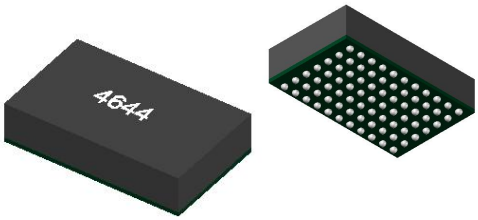
4-channel DC/DC, each output 4A, 4-channel parallel 16A
All-in-one molded and sealed adjustable buck power supply module



1 Features

- **4A continuous full load output current per circuit, up to 5.5A peak**
- **Wide input voltage range: 4.0V to 15V**
- **Output voltage range: 0.8V to 5.5V**
- **Switching Frequency: Typical 1 MHZ, automatically adjustable with input/output**
- **Up to 92% Efficiency**
- **Internal 1mS soft-start (additional external 1mS optional)**
- **±2% of total output voltage regulation**
  - **Over-current protection, over-temperature protection, over-voltage protection, under-voltage protection**
- **Flat and small size:**

  LGA package(9mm*15mm*1.82mm)

2 Applications

- **Multi-rail point-of-load adjustment; CPU and GPU power supply**
- **Power supply for ASIC chips such as CPLDs, DSPs, and FPGAs**

3 Description

The FHT4644L is a non-isolated buck-type integrated molded plastic encapsulated power supply suitable for embedded high-current load points. With its compact size of only 9×15×1.82mm, it can be directly placed next to FPGA/CPU, making it ideal for applications requiring low output voltage and multiple circuits.

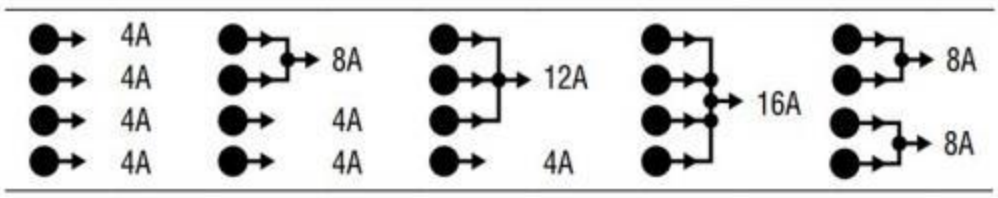
Small-sized LGA and BGA packages integrate ICs, inductors, and corresponding components, allowing for the rapid completion of multi-channel power supply system design with only a few external components: a voltage-regulating resistor and a couple of input and output ceramic capacitors. This simplifies system design and maximizes PCB space savings.

Designed based on synchronous rectification Buck topology, it can deliver a maximum of 4A per channel with high power conversion efficiency. It supports voltage conversion from 4.0V to 15V to 0.8V to 5.5V and provides four-channel ON/OFF control and four-channel Power Good signals. Additionally, it features comprehensive protection functions including OCP (Over Current Protection), OVP (Over Voltage Protection), UVP (Under Voltage Protection), OTP (Over Temperature Protection), and SCP (Short Circuit Protection).

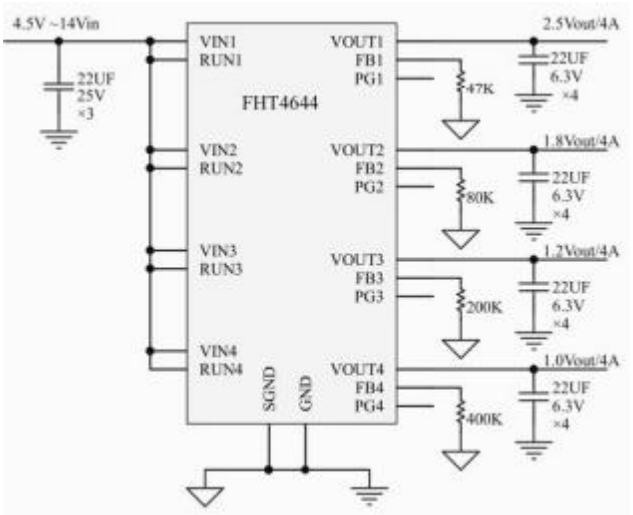
The four output channels of the FHT4644L can be used in parallel, and the power modules can also be paralleled among each other.

Typical Applications

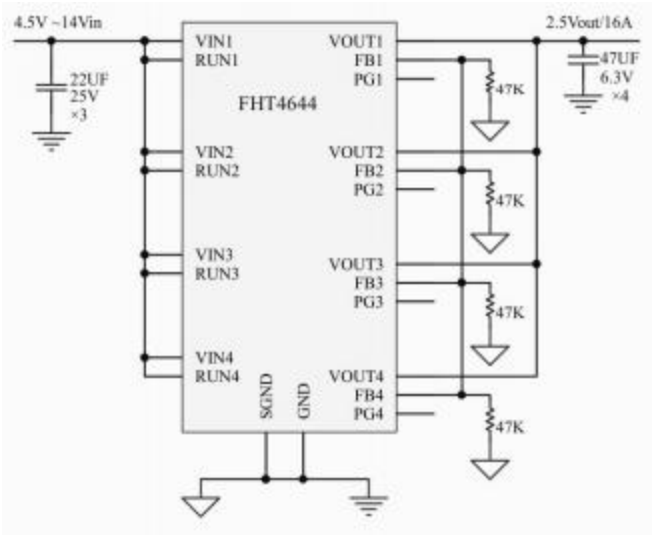
Configurable output array



Quad Output Application Circuit



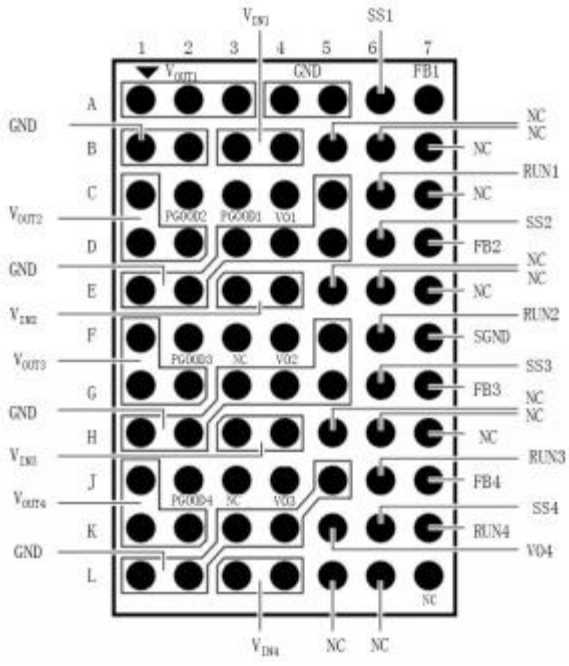
Non-parallel applications



Parallel

PIN CONFIGURATION

TOP VIEW



PIN CONFIGURATION

Pin	Description
V_{OUT1} (A1,A2,A3), V_{OUT2} (C1,D1,D2), V_{OUT3} (F1,G1,G2), V_{OUT4} (J1,K1,K2),	Power Module Quad Output Pins
V_{IN1} (B3,B4),V_{IN2} (E3,E4),V_{IN3} (H3,H4),V_{IN4} (L3,L4)	Power Module Quad Input Pins
GND (A4,A5, B1,B2, C5, D3,D4,D5, E1,E2, F5, G3,G4,G5,) h1, h2, j5, k3, k4, l1, l2)	ground pin
fb1 (a7), fb2 (d7), fb3 (g7), fb4 (j7)	Four output voltage adjustment pins to which 0.5% accuracy regulator resistors can be connected to GND.
run1 (c6), run2 (f6), run3 (j6), run4 (k7)	Four-way enable pin, can be directly connected to the input voltage, can also be connected to an external power supply to control the power module, the minimum enable starting voltage of 1.1V, when the enable voltage is lower than 0.95V, the power supply shutdown. It is recommended that this pin should not be left idle when the enable voltage is greater than 1.2V.
pgood1 (c3), pgood2 (c2), pgood3 (f2), pgood4 (j2)	Fault indication pin, PG=high means VOUT is within the voltage range, PG=low means VOUT is below the specified value. This PGOOD pin can be connected to a 100K resistor to the VO pin, can also be connected to other voltage supply to the PGOOD, when the PGOOD is set to low means that the power module is abnormal (the abnormalities include UV, OV, OC, OT, etc.) If you do not need to indicate the function of the fault, do not add this resistor, PGOOD can be left empty.
VO1 (C4), VO2 (F4), VO3 (J4), VO4 (K5)	VO can be used as PG power supply pin, four sets of VO have been connected to four outputs inside the power module respectively, i.e. VO1=VOUT1,VO2=VOUT2, VO3=VOUT3, VO4=VOUT4.
MODE1(B6), MODE2(E6), MODE3(H6), MODE4(L6)	The FHT4644L is a vacant pin with no electrical function, and can be connected to any pin. (The FHT4644L's operating frequency and mode can be automatically adjusted to a typical operating frequency of 1MHz.)
SGND (F7)	For signal ground, it is recommended that GND (power ground) and SGND be wired separately and eventually connected with a 0 ohm resistor.
SS1 (A6), SS2 (D6), SS3 (G6), SS4 (K6)	External soft start pin, external 3.3nF ceramic capacitor can be connected to signal ground, if there is no need to increase the external soft start function, this capacitor can not be added, SS pin is empty.
NC (E7, H7, L7, C7, L5, H5, E5, B5, J3, F3)	Empty pin, no electrical function, can be connected to any pin.

Electrical Characteristics

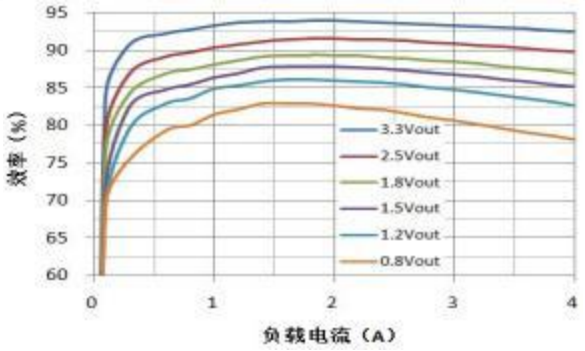
Absolute Maximum Ratings	Condition	Minimum value	Nominal value	Maximum value	Unit
VIN (each way)		-0.3		17	V
FB, VOUT (each way)		-0.3		7	V
PGOOD (each way)		-0.3		12	V
PGOOD current (each way)				10	mA
VO, SS/TR (each way)		-0.3		7	V
RUN (each way)		-0.3		17	V
Storage temperature		-55		150	℃
Reflow temperature				245	℃
Input Characteristics	**Condition**	**Minimum value**	**Nominal value**	**Maximum value**	**Unit**
Input Voltage Range		4.0	12	14	V
Power-on voltage threshold			3.95		V
Shutdown Voltage Threshold		3.5	3.6	3.9	V
Input current at full load	VIN =12V, VOUT =1.5V, IOUT =4A		0.6		A
Input current at low voltage full load	VIN =5V, VOUT =1.5V, IOUT =4A		1.5		A
Input current at no load	VIN =12V, VOUT =1.5V, IOUT =0A		650		μA
Static Input Current	ON/OFF=OFF		15		μA
General Requirements	**Condition**	**Minimum Value**	**Nominal Value**	**Maximum Value**	**Unit**
Switching Frequency	Automatic Adjustment		1000		KHz
Efficiency	Vin=5V , Vout=3.3V			92	%
Soft Start Time	SS pin with 3.3nF ceramic capacitor		2		ms
Enable	**Condition**	**Minimum value**	**Nominal value**	**Maximum value**	**Unit**
RUN enable voltage		1.2	-	14	V
Output Characteristics	**Condition**	**Minimum value**	**Nominal value**	**Maximum value**	**Unit**
Output Voltage Range	Adjusted by FB pin resistor	0.8		5.5	V
Output Voltage	CIN = 22μF, COUT = 22uF×4, VIN = 4V to 15V, IOUT = 0A to 4A	1.47	1.5	1.53	V
Linear Regulation	V_{OUT} = 1.5V , 4V < V_{IN} < 15V , I_{LOAD} = 4A			±0.5	%
Load Regulation	V_{IN} =12V , V_{OUT} =1.5V,1A < I_{LOAD} ≤ 4A			±1	%
Ripple and Noise	V_{IN} =12V , V_{OUT} =1.5V , I_{OUT} =4A, C_{out} =22uF×4 , 20MHz bandwidth		10	50	mV
Dynamic Load Response	75-100% full load, di/dt = 1A/μS C_{out} =22uF×4		50, 40		mV , μs

Electrical Characteristics

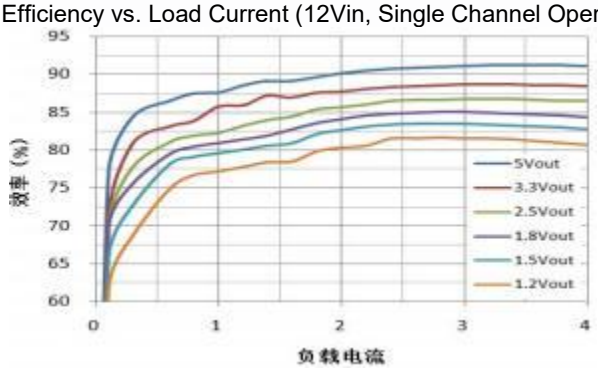
Output Characteristics	Condition	Minimum value	Nominal value	Maximum value	Unit
Output Overcurrent Protection	Iout%	115	120	125	%
Output Overvoltage Protection	Vout%	115	115	130	%
Over-Temperature Protection	Case temperature (Tc)	-	-	135	℃
Structural Characteristics	**Conditions**	**Minimum Value**	**Nominal value**	**Maximum value**	**Unit**
Packaging	LGA, BGA	-	-	-	-
Size	lga: 9*15*1.82; bga: 9*15*2.42	-	-	-	mm
Weights			1.6		g
Environmental Adaptability	**Condition**	**Minimum value**	**Nominal value**	**Maximum value**	**Unit**
Operating temperature (Case temperature)		-55		125	℃
High temperature storage (ambient temperature)	+125°C, 48h			125	℃
High temperature operation (ambient temperature)	+85°C, 24h; Input low voltage, standard voltage, load derating, high voltage each 8h			85	℃
Low temperature storage (ambient temperature)	-55°C, 24h	-55			℃
Low temperature operation (ambient temperature)	-55°C, 24h; Input low pressure, standard pressure, high pressure each 8h	-55			℃
Damp heat	High temperature/high humidity stage: 60℃, 95%; Low temperature/high humidity stage: 30℃, 95%; 10 cycles of 24h each.	30		60	℃
Thermal shock	High temperature 125 ℃, low temperature -55 ℃, high and low temperature for an hour for a cycle, a total of 32 test cycles	-55		125	℃

NOTE : Stresses above the values listed in the "Limit Values" section may cause permanent damage to the device. Prolonged exposure to any of the absolute maximum ratings may affect the reliability and life of the device.

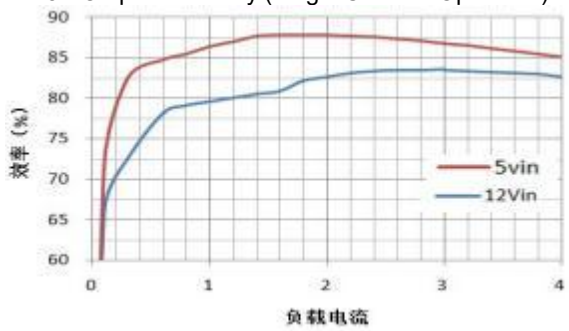
Efficiency vs. Load Current (5Vin, Single Channel Operation)



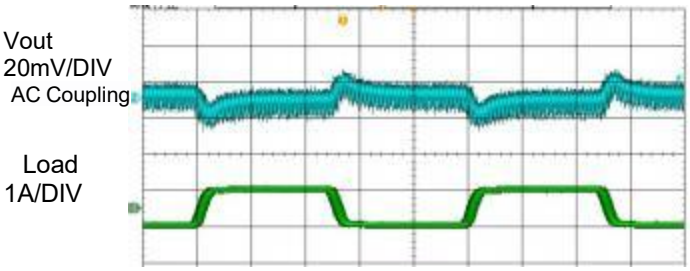
Efficiency vs. Load Current (12Vin, Single Channel Operation)



1.5V Output Efficiency (Single Channel Operation)



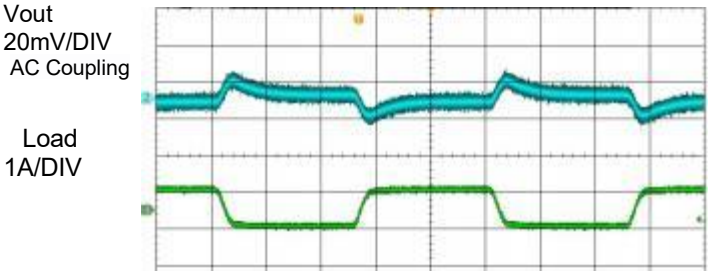
Dynamic Load Response at 1.0V



40us/DIV

Vin=12V,Vout=1.0V,Iout=3A-4A,1A/us Output capacitance=4*22uF+0.1uF ceramic capacitor

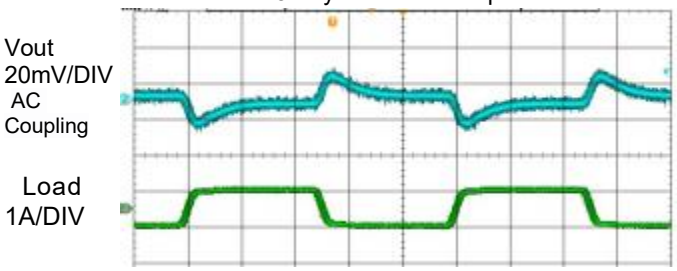
1.5V dynamic load response



40us/DIV

Vin=12V,Vout=1.5V,Iout=3A-4A,1A/us Output capacitance=4*22uF+0.1uF ceramic capacitor

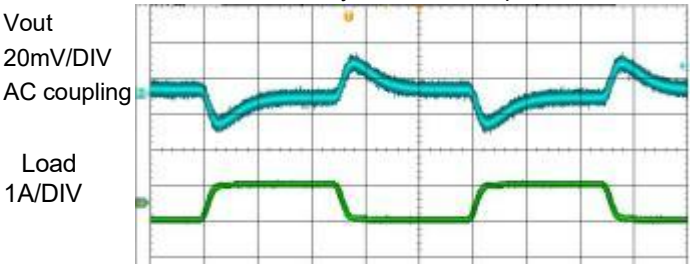
2.5V dynamic load response



40us/DIV

Vin=12V,Vout=2.5V,Iout=3A-4A,1A/us Output capacitance=4*22uF+0.1uF ceramic capacitor

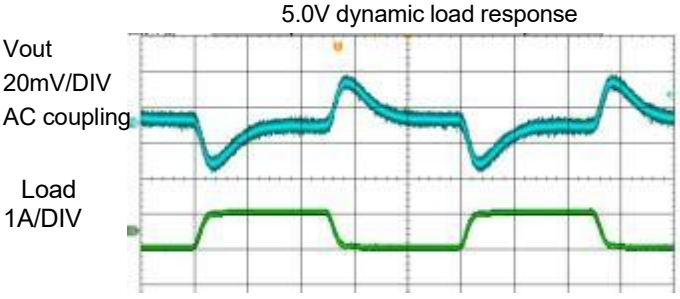
3.3V dynamic load response



40us/DIV

Vin=12V,Vout=3.3V,Iout=3A-4A,1A/us Output capacitance=4*22uF+0.1uF ceramic capacitor

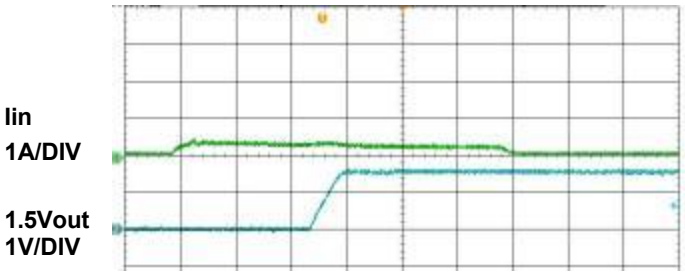
5.0V dynamic load response



40us/DIV

Vin=12V,Vout=5V,Iout=3A-4A,1A/us Output capacitance=4*22uF+0.1uF ceramic capacitor

Output start-up - no load

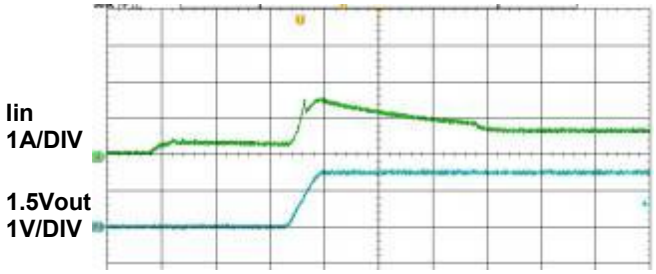


2ms/DIV

Vin=12V,Vout=1.5V,Iout=0A

Input capacitance = 150uF electrolytic capacitor + 4*22uF + 0.1uF ceramic capacitor Output capacitance = 4*22uF + 0.1uF ceramic capacitor

Output start-up - 4A load

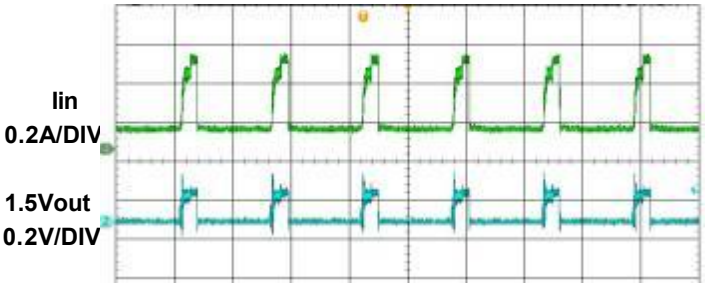


2ms/DIV

Vin=12V,Vout=1.5V,Iout=4.0A

Input capacitance = 150uF electrolytic capacitor + 4*22uF + 0.1uF ceramic capacitor Output capacitance = 4*22uF + 0.1uF ceramic capacitor

Output shorted-no load (normal, hiccup mode)



4ms/DIV

Vin=12V,Vout=1.5V,Iout=0A

Input capacitance = 150uF electrolytic capacitor + 4*22uF + 0.1uF ceramic capacitor Output capacitance = 4*22uF + 0.1uF ceramic capacitor

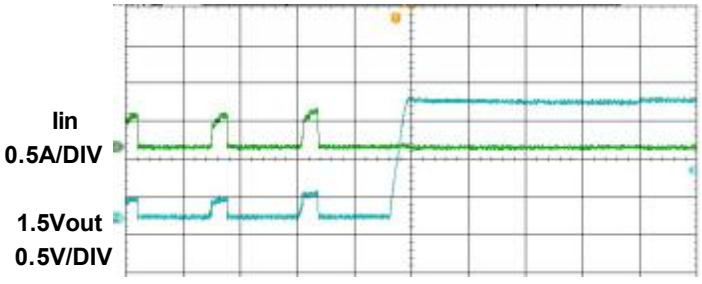
Output shorted-4A load (normal hiccup mode)

4ms/DIV

Vin=12V,Vout=1.5V,Iout=4.0A

Input capacitance = 150uF electrolytic capacitor + 4*22uF + 0.1uF ceramic capacitor Output capacitance = 4*22uF + 0.1uF ceramic capacitor

Output Short Circuit Removal - No Load (Transient, Hiccup Mode)

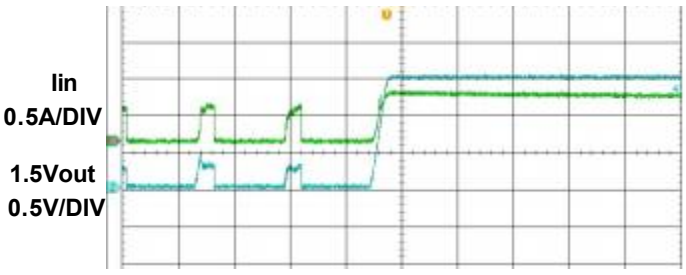


4ms/DIV

Vin=12V,Vout=1.5V,Iout=0A

Input capacitance = 150uF electrolytic capacitor + 4*22uF + 0.1uF ceramic capacitor Output capacitance = 4*22uF + 0.1uF ceramic capacitor

Output Short Circuit Removal - 4A Load (Transient, Hiccup Mode)

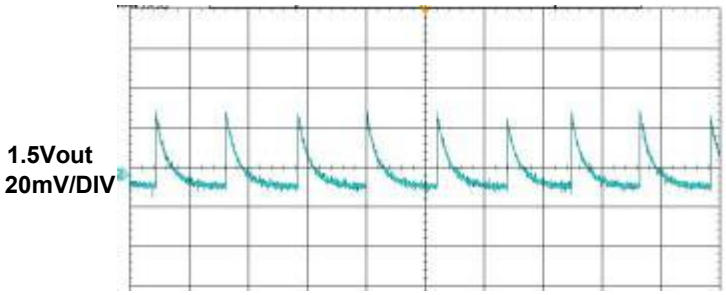


4ms/DIV

Vin=12V,Vout=1.5V,Iout=4.0A

Input capacitance = 150uF electrolytic capacitor + 4*22uF + 0.1uF ceramic capacitor Output capacitance = 4*22uF + 0.1uF ceramic capacitor

1.5V output ripple - no load

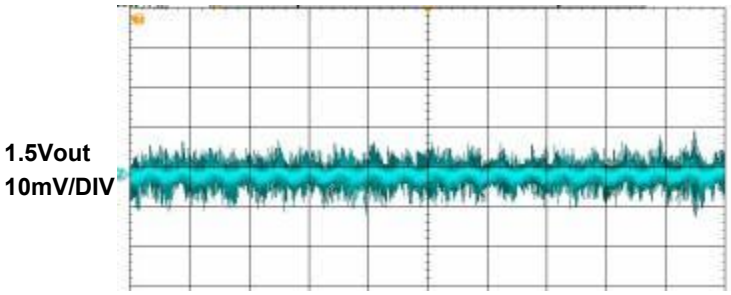


100ms/DIV

Vin=12V,Vout=1.5V,Iout=0A

Input capacitance = 4*22uF+0.1uF ceramic capacitor
Output capacitance = 4*22uF+0.1uF ceramic capacitor
20MHZ bandwidth limitation

1.5V Output Ripple - 4A Load

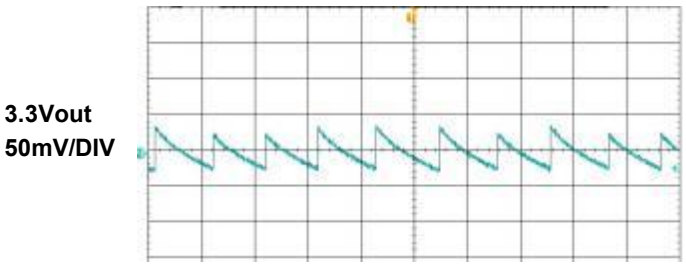


2us/DIV

Vin=12V,Vout=1.5V,Iout=4.0A

Input capacitance=4*22uF+0.1uF ceramic capacitance Output capacitance=4*22uF+0.1uF ceramic capacitance 20MHz bandwidth limitation

3.3V output ripple-no load

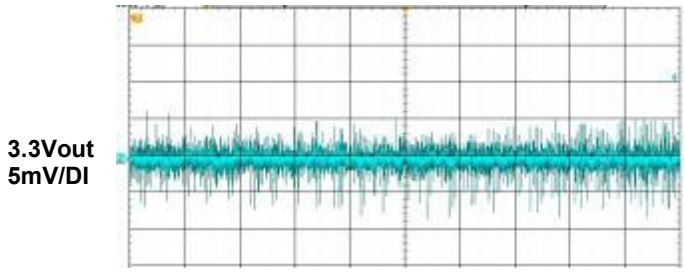


20ms/DIV

Vin=12V,Vout=3.3V,Iout=0A

Input capacitance = 4*22uF+0.1uF ceramic capacitor Output capacitance = 4*22uF+0.1uF ceramic capacitor 20MHZ bandwidth limitation

3.3V output ripple-4A load

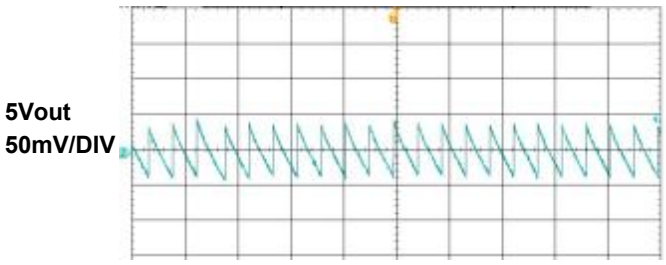


100us/DIV

Vin=12V,Vout=3.3V,Iout=4.0A

Input capacitance=4*22uF+0.1uF ceramic capacitance Output capacitance=4*22uF+0.1uF ceramic capacitance 20MHz bandwidth limitation

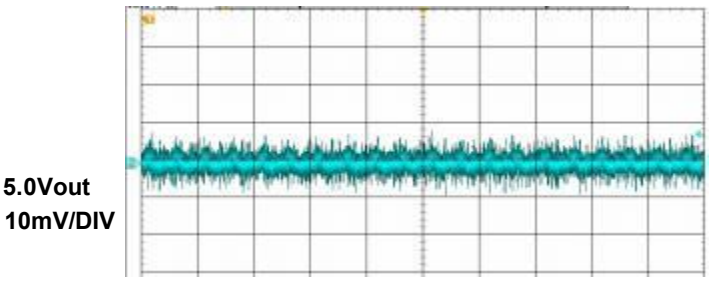
5V Output Ripple-No Load



Vin=12V,Vout=5.0V,Iout=0A

Input capacitance = 4*22uF+0.1uF ceramic capacitor Output capacitance = 4*22uF+0.1uF ceramic capacitor 20MHZ bandwidth limitation

5V Output Ripple-4A Load



100us/DIV

Vin=12V,Vout=5.0V,Iout=4.0A

Input capacitance=4*22uF+0.1uF ceramic capacitance Output capacitance=4*22uF+0.1uF ceramic capacitance 20MHz bandwidth limitation

Operation

The FHT4644L is a four-channel independently outputting, non-isolated DC/DC switching voltage regulator. It boasts four individual regulator channels, each capable of delivering up to 4A of continuous output current with minimal external input and output capacitance required. Across an input voltage range of 4.0V to 15V, each voltage regulator channel can provide a precisely adjustable output voltage, ranging from 0.8V to 5.5V, via an external resistor.

RUN Start

Pulling the RUN pin of each voltage regulator channel to ground forces the regulator into a shutdown state, turning off the power MOSFET and most of the internal control circuits. Placing the RUN pin above 0.7V only turns on the internal reference while still keeping the power MOSFET off. Increasing the RUN pin voltage further to above 1.2V will turn on the entire voltage regulator channel.

Output Voltage Setting

Internally in the FHT4644L, the FB pin is connected to the VOUT terminal of each channel through a 100kΩ precision resistor. The output voltage of this module can be controlled by programming the resistance between the FB and GND pins. The calculation is shown below: The reference calculation formula is as follows:

Note: It is recommended to reserve two resistor positions with a precision of 0.5% for fine-tuning the output voltage. The following formula is the calculation formula for the output voltage adjustment resistor:

$$R_{FB}(K) = \frac{100k}{\frac{Vout}{0.8} - 1}$$

Table 1 below shows the relationship between the R_{FB} resistance and each output voltage.

V_{OUT} (V)	R_{FB} (kΩ)	V_{OUT} (V)	R_{FB} (kΩ)
0.8	Open	1.8	80
1.0	400	2.5	47.06
1.2	200	3.3	32
1.5	114.3	5.0	19.05

Table 1 R_{FB} resistor versus each output voltage

Soft Start

The module has a built-in soft-start and an external soft-start pin is available. Connecting a ceramic capacitor of about 3.3nF can increase the delay time.
Input under-voltage protection
Under-voltage lockout when VIN drops below 3.7V.
Note: If the input wires are relatively long, due to the presence of line voltage drop, it is necessary to ensure that the voltage at the input pins of the module is greater than 4.0V to guarantee normal output.

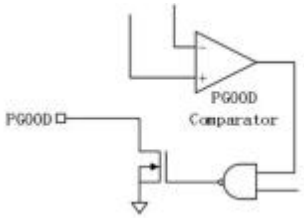
Output over-current protection

When the output current exceeds the current limit value, the FHT4644L enters the protection state. When the output current returns to the normal range, the converter enters the normal operation state.

Power Good

The PGOOD pin is an open-drain pin that can be used to monitor each valid output voltage. When Vout falls below the threshold voltage set for the output voltage, PGOOD goes high. It can also be used to monitor protection functions such as UVLO (Under Voltage Lock Out) and OTP (Over Temperature Protection). By pulling up the resistor to a specific supply voltage, monitoring can be achieved.

The following is a schematic diagram of the PG circuit, and Table 2 presents the PGOOD pin logic table:



PGOOD Circuit

Monitoring item	Prerequisite	PG status
UVLO	0.7V < VIN < VUVLO	low level
Power on (RUN=High)	VFB≥VTH_PG	high level
	VFB≤VTH_PG	low level
Shutdown (RUN=Low)		low level
Temperature protection shutdown	TJ>TSD	low level
Power Removal	VIN<0.7V	high level

Note: V_{FB} is the voltage feedback pin voltage, V_{TH_PG} is the PGOOD threshold voltage, T_J is the junction temperature, and T_{SD} is the temperature during power protection shutdown.

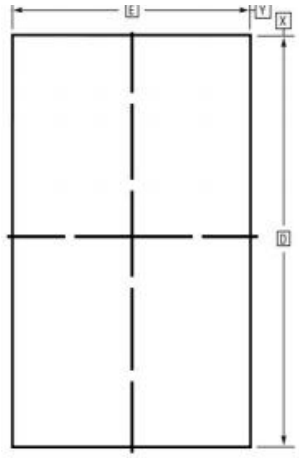
Table 2 PGOOD pin schematic diagram

Over-temperature Protection

When the case temperature of the FHT4644L rises above 135°C, it enters the over-temperature protection state.

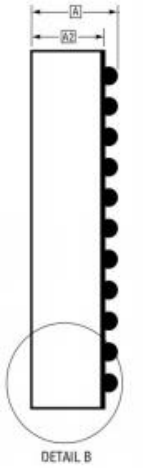
Package Description (77 pins)

LGA package (9mm x 15mm x 1.82mm)
BGA package (9mm x 15mm x 2.42mm)

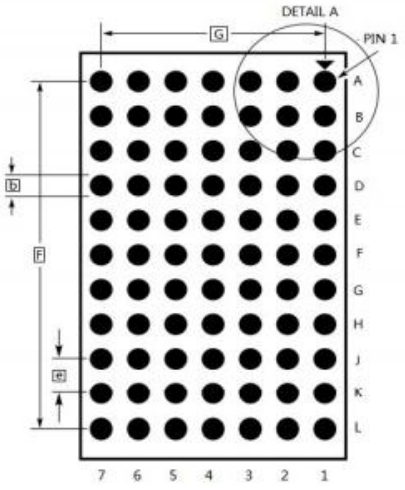


TOP VIEW

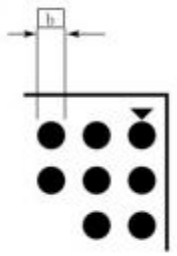
LGA SIDE VIEW



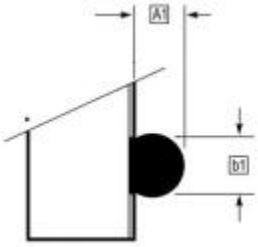
BGA SIDE VIEW



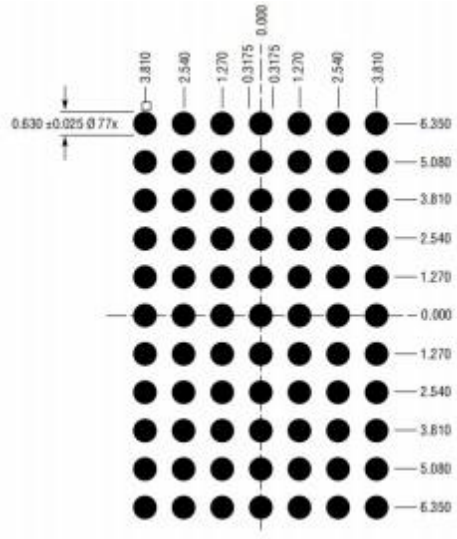
BOTTOM VIEW



DETAIL A



DETAIL B



TOP VIEW
(PCB LAYOUT recommended size)

LGA Size

SYMBOL	MIN	NOM	MAX
A2	1.62	1.82	2.02
b	0.60	0.70	0.90
D	14.8	15	15.2
E	8.8	9	9.2
e		1.27	
F		12.70	
G		7.62	

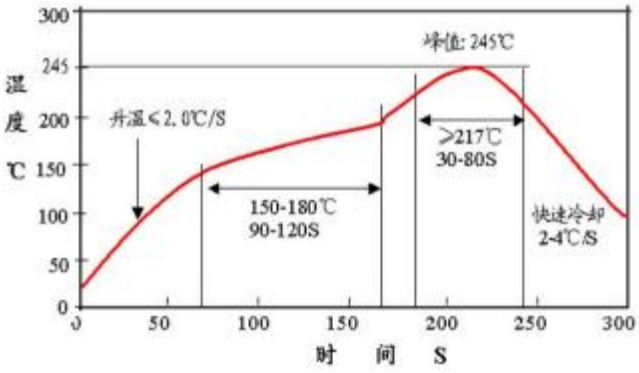
BGA Size

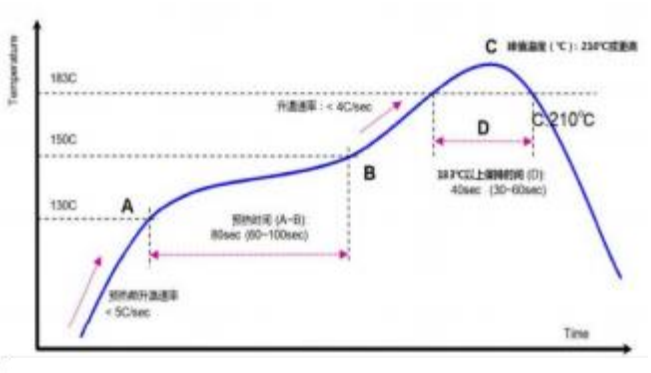
SYMBOL	MIN	NOM	MAX
A	2.22	2.42	2.62
b	0.60	0.75	0.90
A1	0.50	0.60	0.70
b1	0.60	0.63	0.66
D	14.8	15	15.2
E	8.8	9	9.2
e		1.27	
F		12.70	
G		7.62	

Soldering and Storage Precautions

For lead-free BGA solder ball products, the peak temperature should not exceed 245℃; For leaded BGA solder ball products, the peak temperature should not exceed 225℃.

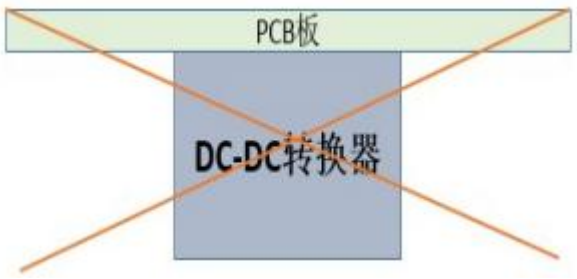
Recommended reflow soldering profile for reference recommended curves for reference:





Lead Free Processes Leaded Processes

Caution:



1.Due to the large size of the module, please do not place the module under the board for reflow soldering to avoid falling off.

2.For bulk products and those that have been taken out of their original packaging, they should be stored in a desiccator (with a relative humidity of less than 10% inside). For products still in their original packaging, they should also be stored in a desiccator whenever possible.

3.Before mounting on the board, it is necessary to strictly follow the baking conditions to dry the samples: bake at 125°C for more than 48 hours.

Ordering Information

Product Model	Input		Output		Efficiency	Enable Voltage	Packaging	Grade	Temperature range (Case temperature)	Packaging
	Input Range	Nominal Input	Output range	Nominal Output						
FHT4644LIY	4.0-15V	12V	0.8-5.5V	5.0, 3.3, 2.5,1.5V	92%	1.2-15V	BGA (leaded)	industrial grade	-40-125°C	Tray
FHT4644LIY#PBF	4.0-15V	12V	0.8-5.5V	5.0, 3.3, 2.5,1.5V	92%	1.2-15V	BGA (lead-free)	industrial grade	-40-125°C	Tray
FHT4644LIV#PBF	4.0-15V	12V	0.8-5.5V	5.0, 3.3, 2.5,1.5V	92%	1.2-15V	LGA (lead-free)	industrial grade	-40-125°C	Tray
FHT4644LMY	4.0-15V	12V	0.8-5.5V	5.0, 3.3, 2.5,1.5V	92%	1.2-15V	BGA (leaded)	general military grade	-55-125°C	Tray
FHT4644LMY#PBF	4.0-15V	12V	0.8-5.5V	5.0, 3.3, 2.5,1.5V	92%	1.2-15V	BGA (lead-free)	general military grade	-55-125°C	Tray
FHT4644LMV#PBF	4.0-15V	12V	0.8-5.5V	5.0, 3.3, 2.5,1.5V	92%	1.2-15V	LGA (lead-free)	general military grade	-55-125°C	Tray