18W OUTPUT STEP-DOWN CONVERTER with FAST CHARGE PROTOCOLS (DCP/QC2.0/QC3.0/FCP/AFC)

1 Features

- **Synchronous step-down converter**
  - Built-in Power MOSFETs
  - Wide Input Voltage Range, 9.6V to 32V
  - Wide Output Voltage Range, 3V to12V, Automatically Adjusted Based on Corresponding Fast Charge Protocol
  - 18W Max. Output Power (5V@3.4A, 9V@2A, 12V@1.5A)
  - Output Current Limit Protection
  - Conversion efficiency up to 98%
  - Soft-Start
  - Output Voltage Line Loss Compensation, 50mV@1A
- **Fast Charge Protocols**
  - Supports DCP (BC1.2, Apple, Samsung)
  - Supports Qualcomm Quick Charge Protocol QC2.0 and QC3.0
  - Supports Huawei Fast Charge Protocol FCP
  - Supports Samsung Fast Charge Protocol AFC
- **Multiple Safety Protections**
  - Input Over-Current Protection, Output Over-Current Protection, Input Over/Under Voltage Protection, Short Circuit Protection
  - Over Temperature Protection
  - DP/DM Over Voltage Protection
  - Input Voltage Withstand up to 40V
  - ESD 4KV

2 Application

- **Car Charger**
- **Fast Charge Adapter**
- **Intelligent Power Hub**

3 Introduction

IP6525T is a synchronous step-down converter with built-in power MOSFETs. IP6525T supports four fast charge protocols, providing total solution to car charger, fast charge adapter and intelligent power hub applications.

IP6525T supports wide input and output voltage range with 18W max. output power. The output voltage is automatically adjusted based on the corresponding protocol identified by IP6525T. Typical output portfolio is 5V@3.4A, 9V@2A and 12V@1.5A. The Max. conversion efficiency is up to 98%

IP6525T supports output voltage compensation due to the line loss. The output voltage increases 150mV as the load current increases to 3A.

IP6525T incorporates soft-start function to prevent the inrush current during start-up.

IP6525T supports multiple fast charge protocols. The protocol is identified by the signal on DP/DM, and IP6525T adjusts output voltage according to the corresponding protocols. IP6525T supports DCP (BC1.2, Apple, Samsung), Qualcomm Quick Charge QC2.0 and QC3.0, Huawei FCP and Samsung AFC.

IP6525T incorporates multiple safety protections, such as input OV/UV, output OV/UV/OC and SC protection.

The package of IP6525T is ESOP8.

4 PIN Definition

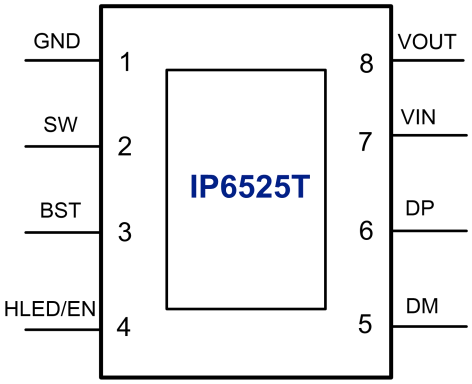


Fig. 2 IP6525T PIN Configuration

NO.	Name	Description
1	GND	Power ground
2	SW	Switching node of the DC-DC converter
3	BST	Bootstrap capacitor node
4	HLED/EN	Fast charge LED indication/chip enable(EN function needs to be customed)
5	DM	USB DM terminal for fast charge protocol
6	DP	USB DP terminal for fast charge protocol
7	VIN	Input voltage node
8	VOUT	Output voltage feedback node
9(EPAD)	GND	Power and thermal ground

5. IP6525T Series Product Introduction

IC PART	USB	OUTPUT POWER				PIN4 FUNCTION
IP6525T_NU	USBA	QC	5V/3A	9V/2A	12V/1.5A	PIN4 is set to HLED function.
IP6525T_NU_EN	USBA	QC	5V/3A	9V/2A	12V/1.5A	PIN4 is set to EN function.

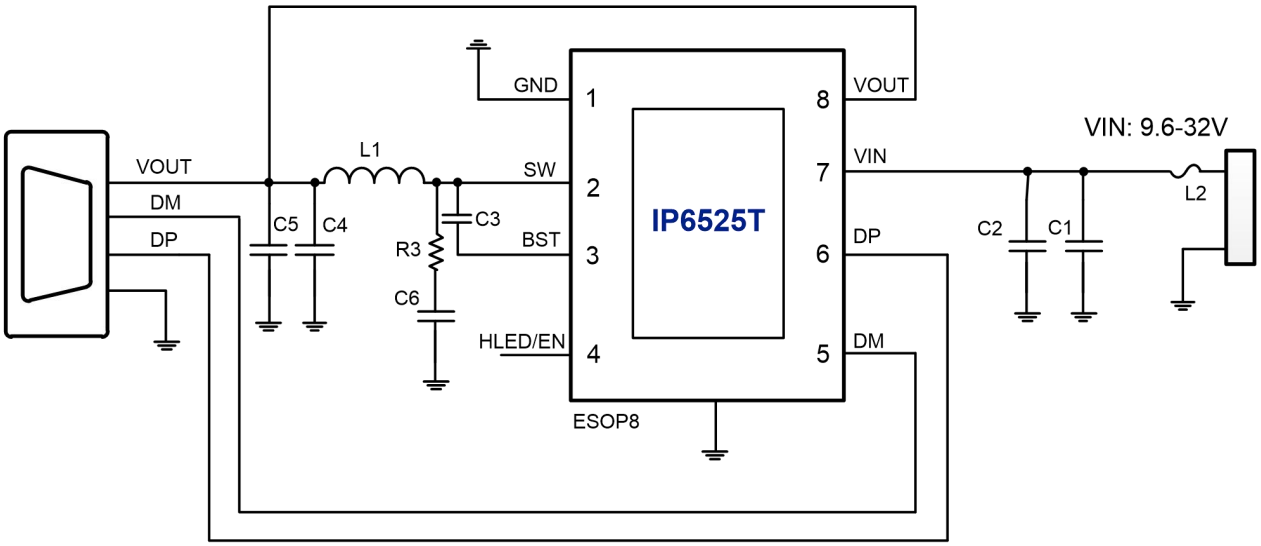


Fig. 1 IP6525T Simplified Application Schematic

6 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
VOUT voltage range	$V_{VSP/VSN}$	-0.3 ~ 25	V
Junction Temp range	T_J	-40 ~ 150	℃
Storage Temp range	Tstg	-60 ~ 150	℃
Thermal resistance (junction to ambient)	θ_{JA}	40	℃/W
ESD（HBM）	ESD	4	KV

* Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions are not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability. Unless otherwise specified, all voltages are referenced to VSS pin.

7 Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Input voltage	V_{IN}	9.6	12/24	32	V

8 Electrical Charateristics

TA=25℃，L=22uH，C_{OUT}=100uF P-cap(About 30mΩ ESR)，VIN=12V，VOUT=5V, otherwise specified

Parameter	Symbol	Test Condition	Min.	Typ.	Max.	Unit
Input System						
Input voltage	V_{IN}		9.6	12	32	V
Input under voltage threshold	V_{IN-UV}			9.6		V
		hysteresis		0.5		V
Input over voltage threshold	V_{IN-OV}			32		V
		hysteresis		0.2		V
Input quiescent current	I_Q	VIN=12V, VOUT=5V@0A		1.5		mA
Converter System						
High side MOSFET on resistance	$R_{DS(ON)}$			30		mΩ
Low side MOSFET on resistance	$R_{DS(ON)}$			20		mΩ
Switching frequency	F_{SW}			115		KHz
Output System						
Output voltage	V_{OUT}		3	5	12	V
Output voltage ripple	ΔV_{OUT}	VIN=12V，VOUT=5V@3A		135		mV
		VIN=12V，VOUT=9V@2A		75		mV
		VIN=24V，VOUT=12V@1.5A		180		mV
Soft-start time	T_{SS}	VIN=12V，VOUT=5V		1.4		ms
Line loss compensation	V_{COMP}	VIN=12V,VOUT=5V,IOUT=3A		150		mV
Current limit in CC mode	I_{OUT}	VIN=12V，VOUT<=4V		3.4		A
		VIN=12V，4V<VOUT<=5V		3.4		A
		VIN=12V，7V<VOUT<=9V		2		A
		VIN=24V，9V<VOUT<=12V		1.5		A
Hiccup output voltage	V_{OUT}	CC mode		2.6		V

Thermal shutdown Temp.	T_{OTP}			150		℃
Thermal shutdown Temp. hysteresis	ΔT_{OTP}			40		℃

9 Detailed Description

9.1 Synchronous Step-Down Converter

The IP6525T is a synchronous step-down converter with built-in power MOSFETs. IP6525T supports four fast charge protocols, providing total solution to car charger, fast charge adapter and intelligent power hub applications.IP6525T supports wide input and output voltage range with 18W max. output power. The output voltage is automatically adjusted based on the corresponding protocol identified by IP6525T. Typical output portfolio is 5V@3.4A, 9V@2A and 12V@1.5A. The switching frequency is 115KHz. The conversion efficiency is up to 95.5% at VIN=12V, VOUT=5V@3A. The efficiency under different input voltage and load current is shown in Fig. 3. Fig. 4 show the output voltage characteristics under different load current.

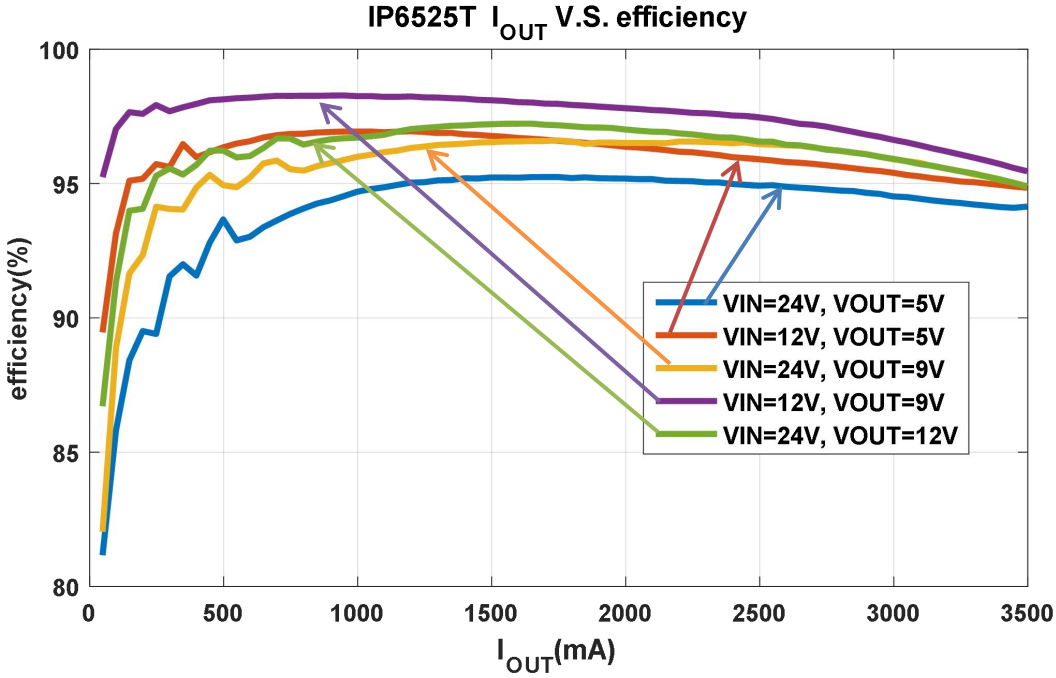


Fig. 3 IP6525T Conversion Efficiency

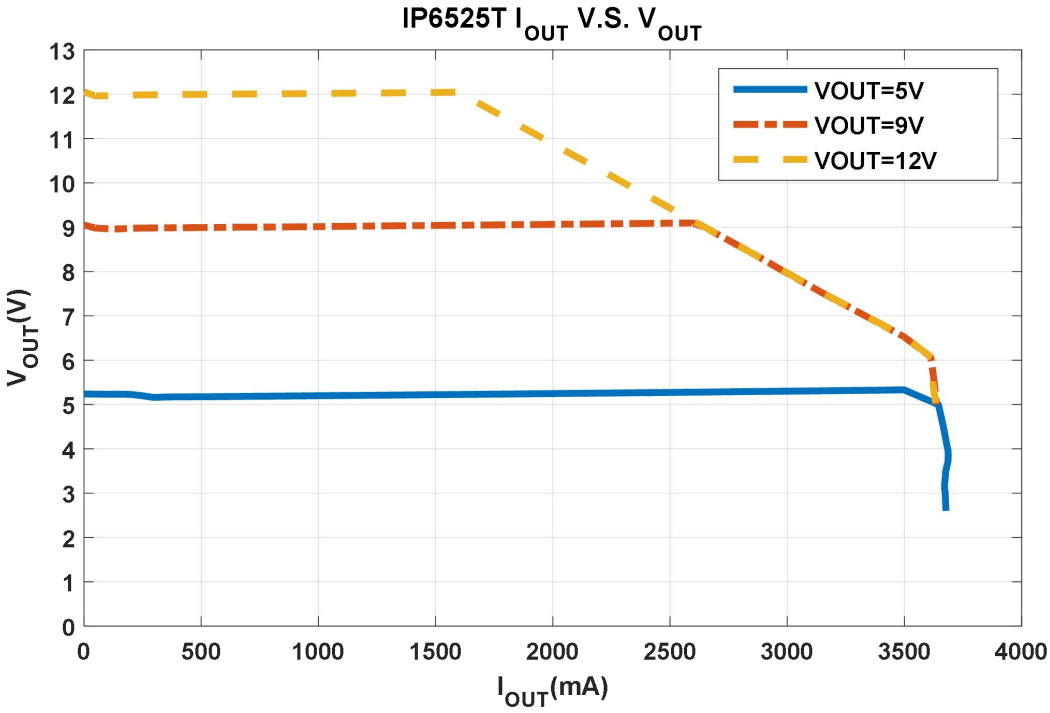


Fig. 4 IP6525T Output Voltage Characteristics

9.2 Output Voltage Line Loss Compensation

IP6525T supports output line loss compensation. The output voltage increases 150mV when the load current is 3A.

9.3 External Chip Enable Function

PIN-4(HLED/EN) can be alternatively used as external chip enable function. Pulling down EN PIN will shut down DC-DC converter. EN PIN cannot be connected to VIN, or else EN PIN will be damaged by high voltage.

9.4 Fast Charge Indication Function

PIN-4(HLED/EN) can be used as fast charge indication. Indication led can be direct connected to this PIN. LED turns on when the fast charge protocol request voltage level higher than 5V.

9.5 CC/CP/CV Characteristics

IP6525T exhibits CV/CP/CC characteristics. The output is in CV mode when the load current lower than current limit, otherwise in CP mode, in which the output voltage decreases as the load current increases. When the voltage drops to 6V, the output enters CC mode, in which the output voltage decreases rapidly to the output voltage under-voltage protection value when the load current increases.

9.6 Protections

IP6525T monitors voltage on VIN. If the voltage is lower than 9.6V, IP6525T enters standby mode, and shuts down the converter. If the voltage is higher than 32V, IP6525T detects over voltage, and then shuts down the converter. When VIN decreases 0.2V lower than the over voltage threshold, IP6525T resumes the output voltage.

IP6525T also monitors voltage on VOUT. If the voltage is lower than 2.5V, IP6525T detects output under voltage, and then shuts down the converter. During output under voltage protection, IP6525T enters hiccup mode, and restarts the converter every 2 seconds.

IP6525T incorporates short circuit protection. After 8ms from start-up, if VOUT is lower than 2.6V, IP6525T detects output short circuit, then shutting down the converter, and enters hiccup mode. IP6525T restarts the converter every 2 seconds.

IP6525T detects over temperature when the chip temperature is higher than 150℃. IP6525T shuts down the converter and restarts the every 2 seconds. When the chip temperature decreases below 110℃, IP6525T returns to normal state.

9.7 Fast Charge Protocols

IP6525T supports multiple fast charge protocols：

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

10 Typical Application

Fig.5 shows the typical application schematic.

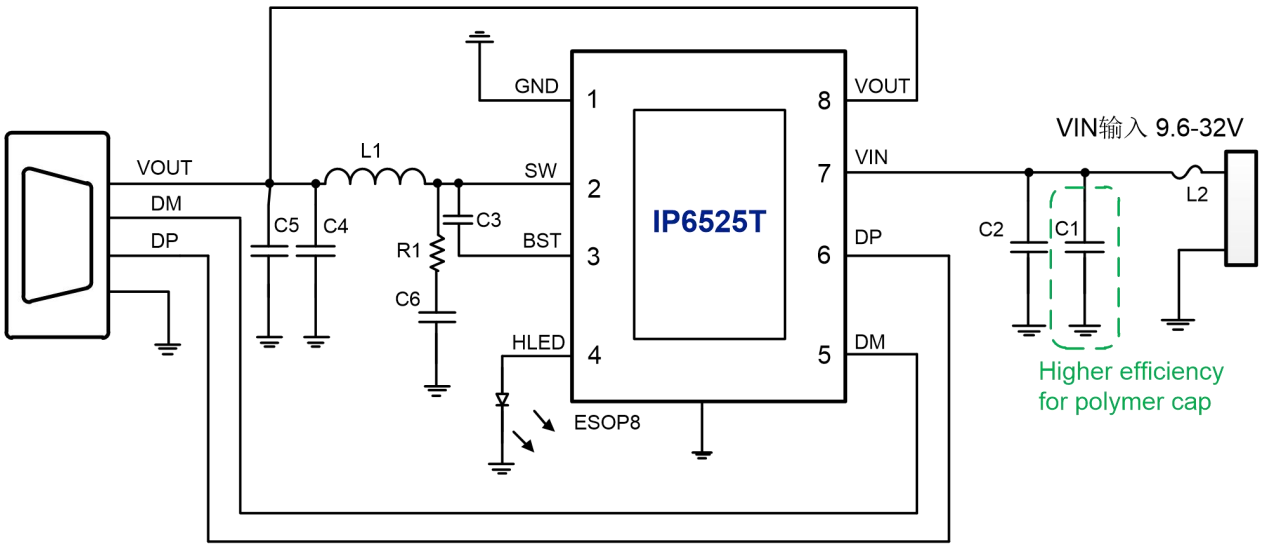


Fig. 5 IP6525T Application Schematic

Notes:

1. IP6525T EPAD must have a good contact with PCB GND;
2. C2 should be placed close to the PIN7 of IP6525T;
3. PIN4 should not be connected anywhere if the HLED indicator light is not needed.

11 BOM

NO.	Device	Spec.	Unit	Counts	Designator	备注
1	IC	IP6525T	PCS	1	U1	
2	polymer capacitor	100uF/35V	PCS	1	C1	Rated voltage>35V
3	polymer capacitor	100uF/25V	PCS	1	C4	Rated voltage>25V
4	TC-220M-4.5A-CS137125	22uH+/-20%，Nominal current 4.5A DCR<12mohm	PCS	1	L1	3L Electronic
5	ceramic capacitor	0603 100nF 10%	PCS	1	C2	Rated voltage>35V. Close to IC PIN.
6	ceramic capacitor	0603 100nF 10%	PCS	1	C5	Rated voltage>16V
7	ceramic capacitor	0603 2.2uF 10%	PCS	1	C3	Rated voltage>16V
8	resistor	0603 2ohm 5%	PCS	1	R1	
9	ceramic capacitor	0603 1nF 10%	PCS	1	C6	
10	fuse	F1	PCS	1	F1	Nominal current>4A
11	LED	0603	PCS	1	D1	

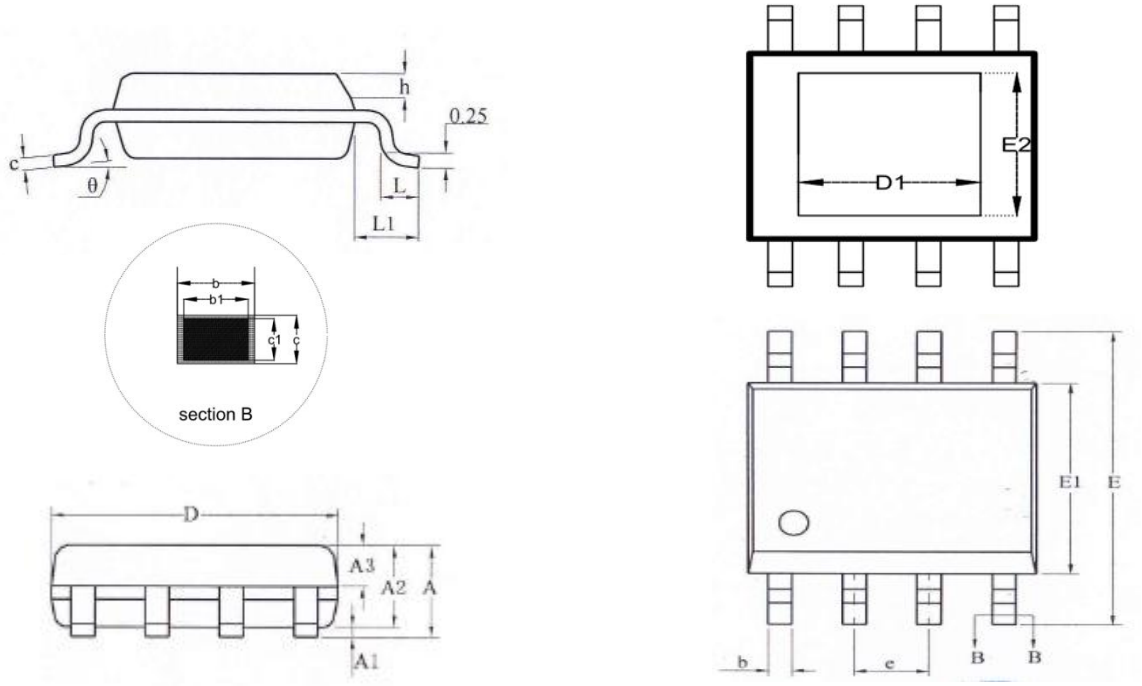
Recommended inductor: TC-220M-4.5A-CS137125

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	

12. IP Series IC Products List

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
IP6523S_N	3.4A	–	√	–	–	–	–	–	–	–	–	–	ESOP8	PIN2PIN
IP6536	2.4A	√	√	–	–	–	–	–	–	–	–	–	ESOP8	
IP6525T_NU	18W	–	√	√	√	√	–	√	–	–	–	–	ESOP8	PIN2PIN
IP6525S	18W	–	√	√	√	√	√	√	√	√	–	–	ESOP8	
IP6510	18W	–	√	√	√	√	–	√	–	–	√	–	ESOP8	PIN2PIN
IP6520	18W	–	√	√	√	√	√	√	√	–	√	–	ESOP8	
IP6520_PPS	18W	–	√	√	√	√	√	√	√	–	√	√	ESOP8	
IP6537_C	18W	–	√	√	√	√	√	√	√	√	√	√	QFN24	PIN2PIN
IP6537_C_30W20V	30W	–	√	√	√	√	√	√	√	√	√	√	QFN24	
IP6515	4.8A	√	√	–	–	–	–	–	–	–	–	–	QFN32	
IP6538_CC	27W	√	√	√	√	√	–	√	√	–	√	√	QFN32	PIN2PIN
IP6538_AC	27W	√	√	√	√	√	√	√	√	–	√	√	QFN32	
IP6538_AA	24W	√	√	√	√	√	√	√	√	–	–	–	QFN32	
IP6527S_A	24W	–	√	√	√	√	√	√	√	–	–	–	QFN32	PIN2PIN
IP6527S_C	27W	–	√	√	√	√	–	√	√	–	√	√	QFN32	
IP6527S_C_18WPD	18W	–	√	√	√	√	–	√	√	–	√	√	QFN32	

13 Package



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	--	--	1.65
A1	0.05	--	0.15
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	--	0.47
b1	0.38	0.41	0.44
c	0.20	--	0.24
c1	0.19	0.20	0.21
D	4.80	4.90	5.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.27BSC		
h	0.25	--	0.50
L	0.50	0.60	0.80
L1	1.05REF		
θ	0	--	8°
D1	--	3.10REF	--
E2	--	2.21REF	--

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