DIO6905B
2 A, Synchronous, Step-Down Converter with Forced PWM

Features

- 1.8 MHz switching frequency
- EN for power sequencing
- Wide 2.3 V to 5.5 V operating input range
- Output adjustable from 0.6 V
- Up to 2 A output current
- 120 mΩ and 80 mΩ internal power MOSFET switches
- Forced PWM operation
- Output discharge
- Short-circuit protection (SCP) with hiccup mode
- Stable with low ESR output ceramic capacitors
- Available in SOT563 and DFN2*2-8 packages
- 100% duty cycle

Applications

- Wireless/networking cards
- Portable and mobile devices
- Battery-powered devices
- Low-voltage I/O system power
- Solid-state drives (SSDs)

Descriptions

The DIO6905B is a monolithic, step-down, switch-mode converter with built-in, internal power MOSFETs. It achieves 2 A of output current from a 2.3 V to 5.5 V input voltage with excellent load and line regulation. The output voltage can be regulated as low as 0.6 V.

The constant-on-time control scheme provides a fast transient response and eases loop stabilization. Full protection features include cycle-by-cycle current limiting and thermal shutdown.

The DIO6905B is available in SOT563 and DFN2*2-8 packages and requires a minimal number of readily available, standard, external components.

The DIO6905B is ideal for a wide range of applications, including high-performance DSPs, wireless power, portable and mobile devices, and other low-power systems.

Ordering Information

Part Number	Top Marking	RoHS	T_A	Package	
DIO6905BSH3	W5B	Green	-40 to 85°C	SOT563	Tape & Reel, 5000
DIO6905BCN8	JV5B	Green	-40 to 85°C	DFN2*2-8	Tape & Reel, 3000

Pin Assignments

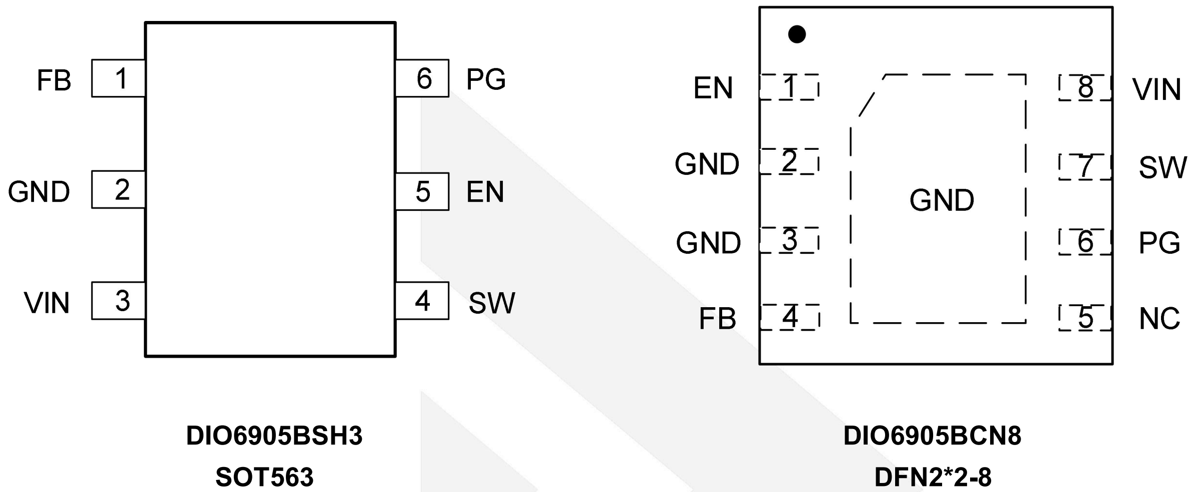


Figure 1. Pin Assignment (Top View)

Pin Definitions

Pin Name	Description
FB	**Feedback.** An external resistor divider from the output to GND tapped to FB sets the output voltage.
GND	**Power ground.**
VIN	**Supply voltage.** The DIO6905B operates from a 2.3 V to 5.5 V unregulated input. A decoupling capacitor is required to prevent large voltage spikes from appearing at the input.
SW	**Output switching node.** SW is the drain of the internal high-side P-channel MOSFET. Connect the inductor to SW to complete the converter.
EN	**On/off control.**
PG	**Power good indicator.** Power good indicator (open drain output). Low if the output < 90% or the output > 120% of regulation voltage; high otherwise. Connect a pull-up resistor to the input.
NC	**No connection.**

Absolute Maximum Ratings

Stresses beyond those listed under the Absolute Maximum Rating table may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Symbol	Parameter	Rating	Unit
V_{IN}	Supply voltage	6.0	V
V_{SW}	Switch voltage	-0.3 (-5 V for < 20 ns) to 6.0 (8 V for < 20 ns or 10 V for < 10 ns)	V
	All other pins	-0.3 to 6.0	V
T_J	Junction temperature range	150	°C
T_L	Lead temperature range	260	°C
P_D	Continuous power dissipation (T_A = 25°C)	1	W
T_{STG}	Storage temperature	-65 to 150	°C

Recommend Operating Conditions

Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. DIOO does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Rating	Unit
V_{IN}	Supply voltage	2.3 to 5.5	V
T_J	Operating junction temperature range	-40 to 125	°C
Θ_{JA}	Package thermal resistance	130	°C/W
Θ_{JC}		60	

Electrical Characteristics

V_{IN} = 3.6 V, T_A = 25°C, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{FB}	Feedback voltage	2.3 V ≤ V_{IN} ≤ 5.5 V, T_J = 25°C	594	600	606	mV
		T_J = -40°C to 125°C	588		612	
I_{FB}	Feedback current	V_{FB} = 0.63 V		50	100	nA
R_{DSON_P}	P-FET switch on resistance			120		mΩ
R_{DSON_N}	N-FET switch on resistance			80		mΩ
	P-FET peak current limit	Sourcing	2.4			A
	N-FET valley current limit	Sourcing, valley current limit		1.6		A
T_{ON}	On time	V_{IN} = 5 V, V_{OUT} = 1.2 V		133		ns
		V_{IN} = 3.6 V, V_{OUT} = 1.2 V		185		
f_S	Switching frequency	V_{IN} = 5 V, V_{OUT} = 1.2 V, I_{OUT} = 500 mA, T_J = 25°C (1)	1400	1800	2200	kHz
		V_{IN} = 5 V, V_{OUT} = 1.2 V , I_{OUT} = 500 mA, T_J = -40°C to 125°C (1)	1400	1800	2200	kHz
$T_{MIN-OFF}$	Minimum off time			60		ns
T_{MIN-ON}	Minimum on time(1)			60		ns
T_{SS-ON}	Soft-start time	V_{OUT} rise from 10% to 90%		0.6		ms
	Undervoltage lockout threshold rising			2.1	2.3	V
	Undervoltage lockout threshold hysteresis			50		mV
	EN input logic low voltage				0.4	V
	EN input logic high voltage		1.2			V
R_{DIS}	Output discharge resistor	V_{EN} = 0 V, V_{OUT} = 1.2 V		1		kΩ
	EN input current	V_{EN} = 2 V		2		μA
		V_{EN} = 0 V		0		μA
	Supply current (shutdown)	V_{EN} = 0 V, T_J = 25°C		0.1	1	μA
	Supply current (quiescent)	V_{EN} = 2 V, V_{FB} = 0.63 V, V_{IN} = 3.6 V, 5 V, T_J = 25°C		30	60	μA
	Thermal shutdown(2)			160		°C
	Thermal hysteresis(2)			30		°C

Note:

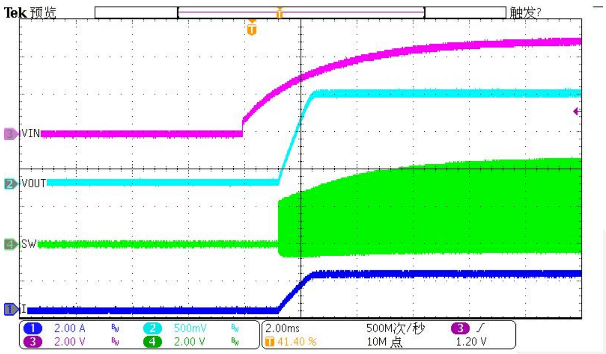
(1). Guaranteed by characterization.

(2). Guaranteed by design.

(3). Specification subject to change without notice.

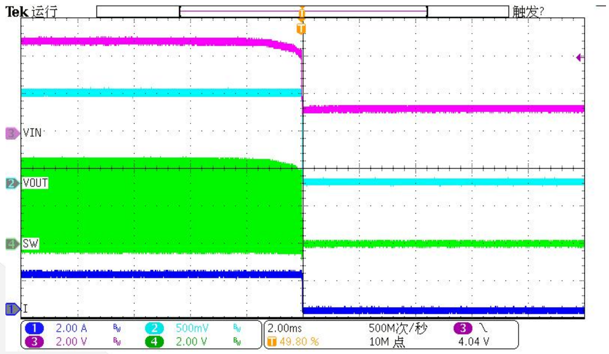
Typical Performance Characteristics

V_{IN} = 5 V, V_{OUT} = 1.2 V, L = 2.2 uH, C_{IN} = C_{OUT} = 10 uF, T_A = 25°C, unless otherwise specified.



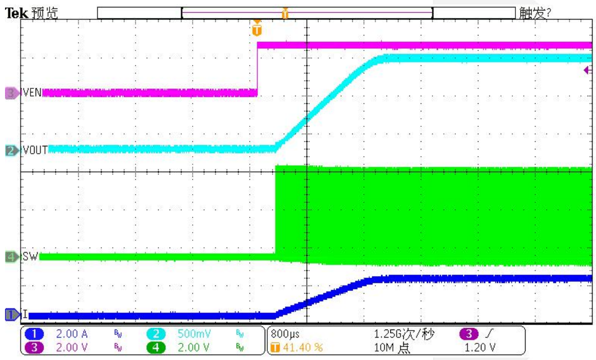
V_{IN} start-up

V_{IN} = 5 V, V_{OUT} = 1.2 V with 2 A load



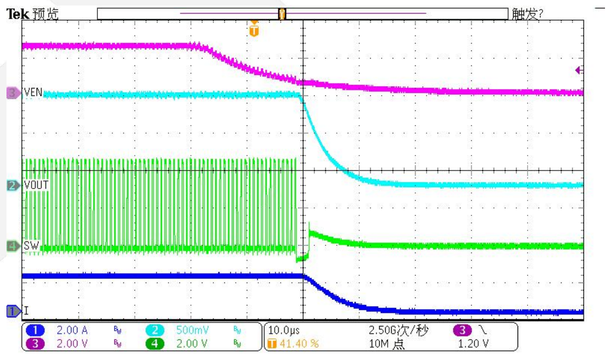
V_{IN} drop

V_{IN} = 5 V, V_{OUT} = 1.2 V with 2 A load



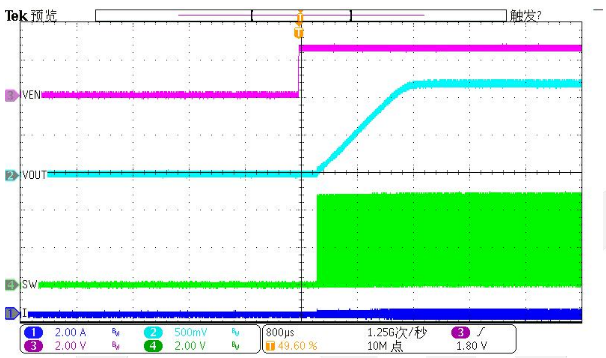
V_{EN} start-up

V_{IN} = 5 V, V_{OUT} = 1.2 V with 2 A load



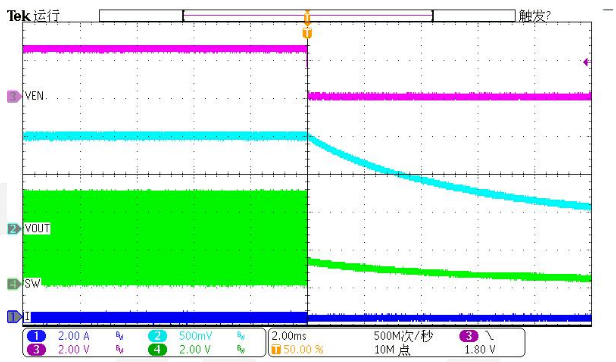
V_{EN} drop

V_{IN} = 5 V, V_{OUT} = 1.2 V with 2 A load



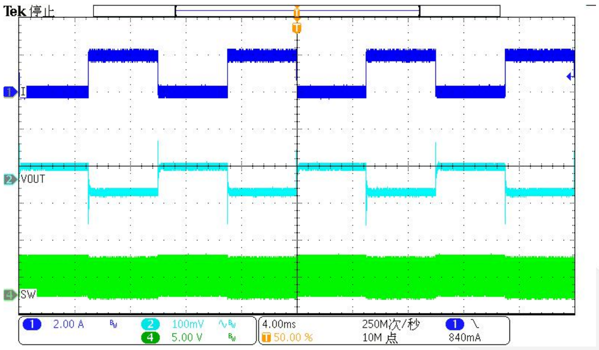
V_{EN} start-up

V_{IN} = 5 V, V_{OUT} = 1.2 V without load



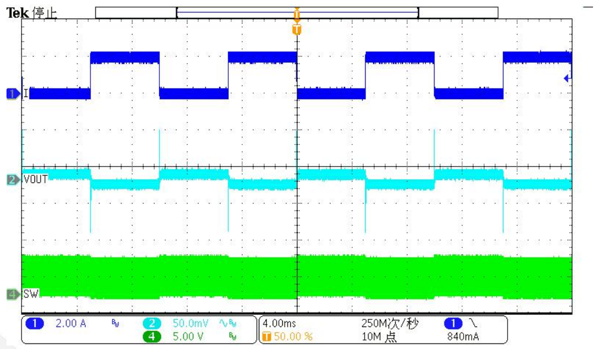
V_{EN} drop

V_{IN} = 5 V, V_{OUT} = 1.2 V without load



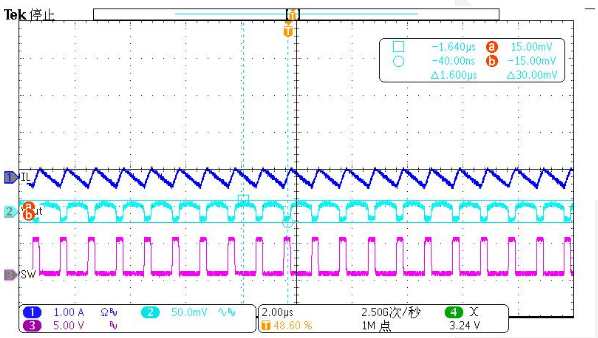
Load transient

V_{IN} = 5 V, V_{OUT} = 3.3 V, 0 A ~ 2 A



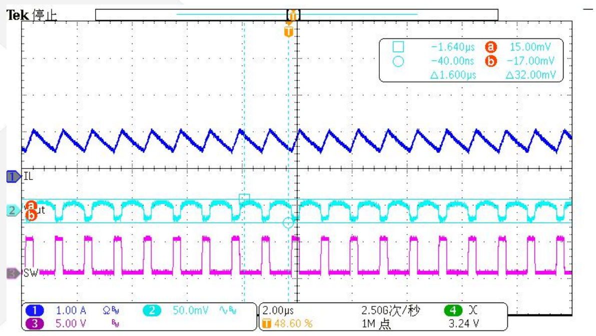
Load transient

V_{IN} = 5 V, V_{OUT} = 1.2 V, 0 A ~ 2 A



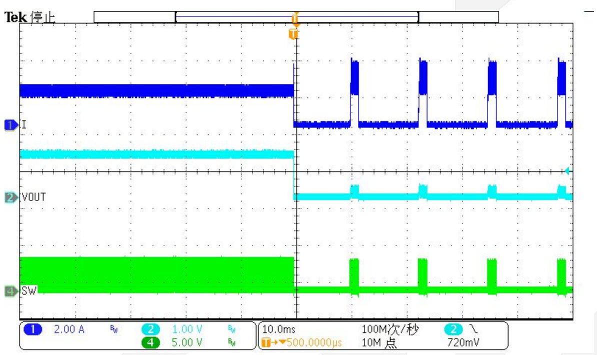
Ripple

V_{IN} = 5 V, V_{OUT} = 1.2 V, I_{LOAD} = 0 A



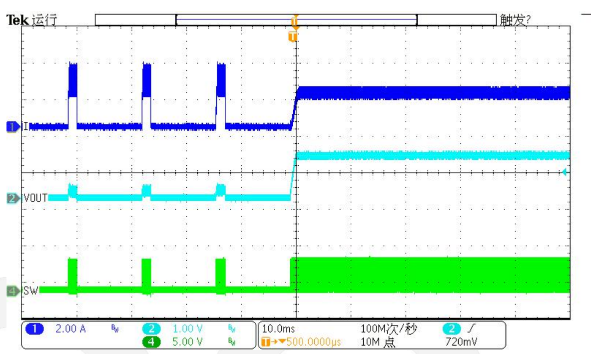
Ripple

V_{IN} = 5 V, V_{OUT} = 1.2 V, I_{LOAD} = 1 A



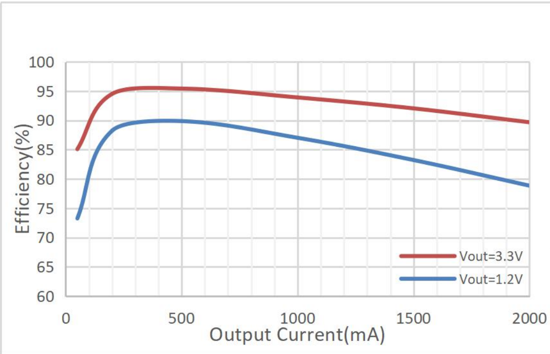
Short circuit protection

V_{IN} = 5 V, V_{OUT} = 1.2 V, 2 A → short

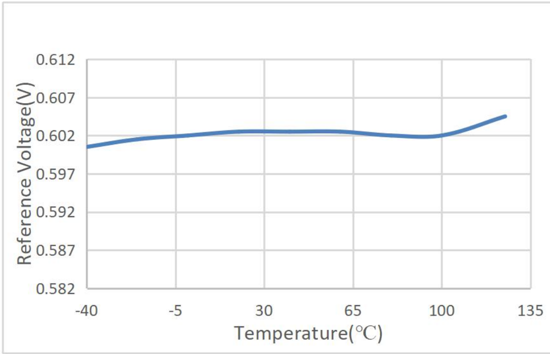


Short circuit protection

V_{IN} = 5 V, V_{OUT} = 1.2 V, short → 2 A

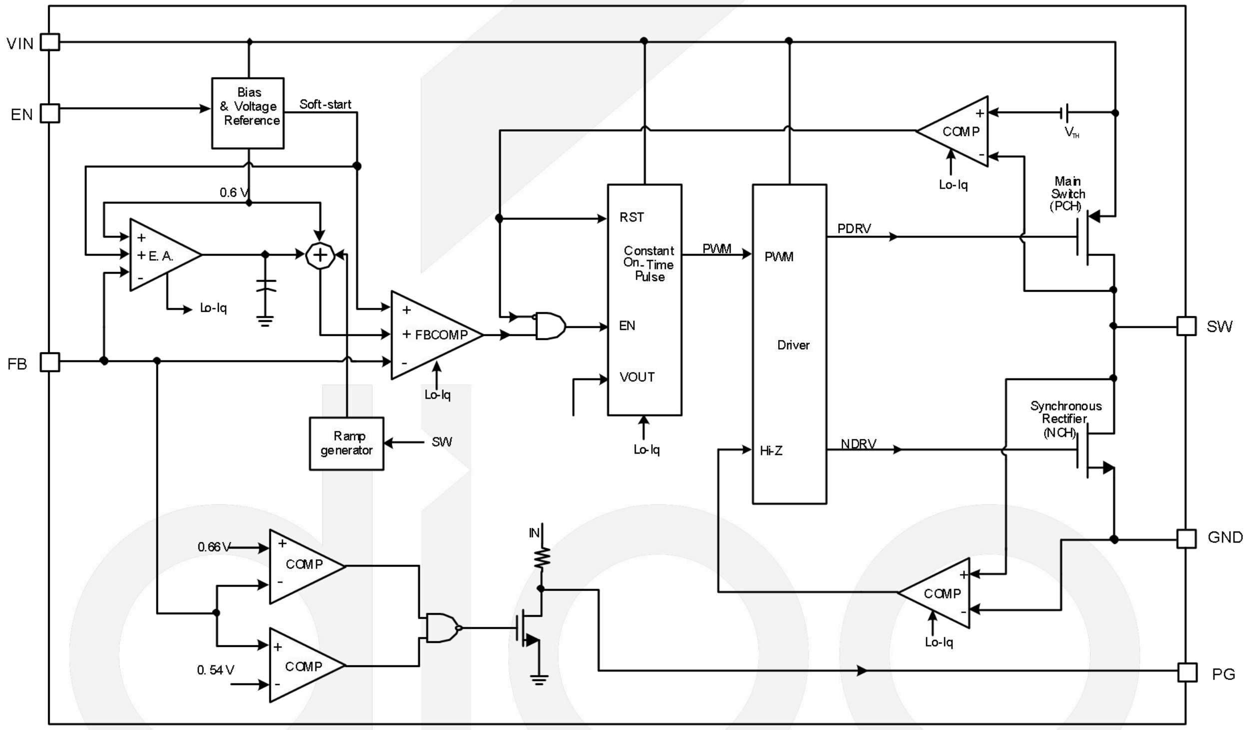


Efficiency vs. output current

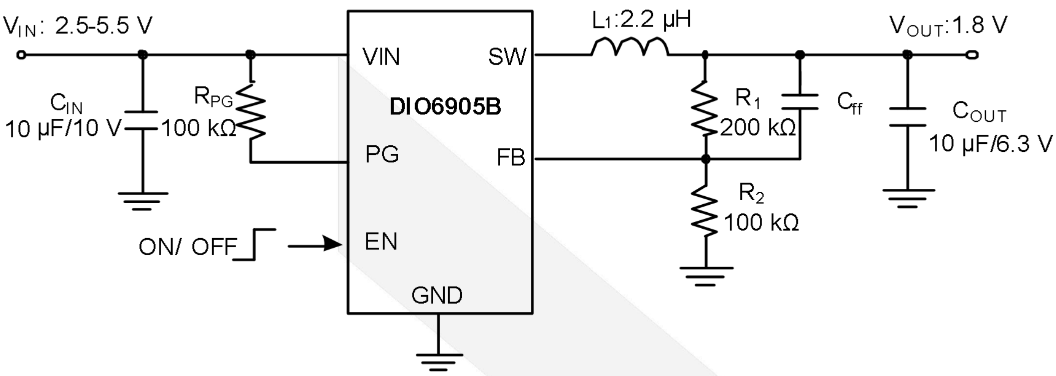


Reference voltage vs. temperature

Block Diagram



Typical Application



Detailed Description

The DIO6905B uses constant on-time control with input voltage feed-forward to stabilize the switching frequency over its full input voltage range. It achieves 2 A of output current from a 2.3 V to 5.5 V input voltage range with excellent load and line regulation. The output voltage can be regulated as low as 0.6 V.

Constant-On-Time Control

When compared to fixed-frequency PWM control, constant-on-time control offers a simpler control loop and faster transient response. By using input voltage feed-forward, the DIO6905B maintains a nearly constant switching frequency across the input and output voltage ranges. The switching pulse on time can be estimated with Equation (1):

$$t_{ON} = \frac{V_{OUT}}{V_{IN}} \times 0.556us \qquad (1)$$

To prevent inductor current runaway during the load transient, the DIO6905B has a fixed minimum off time of 60 ns.

Enable (EN)

When the input voltage is greater than the under-voltage lockout (UVLO) threshold (typically 2.1 V), the DIO6905B can be enabled by pulling EN higher than 1.2 V. Leaving EN floating or pulling it down to ground disables the DIO6905B. There is an internal 1 MΩ resistor from EN to the ground.

When the DIO6905B is disabled, the part goes into output discharge mode automatically. The internal discharge MOSFET provides a resistive discharge path for the output capacitor.

Soft-Start

The DIO6905B uses a built-in soft-start (SS) that ramps up the output voltage at a controlled slew rate to avoid overshooting at start-up. The soft-start time is about 0.6 ms, typically.

Current Limit

The DIO6905B has a 2.4 A, minimum, high-side, switch-current limit. When the high-side switch reaches its current limit, the DIO6905B remains in hiccup mode until the current drops. This prevents the inductor current from continuing to rise and damaging components.

Short Circuit and Recovery

The DIO6905B enters short-circuit protection (SCP) mode when it reaches the current limit and attempts to recover with hiccup mode. The DIO6905B disables the output power stage, discharges the soft-start capacitor, and attempts to soft-start again automatically. If the short circuit condition remains after the soft start ends, the DIO6905B repeats this cycle until the short circuit disappears and the output rises back to regulation levels.

Application Information

Setting the Output Voltage

The external resistor divider sets the output voltage. Select the feedback resistor R1 which reduces the V_{OUT} leakage current, typically between 40 kΩ to 200 kΩ. There is no strict requirement for the feedback resistor. R1 > 10 kΩ is reasoned for most applications. R2 can be calculated with Equation (2):

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.6} - 1} \qquad (2)$$

The feedback circuit is shown in Figure 2:

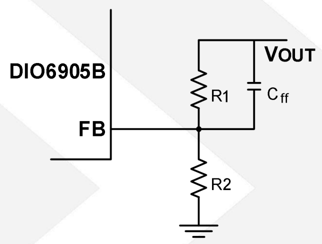


Figure 2. Feedback Network

Table 1 lists the recommended values of resistors for common output voltages:

Table 1. Resistor Values for Common Output Voltages

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)	L (μH)	C_{OUT} (μF)	C_{ff} (pF)
1.2	200	200	2.2	10	47
1.8	200	100	2.2	10	47
2.5	200	63.2	2.2	10	47
3.3	200	44.2	2.2	10	47
4.2	200	33	2.2	10	47

Selecting the Inductor

Most applications work best with a 1 μH to 2.2 μH inductor. Select an inductor with a DC resistance of less than 15 mΩ to optimize efficiency.

A high-frequency switch-mode power supply with a magnetic device has strong electronic magnetic inference. Avoid using unshielded power inductors. Metal alloy or multiplayer chip power inductors are ideal shielded inductors for the application because they can decrease the influence effectively. Table 2 lists some recommended inductors.

Table 2. Recommended Inductors

Manufacturer P/N	Inductance (μH)	Manufacturer
744 777 002	2.2	Wurth

For most designs, the inductance value can be estimated with Equation (3):

$$L_1 = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \triangle I_L \times f_{OSC}} \qquad (3)$$

Where ΔI_L is the inductor ripple current.

Choose an inductor current to be approximately 30% of the maximum load current. The maximum inductor peak current can be calculated with Equation (4):

$$I_{L(MAX)} = I_{LOAD} + \frac{\triangle I_L}{2} \qquad (4)$$

Selecting the Input Capacitor

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low-ESR capacitors for the best performance. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR values and small temperature coefficients. For most applications, a 10 μF capacitor is sufficient. Higher output voltages may require a 22 μF capacitor to increase system stability.

The input capacitor requires an adequate ripple current rating since it absorbs the input switching current. Estimate the RMS current in the input capacitor with Equation (5):

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \qquad (5)$$

The worst-case scenario occurs at V_{IN} = 2 V_{OUT}, shown in Equation (6):

$$I_{C1} = \frac{I_{LOAD}}{2} \qquad (6)$$

For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum, or ceramic. When using electrolytic or tantalum capacitors, add a small, high-quality, 0.1 μF ceramic capacitor as close to the IC as possible. When using ceramic capacitors, ensure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at the input. The input voltage ripple caused by capacitance can be estimated with Equation (7):

$$\triangle V_{IN} = \frac{I_{LOAD}}{fs \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \qquad (7)$$

Selecting the Output Capacitor

The output capacitor stabilizes the DC output voltage. Ceramic capacitors are recommended. Use low ESR capacitors to limit the output voltage ripple. Estimate the output voltage ripple with Equation (8):

$$\triangle V_{OUT} = \frac{V_{OUT}}{f_S \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C2}\right) \qquad (8)$$

Where L_1 is the inductor value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor. When using ceramic capacitors, the capacitance dominates the impedance at the switching frequency and causes most of the output voltage ripple. For simplification, the output voltage ripple can be estimated with Equation (9):

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^2 \times L_1 \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (9)$$

For tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated with Equation (10):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR} \quad (10)$$

The characteristics of the output capacitor also affect the stability of the regulation system.

PCB Layout Recommendation

An efficient PCB layout is critical for stable operation. For the high-frequency switching converter, a poor layout design can result in poor line or load regulation and stability issues.

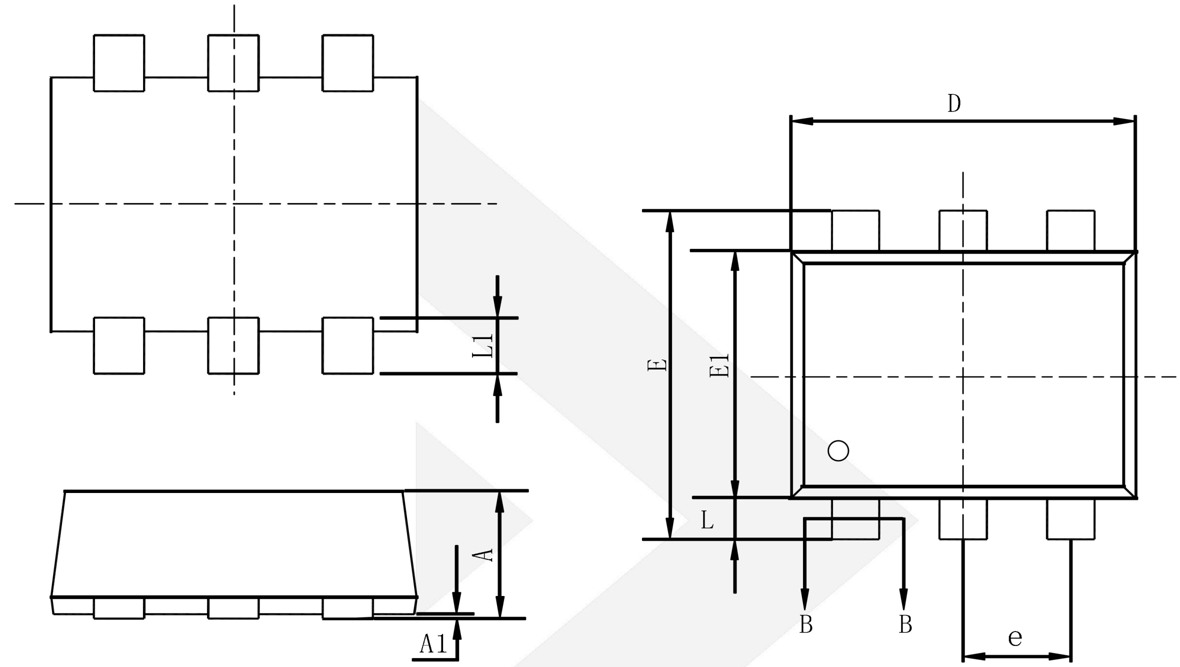
(1) Place the high-current paths (GND, IN, and SW) as close to the device as possible with short, direct, and wide traces.

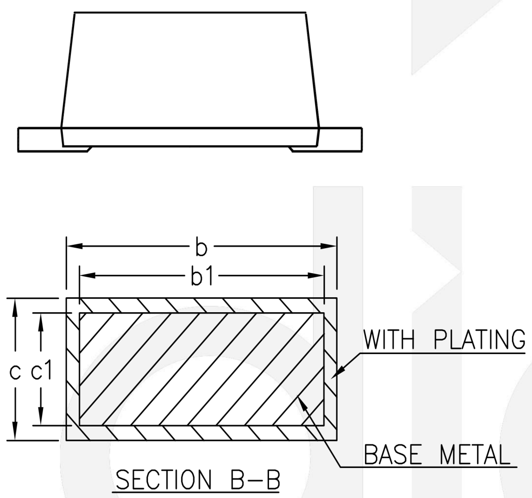
(2) Keep the input capacitor as close to IN and GND as possible.

(3) Place the external feedback resistors next to FB.

(4) Keep the switching node SW short and away from the feedback network.

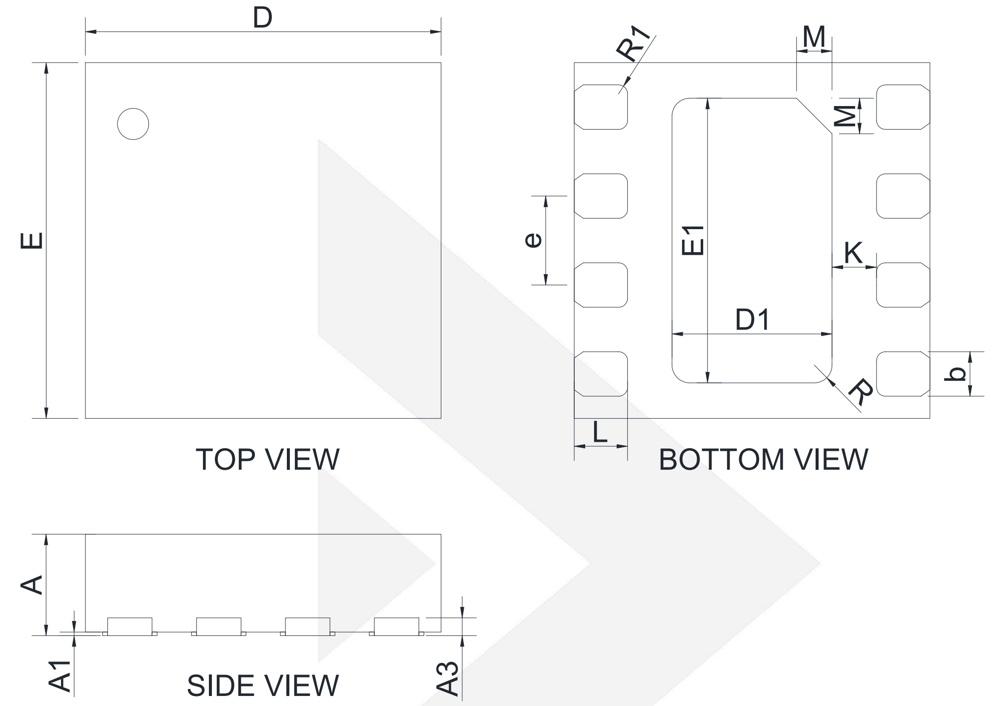
Physical Dimensions: SOT563





Dimensions in Millimeters			
Symbol	**Min**	**Nom**	**Max**
A	0.53	-	0.60
A1	0.00	-	0.05
b	0.19	-	0.27
b1	0.18	0.20	0.23
c	0.11	-	0.16
c1	0.10	0.11	0.12
D	1.50	1.60	1.70
E	1.50	1.60	1.70
E1	1.10	1.20	1.30
e		0.50 BSC	
L	0.10	0.20	0.30
L1	0.20	0.30	0.40

Physical Dimensions: DFN2*2-8



Symbol	Dimensions in Millimeters		
	Min	Nom	Max
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3	0.10	-	0.13
b	0.20	0.25	0.30
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D1	0.80	0.90	1.00
E1	1.50	1.60	1.70
e	0.45	0.50	0.55
K	0.15	0.25	0.35
L	0.25	0.30	0.35
M	0.20 REF		
R	0.10 REF		
R1	0.05 REF		

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For additional product information or full datasheet, please contact our sales department or representatives.