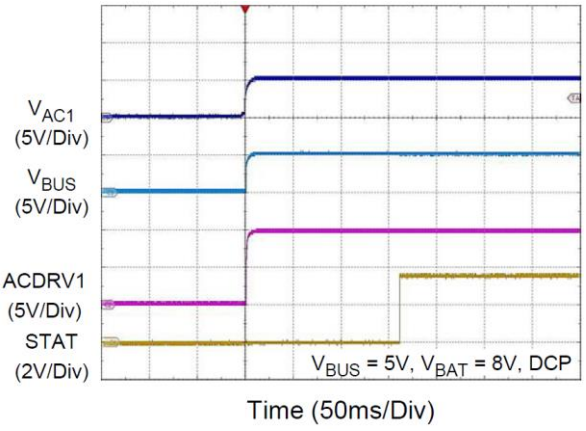
6. Measure the VBUS pin and VAC pin to verify the OTG setting level.

7. After OTG starts, OTG voltage is still able to be set.

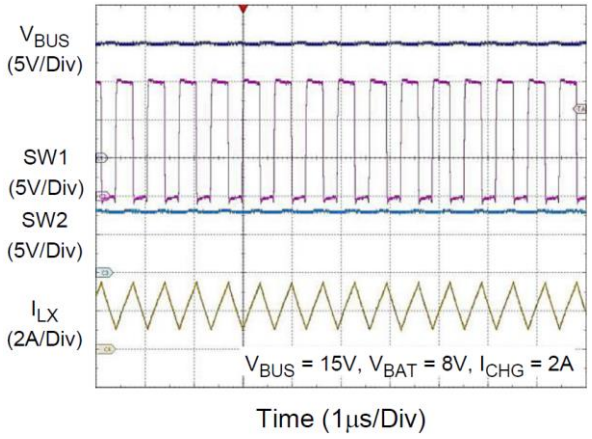


Measure Results Reference

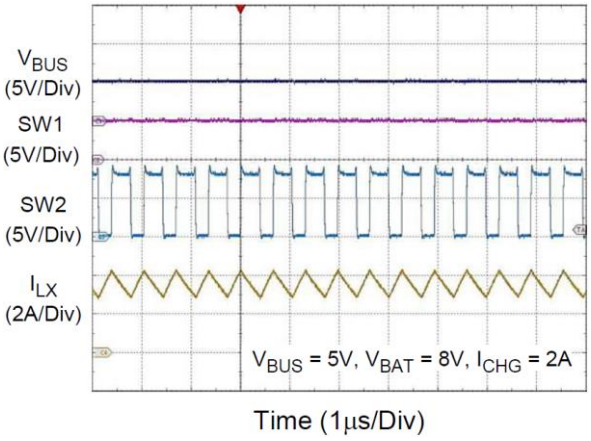
Power-UP with AC_RB1, VAC1 Plug in



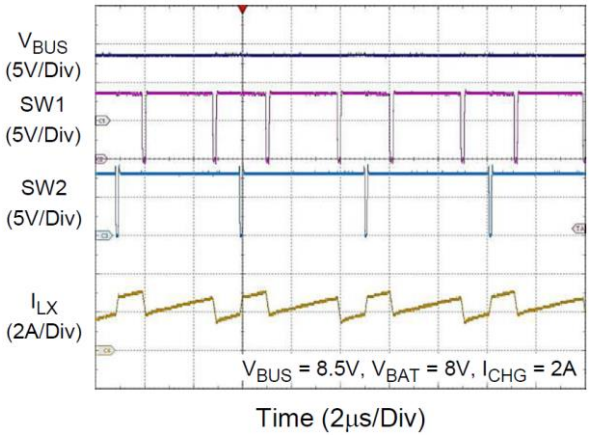
Charging in Buck Mode



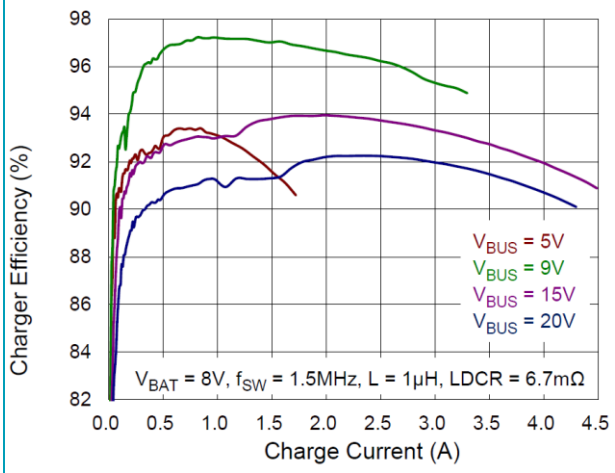
Charging in Boost Mode



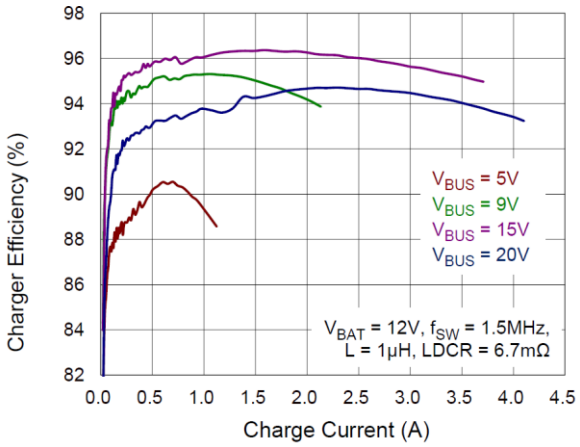
Charging in Buck-Boost Mode



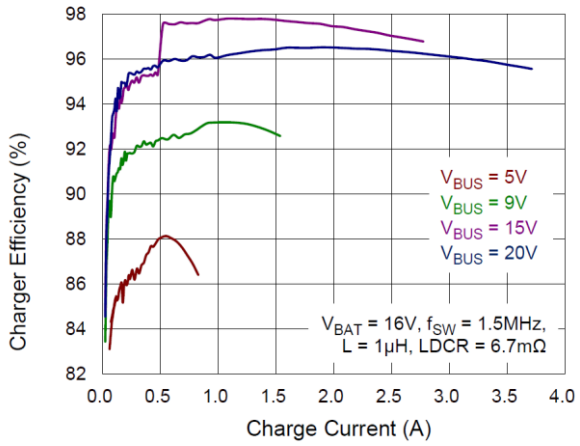
2s Battery Charger Efficiency



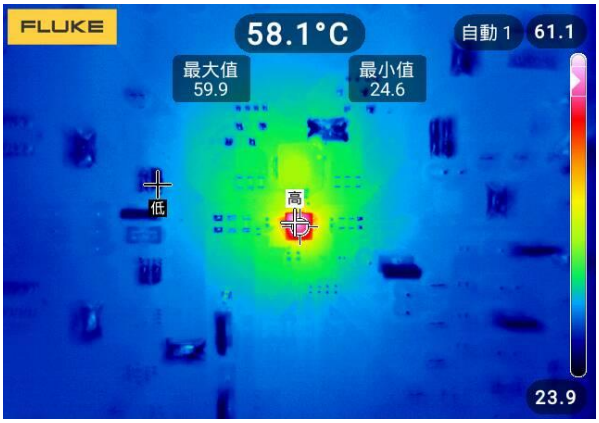
3s Battery Charger Efficiency



4s Battery Charger Efficiency



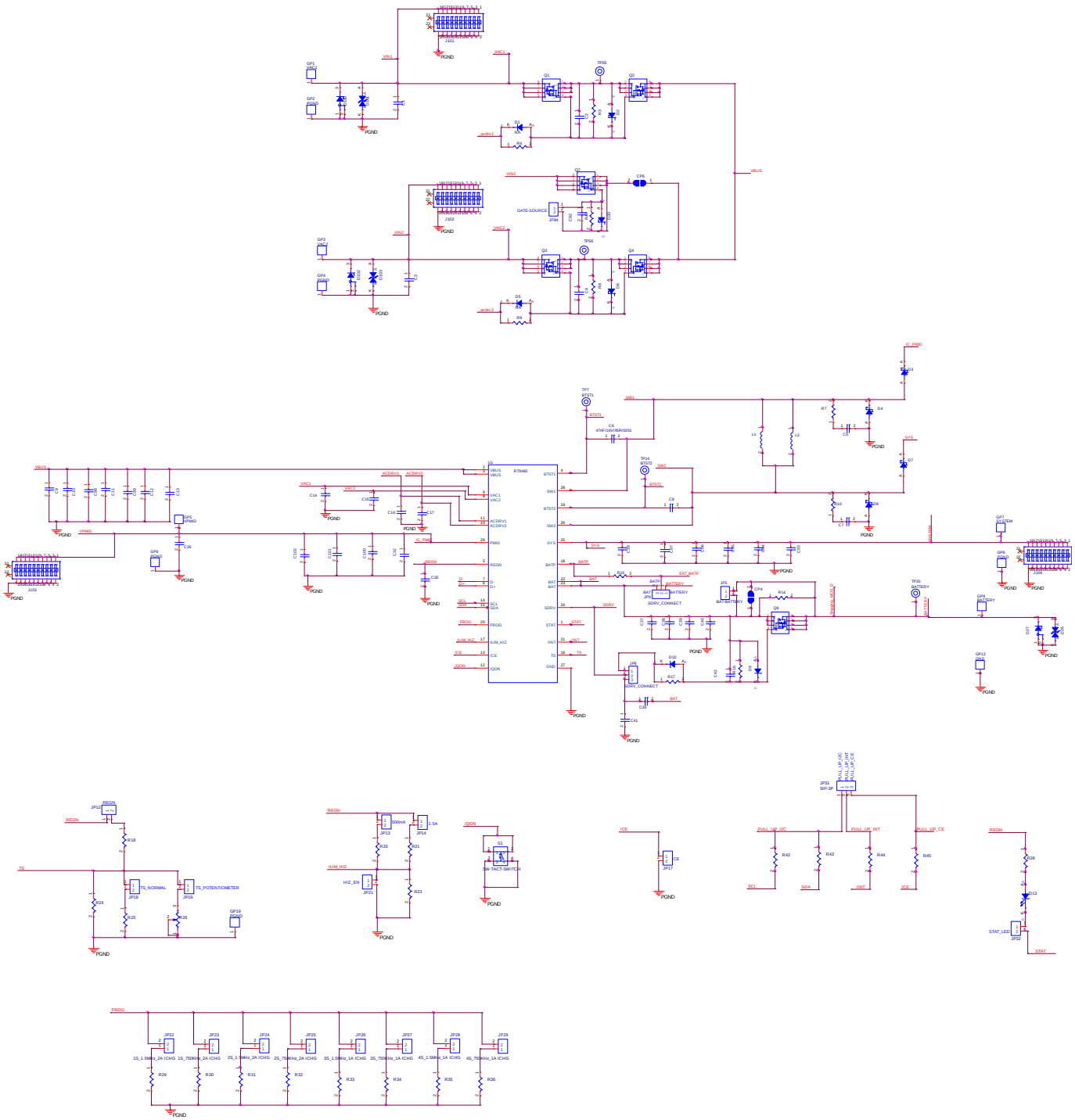
Thermal Image at V_{IN} = 15V, V_{BAT} = 8V, I_{CHG} = 2A



Note: 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 capacitor.

Typical Applications

EVB Schematic Diagram



Bill of Materials

fsw = 1.5MHz						
Reference	Count	Part Number	Value	Description	Package	Manufacturer
U1	1	RT9492GQVF(2)	--	Switching charger	VQFN-29TL 4x4 (FC)	RICHTEK
C6, C8	2	GRM033R61C473KE84	47nF	Capacitor, Ceramic, 16V, X5R	C-0201	MURATA
C14, C15, C18, C32	4	0402B104K500CT	0.1µF	Capacitor, Ceramic, 50V, X7R	C-0402	WALSIN
C35	1	GRM155R60J475ME47D	4.7µF	Capacitor, Ceramic, 6.3V, X5R	C-0402	MURATA
C38, C39, C95, C96, C97	5	GRM188R61E106KA73	10µF	Capacitor, Ceramic, 25V, X5R	C-0603	MURATA
C41	1	0402B102K500CT	1nF	Capacitor, Ceramic, 50V, X7R	C-0402	WALSIN
C98, C99, C100, C101, C102	5	GRM188R6YA106MA73	10µF	Capacitor, Ceramic, 35V, X5R	C-0603	MURATA
D13	1	LNL-190SUG	--	LED_GREEN	LED-0603	LighTop
L2	1	PIMB063T-1R0MS-68	1µH	20%/6.7mΩ	L-7-4X6-8	CYNTEC
PD1	1	C-NBR2L-AK5322	--	USB TYPE-C 3.1	9.24x9.1mm	ADVANCED-CONNECTEK
Q1, Q2, Q3, Q4	4	AONR36366	--	MOS	DFN 3X3 EP	ALPHA & OMEGA SEMICONDUCTOR
Q6	1	AON7528	--	MOS	DFN 3.3X3.3 EP	ALPHA & OMEGA SEMICONDUCTOR
R15	1	WR06X1000FTL	100Ω	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R18	1	CR-02FL6---5K1	5.1kΩ	Resistor, Chip, 1/16W, 1%	R-0402	VIKING
R20	1	RTT032553FTP	255kΩ	Resistor, Chip, 1/10W, 1%	R-0603	RALEC
R21	1	WR06X1273FTL	127kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R23	1	WR06X1003FTL	100kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R24	1	WR06X3012FTL	30.1kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R25, R44, R45	3	WR04X1002FTL	10kΩ	Resistor, Chip, 1/10W, 1%	R-0402	WALSIN
R28	1	WR04X4701FTL	4.7kΩ	Resistor, Chip, 1/16W, 1%	R-0402	WALSIN

fsw = 1.5MHz						
Reference	Count	Part Number	Value	Description	Package	Manufacturer
R29	1	WR06X3001FTL	3kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R30	1	WR06X4701FTL	4.7kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R31	1	RC0603FR-076K04L	6.04kΩ	Resistor, Chip, 1/10W, 1%	R-0603	YAGEO
R32	1	WR06X8201FTL	8.2kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R33	1	WR06X1052FTL	10.5kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R34	1	WR06X1372FTL	13.7kΩ	Resistor, Chip, 1/10W, 1%	R-0603	WALSIN
R35	1	RTT031742FTP	17.4kΩ	Resistor, Chip, 1/10W, 1%	R-0603	RALEC
R36	1	CR0603F27K0P05Z	27kΩ	Resistor, Chip, 1/10W, 1%	R-0603	EVER OHMS
S1	1	HTS6601H	--	SW-TACT-SWITCH	TACT-BTN	High-Tronics

Evaluation Board Layout

Figure 1 to Figure 4 are RT9492GQVF(2) Evaluation Board layout. This board size is 101.6mm x 109.7mm and is constructed on four-layer PCB, outer layers with 1 oz. Cu and inner layers with 1 oz. Cu.

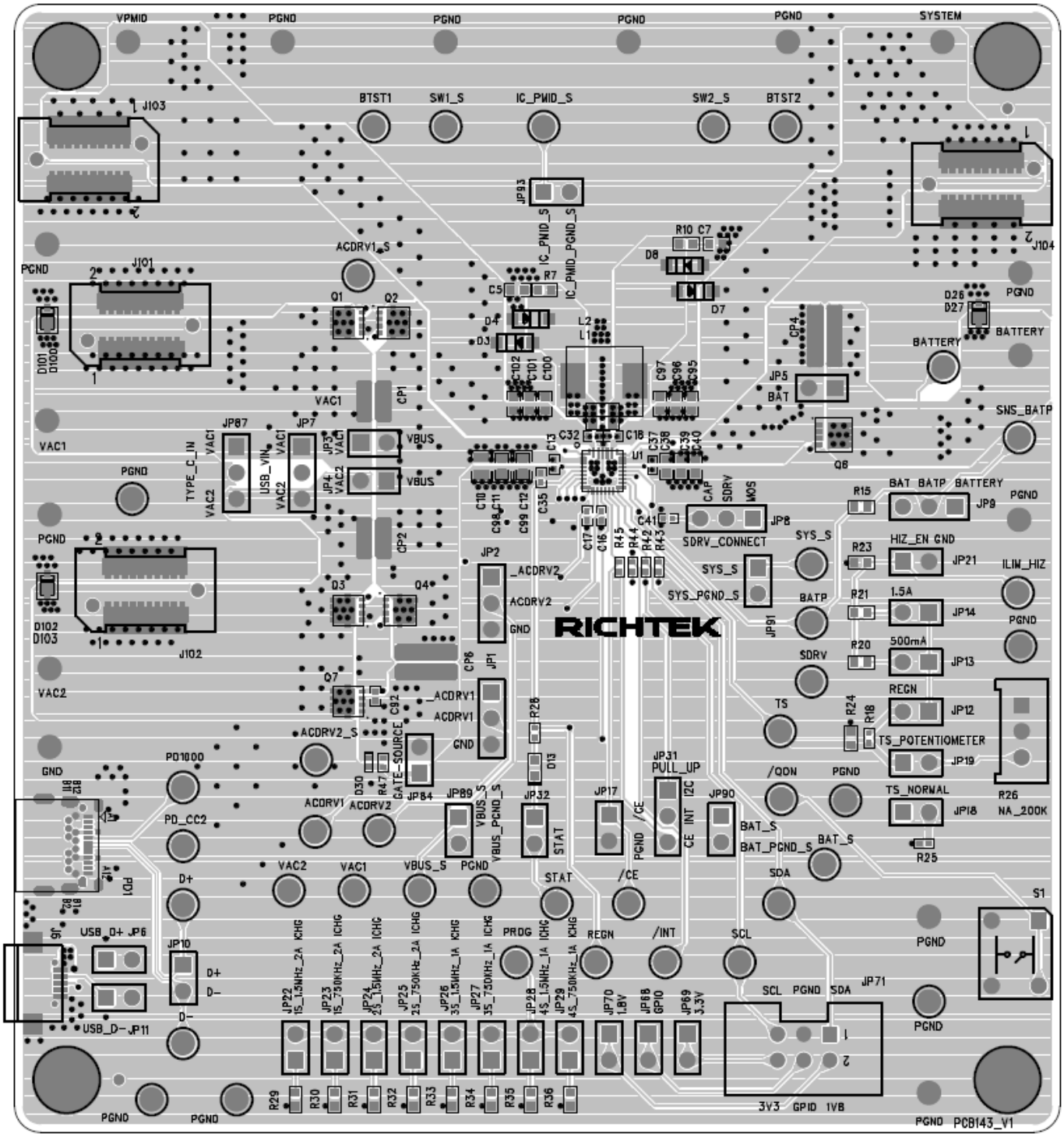


Figure 1. Top View (1st layer)

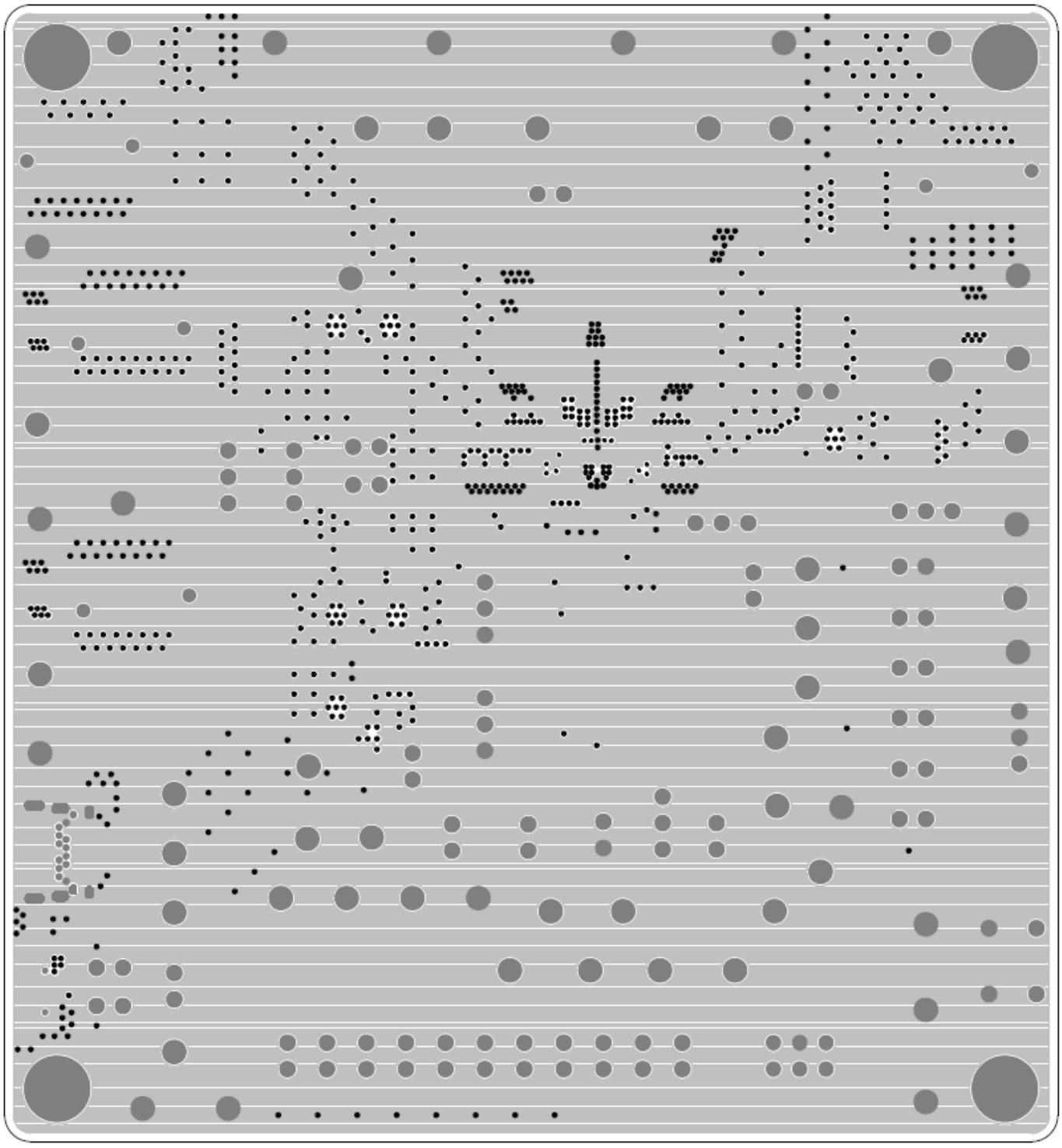


Figure 2. PCB Layout—Inner Side (2nd Layer)

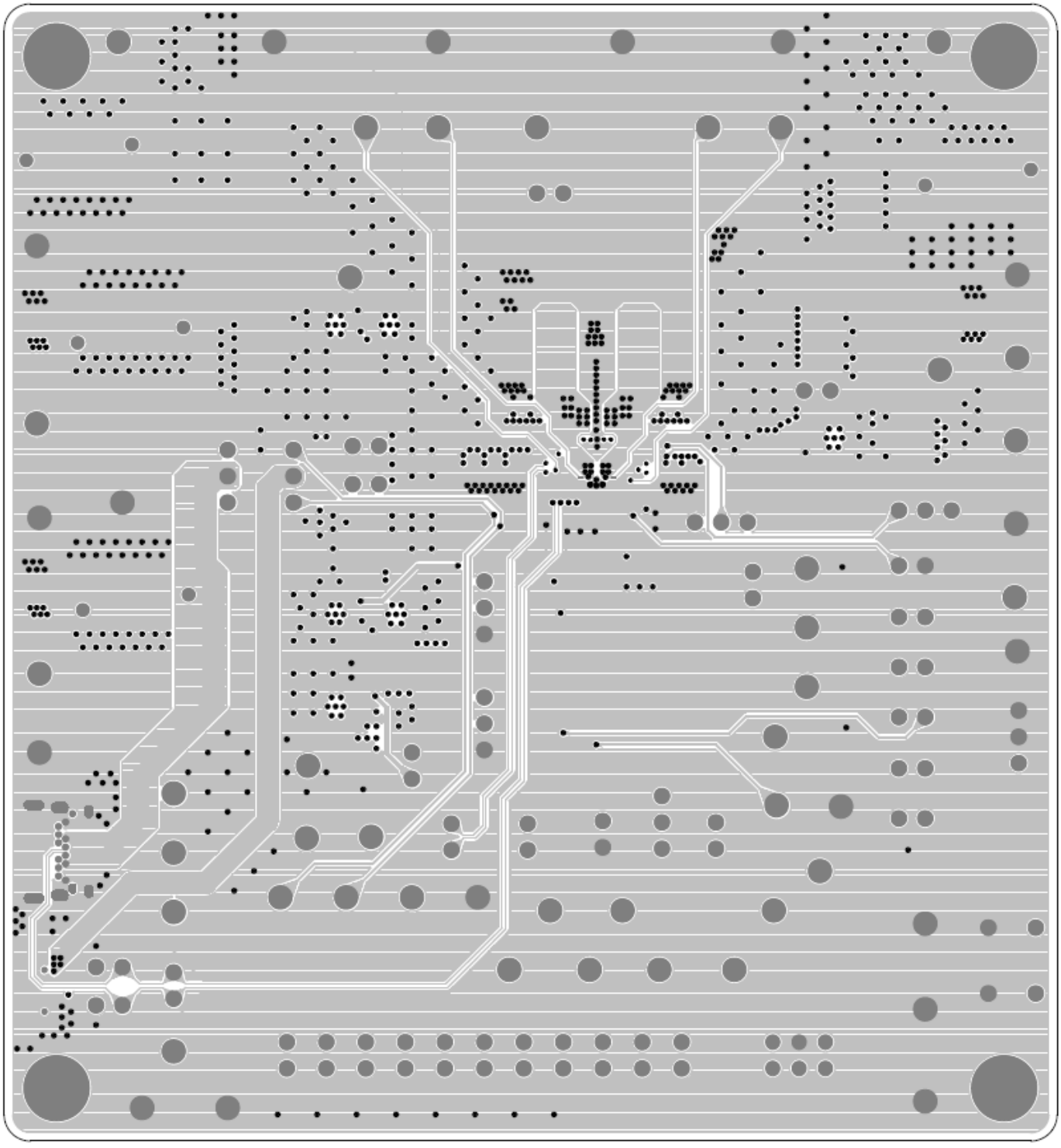


Figure 3. PCB Layout—Inner Side (3rd Layer)

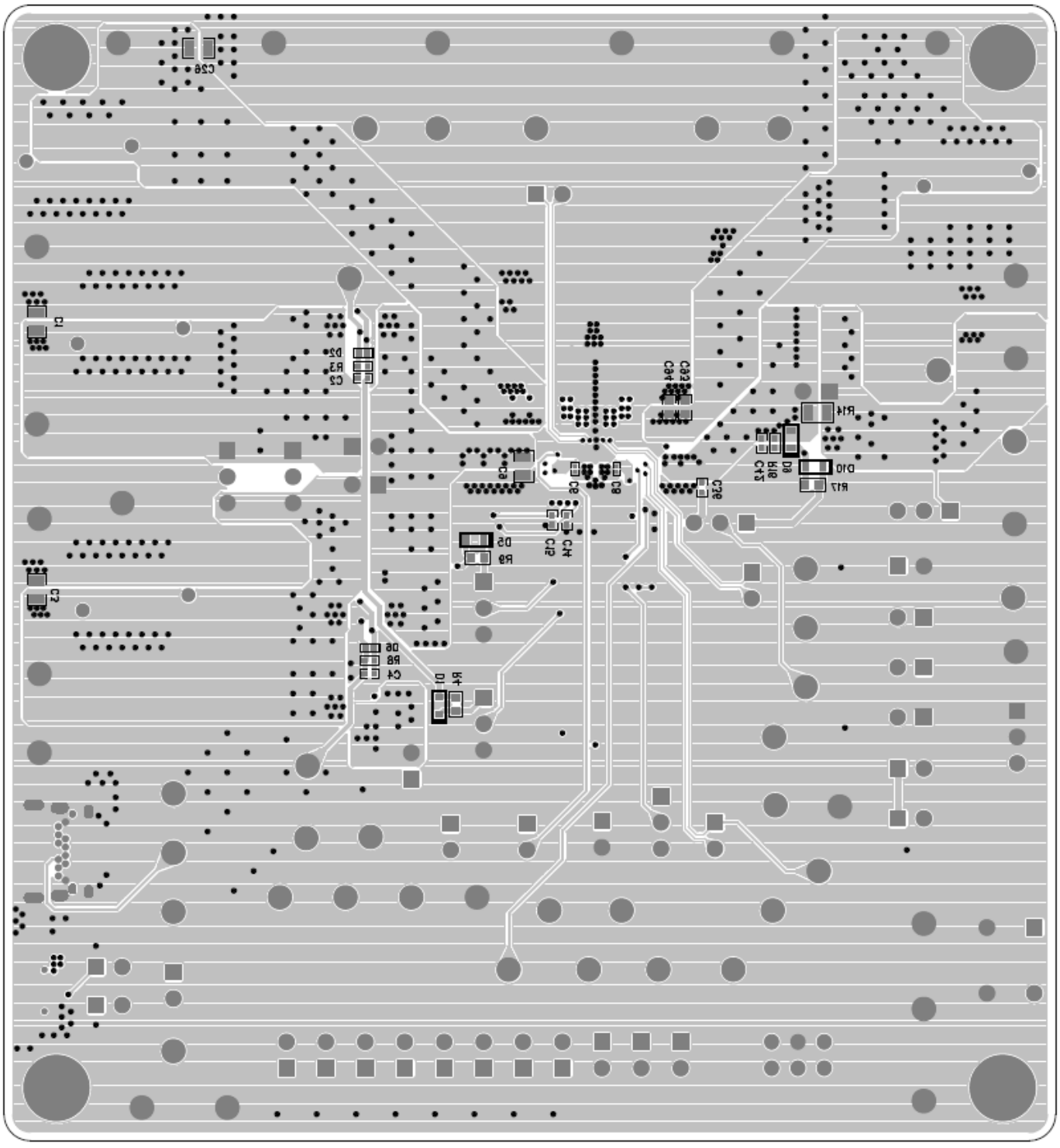


Figure 4. Bottom View (4th Layer)

More Information

For more information, please find the related datasheet or application notes from Richtek website http://www.richtek.com.

Important Notice for Richtek Evaluation Board