

Datasheet

Quad high-side smart power solid-state relay in QFN48L 8x6 mm package





Product status link IPS4140HQ IPS4140HQ-1



Features

- Operating output current: 0.6 A (IPS4140HQ) or 1.0 A (IPS4140HQ-1) per channel
- Per channel short-circuit protection
- Per channel overtemperature protection
- Thermal case protection
- Not simultaneous channel reactivation at thermal case reset
- All type of loads (resistive, capacitive, inductive load) are driven
- Loss of GND protection
- Undervoltage shutdown with hysteresis
- Overvoltage protection (V_{CC} clamping)
- Very low supply current
- Per channel open drain thermal fault pins
- 5 V and 3.3 V compatible I/Os
- · Fast demagnetization of inductive loads
- Designed to meet IEC61131-2, IEC61000-4-4, and IEC61000-4-5
- ESD according to IEC 61000-4-2 up to ±25 kV

Applications

- Programmable logic control
- Industrial PC peripheral input/output
- · Numerical control machines

Description

The IPS4140HQ (for loads up to 0.6 A) and IPS4140HQ-1 (for loads up to 1.0 A) are monolithic 4-channel drivers featuring very low $R_{DS(on)}$ and per-channel diagnostic. The ICs, realized in STMicroelectronics $^{\text{TM}}$ VIPower $^{\text{TM}}$ technology, are intended to drive any kind of load with one side connected to ground.

Active channel current limitation combined with thermal shutdown, independent for each channel, and automatic restart, protect the device against overload.

A channel in an overload condition overheats and turns OFF and back ON automatically in order to maintain its junction temperature between T_{TSD} and T_{R} . If this condition makes case temperature reach T_{CSD} , the overloaded channel is turned OFF and restarts only when case temperature has decreased down to T_{CR} . In case of more than one channel in overload, restart of the overloaded channels is not simultaneous, in order to avoid high peak current from the supply. Non-overloaded (non-overheated) channels continue operating normally.

The four open drain $STATUS_X$ output pins indicate per-channel overtemperature conditions.



1 Block diagram

Undervoltage Detection Vcc Clamp Input 1 GND Output 1 Input 2 Clamp Power Input 3 Output 2 Input 4Output 3 Current Limiter LOGIC Output 4 Junction Temp. Detection Status 1 Same structure for all channels Status 2 Status 3 Case Temp. Detection Status 4

Figure 1. Block diagram

DS14694 - Rev 1 page 2/28



2 Pin connection

NC VCC (TAB) NC NCNC NC NC NC NC NC NC NC NC NC STAT1 STAT3 STAT4

Figure 2. Pin connection (top through view)

Table 1. Pin description

Pin	Name	Туре	Description
TAB	V _{CC}	Supply	IC supply voltage.
1 to 12, 22 to 35, 48	NC	-	Internally not connected (these pins can be routed at pcb level).
13	IN1	Logic input	Channel 1 input, 3.3 V CMOS/TTL compatible.
14	STAT1	Output/Open drain	Channel 1 overtemperature status (active low).
15	IN2	Logic input	Channel 2 input, 3.3 V CMOS/TTL compatible.
16	STAT2	Output/Open drain	Channel 2 overtemperature status (active low).
17	GND	Ground	Device ground connection.
18	STAT3	Output/Open drain	Channel 3 overtemperature status (active low).
19	IN3	Logic input	Channel 3 input, 3.3 V CMOS/TTL compatible.
20	STAT4	Output/Open drain	Channel 4 overtemperature status (active low).
21	IN4	Logic input	Channel 4 input, 3.3 V CMOS/TTL compatible.
36,37,38	OUT4	Output	Channel 4 power stage output, internally protected. These three pins must be shorted on the application.
39,40,41	OUT3	Output	Channel 3 power stage output, internally protected. These three pins must be shorted on the application.
42,43,44	OUT2	Output	Channel 2 power stage output, internally protected. These three pins must be shorted on the application.
45,46,47	OUT1	Output	Channel 1 power stage output, internally protected. These three pins must be shorted on the application.

DS14694 - Rev 1 page 3/28



Maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V _{CC}	Power supply voltage	-0.3 to 41	V
I _{GND}	DC ground reverse current	-250	mA
l _{OUT}	DC output current	Internally limited (1)	Α
I _R	DC reverse output current (per channel)	-15 ⁽²⁾	Α
I _{IN}	Input pin current (per channel)	+/-10	mA
V _{IN}	Input pin voltage	+V _{CC}	V
V _{STAT}	Status pin voltage	+V _{CC}	V
I _{STAT}	Status pin current (per pin)	+/-10	mA
V _{ESD}	Electrostatic discharge (R = 1.5 kΩ; C = 100 pF)	2000	V
E _{AS} (3)	Single channel/single pulse avalanche energy $@T_{amb} = 125 ^{\circ}C$, $I_{OUT} = 0.5 A$	2.5	J
P _{TOT}	Power dissipation at T _C = 25 °C	Internally limited (1)	W
T _J	Junction operating temperature	Internally limited (1)	°C
T _{STG}	Storage temperature	-55 to 150	°C

Protection functions are intended to avoid IC damage in fault conditions and are not intended for continuous operation. Continuous and repetitive operation of protection functions may reduce the IC lifetime.

Table 3. Thermal data

Symbol	Parameter	Value	Unit
R _{th(JC)}	Thermal resistance junction-case (1)	1.5	°C/W
R _{th(JA)}	Thermal resistance junction-ambient (2)	27	°C/W

^{1.} Rth between the die and the bottom case surface measured by cold plate as per JESD51-12

2. JESD51-7

DS14694 - Rev 1 page 4/28

^{2.} Intended with the 3 pins of each OUTX connected together in the application board.

^{3.} Single pulse, not repetitive



Recommended operating

Recommended operating conditions

Table 4. Input switching limits

Symbol	Parameter	Value	Unit
f _{VIN(MAX)}	Maximum input switching frequency	10	kHz

page 5/28



5 Electrical characteristics

10.5 V < V_{CC} < 36 V; -40 °C < T_{J} < 125 °C; unless otherwise specified

5.1 Power section

Table 5. Power section

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
V _{CC}	Supply voltage		10.5		36	V
		IPS4140HQ, I _{OUT} = 0.5 A @T _J = 25 °C			0.08	
D		IPS4140HQ, I _{OUT} = 0.5 A			0.14	
R _{DS(on)} ON-state resistance	ON-state resistance	IPS4140HQ-1, I _{OUT} = 0.7 A @T _J = 25 °C			0.08	Ω
		IPS4140HQ-1, I _{OUT} = 0.7 A			0.14	
		All channels in OFF-state		0.25		mA
Is	V _{CC} supply current	All channels in ON-state, V _{IN14} = 5 V		2.4	4	mA
V _{CC} clamp	Clamp on V _{CC}	I _S = 20 mA	41	45	52	V
V _{OUT(OFF)}	OFF-state output voltage	V _{IN} = 0 V, I _{OUT} = 0 A, V _{CC} = 24V			1	V
I _{OUT(OFF)}	OFF-state output current	V _{IN} = V _{OUT} = 0 V, V _{CC} = 24V	0		5	μA
	IPS4140HQ output current at GND disconnection	V _{CC} = V _{IN} = V _{STAT} = V _{GND} = 24 V;			1.0	mA
current	IPS4140HQ-1 output current at GND disconnection	$V_{OUT} = 0 V$			0.5	mA
f _{CP}	Charge pump frequency	Channel in ON-state (1)		1.45		MHz

^{1.} To cover EN55022 class A and class B normative.

5.2 Switching

Table 6. Switching

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
t _{PD(L-H)}	Turn-on delay time		-	16	35	μs
t _r	Rise time		-	8	25	μs
t _{PD(H-L)}	Turn-off delay time	V_{CC} = 24 V, R _L = 48 Ω, input rise time < 0.1 μs, see Figure 3	-	21	36	μs
t _f	Fall time		-	4	12	μs
dV _(ON) /dt _r	Turn-on voltage slope		-	2	-	V/µs
dV _(OFF) /dt _f	Turn-off voltage slope		-	4	-	V/µs

DS14694 - Rev 1 page 6/28



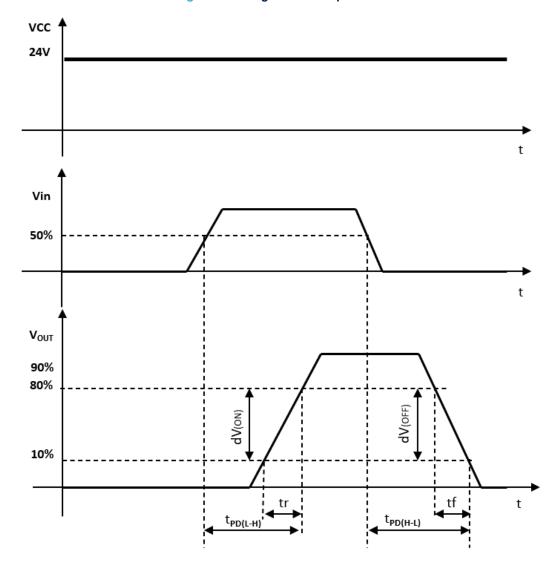


Figure 3. Timing in normal operation

5.3 Logic inputs

Table 7. Logic inputs

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
V _{IL}	Input low level voltage				0.8	V
V _{IH}	Input high level voltage		2.20			V
V _{I(HYST)}	Input hysteresis voltage			0.15		V
	1	V _{IN} = 15 V			10	
I _{IN} In	Input current	V _{IN} = 36 V			210	μA

DS14694 - Rev 1 page 7/28



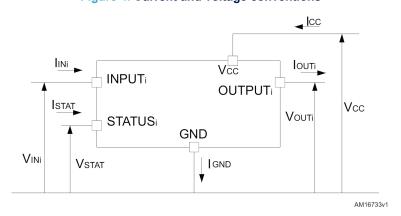
5.4 Protection and diagnostic

Table 8. Protection and diagnostic

Symbol	Parameter	Test conditions	Min.	Тур.	Max.	Unit
V _{STAT}	Status voltage output low	I _{STAT} = 1.6 mA			0.6	V
V _{USD}	Undervoltage protection		7		10.5	V
V _{USDHYS}	Undervoltage hysteresis		0.4	0.5		V
1	IPS4140HQ maximum DC output current	Dynamic load		1.3		Α
IPEAK	IPS4140HQ-1 maximum DC output current	- Dynamic load		1.6		A
1	IPS4140HQ, DC short-circuit current	V = 24 V B < 10 mO	0.7	1.0	1.7	Α
I _{LIM}	IPS4140HQ-1, DC short- circuit current	$V_{CC} = 24 \text{ V}, R_{LOAD} \le 10 \text{ m}\Omega$	1.1	1.5	2.6	A
I _{LSTAT}	Status leakage current	V _{CC} = V _{STAT} = 36 V		30		μA
T _{TSD}	Junction shutdown temperature		150	170	190	°C
T_{R}	Junction reset temperature		135			°C
T _{HYST}	Junction thermal hysteresis		7	15		°C
T _{CSD}	Case shutdown temperature		125	130	135	°C
T _{CR}	Case reset temperature		110			°C
T _{CHYST}	Case thermal hysteresis		7	15		°C
V _{DEMAG}	Output voltage at turn-OFF	I _{OUT} = 0.5 A; L _{LOAD} ≥ 1 mH	V _{CC} - 41	V _{CC} - 45	V _{CC} - 52	V

5.5 Current and voltage conventions

Figure 4. Current and voltage conventions



DS14694 - Rev 1 page 8/28



6 Truth table

Table 9. Truth table

Condition	Input _n	Output _n	Status _n
Normal operation	L	L	Н
Normal operation	Н	Н	Н
Quartamperatura	L	L	Н
Overtemperature	Н	L	L
	L	L	X
Undervoltage	Н	L	X
Output overload	L	L	Н
(current limitation before overtemperature)	Н	X	Н

Note: X = don't care

DS14694 - Rev 1 page 9/28



7 Typical application circuit

Vcc 100 n OUT Vcc IN 1 IN 2 IN 3 IN 4 LOAD1 OUT1 LOAD2 OUT2 IC $\mu \mathrm{C}$ Vdd LOAD3 OUT3 STAT 1 STAT 2 STAT 3 STAT 4 10k LOAD4 OUT4 10 n GND

Figure 5. Typical application circuit

DS14694 - Rev 1 page 10/28



8 Thermal management

The power dissipation in the IC is the main factor that sets the safe operating condition of the device in the application. Therefore, it must be considered very carefully. Furthermore, the available space on the PCB should be chosen considering the power dissipation. Heat sinking can be achieved using copper on the PCB with proper area and thickness. Two different protections have been implemented to guarantee safety of the device if it overheats due to an overloaded condition or high environment temperature. The following flowchart explains in detail this protection functionality.

OUT(i) On STAT(i) Off (H) 1 NO YES Tj(i) > Ttsd OUT(i) Off STAT(i) On (L) YES NO 2 Tc > Tcsd 4 YES NO Tc >Tar YES NO $T_{j}(i) > T_{j}r$ 3 GIPG030420151405LM

Figure 6. Thermal behavior

Note: 1 Thermal shutdown

2 Junction hysteresis

3 Restore to idle condition

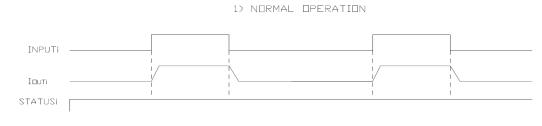
4 Case hysteresis

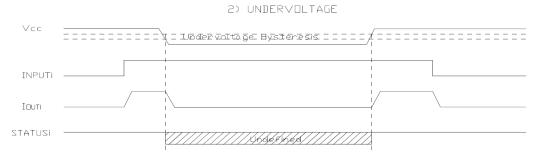
DS14694 - Rev 1 page 11/28

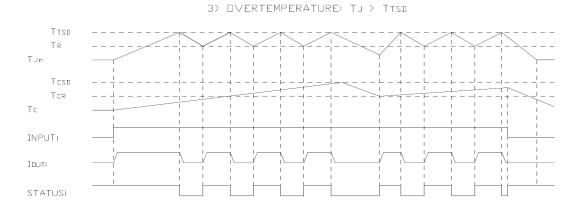


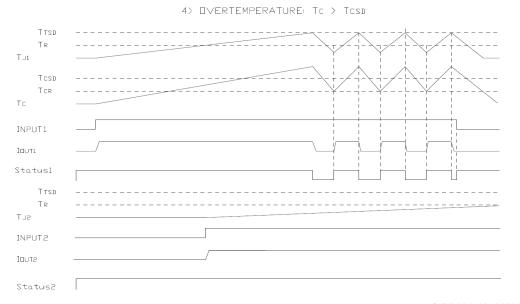
9 Switching waveforms

Figure 7. Switching waveforms









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DS14694 - Rev 1 page 12/28



10 Pin function description

Figure 8. Input circuit

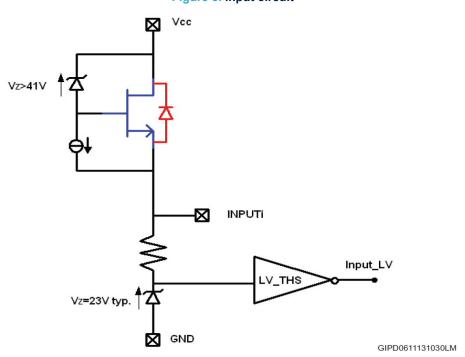
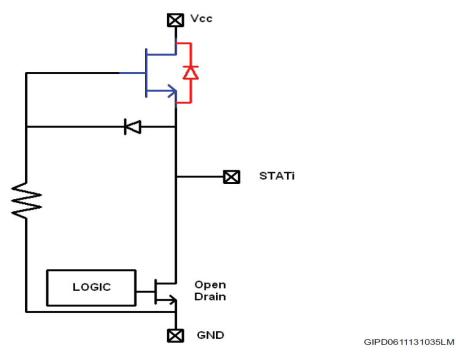


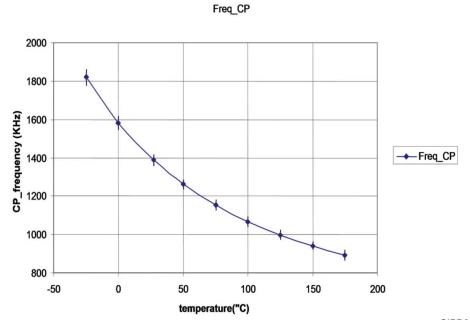
Figure 9. Status circuit



DS14694 - Rev 1 page 13/28



Figure 10. Charge pump switching frequency (typical) vs. temperature



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DS14694 - Rev 1 page 14/28



11 Thermal data

The power dissipation in the IC is the main factor that sets the safe operating condition of the device in the application. Therefore, it must be taken into account very carefully.

Heatsinking can be achieved using copper on the PCB with proper area and thickness.

The following image shows the junction-to-ambient thermal impedance values for the QFN48L 8x6 mm package referred to JEDEC conditions with 2s2p layers and thermal vias below the exposed pad.

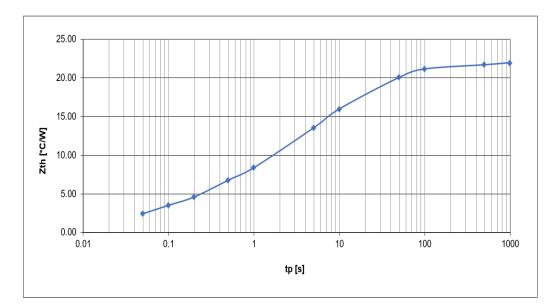


Figure 11. QFN48L 8x6 mm, thermal impedance

DS14694 - Rev 1 page 15/28



12 Reverse polarity protection

Reverse polarity protection can be implemented on-board using two different solutions:

- 1. Placing a resistor (R_{GND}) between IC GND pin and load GND
- 2. Placing a diode between IC GND pin and load GND

If option 1 is selected, the minimum resistance value has to be selected according to the following equation:

where I_{GND} is the DC reverse ground pin current and can be found in Section 3 of this datasheet.

Power dissipated by R_{GND} (when $V_{CC} < 0$: during reverse polarity situations) is:

$$P_D = (V_{CC})^2 / R_{GND}$$

If option 2 is selected, the diode has to be chosen by taking into account VRRM $>|V_{CC}|$ and its power dissipation capability:

$$P_D \ge I_S^*V_F$$

Note:

In normal conditions (no reverse polarity), due to the diode, there is a voltage drop between GND of the device and GND of the system.

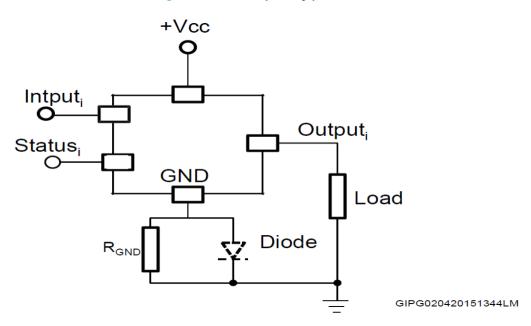


Figure 12. Reverse polarity protection

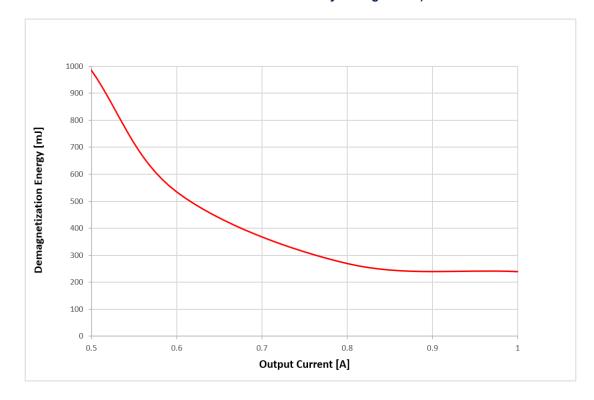
This schematic can be used with any type of load.

DS14694 - Rev 1 page 16/28



13 Demagnetization energy

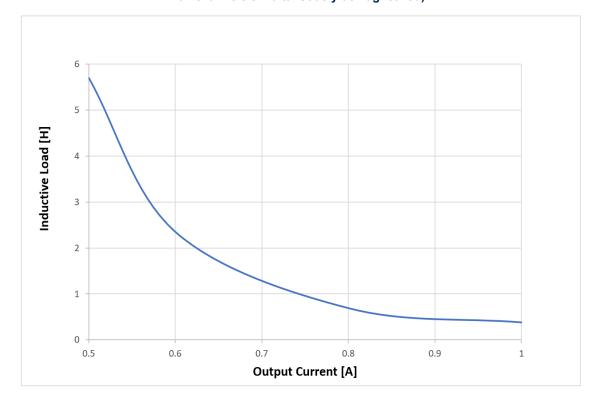
Figure 13. Typical single pulse (not repetitive) demagnetization: E_{OFF} vs I_{OUT} (V_{CC} = 24 V, T_{AMB} = 125 °C, all channels simultaneously demagnetized)



DS14694 - Rev 1 page 17/28



Figure 14. Typical single pulse (not repetitive) demagnetization: L_{LOAD} vs I_{OUT} (V_{CC} = 24 V, T_{AMB} = 125 °C, all channels simultaneously demagnetized)



DS14694 - Rev 1 page 18/28



14 Package information

To meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions, and product status are available at: www.st.com. ECOPACK is an ST trademark.

14.1 Package mechanical data

Figure 15. QFN48L 8x6 mm package dimensions

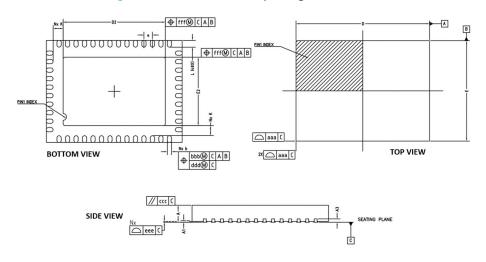


Table 10. QFN48L, mechanical data

Dim.		(mm)		
Dilli.	Min.	Тур.	Max.	
Α	0.80	0.85	0.90	
A1	0.00	-	0.05	
A3		0.20 REF.		
b	0.20	0.25	0.30	
D		8.00 BSC		
е	0.50 BSD			
E	6.00 BSC			
D2	5.97	6.02	4.07	
E2	3.97	4.02	4.07	
L	0.365	0.40	0.435	
k	0.53	-	-	
N		Tolerance of forms and positions	;	
aaa		0.10		
bbb		0.10		
ccc		0.10		
ddd	0.05			
eee		0.05		
fff		0.10		

DS14694 - Rev 1 page 19/28



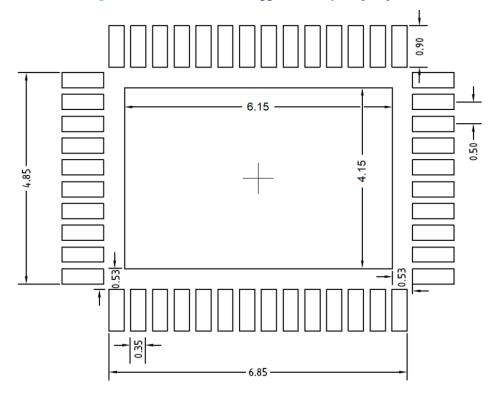


Figure 16. QFN48L 8x6 mm suggested footprint [mm]

Note:

STMicroelectronics is not responsible for any PCB related issues. The footprint shown in the above figure is a suggestion which might not be in line with the customer PCB supplier design rules.

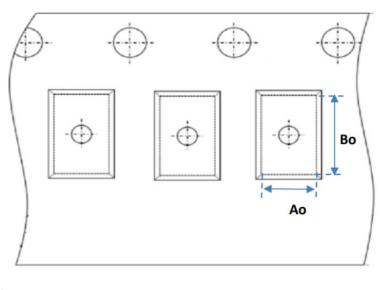
DS14694 - Rev 1 page 20/28



15

QFN48L, packing information

Figure 17. QFN48L reel shipment reference



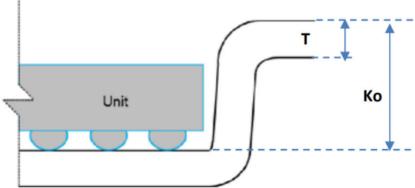


Table 11. Standard SPC parameters

Description	Value
Ao	Pocket Length
Во	Pocket Width
Ко	Pocket Depth
Т	Tape Thickness

DS14694 - Rev 1 page 21/28

QFN48L, packing

2.00±0.05 SEE NOTE 2

4.00 SEE NOTE 1

B

1.75±0.1

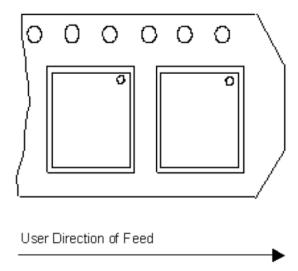
12.00±0.3

R0.30 MAX

Figure 18. QFN48L carrier tape dimensions [mm]



SECTION A-A



DS14694 - Rev 1 page 22/28



16 Ordering information

Table 12. Order codes

Order code	Package	Package marking	Packaging
IPS4140HQTR	QFN48L 8x6 mm	IPS4140HQ	Tape and reel
IPS4140HQTR-1	QI N40L 0X0 IIIIII	IPS4140HQ-1	Tape and reel

DS14694 - Rev 1 page 23/28



Revision history

Table 13. Document revision history

Date	Version	Changes
06-Dec-2024	1	Initial release.

DS14694 - Rev 1 page 24/28



Contents

1	Bloc	ck diagram	2
2	Pin	connection	3
3	Max	imum ratings	4
4	Rec	ommended operating conditions	5
5	Elec	etrical characteristics	6
	5.1	Power section	6
	5.2	Switching	6
	5.3	Logic inputs	7
	5.4	Protection and diagnostic	8
	5.5	Current and voltage conventions	8
6	Trut	h table	9
7	Турі	cal application circuit	.10
8	The	rmal management	.11
9	Swit	ching waveforms	.12
10	Pin	function description	.13
11	The	rmal data	.15
12	Rev	erse polarity protection	.16
13	Dem	nagnetization energy	.17
14	Pac	kage information	.19
	14.1	Package mechanical data	. 19
15	QFN	I48L, packing information	.21
16	Ord	ering information	.23
Rev	ision	history	.24
List	of ta	bles	.26
l iet	of fic	nires	27





List of tables

Table 1.	Pin description	. 3
Table 2.	Absolute maximum ratings	. 4
Table 3.	Thermal data	
Table 4.	Input switching limits	
Table 5.	Power section	
Table 6.	Switching	
Table 7.	Logic inputs	
Table 8.	Protection and diagnostic	
Table 9.	Truth table	. 9
	QFN48L, mechanical data	
	Standard SPC parameters	
Table 12.	Order codes	23
Table 13.	Document revision history	24

DS14694 - Rev 1 page 26/28





List of figures

Figure 1.	Block diagram	. 2
Figure 2.	Pin connection (top through view)	. 3
Figure 3.	Timing in normal operation	. 7
Figure 4.	Current and voltage conventions	. 8
Figure 5.	Typical application circuit	10
Figure 6.	Thermal behavior	11
Figure 7.	Switching waveforms	12
Figure 8.	Input circuit	13
Figure 9.	Status circuit	13
Figure 10.	Charge pump switching frequency (typical) vs. temperature	14
Figure 11.	QFN48L 8x6 mm, thermal impedance	15
Figure 12.	Reverse polarity protection	16
Figure 13.	Typical single pulse (not repetitive) demagnetization: E_{OFF} vs I_{OUT} (V_{CC} = 24 V, T_{AMB} = 125 °C, all channels simultaneously demagnetized)	17
Figure 14.	Typical single pulse (not repetitive) demagnetization: L_{LOAD} vs I_{OUT} (V_{CC} = 24 V, T_{AMB} = 125 °C, all channels simultaneously demagnetized)	18
Figure 15.	QFN48L 8x6 mm package dimensions	19
Figure 16.	QFN48L 8x6 mm suggested footprint [mm]	20
Figure 17.	QFN48L reel shipment reference	21
Figure 18.	QFN48L carrier tape dimensions [mm]	22
Figure 19.	QFN48L carrier tape, Pin 1 indication	22

DS14694 - Rev 1 page 27/28



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DS14694 - Rev 1 page 28/28