IP6520T

Maximum 30W PD Output Fast Charge SOC

Protocols: DCP/QC2.0/QC3.0/QC3+/FCP/AFC/PD2.0/PD3.0(PPS)

1 Features

- **Synchronous Switch Regulator**
  - ◇ Built-in power MOSFET
  - ◇ Input voltage range: 7.3V~32V
  - ◇ Output voltage range: 3V~12V, adjust along with fast charge protocol
  - ◇ Output power of PD: up to 30W (5V@3A, 9V@3A, 12V@2.5A)
  - ◇ conversion efficiency up to 93.7% with VIN=24V, VOUT=5V@3A
  - ◇ Soft start function
  - ◇ Output voltage line compensate: 60mV@1A
- **Supports Type-C output and PD protocol**
  - ◇ Supports 5V, 9V, 12V output
  - ◇ Supports PD2.0/PD3.0(PPS) output protocol
  - ◇ PPS supports 3~11V adjustable voltage with 20mV/step output
- **Fast charge output**
  - ◇ Supports Type-C PD output
  - ◇ Supports BC1.2 and Apple
  - ◇ Supports Qualcomm QC2.0, QC3.0 and QC3+
  - ◇ Supports Huawei fast charge: FCP
  - ◇ Supports Samsung fast charge: AFC (MAX 12V)
- **Multi-protection and high reliability**
  - ◇ Input overvoltage, input undervoltage, output short circuit, output overcurrent protection
  - ◇ Whole system over-temperature protection
  - ◇ DP/DM/CC overvoltage protection
  - ◇ ESD 4KV; DC voltage withstand 40V
- **Package: ESOP8**

2 Applications

- **Car Charger**
- **Fast Charge Adaptor**
- **Smart Power Strip**

3 Description

IP6520T is a buck converter integrated with synchronous switch, which supports multiple fast charge output standards, supports Type-C output and USB PD2.0/PD3.0(PPS) protocol, providing complete solutions for car charger, fast charge adaptor and smart power strip.

IP6520T has built-in power MOSFET, input voltage range is 7.3V to 32V, output voltage ranges from 3V to 12V, and supplies up to 30W output power, can adjust output voltage and current automatically according to fast charge protocol. Typical output voltage and current: 5V@3A, 9V@2.22A, 12V@1.67A.

IP6520T PD 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 as the output current increases in CC output mode.

IP6520T output voltage has line complement function, the output voltage will be increased accordingly as the output current increases, to compensate for the voltage drop caused by the connection line impedance.

IP6520T supports Type-C output and integrated with multiple fast charge protocols. The fast charge protocol supported by the output access device can be automatically identified by CC1/CC2 or DP/DM, and then adjust the output voltage and current automatically.

IP6520T supports multiple protective functions, including input overvoltage and undervoltage, output overcurrent, overvoltage, undervoltage and short circuit.

Contents

4 Typical Application Schematic

With IP6520T, only inductor, resistor and a few capacitors are needed in the periphery to realize a total solution of car charger.

Figure 1　IP6520T Simplified Output Application Schematic

Notes:
- EPAD of IP6520T must have good contact with PCB board ground.
- C1 and C2 should be placed close to the PIN2; If the C2 capacitor is far away from the 100μF capacitor or the power supply VIN, the capacitance should be increased appropriately.
- C5 should be placed close to the PIN1.
- The RC circuit composed of R1 and C6 should be placed close to PIN3, the loop composed of RC circuit, IC SW and PGND should be minimized on the PCB board.

5 IP Comparison Table

5.1 Car Charge 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
IP6536S_N	3.4A	–	√	–	–	–	–	–	–	–	–	–	ESOP8	PIN2PIN
IP6525TQ	18W	–	√	√	√	√	–	√	–	–	–	–	ESOP8	
IP6525T	18W	–	√	√	√	√	–	√	–	–	–	–	ESOP8	PIN2PIN
IP6525S	18W	–	√	√	√	√	√	√	√	√	–	–	ESOP8	PIN2PIN
IP6525S_OC	18W	–	√	√	√	√	√	√	–	√	–	–	ESOP8	
IP6520	18W	–	√	√	√	√	√	√	√	–	√	–	ESOP8	PIN2PIN
IP6520_PPS	18W	–	√	√	√	√	√	√	√	–	√	√	ESOP8	PIN2PIN
IP6520T	20W	–	√	√	√	√	–	√	–	–	√	–	ESOP8	PIN2PIN
IP6520T_PPS	20W	–	√	√	√	√	–	√	–	–	√	√	ESOP8	
IP6520_30W	30W	–	√	√	√	√	√	√	√	–	√	–	ESOP8	
IP6520_30W_PPS	30W	–	√	√	√	√	√	√	√	–	√	√	ESOP8	
IP6537_C	18W	–	√	√	√	√	√	√	√	√	√	√	QFN24	PIN2PIN
IP6537_C_30W20V	30W	–	√	√	√	√	√	√	√	√	√	√	QFN24	PIN2PIN
IP6538U_AA	24W	√	√	√	√	√	√	√	√	–	–	–	QFN32	PIN2PIN
IP6538U_AC	27W	√	√	√	√	√	√	√	√	–	√	√	QFN32	PIN2PIN
IP6538U_CC	27W	√	√	√	√	√	–	√	√	–	√	√	QFN32	
IP6527U_A	24W	–	√	√	√	√	√	√	√	–	–	–	QFN32	PIN2PIN
IP6527U_C	27W	–	√	√	√	√	–	√	√	–	√	√	QFN32	PIN2PIN

5.2 IP6520T Series Commonly Used Models Introduction

Model name	USB	Output Power					
IP6520T	USB Type-C	PDO	5V/3A	9V/2.22A	12V/1.67A	-	-
		QC	5V/3A	9V/2A	12V/1.5A	-	-
IP6520T_PPS	USB Type-C	PDO	5V/3A	9V/2.22A	12V/1.67A	3.3V-5.9V/3A	3.3V-11V/2A
		QC	5V/3A	9V/2A	12V/1.5A	-	-
IP6520T_30W	USB Type-C	PDO	5V/3A	9V/3A	12V/2.5A	-	-
		QC	5V/3A	9V/2A	12V/1.5A	-	-
IP6520T_30W_PPS	USB Type-C	PDO	5V/3A	9V/3A	12V/2.5A	-	3.3V-11V/3A
		QC	5V/3A	9V/2A	12V/1.5A	-	-

Notes:

- QC represents the output power of high voltage fast charge.
- QC fast charge output of IP6520T supports CV/CP/CC power loop.
  PD fast charge output of IP6520T supports CV/CC power loop.
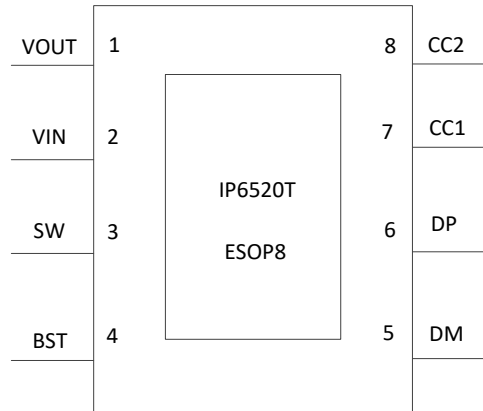
6 Pin Configuration And Function

Figure 2   IP6520T Pin Assignment

PIN List:

| Pin		Description
No	**Name**	
1	VOUT	Output voltage feedback pin
2	VIN	Input voltage, place filter capacitor nearby
3	SW	DCDC switch node, connect to the inductor
4	BST	Bootstrap circuit pin, place a 2.2μF capacitor close to the BST pin and LX pin, providing drive voltage for the gate of the upper MOSFET
5	DM	Connect to USB DM data line
6	DP	Connect to USB DP data line
7	CC1	Connect to USB Type-C CC1 line
8	CC2	Connect to USB Type-C CC2 line
9(EPAD)	PGND	Power and heat dissipation ground

7 Functional Block Diagram
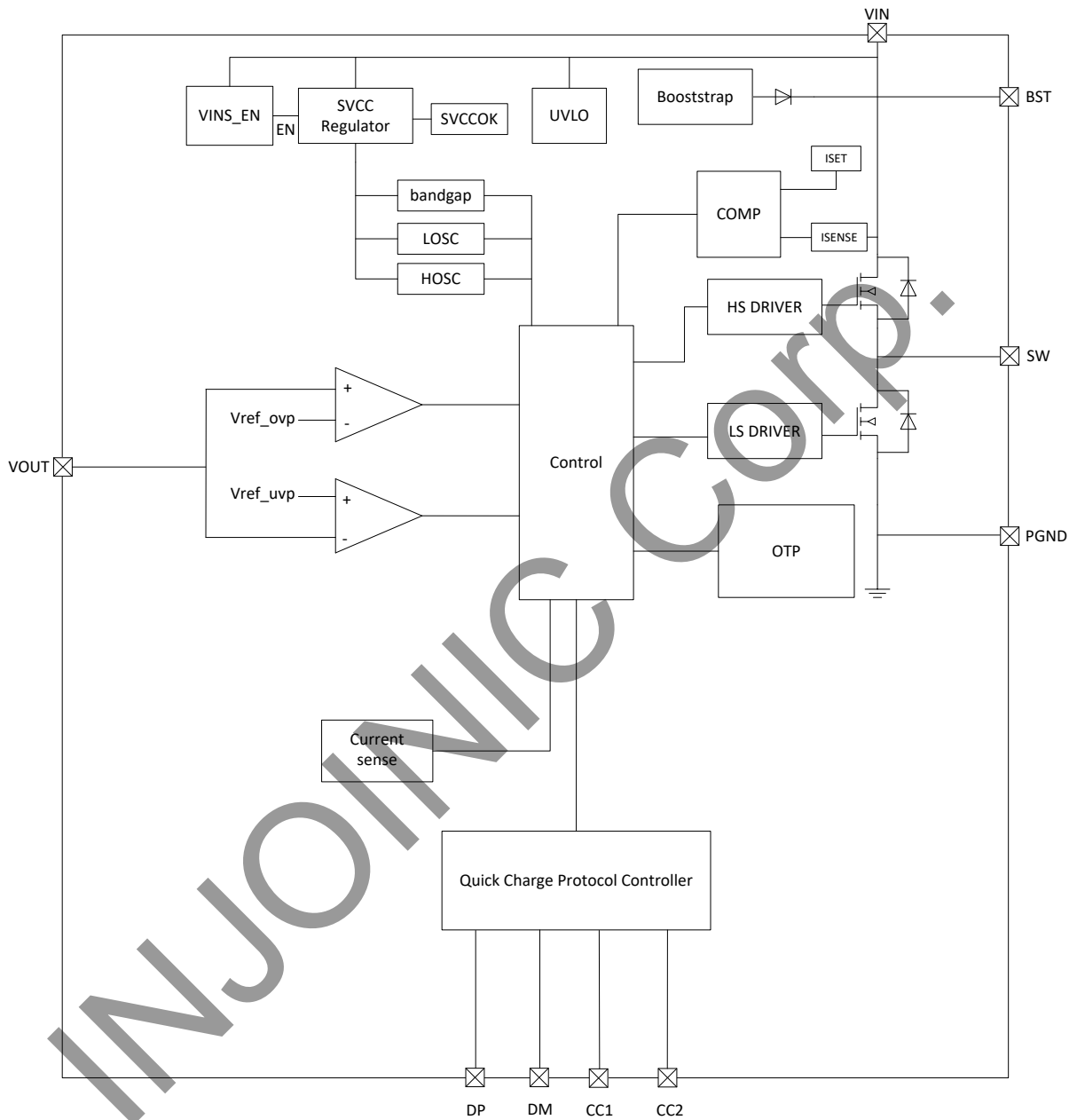
Figure 3   IP6520T Internal Block Diagram

IP6520T

8 Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Input voltage	V_{IN}	-0.3 ~ 40	V
SW voltage	V_{SW}	-0.3 ~ 40	V
DM/DP voltage	$V_{DM/DP}$	-0.3 ~ 6	V
CC voltage	$V_{CC1/CC2}$	-0.3 ~ 15	V
Output voltage	V_{OUT}	-0.3 ~ 20	V
Junction temperature	T_J	-40 ~ 150	℃
Storage temperature	Tstg	-60 ~ 150	℃
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 period may affect the reliability and service life of devices.

9 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input voltage	V_{IN}	7.3	12/24	32	V

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

10 Electrical Characteristics

Unless otherwise specified,

T_A=25℃, L=22µH, C_{OUT}=100µF solid state capacitor (About 40mΩ ESR), VIN=12V, VOUT=5V

Parameters	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input system						
Input voltage	V_{IN}		7.3	12	32	V
Input under voltage	V_{IN-UV}	Rising voltage	7.15	7.3	7.45	V
	$V_{IN-UV-TH}$	Hysteresis voltage	-	0.4	-	V
Input over voltage	V_{IN-OV}	Rising voltage	32	32.5	33	V
	$V_{IN-OV-TH}$	Hysteresis voltage	-	0.2	-	V
Input quiescent current	I_Q	VIN=12V, VOUT=5V/0A	-	2.5	-	mA
Power switch system						
High-side drain-source on-state resistance	$R_{DS(ON)-HIGH}$		-	30	-	mΩ
Low-side drain-source on-state resistance	$R_{DS(ON)-LOW}$		-	20	-	mΩ
Switching frequency	F_{SW}		95	115	130	KHz
Output system						
Output voltage	V_{OUT}		3	5	12	V
Output voltage ripple	ΔV_{OUT}	VIN=12V, VOUT=5V/3A	-	80	-	mV
		VIN=12V, VOUT=9V/2A	-	85	-	mV
		VIN=24V, VOUT=12V/1.5A	-	90	-	mV
		Note: Test typical values under the Demo board reference design				
Soft start time	T_{SS}	VIN=12V, VOUT=5V	-	4	-	ms
Output line compensate voltage	V_{COMP}	VIN=12V, VOUT=5V, IOUT=3A	-	180	-	mV
Max output current in CC mode (IP6520T)	I_{OUT}	VIN=12V, VOUT<=4V	-	3.2	-	A
		VIN=12V, 4V<VOUT<=5V	-	3.2	-	A
		VIN=12V, 7V<VOUT<=9V	-	2.22	-	A
		VIN=24V, 9V<VOUT<=12V	-	1.67	-	A
Output hiccup restart voltage	V_{OUT}	Hiccup restart voltage when output enter CC mode (VOUT preset voltage >= 5V)	-	4.1	-	V

Parameters	Symbol	Test Condition	Min.	Typ.	Max	Unit
Output hiccup restart voltage	V_{OUT}	Hiccup restart voltage when output enter CC mode (VOUT preset voltage < 5V)	-	3	-	V
Output hiccup restart time	T_{HIC}	VIN=12V, output short circuit	-	2	-	s
DPDM overvoltage protection voltage	V_{OVP_DPDM}	VIN=12V, VOUT=5V	-	4.5	-	V
CC overvoltage protection voltage	V_{OVP_CC}	VIN=12V, VOUT=5V	-	6.0	-	V
Thermal shutdown temperature	T_{OTP}	Rising temperature	-	150	-	℃
Thermal shutdown temperature hysteresis	ΔT_{OTP}		-	40	-	℃

11 Function Description

11.1 Synchronous Switch Buck Regulator

IP6520T integrates a synchronous switch buck regulator, input voltage ranges from 7.3V to 32V and output voltage from 3V to 12V, and typical output is 5V@3A, 9V@2.22A, 12V@1.67A.

IP6520T integrates power switch MOSFET with 115 kHz working frequency. When VIN=24V, VOUT=5V@3A, the power conversion efficiency is 93.7%. The efficiency curve is shown in Figure 4.

IP6520T can adjust the output voltage automatically based on the identified fast charging protocol.
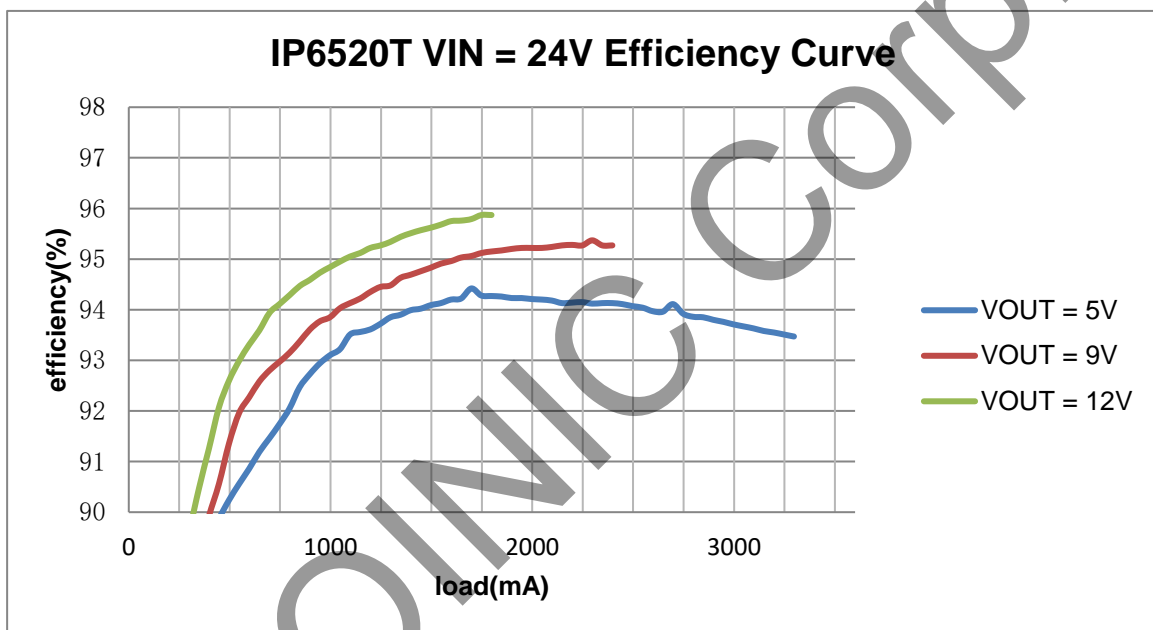

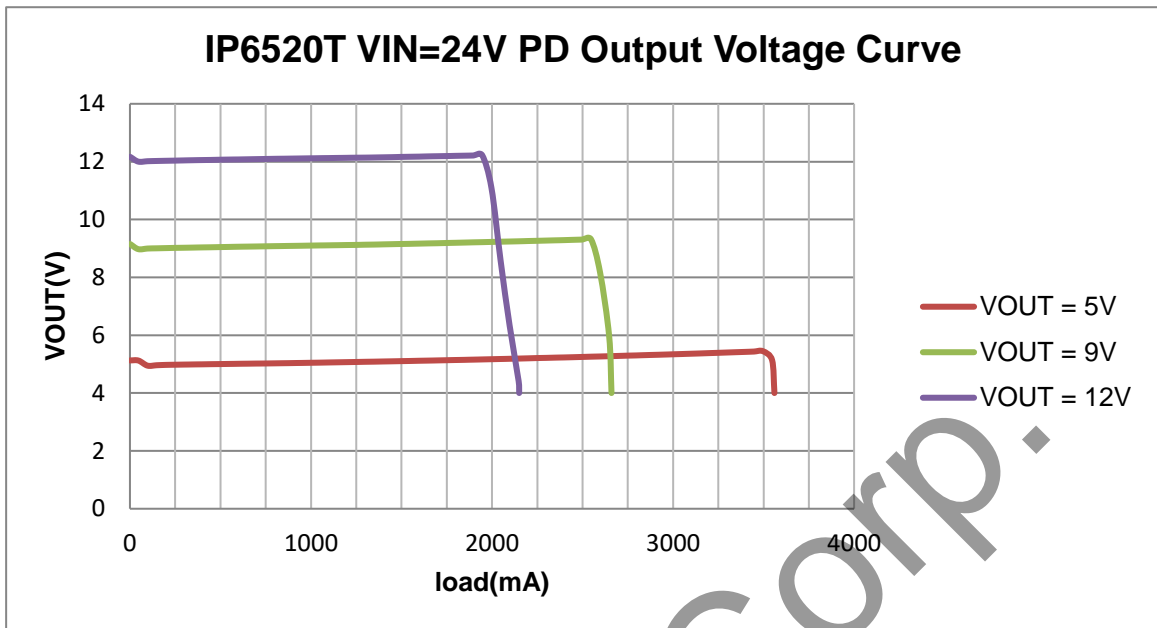Figure4   IP6520T VIN=24V Efficiency Curve

IP6520T VIN=24V PD Output Voltage Curve

Figure 5   IP6520T VIN=24V PD Output VOUT-IOUT Curve

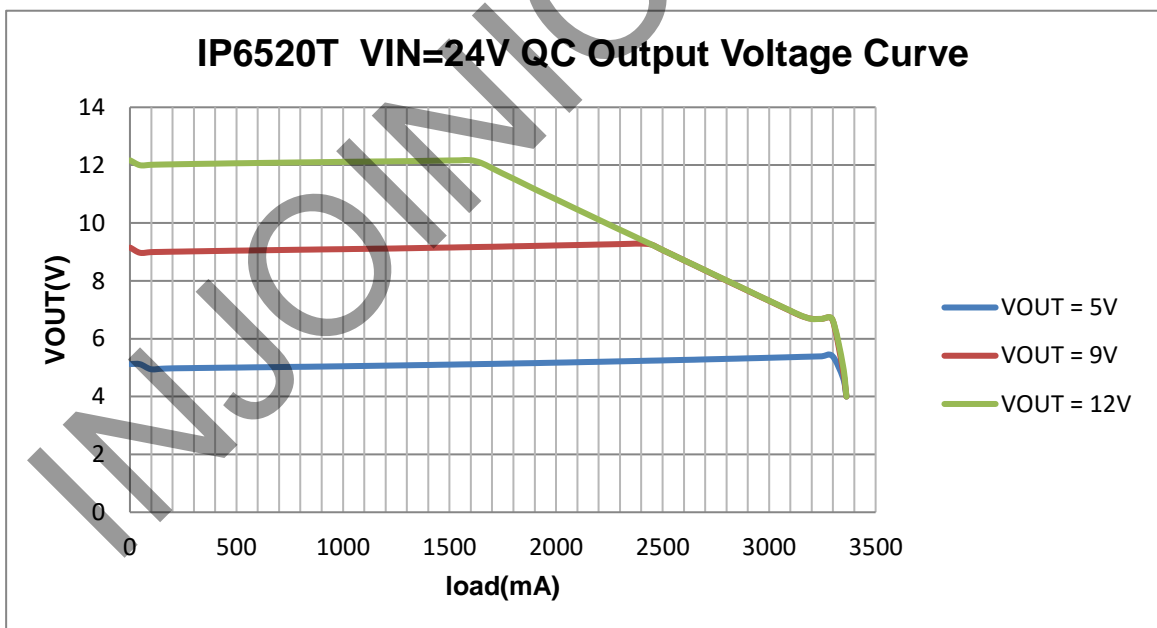**IP6520T VIN=24V QC Output Voltage Curve**

Figure 6   IP6520T VIN=24V QC Output VOUT-IOUT Curve

11.2 Output Voltage Line Compensate Function

IP6520T supports output line compensate, output voltage will increase about 60mV as output current increases 1A at VIN=12V.

11.3 Output CV/CC Characteristic

When IP6520T works with QC high voltage protocol ,IP6520T supports output CV/CP/CC: when the output current is lower than the preset value, output is CV mode with constant output voltage; while the output current is higher than the preset value, output is CP mode, as the output current increases, the output voltage decreases; when the voltage drops to 6.7V, enters CC mode, as the output current continues to increase, the output voltage will decrease rapidly until the output voltage undervoltage protection is triggered.

When IP6520T works with PD high voltage protocol, IP6520T supports output CV /CC: when the output current is lower than the preset value, output is CV mode with constant output voltage; while the output current is higher than the preset value, output is CC mode, as the output current continues to increase, the output voltage will decrease rapidly until the output voltage undervoltage protection is triggered.

When VOUT preset voltage is higher or equal to 5V, if the output current continues to increase and output voltage is lower than 4.1V, the output will be turned off and hiccup restart after 2 sec; When VOUT preset voltage is lower than 5V, if the output current continues to increase and output voltage is lower than 3V, the output will be turned off and hiccup restart after 2 sec.

11.4 Protective Function

IP6520T supports input undervoltage protective function. When VIN is lower than 6.9V, IP6520T detects the input is under voltage and turns off the output.

IP6520T supports input overvoltage protective function. When VIN is above 32.5V, IP6520T detects the input is over voltage and turns off the output; when the VIN voltage drops to 32.3V again, IP6520T considers the input is normal and turns on the output.

IP6520T supports output undervoltage protective function. When VOUT preset voltage is higher or equal to 5V, if the VOUT voltage is lower than 4.1V, IP6520T determines the output is under voltage and will turn off the output, and hiccup restart after 2sec. when VOUT preset voltage is lower than 5V, if the VOUT voltage is lower than 3V, IP6520T determines the output is under voltage and will turn off the output, and hiccup restart after 2sec.

IP6520T supports output short circuit protective function. If VOUT is lower than 4.1V after 8ms startup, output short circuit is determined and output will be turned off, and hiccup restart after 2sec.

IP6520T supports DP/DM/CC overvoltage protective function. when the DP/DM voltage is higher than 4.5V, or when the CC1/CC2 voltage is higher than 6.0V, IP6520T determines the signals of DP/DM/CC is over voltage and will turn off the output and hiccup restart after 2sec.

IP6520T supports over-temperature protective function. when the chip temperature is higher than 150℃, the output will be turn off; When the temperature decreases to 110℃, IP6520T determines that the temperature has recovered and will restart the output.

11.5 Output Fast Charge Protocol

IP6520T supports multiple fast charge protocols:
- ✧ Support BC1.2 and Apple
- ✧ Support Qualcomm QC2.0, QC3.0 and QC3+
- ✧ Support Huawei fast charge: FCP
- ✧ Support Samsung fast charge: AFC (MAX 12V)
- ✧ Support Type-C output and USB PD2.0/PD3.0 (PPS) protocol

11.6 Type-C Port and USB PD Protocol

IP6520T supports Type-C output and USB PD2.0/PD3.0 (PPS) protocol.

IP6520T supports USB PD protocol output 20W; Package broadcast: 5V/3A, 9V/2.22A, 12V/1.67A, and don't support PPS.

IP6520T_PPS supports USB PD protocol output 20W; Package broadcast: 5V/3A, 9V/2.22A, 12V/1.67A and PPS 3.3V-5.9V/3A, 3.3V-11V/2A.

IP6520T supports the standard Type-C specification and will not turn on the output until the CC connection is successful.

IP6520T Type-C port can detects the fast charge protocol supported by the access device automatically through DP/DM and CC1/CC2 pins, and adjusts the output voltage and current accordingly.

12 Application Schematic

With IP6520T, only inductor, resistor and a few capacitors are needed in the periphery to realize a total solution of car charger.
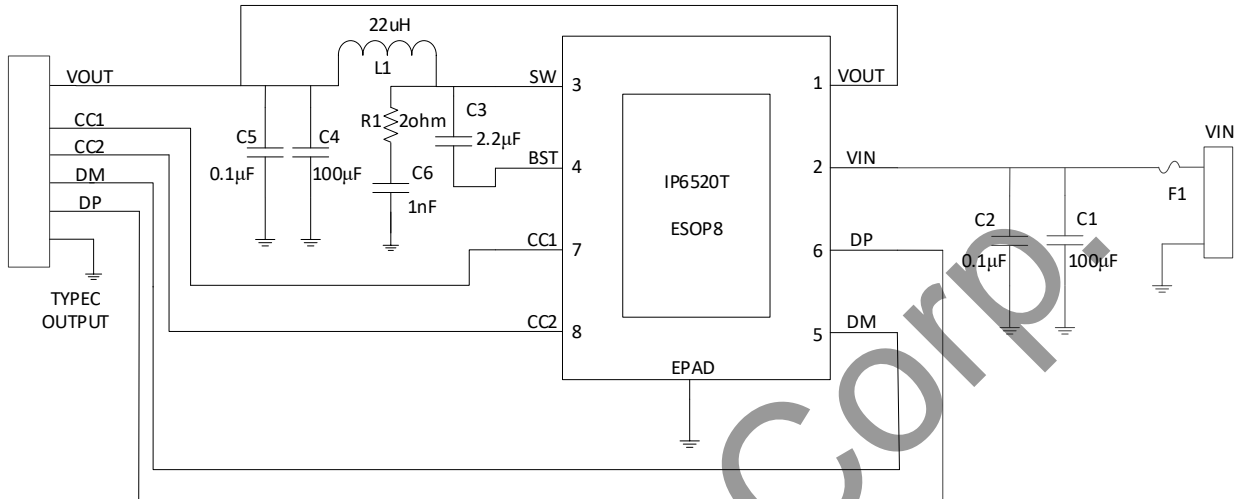

Figure 7 IP6520T Output Typical Application Schematic

Notes:
- EPAD of IP6520T must have good contact with PCB board ground.
- C1 and C2 should be placed close to the PIN2; If the C2 capacitor is far away from the 100μF capacitor or the power supply VIN, the capacitance should be increased appropriately.
- C5 should be placed close to the PIN1.
- The RC circuit composed of R1 and C6 should be placed close to PIN3 of IP6520T, and the loop composed of RC circuit, IC SW and PGND should be minimized on the PCB board.

13 BOM

No.	Part Name	Type	Unit	Num.	Location	Note
1	IC	IP6520T	PCS	1	U1	
2	Electrolytic capacitor	100µF/35V	PCS	1	C1	Withstand voltage higher than 35V, using solid-state capacitor can improve efficiency
3	Electrolytic capacitor	100µF/16V	PCS	1	C4	Withstand voltage higher than 16V
4	Power inductor	22µH+/-20%, current 4.5A, DCR<12mohm	PCS	1	L1	3L Electronic
5	SMT capacitor	0603 2.2µF 10%	PCS	1	C3	Withstand voltage higher than 16V
6	SMT capacitor	0603 100nF 10%	PCS	1	C2	Withstand voltage higher than 35V, place near IC PIN in layout.
7	SMT capacitor	0603 100nF 10%	PCS	1	C5	Withstand voltage higher than 16V
8	SMD resistor	0603 2ohm 5%	PCS	1	R1	
9	SMT capacitor	0603 1nF 10%	PCS	1	C6	
10	Fuse	F1	PCS	1	F1	Current value 4A

Inductor type recommend: TC-220M-4.5A-CS137125

3L product No.	Inductance (µH)	Tolerance	DC Resistance (mΩ)		Heat Rating Current DC Amp.	Saturation Current DC Amps.	Measuring Condition
			Typ.	Max.	Idc(A)Max	Isat(A)Max	
TC-220M-4.5A-CS137125	22.0	±20%	12	14	4.5	8	

14 Package
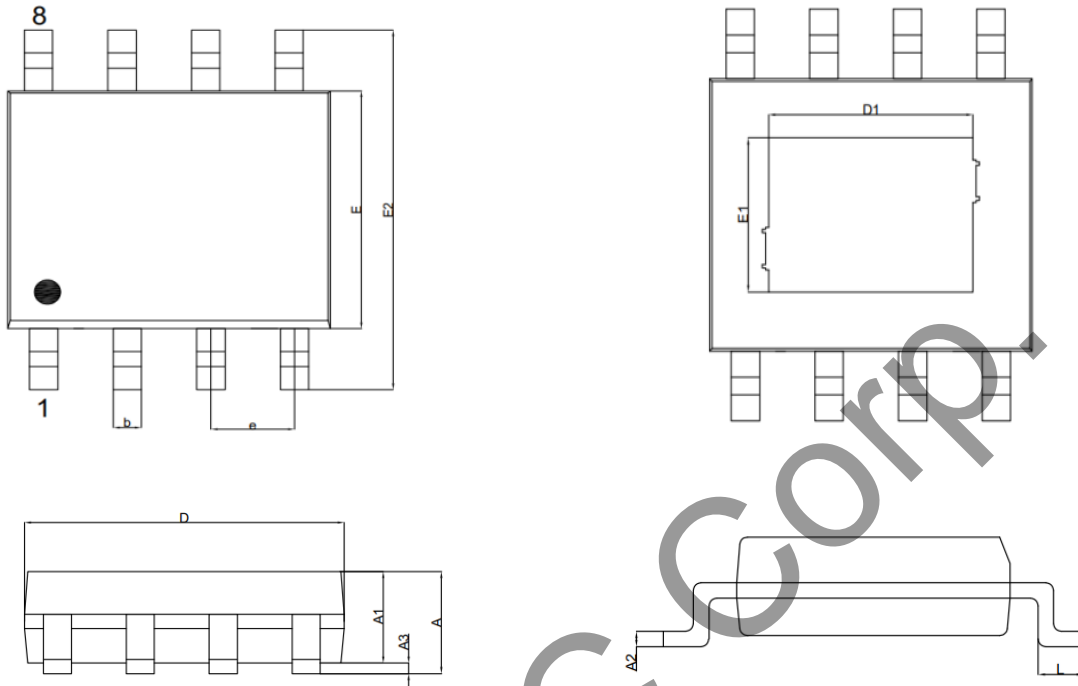
	POD	ESOP8L		
		Size unit: mm		
	Symbol	Minimum	Normal	Maximum
Total Thickness	A	-	-	1.65
Molding Thickness	A1	1.30	1.40	1.50
LF Thickness	A2	0.20	-	0.24
Stand Off	A3	0.05	-	0.15
Body Size	D	4.80	4.90	5.00
	E	3.80	3.90	4.00
	E2	5.80	6.00	6.20
Exposed Pad Size	D1	-	3.1	-
	E1	-	2.21	-
Lead Width	b	0.39	-	0.47
Lead Length	L	0.50	0.60	0.80
Lead Pitch	e	1.27 BSC		

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