IP6551

Maximum output **4.8A**，Buck converter with Dual DCP Protocol

1 Features

- **Synchronous-rectified buck converter**
  - ✧ Dual N-channel MOSFET converter
  - ✧ Input voltage range: 4.5V~36V
  - ✧ Support sampling resistor short circuit protection function
  - ✧ Support low ESR output capacitors
  - ✧ Support line compensate function
  - ✧ Support CV/CC output mode
- **Charge output protocol**
  - ✧ Support BC1.2, Apple and Samsung
- **Multi-protection and high reliability**
  - ✧ Support input over voltage and under voltage protection
  - ✧ Support output short circuit and over current protection
  - ✧ Over temperature protection
  - ✧ ESD 4KV
  - ✧ DC voltage withstand 42V
- **Package: QFN32(5*5)**

2 Applications

- Car Charger
- Fast Charge Adaptor
- Smart Power Strip
- Dash Cam

3 Description

IP6551 integrates a Synchronous-Rectified Buck converter and DCP output standards with dual USB A output ports. It provides solutions for car charger, fast charge adaptor, smart power strip and dash cam.

IP6551 supports up to 36V input voltage and supports sampling resistor short circuit protection function.

IP6551 output has CV/CC mode, when the output current is lower than preset value, the output voltage will be constant in CV output mode; when the output current is higher than preset value, the output voltage will decrease in CC output mode.

IP6551 supports output line compensation, when output current increases, the output voltage will increase accordingly that makes up the resistive voltage drop introduced by connection, wire, and PCB traces.

IP6551 supports soft start function that protects the input power from inrush current at start up.

IP6551 supports multi-protection on input overvoltage and under voltage, output over current, overvoltage, under voltage and short circuit.

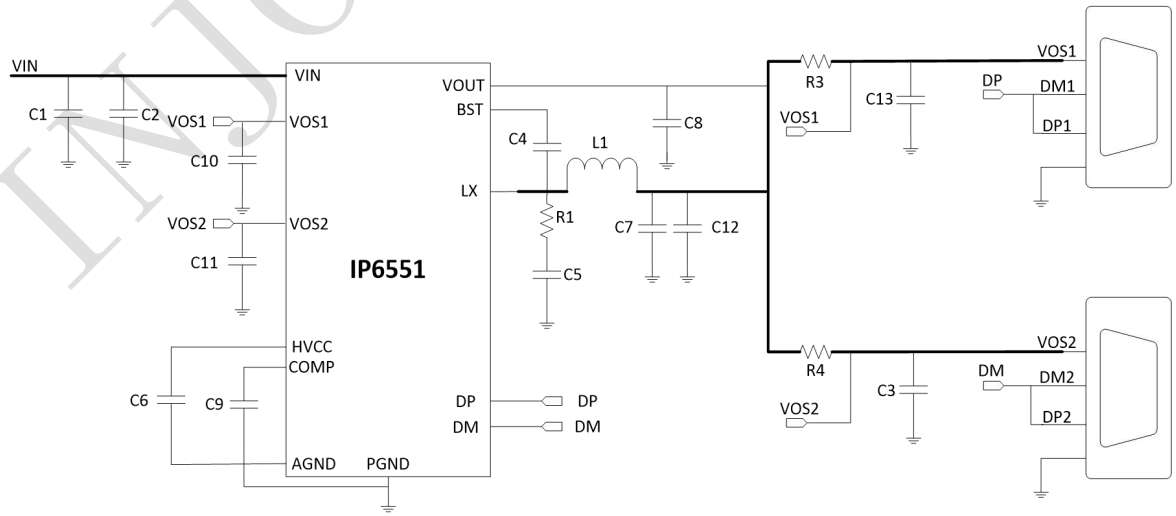

Figure 1. IP6551 dual USB A output ports simplified application schematic diagram

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4 Typical Application Schematic

IP6551 car charging solution only needs inductor, capacitor and resistor.

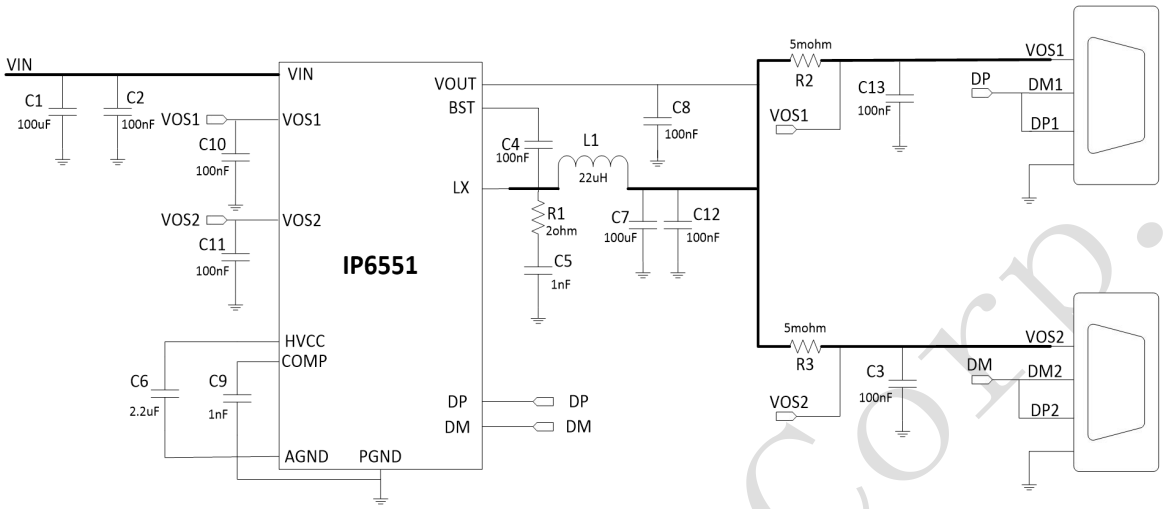


Figure 2. IP6551 dual USB A output ports application schematic diagram

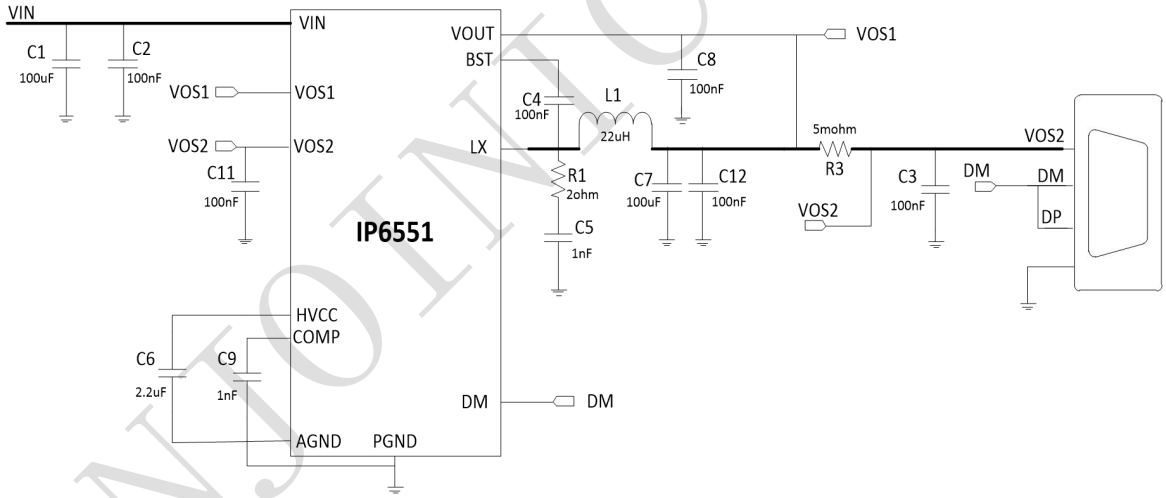


Figure 3. IP6551 Single USB A output ports application schematic diagram

NOTES:

1.IP6551 limits the output current through a 5mohm sensing resistor between VOUT and VOS1/VOS2.

2.IP6551 supports the function of EN PIN to control DCDC turn on or off. This feature must be customized if required.

5 IP Comparison Table

5.1 Car Charger IC

IC Part	Output Current	Dual Ports	Protocols										Package	
			DCP	QC2.0	QC3.0	FCP	SCP	AFC	MTK PE	SFCP	PD2.0	PD3.0 (PPS)	Pkg	P2P
IP6536	2.4A	√	√	-	-	-	-	-	-	-	-	-	ESOP8	PIN2PIN
IP6523S_N	3.4A	-	√	-	-	-	-	-	-	-	-	-	ESOP8	
IP6520TQ	18W	-	√	√	√	√	-	√	-	-	-	-	ESOP8	
IP6525T	18W	-	√	√	√	√	-	√	-	-	-	-	ESOP8	PIN2PIN
IP6525S	18W	-	√	√	√	√	√	√	√	√	-	-	ESOP8	
IP6525S_OC	18W	-	√	√	√	√	√	√	-	√	-	-	ESOP8	
IP6520	18W	-	√	√	√	√	√	√	√	-	√	-	ESOP8	PIN2PIN
IP6520_PPS	18W	-	√	√	√	√	√	√	√	-	√	√	ESOP8	
IP6520T	20W	-	√	√	√	√	-	√	-	-	√	-	ESOP8	
IP6520T_PPS	20W	-	√	√	√	√	-	√	-	-	√	√	ESOP8	
IP6520_30W	30W	-	√	√	√	√	√	√	√	-	√	-	ESOP8	
IP6520_30W_PPS	30W	-	√	√	√	√	√	√	√	-	√	√	ESOP8	
IP6537_C	18W	-	√	√	√	√	√	√	√	√	√	√	QFN24	PIN2PIN
IP6537_C_30W20V	30W	-	√	√	√	√	√	√	√	√	√	√	QFN24	
IP6538U_AA	24W	√	√	√	√	√	√	√	√	-	-	-	QFN32	PIN2PIN
IP6538U_AC	27W	√	√	√	√	√	√	√	√	-	√	√	QFN32	
IP6538U_CC	27W	√	√	√	√	√	-	√	√	-	√	√	QFN32	
IP6527U_A	24W	-	√	√	√	√	√	√	√	-	-	-	QFN32	PIN2PIN
IP6527U_C	27W	-	√	√	√	√	-	√	√	-	√	√	QFN32	

5.2 IP6551 Series Product Introduction

Product	Introduction
IP6551	Single port output 5V/2.4A, dual ports output 5V/4.8A with Dual DCP Protocol.

6 Pin Functions

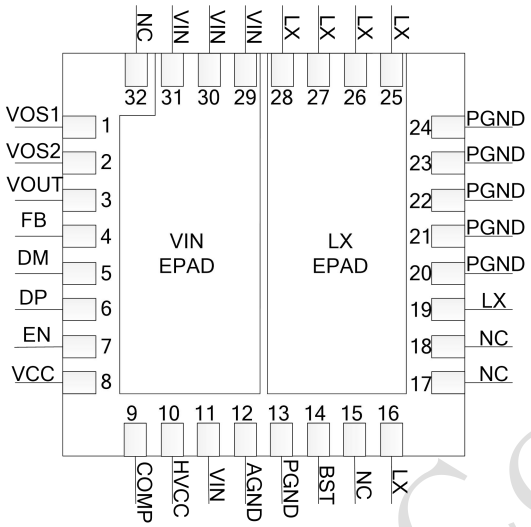


Figure 4.IP6551 (QFN32) Pin functions

Pins		Description
Pin No.	Pin Name	
1	VOS1	VOUT1 output current negative sense pin
2	VOS2	VOUT2 output current negative sense pin
3	VOUT	Output voltage sense pin/output current positive sense pin
4	FB	External feedback pin
5	DM	Connect to USB DM data line
6	DP	Connect to USB DP data line
7	EN	DCDC enable pin
8	VCC	VCC LDO pin
9	COMP	Control loop compensating pin
10	HVCC	Power output pin for driver LDO
11/29/30/31	VIN	Power input
12	AGND	Ground
13/20/21/22/23/24	PGND	Power ground
14	BST	Connect to bootstrap capacitor
15/17/18/32	NC	Floating PIN, do not connect
16/19/25/26/27/28	LX	DCDC switch point, connect to inductor

7 Internal Block Diagram

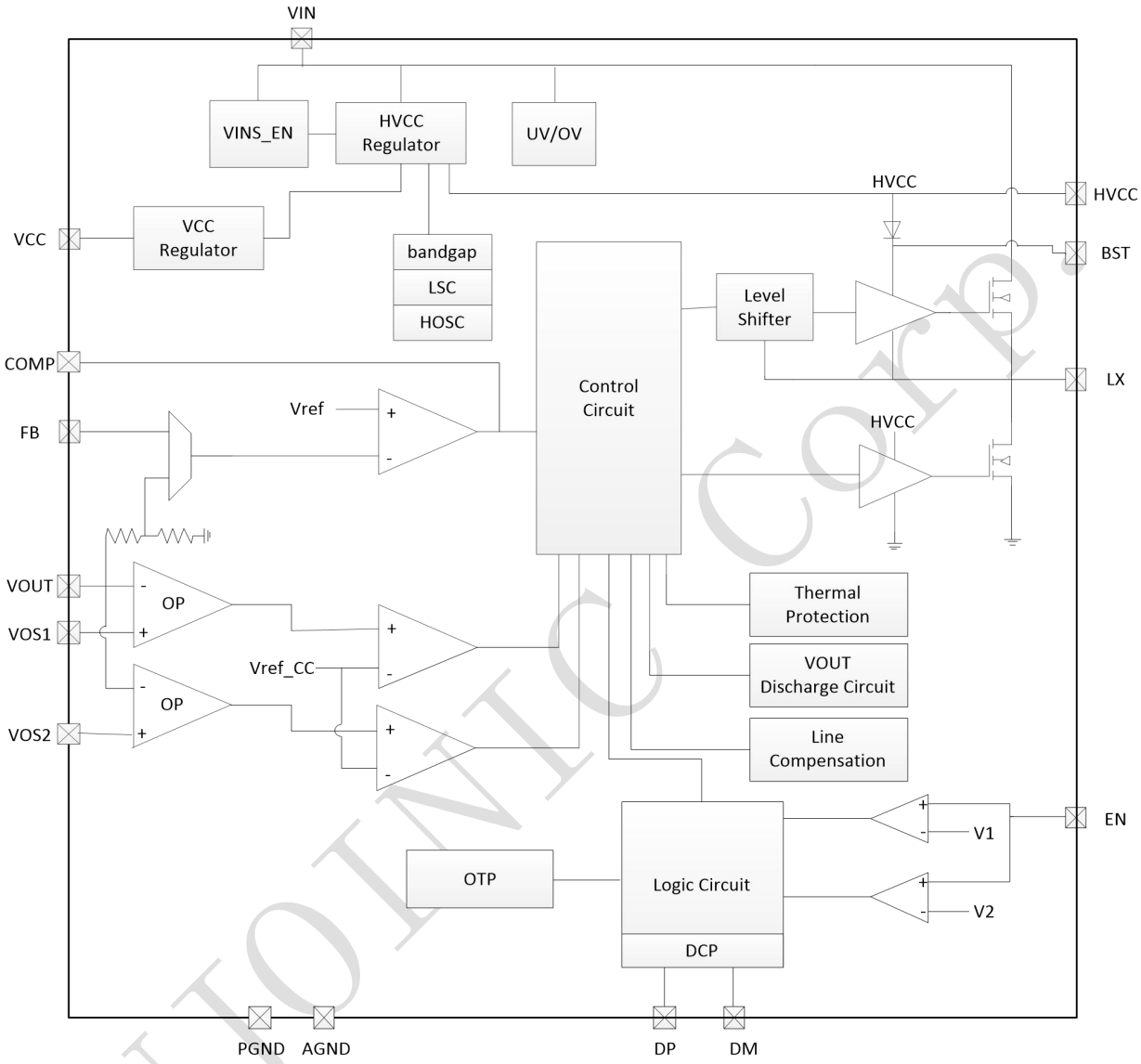


Figure 5.IP6551 Internal block diagram

8 Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Input voltage	V_{IN}	-0.3 ~ 42	V
LX voltage	V_{LX}	-0.3 ~ VIN+0.3	V
BST voltage	V_{BST}	-0.3 ~ 44	V
VOUT voltage	V_{VOUT}	-0.3 ~ 24	V
DM/DP voltage	$V_{DM/DP}$	-0.3 ~ 6	V
Junction temperature	T_J	-40 ~ 150	℃
Storage temperature	Tstg	-55 ~ 150	℃
Ambient Temperature	T_A	-40~120	℃
Thermal resistance (junction to ambient)	θ_{JA}	40	℃/W
Human body model (HBM)	ESD	4	KV

*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.

9 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input voltage	V_{IN}	4.5		36	V

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

10 Electrical Characteristics

Unless otherwise specified, the test IC is IP6551, L=22uH, VIN=12V, VOUT=5V

Parameters	Symbol	Test Condition	Min.	Typ.	Max	Unit
Input system						
Input voltage	V_{IN}		4.5		36	V
Input under voltage	V_{IN-UV}	Rising voltage	4.3	4.5	4.65	V
	$V_{IN-UV-TH}$	Hysteresis voltage		0.4		V
Input over voltage	V_{IN-OV}	Rising voltage	35	36	38	V
	$V_{IN-OV-TH}$	Hysteresis voltage		0.8		V
Input quiescent current	I_Q	VIN=12V, VOUT=5V@0A, no switching		0.2	0.6	mA
Drive system						
High-side MOS Ron resistance	$R_{DS(ON)}$			10		mΩ
Low-side MOS Ron resistance	$R_{DS(ON)}$			10		mΩ
HG maximum duty cycle	D_{HG_MAX}	VIN=5V,Fs=127kHz		97.8		%
Switching frequency	F_S	VIN=12V,VOUT=5v	120	127	137	kHz
Output system						
Output voltage	V_{OUT}	Voltage Feedback through VOUT PIN		5		V
Output voltage ripple	ΔV_{OUT}	VIN=24V，VOUT=5V@3A Cout: 100uf solid-state cap	70	80	90	mV
Soft start time	T_{SS}	VIN=12V，VOUT=5V		3		ms
Output line compensate voltage	V_{COMP}	VIN=12V，VOUT=5V，IOUT=1A		50		mV
Output current in CC mode	I_{OUT}	IP6551 Single port output		2.4		A
		IP6551 Dual ports output		4.8		A
Output overvoltage threshold	V_{OUT}	After the output enters CC mode, the output hiccup restart voltage		2.8		V
Thermal shutdown temperature	T_{OTP}	Rising temperature		150		℃
Thermal shutdown temperature hysteresis	ΔT_{OTP}			40		℃
EN PIN						
EN PIN turn-on voltage	V_{EN-ON}			2.0		V
EN PIN hysteresis voltage	V_{EN-TH}			0.2		V

EN PIN turn-on delay	T_{EN-ON}			800		us
EN PIN turn-off delay	T_{EN-OFF}			100		us

11 Function Description

11.1 Synchronized Switch Buck converter

IP6551 integrates a synchronized switch buck converter, input voltage ranges from 4.5V to 36V and output 5V, Dual ports output 4.8A.

IP6551 supports sampling resistor short circuit protection function.

IP6551 output is driven at a switching frequency of 127kHz.It can be adjusted internally.

IP6551 has soft start function, preventing the huge inrush current cause damage to the IC. When VIN=24V, VOUT=5V, the soft start time is 3ms.

VIN=12V, VOUT=5V@4.8A, the conversion efficiency is 95.8%; VIN=24V, VOUT=5V@4.8A, the conversion efficiency is 94.7%.

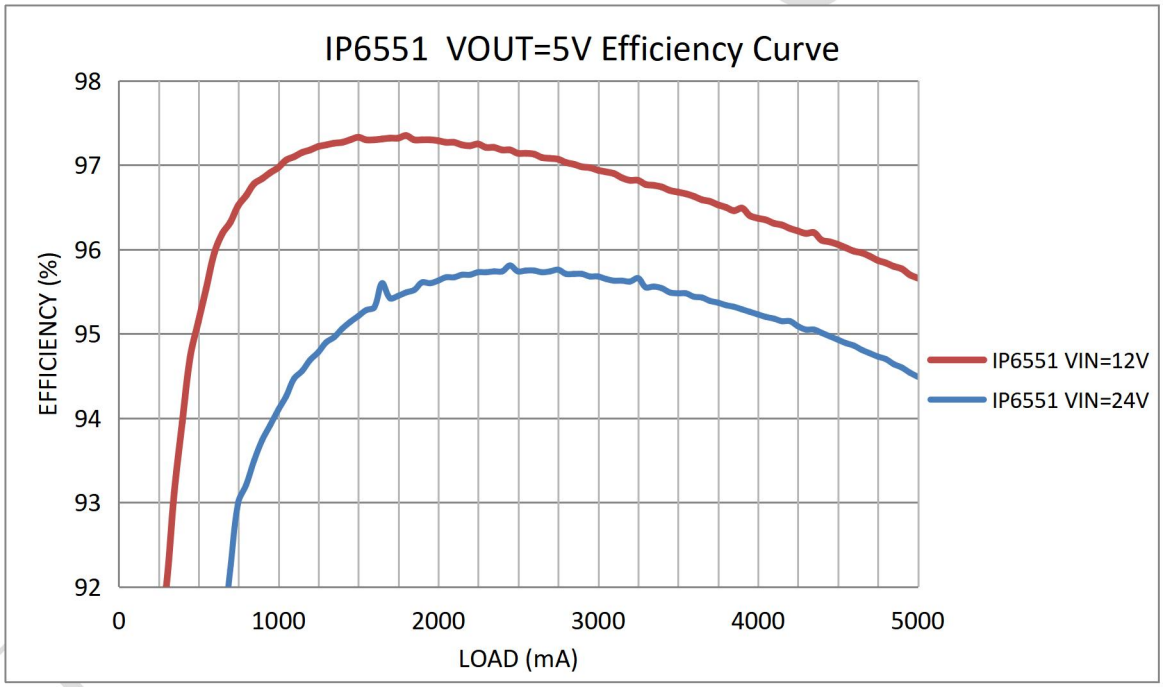


Figure 6.IP6551 VOUT=5V output efficiency curve

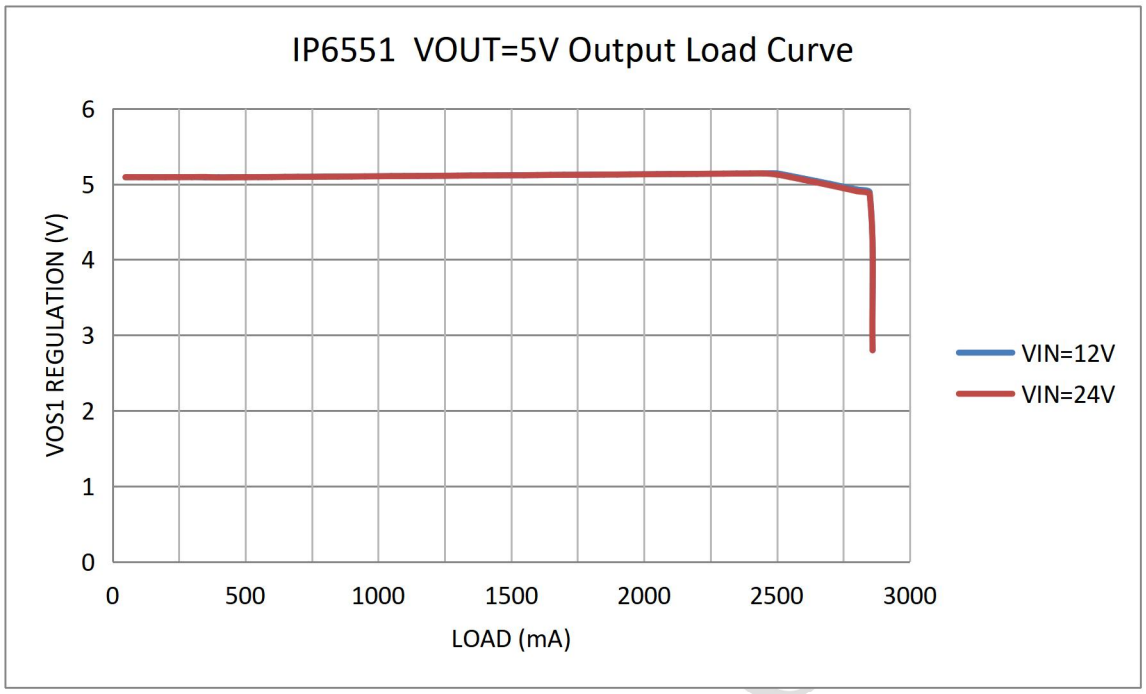


Figure 7.IP6551 VOUT-IOUT curve

11.2 Output Voltage Line Compensate

IP6551 supports output line compensate, output voltage will increase about 50mV as output current increase 1A.

11.3 Output CV/CC Characteristic

IP6551 output has CV/CC mode: when the output current is lower than preset value, the output is in CV mode with constant voltage; when the output current is higher than preset value, the output is in CC mode with decreasing output voltage. The load current continues to increase and the output voltage rapidly decreases until the output voltage under voltage protection is triggered.

11.4 Output CC Current Set

IP6551 VOUT1 output current limit can be adjusted by regulate the 5mOhm sensing resistor between VOUT and VOS1. VOUT2 output current limit can be adjusted by regulate the 5mOhm sensing resistor between VOUT and VOS2. The load current is measured by detect the voltage drop between VOUT and VOS.

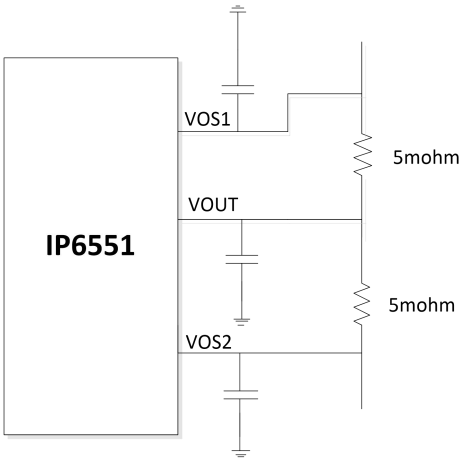


Figure 8. IP6551 dual output current limiting circuit

When the value of 5mohm current detect resistor is changed, the current limit of VOUT1 and VOUT2 will change accordingly.

In PCB layout, pay attention to the trace routing of VOUT and VOS1/VOS2, the trace should go out directly from the two side of 5mOhm resistor, avoiding introduce current limit deviation because of additional PCB trace resistor. Other than that, the 10mOhm resistor should use alloy resistor with good temperature coefficient (100ppm) and high precision of 1%.

11.5 Protection Function

IP6551 will detect the VIN voltage, if VIN voltage is lower than 4.5V, IP6551 will enter standby mode and shut down the output.

IP6551 supports input over voltage protection: when the VIN voltage is higher than 36V, IP6551 determines the VIN is over voltage and shutdown the output; when VIN decrease under 35.6V, IP6551 determines the input voltage recovers and opens the output.

IP6551 supports output under voltage protection: if the VOUT voltage is lower than 2.8V, IP6551 determines the output is under voltage and will shut down the output and hiccup restart after 2sec.

IP6551 supports short circuit protect, 16ms after the circuit is started, if VOUT voltage is under 2.8V, IP6551 determines the output is short circuit and will shut down the output and hiccup restart after 2sec.

IP6551 supports over temperature protection: when the temperature detected is higher than 150℃, the output will be shut down. When the temperature decreases below 110℃, IP6551 determines the temperature has recovered and will restart the output.

11.6 Dual Output Ports

IP6551 supports two USB A output ports, single port output power is 5V/2.4A.

When dual ports have attached device, dual ports overall output power is 5V/4.8A and single port output power is 5V/2.4A.

11.7 EN PIN Function

IP6551 supports EN PIN to control the device on and off. There is no internal pull up or down of the EN PIN, and the voltage needs to be controlled by external control.

When the device detects that the EN PIN voltage is greater than the upper EN input threshold, the DCDC function is enabled. When the device detects that the EN PIN voltage is lower than the lower EN input threshold, turn off the DCDC.

IP6551 turns off the EN function by default .This feature must be customized if required.

12 Application Notes

12.1 Input Capacitance Selection

The ESR of the input capacitor should be as small as possible. The ESR will affect the conversion efficiency of the system.

The maximum ripple current supported by the input capacitor must be greater than the maximum VIN ripple current of the system. The ripple current RMS value of the input capacitor is calculated as follows:

$$I_{RMS} = I_{LOAD} * \sqrt{\frac{V_{OUT}}{V_{IN}} * (1 - \frac{V_{OUT}}{V_{IN}})}$$

I_{LOAD} is the load current, V_{IN} is the input voltage, V_{OUT} is the output voltage.

12.2 Inductance Selection

The inductor with 22uH is recommended for most applications.

The DCR of inductor has great influence on the conversion efficiency of the system, low DCR inductors are recommended. For solutions above 30W, it is recommended to use an inductor with a DCR of less than 10mohm.

The inductor saturation current should be at least 20% greater than the system's peak inductor current limit, In order to avoid inductance saturation, resulting in a decrease in inductance, system instability.

The calculation formula of the PEAK current (IL(PEAK)) is as follows:

$$I_{L(PEAK)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

I_{LOAD} is the LOAD current, ΔI_L is the peak-to-peak value of the inductor current, The calculation formula of ΔI_L is as follows:

$$\Delta I_L = \frac{V_{OUT} * (V_{IN} - V_{OUT})}{V_{IN} * L * F_S}$$

V_{IN} is the input voltage, V_{OUT} is the output voltage, L is the inductance, F_S is the switching frequency;

12.3 Output Capacitance Selection

The output capacitance is used to keep the output stable. The value of ESR and capacitance has an effect on the output ripple. The output ripple voltage $V_{out-ripple}$ can be calculated as follows:

$$V_{out-ripple} = \Delta I_L * (R_{ESR} + \frac{1}{8 * F_S * C_{OUT}})$$

ΔI_L is the peak-to-peak value of the inductor current, R_{ESR} is the equivalent serial resistance value of the output capacitance, F_S is the switching frequency, C_{OUT} is the output capacitance value.

13 BOM List

With the application of IP6551 dual-port output, the finished BOM is as follows:

No.	Part Name	Type	Unit	Qty	Location	Notes
1	IC	IP6551 QFN32	PCS	1	U1	
2	Inductor	22uH+/-20%, current 5A DCR<10mohm	PCS	1	L1	
3	Electrolytic capacitor	100uF	PCS	1	C1	Withstand voltage higher than 36V
4	Solid-state capacitor	100uF	PCS	1	C7	Withstand voltage higher than 6.3V
5	SMD capacitor	0603 100nF 10%	PCS	1	C2	Withstand voltage higher than 36V
6	SMD capacitor	0603 100nF 10%	PCS	7	C3、C4、C8、C10、C11、C12、C13	Withstand voltage higher than 6.3V
7	SMD capacitor	0603 1nF 10%	PCS	2	C5、C9	Withstand voltage higher than 36V
8	SMD capacitor	0603 2.2uF 10%	PCS	1	C6	Withstand voltage higher than 16V
9	SMD resistor	0603 2R 5%	PCS	1	R1	
10	SMD resistor	1206 5mohm 1% precision, temperature coefficient less than 100ppm	PCS	2	R2、R3	Current sense resistor

14 Considerations for PCB layout

IP6551 integrates step-down converter. PCB layout is important for system stability, EMI, and other performance indicators. The PCB layout suggestions are as follows:

1. The loop composed of LX buffer circuit and PGND should be as small as possible.

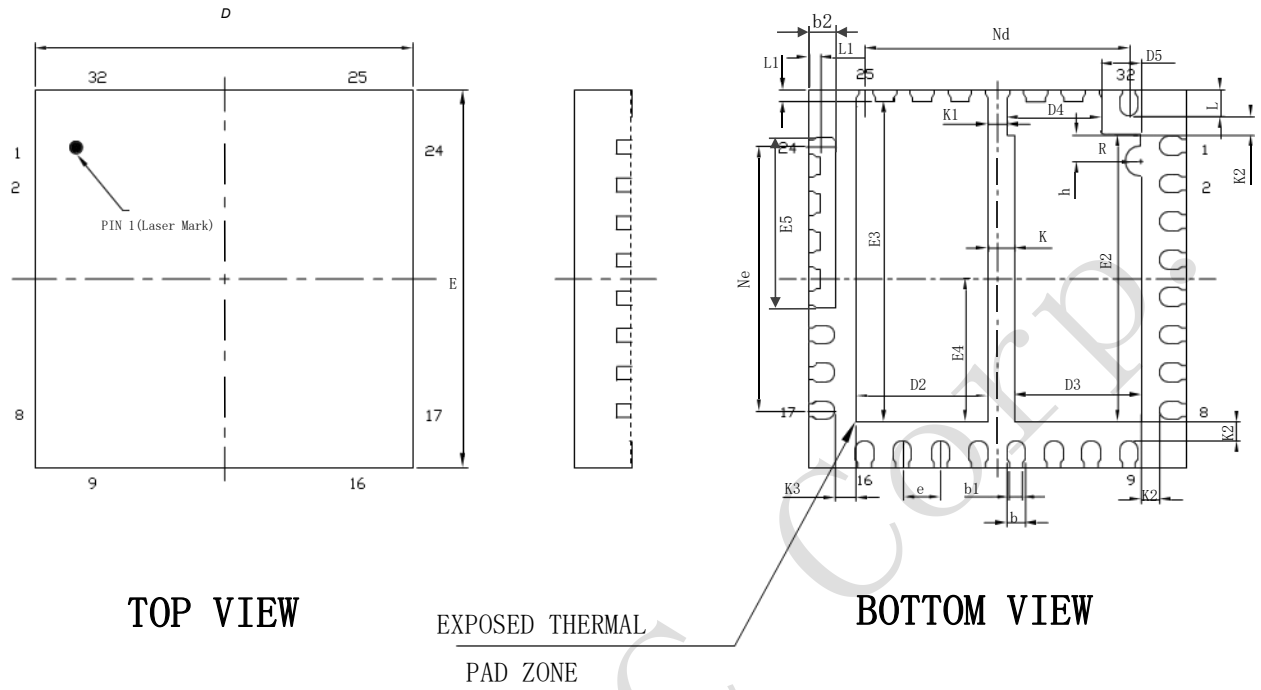
2. The current sampling line for 5Mohm resistance is directly drawn from both ends of the resistance. The line is parallel, as short as possible and avoids SW and other nodes.

3. The capacitance of HVCC and COMP is placed close to the device PIN.

4. The GND of the input and output capacitors must be connected to the PGND of a large area.

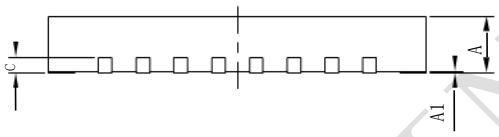
5. Please refer to the IP6551 Application Notes for further information.

15 Package



TOP VIEW

BOTTOM VIEW



SIDE VIEW

SYMBOL	MILLIMETER			SYMBOL	MILLIMETER		
	MIN	NOM	MAX		MIN	NOM	MAX
A	0.70	0.75	0.80	E	4.90	5.00	5.10
A1	0.00	0.02	0.05	E2	3.70	3.80	3.90
b	0.20	0.25	0.30	E3	4.15	4.25	4.35
b1	0.18REF			E4	1.80	1.90	2.00
b2	0.35REF			E5	2.35REF		
c	0.203REF			Ne	3.50BSC		
D	4.90	5.00	5.10	L	0.30	0.35	0.40
D2	1.65	1.75	1.85	L1	0.10	0.15	0.20
D3	1.575	1.675	1.775	K	0.30	0.35	0.40
D4	1.15	1.25	1.35	K1	0.20	0.25	0.30
D5	0.475	0.525	0.575	K2	0.20	0.25	0.30
e	0.50BSC			K3	0.225	0.275	0.325
Nd	3.50BSC			R	0.20REF		
				h	0.30	0.35	0.40

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