JWH5125

65V/5A Asynchronous Step-Down Converter

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

The JW®H5125 is a current mode monolithic buck switching regulator. Operating with an input range of 4.7V~65V, the JWH5125 delivers 5A of continuous output current with an integrated high side N-Channel MOSFET. At light loads, the regulator operates in low frequency to maintain high efficiency. Current mode control provides tight load transient response and cycle-by-cycle current limit.

The JWH5125 guarantees robustness with short-circuit protection, thermal protection, current run-away protection, and input under voltage lockout.

The JWH5125 is available in DFN4x4-10 package, which provides a compact solution with minimal external components.

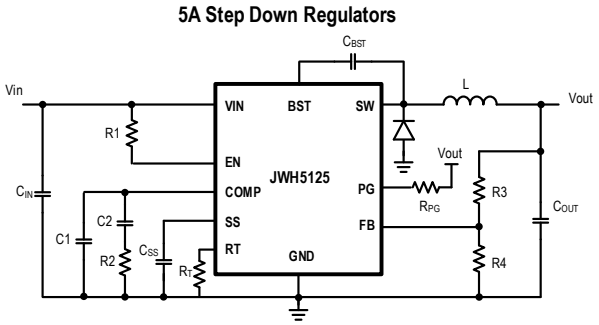
FEATURES

- 4.7V to 65V operating input range
  5A output current
- 0.8V±1% internal voltage reference
- Adjustable soft-start
- Adjustable switching frequency
- UV and OV power good indicator
- Adjustable UVLO and hysteresis
- Current run-away protection
- Short circuit protection
- Thermal protection
- Available in DFN4x4-10 package

APPLICATIONS

- Industrial Automation and Motor Control
- Vehicle Accessories: GPS Entertainment
- USB Dedicated Charging Ports and Battery Chargers
- 12-V, 24-V and 48-V Industrial, Automotive and Communications Power Systems

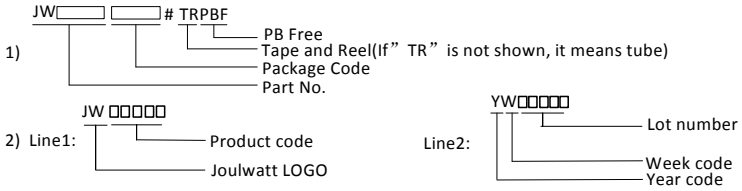
TYPICAL APPLICATION



ORDER INFORMATION

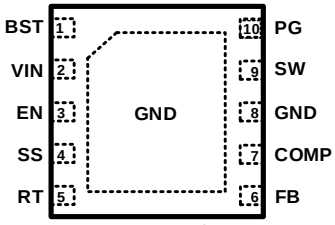
DEVICE[1)]	PACKAGE	TOP MARKING[2)]
JWH5125DFNM#TRPBF	DFN4x4-10	JWH5125 YW□□□□□

Notes:



PIN CONFIGURATION

TOP VIEW



DFN4x4-10

ABSOLUTE MAXIMUM RATING[1)]

VIN, SW Pin ..... -0.3V to 72V
EN Pin ..... -0.3V to 8.4V
BST Pin ..... SW-0.3V to SW+6V
COMP, SS Pin..... -0.3V to 3V
All Other Pins ..... -0.3V to 6V
Junction Temperature[2)] 150ºC
Lead Temperature 260ºC
Storage Temperature ..... -65ºC to +150ºC

RECOMMENDED OPERATING CONDITIONS[3)]

Input Voltage V_{IN} .....4.7V to 65V
Output Voltage Vout.....0.8V to Dmax x VIN
Operating Junction Temperature .....-40ºC to 125ºC

THERMAL PERFORMANCE[4)]

	θ_{JA}	θ_{Jc}
DFN4x4-10	36	3ºC/W

Note：

1) Exceeding these ratings may damage the device. These stress ratings do not imply function operation of the device at any other conditions beyond those indicated under RECOMMENDED OPERATING CONDITIONS.

2) The JWH5125 includes thermal protection that is intended to protect the device in overload conditions. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.

3) The device is not guaranteed to function outside of its operating conditions.

4) Measured on JESD51-7, 4-layer PCB

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A = 25 ºC, unless otherwise stated.

Item	Symbol	Condition	Min.	Typ.	Max.	Units
V_{IN} Under voltage Lockout Threshold	V_{IN_MIN}	V_{IN} rising		4.4		V
V_{IN} Under voltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$			200		mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V		4		μA
Supply Current	I_Q	V_{EN}=5V, V_{FB}=1V		180		μA
Feedback Voltage	V_{FB}	4.7V≤V_{VIN}≤60V, T_J =-40 ºC ~125 ºC		800		mV
Power Switch Resistance	$R_{DS(ON)}$			97		mΩ
Power Switch Leakage Current	I_{LEAK}	V_{IN}=60V, V_{EN}=0V, V_{SW}=0V			6	uA
Current Limit Threshold	I_{LIM}	T_J =-40 ºC ~125 ºC		7.2		A
Error Amplifier Transconductance	g_M			285		uA/V
Error Amplifier DC Gain[5)]	Gain			1000		V/V
Error Amplifier Source/Sink	I_{EA}			±37		uA
COMP to SW Current Transconductance[5)]	g_{CS}			18		A/V
Switch Frequency	f_{SW}	R_{RT}=200k		414		kHz
Switch Frequency Range			100		2000	kHz
Minimum On Time[5)]	T_{ON_MIN}			100		ns
Minimum Off Time	T_{OFF_MIN}	V_{FB}=0V		165		ns
Soft-Start Charge Current	I_{SS}			1.8		uA
Power Good Lower Threshold	PGD_{LTH}	FB rising		93%		V_{REF}
		FB falling		90%		V_{REF}
Power Good Upper Threshold	PGD_{UTH}	FB rising		108%		V_{REF}
		FB falling		106%		V_{REF}
Power Good Sink Current	I_{PG}	V_{PG}=0.4V	1			mA
EN shut down threshold voltage	V_{EN_TH}	V_{EN} rising, FB=0.6V		1.22		V
EN shut down hysteresis	V_{EN_HYST}			100		mV
Thermal Shutdown[5)]	T_{TSD}			170		°C
Thermal Shutdown hysteresis[5)]	T_{TSD_HYST}			20		°C

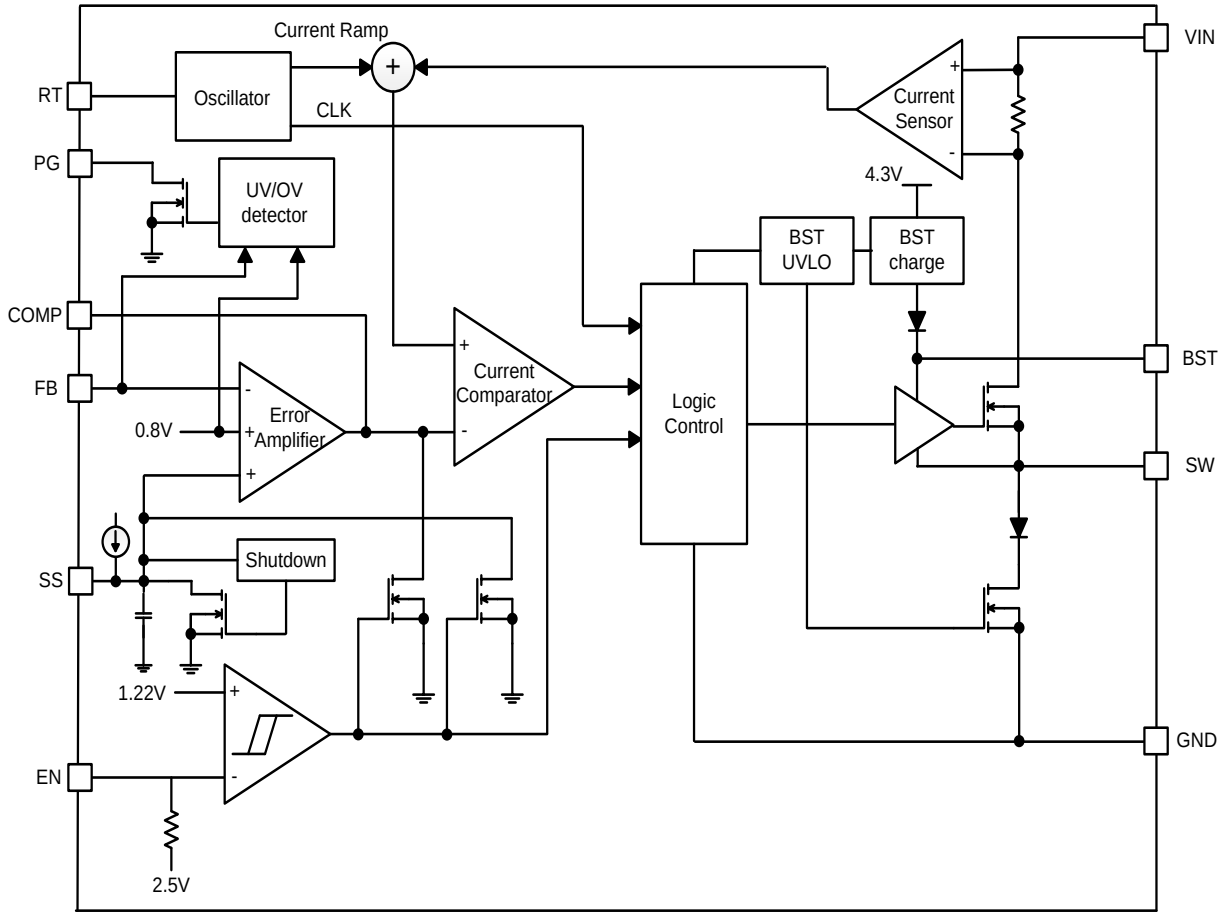
Note：

5) Guaranteed by design.

PIN DESCRIPTION

Pin DFN4X4-10	Name	Description
1	BST	Bootstrap pin for top switch.
2	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 4.7V to 65V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
3	EN	Drive EN pin high or floating to turn on the regulator and low to turn off the regulator.
4	SS	Soft-start control pin. Leave floating for internal soft-start slew rate. Connect to a capacitor to extend soft start time.
5	RT	Switching frequency program. Connect an external resistor from RT pin to ground to set the switching frequency.
6	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 800mV. Connect a resistive divider at FB.
7	COMP	Error amplifier output and input to the output switch current (PWM) comparator. Connect frequency compensation components to this pin.
8	GND	Ground.
9	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.
10	PG	Open drain output for power-good flag. Use a 10kΩ to 100kΩ pull-up resistor to logic rail or other DC voltage no higher than 5V.
	Thermal Pad	GND pin must be electrically connected to the exposed pad on the printed circuit board for proper operation.

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The JWH5125 is an asynchronous, current-mode, step-down regulator. It regulates input voltages from 4.7V to 65V down to an output voltage as low as 0.8V, and is capable of supplying up to 5A of load current.

Power Switch

N-Channel MOSFET switch is integrated on the JWH5125 to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage greater than the input voltage, a boost capacitor connected between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 4.3V rail when SW is low.

Current-Mode Control

The JWH5125 utilizes fixed frequency, peak current-mode control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive voltage divider and the error is amplified by the internal transconductance error amplifier. The voltage feedback loop is compensated by an external RC network connected between the COMP pin and GND pin.

An internal oscillator initiates the turn on of the high side power switch, and the error amplifier output at the COMP pin controls the high side power switch current that when the high side MOSFET switch current reaches the threshold level set by the COMP voltage, the power switch is turned off.

The COMP pin voltage will increase and decrease as the output current increases and decreases. The device implements current limiting by clamping the COMP pin voltage to a maximum level. The PFM mode is implemented with a minimum voltage clamp on the COMP pin.

PFM Mode

The JWH5125 operates in PFM mode at light load to improve efficiency by reducing switching and gate drive losses.

During PFM mode operation, the JWH5125 senses and controls peak switch current, not the average load current. Therefore the load current at which the device enters PFM mode is dependent on the output inductor value.

Slope Compensation Output Current

The JWH5125 adds a compensating ramp to the COMP voltage to prevent sub-harmonic oscillations at duty cycles greater than 50%. The peak current limit of the high side switch will constant with duty cycle increases.

Shut-Down Mode

The JWH5125 shuts down when voltage at EN pin is below 0.3V. The entire regulator is off and the supply current consumed by the JWH5125 drops below 4uA.

Enable and Adjustable UVLO Protection

The JWH5125 is enabled when the VIN pin voltage rises above 4.4V and the EN pin voltage exceeds the enable threshold of 1.22V. The JWH5125 is disabled when the VIN pin voltage falls below 4.2V or when the EN pin voltage is below 1.12V. The EN pin has an internal pull-up resistor that enables operation of the JWH5125 when the EN pin floats.

If an application requires a higher VIN under-voltage lockout (UVLO) threshold, use a

resistive divider connected between VIN and ground with the central tap connected to EN to adjust the input voltage UVLO. (Shown in Figure 1). So that when VIN rises to the pre-set value, EN rises above 1.22V to enable the device and when Vin drops below the pre-set value, EN drops below 1.12V to trigger input under voltage lockout protection.

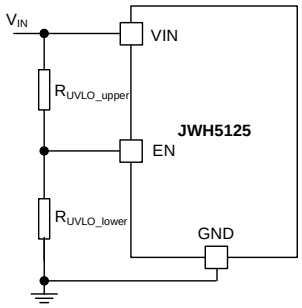


Fig. 1 Adjustable UVLO

The input voltage UVLO threshold (V_{UVLO}) and hysteresis (V_{UVLO_HYS}) can be calculated by the following equation.

$$V_{UVLO} := \frac{R_{UVLO\_upper} + R_{UVLO\_lower}}{R_{UVLO\_lower}} \cdot V_{EN\_TH}$$

$$V_{UVLO\_HYS} := \frac{R_{UVLO\_upper} + R_{UVLO\_lower}}{R_{UVLO\_lower}} \cdot V_{EN\_HYS}$$

where

V_{EN_TH} is enable shutdown threshold (1.22V typ.);

V_{EN_HYS} is enable shutdown hysteresis (100mV typ.);

External Soft-start

Soft-start is designed in JWH5125 to prevent the converter output voltage from overshooting during startup and short-circuit recovery. An internal current source (I_{SS}) of 1.8uA is designed to charge the external soft-start capacitor (C_{SS}) and generates a soft-start (SS) voltage ramping up from 0V to 3V. When it is less than internal reference voltage ($V_{REF,}$ typ. 0.8V), SS voltage overrides V_{REF} and the error amplifier uses SS voltage as the reference. When SS exceeds V_{REF}, V_{REF} regains control.

The soft start time (10% to 90%) T_{SS} can be calculated by the following equation.

$$T_{SS}(ms) := \frac{C_{SS}(nF) \cdot V_{REF}(V) \cdot 0.8}{I_{SS}(\mu A)}$$

Switching Frequency

The switching frequency of JWH5124 can be programmed by the resistor R_T from the RT pin and GND pin over a wide range from 100 kHz to 2000 kHz. The RT pin voltage is typically 1.2V and must have a resistor to ground to set the switching frequency. The R_T resistance can be calculated by the following equation for a given switching frequency f_{SW}.

$$R_T(K\Omega) = \frac{92417}{f_{sw}(KHz)} - 23$$

$$f_{sw}(KHz) = \frac{92417}{(R_T + 23)(K\Omega)}$$

To reduce the solution size one would typically set the switching frequency as high as possible, but tradeoffs of the conversion efficiency, maximum input voltage and minimum controllable on time should be considered. The minimum controllable on time is typically 100 ns which limit the maximum operating frequency in applications with high input to output step down ratios.

Maximum Switching Frequency

To protect the converter in overload conditions at higher switching frequencies and input voltages, the JWH5125 implements a frequency fold-back. The oscillator frequency is divided by 4 as the FB voltage drops from 0.8V to below 0.35V. When the FB voltage rise above 0.4V, the frequency exist fold-back state. The oscillator frequency is divided by 8 as the FB voltage drops to 0.18V. When the FB voltage

rise above 0.2V, the frequency exist fold-back state.

When the output voltage is forced low by the shorted load, the inductor current decreases slowly during the switch off time. The frequency fold-back effectively increases the off time by increasing the period of the switching cycle providing more time for the inductor current to ramp down.

The frequency fold-back effectively increases the off time by increasing the period of the switching cycle providing more time for the inductor current to ramp down. With a maximum frequency fold-back ratio of 8, there is a maximum frequency at which the inductor current can be controlled by frequency fold-back protection.

The following equation calculates the maximum switching frequency at which the inductor current will remain under control when V_{OUT} is forced to V_{OUT_SC}. The selected operating frequency should not exceed the calculated value.

$$f_{SW\_SC} = \frac{f_{DIV}}{t_{ON}} \cdot \left(\frac{I_{LIM} \cdot R_{dc} + V_{OUT\_SC} + V_d}{V_{IN} - I_{LIM} \cdot R_{DSON} + V_d} \right)$$

The following equation calculates the maximum switching frequency limitation set by the minimum controllable on time and the input to output step down ratio. Setting the switching frequency above this value will cause the regulator to skip switching pulses to achieve the low duty cycle required to regulate the output at maximum input voltage.

$$f_{SW\_maxskip} = \frac{1}{t_{ON}} \cdot \left[\frac{I_O \cdot (R_{dc} + V_{OUT}) + V_d}{V_{IN} - I_O \cdot R_{DSON} + V_d} \right]$$

where I_O means output current,

I_{LIM} means current limit

R_{dc} means inductor resistance

V_{IN} means maximum input voltage

V_{OUT} means output voltage

V_{OUT_SC} means output voltage during short

V_d means diode voltage drop

R_{DSON} means switch on resistance

t_{ON} means controllable on time

f_{DIV} means frequency divide equals (1,4,8)

Power Good

The JWH5125 has power-good (PG) output. The PG pin is the open drain of a MOSFET. Connect to a voltage source (such as V_{OUT}) through a resistor. When the output voltage becomes within +6% and -7% of the target value, internal comparators detect power good state and the power good signal becomes high. If the feedback voltage goes under -10% or higher +8% of the target value, the power good signal becomes low.

RT Short Protection

If the RT pin is detected to be short to ground, JWH5125 is not allowed to switch to prevent abnormal operation state. The regulator can be reactivated again when the short condition at the RT pin is removed.

Overvoltage Protection

Output overvoltage protection (OVP) is designed in JWH5125 to minimize voltage overshoot when recovering from output fault conditions or strong unload transients in designs with low output capacitance and the power supply output voltage increase faster than the response of the error amplifier output resulting in an output overshoot.

The OVP feature minimizes output overshoot when using a low value output capacitor by comparing the FB pin voltage to the rising OVP threshold which is nominally 108% of the internal voltage reference. If the FB pin voltage is greater than the rising OVP threshold, the

high side MOSFET is immediately disabled to minimize output overshoot. When the FB voltage drops below the falling OVP threshold which is nominally 106% of the internal voltage reference, the high side MOSFET resumes normal operation.

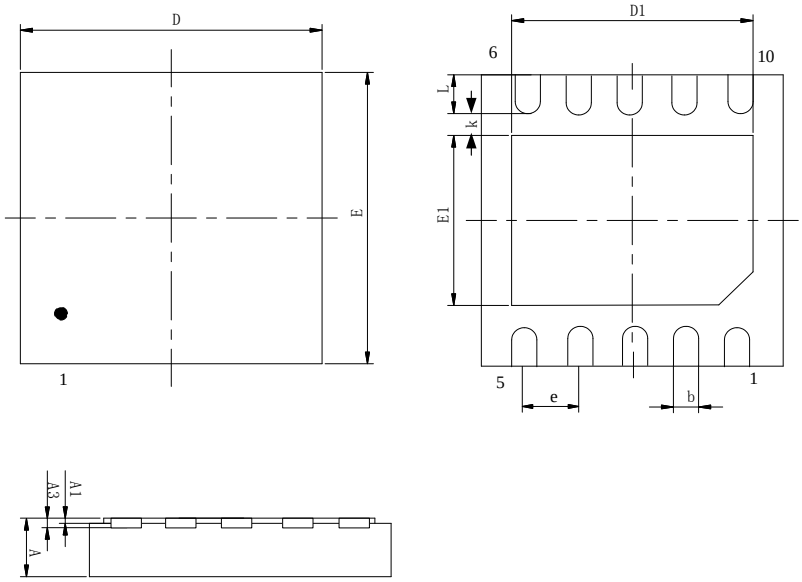
Thermal Protection

When the temperature of the JWH5125 rises above 170°C, it is forced into thermal shut-down.

Only when core temperature drops below 150°C can the regulator becomes active again.

PACKAGE OUTLINE

DFN4x4-10 UNIT: mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.203REF	
D		4.00BSC	
E		4.00BSC	
D1	2.90	3.00	3.10
E1	2.50	2.60	2.70
k		0.30REF	
b	0.25	0.30	0.35
e		0.80BCS	
L	0.30	0.40	0.50

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