

## Description

The P9241-G-EVK Evaluation Kit demonstrates the features of the P9241-G 5 to 10W Wireless Power Transmitter (TX) with a fixed frequency. It is intended to evaluate the functionality and performance of the P9241-G when combined with a WPC Qi Baseline Power Profile (BPP) power receiver in a wireless charging system capable of providing 7.5W wireless charging for iPhone mode or 10W wireless charging for Android proprietary modes. The P9241-G-EVK offers the flexibility to select parameters, such as the LED pattern, power-loss foreign object detection (FOD) threshold, and external temperature sensing function. The printed circuit board (PCB) has four layers. It can be used with the user's WPC-1.2.4 compliant receiver.

The high-efficiency, turnkey reference design is supported by comprehensive online, digital resources to significantly expedite the design-in effort and enable rapid prototyping.

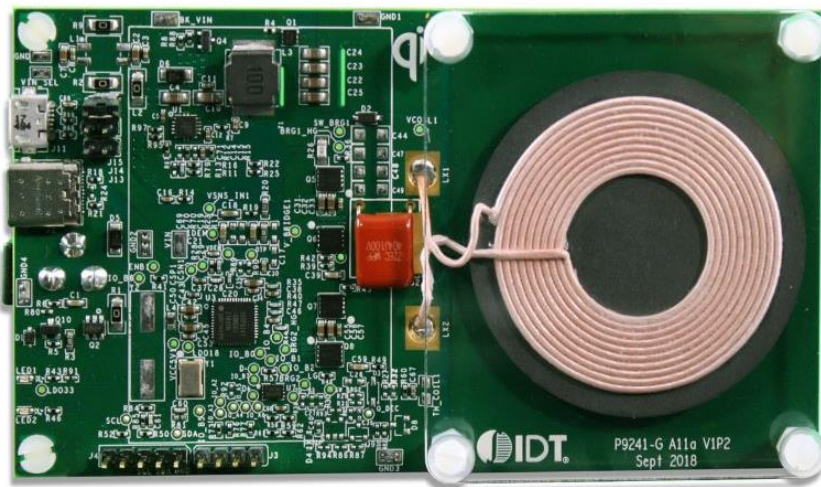
## Features

- P9241-G Evaluation Board with support for WPC-1.2.4 BPP receivers, such as IDT's P9225-R-EVK (sold separately)
- Supports 7.5W wireless charging for iOS iPhones
- Supports 10W wireless charging for Android phones
- Adjustable power-loss FOD threshold
- Adjustable temperature shutdown
- Two programmable LED status indicators
- Four-layer PCB
- Fully assembled with test points and coil fixture

## Kit Contents

- P9241-G-EVK Evaluation Board
- 12V/2.0A QC3.0 Quick Charge USB Wall Charger
- Micro-USB Cable

## Contents for P9241-G-EVK Evaluation Kit



P9241-G-EVK Evaluation Board

Micro-USB Cable



Quick Charge Wall Adaptor  
12V/2.0A (Not to scale)

**Important Notes**

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**Restrictions in Use**

IDT's P9241-G-EVK Evaluation Kit consisting of the P9241-G-EVK Evaluation Board, 12V/2.0A QC3.0 Quick Charge USB Wall Charger, and Micro-USB Cable, is designed for evaluation purposes only. IDT's P9241-G-EVK Evaluation Kit must not be used for module production or production test setups.

IDT's P9241-G-EVK Evaluation Kit is provided "as is" without any warranty. It is intended only as an engineering prototype/debugging tool. IDT is not responsible for any problems that might occur if a customer uses the Evaluation Kit for any commercial or production purposes.



**Important Safety Warning:** These procedures can result in high currents, which can cause severe injury or death and/or equipment damage. Only trained professional staff should connect external equipment and operate the hardware.



**Important Equipment Warning:** Ensure the correct connection of all cables. Supplying the board using the wrong polarity could result in damage to the board and/or the equipment. Check that all jumpers are properly positioned on the board before applying power.

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# 1. Hardware Setup

## 1.1 Required or Recommended User Equipment

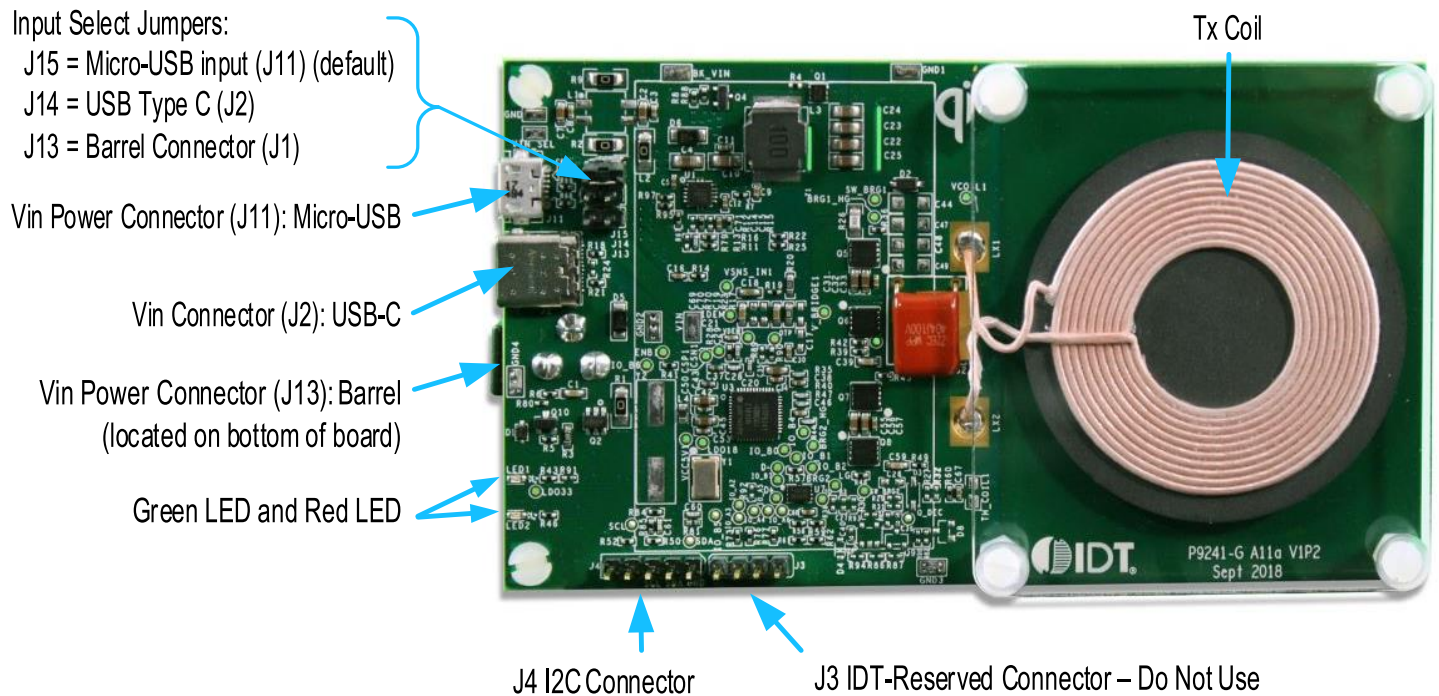
The following additional lab equipment is required for using the kit:

- P9225-R-EVK Receiver Evaluation Board or any WPC-1.2.4 compliant receiver
- Power supply capable of 5V, 9V, 12V, 16V to 19V/1.8A or the 12V/2.0A QC3.0 Quick Charge USB Wall Charger with the Micro-USB Cable

# 2. Usage Guide

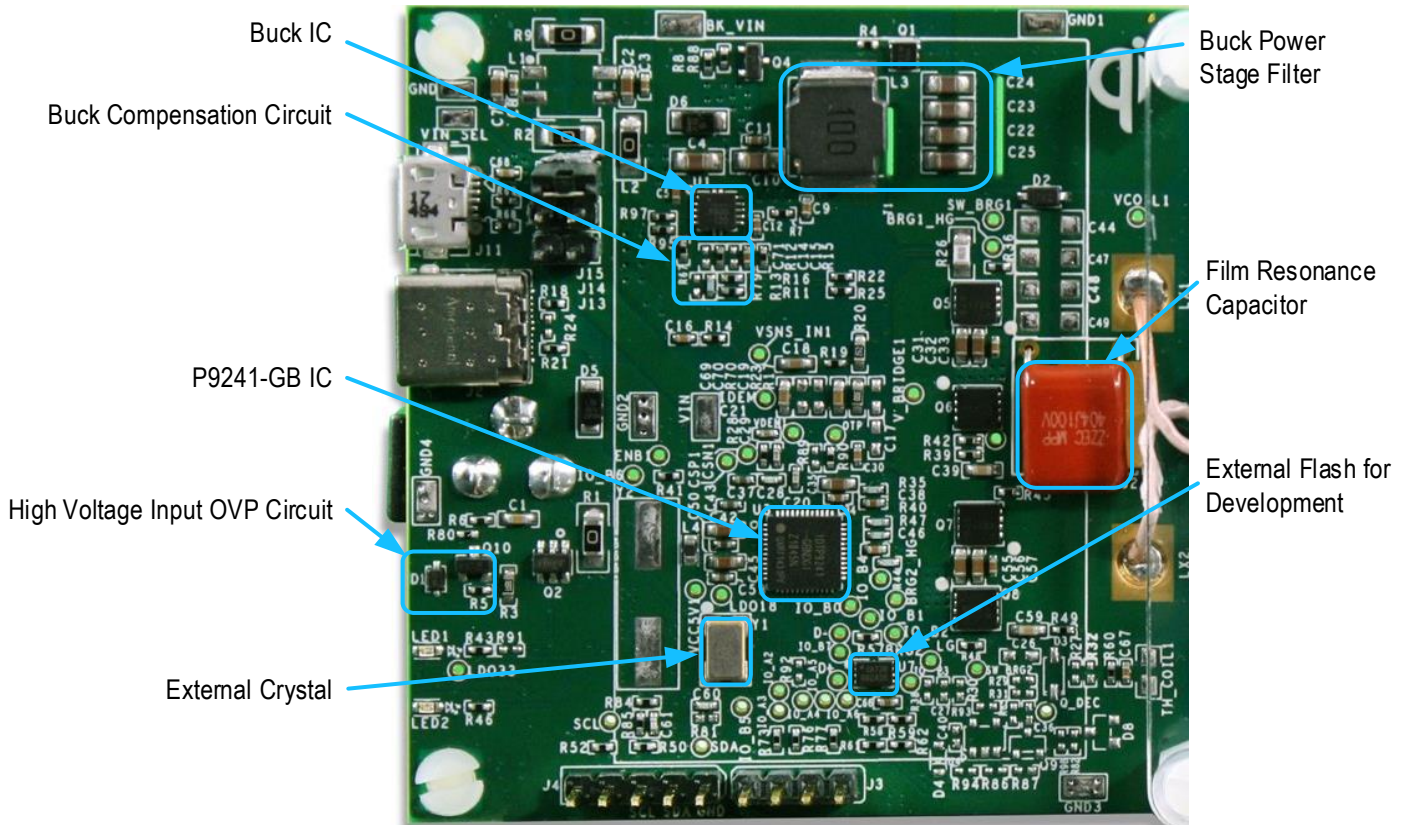
## 2.1 Overview of the P9241-G-EVK

**Figure 1. P9241-G V1.2 Evaluation Board Features**





**Figure 2. P9241-G V1.2 Evaluation Board Details**



Note: The P9241-GB IC is used instead of the production P9241-G IC on the P9241-G V1.2 Evaluation Board. The P9241-G IC has firmware pre-programmed into the one-time programmable memory and does not allow users to customize the firmware. The P9241-GB also offers a pre-programmed bootloader that must be used in conjunction with an external flash. Firmware is loaded into the external flash. Users can customize the firmware in external flash. There is no functionality difference for the P9241-G V1.2 Evaluation Board using the P9241-G or the P9241-GB with external flash.

## 2.2 LED Pattern Selection

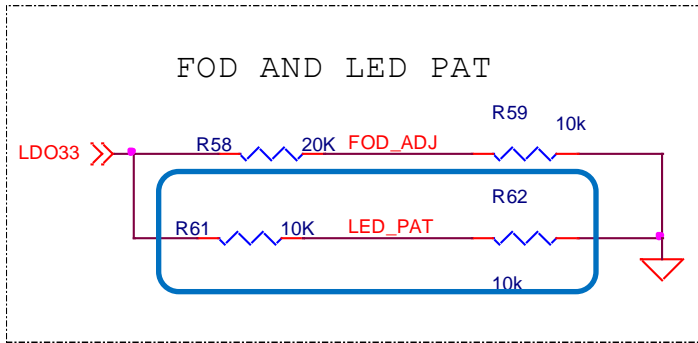
The P9241-G-EVK uses two LEDs (LED1 and LED2 (see Figure 1) to indicate the power transfer status, faults, and operating modes. The LEDs are connected to the LED1 and LED2 pins of the P9241-GB (see note below Figure 2) as shown in the P9241-G-EVK schematics.

The LED patterns can be selected by setting the voltage on the GPIO\_A3 pin (see Table 1) via the resistor divider R61 and R62 (for location, refer to Figure 3 and Figure 4). On the Evaluation Board, the GPIO\_A3 pin is pulled down to GND through R62. R61 is unpopulated; therefore, option 1 is the default option.

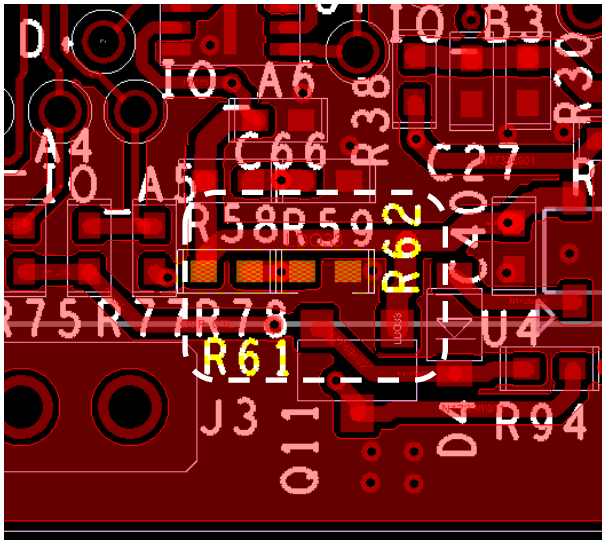
**Table 1. LED Pattern Selection**

Option	Voltage on GPIO_A3 Pin	LED1/LED2 Pin	Status			
			Standby	Transfer	Complete	Fault
1	$0V \leq V_{GPIO\_A3} < 0.1V$ ; $0.7V < V_{GPIO\_A3} < 0.8V$ ; $1.4V < V_{GPIO\_A3} < 1.5V$ ; $2.1V < V_{GPIO\_A3} < 2.4V$	LED2	Off	On	Off	Off
		LED1	Off	Off	Off	Blink 4Hz
2	$0.1V < V_{GPIO\_A3} < 0.2V$ ; $0.8V < V_{GPIO\_A3} < 0.9V$ ; $1.5V < V_{GPIO\_A3} < 1.6V$	LED2	On	On	Off	Off
		LED1	On	Off	Off	Blink 4Hz
3	$0.2V < V_{GPIO\_A3} < 0.3V$ ; $0.9V < V_{GPIO\_A3} < 1.0V$ ; $1.6V < V_{GPIO\_A3} < 1.7V$	LED2	Off	Blink 1Hz	On	Blink 4Hz
		LED1	Off	Off	Off	Off
4	$0.3V < V_{GPIO\_A3} < 0.4V$ ; $1.0V < V_{GPIO\_A3} < 1.1V$ ; $1.7V < V_{GPIO\_A3} < 1.8V$	LED2	Off	On	Off	Blink 4Hz
		LED1	Off	Off	Off	Off
5	$0.4V < V_{GPIO\_A3} < 0.5V$ ; $1.1V < V_{GPIO\_A3} < 1.2V$ ; $1.8V < V_{GPIO\_A3} < 1.9V$	LED2	On	Blink 1Hz	On	Off
		LED1	On	Off	Off	Blink 4Hz
6	$0.5V < V_{GPIO\_A3} < 0.6V$ ; $1.2V < V_{GPIO\_A3} < 1.3V$ ; $1.9V < V_{GPIO\_A3} < 2.0V$	LED2	Off	Off	On	Off
		LED1	Off	On	Off	Blink 4Hz
7	$0.6V < V_{GPIO\_A3} < 0.7V$ ; $1.3V < V_{GPIO\_A3} < 1.4V$ ; $2.0V < V_{GPIO\_A3} < 2.1V$	LED2	Off	Blink 1Hz	On	Off
		LED1	Off	Off	Off	Blink 4Hz

**Figure 3. R61 and R62 Location in the Schematic**



**Figure 4. R61 and R62 PCB Location**



### 2.3 External Temperature Sensing (TS)

The P9241-G includes an optional temperature sense input pin, TS, that is used to monitor a remote temperature, such as for a coil or a battery charger. The TS pin voltage can be calculated using Equation 1.

$$V_{TS} = V_{LDO33} * \frac{NTC}{R60 + NTC}$$

**Equation 1**

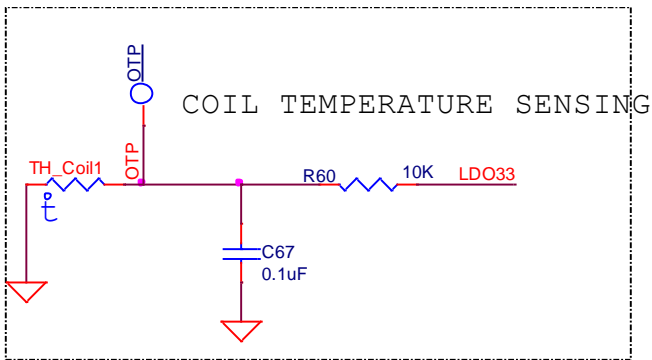
Where

NTC = The thermistor's resistance (RTH1)

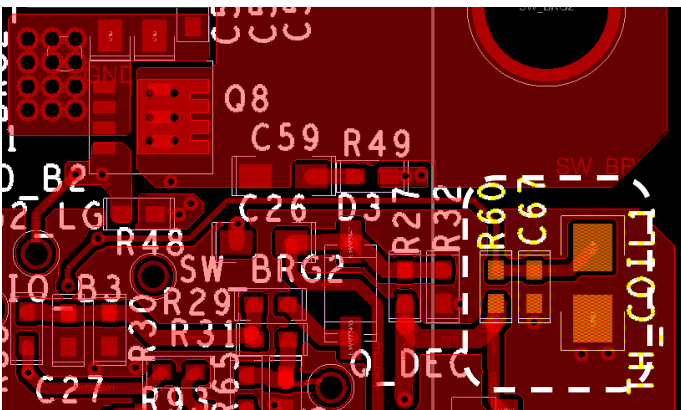
R60 = The pull-up resistor connected to the 3.3V supply voltage on the P9241-G Evaluation Board

The over-temperature shutdown is triggered if the voltage on the TS pin is lower than 0.6V and recovers at 0.8V. The RTH1 is not populated on the P9241-G Evaluation Board.

**Figure 5. TH\_COIL1, R60, and RC67 Location in the Schematic**



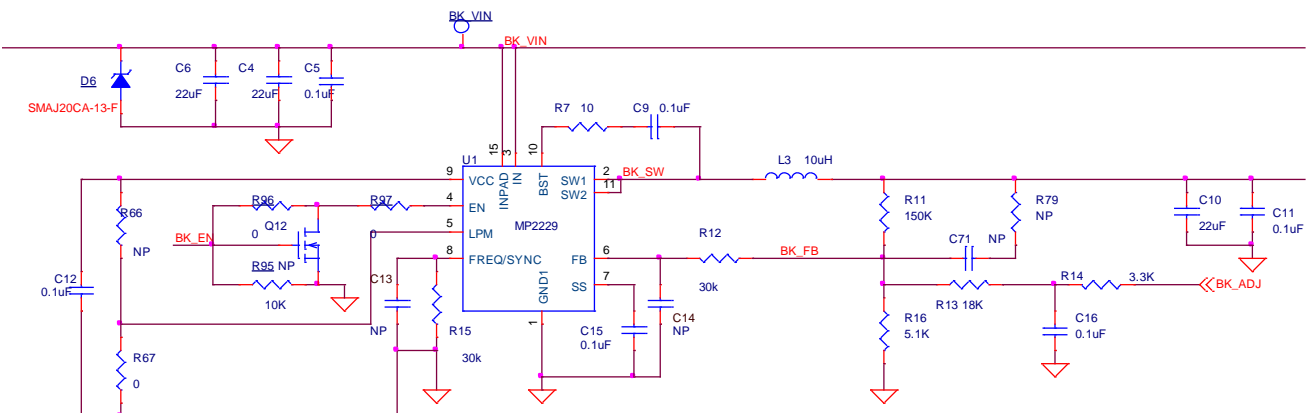
**Figure 6. TH\_COIL1, R60, and RC67 PCB Location**



## 2.4 External Buck Regulator

To operate at a fixed 127.7kHz frequency, the P9241-G-EVK has adopted an MP2229 buck IC to adjust the power transfer between the transmitter and receiver. GPIO\_A4 and GPIO\_B4 are assigned to adjust the MP2229 FB control. The MP2229 is operating at a fixed 500kHz frequency on the board. The buck regulator power stage is designed to accommodate a wide range of input voltages. The feedback loop and the external PWM signal are designed for the MP2229 and changing this circuit is not recommended. The resolution of the MP2229 is approximately 35mV. The buck and external components in the PCB layout should be isolated from any noise generating circuits.

**Figure 7. Buck Regulator Location in the Schematic**







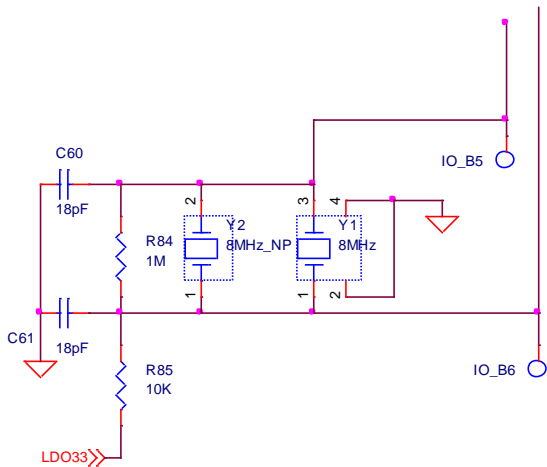
## 2.6 External Crystal Circuit

To guarantee that the switching frequency is fixed at an accurate 127.7 kHz, two different types of crystals can be used to guarantee that the frequency will be in the range defined in Table 2. Only one crystal is necessary; a choice can be made between the crystals designated as Y1 and Y2 in Table 2 by comparing cost and package size. By default, Y1 is populated on the P9241-G EVK board. GPIO\_B6 and GPIO\_B5 are used to synchronize with the external crystal. Table 2 gives a list of the recommended devices for the crystal.

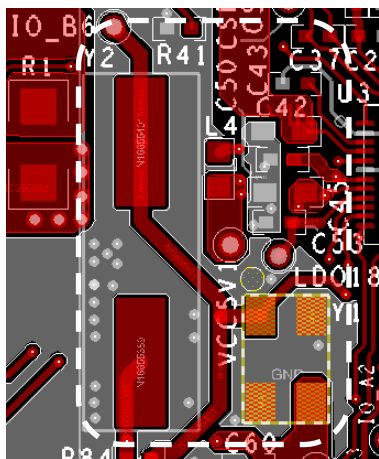
**Table 2. External Oscillator Selection**

Type	Vendor	Part Number	Typical Frequency (MHz)	Designator
Crystal	ECS, Inc.	ECS-80-18-30B-AGN-TR	8 (±50ppm)	Y1
	Abracon, LLC	ABLS2-8.000MHZ-D4Y-T	8 (±50ppm)	Y2

**Figure 11. Crystal Location in the Schematic**



**Figure 12. Crystal PCB Location**



## 2.7 Resonant Capacitor

The P9241-G-EVK can use four 100nF/100V/NPO/1206 capacitors as the resonant cap for best performance. For a lower cost solution, only one film capacitor (400nF/100V or 250V) is used by default. For film capacitors used as the resonant capacitors, they must be carefully selected.

The important considerations include the following:

- Metalized polypropylene type
- High voltage rating
- Stable DC characteristic
- Stable AC characteristic; AC RMS rating de-rates based on operating frequency
- Stable temperature characteristic; voltage rating degrades above 85°C, so it is better to use it at temperatures < 85°C
- The ESR will be higher than that of 4 or 5 parallel C0G capacitors; therefore efficiency might be impacted

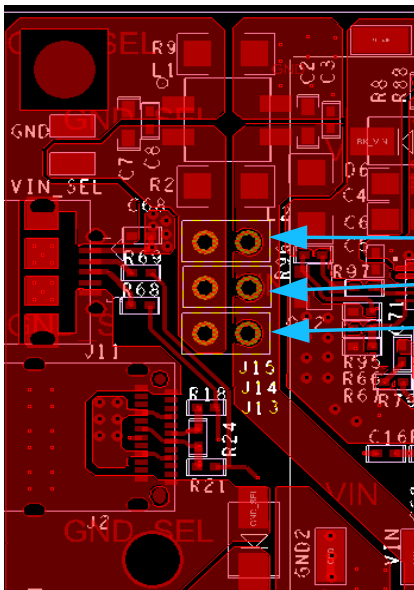
**Table 3. Options for the Resonant Capacitor**

Option	Resonant Capacitor
1	4 × 100nF, 100V, NPO, 1206
2 (low cost: < \$0.2)	400nF; 100V or 250V; L8.6mm × W10.3mm × T3.5mm

## 2.8 Selection of Input Source and Operation Mode

The P9241-G-EVK supports different types of AD/DC adaptors and connectors. A shunt on the jumpers identified in Figure 13 can be used to select the USB-Micro connector, USB-C connector, or DC jack adaptor. To select the proper jumper settings, refer to Figure 13.

**Figure 13. Input Source Selection Jumpers on the PCB**



- Input Select Jumpers:
- J15 = Micro-USB input (J11)
  - J14 = USB Type C (J2)
  - J13 = Barrel Connector (J1)

Note: Place the jumper shunt on J15 when using the Wall Adaptor and Micro-USB Cable included in the kit.

The P9241-G-EVK supports a wide range of input DC sources from 5V to 19V. Based on the input source, the P9241-G-EVK supports different types of receivers. Table 4 lists the P9241-G-EVK operation modes.

**Table 4. P9241-G-EVK Operation Modes**

Input Voltage(V)	Rx	Operating Frequency range(kHz)
5	BPP 5W (Bypass Buck)	110 to 148
9	BPP 5W (Buck)	110 to 148
	Samsung AFC(10W)	110 to 148
	iPhone 7.5W (Buck)	127.7
12	BPP 5W (Buck)	110 to 148
	Samsung AFC 10W (Buck)	110 to 148
	iPhone 7.5W (Buck)	127.7
16 to 19	BPP 5W (Buck)	110 to 148
	Samsung AFC 10W (Buck)	110 to 148
	iPhone 7.5W (Buck)	127.7

## 2.9 Transmitter Coil

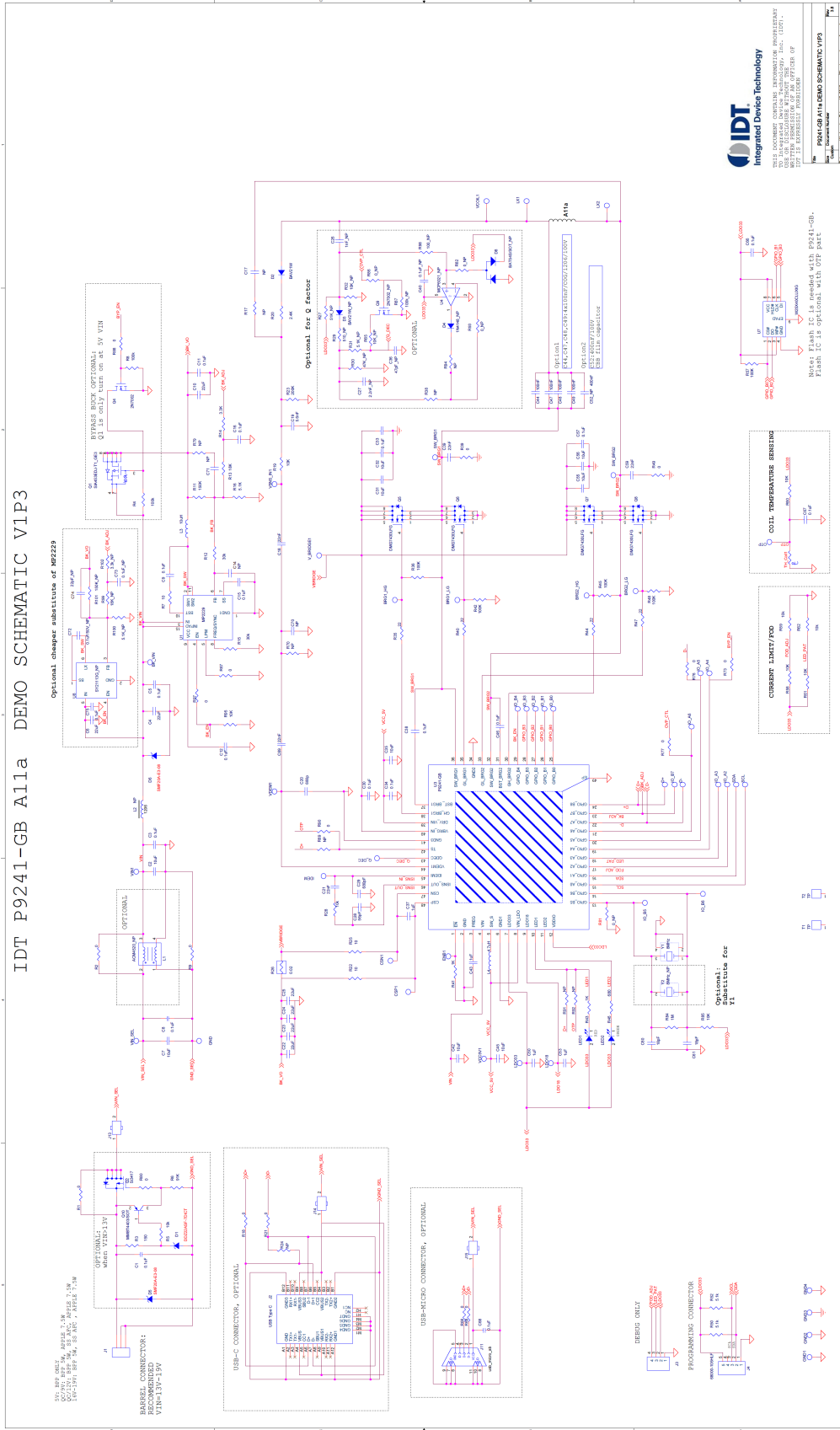
The A11a coils in Table 5 are recommended for use with the P9241-G transmitter for optimum performance. The recommended vendor has been tested and verified.

**Table 5. Recommended Coil Manufacturers**

Output Power	Vendor	Part Number	Inductance at 100kHz	Typical DCR at 25°C
5W to 10W	SUNLORD	MQQTC505030S6R3	6.3μH	38mΩ
5W to 10W	CYNTEC	WTCL05054F-6R3ABKS-70	6.3μH	38mΩ

### 3. P9241-G Evaluation Board Schematic

IDT P9241-GB A11a DEMO SCHEMATIC VIP3



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Rev: P9241-GB A11a DEMO SCHEMATIC VIP3

Doc: P9241-GB A11a DEMO SCHEMATIC VIP3

## 4. Bill of Materials (BOM)

**Table 3. P9241-G-EVK BOM**

Item	Reference	Value	Description	Part Number	Manufacturer	Qty.
1	C1	0.1 $\mu$ F	CAP CER 0.1UF 25V X7R 0603	885012206071	Würth Electronics Inc.	1
2	C2, C7, C31, C32, C35, C42, C45, C55, C56	10 $\mu$ F	CAP CER 10UF 25V 20% X5R 0603	C1608X5R1E106M080AC	TDK	9
3	C3, C5, C8, C9, C11, C12, C15, C16, C30, C33, C34, C38, C46, C57, C66, C67, C68, C75	0.1 $\mu$ F	CAP CER 0.1UF 25V 10% X7R 0402	CC0402KRX7R8BB104	Yageo	18
4	C4, C6, C10, C22, C23, C24, C25	22 $\mu$ F	CAP CER 22UF 25V X5R 0805	GRM21BR61E226ME44	Murata Electronics	7
5	C18, C69	22nF	CAP CER 0.022UF 100V X7R 0603 CAP	C1608X7R2A223M080AA	TDK	2
6	C19	5.6nF	CAP CER 5600PF 100V X7R 0603	06031C562JAT2A	AVX Corporation	1
7	C20, 29	680p	CAP CER 680PF 50V X7R 0402	CL05B681KB5NNNC	Samsung Electro-Mechanics	2
8	C21	22nF	CAP CER 0.022UF 25V X7R 0402	GRM155R71E223JA61D	Murata Electronics	1
9	C28	56pF	CAP CER 56PF 50V NP0 0402	CL05C560JB5NNNC	Samsung Electro-Mechanics	1
10	C37, C43, C50, C53	1 $\mu$ F	CAP CER 1UF 25V 20% X5R 0402	CGB2A1X5R1E105M033BC	TDK	4
11	C39, C59	22nF	CAP CER 0.022UF 50V X7R 0603	GCM188R71H223KA37D	Murata Electronics	2
12	C44, C47, C48, C49 (Option 1)	100nF	CAP CER 100nF 100V C0G 1206	C3216C0G2A104J160AC	TDK	4
12	C52 (Option 2)	400nF	CAP CER 400nF 100V Film, CBB21, L8.6mm $\times$ W10.3mm $\times$ T3.5mm	CBB21-404J-100V	ZZEC Guangzhou Zhongzheng Electronic Development Co	1
13	C60, C61	18pF	CAP CER 18PF 50V C0G/NPO 0402	CC0402JRNPO9BN180	Yageo	2
14	D1	DDZ22ASF-7DICT	18.63~19.59V 300mW Zener, DDZ22ASF	DDZ22ASF-7	Diodes Incorporated	1
15	D2	BAV21W	DIODE GEN PURP 80V 125MA DFN, sod123	BAV21W	Diodes Incorporated	1
16	D5, D6	SMF20A-E3-08	TVS DIODE 20V 32.4V DO219AB SMF20A	SMF20A-E3-08	Vishay	2
17	J1	AC_Adapter	CONN POWER JACK 2.5X5.5MM HI CUR	PJ-002AH	CUI Inc.	1
18	J2	USB Type C	USB Type C connector, USB-C12401610E4	12401610E4#2A	Amphenol ICC	1

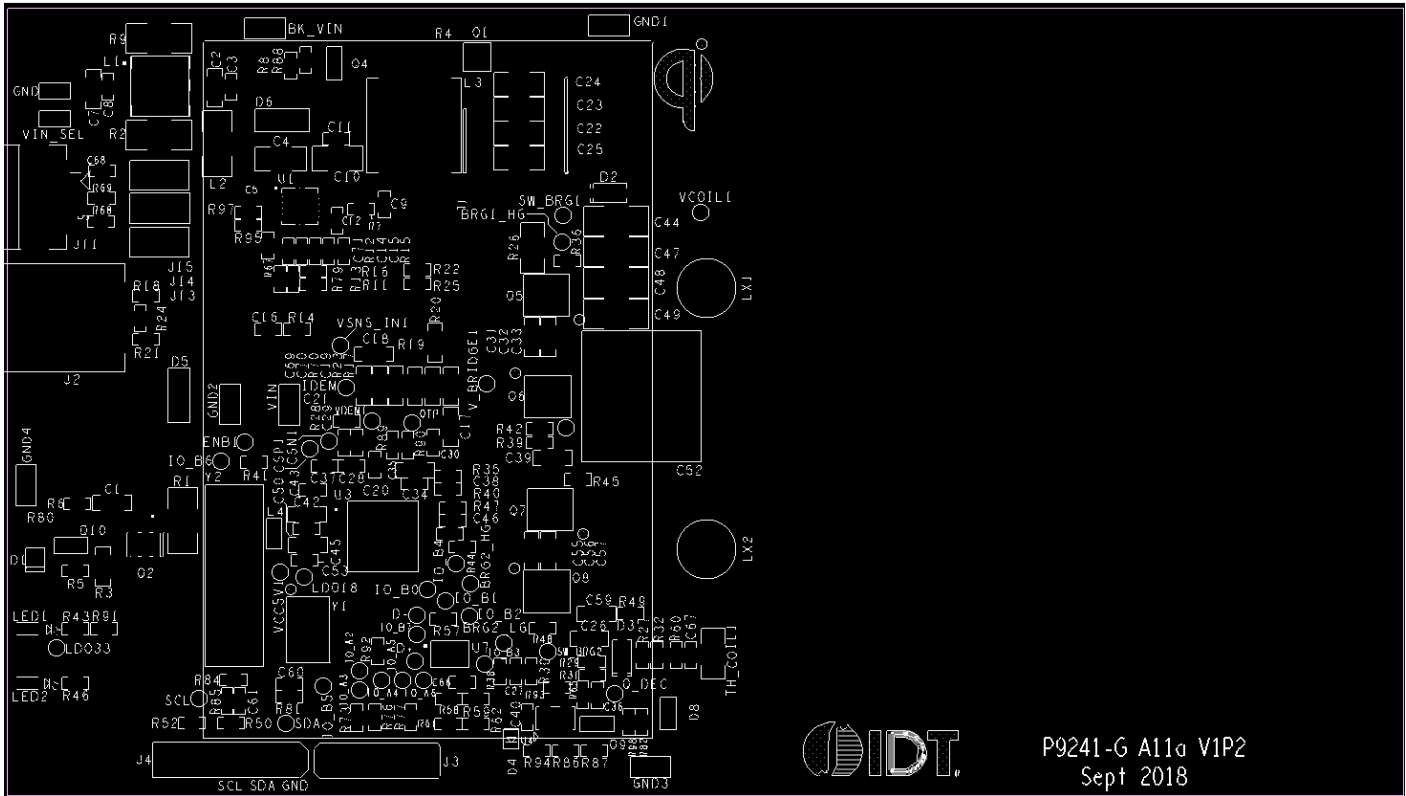


Item	Reference	Value	Description	Part Number	Manufacturer	Qty.
19	J3	SIP con	4 Positions Header, Unshrouded Connector 0.100" (2.54mm) Through Hole Gold or Gold, GXT961104-6404-AR, sip-4	961104-6404-AR	3M	1
20	J4	68000-105HLF	BERGSTIK II .100" SR STRAIGHT, sip5	68000-105HLF	Amphenol ICC	1
21	J11	5P	CONN RCPT MCR USB AB SMD TH SHLL, usb_micro_ab	ZX62D-AB-5P8		1
22	LED1	LED	LED RED CLEAR 0603 SMD	150060RS75000	Würth Electronics Inc.	1
23	LED2	LED	LED GREEN CLEAR 0603 SMD	150060GS75000	Würth Electronics Inc.	1
24	L3	10 $\mu$ H	29mOhm, 3.6A inductor, 5x5-10x10	SWPA8040S100MT	SHENZHEN SUNLORD ELECTRONICS	1
25	L4	4.7 $\mu$ H	FIXED IND 4.7UH 620MA 500 MOHM, L0603	CIG10W4R7MNC	Samsung Electro-Mechanics	1
26	Q1	SIA453EDJ-T1_GE3	MOSFET P-CH 30V 24A PPAK SC-70-6, sc70_6ld_fet	SIA453EDJ-T1-GE3	Vishay Siliconix	1
27	Q2	Si3417	P-Channel 30 V , 35mOhm, 15nC MOSFET, SOT-23-6	Si3417DV-T1-GE3	Vishay Siliconix	1
28	Q4	2N7002	N-Channel 60-V (D-S) MOSFET, SOT23_3	2N7002KT1G	On Semiconductor	1
29	Q5, Q6, Q7, Q8	DMG7430LFG	MOSFET N-CH 30V 12A PWRDI3333, powerdi3333_8ld_fet	DMG7430LFG-7	Diodes Incorporated	4
30	Q10	MMBT4403/SOT	TRANS PNP 40V 0.6A, SOT23-3	MMBT4403-7-F	Diodes Incorporated	1
31	R1,R2,R9	0 $\Omega$	RES SMD 0.0 OHM JUMPER 1/4W 1206	RC1206JR-070RL	Yageo	3
32	R3	150 $\Omega$	RES SMD 150 OHM 1% 1/10W 0603	RC0603FR-07150RL	Yageo	1
33	R4,R8	100k $\Omega$	RES SMD 100K OHM 1% 1/10W 0402	RC0402FR-07100KL	Yageo	2
34	R5, R19, R28, R58, R59, R60, R61, R62, R85, R95	10k $\Omega$	RES SMD 10K OHM 1% 1/10W 0402	RC0402FR-0710KL	Yageo	10
35	R6	91k $\Omega$	RES SMD 91K OHM 1% 1/16W 0402	RC0402FR-0791KL	Yageo	1
36	R7	10 $\Omega$	RES SMD 10OHM 1% 1/10W 0402	RC0402FR-0710RL	Yageo	1
37	R11	150k $\Omega$	RES SMD 150K OHM 1% 1/16W 0402	RC0402FR-07150KL	Yageo	1
38	R12, R15	30k $\Omega$	RES SMD 30K OHM 1% 1/10W 0402	RC0402FR-0730KL	Yageo	2
39	R13	18k $\Omega$	RES 18K OHM 1% 1/10W 0402	MCS04020C1802FE000	Vishay Beyschlag	1
40	R14	3.3k $\Omega$	RES SMD 3.3K OHM 1% 1/16W 0402	RC0402FR-073K3P	Yageo	1
41	R16, R50, R52	5.1k $\Omega$	RES SMD 5.1K OHM 1% 1/10W 0402	ERJ-2RKF5101X	Panasonic	3

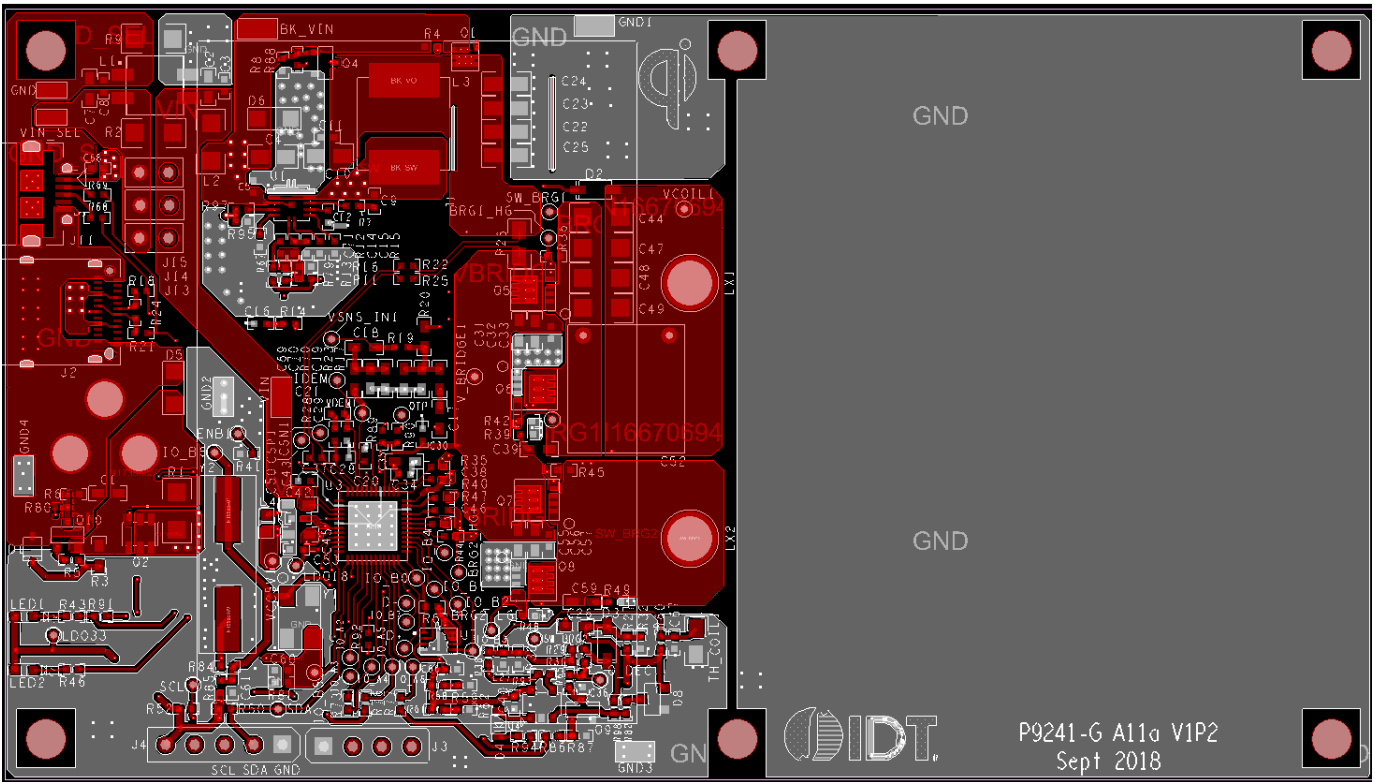
Item	Reference	Value	Description	Part Number	Manufacturer	Qty.
42	R20	2.4k $\Omega$	RES SMD 2.4K OHM 1% 1/10W 0603	RC0603FR-072K4L	Yageo	1
43	R22, R25	10 $\Omega$	RES SMD 10 OHM 1% 1/10W 0402	ERJ-2RKF10R0X	Yageo	2
44	R23	200k $\Omega$	RES SMD 200K OHM 1% 1/10W 0603	RC1608F204CS	Samsung Electro-Mechanics	1
45	R26	0.02 $\Omega$	RES SMD 0.02 OHM 1% 1/3W 0805	UCR10EVHFSR020	Rohm Semiconductor	1
46	R35, R40, R44, R47	22 $\Omega$	RES SMD 22 OHM 5% 1/10W 0402	ERJ-2GEJ220X	Panasonic Electronic Components	4
47	R36, R42, R45, R48, R57	100k $\Omega$	RES SMD 100K OHM 5% 1/10W 0402	ERJ-2GEJ104X	Panasonic Electronic Components	5
48	R41, R43	1k $\Omega$	RES SMD 1K OHM 5% 1/16W 0402	RC0402JR-071KL	Yageo	2
49	R46	680 $\Omega$	RES SMD 680 OHM 5% 1/16W 0402	RC0402JR-07680RL	Yageo	1
50	R18, R21, R39, R49, R67, R68, R69, R73, R76, R77, R80, R88, R90, R97	0 $\Omega$	RES SMD 0 OHM JUMPER 1/16W 0402	RC0402JR-070RL	Yageo	14
51	R84	1M $\Omega$	RES SMD 1M OHM 5% 1/16W 0402	RC0402JR-071ML	Yageo	1
52	U1	MP2229	Buck Converter Chip, QFN-14 (3X3), MP_2229	MP2229GQ	Monolithic Power Systems Inc.	1
53	U3	P9241-GB	Medium Power Transmitter, socketqfn_48_6x6_0p4	P9241-GB	IDT	1
54	U7	W25X40CLUXIG	IC FLASH 4M SPI 104MHZ 8USON, uson_2x3_8LD	W25X40CLUXIG	Winbond Electronics	1
55	Y1	8MHz	CRYSTAL 8MHZ 18PF SMD, ECX-53B	ECS-80-18-30B-AGN-TR	ECS Inc.	1

## 5. Board Layout

Figure 14. Silkscreen – Top of Board



**Figure 15. Copper – Top Layer**



**Figure 16. Copper – L1 Layer**

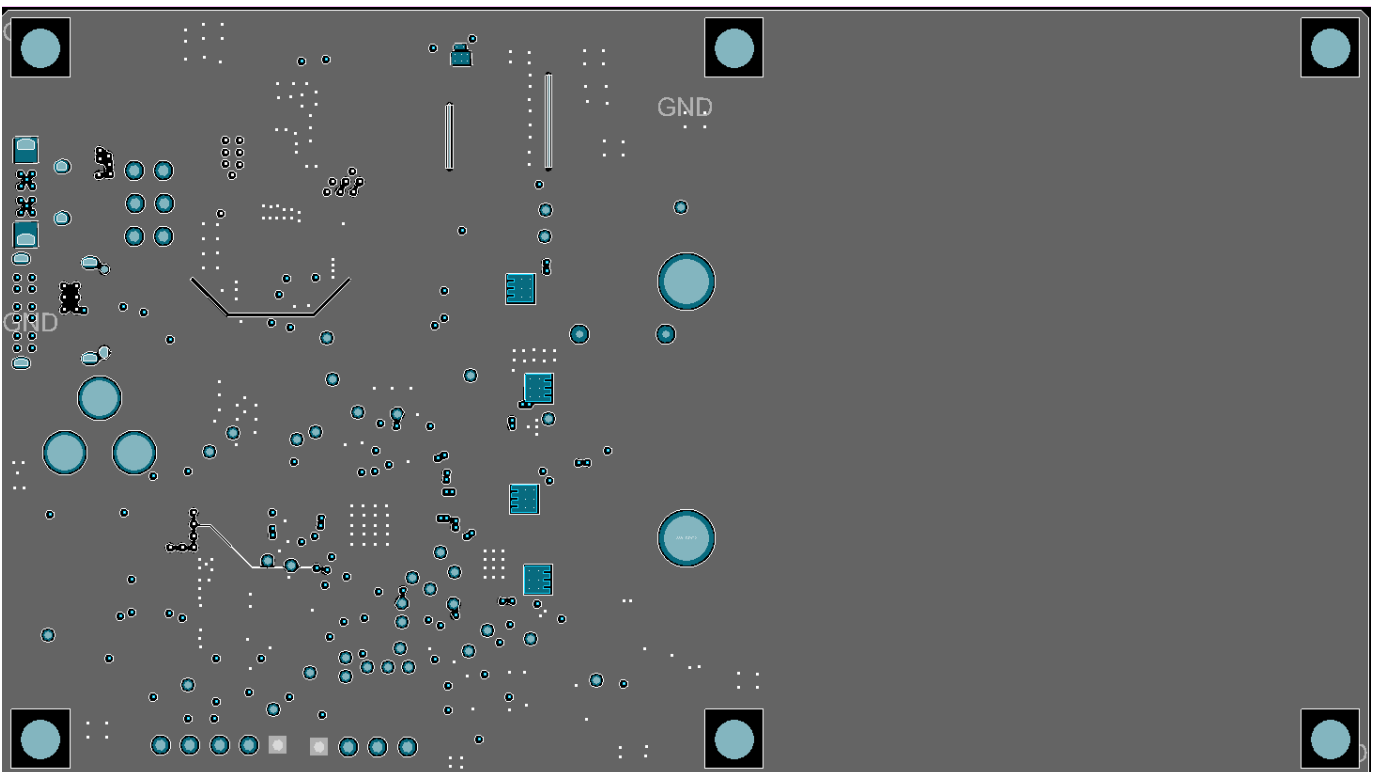


Figure 17. Copper – L2 Layer

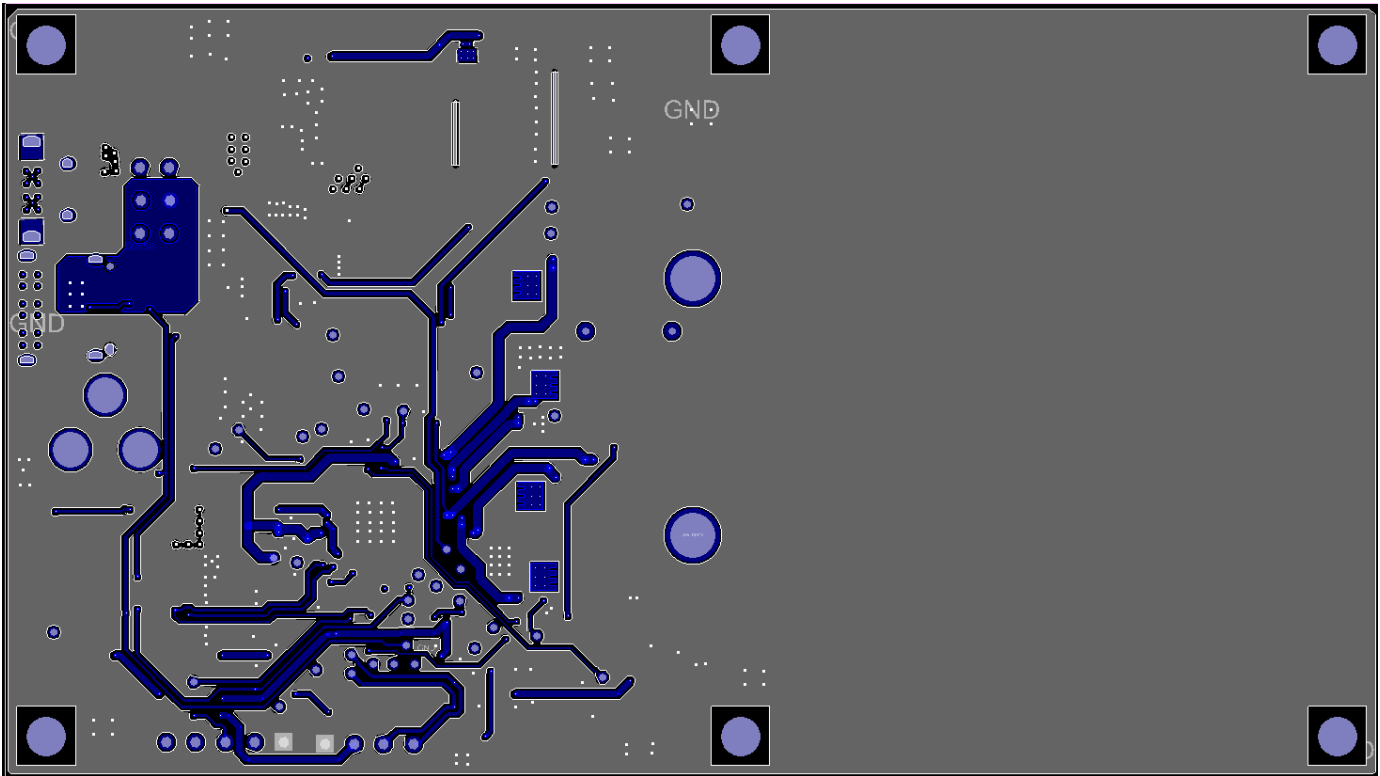
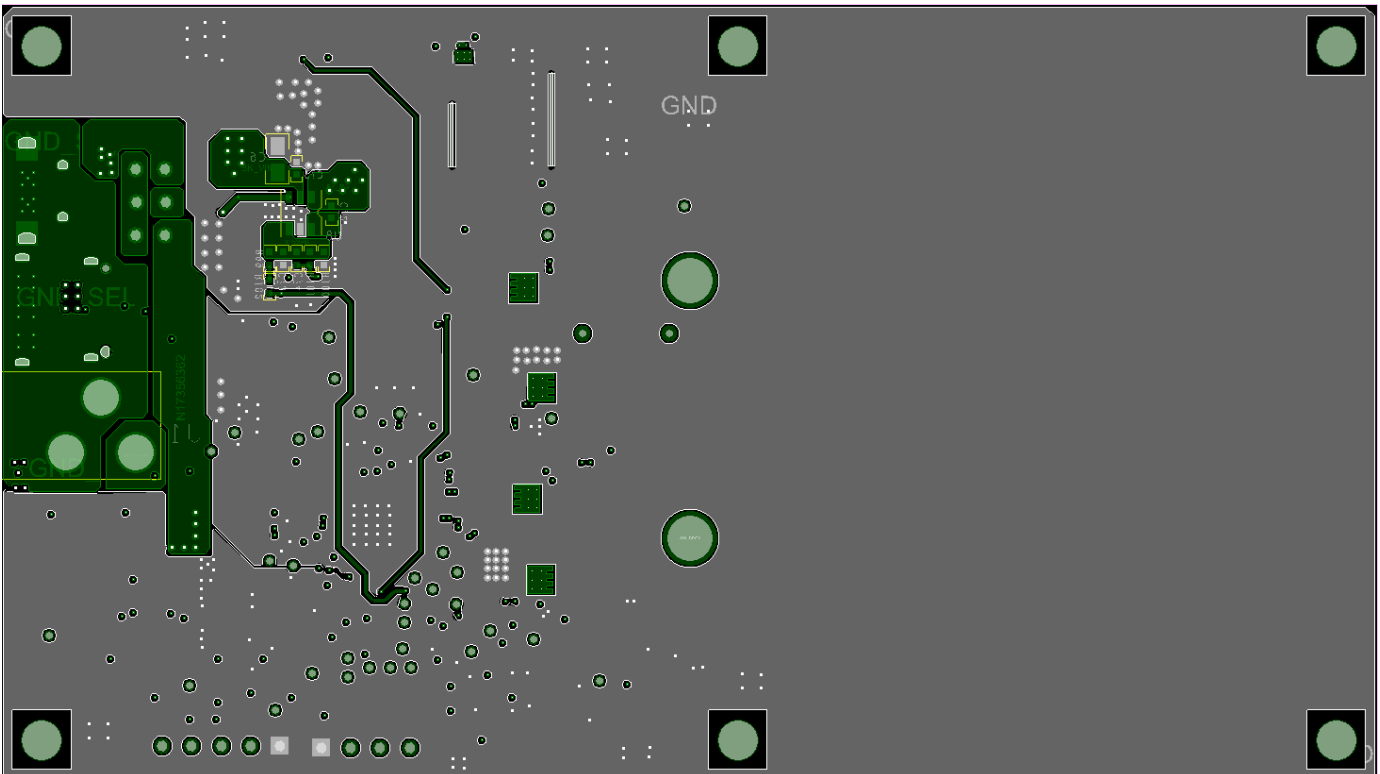


Figure 18. Copper – Bottom Layer



## 6. Ordering Information

Orderable Part Number	Description
P9241-G-EVK	P9241-G-EVK Evaluation Board, 12V/2.0A QC3.0 Quick Charge USB Wall Charger, and Micro-USB cable.

## 7. Revision History

Revision Date	Description of Change
March 1, 2019	Initial release.



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### Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

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