Multi-coil Wireless Power Transmitter Compliant with WPC V1.2.4 protocol of 7.5W/10W/15W

Features

- **Compliant with the WPC V1.2.4 specificatiosn transmitter design**
- **Support 5~15W applications**
  - ✧ **Single 5W applications**
  - ✧ **Fast charge input for 5~10W applications**
  - ✧ **5V DC input for step-up of 5~10W output applications**
  - ✧ **9~15V DC input for step-down of 5~10W output applications**
  - ✧ **12~19V DC input for 15W applications**
- **Support multiple coils**
  - ✧ **Support 2~3 coils**
  - ✧ **Support automatic detection of receiving coil placement**
  - ✧ **Determine the 2/3 coils through the level state of the specific IO pin**
- **Input withstand voltage up to 25V**
- **Integrate NMOS full bridge driver**
- **Integrate voltage/current demodulator**
- **Support FOD (Foreign Object Detection) function**
  - ✧ **High sensitivity**
  - ✧ **Support dynamic FOD**
  - ✧ **Adjustable FOD parameters**
- **Low quiescent dissipation and high efficiency**
  - ✧ **4mA quiescent current**
  - ✧ **Charging efficiency is up to 79%**
- **Compatible with NPO and CBB capacitors**
- **Support online firmware upgrade**
- **Support Dynamic Power Modulation (DPM) for insufficient USB power source**
  - ✧ Support low voltage charger of 5V/500mA
- **Input overvoltage, overcurrent protection**
- **Support PD3.0 input**
- **Support NTC**
- **3 LEDs for system states indication**
  - ✧ **support the customization of light display**
- **Pacage: QFN40 6mm*6mm 0.5 pitch**

Description

IP6809 is a wireless power transmitter controller SoC that integrates all required functions for the latest WPC Qi V1.2.4 specifications compliant wireless power transmitter design. Support 3 coils applications. support A28 coil, MP-A28 coil, MP-A2 coil,support 5W, Apple 7.5W, Samsung 10W, 15W charging. It used analog PING to detect a RX wireless device for charging with low standby power. IP6809 determines the position of the receiver by switching the different working coils to perform analog ping and detecting the signal strength, and selects the coil with the strongest signal to perform the charging action.Once RX device is detected, the IP6809 establish a communication with the RX wireless device and controls the coil power transfer by adjusting operation frequency, depended on calculating the data packages, received from RX device, with PID algorithm. IP6809 terminate power transfer when RX device is fully charged.

IP6809 integrate full-bridge driver, includes voltage and current two-way ASK demodulation module, and input overvoltage/current protection and FOD module. IP6809 is a highly integrated SoC for small-size and low bom cost solutions and reduced time-to-market.

Applications

- **Charge Jacket, wireless charging base**
- **Car wireless charging device**

System Functional Diagram

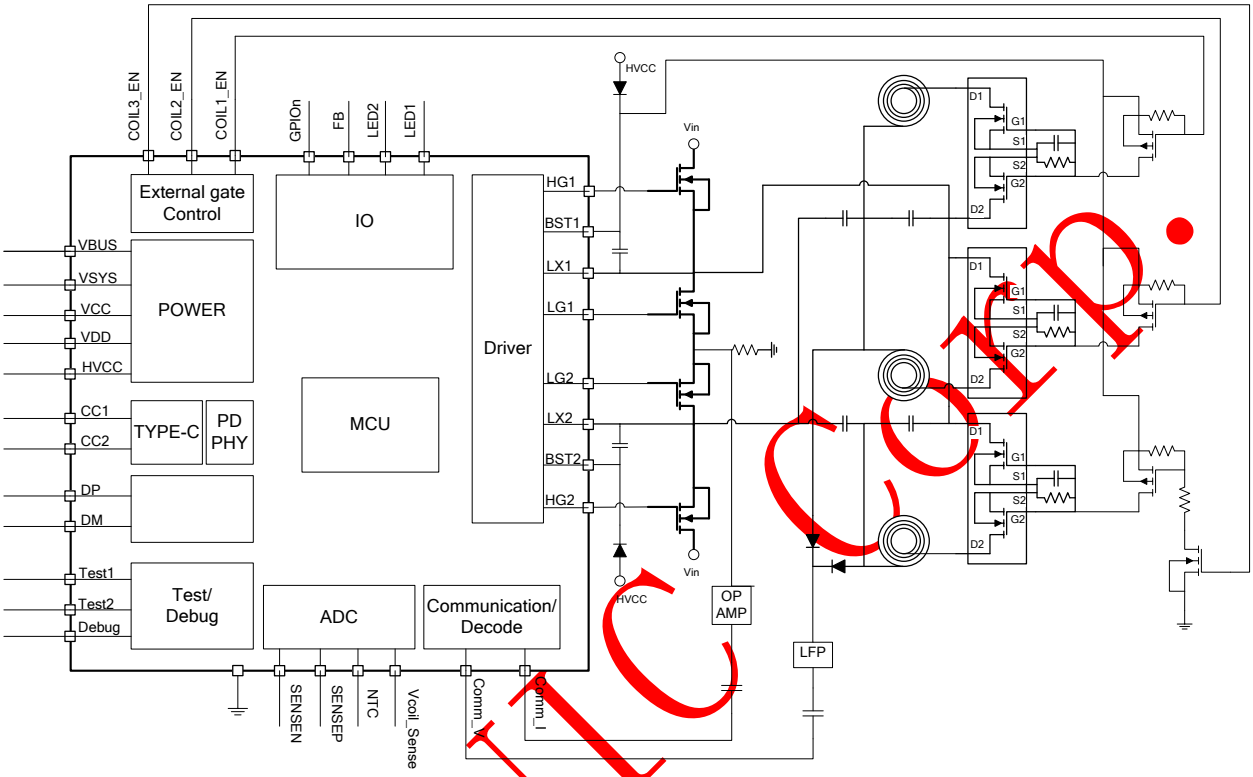
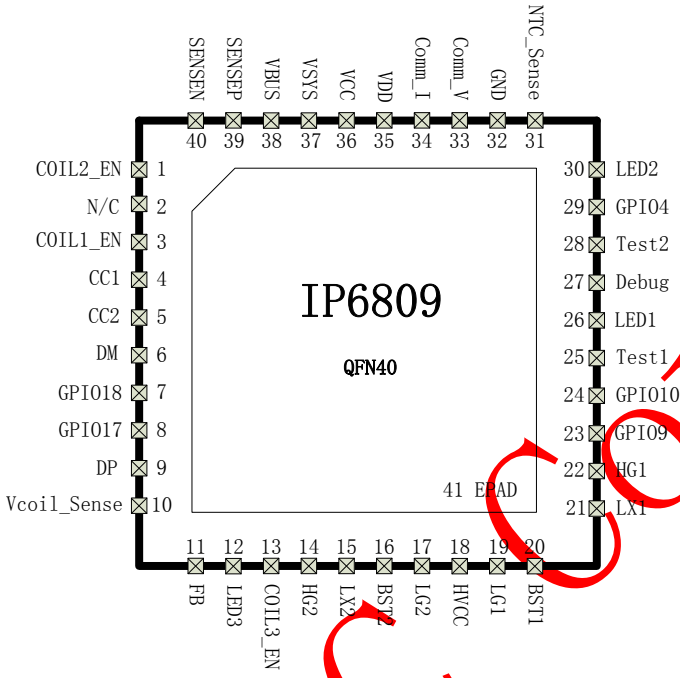


Figure System functional diagram

Product Package Introduction

Product	Description
IP6809_A_S_XXXXX	10W wireless charging single coil application, support 5V/9V DC input
IP6809_A_M_XXXXX	10W wireless charging multi-coil application , support 5V/9V DC input
IP6809_F_S_XXXXX	15W wireless charging single coil application, support 12V/19V DC input

1. Pin Description



Pin No.	Pin Name	Description
1	COIL1_EN	Coil 1 enable pin
2	N/C	Float
3	COIL2_EN	Coil 2 enable pin
4	CC1	Type-C port CC1 line, support firmware upgrade. Connect to ID line when applied in Micro USB port
5	CC2	Type-C port CC2 line, support firmware upgrade
6	DM	USB DM
7	GPIO18	General-Purpose Input/Output
8	GPIO17	General-Purpose Input/Output
9	DP	USB DP
10	Vcoil_Sense	Coil voltage sense input
11	FB	External DCDC voltage control pin
12	LED3	LED3 output
13	COIL3_EN	Coil 3 enable pin
14	HG2	H-bridge high-side NMOS drive
15	LX2	H-bridge switching node
16	BST2	Internal high voltage drive, connect to capacitor to LX2

17	LG2	H-bridge low-side NMOS drive
18	HVCC	5V LDO output, used for H-bridge high-sied MOSFET boost drive
19	LG1	H-bridge low-side NMOS drive
20	BST1	Internal high voltage drive, connect to capacitor to LX1
21	LX1	H-bridge switching node
22	HG1	H-bridge high-side NMOS drive
23	GPIO9	General-Purpose Input/Output
24	GPIO10	General-Purpose Input/Output
25	Test1	Test1
26	LED1	LED1 output
27	DEBUG	Debug pin
28	Test2	Test2
29	GPIO4	General-Purpose Input/Output
30	LED2	LED2 output
31	NTC_Sense	NTC output
32	GND	Analog Ground
33	Comm_V	Voltage communication/demodulation input
34	Comm_I	Current communication/demodulation input
35	VDD	VDD internal power source output, connect to 1uF capacitor
36	VCC	VCC internal power source output, connect to 1uF capacitor
37	VSYS	System power input
38	VBUS	VBUS charge/discharge detect pin
39	SENSEP	VBUS current positive sense node
40	SENSEN	VBUS current negative sense node
41	EPAD (PGND)	Power dissipation ground, connect with ground well

2. Absolute Maximum Ratings

Parameters	Symbol	Min	Max	Unit
Input Voltage Range	VBUS	-0.3	25	V
	VCC	-0.3	5	
	SENSEN	-0.3	25	
	SENSEP	-0.3	25	
Output Voltage Range	VCC	-0.3	3.3	V
	VDD	-0.3	2.2	
I/O Voltage Range	LED1,LED2,LED3	-0.3	VCC+0.3	V
	GPIO4,9,10,17,18	-0.3	VCC+0.3	
	TEST1, TEST2	-0.3	VCC+0.3	
	CC1, CC2	-0.3	25	
	DP, DM	-0.3	20	
Junction Temperature Range	T_J	-40	125	℃
Storage Temperature Range	Tstg	-60	125	℃
Package Thermal Resistance	θ_{JA}	18		℃/W
Human Body Model (HBM)	ESD			V

*Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to Absolute Maximum Rated conditions for extended periods may affect device reliability.

*Voltages are referenced to GND unless otherwise noted.

3. Recommended Operating Conditions

Parameters	Symbol	Min	Typ	Max	Unit
Input Voltage Range	VBUS	4.5		22	V
	VCC	2.8		3.3	
I/O Voltage Range	LED1,LED2,LED3	GND-0.3V		VCC+0.3V	V
	GPIO4,9,10,17,18	GND-0.3V		VCC+0.3V	
	TEST1, TEST2	GND-0.3V		VCC+0.3V	
	CC1, CC2	GND-0.3V		5.5	
	DP, DM	GND-0.3V		5.5	

*Devices' performance cannot be guaranteed when working beyond those Recommended Operating Conditions.

4. Electrical Characteristics

Unless otherwise specified, TA =25℃

Parameters	Symbol	Min	Typ	Max	Unit	Test Condition
HVCC			5		V	BST
VCC			3.15		V	
VDD			1.8		V	
VBUS		4.5		22	V	

Parameters	Symbol	Min	Typ	Max	Unit	Test Condition
VIH	Input high level	0.7x VCC			V	
VIL	Input low level			0.3x VCC	V	
VOH	Input high level		VCC		V	
VOL	Input low level		GND		V	
Rpu	Pull-up resistor		10		k	Pull-up resistor enable
Source current	Output current capability		2	4	mA	Source current to output high level is 0.8*VCC

5. Function Description

Full-bridge/half-bridge Drive

IP6808 includes two symmetry half-bridge drive module, support multi-level of deadtime control and drive capability control to match with various external NMOS. PWM frequency adjustable range is 110kHz~205kHz with 0.25kHz/step.

Multi-coil switching

The IP6809 supports 2/3 coils wireless charging applications. By controlling the pin level status of COIL1_EN, COIL2_EN and COIL3_EN, the coil's operating state can be set.

If a 2-coil scheme is used, the COIL3_EN string resistor needs to be connected to VCC.

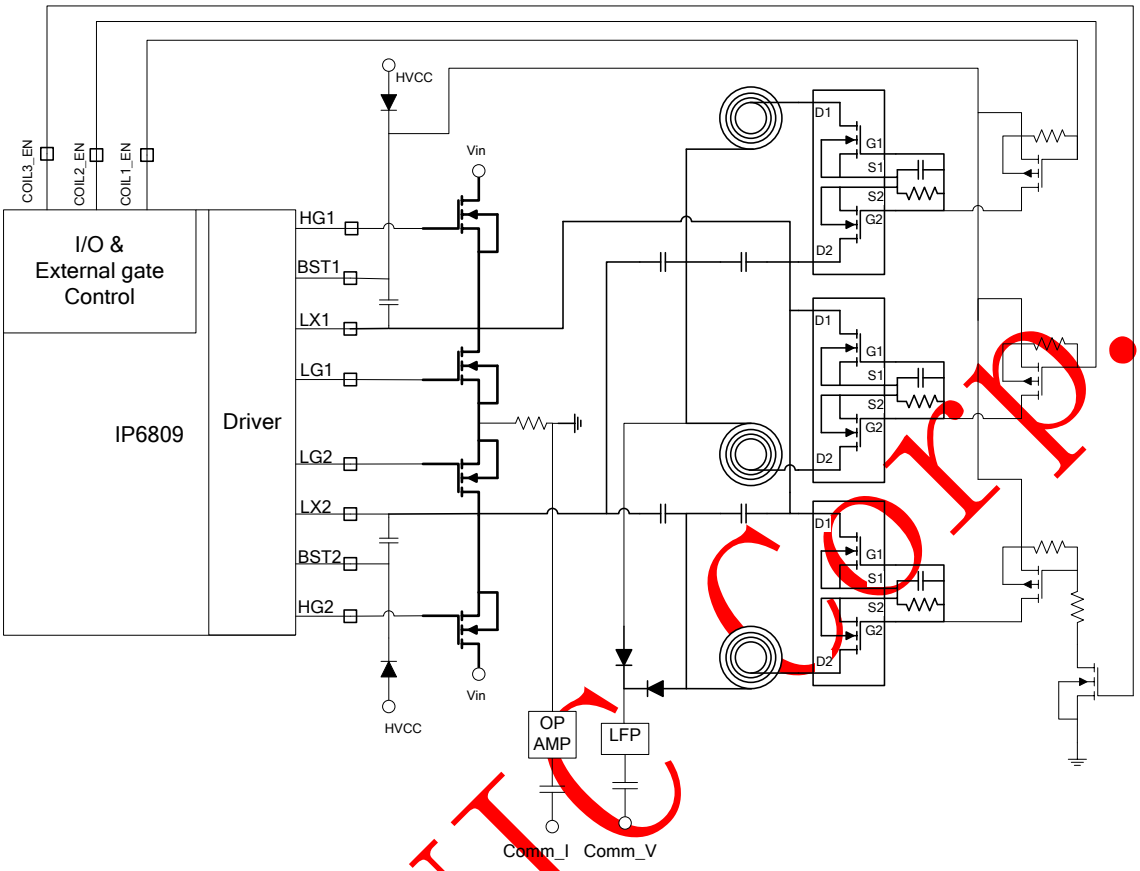


Figure full-bridge drive ,3 coils,application circuit

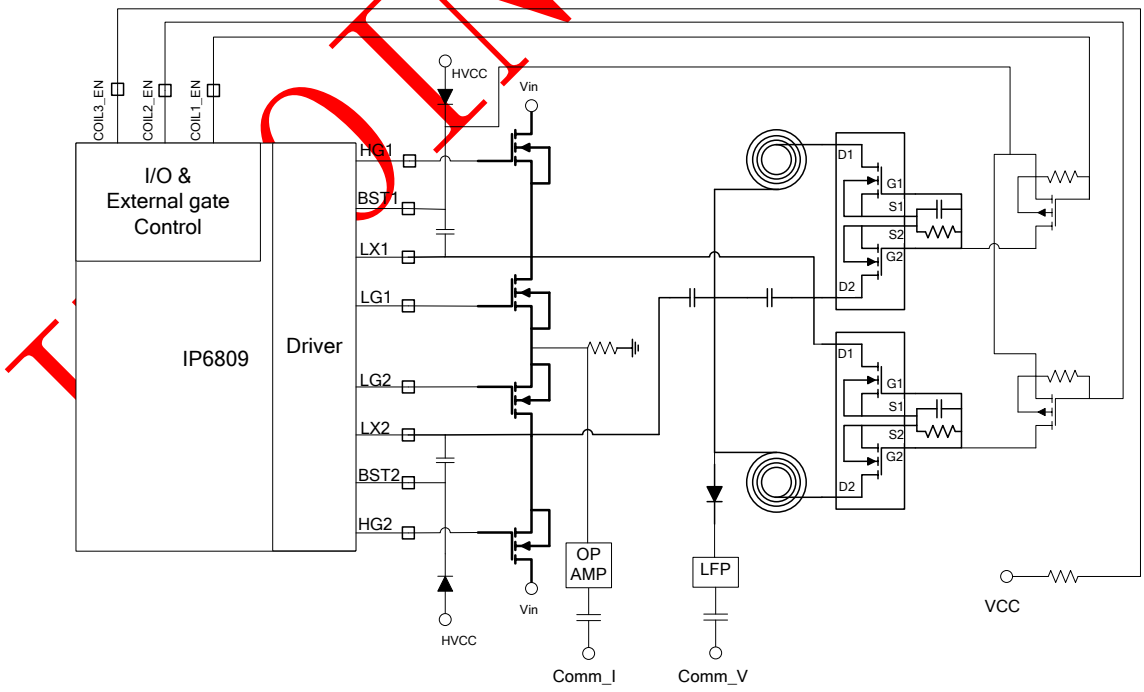


Figure full-bridge drive ,2 coils,application circuit

DPM

IP6809 support Dynamic Power Management function for USB power source with insufficient power supply ability, which can guarantee the charging status will not break off or suspend. When the system detect the input voltage is lower than 4.0V, DPM function will be enabled and the transmitting power will be reduced. When the input voltage returns to above 4.8V and the input current is reduced by 200mA compared to when entering DPM, the system exits the DPM state.

Digital Demodulation

Integrate two-way ASK demodulation module, sampling the voltage and current of the coil separately. Current demodulation, additional separate devices are needed for low pass filters and first amplifier, signals is send to IC for digital demodulation and decode after DC blocked.

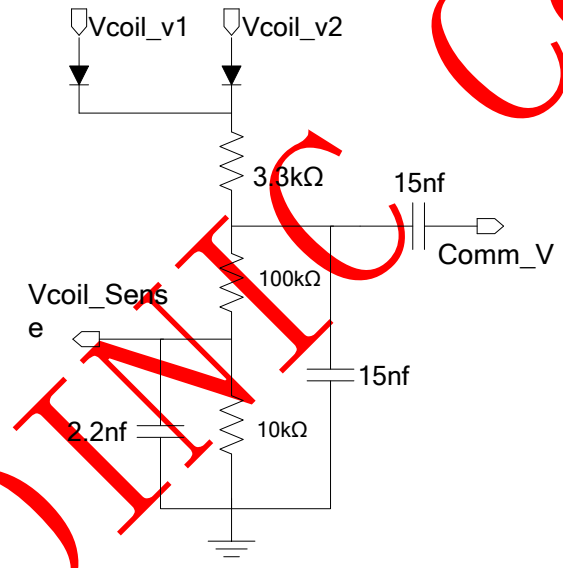


Figure Voltage ASK demodulation external circuit

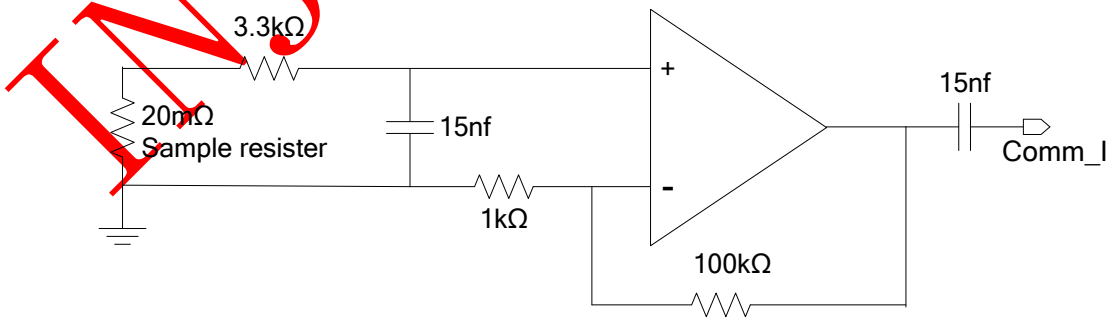


Figure Current ASK demodulation external circuit

NTC Thermal Protection

IP6809 5W typical application do not need additional thermal protection. The NTC thermal shutdown protection is for enhancement application, but not limited to thermal shutdown. When NTC voltage is lower than 1V, the system will terminate the power transmittion. After entering NTC protection, the NTC voltage is greater than 1.3V, and normal charging resumes. If NTC is not used, NTC pin must pull high.

NTC resistor selection, refer to the following stage:

1. Refer to NTC resistor data handbook, search the resistor-temperature relation sheet
2. Find the related resistor R_NTC according to the protection temperature
3. Calculate the pull-up resistor R_SetPoint value according to the expression: R_Setpoint = (VCC-1)*R_NTC

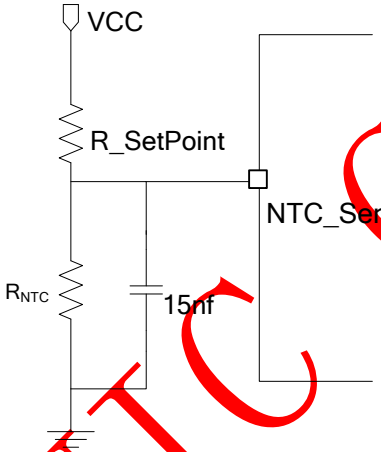


Figure NTC application

LED Status Indicator

IP6809 can drive 3 LEDs directly through serial current-limit resistor. LED1,LED2 status and system status relations are listed below:

Status	LED2	LED1
Normal	Off	Off
In charging	Off	On
Charging accomplished	On	Off
FOD	Toggle	Off

Toggle: 500ms high level->500ms low level->500ms high level

On： high level

Off： low level

Firmware Upgrade

Different wireless charging application regulation method is different, different applications has its own firmware and can not be exchanged, otherwise abnormal working situation may occur and lead to high voltage at RX side.

Method 1:

Use TEST1, TEST2 two pins for firmware upgrade, it is not convenient for online upgrade, test points should be reserved on PCB board for debug and upgrade.

Method 2:

In Type-C USB application, the standard Type-C firmware upgrade method can be used for online upgrade, a firmware upgrade tool is provided for IP6808.

Method 3:

In Micro USB application, if online upgrade is needed, connect CC1 pin to ID line of Micro USB port, and use dedicated firmware upgrade tool for IP6808.

6. Test Waveform

Using TI bq51020 solution for RX device, the relationship of efficiency and system output power and test method are outlined below. (VOUT=5V).

$$\eta_{\text{system}} = \frac{P_{\text{OL}}}{P_{\text{in}}}$$

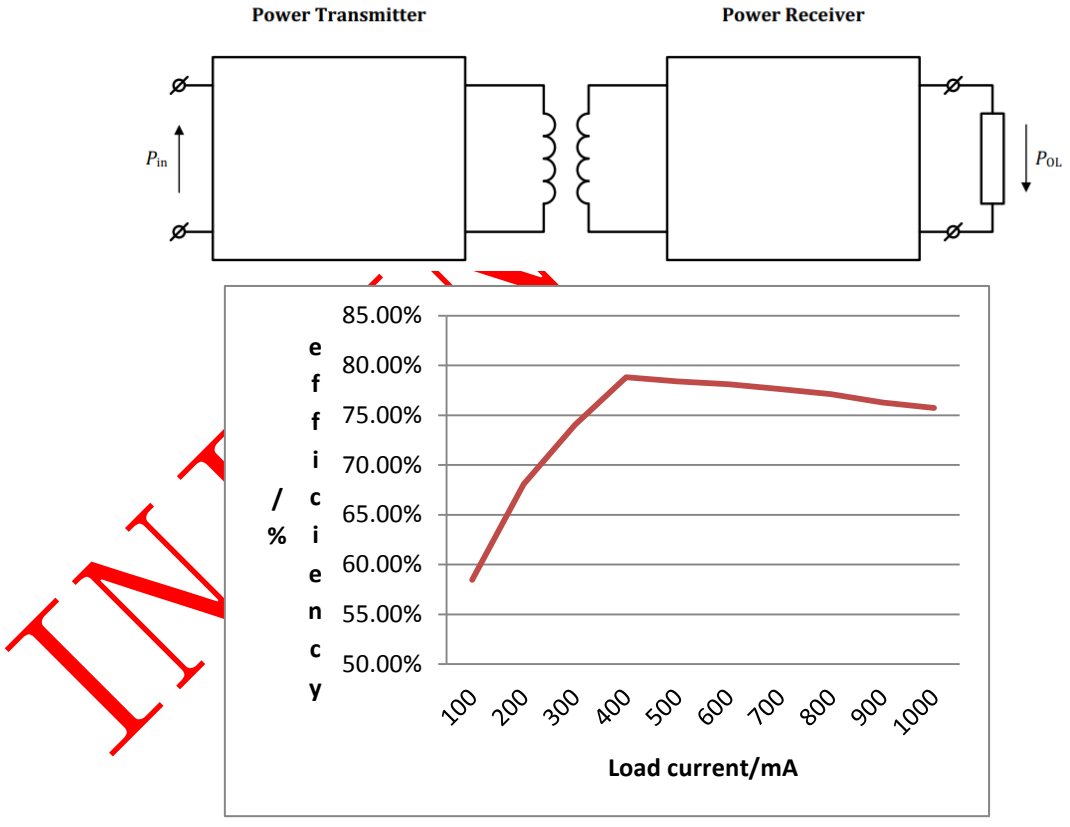
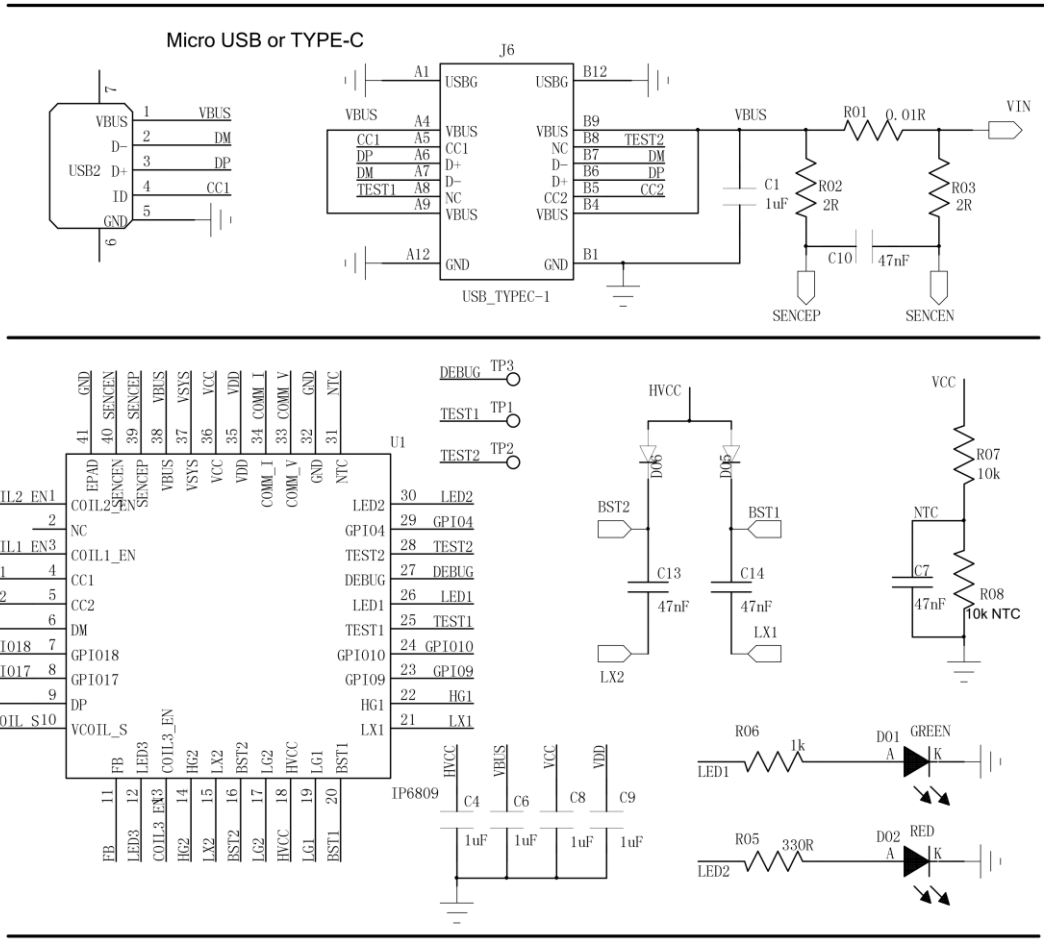


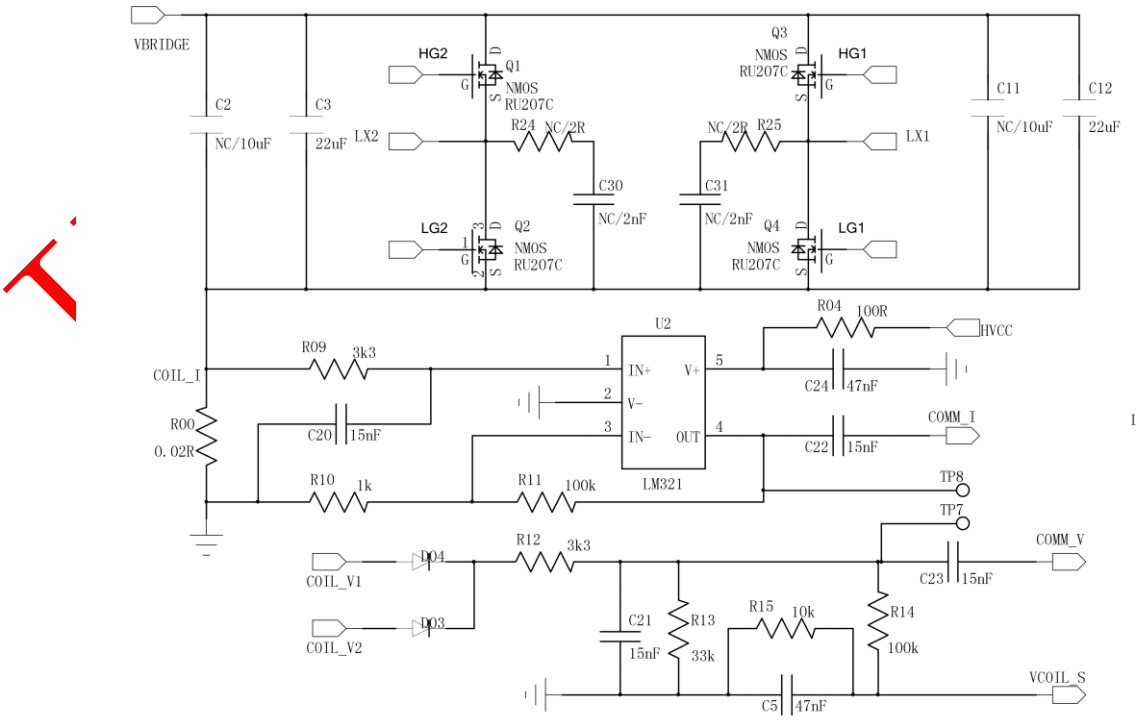
Figure System efficiency (using bq51020 RX)

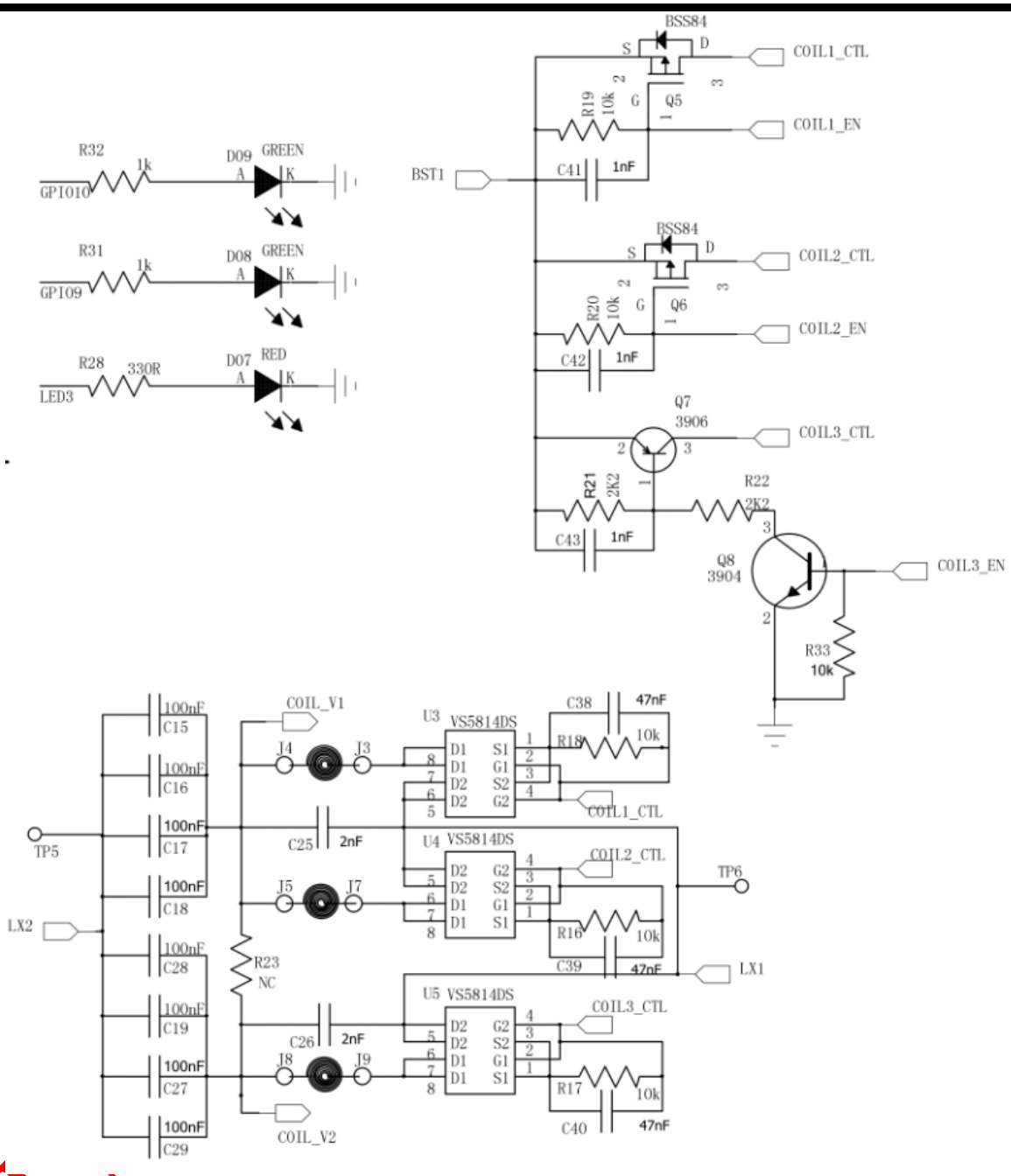
7. Typical Application Schematic

IP6809 wireless charging solution only needs MOSFET, a OP amp, capacitors, resistors and few passive devices.

5W~10W 3 coils Application







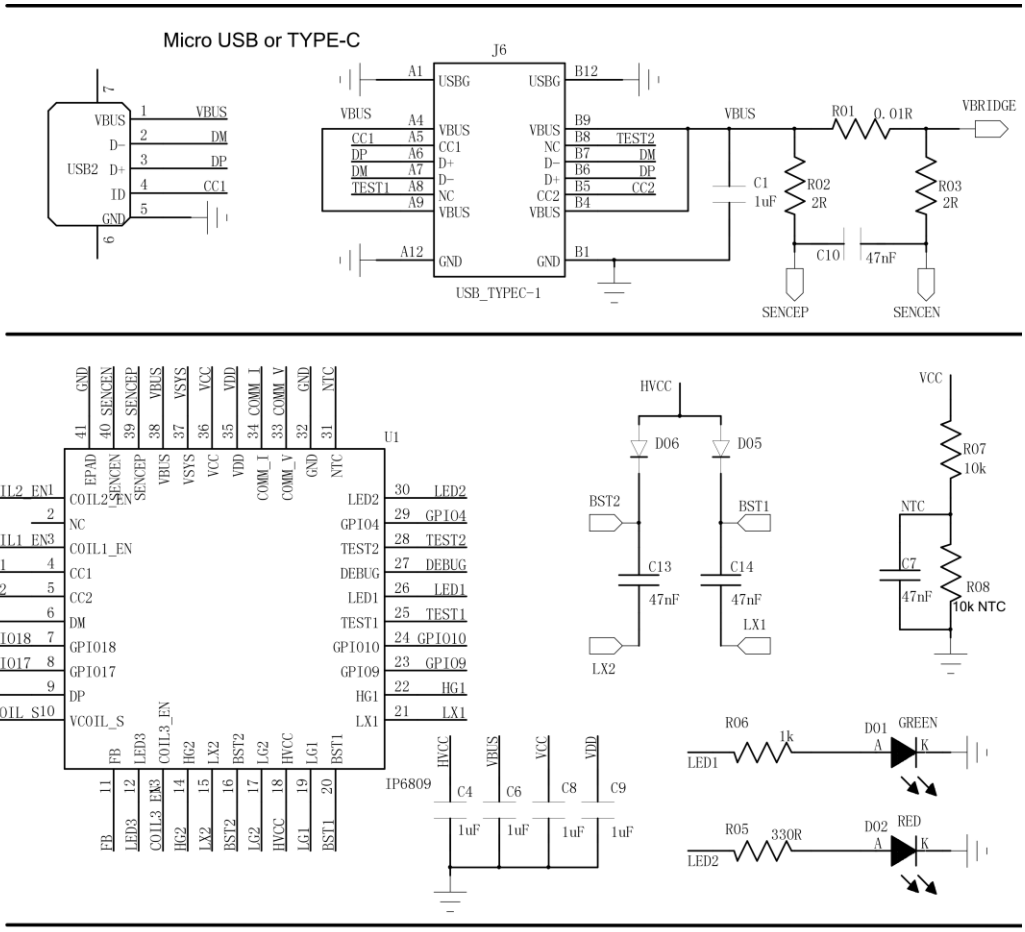
The value of the resonant capacitor should be determined according to the application coil. For example, the equivalent capacitance value of C15, C16, C17, and C18 in parallel is designed as 345nF, and the equivalent capacitance value of C19, C28, C27, and C29 in parallel is designed to be 400nF. For A28 coil, other types of coil customization are supported.

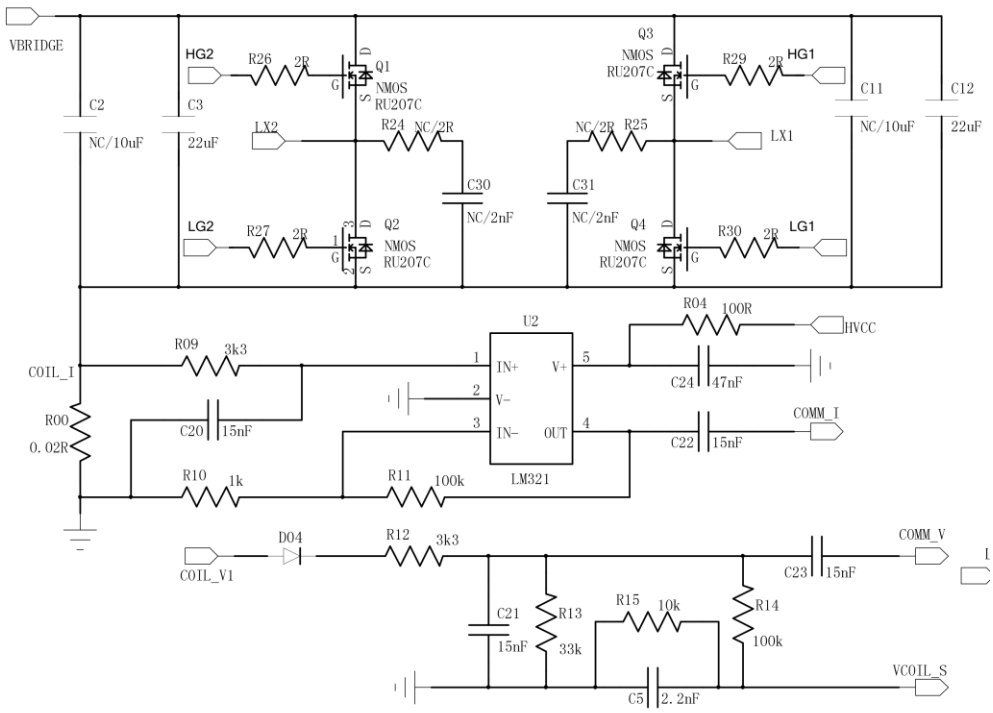
BOM List

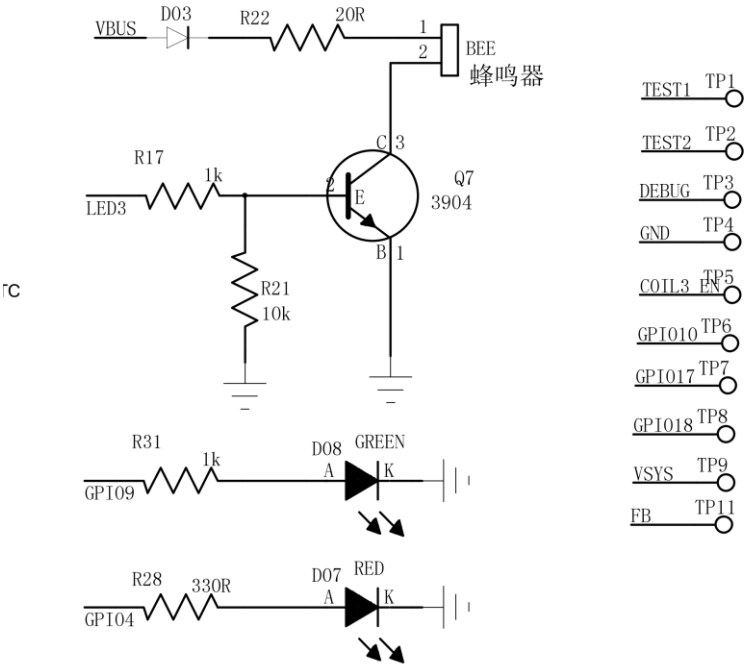
Item	Qty	Reference	Part Name	Description
1	1	U1	IP6809	IP6809_QFN40
2	1	U2	LM321 or BL321	OP amp
3	3	U3-5	VS5814DS	NMOS
5	4	Q1-4	NMOS,RU207C	Full-bridge NMOS
6	2	Q5-6	PMOS	PMOS,BSS84
7	1	Q7	PNP	3906
8	1	Q8	NPN	3904
9	3	D01,D08-09	LED_BLUE,GREEN	LED
10	2	D02,D07	LED_BLUE,RED	LED
11	4	D03-06	DIODE,IN5819	Schottky diode
12	1	R01	1210R,0.01R,1%	SMD resistor
13	1	R00	1210R,0.02R,1%	SMD resistor
14	1	R29	R0603,0R	SMD resistor
15	1	R04	R0603,100R	SMD resistor
16	3	R11,R14,R26	R0603,100K	SMD resistor
17	8	R07,R15-20,R33	R0603,10K	SMD resistor
18	1	R08	R0603,10K NTC	NTC
19	1	R27	R0603,13K	SMD resistor
20	5	R06,R10,R30-32	R0603,1K	SMD resistor
21	2	R21-22	R0603,2K2	SMD resistor
22	6	R02-03,R34-37	R0603,2R	SMD resistor
23	2	R05,R28	R0603,330R	SMD resistor
24	1	R13	R0603,33K	SMD resistor
25	1	R09,R12	R0603,3K3	SMD resistor
26	2	R24-25	R0603,NC/2R	SMD resistor
27	1	R23	R0603,NC/2R	SMD resistor
28	8	C15-19,C27-29	C1210,100nF,100V	NPO or CBB capacitor
29	2	C33-34	C0603,100nF,50V	SMD capacitor
30	4	C20-23	C0603,15nF	SMD capacitor
31	3	C41-43	C0603,1nF	SMD capacitor
32	1	C5	C0603,2.2nF	SMD capacitor
33	2	C25-26	C0603,2nF	SMD capacitor
34	7	C7,C13-14,C24,C38-40	C0603,47nF	SMD capacitor
35	1	C37	C0603,68pF	SMD capacitor
36	2	C30-31	C0603,NC/2nF	SMD capacitor
37	1	C35	C0603,100nF	SMD capacitor
38	5	C1,C4,C6,C8-9	C0603,1uF,10%	SMD capacitor
39	4	C3,C12,C32,C36	C0805,22uF,10%	SMD capacitor
40	1	C10	C0603,47nF	SMD capacitor

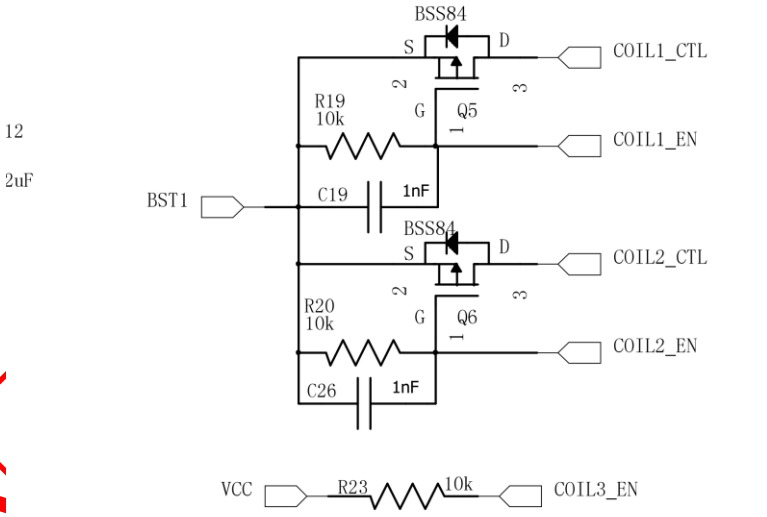
41	2	C2,C11	C0603,NC/10uF,10%	SMD capacitor
42	1	CP1	CAP_POL1,100uF	SMD capacitor b
43	1	L1	IND-MOLDED, 10uH	MOLDED INDUCTOR, 0.5" PIN SPACING,
44	1	USB2	MINIUSB_7PIN	Micro_USB
45	6	J3-5 J7-9	BAT	
46	3	TP1-3	TP,nc	Test point
47	1	J6	USB_TYPEC-1	TYPEC
48	2	J1-2	NODE_POWER	Test point

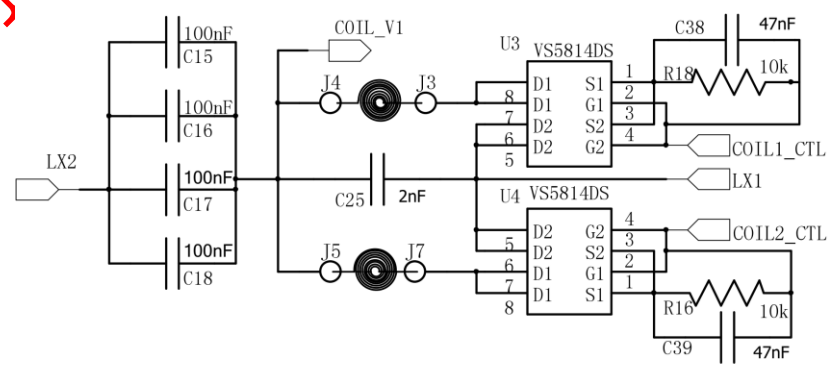
5W~10W 2coils Application











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4	4	Q1-4	NMOS,RU207C	Full-bridge NMOS
5	2	Q5-6	PMOS	PMOS,BSS84
6	1	Q7	NPN	3904
7	2	D01,D08	LED,GREEN	LED
8	2	D02,D07	LED,RED	LED
9	4	D03-06	DIODE,IN5819	Schottky diode
10	1	R01	1210R,0.01R,1%	SMD resistor
11	1	R00	1210R,0.02R,1%	SMD resistor
12	1	R04	R0603,100R	SMD resistor
13	2	R11,R14	R0603,100K	SMD resistor
14	8	R07,R15-16,R18-21,R23	R0603,10K	SMD resistor
15	1	R08	R0603,10K NTC	NTC
16	5	R06,R10,R17,R31	R0603,1K	SMD resistor
17	1	R22	R0603,20R	SMD resistor
18	6	R02-03,R26-27,R29-30	R0603,2R	SMD resistor
19	2	R05,R28	R0603,330R	SMD resistor
20	1	R13	R0603,33K	SMD resistor
21	2	R09,R12	R0603,3K3	SMD resistor
22	2	R24-25	R0603,NC/2R	SMD resistor
23	4	C15-18	C1210,100nF,100V	NPO or CBB capacitor
24	4	C20-23	C0603,15nF	SMD capacitor
25	2	C19,C26	C0603,1nF	SMD capacitor
26	1	C5	C0603,2.2nF	SMD capacitor
27	1	C25	C0603,2nF	SMD capacitor
28	6	C7,C13-14,C24,C38-39	C0603,47nF	SMD capacitor
29	2	C30-31	C0603,NC/2nF	SMD capacitor
30	5	C1,C4,C6,C8-9	C0603,1uF,10%	SMD capacitor
31	2	C3,C12	C0805,22uF,10%	SMD capacitor
32	1	C10	C0603,47nF	SMD capacitor
33	2	C2,C11	C0603,NC/10uF,10%	SMD capacitor
34	1	B1	BEEP	
35	1	USB2	MINIUSB_7PIN	Micro_USB
36	4	J3-5 J7	BAT	
37	11	TP1-11	TP,nc	Test point
38	1	J6	USB_TYPEC-1	TYPEC

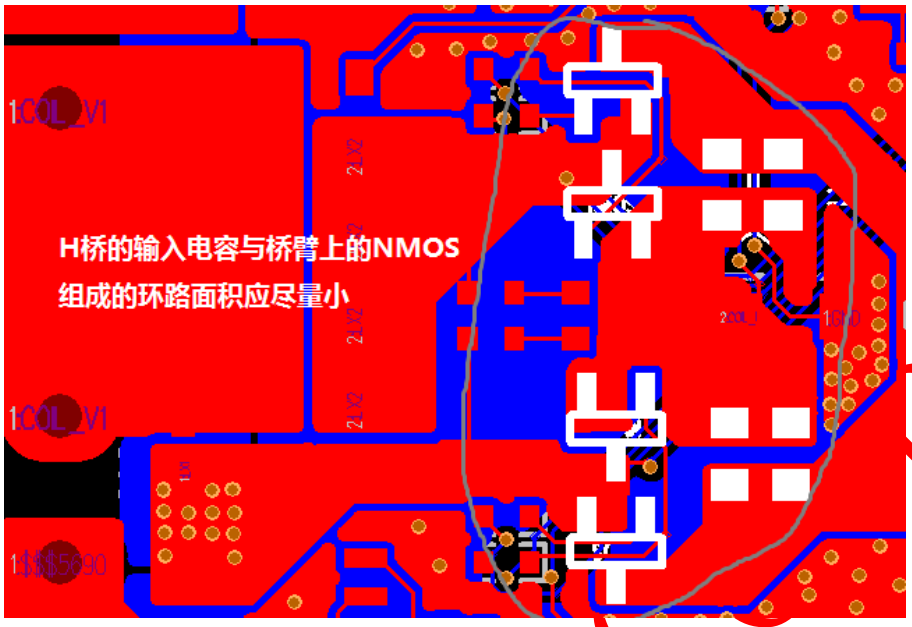
8. Layout Notifications

Here list some notifications that may affect the function and performance, other notes will be described in other attached files.

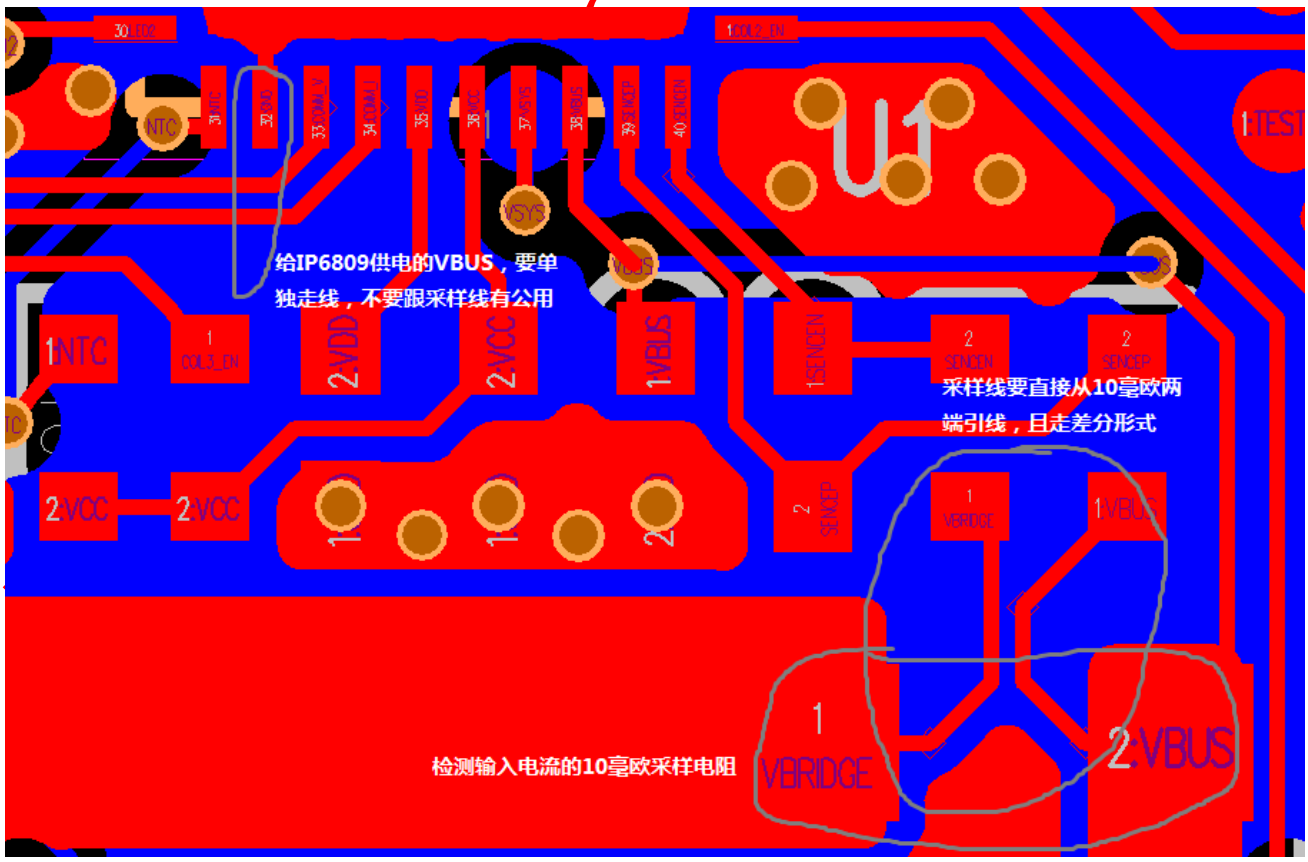
Layout methods has great influence on function and performance of the wireless charging system, un-appropriate layout may affect the ASK communication and the sensitivity of FOD detection.

1. Make sure IP6809 pins and EPAD GND PAD has a good continuous current loop.
2. The 20mOhm sample resistor for current demodulating , should differentially layout to OP amp inputs or use other low noise interference method.

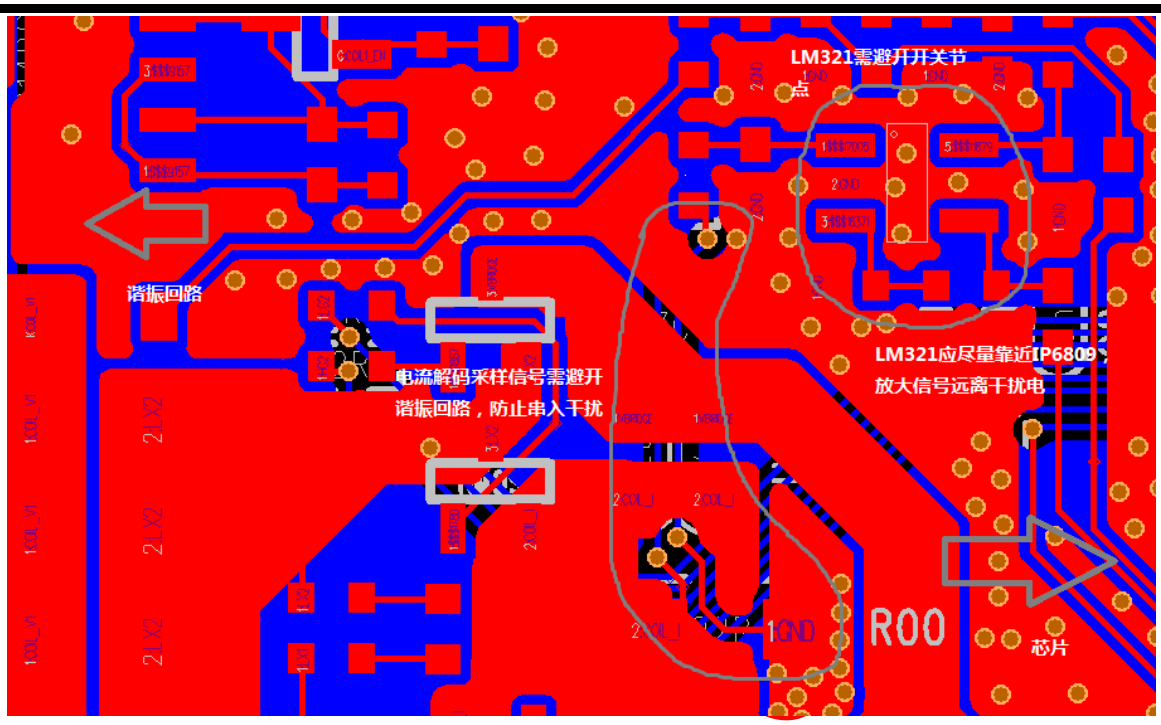
3. CODE_DET_I and CODE_DET_V are sensitive signals should be wrapped up by ground and placed far away from switching MOSFET.
4. H-bridge input capacitor and NMOS loop area should be as small as possible.



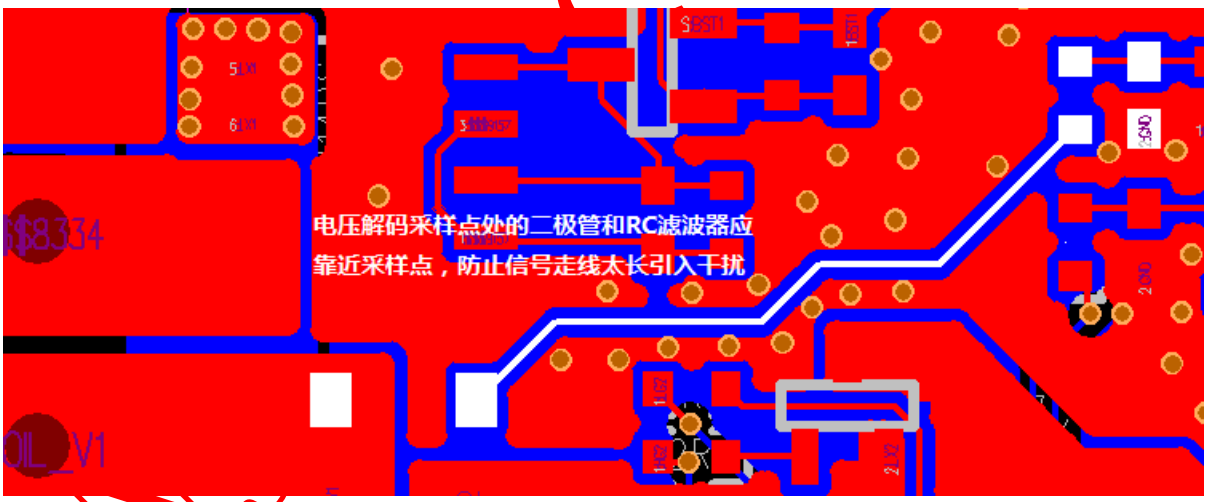
5. The 10mOhm sample resistor for the input current detecting ,the sampling line should be directly from the the sample resistor at both ends of the lead; pay attention to the IP6809 32 pin power supply VBUS routing, to separate the line, do not It is coincident with the sampling line of VBUS (the 1 pin);



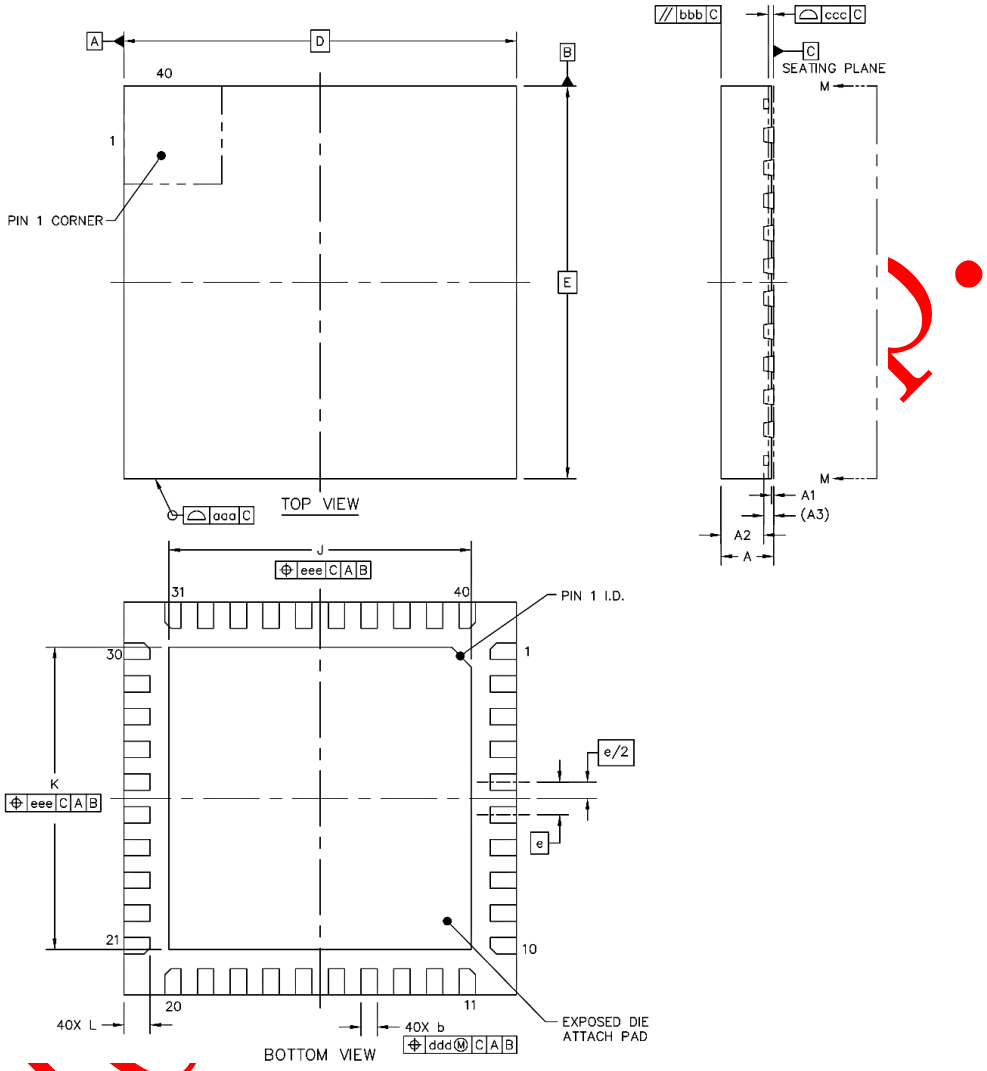
6. The current decoding sampling signal needs to avoid the resonant circuit to prevent serial interference; LM321 should avoid the switch node, and should be as close as possible to IP6809, and the amplified signal should be away from the interference point.



7. The diode and RC filter at the voltage decode sample point should be close to the sample point to prevent the signal trace from being too long to introduce interference.



9. Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.035	0.05
A2	-	0.65	0.67
A3	-	0.125	-
b	0.2	0.25	0.30
e		0.5 BSC	
D		6 BSC	
E		6 BSC	
J	4.52	4.62	4.72
K	4.52	4.62	4.72
L	0.35	0.40	0.45
aaa		0.1	
bbb		0.1	
ccc		0.08	
ddd		0.1	
eee		0.1	

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