# Integrated Multiple Fast Charge Protocols, Built-in MOS Buck SOC

# Protocols:DCP/QC2.0/QC3.0/QC3+/FCP/AFC

## 1 Features

- **Synchronous Buck Converter**
  - ✧ Built-in Power MOSFET
  - ✧ Input Voltage Range: 5.2V-32V
  - ✧ Output voltage range:3V-12V, adjustable according to the fast charge protocol
  - ✧ Output has CV/CP/CC characteristics
  - ✧ VIN=24V, VOUT=5V/3A, Conversion efficiency up to 94.43%
  - ✧ Soft-start function
  - ✧ Output voltage line compensate: 60mV/A
- **Fast Charge Protocols**
  - ✧ Supports DCP (BC1.2, Apple and Samsung)
  - ✧ Supports QC2.0, QC3.0 and QC3+
  - ✧ Supports Huawei fast charge: FCP
  - ✧ Supports Samsung fast charge protocol AFC (MAX 12V)
- **Multi-protection and high reliability**
  - ✧ Input overvoltage, input undervoltage, output short circuit,output overcurrent protection
  - ✧ Over-temperature protection
  - ✧ DP/DM overvoltage protection
  - ✧ ESD 4KV, DC voltage withstand 40V

## 2 Applications

- **Car Charger, Fast Charge Adapter**
- **Smart Power Strip**
- **Energy Storage Power**

## 3 Description

IP6525TQ is a synchronized switch buck regulator and supports multiple fast charge output standards, providing solutions for car charger, fast charge adaptor, smart power strip and energy storage power.

IP6525TQ has built-in power MOSFET, the input voltage range is 5.2V to 32V, and the output voltage range is 3V to 12V, providing a maximum output power of 24W. IP6525TQ automatically adjusts output voltage and current according to the fast charge protocol. Typical output voltage and current is: 5V/3A, 9V/2A, 12V/1.5A.

IP6525TQ has the ENB function. When the ENB pin is low voltage, IP6525TQ turns on the output. When the ENB pin is higher than 2V, IP6525TQ turns off the output. The shutdown current at 12V input is 15uA.

The PIN4 of the IP6525TQ can be multiplexed as a power control function. When the PIN4 voltage is higher than 2V, IP6525TQ turns off the fast charge function and outputs 5V/2.4A. When the PIN4 voltage is lower than 0.5V, IP6525TQ turns on the fast charge function.

IP6525TQ supports multiple fast charge protocols. IP6525TQ identifies the fast charge protocol of the device through the DP/DM, and then automatically adjusts the output voltage and current. IP6525TQ supports DCP (BC1.2, Apple and Samsung), Qualcomm Quick Charge QC2.0, QC3.0 and QC3+, Huawei FCP, Samsung AFC (MAX 12V).

IP6525TQ supports multi-protection on input overvoltage and under voltage, output overcurrent, overvoltage, under voltage and short circuit.

The IP6525TQ package is ESOP8.



# Contents





## 4 Typical Application Schematic

With IP6525TQ, only inductor, resistor and a few capacitors are needed in the periphery to realize a total solution of car charger.

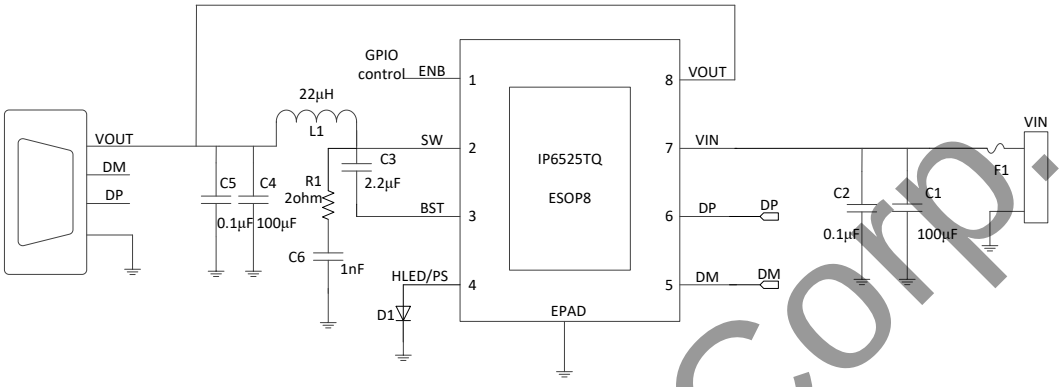



Figure 1 IP6525TQ Simplified Application Schematic

Notes:

(1) EPAD of IP6525TQ must have good contact with PCB PGND.

(2) ENB can't be floating, and a certain voltage should be given. When the ENB is at a low voltage, IP6525TQ turns on the output. When the ENB is higher than 2V, IP6525TQ turns off the output.

(3) The default PIN4 function is fast charge indication. If not required, PIN4 can be floating.

(4) C1 and C2 should be placed close to the PIN7 of IP6525TQ. If the C2 capacitor is far away from the 100μF capacitor or the power supply VIN, the capacitance should be increased appropriately

(5) C5 should be placed close to PIN8 of IP6525TQ.

(6) R1 and C6 should be placed close to the PIN2 of IP6525TQ, the loop composed of SW(PIN2), R1, C6 and GND should be minimized on the PCB board.

(7) PIN6 cannot contact high voltage. It is recommended to add white oil on PCB between PIN6 and PIN7 to prevent damage of pin caused by contact.



# 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 IP6525TQ Series Commonly Used Models Introduction

| Name | USB | Output Power | | | | PIN4 Function |
|---|---|---|---|---|---|---|
| IP6525TQ | USBA | QC | 5V/3A | 9V/2A | 12V/1.5A | Fast charge output indication |
| IP6525TQ_PS | USBA | QC | 5V/3A | 9V/2A | 12V/1.5A | Power control |

NOTES:

(1) ENB can't be floating, and a certain voltage should be given. When the ENB is at a low voltage, IP6525TQ turns on the output. When the ENB is higher than 2V, IP6525TQ turns off the output.

(2) When PIN4 is fast charge output indicator function, it is externally connected with LED. If not required, PIN4 can be floating.

(3) When the PIN4 is used for power control, when the PIN4 voltage is higher than 2V, IP6525TQ turns off the fast charge function and outputs 5V/2.4A. When PIN4 voltage is lower than 0.5V, IP6525TQ turns on the fast charge. If not required, PIN4 can be floating.

## 6 PIN Configuration And Function

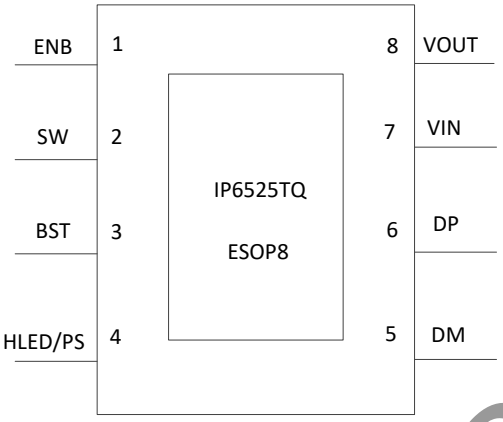



Figure 2 IP6525TQ Pin Configuration

| NO. | Name | Description |
|---|---|---|
| 1 | ENB | Enable pin, can't be floating. IC turns on the output when the voltage is low and turns off the output when the voltage is high. |
| 2 | SW | DCDC switch node, connect to the external inductor. |
| 3 | BST | Bootstrap circuit pin, place a 2.2uF capacitor close to the BST pin and SW pin, providing drive voltage for the gate of the upper MOSFET. |
| 4 | HLED/PS | Fast charge LED indication/ power control function, If not required, this PIN can be floating. |
| 5 | DM | USB DM terminal for fast charge protocol. |
| 6 | DP | USB DP terminal for fast charge protocol. |
| 7 | VIN | Input voltage, place filter capacitor nearby. |
| 8 | VOUT | Output voltage feedback pin. |
| 9(EPAD) | PGND | Power and heat dissipation ground |



## 7 Functional Block Diagram

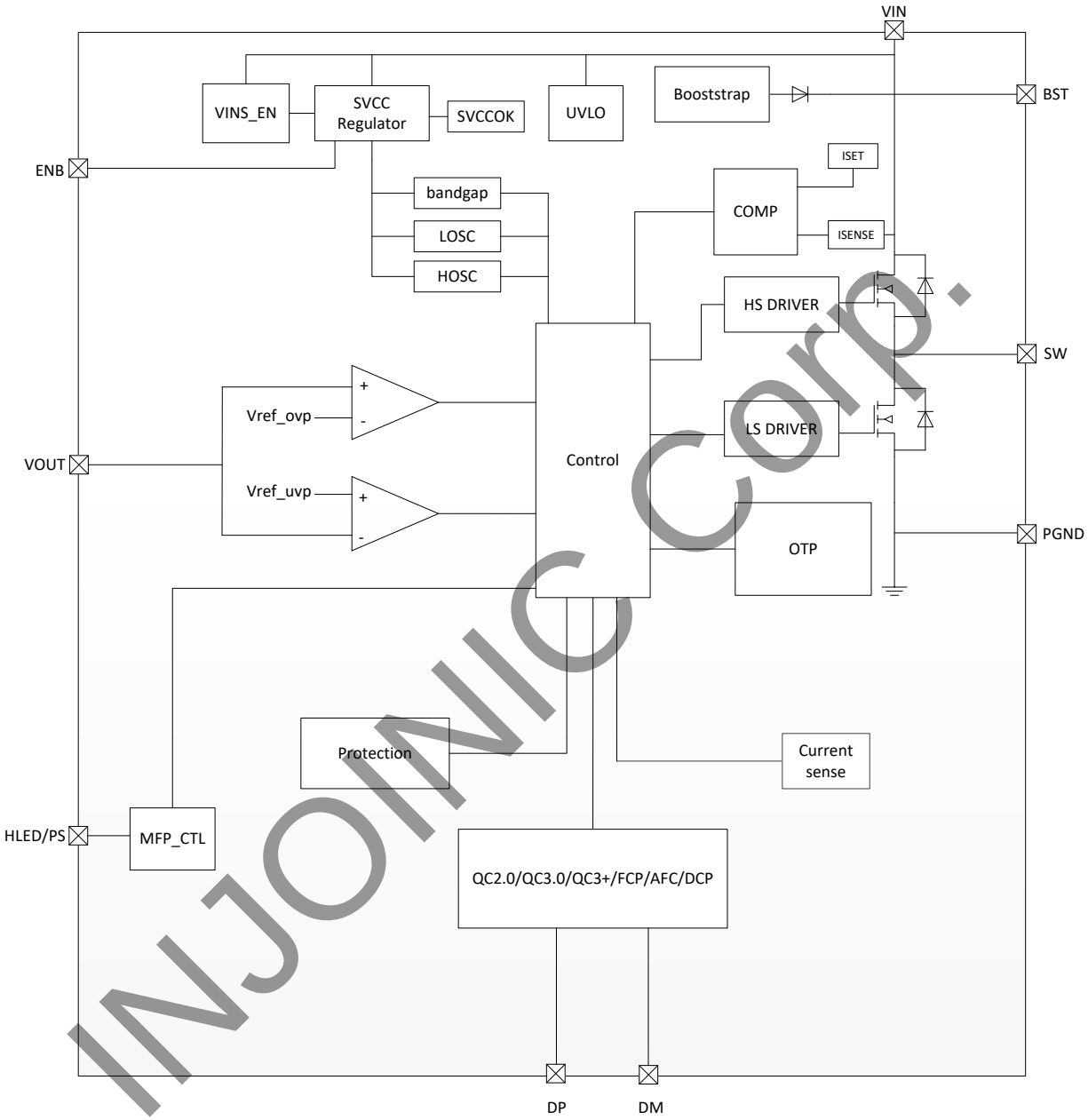



Figure 3 IP6525TQ Internal Block Diagram

## 8 Absolute Maximum Ratings

| Parameters | Symbol | Value | Unit |
|---|---|---|---|
| Input voltage range | $V_{IN}$ | -0.3 ~ 40 | V |
| SW voltage range | $V_{SW}$ | -0.3 ~ 40 | V |
| DM/DP voltage range | $V_{DM/DP}$ | -0.3 ~ 6 | V |
| ENB/HLED/PS voltage range | $V_{ENB/HLED/PS}$ | -0.3 ~ 6 | V |
| VOUT voltage range | $V_{VSP/VSN}$ | -0.3 ~ 20 | V |
| Junction Temp range | $T_J$ | -40 ~ 150 | ℃ |
| Storage Temp range | Tstg | -60 ~ 150 | ℃ |
| Thermal resistance (junction to ambient) | $\theta_{JA}$ | 40 | ℃/W |
| ESD（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 | $V_{IN}$ | 5.2 | 12/24 | 32 | V |

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

## 10 Electrical Characteristics

TA=25℃，L=22μH，COUT=100μF E-cap(About 40mΩ ESR)，VIN=12V，VOUT=5V, otherwise specified

| Parameters | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Input system** | | | | | | |
| Input voltage | $V_{IN}$ | | 5.2 | 12 | 32 | V |
| Input under voltage | $V_{IN-UV}$ | Rising voltage | 5.1 | 5.2 | 5.3 | V |
| | $V_{IN-UV-TH}$ | Falling voltage | - | 0.1 | - | V |
| Input over voltage | $V_{IN-OV}$ | Rising voltage | 32 | 32.5 | 33 | V |
| | $V_{IN-OV-TH}$ | Falling voltage | - | 0.2 | - | V |
| Input quiescent current | $I_Q$ | VIN=12V, VOUT=5V@0A | - | 1.3 | - | mA |
| Shutdown current | $I_{SD}$ | ENB = 3.3V，VIN = 12V | - | 15 | - | μA |
| | | ENB = 3.3V，VIN = 24V | - | 40 | - | μA |
| **Power system** | | | | | | |
| Drain-source on-state resistance (High-side) | $R_{DS(ON)-HIGH}$ | | - | 30 | - | mΩ |
| Drain-source on-state resistance (Low-side) | $R_{DS(ON)-LOW}$ | | - | 20 | - | mΩ |
| Switching frequency | $F_{SW}$ | | 95 | 115 | 130 | KHz |
| **Output system** | | | | | | |
| Output voltage | $V_{OUT}$ | | 3 | 5 | 12 | V |
| Output voltage ripple | $\Delta V_{OUT}$ | VIN=12V, VOUT=5V/3A | - | 90 | - | mV |
| | | VIN=12V, VOUT=9V/2A | - | 70 | - | mV |
| | | VIN=24V, VOUT=12V/1.5A | - | 65 | - | 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 (IP6525TQ) | $I_{OUT}$ | VIN=12V, VOUT<=4V | - | 3.2 | - | A |
| | | VIN=12V, 4V<VOUT<=5V | - | 3.2 | - | A |
| | | VIN=12V, | - | 2 | - | A |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | 7V<VOUT<=9V | | | | |
| | | VIN=24V, 9V<VOUT<=12V | - | 1.5 | - | A |
| Output hiccup restart voltage | $V_{OUT}$ | Hiccup restart voltage when output enter CC mode | - | 3 | - | V |
| Output hiccup restart time | $T_{HIC}$ | VIN=12V, VOUTA short circuit | - | 2 | - | s |
| Thermal shutdown temperature | $T_{OTP}$ | Rising temperature | - | 150 | - | ℃ |
| Thermal shutdown temperature hysteresis | $\Delta T_{OTP}$ | | - | 40 | - | ℃ |
| **HLED PIN** | | | | | | |
| LED drive current | $I_{HLED}$ | | - | 4 | - | mA |
| **ENB PIN** | | | | | | |
| Enable output turn off voltage threshold | $V_{ENB-OFF}$ | ENB voltage rise | 2 | - | - | V |
| Enable output turn on voltage threshold | $V_{ENB-ON}$ | ENB voltage fall | - | - | 0.5 | V |
| Enable turn on delay | $T_{ENB-ON}$ | | - | 130 | - | ms |
| Enable turn off delay | $T_{ENB-OFF}$ | | - | 50 | - | μs |



# 11 Function Description

## 11.1 Synchronized Switch Buck Regulator

IP6525TQ integrates a synchronous switch buck regulator, input voltage ranges from 5.2V to 32V, output voltage ranges from 3V to 12V, typical output voltage and current is: 5V/3A, 9V/2A, 12V/1.5A.

IP6525TQ integrates power switch MOSFET with 115kHz working frequency. The conversion efficiency is up to 94.43% at VIN=24V, VOUT=5V/3A. The efficiency under different output voltage and load current is shown in figure 4, figure 5 show the output voltage characteristics under different load current.

IP6525TQ automatically adjusts output voltage according to the fast charge protocol.

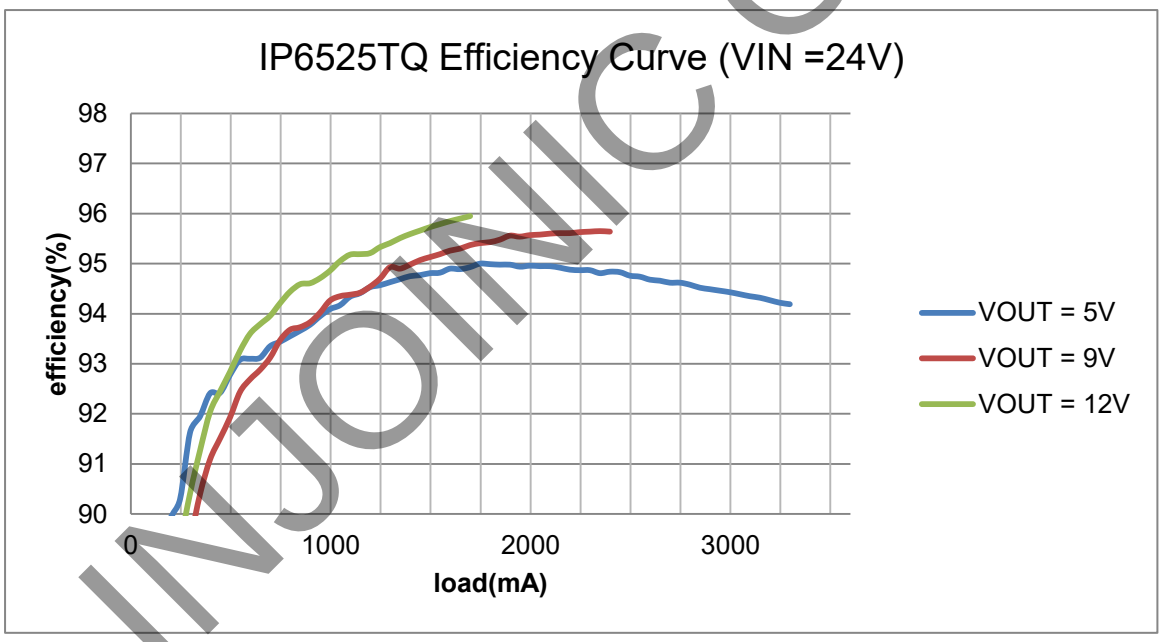



Figure 4 IP6525TQ Efficiency Curve When VIN = 24V



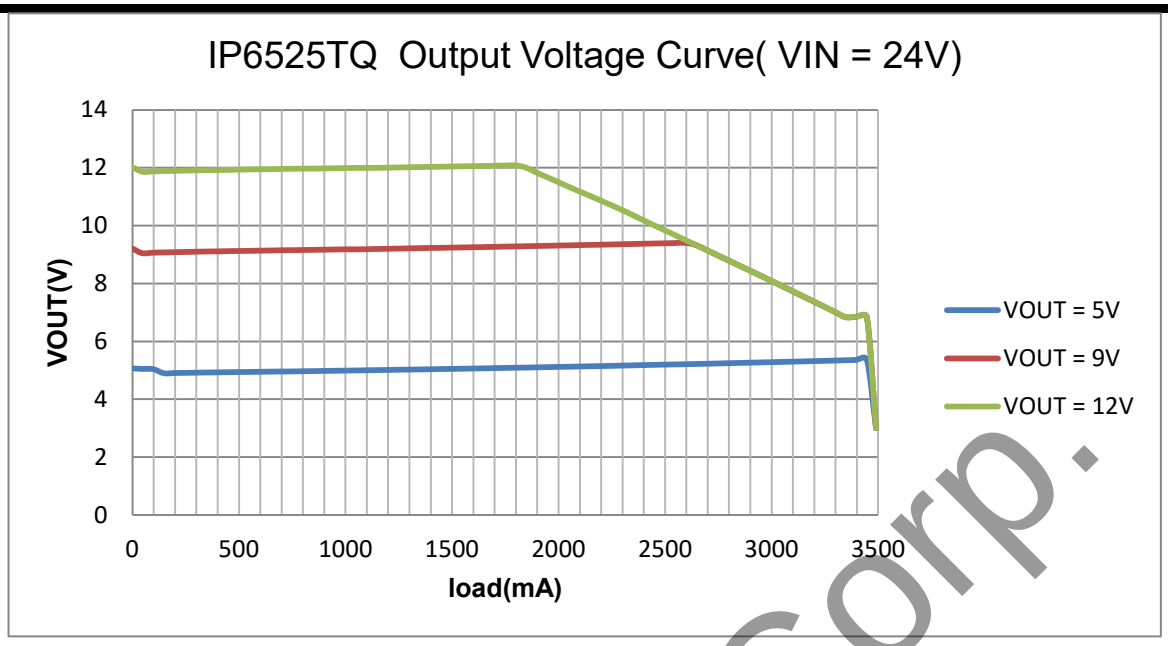



Figure 5 IP6525TQ Output Voltage And Current Relationship Curve

## 11.2 Output Voltage Line Loss Compensation

IP6525 supports output line loss compensation, output voltage will increase about 60mV as output current increases 1A at VIN=12V.

## 11.3 ENB Function

ENB is an external enable pin, which can't be floating and a certain voltage should be given.

When the ENB is at a low voltage, IP6525TQ turns on the output. When the ENB is higher than 2V, IP6525TQ turns off the output. The shutdown current is 15uA when VIN=12V.

ENB can't be directly connected to high voltage VIN, otherwise, this PIN will be broken down due to excessive voltage.

## 11.4 PIN4 Function

PIN4 can be alternatively used as fast charge indication and control power function.

When used as fast charge indication. Indication led can be directly connected to this PIN. LED turns on when the fast charge protocol request voltage level higher than 5V or lower than 5V. If this function is not required, PIN4 can be floating.

When used as a power control function, when the voltage of PIN4 is higher than 2V, IP6525TQ turns off the fast charge function and outputs 5V/2.4A.When the PIN4 voltage is lower than 0.5V, IP6525TQ turns on the fast charge function. If this function is not required, PIN4 can be floating.



PIN4 cannot be connected to VIN, or else this PIN will be broken down due to excessive voltage.

## 11.5 CC/CP/CV Characteristics

IP6525TQ output has CV/CP/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 CP mode with decreasing output voltage, as the output current increases, the output voltage decreases; when the voltage drops to 6.9V, CC mode is entered, the output current continues to increase and the output voltage rapidly decreases until the output voltage undervoltage protection is triggered.

## 11.6 Protective Function

IP6525TQ supports input undervoltage protective function. When VIN is lower than 5.1V, IP6525TQ detects the input is under voltage and turns off the output.

IP6525TQ supports input overvoltage protective function. When VIN voltage is higher than 32.5V, IP6525TQ detects over voltage, and then turns off the output. when VIN decrease under 32.3V, IP6525TQ determines the input voltage recovers and turns on the output.

IP6525TQ supports output under voltage protection. When the VOUT voltage is lower than 3V, IP6525TQ determines the output is under voltage and then turns off the output and hiccup restarts after 2sec.

IP6525TQ supports short circuit protect. After 8ms startup, if the VOUT voltage is lower than 3V, IP6525TQ determines the output is short circuit, turns off the output and hiccups restart after 2sec.

IP6525TQ supports DP/DM over voltage protection, when the DP/DM voltage is higher than 4.5V, IP6525TQ determines the signals are over voltage and turns off the output and hiccups restart after 2sec.

IP6525TQ supports over temperature protection. When the temperature detects is higher than 150℃, the output will be shut down. When the temperature decreases below 110℃, IP6525TQ determines the temperature has recovered and will restart the output.

## 11.7 Fast Charge Protocols

IP6525TQ supports multiple fast charge protocols：

- ✧ DCP (BC1.2, Apple and Samsung)
- ✧ Qualcomm quick charge QC2.0, QC3.0 and QC3+
- ✧ Huawei FCP
- ✧ Samsung AFC (MAX 12V)



## 12 Application Schematic

IP6525TQ car charging solution only needs inductor, capacitor and resistor.

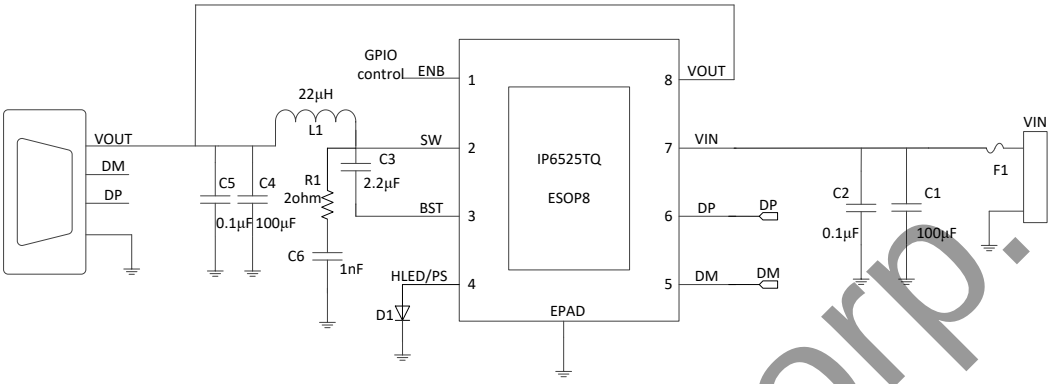



Figure 6 IP6525TQ Application Schematic

Notes:

(1) EPAD of IP6525TQ must have good contact with PCB PGND.

(2) ENB can't be floating, and a certain voltage should be given. When the ENB is at a low voltage, IP6525TQ turns on the output. When the ENB is higher than 2V, IP6525TQ turns off the output.

(3) The default PIN4 function is fast charge indication. If not required, PIN4 can be floating.

(4) C1 and C2 should be placed close to the PIN7 of IP6525TQ. If the C2 capacitor is far away from the 100μF capacitor or the power supply VIN, the capacitance should be increased appropriately

(5) C5 should be placed close to PIN8 of IP6525TQ.

(6) R1 and C6 should be placed close to the PIN2 of IP6525TQ, the loop composed of SW(PIN2), R1, C6 and GND should be minimized on the PCB board.

(7) PIN6 cannot contact high voltage. It is recommended to add white oil on PCB between PIN6 and PIN7 to prevent damage of pin caused by contact.

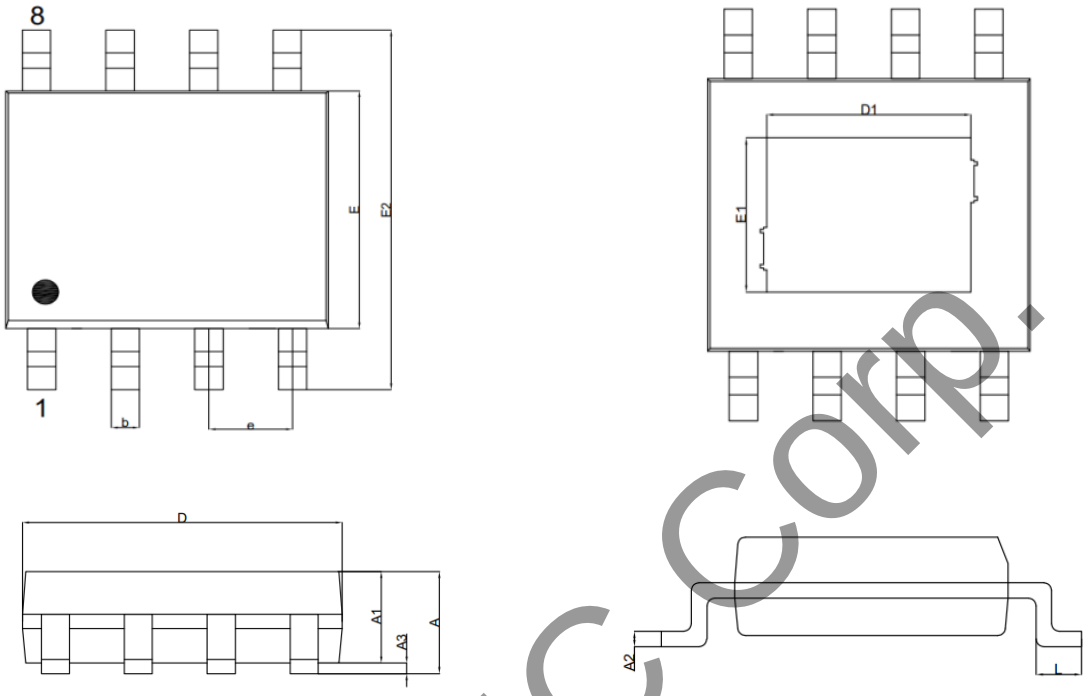
## 13 BOM

| NO. | Device | Spec | Unit | Counts | Designator | Notes |
|---|---|---|---|---|---|---|
| 1 | IC | IP6525TQ | PCS | 1 | U1 | |
| 2 | Electrolytic capacitor | 100uF/35V | PCS | 1 | C1 | Rated voltage>35V. |
| 3 | Electrolytic capacitor | 100uF/16V | PCS | 1 | C4 | Rated voltage>16V |
| 4 | Power inductor | 22uH+/-20%，Nominal current 4.5A DCR<12mohm | PCS | 1 | L1 | 3L Electronic |
| 5 | Ceramic capacitor | 0603 2.2uF 10% | PCS | 1 | C3 | Rated voltage>16V |
| 6 | Ceramic capacitor | 0603 100nF 10% | PCS | 1 | C2 | Rated voltage>35V. Close to IC PIN. |
| 7 | Ceramic capacitor | 0603 100nF 10% | PCS | 1 | C5 | Rated voltage>16V |
| 8 | Resistor | 0603 2ohm 5% | PCS | 1 | R1 | |
| 9 | Ceramic capacitor | 0603 1nF 10% | PCS | 1 | C6 | |
| 10 | LED | 0603 | PCS | 1 | D1 | |
| 11 | Fuse | F1 | PCS | 1 | F1 | Nominal current>4A |

Recommended inductor: TC-220M-4.5A-CS137125

| 3L product No. | Inductance (uH) | 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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