

Maximum power **65W** high efficiency synchronous buck converter

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 CV/CC output mode
- **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_FB integrates a Synchronous-Rectified Buck converter. It provides solutions for car charger, fast charge adaptor, smart power strip and dash cam.

IP6551_FB supports up to 36V input voltage and supports sampling resistor short circuit protection function.

IP6551_FB supports FB voltage regulation mode, output voltage can be adjusted to the needs of the system by means of a peripheral circuit.

IP6551_FB 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_FB supports soft start function that protects the input power from inrush current at start up.

IP6551_FB supports multi-protection on input over voltage and under voltage, output over current, over voltage, under voltage and short circuit.

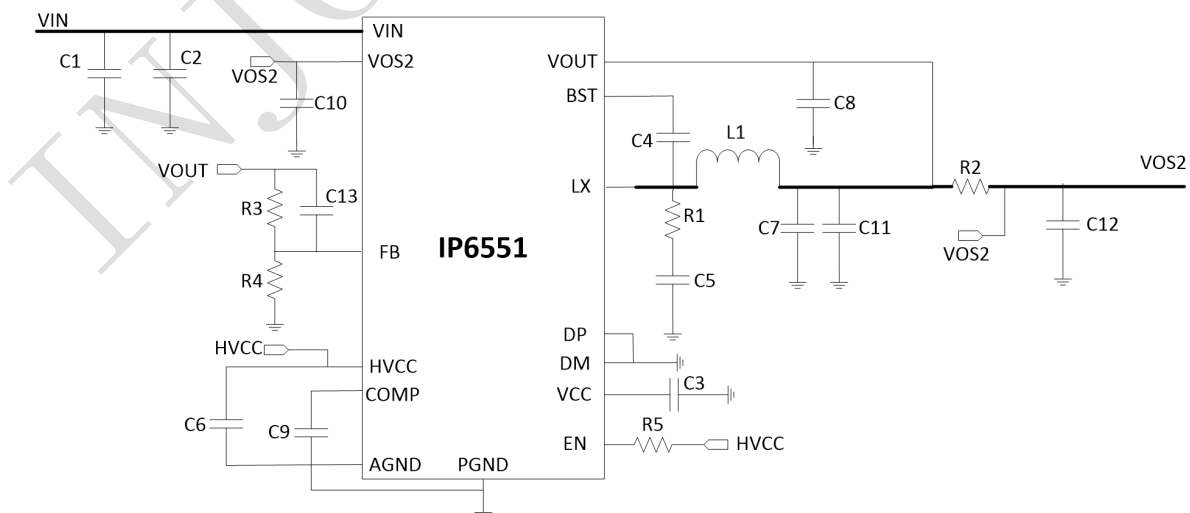


Figure 1. IP6551_FB external feedback output application schematic diagram

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4 Typical Application Schematic

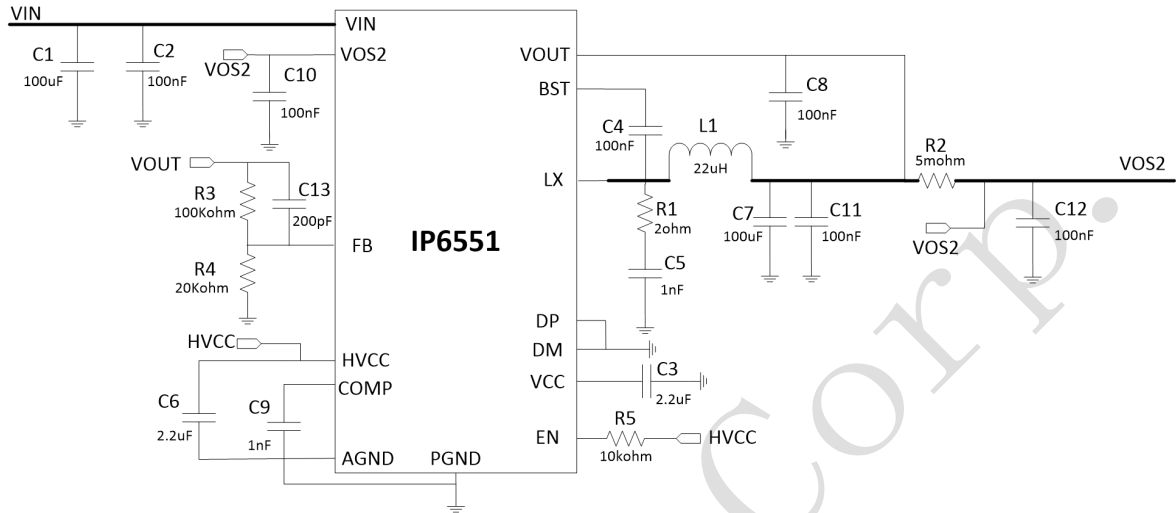


Figure 2. IP6551_FB external feedback output application schematic diagram

NOTES:

1. In the scheme of achieving VOS2 voltage control by pulling or pouring current in FB, A 2kohm resistor needs to be connected in series between the FB pin of the control device and the FB pin of IP6551_FB.
2. IP6551_FB limits the output current through a 5mohm sensing resistor between VOUT and VOS2.
3. IP6551_FB has enabled the function of EN PIN to control DCDC turn on or off. EN PIN can be connected to HVCC via a 10k resistor if this function is not needed.

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 | PIN2PIN |
| IP6525T | 18W | - | √ | √ | √ | √ | - | √ | - | - | - | - | ESOP8 | |
| 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_FB Series Product Introduction

| Product | Introduction |
|-----------|---|
| IP6551_FB | IP6551 output voltage is controlled through FB. Maximum output current is 3.25A(5mohm sensing resistor). |

6 Pin Functions

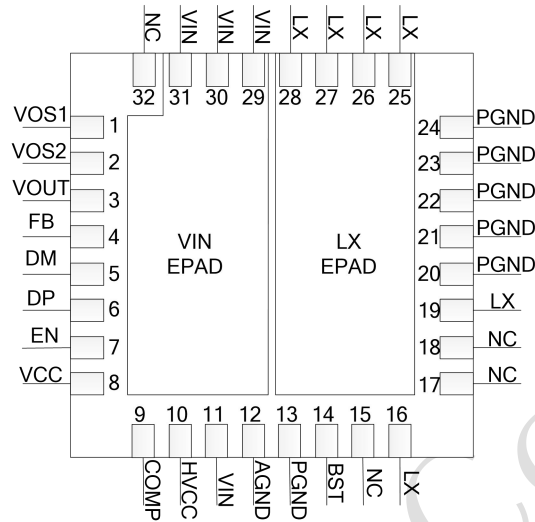


Figure 3.IP6551 (QFN32) Pin functions

| Pins | | Description |
|-------------------|----------|--|
| Pin No. | Pin Name | |
| 1 | VOS1 | VOU1 output current negative sense pin |
| 2 | VOS2 | VOU2 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

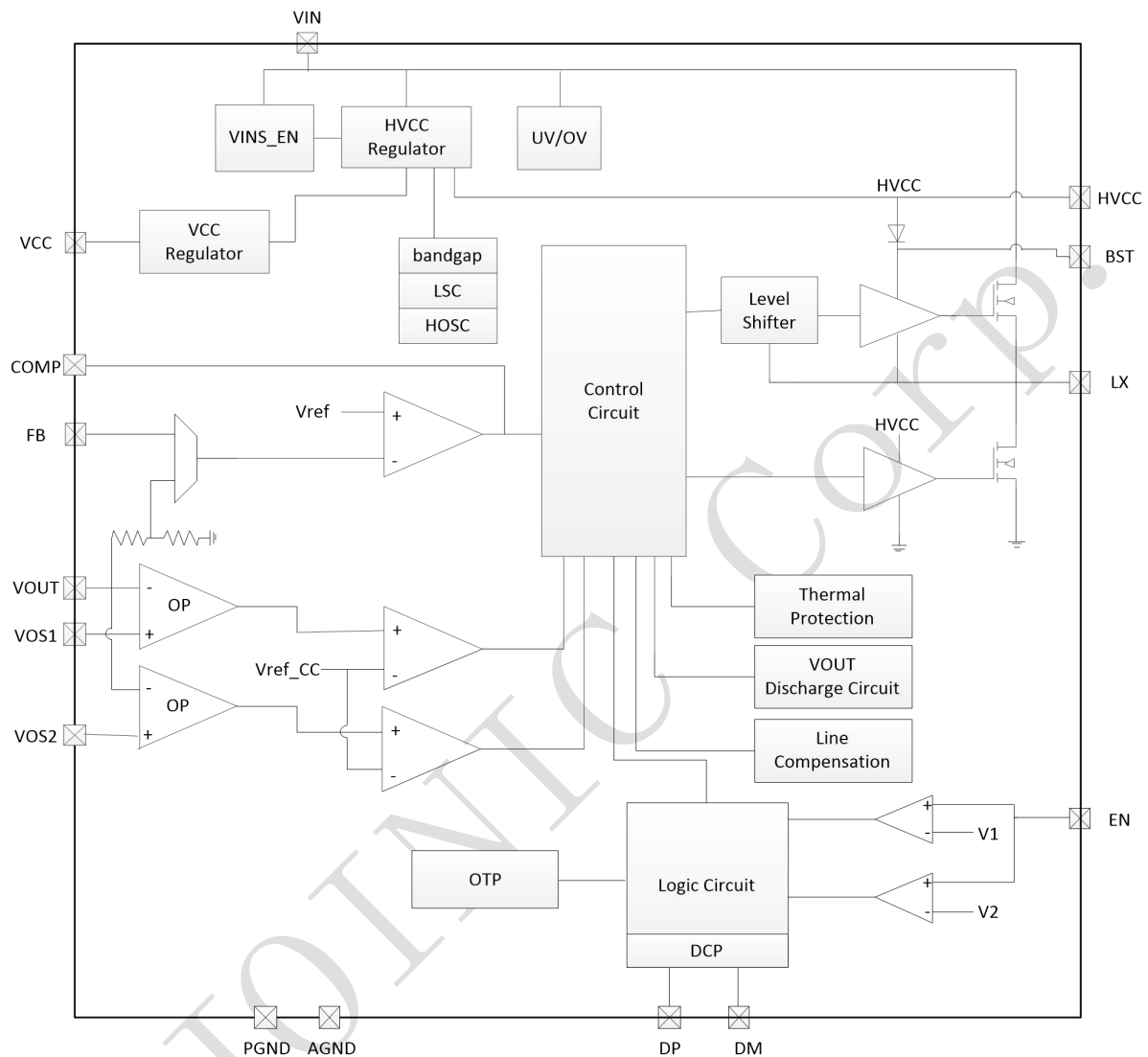


Figure 4.IP6551 Internal block diagram

8 Absolute Maximum Ratings

| Parameters | Symbol | Value | Unit |
|---|---------------|---------------------|------|
| Input voltage | V_{IN} | -0.3 ~ 42 | V |
| LX voltage | V_{LX} | -0.3 ~ $V_{IN}+0.3$ | 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 | °C |
| Storage temperature | T_{stg} | -55 ~ 150 | °C |
| Ambient Temperature | T_A | -40~120 | °C |
| Thermal resistance (junction to ambient) | θ_{JA} | 40 | °C/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_FB, 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 |
| Shutdown current | I _{SD} | VIN=12V, EN=0V | | 20 | | uA |
| 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=12V, 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 | 3 | | 21 | 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 current in CC mode | I _{OUT} | IP6551_FB output | | 3.25 | | 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 | | °C |
| Thermal shutdown temperature hysteresis | ΔT _{OTP} | | | 40 | | °C |
| 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 | $T_{\text{EN-ON}}$ | | | 800 | | us |
| EN PIN turn-off delay | $T_{\text{EN-OFF}}$ | | | 100 | | us |

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11 Function Description

11.1 Synchronized Switch Buck converter

IP6551_FB integrates a synchronized switch buck converter, input voltage ranges from 4.5V to 36V and output voltage ranges from 3V to 21V.

IP6551_FB supports sampling resistor short circuit protection function.

IP6551_FB output is driven at a switching frequency of 127kHz. It can be adjusted internally.

IP6551_FB has soft start function, preventing the huge inrush current cause damage to the IC. When $V_{IN}=24V$, $V_{OUT}=5V$, the soft start time is 3ms.

$V_{IN}=24V$, $V_{OUT}=5V@3A$, the conversion efficiency is 95.4%.

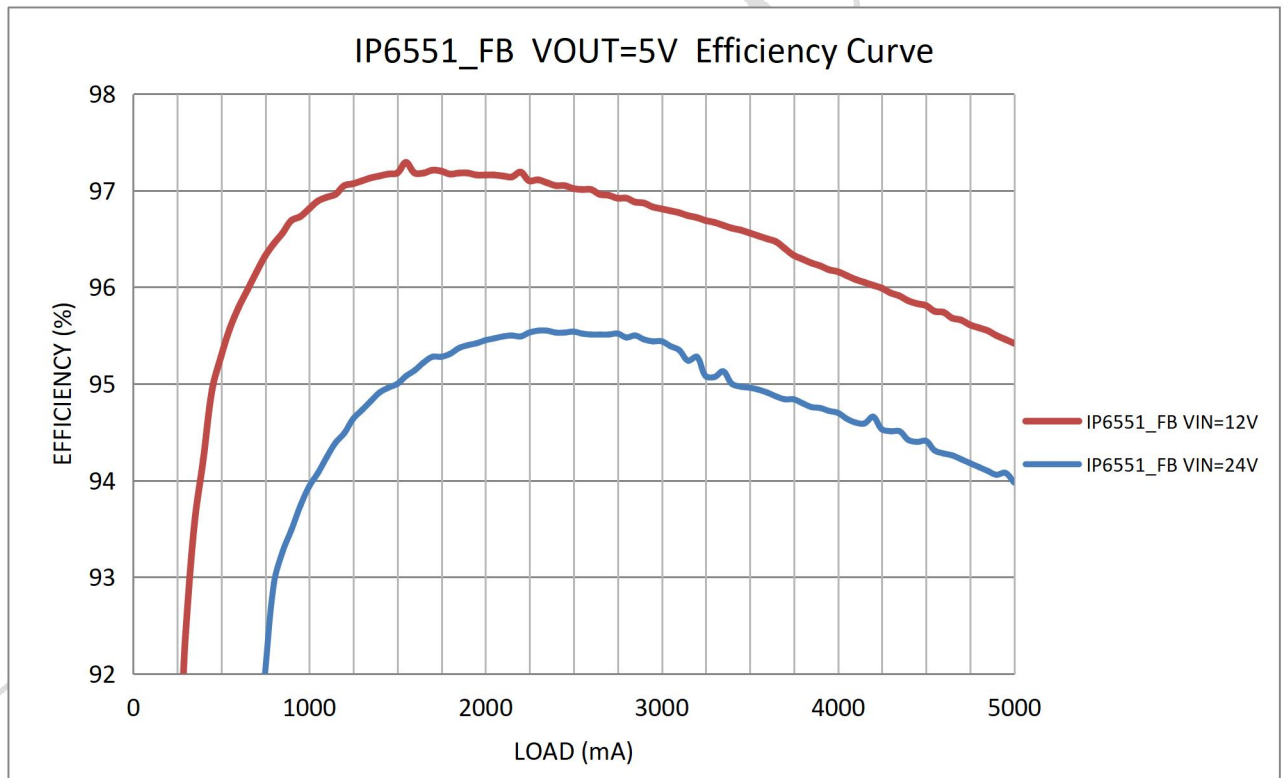


Figure 5. IP6551_FB VOUT=5V output efficiency curve

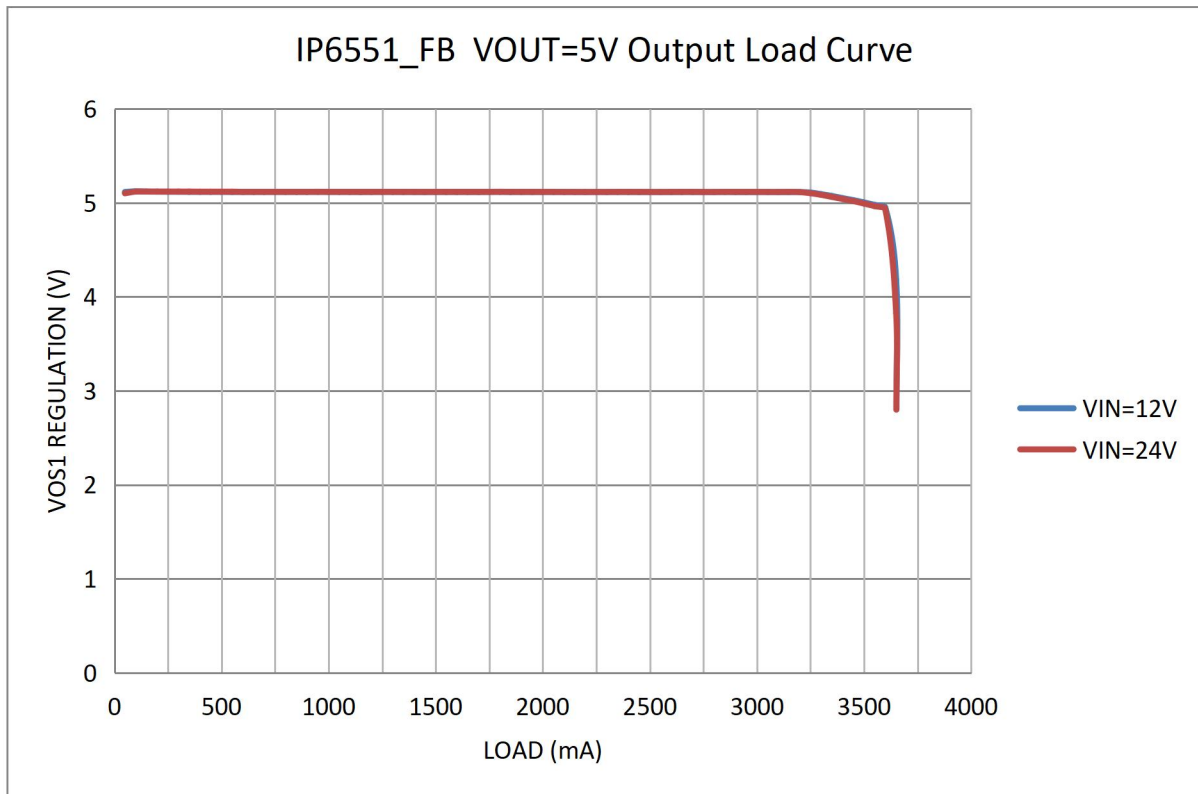


Figure 6.IP6551_FB VOUT-IOUT curve

11.2 Output CV/CC Characteristic

IP6551_FB 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.

11.3 Output CC Current Set

IP6551_FB 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.

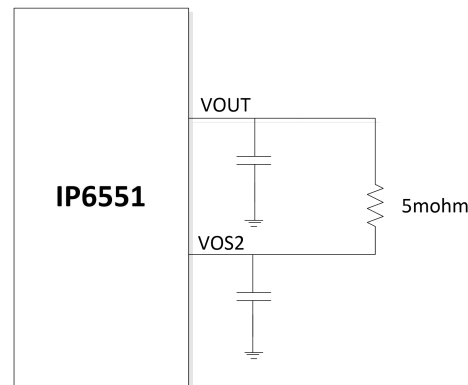


Figure 7. IP6551_FB output current limiting circuit

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%.

11.4 Protection Function

IP6551_FB will detect the VIN voltage, if VIN voltage is lower than 4.5V, IP6551_FB will enter standby mode and shut down the output.

IP6551_FB supports input over voltage protection: when the VIN voltage is higher than 36V, IP6551_FB determines the VIN is over voltage and shutdown the output; when VIN decrease under 35.6V, IP6551_FB determines the input voltage recovers and opens the output.

IP6551_FB supports output under voltage protection: if the VOUT voltage is lower than 2.8V, IP6551_FB determines the output is under voltage and will shut down the output and hiccup restart after 2sec.

IP6551_FB supports short circuit protect, 16ms after the circuit is started, if VOUT voltage is under 2.8V, IP6551_FB determines the output is short circuit and will shut down the output and hiccup restart after 2sec.

IP6551_FB 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_FB determines the temperature has recovered and will restart the output.

11.5 EN PIN Function

IP6551_FB 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.

11.6 FB Feedback

IP6551_FB supports the function of FB external feedback. For the devices that support FB voltage regulating, the FB voltage is 0.84V. The circuit is as follows:

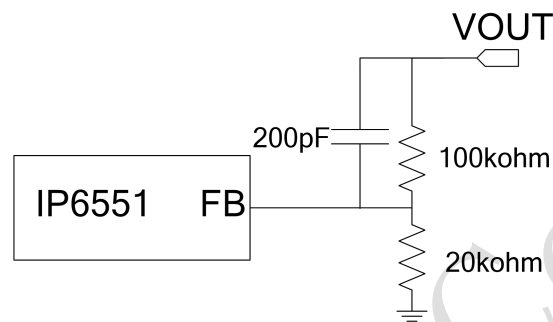


Figure 8. IP6551 FB feedback circuit diagram

The feedback resistance can be adjusted according to the need to get the appropriate output voltage.

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 ($I_L(PEAK)$) 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_FB output, the finished BOM is as follows:

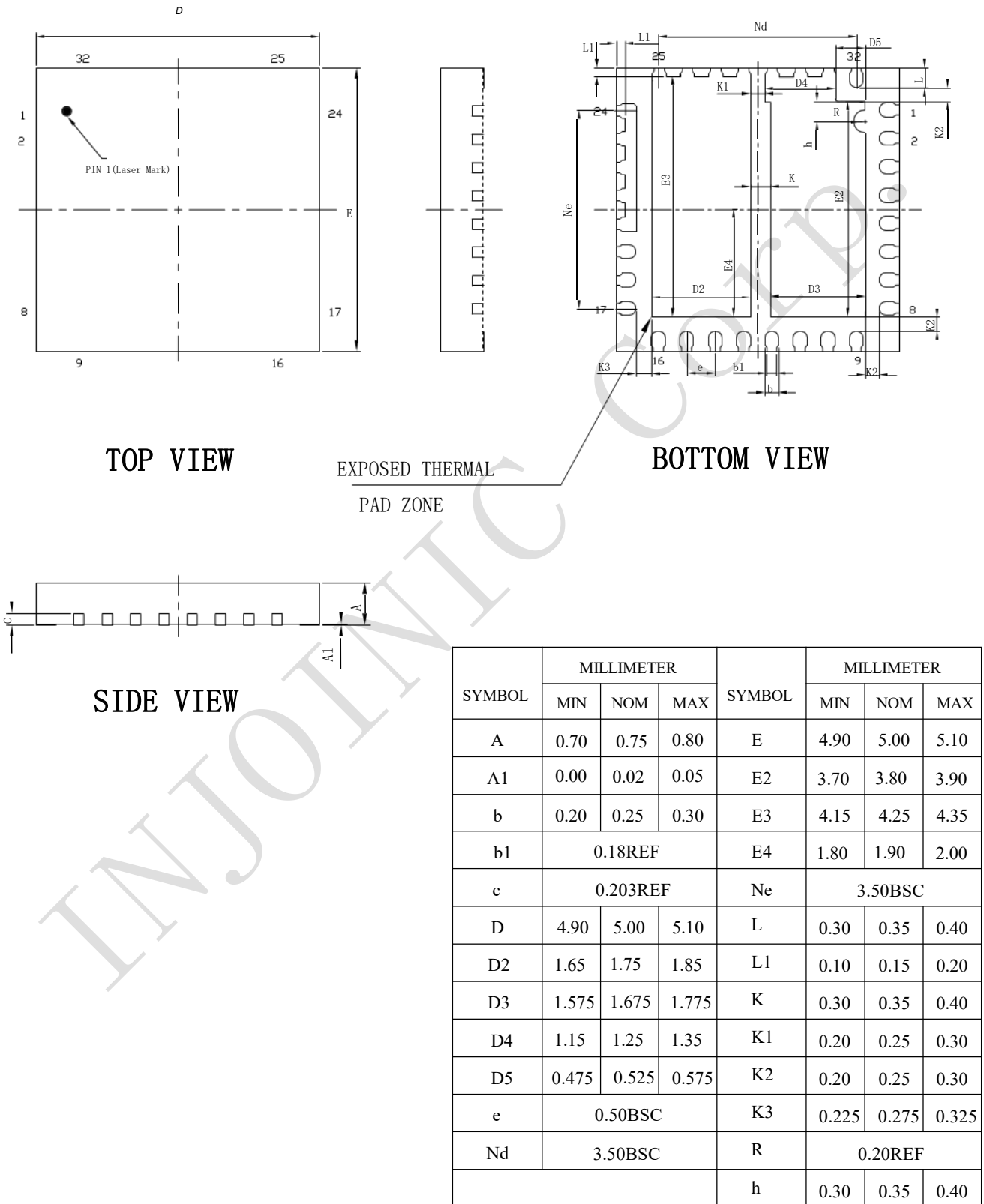
| No. | Part Name | Type | Unit | Qty | Location | Notes |
|-----|------------------------|---|------|-----|-------------------|-----------------------------------|
| 1 | IC | IP6551_FB QFN32 | PCS | 1 | U1 | |
| 2 | Inductor | 22uH+/-20%, current 4.5A DCR<10mohm | PCS | 1 | L1 | |
| 3 | Electrolytic capacitor | 100uF | PCS | 1 | C1 | Withstand voltage higher than 36V |
| 4 | Solid-state capacitor | 100uF | PCS | 1 | C7 | Withstand voltage higher than 25V |
| 5 | SMD capacitor | 0603 200PF | PCS | 1 | C13 | Withstand voltage higher than 10V |
| 6 | SMD capacitor | 0603 100nF 10% | PCS | 1 | C2 | Withstand voltage higher than 36V |
| 7 | SMD capacitor | 0603 100nF 10% | PCS | 5 | C4、C8、C10、C11、C12 | Withstand voltage higher than 10V |
| 8 | SMD capacitor | 0603 1nF 10% | PCS | 2 | C5、C9 | Withstand voltage higher than 36V |
| 9 | SMD capacitor | 0603 2.2uF 10% | PCS | 2 | C3、C6 | Withstand voltage higher than 16V |
| 10 | SMD resistor | 0603 2R 5% | PCS | 1 | R1 | |
| 11 | SMD resistor | 0603 10kohm 5% | PCS | 1 | R5 | |
| 12 | SMD resistor | 0603 20kohm 5% | PCS | 1 | R4 | |
| 13 | SMD resistor | 0603 100kohm 5% | PCS | 1 | R3 | |
| 14 | SMD resistor | 1206 5mohm 1% precision, temperature coefficient less than 100ppm | PCS | 1 | R2 | Current sense resistor |

14 Considerations for PCB layout

IP6551_FB 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_FB Application Notes for further information.

15 Package



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