55V, 600mA Step-Down Switching Regulator

GENERAL DESCRIPTION

The PW2312A is a high frequency, synchronous, rectified, step-down, switch-mode converter with internal power MOSFETs. It offers a very compact solution to achieve a 0.6A output current over a wide input supply range, with excellent load and line regulation.

The PW2312A requires a minimal number of readily available, external components and is available in a space saving SOT23-6 package.

FEATURES

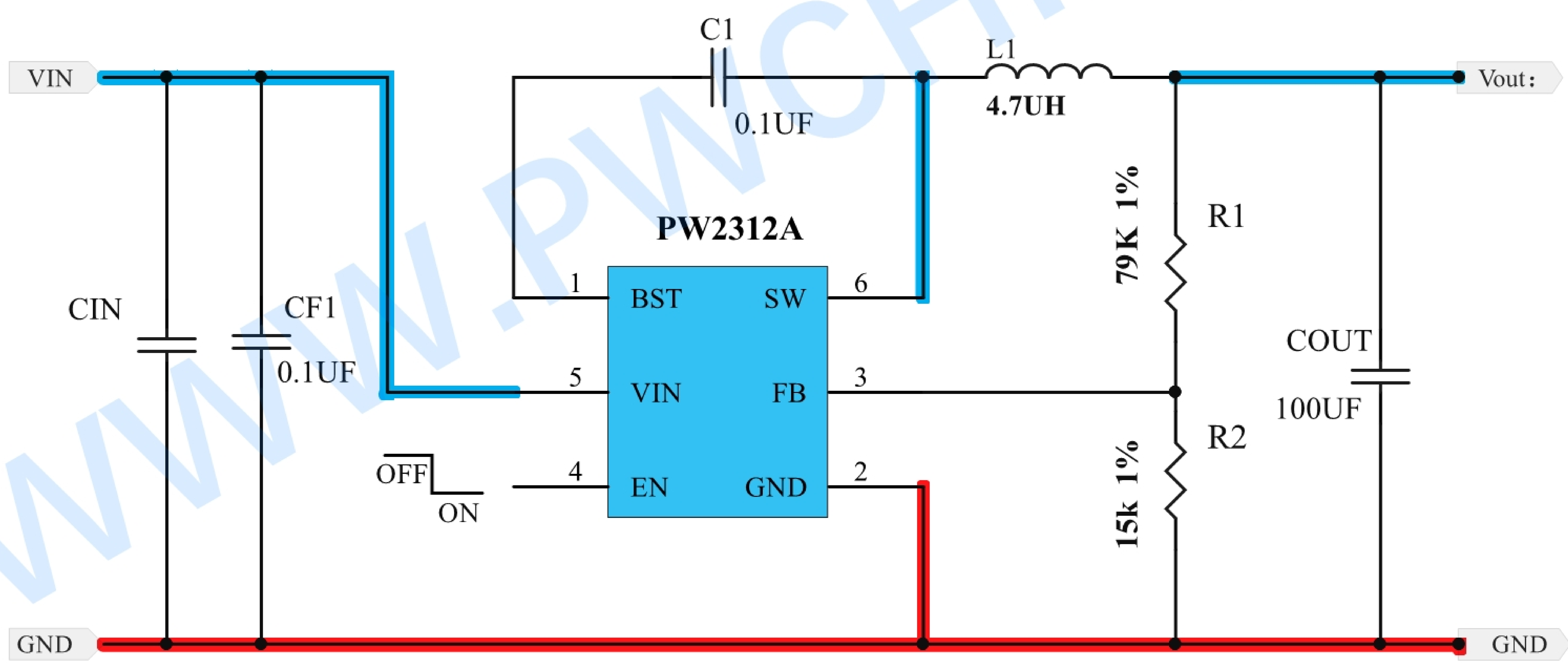
- 600mA continuous output current Mcapability
- Internal Soft-Start limits the inrush current at turn-on
- Internal compensation to save external components
- Input over-voltage protection to protect device from working in high voltage and high current condition
- Integrated 550mΩ high side and 350mΩ low side power 80V MOSFET switches
- Pulse skip mode at light load to improve light load efficiency
- Stable with Low ESR Ceramic Output Capacitors
- Input Under-Voltage Lockout
- Output Over-Voltage Protection
- Output short protection
- Over-Temperature Protection
- Fixed 1200k Switching Frequency
- 6.5V to 55V wide operating input range
- Up to 92% efficiency
- SOT23-6L Package

APPLICATIONS

- Power Meters
- Distributed Power Systems
- Battery Chargers
- Pre-Regulator for Linear Regulators
- WLED Drivers

TYPICAL APPLICATION CIRCUIT

$$\boldsymbol{VOUT} = \left(\frac{\boldsymbol{R1}}{\boldsymbol{R2}} + 1\right) * 0.8\boldsymbol{V}$$



Note: VIN ≦15V , CIN: 22uF (MCLL) ; VIN>15V , CIN: 100uF (EC+)
VOUT≧12V , COUT: 100uF (EC+) +10uF (MCLL) ; VOUT≦9V, COUT: 22uF*2 (MCLL)

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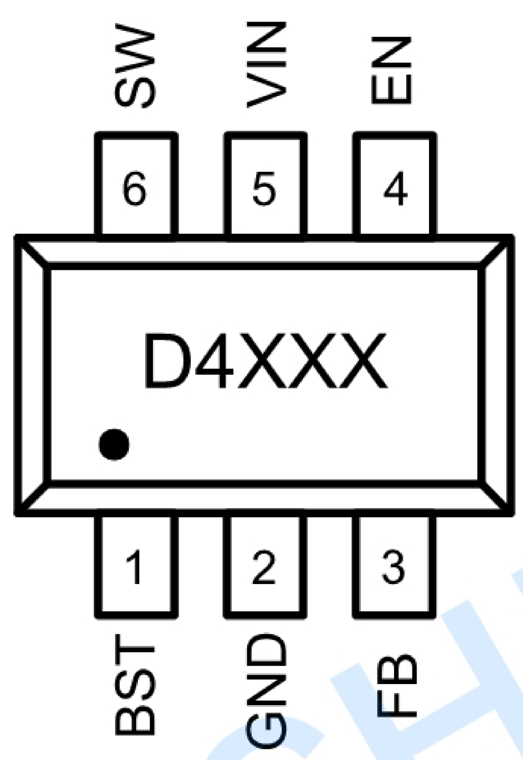
PIN ASSIGNMENT/DESCRIPTION



Pin No	Pin Name	Functions
1	BST	Boot-Strap pin Connect a 0.1μF or greater capacitor between SW and BST to power the high side gate driver.
2	GND	Ground.
3	FB	Feedback Input. FB senses the output voltage. Connect FB with a resistor divider connected between the output and ground. FB is a sensitive node. Keep FB away from SW and BST pin.
4	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator; low to turn it off. EN pin is pulled to VIN internally by a larger resistor.
5	VIN	Power Input. Vin supplies the power to the IC. Supply Vin with a 4.5V to 55V power source. Bypass Vin to GND with a large capacitor and at least another 0.1uF ceramic capacitor to eliminate noise on the input to the IC. Put the capacitors close to Vin and GND pins.
6	SW	Power Switching pin. Connect this pin to the switching node of inductor.

Absolute Maximum Ratings

	PARAMETER	VALUE	Unit
Input Voltages	VIN to GND	-0.3v ~ 65	v
	VEN to GND	-0.3 ~ 6	v
	VFB to GND	-0.3 ~ 6	v
	VBST to VSW	-0.3 ~ 6	v
	VSW to GND	-1 ~ VIN+ 0.3	v
T_{ST}	Storage Temperature Range	-65 ~ 150	°C
T_J	Junction Temperature	+160	°C
T_L	Lead Temperature	+260	°C
V_{ESD}	HBM Human body model	2	kV

Note： Exceeding these ratings may damage the device.

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PCB Layout

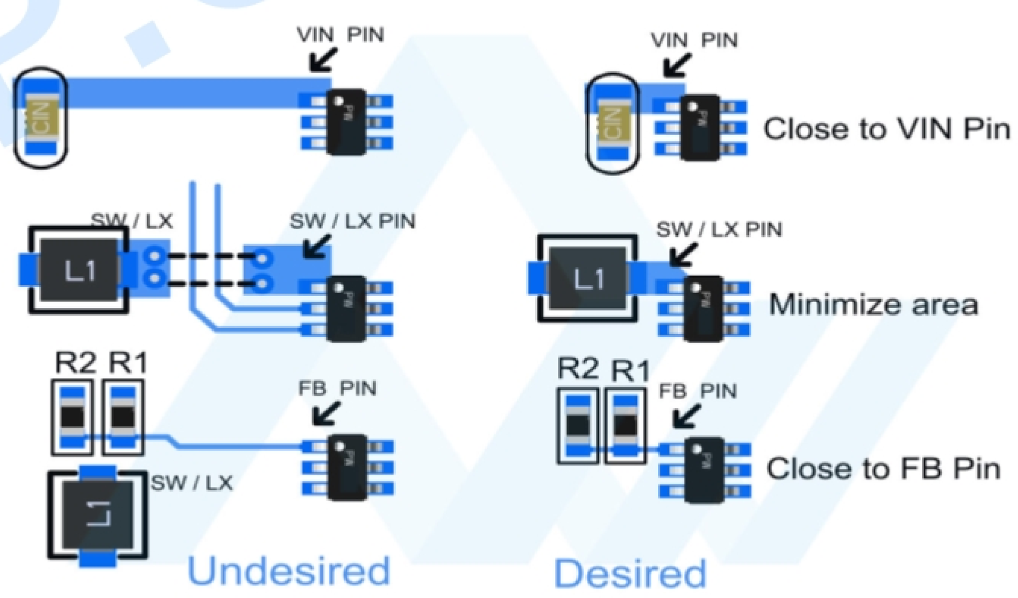
PCB layout is a critical portion of good power supply design. The following guidelines will help users design a PCB with the best power conversion efficiency, thermal performance, and minimized EMI.

1. The feedback network, resistor R1 and R2, should be kept close to FB pin. Vout sensing path should stay away from noisy nodes, such as SW and BST signals. The ground of R2 should be connected directly to GND pin by a single point. An optional 47pF capacitor may be needed to improve the noise immunity for a poor placed PCB.

2. The input bypass capacitor CF1 must be placed as close as possible to VIN pin and GND pin. Grounding for both the input and output capacitors should consist of localized top side planes. Make the GND plane as big as possible for best thermal performance.

3. Input capacitor, output capacitor, inductor and PW2312A should be placed evenly on the PCB board for the best thermal performance. Separate PW2312A from inductor as much as possible since they are the hottest components on the PCB.

PCB layout

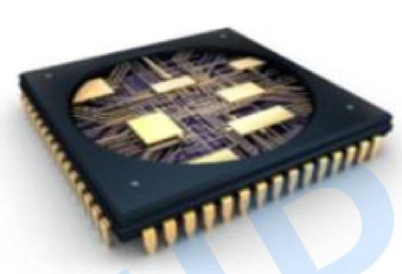


Products

<table>
<tr><th rowspan="8">Reel /outer anti-static packaging</th><th colspan="2">Product</th></tr>
<tr><td colspan="2">PW2312A</td></tr>
<tr><th>Brand</th><th>Package</th></tr>
<tr><td>平芯微/PWCHIP</td><td>SOT23-6L</td></tr>
<tr><th>Specification</th><th>Qty per reel</th></tr>
<tr><td>Taping & Reel</td><td>3000 PCS</td></tr>
<tr><th colspan="2">Marking</th></tr>
<tr><td colspan="2">D4XXX
Device code: D4； Lot number code: XXX</td></tr>
</table>

NO：1, QR code content: WWW.PWCHIP.COM;
2. Product: PWCHIP product model name;
3. Lot No: wafer batch code/internal system production code (customers can send this code to support@pwchip.com to verify product information and confirm);
4. D/C: packaging cycle;
5. QTY: packaging quantity (box/disc);
6. Data: packaging time.

Product Center



MOSFET OVP/OCP Protection Li-ion Charger Li-ion Protector Li-ion charge-discharge LDO
Voltage Detector DC-DC Boost DC-DC Buck DC-DC Boost-Buck USB Fast charging LED driver

Product Title	MODE	Vin Range	Vout Range	Iout MAX	FOSC	Iq typ	Package	Link
PW2052B	Synchronous	2.3V～6V	0.6V～5V	2A	1.5MHZ	150uA	SOT23-6L	Detail
PW2335	Synchronous	4.5V~30V	ADJ	3A	500KHZ	600uA	SOP8-EP	Detail
PW2312A	Synchronous	4.5V～55V	ADJ	0.6A	1.2MHZ	250uA	SOT23-6L	Detail
PW2458	Synchronous	3.8V～36V	0.8V～35V	5A	0.1-1.1MHZ	25uA	SOP8-EP	Detail
PW2153	Asynchronous	8V~150V	5V~30V	10A	140KHZ	1mA	SOP8	Detail
PW2902	Asynchronous	8V~90V	5V~30V	2A	140KHZ	1mA	SOP8-EP	Detail
PW2906	Asynchronous	12V～90V	1.3V～20V	0.6A	150KHZ	2.5mA	SOP8-EP	Detail
PW2815	Asynchronous	4.5V～80V	ADJ	1.5A	480KHZ	0.73mA	SOP8-EP	Detail

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Recommended Operating Conditions

	PARAMETER	VALUE	UNIT
Input Voltages	V_{IN} to GND	6.5 ~ 55	V
FB Voltages	FB	-0.3 ~ 3.3	V
Output Voltages	V_{OUT}	0.8 ~ 51	V
Output Current	I_{OUT}	0 ~ 600	mA
Operating junction temperature range, T_J	Temperature	-40 ~ +125	°C
Junction to ambient thermal resistance	θJA	180	°C/W
Junction to case thermal resistance	θJC	34	°C/W

Note:

1,The device function is not guaranteed outside of the recommended operating conditions.

2,Measured on approximately 1" square of 1 oz copper.

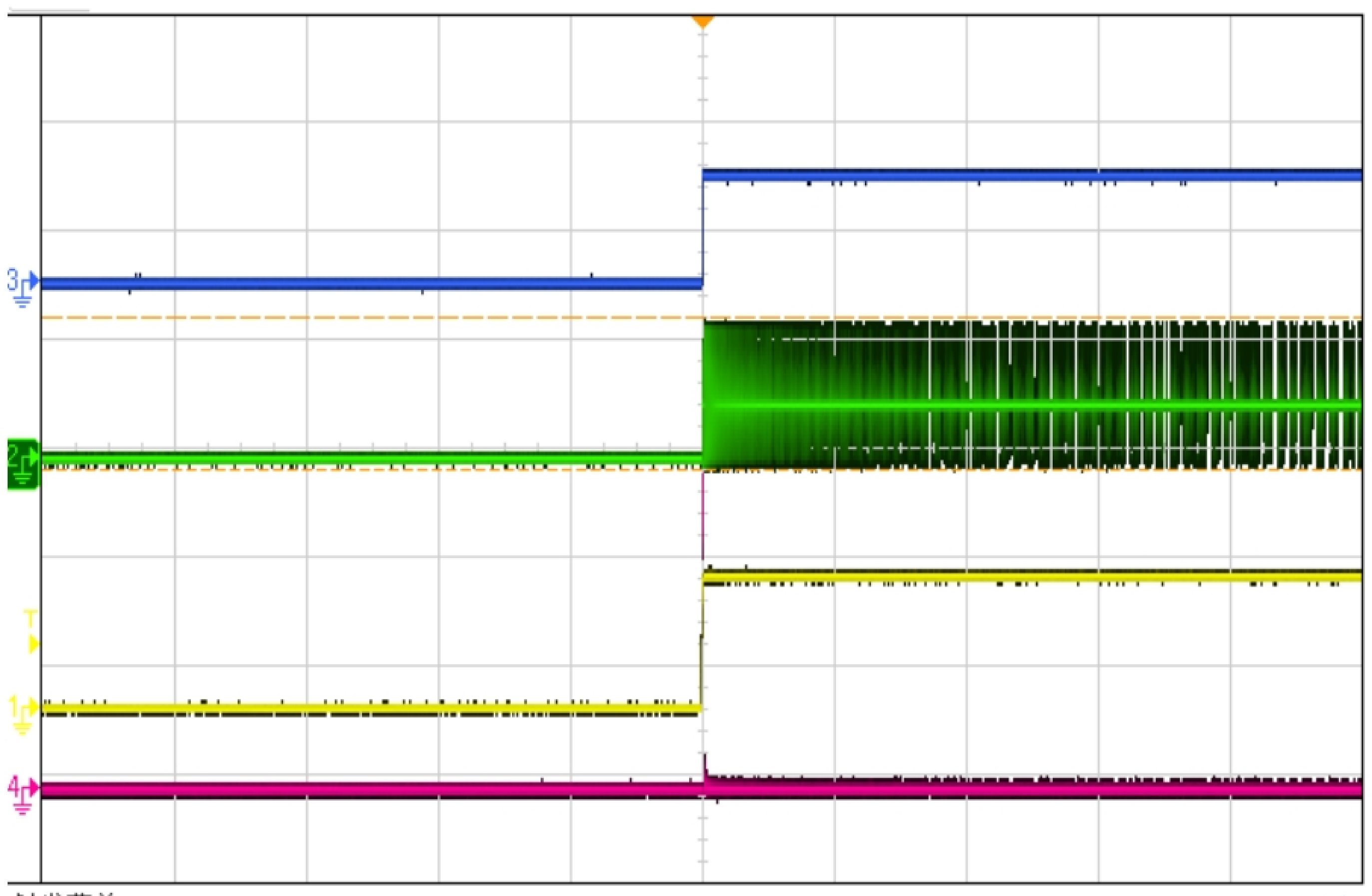
Electrical Characteristics

(Typical at Vin = 12V, TJ=25°C, unless otherwise noted.)

SYMBOL	PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
MOSFET Ileak_sw	High-Side Switch Leakage Current	VEN = 0V, VSW= 0V		0	10	μA
RDS(ON)_H	High-Side Switch On-Resistance	IOUT = 600mA, VOUT = 3.3V		550		mΩ
RDS(ON)_L	Low-Side Switch On-Resistance	IOUT = 600mA, VOUT = 3.3V		350		mΩ
VUVLO_up	Minimum input voltage for startup			4.6		V
VUVLO_down				4.3		V
VUVLO_hys				0.4		
IQ-NONSW	Operating quiescent current	VFB =0.8V		250		μA
Foscb	Buck oscillator frequency			1200		kHz
VFB	Feedback Voltage	6.5V ≤ VIN ≤ 33V		0.8		V
VFB_OVP	Feedback Over-voltage Threshold			1.1* VFB		V
Dmax	Maximum Duty Cycle(Note)			94		%
Ton	Minimum On Time(Note)			100		ns
Vinovp	Input Over voltage protection			62		v
Thsd	Thermal Shutdown(Note)			150		°C
Thsdhys	Thermal Shutdown Hysteresis(Note)			40		°C

Note::Guaranteed by design, not tested in production.

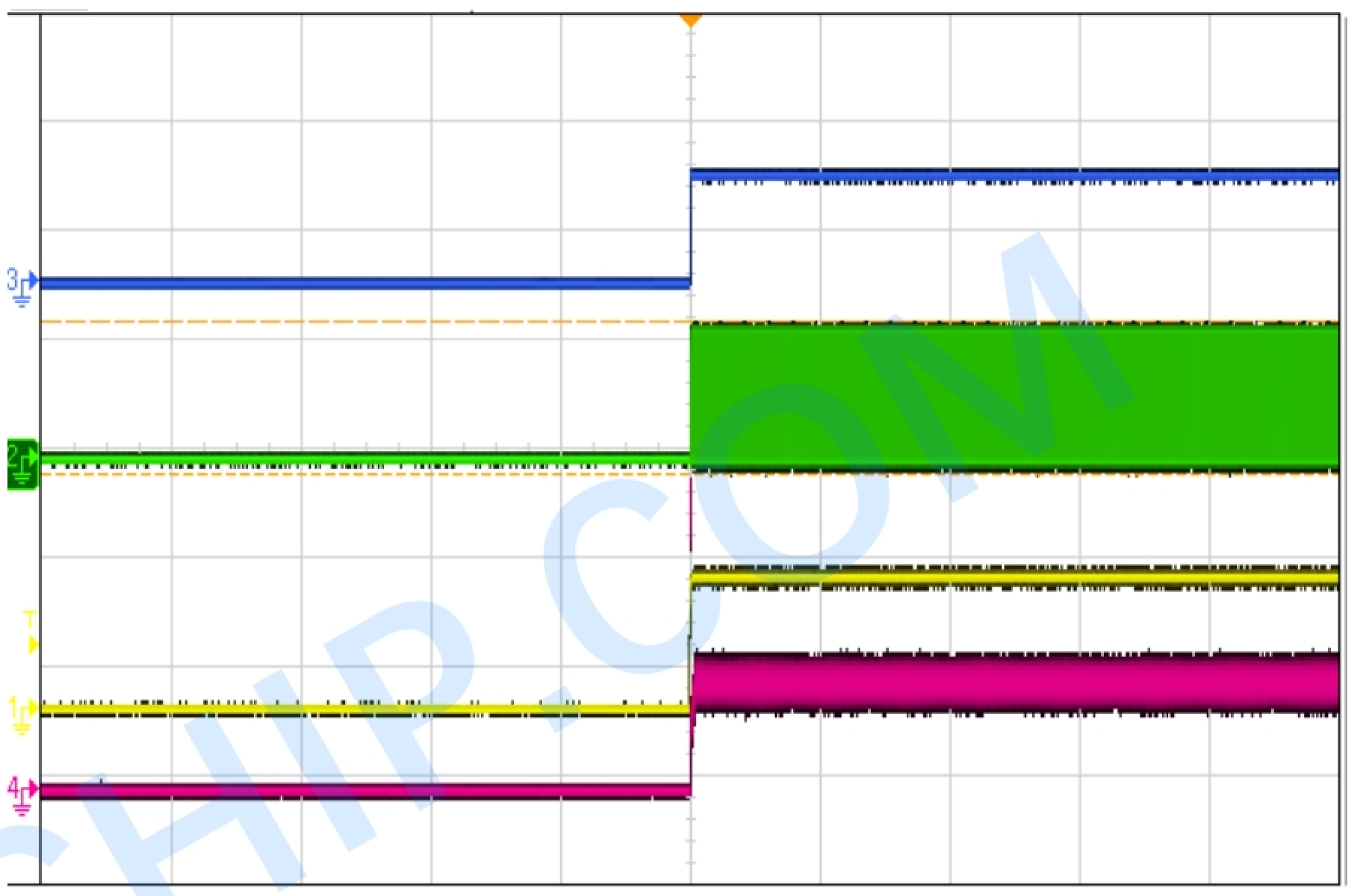
Typical Characteristics



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=12V Vout=5V

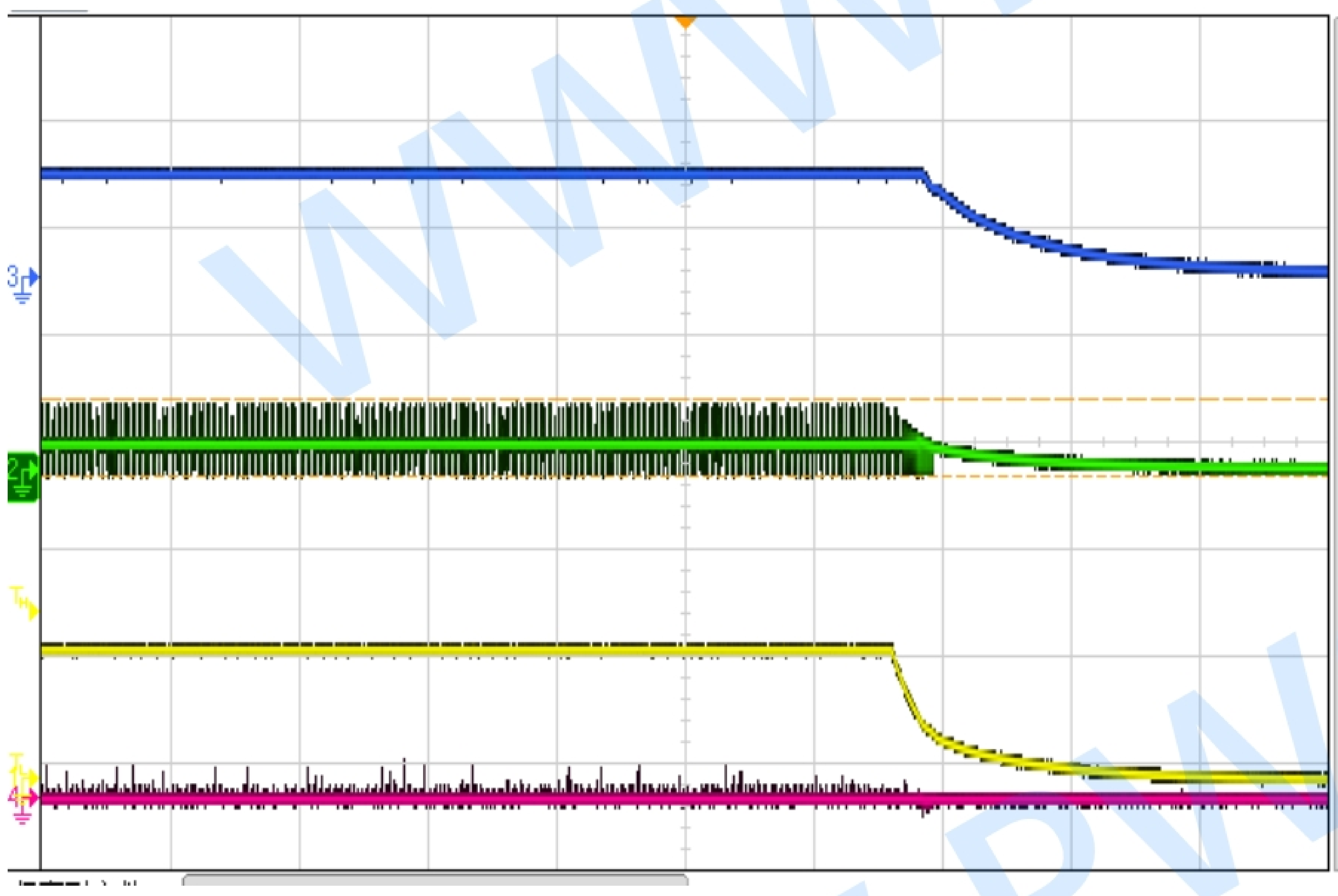
Start up waveform, Iout =0A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=12V Vout=5V

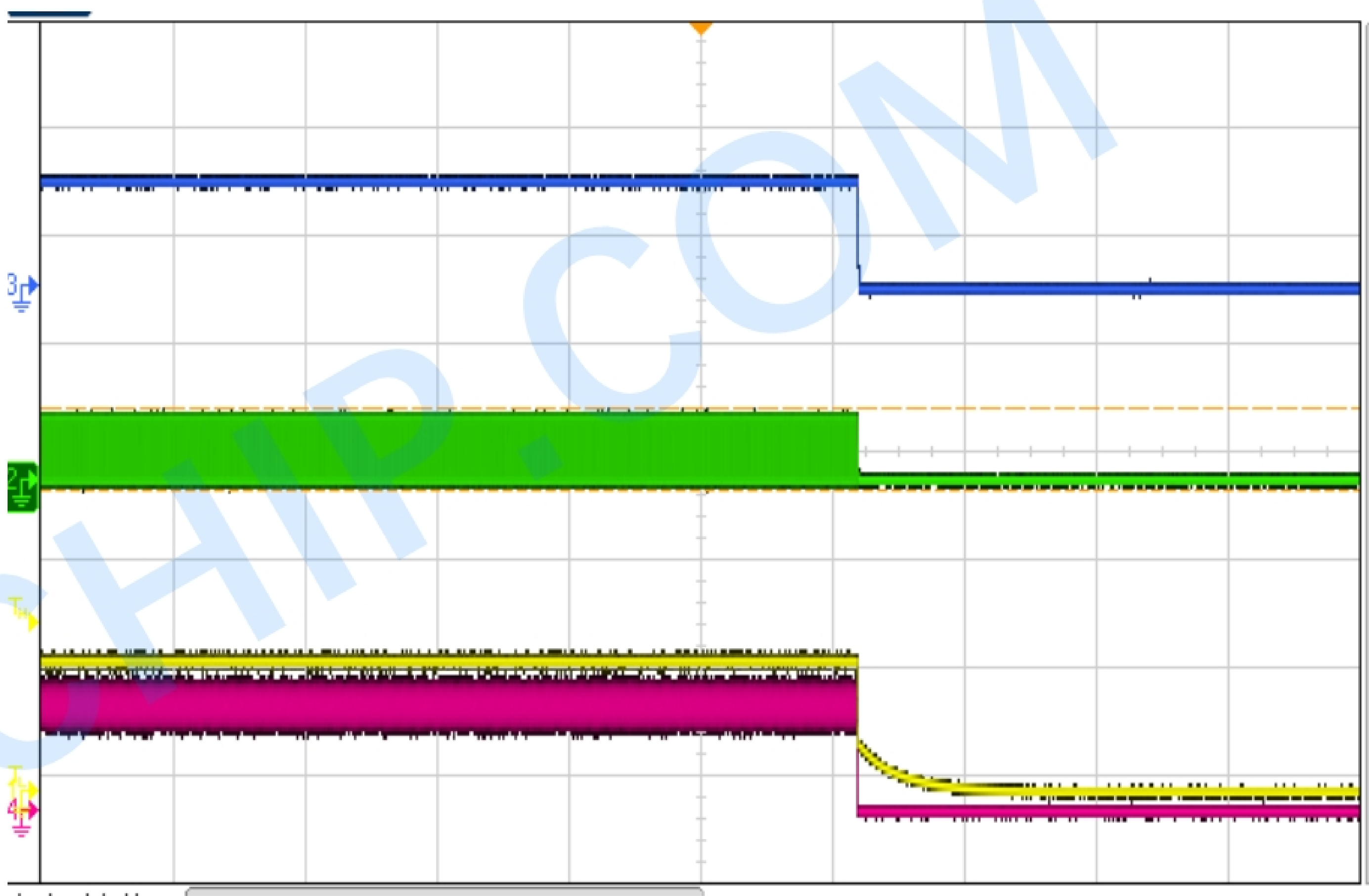
Start up waveform, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=12V Vout=5V

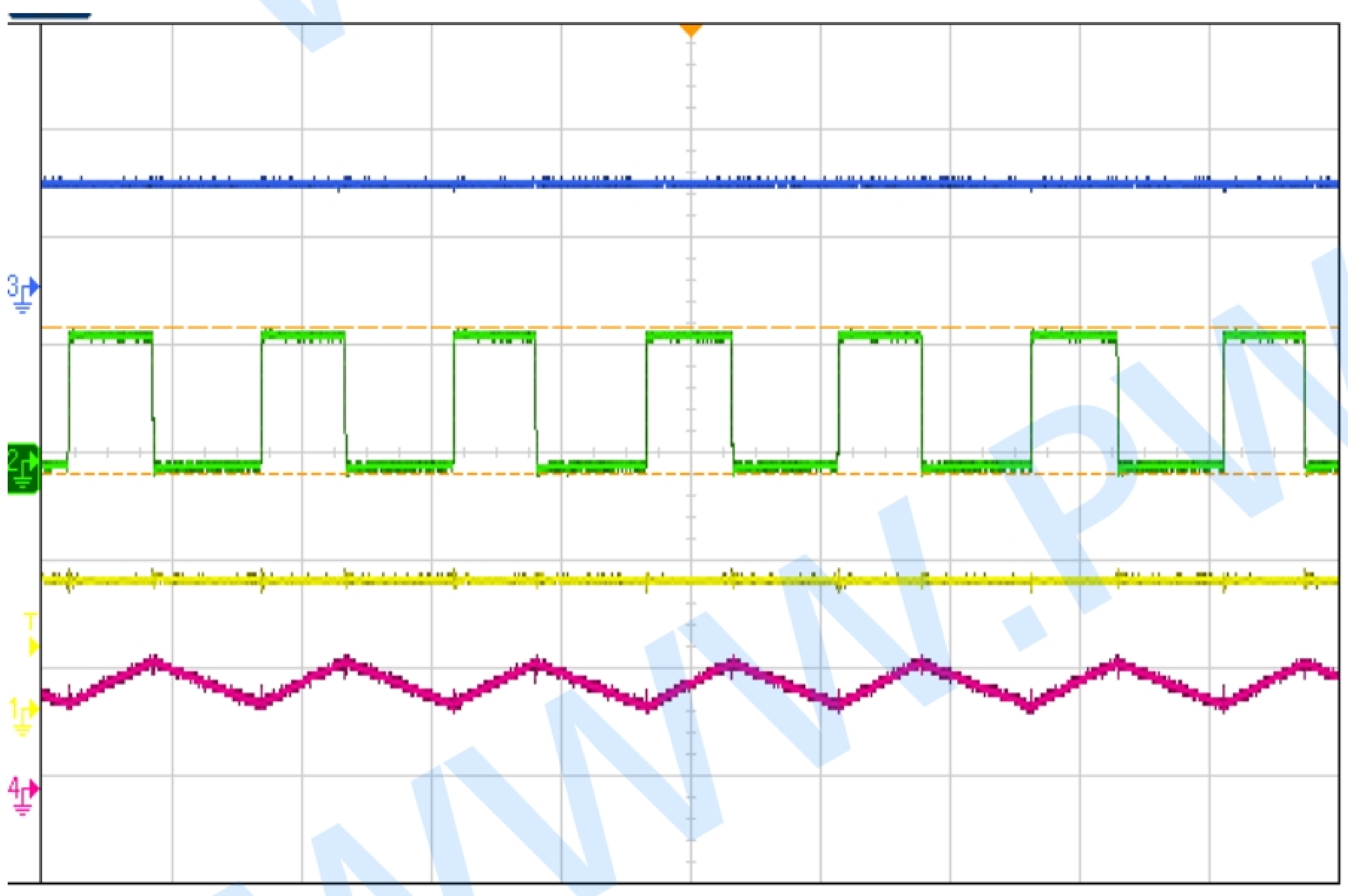
Shut down waveform, Iout =0A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=12V Vout=5V

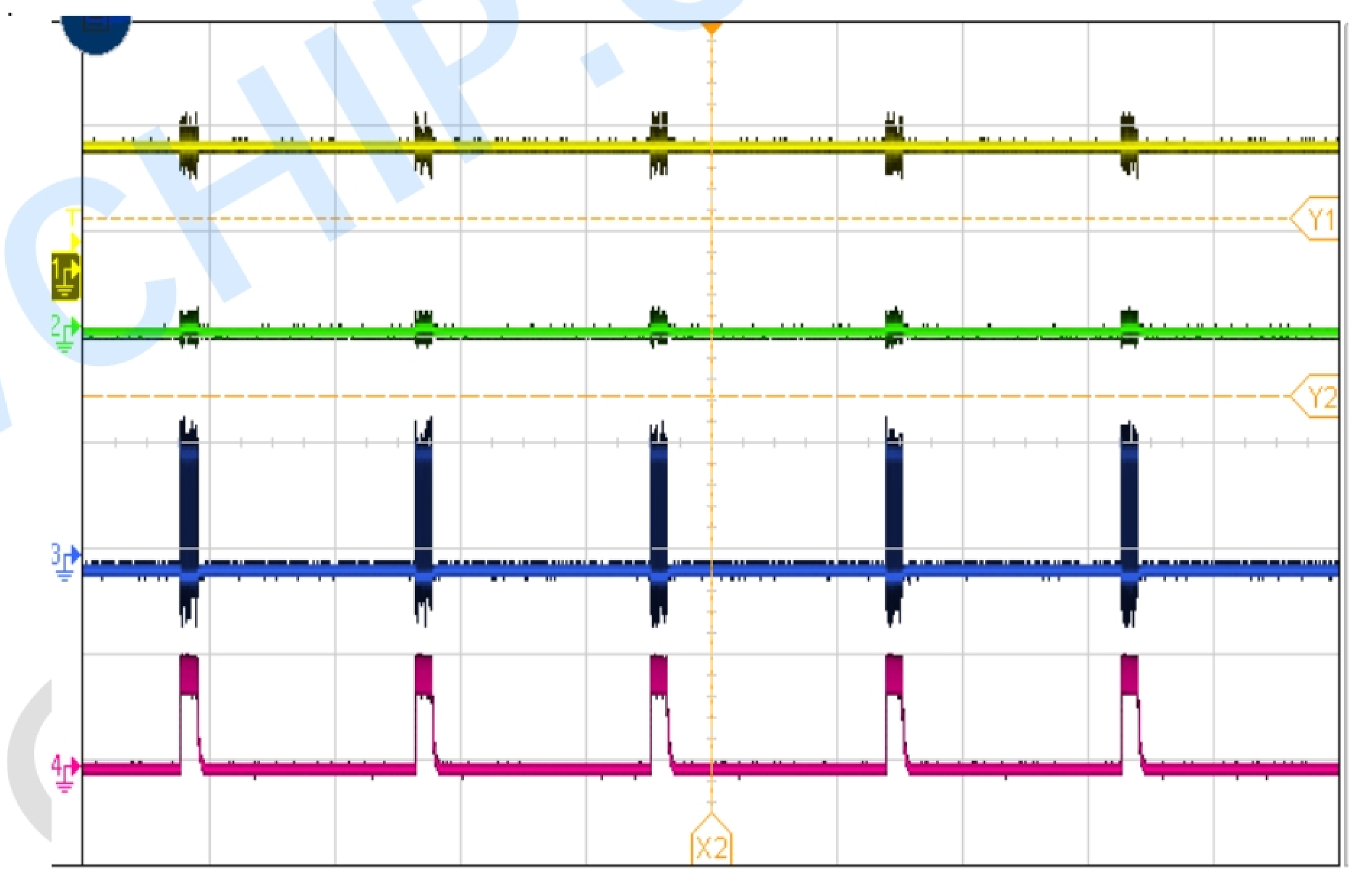
Shut down waveform, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=12V Vout=5V

Steady State, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=12V Vout=5V

Short Circuit waveform

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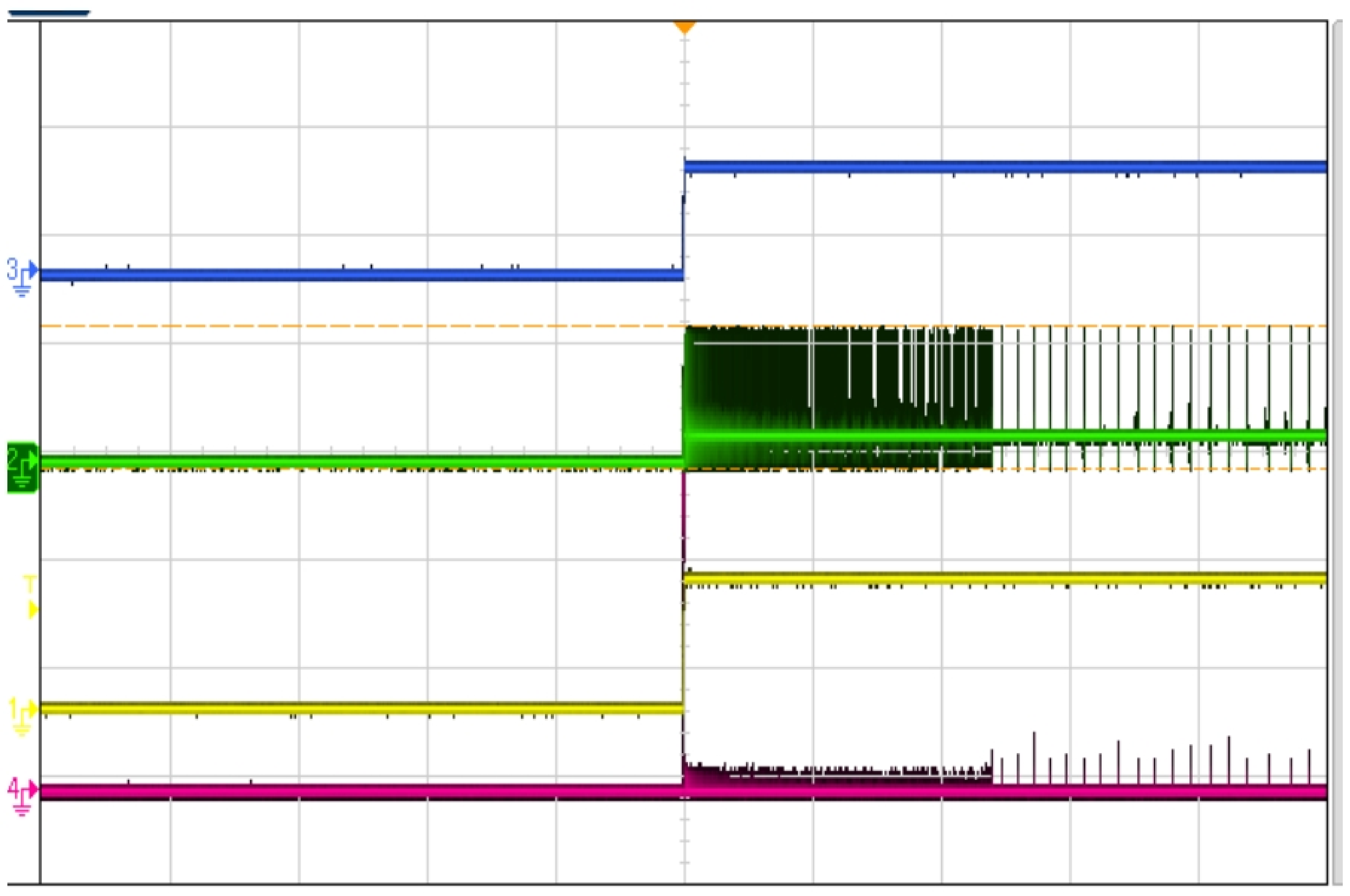
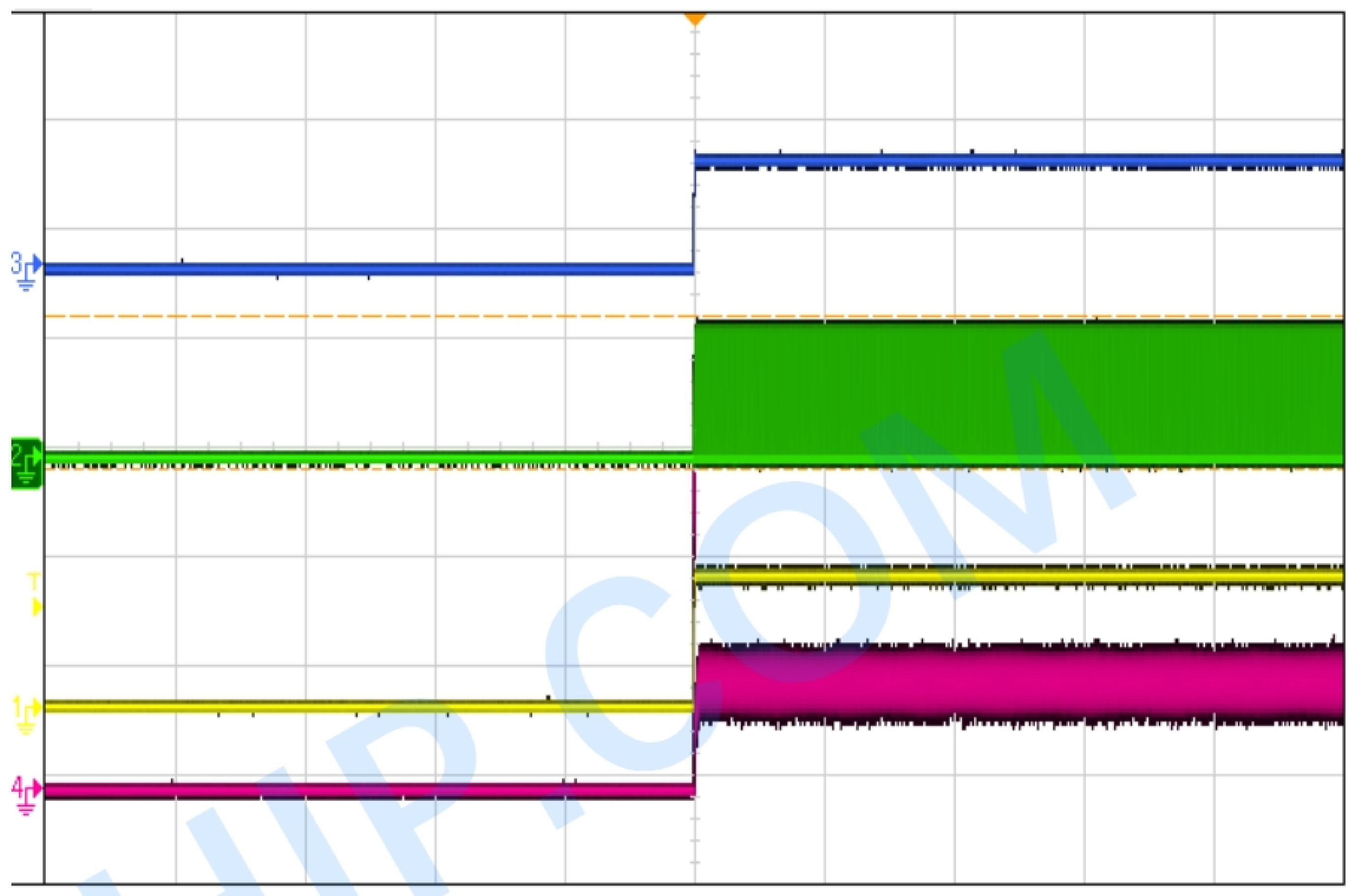


CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=24V Vout=5V

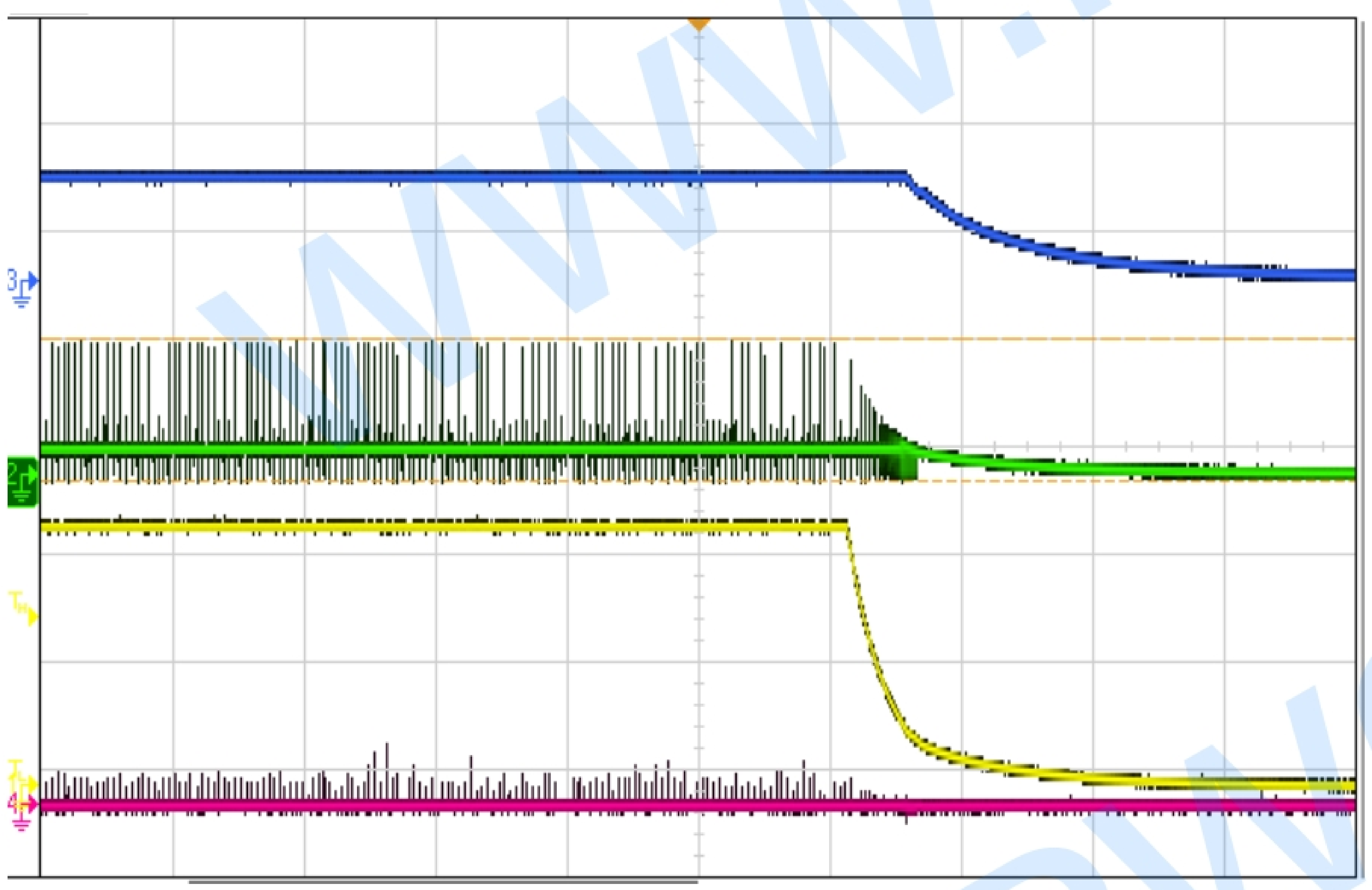
Start up waveform, Iout =0A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=24V Vout=5V

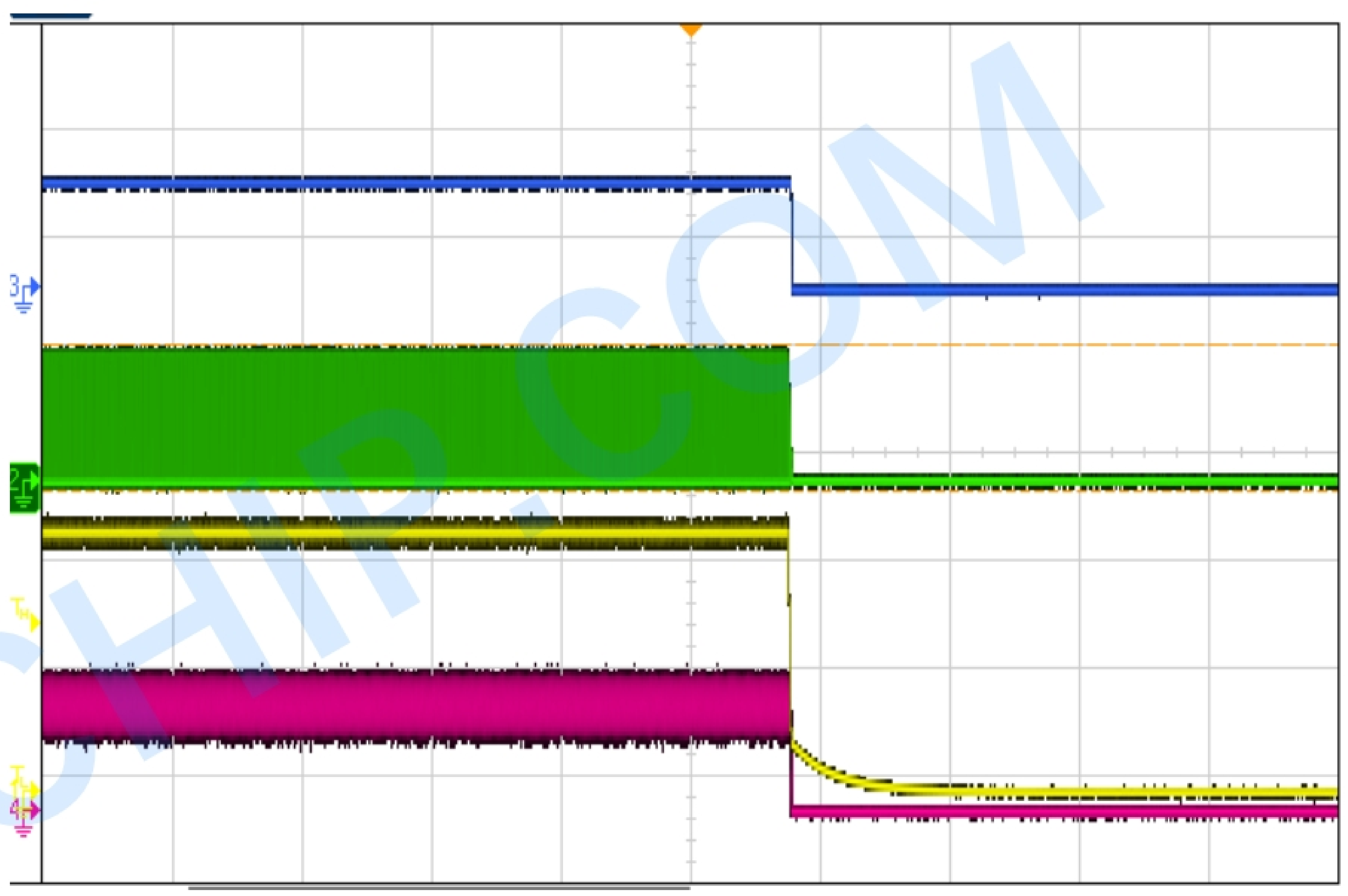
Start up waveform, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=24V Vout=5V

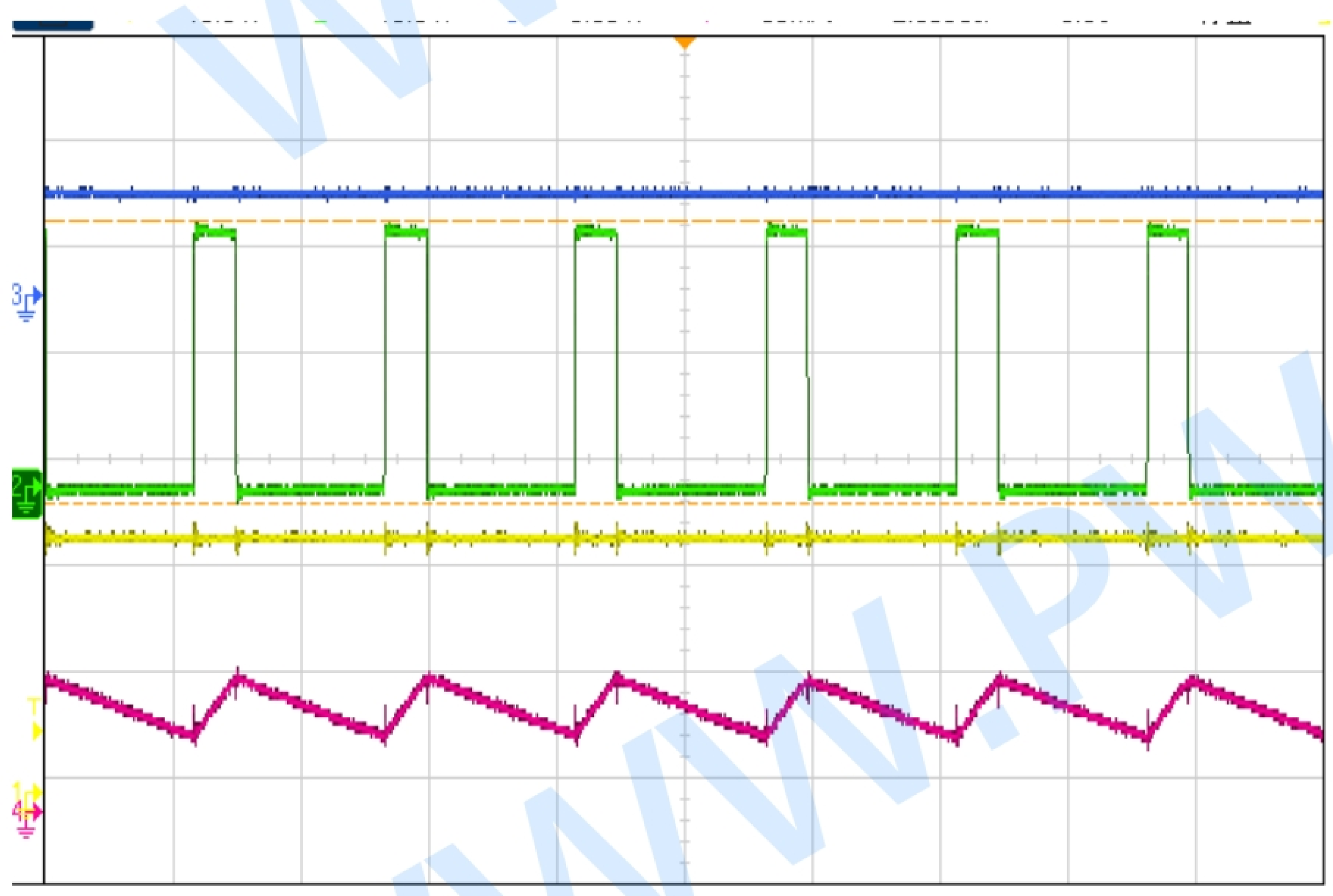
Shut down waveform, Iout =0A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=24V Vout=5V

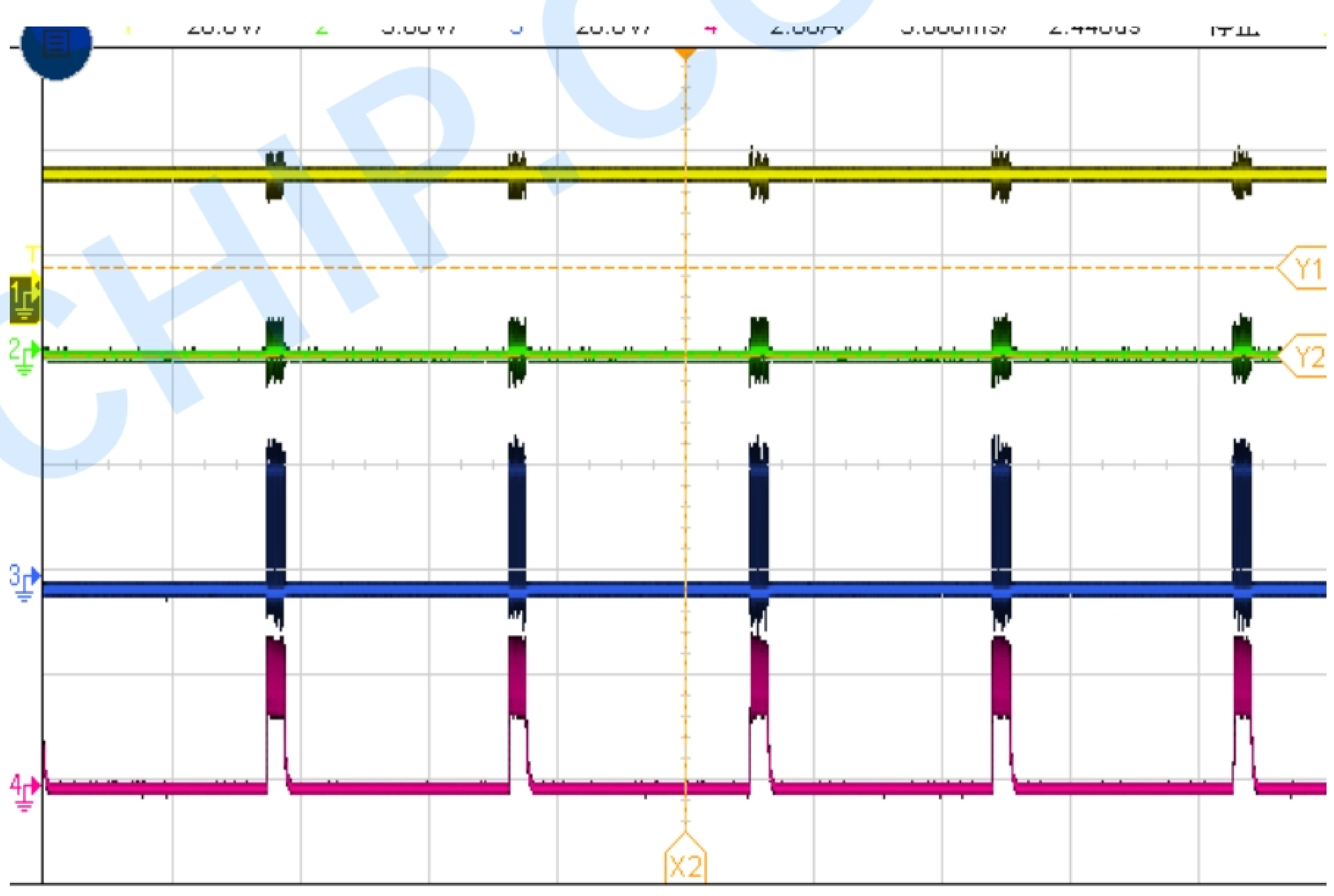
Shut down waveform, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=24V Vout=5V

Steady State, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=24V Vout=5V

Short Circuit waveform

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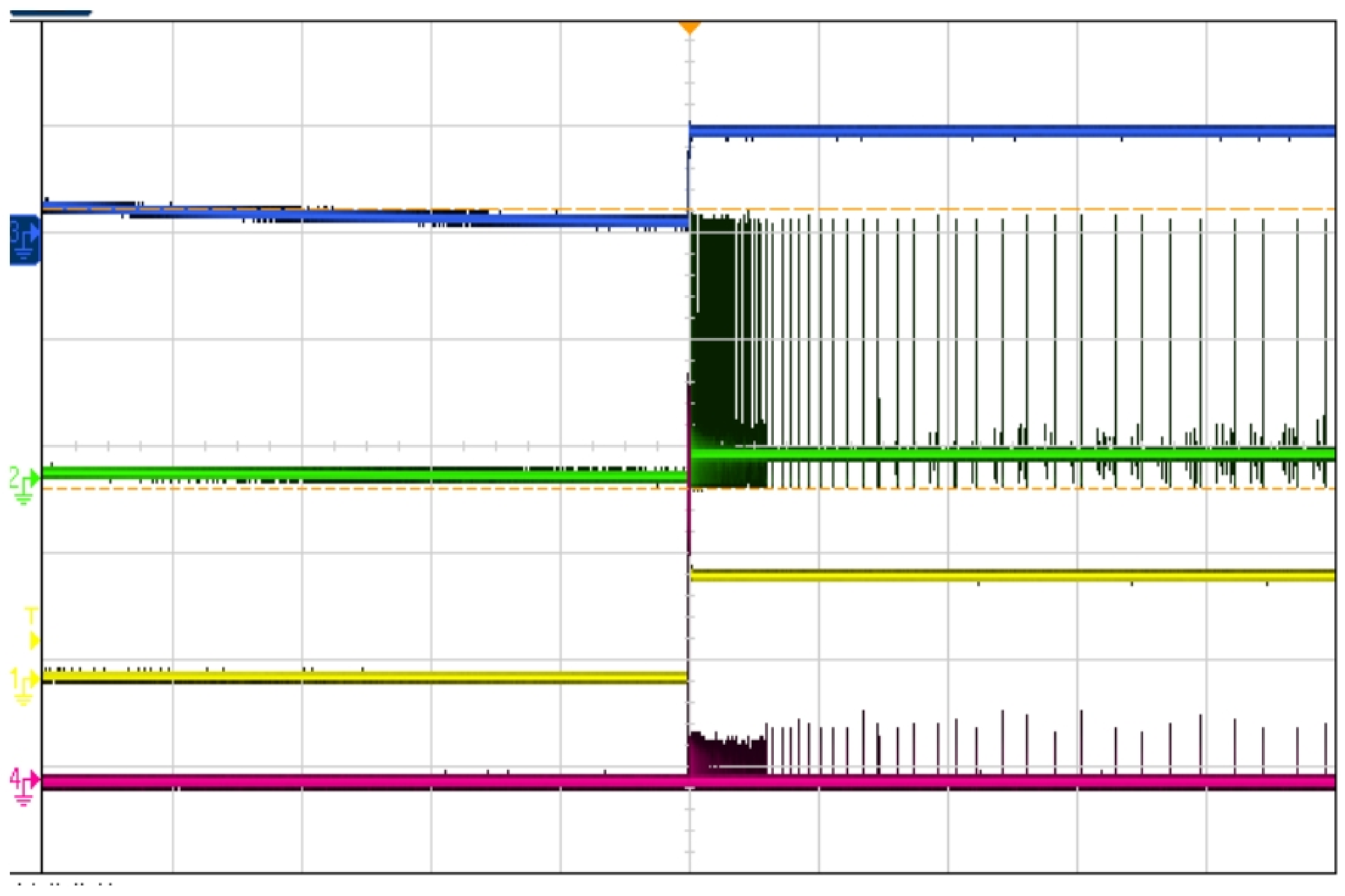
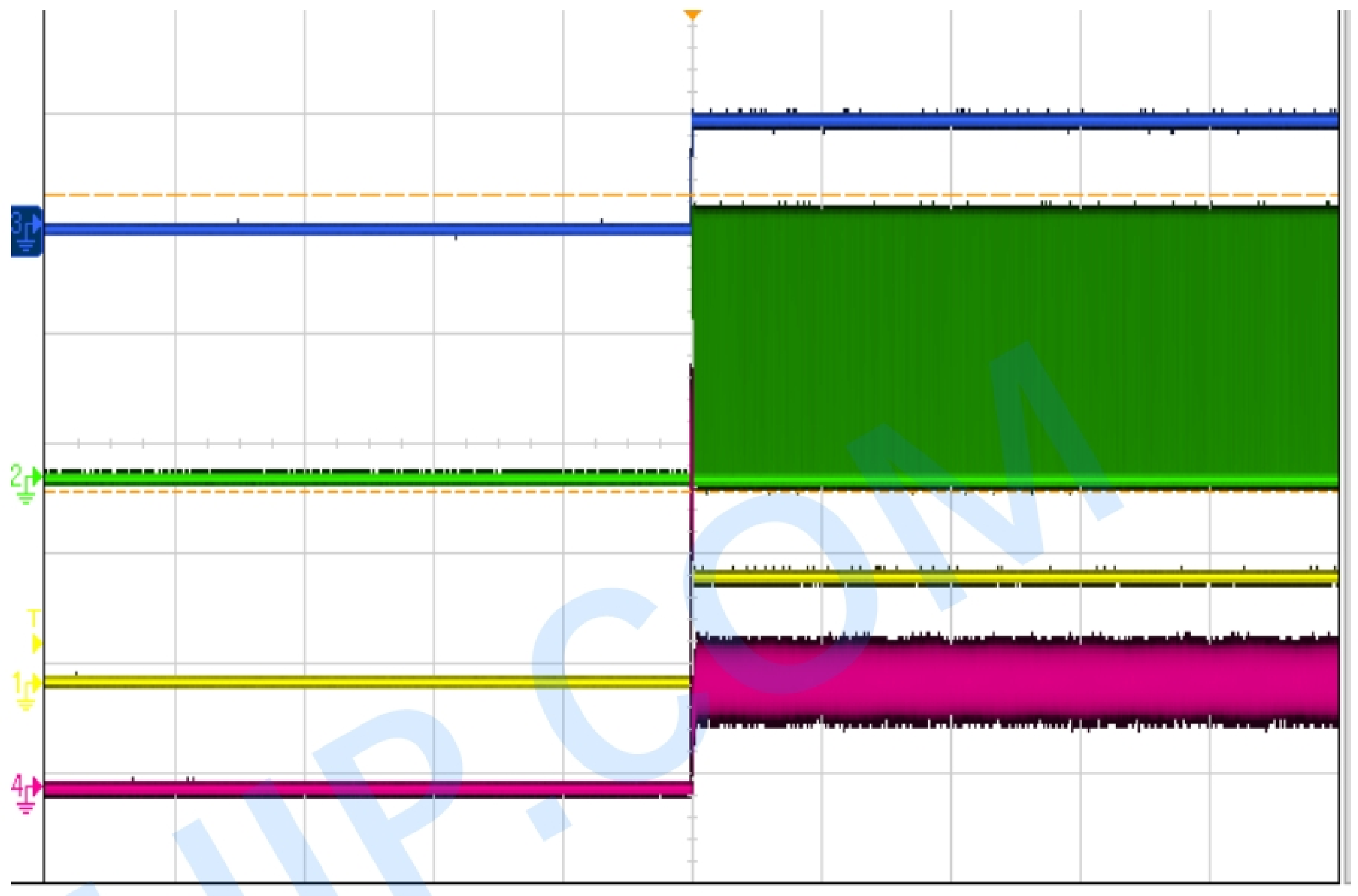


CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=48V Vout=5V

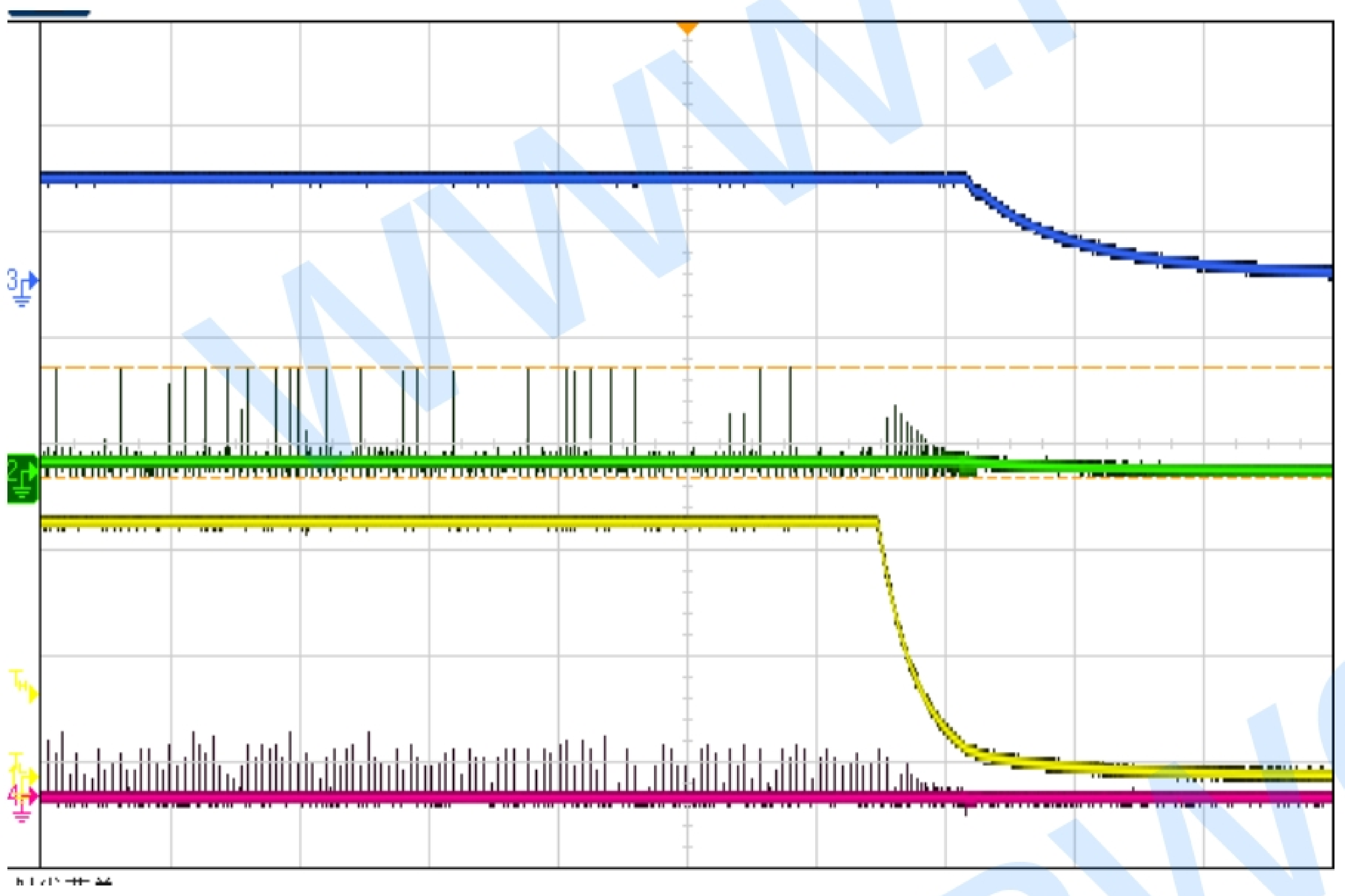
Start up waveform, Iout =0A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=48V Vout=5V

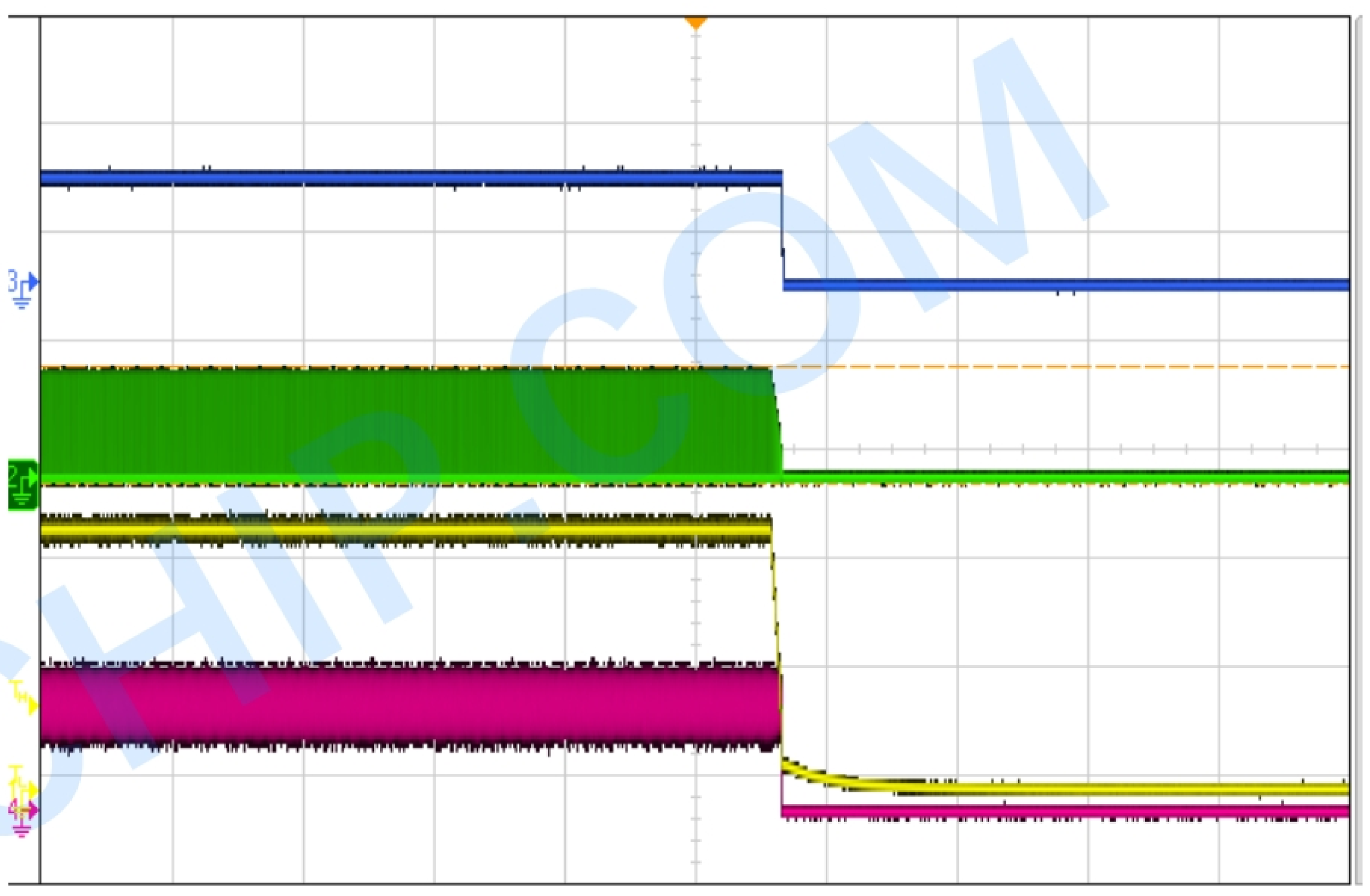
Start up waveform, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=48V Vout=5V

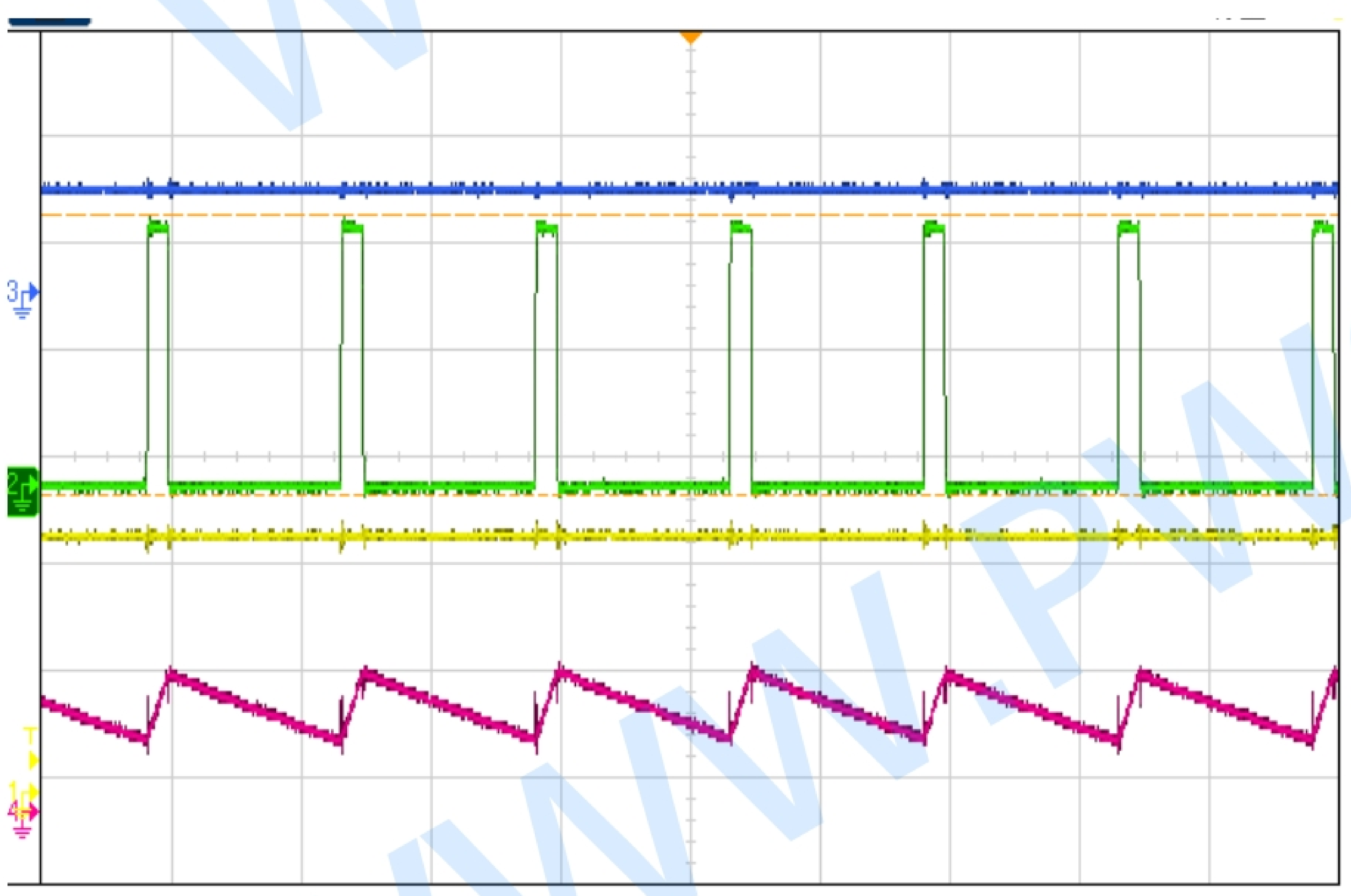
Shut down waveform, Iout =0A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=48V Vout=5V

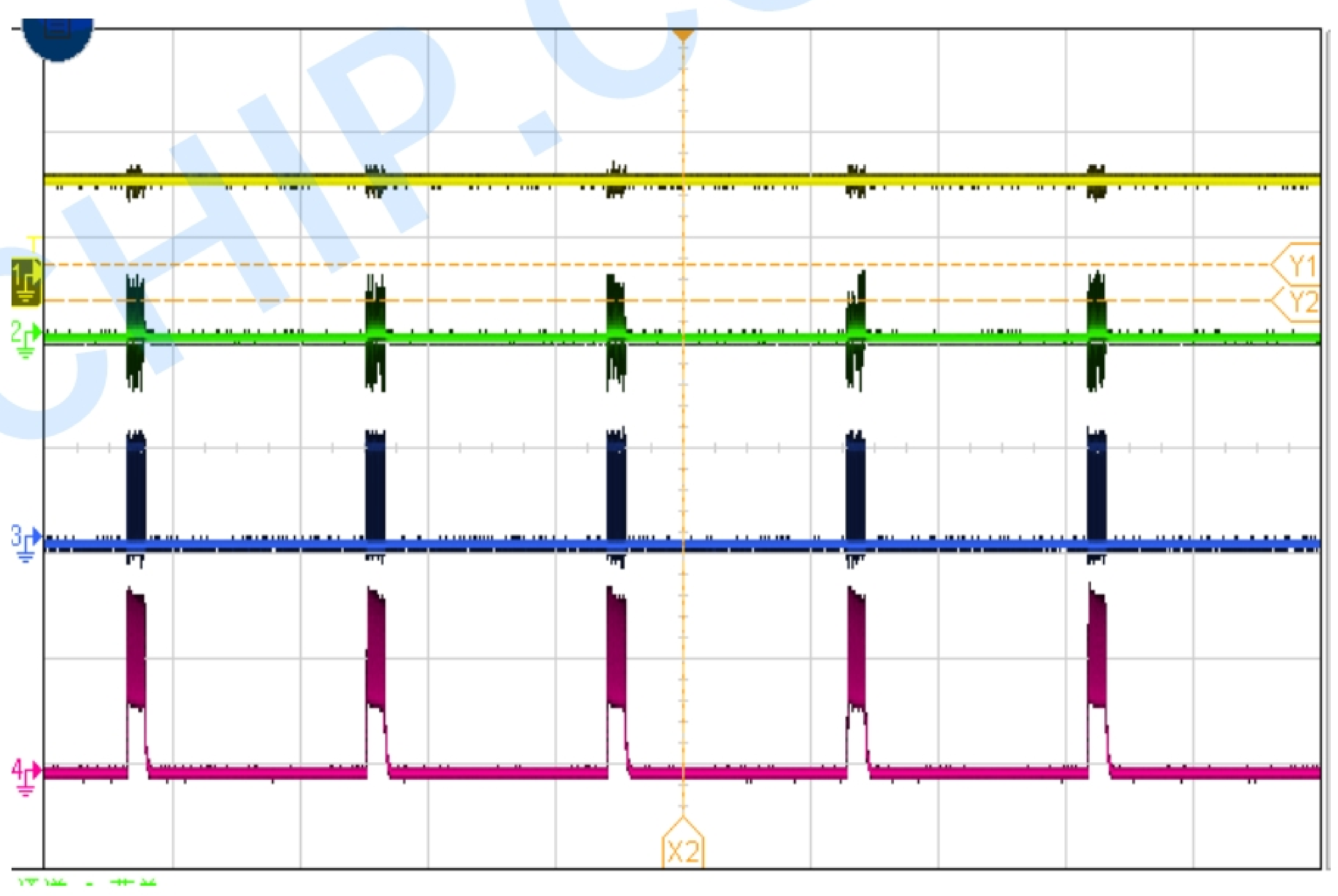
Shut down waveform, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=48V Vout=5V

Steady State, Iout =0.6A



CH1:VIN CH2:SW2 CH3:Vout CH4:IL

Vin=48V Vout=5V

Short Circuit waveform

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Detailed Description

Overview

PW2312A is an easy to use synchronous step-down DC-DC converter that operates from 4.5V to 55V supply voltage. It is capable of delivering up to 600mA continuous load current with high efficiency and thermal performance in a very small solution size. PW2312A also integrates input over voltage and output over voltage protection. This feature helps customers to design a safe DC-DC converter easily.

Peak Current Mode Control

PW2312A employs a fixed 1200kHz frequency peak current mode control. The output voltage is sensed by an external feedback resistor string on FB pin and fed to an internal error amplifier. The output of error amplifier will compare with high side current sense signal by an internal PWM comparator. When the second signal is higher than the first one, the PWM comparator will generate a turn-off signal to turn off high side switch. The output voltage of error amplifier will increase or decrease proportionally with the output load current. PW2312A has a cycle-by-cycle peak current limit feature inside to help maintain load current in a safe region.

Sleep Operation for Light Load Efficiency

PW2312A has an internal feature to help improving light load efficiency. When output current is low, PW2312A will go into sleep mode.

Setting Output Voltage

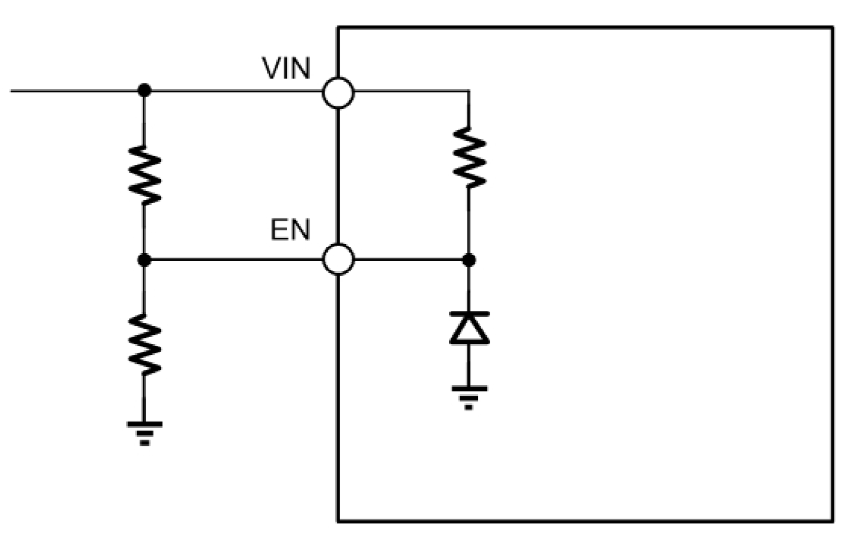
The output voltage is set with a resistor divider from the output node to the FB pin. 1% resistance accuracy of this resistor divider is preferred. The output voltage value is set as equation 1 below (R1 is the upper resistor, R2 is the lower resistor).

$$\boldsymbol{VOUT} = \left(\frac{\boldsymbol{R1}}{\boldsymbol{R2}} + \boldsymbol{1}\right) * \boldsymbol{0.8V} \qquad (\boldsymbol{0.8V} = \boldsymbol{VFB})$$

VFB is the internal reference voltage of PW2312A, which is 0.8V.

Setting Enable Threshold

When the voltage at EN pin exceeds the threshold, PW2312A begins to work. When keeping EN low (below threshold), PW2312A stops working. The quiescent current of PW2312A is very low to maintain a good shut down operation for system. PW2312A has an internal pull up resistor to make sure IC work when EN pin is float. If an application requires to control EN pin, use open drain or open collector output logic circuit to interface with it. When system needs a higher VIN UVLO threshold, the EN pin can be configured as shown in Figure below.



Thermal Shutdown

The internal thermal-shutdown circuitry forces the device to stop switching if the junction temperature exceeds 155°C typically. When the junction temperature drops below 110°C, IC will start to work again.

Application and Implementation

Inductor selection

An inductor is required to supply constant current to the load while being driven by the switched input voltage. A larger value inductor will result in less current ripple and lower output voltage ripple. However, the larger value inductor will have larger physical size, higher DC resistance, and/or lower saturation current. A good rule to calculate the inductance is to allow the peak-to-peak ripple current in the inductor to be approximately 25% of the maximum load current. At the same time, it is needed to make sure that the peak inductor current is below the inductor saturation current. The inductance value can be calculated by:

$$L=\frac{V_{OUT}}{f_s \times \Delta I_L}\left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

Where VOUT is the output voltage, VIN is the input voltage, fS is the switching frequency, and ΔIL is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum peak current. The peak inductor current can be calculated by:

$$I_{L\_P}=I_{load}+\frac{V_{OUT}}{2 \times f_s \times L}\left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

Where Iload is the load current. The choice of inductor material mainly depends on the price vs. size requirements and EMI constraints.

Input capacitors selection

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the converter. It is recommend to use low ESR capacitors to optimize the performance. Ceramic capacitor is preferred, but tantalum or low-ESR electrolytic capacitors may also meet the requirements. It is better to choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (CIN) absorbs the input switching current, a good ripple current rating is required for the capacitor. The RMS current in the input capacitor can be estimated by:

$$I_{CIN}=I_{load} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right)}$$

The worst-case condition occurs at VIN = 2×VOUT, where:

$$I_{CIN}=\frac{I_{load}}{2}$$

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For simplification, choose the input capacitor whose RMS current rating is greater than half of the maximum load current

When electrolytic or tantalum capacitors are used, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When ceramic capacitors are used, make sure that they have enough capacitance to maintain voltage ripple at input. The input voltage ripple caused by capacitance can be estimated by：（CIN is the input capacitance.）

$$\Delta V_{IN}=\frac{I_{load}}{f_s \times C_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

Output capacitors selection

The output capacitor (COUT) is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended.

Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by

$$\Delta V_{OUT}=\frac{V_{OUT}}{f_s \times L} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR}+\frac{1}{8 \times f_s \times C_{OUT}}\right)$$

Where L is the inductor value, RESR is the equivalent series resistance (ESR) value of the output capacitor and COUT is the output capacitance value. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly determined by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT}=\frac{V_{OUT}}{8 \times f_s^2 \times L \times C_{OUT}} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right)$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT}=\frac{V_{OUT}}{f_s \times L} \times \left(1-\frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulator. PW2312A is optimized for a wide range of capacitance and ESR values.

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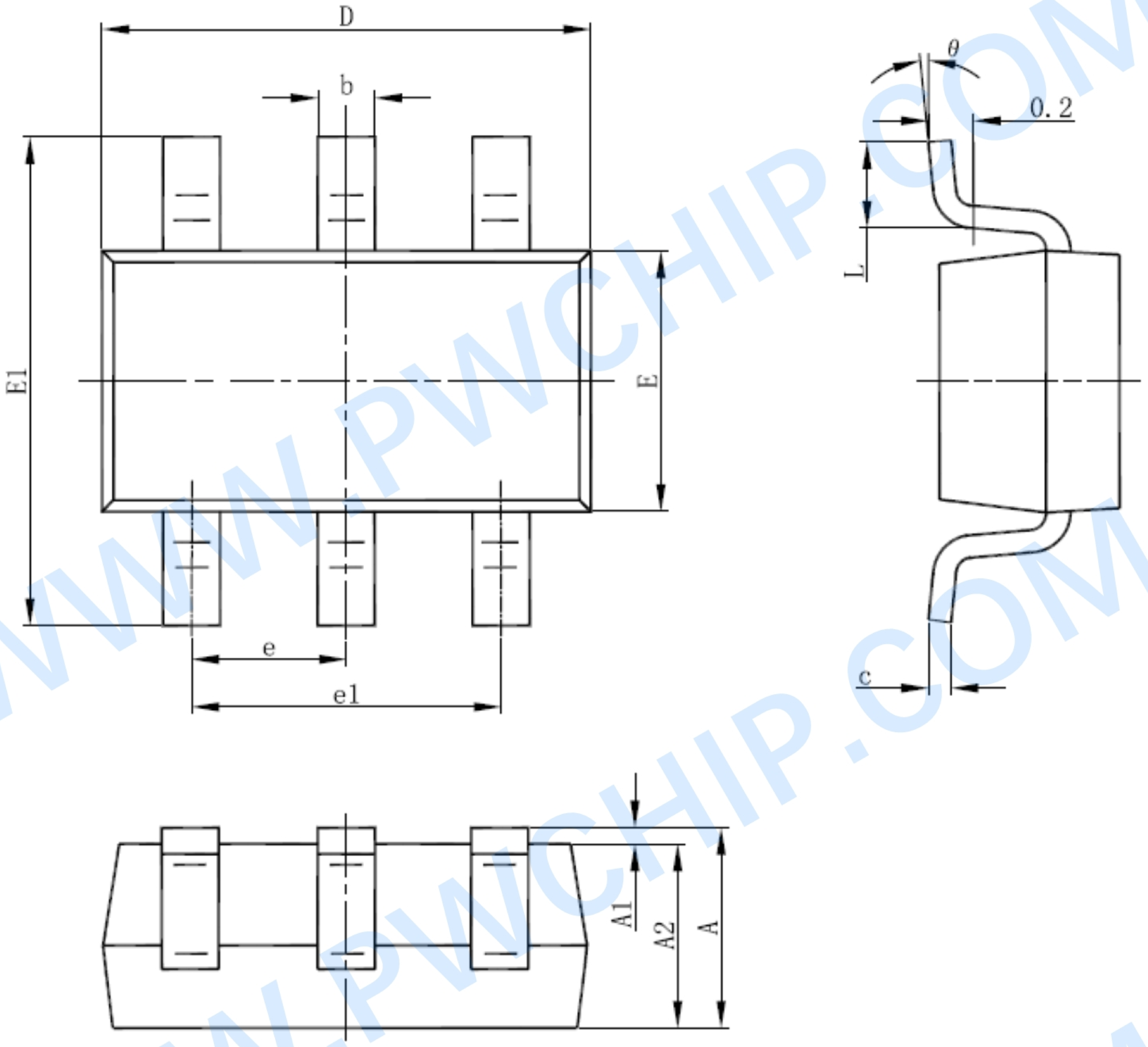
PACKAGE DESCRIPTION

SOT23-6L



Symbol	Dimensions In Millimeters	
	Min	Max
A	0.900	1.450
A1	0.000	0.150
A2	0.900	1.300
b	0.300	0.500
c	0.100	0.200
D	2.800	3.000
E	1.500	1.700
E1	2.650	2.950
e	0.950(BSC)	
e1	1.800	2.000
L	0.300	0.600
θ	0°	8°

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