3W, Primary Side H-Bridge Isolated Power Control Chip

1 Description

CN35K180 is a high voltage 24V H-bridge drive isolated power control chip. The chip integrates OSC, over-current protection circuit, over-temperature protection circuit and H-bridge power Mosfet, which can drive the transformer second-side output power up to 3W, and the operating frequency and duty cycle are externally adjustable, which is convenient for adjusting the power consumption and the EMC design of the project. The CN35K180 is specially designed for the needs of small-size, isolated power supply program in the application of low-voltage single-supply isolation interface.

CN35K180 is available in a SOT23-6 package.

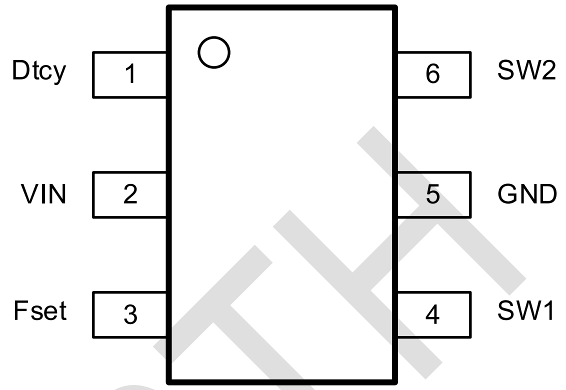
2 Features

- Highly integrated, simple periphery
- Maximum output power: 3W
- 4-24V Input Voltage Range
- Adjustable switching frequency: 200KHz-2MHz, suitable for small transformer size
- Adjustable duty cycle: 50% maximum
- Over temperature protection and over current protection

3 Applications

- CAN, RS-485, RS-232, SPI, I2C and other low-power isolated power supplies
- Process control
- Precision Instruments/Medical Instruments
- Distributed power, radio power, telecom power
- Low Noise Isolated USB Power Supplies
- Low Noise Filament Power Supplies

4 Pinout



SOT23-6

5 Marking

Product Number	Marking
CN35K180	180YW

Note: YY=Year WW=Week.

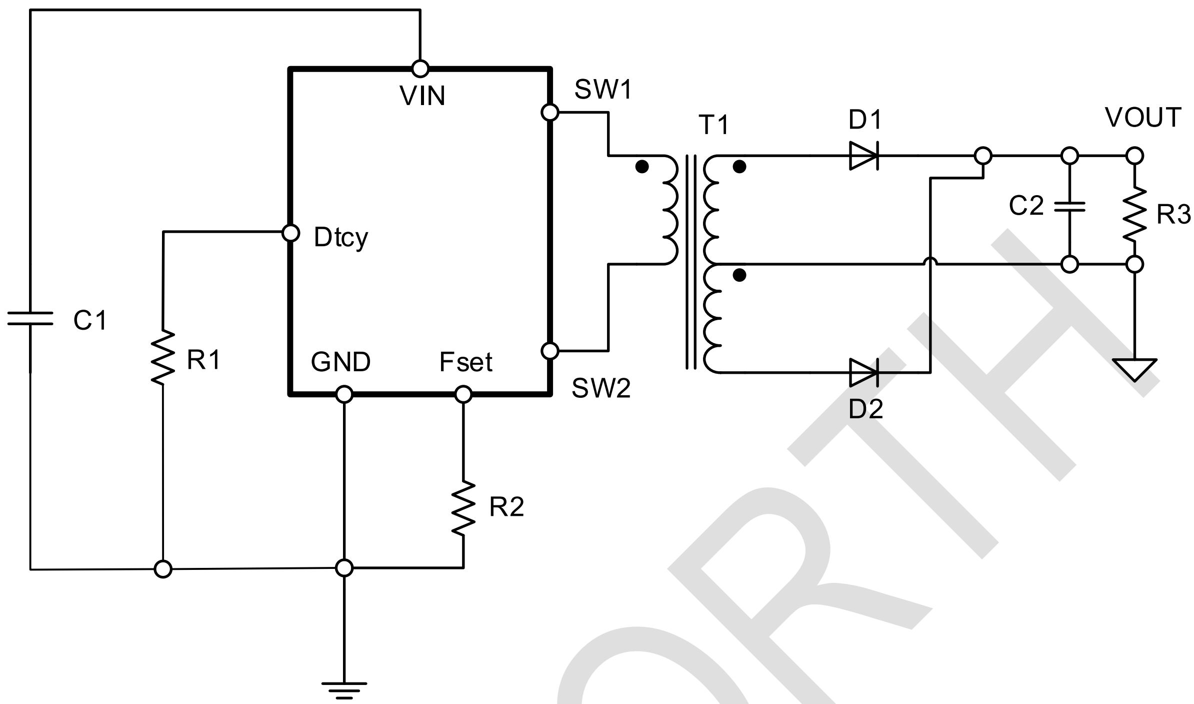
Green (RoHS & HF): CHIPNORTH defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your CHIPNORTH representative directly.

Moisture sensitivity level (MSL):3

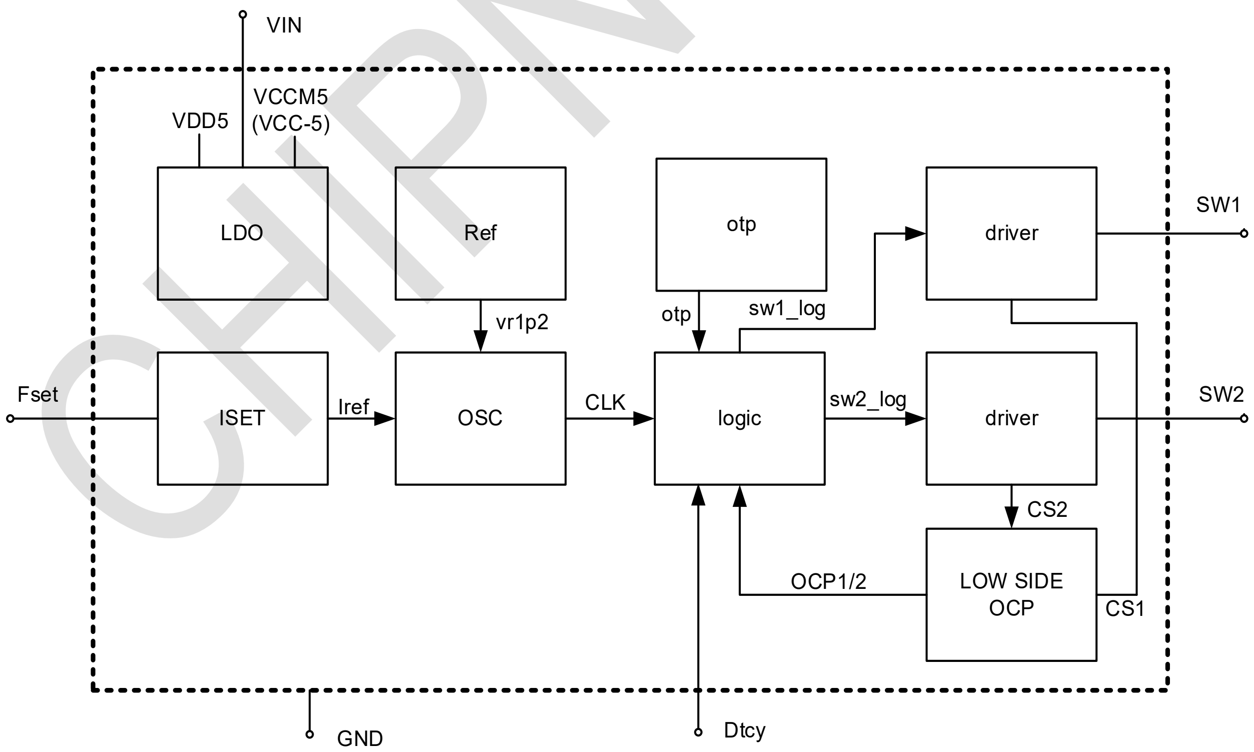
6 Ordering information

Product Number	Package	Quantity/Tape
CN35K180	SOT23-6	3000/Tape

7 Typical Application



8 Block Diagram



9 Pin Description

Pin NO	Pin Name	Descriptions
3	Fset	Frequency Adjustment pin that adjusts the frequency by adjusting the resistance to GND.
2	VIN	For power input, add a 1uF capacitor to GND and place the capacitor as close to the chip as possible.
1	Dtcy	Duty Cycle Adjustment pin, adjusts the duty cycle by adjusting the resistance to GND.
6	SW2	Transformer drive output 2.
5	GND	Logic circuit ground and analog circuit ground.
4	SW1	Transformer drive output 1.

10 Specifications

10.1 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Input Voltage	VIN	-0.3 ~ 26	V
Dtcy Voltage	Dtcy	-0.3 ~ 6	V
R_{SET} Voltage	R_{SET}	-0.3 ~ 6	V
SW1 Voltage	SW1	-0.3 ~ 26	V
SW2 Voltage	SW2	-0.3 ~ 26	V
Welding temperature	T_{LEAD}	260（soldering,10s）	°C
Storage temperature range	T_{STG}	-55 ~ 150	°C

Note: Stress exceeds these ratings listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Expose to absolute-maximum-rated conditions for extended periods may affect device reliability.

10.2 ESD Ratings

Discharge mode	Value	Units
Human Body Model (HBM)	±2000	V
Charged Device Model (CDM)	±2000	V
Latch up	±800	mA

10.3 Recommended Operating Range

Parameter	Symbol	Value		Units
		Min.	Max.	
Input Voltage Range	V_{IN}	4	24	V
Input Capacitance Range	C_{IN}	4.7		μF
Output Capacitance Range	C_{OUT}	4.7		μF
Operating temperature range	T_A	-40	105	°C

10.4 Thermal Information

Package	Parameter	Symbol	Value	Units
SOT23-6	Junction to ambient thermal resistance	θja	173	°C/W
	Junction to enclosure (top) thermal resistance	θjc（top）	116	°C/W
	Junction to board thermal resistance	θjc（bot）	31	°C/W

10.5 Electrical Characteristics

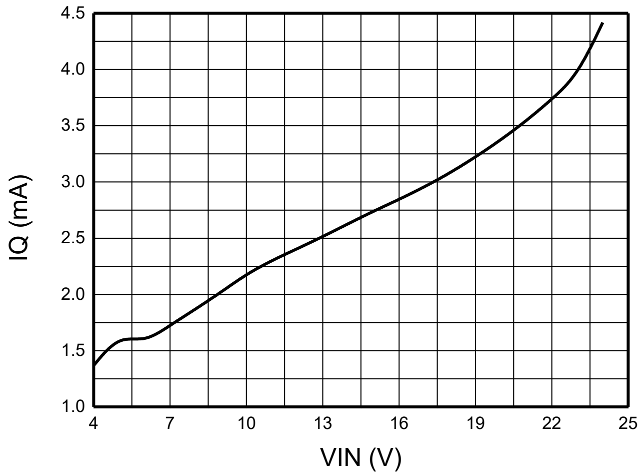
(The following parameters were measured at VIN=12V, Cin=4.7uF, and TA=25°C, unless otherwise specified.)

Parameter	Symbol	Conditions	Value			Units
			Min	Typ	Max	
Input Voltage	V_{IN}		4		24	V
Supply Current	I_{CC}	R_{SET} floating, DTCY floating		2.5		mA
Upper On-Resistance	Rdson_hs	V_{IN}=12V		485		mΩ
Lower On-Resistance	Rdson_ls	V_{IN}=12V		250		mΩ
Undervoltage Lockout Threshold	V_{UVLO}	V_{IN} rising		3.7		V
Undervoltage Blocking Hysteresis	V_{UVLO_HYS}			300		mV
Adjustable Duty Cycle	SW1/SW2	Dtcy floating		50		%
		R_{DTCY}=10kΩ		16		%
DTCY Pin Output Current	I_{DTCY}	Dtcy floating		40		uA
Overcurrent Limitation	I_{OCP}			1		A
Switching Frequency	F_{sw}	R_{set}=500kΩ		180		KHz
		R_{set}=39kΩ		2000		
Thermal Shutdown	T_{SD}			150		°C
Thermal Shutdown Hysteresis	T_{SH}			25		°C

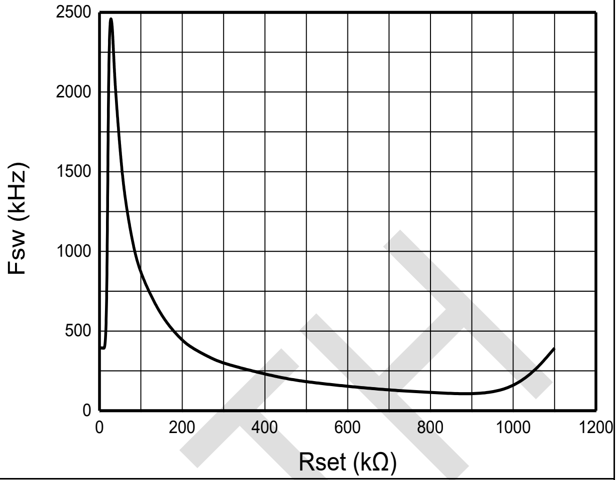
10.6 Characteristics Curve

(V_{IN}=12V, T_A=25°C, unless otherwise specified.)

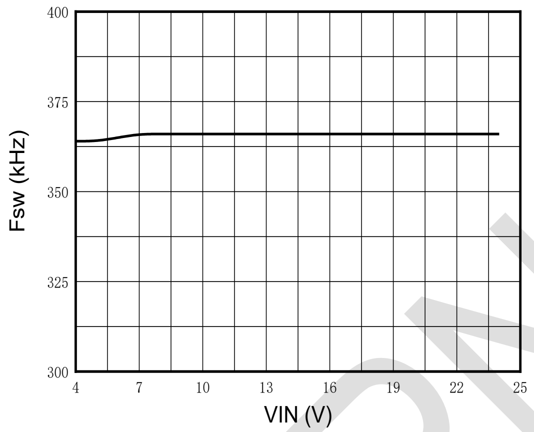
IQ vs VIN



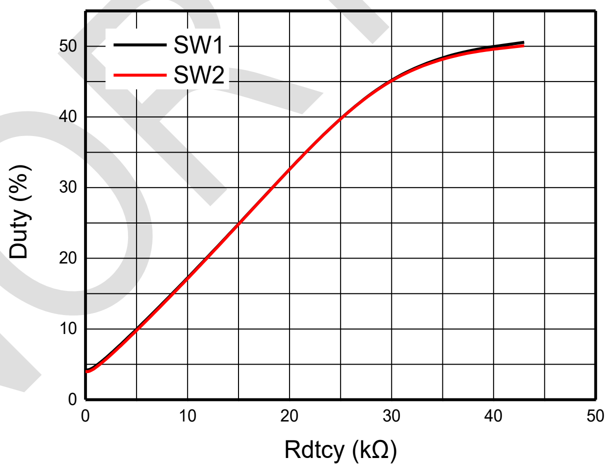
Fsw vs Rset



Fsw vs VIN



Duty vs Rdtcy



11 Detailed Description

11.1 Overview

The CN35K180 is a 24V H-bridge drive isolated power control chip. It integrates two N MOS and two P MOS.It is specially designed for low-cost, small size, low EMI isolated DC/DC power supply.

The chip includes an oscillator to power the gate drive circuit. The gate driver circuit includes a frequency divider and a break-before-break (BBM) logic that provides two complementary output signals to alternately turn on and off the two NMOS, with a dead time added between turning on and off the NMOS to avoid shorting the transformer primary windings at both ends. The resulting output signals drive the isolation transformer and rectifier to convert the input voltage to an isolated output voltage.

The CN35K180 has a variety of protection functions. The overcurrent protection helps to control the transformer current to avoid transformer saturation; when the junction temperature is higher than the thermal shutdown threshold, it will disconnect the NMOS to prevent the chip from being damaged by high temperature, and it also has an input UVLO to ensure stable operation.

11.2 Adjustable Frequency

The CN35K180 contains a 200kHz to 2MHz programmable oscillator. The oscillator frequency of 1MHz is set by connecting RSET to GND with a 100kΩ resistor. When RSET is left floating or shorted to GND, the default oscillator frequency is 360KHz, and RSET less than 22K and RSET greater than 1M are built-in frequencies. The recommended resistance range is 33K~1M, beyond which the formula is incorrect. the relationship between RSET and Fsw is as follows:

$$Fsw(KHz) = 440 \times \frac{207.5k\Omega}{RSET + 7.5k\Omega} \qquad (33k\Omega < RSET < 1000k\Omega)$$

- RSET=500KΩ Fsw=180KHz
- RSET=39KΩ Fsw=1970KHz

11.3 DTCY Pin

The DTCY pin is used to set the duty cycle of each half-bridge switch to 5% to 50% by connecting a resistor. The output current of the DTCY pin is 40uA, and its voltage value is determined by the resistor connected to the DTCY pin. DTCY is connected to GND, and the on-time of each half-bridge is the minimum on-time, and the typical value is 100nS; The DTCY floats, the voltage is internal VDD, the maximum internal VDD is 5V, and the duty cycle of each half-bridge switch is 50%. When the DTCY voltage is greater than 1.2V, the duty cycle of the half-bridge switch is 50%; When the DTCY voltage is less than 1.2V, the duty cycle is determined by the following formula:

$$Duty = \frac{I_{Dtcy} \times R_{Dtcy}}{2.4}$$

11.4 Thermal Shutdown

When the junction temperature of the built-in driver transistor reaches the temperature limit, the thermal shutdown circuit operates and the driver transistor is set to shut down. When the thermal shutdown function is released, the IC will resume operation automatically as the junction temperature drops to the level of the thermal shutdown release voltage.

11.5 Over current Protection

The CN35K180 provides over current limiting protection. When the output current triggers the OCP, the low-side FET turns on, the high-side FET turns off, and the load current is attenuated through the low-side FET until the next clock cycle.

12 Application information

12.1 Typical applications

The following figure shows a typical application schematic for a circuit that can be used to evaluate the performance of the CN35K180.

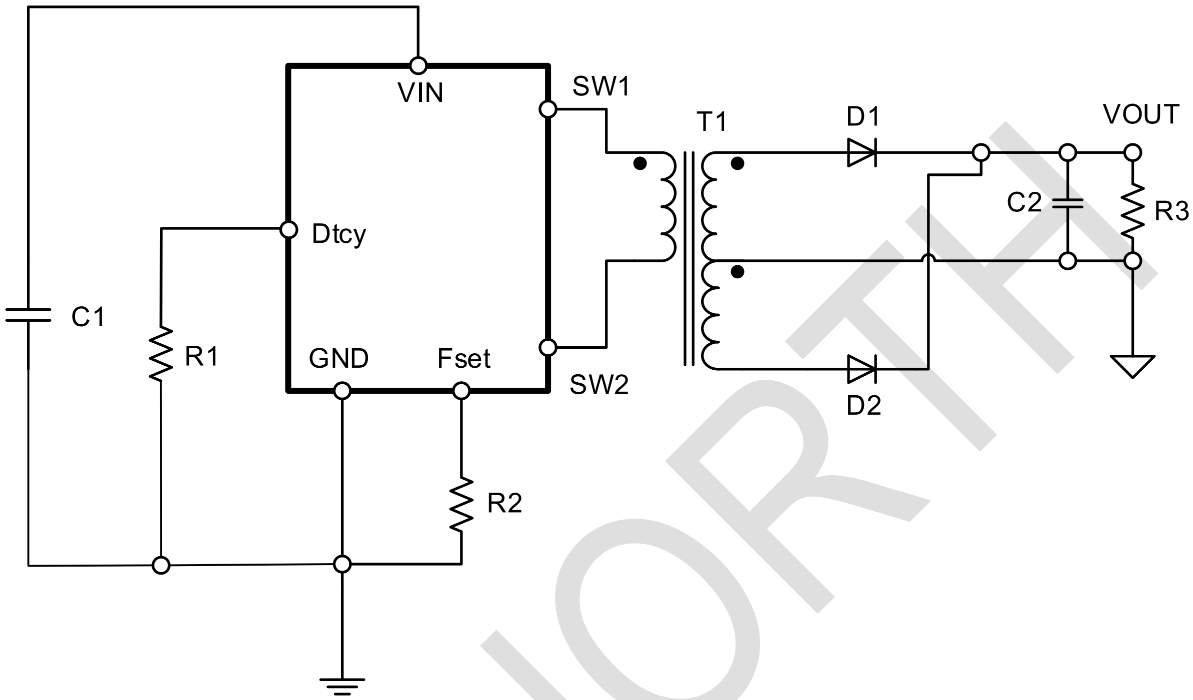


Figure12-1 Application Schematic

12.2 Design Requirements

Parameter	Min.	Typ.	Max.	Units
5V Output	4.5	5	5.5	V
Input Voltage		5		V
fsw		360		KHZ
IOUT		400		mA
operating temperature	-40	25	105	°C

12.3 Design Process

12.3.1 Input Capacitance Selection

Input capacitor C1 serves as energy storage, filtering and decoupling. If necessary, an additional 0.1uF ceramic decoupling capacitor can be connected in parallel between VIN and GND of the chip, and the decoupling capacitor should be placed as close as possible to the chip. Full-bridge converter operating process, capacitor C1 for the converter to provide a certain size of the transient current, so the capacity is recommended in the range of 1uF-10uF selected to reduce the input voltage ripple. The withstand voltage of the capacitor must be able to meet the requirements of the highest input voltage, and at the same time to ensure the use of derating, it is recommended to use a smaller ESR and relatively stable temperature characteristics of the chip ceramic capacitors. In order to achieve better filtering effect, capacitor C1 should be placed as close as possible to the chip, and the power circuit alignment should be thickened and shortened as much as possible, so as to avoid unnecessary voltage spikes caused by alternating currents flowing through the PCB parasitic inductors during the working process.

12.3.2 Output Capacitance Selection

The full-bridge converter can theoretically realize 100% duty cycle to transfer energy to the secondary side, but in order to ensure the reliable operation of the full-bridge converter, the switching process of the two bridge arms needs to reserve a certain dead time to prevent the emergence of the common-pass. During the dead time, the output energy mainly relies on the output filter capacitor C2 to provide, so a certain amplitude of output ripple will be generated at this stage. In practice, capacitor C2 is recommended to use 4.7uF-10uF ceramic capacitors, which can bring better filtering effect for the converter.

12.3.3 Output Rectifier Diode Selection

The output rectifier circuit is recommended to use Schottky diode with low on-state voltage drop and short reverse recovery time, which can bring better load regulation ratio and higher conversion efficiency for the full-bridge converter. This application program uses the output full-wave rectifier circuit structure, the rectifier diode reverse voltage stress for the output voltage amplitude of 2 times, so the output rectifier diode reverse withstand voltage amplitude should be in accordance with the output voltage of the largest value (in the highest input voltage, the smallest load conditions) of more than 2 times to ensure that the use of derating. Rectifier diode reverse withstand voltage calculation formula is:

$$Diode\ V_R > 1.5 * 2 * \frac{N_S}{N_P} * V_{INMAX}$$

Where NP is the number of turns of the primary winding of the full-bridge transformer, NS is the number of turns of the secondary winding of the full-bridge transformer, and $_{VOUTMAX}$ is the maximum output voltage.

Output rectifier diode should be selected to meet the requirements of the actual operating temperature range of models, in particular, it should be noted that the maximum operating temperature conditions, Schottky diode reverse leakage current will increase significantly, so the need for diodes according to the high-temperature operating characteristics of the reasonable use of the dosage, specific specific diode specifications can be viewed in the temperature derating curve.

In order to ensure that the full-bridge converter in any working conditions, reliable and stable operation, the output rectifier diode selection also need to consider the maximum operating current in the output side of the short-circuit anomaly.CN35K180 triggered short-circuit protection, the current in the Mosfet reaches the protection threshold ILIM (typical value of 1A), the chip will be disconnected from the Mosfet until the next cycle and then conduction of the MOS.At this time, the output rectifier can be derived according to the relationship between transformer turns ratio and the output rectifier current, and the output rectifier current can be reduced to the maximum current. Turns ratio relationship to derive the maximum operating current of the output rectifier diode, which can be calculated by the following formula:

$$I_{D-MAX} = \frac{N_P}{N_S} \times I_{LIM-MAX}$$

Where ILIM-MAX is the current limit maximum of the chip.

This application program can choose the model RB060M-30 Schottky diode, this diode at 75 °C, forward conduction voltage drop is 300mV@0.4A, reverse leakage current 100uA @ 15V, forward peak current $_{IFSM}$ = 55A. If there are higher operating temperature requirements, it is recommended to choose a high temperature reverse leakage current smaller Schottky diode.

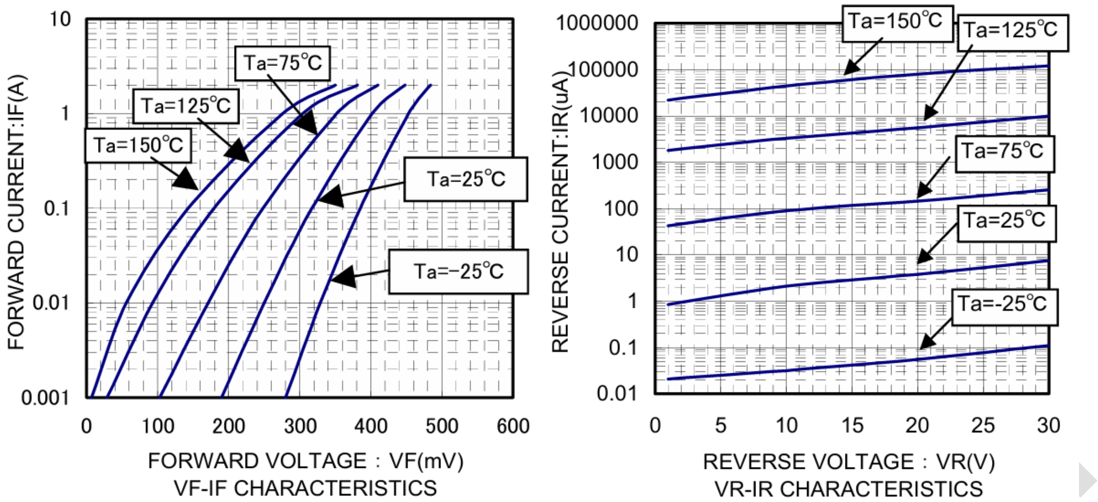


Figure12-2 Schottky RB060M-30 Operating Characteristics Curve

12.3.4 Full Bridge Transformer Design

（1）Estimation of turns ratio of primary and secondary side windings

Assuming that the output rectifier diode of the full-bridge converter has been selected according to the design requirements, the forward conduction voltage drop of the rectifier diode under maximum output load conditions, $_{VF}$, can be used to estimate the turns ratio of the primary and secondary windings of the full-bridge transformer based on the input voltage of the primary winding and the minimum output voltage of the secondary winding. Under nominal input, output full load conditions, the full-bridge transformer primary winding input voltage is:

$$V_P = V_{IN} - \frac{P_{O\_MAX}}{\eta * V_{IN}}(R_{ON\_N} + R_{ON\_P})$$

Where $P_{O\text{-}MAX}$ is the maximum output power of the full-bridge converter, η is efficiency, the estimated conversion efficiency of the full-bridge converter under full-load conditions, and R_{ON_N} and R_{ON_P} are the on-resistance of the chip's built-in N-MOS and P-MOS. The output minimum voltage of the secondary winding under full load condition is:

$$V_S = V_{O-MIN} + V_F$$

Among them, $V_{O\text{-}MIN}$ is the minimum voltage allowed to be output from the full-bridge converter under full-load conditions, and in order to ensure that the output voltage characteristic curve meets the specifications under full-load conditions, $V_{O\text{-}MIN}$ can be estimated at 97% of the nominal output voltage (-3% accuracy of the nominal output voltage), and VF is the forward conduction voltage drop of the selected output rectifier diode under full-load conditions. From the above formula can be derived from the original secondary winding turns ratio formula:

$$N_{PS} = \frac{V_{IN} - \frac{P_{O\_MAX}}{\eta * V_{IN}}(R_{ON\_N} + R_{ON\_P})}{V_{O\_MIN} + V_F}$$

Taking the input and output requirements of this application case and assuming that the conversion efficiency of the full-bridge converter is 85%, the turns ratio of the primary and secondary windings of the full-bridge transformer can be estimated to be:

$$N_{PS} = \frac{5V - \frac{2W}{0.85 * 5V} * (0.485\Omega + 0.25\Omega)}{5V * 0.97 + 0.3V} \approx 0.9$$

（2）Full-bridge transformer volt-second product estimation

To prevent transformer saturation, the volt-second product of the selected full-bridge transformer must be greater than the maximum volt-second product generated by the CN35K180 under all normal operating conditions. In the narrow range of input isolation power supply applications, usually ± 10% of the nominal input voltage as the input range of the power supply, so the volt-second product of the full-bridge transformer should be in accordance with the upper limit of the input voltage of the power supply as the basis for calculation. The frequency and tolerance set by the chip itself should also be taken into account to meet the minimum operating frequency conditions without saturation. The maximum volt-second product applied to the primary winding of the transformer through the CN35K180 is generated under the conditions of half of the switching period corresponding to the set minimum operating frequency and the maximum input voltage. Therefore, the minimum volt-second product of the full-bridge transformer can be estimated by referring to the following calculation method:

$$Vt_{MIN} \geq V_{IN-MAX} \times \frac{T_{MAX}}{2} = \frac{V_{IN-MAX}}{2 \times f_{MIN}}$$

With the design requirements of this application case, assuming that the typical value of the set operating frequency is 360 KHz and the minimum operating frequency is 324 KHz, the volt-second product of the selected full-bridge transformer should satisfy, under the highest input condition:

$$Vt_{MIN} \geq \frac{5V * 110\%}{2 * 324K} \approx 8.5V\ us$$

Full-bridge transformer selection should be based on the actual application requirements to find the appropriate size of the volt-second product and the turns ratio of the original and secondary windings, at the same time, the maximum output power, the isolation voltage level, isolation and distribution capacitance, etc. should also be used as an important reference for the selection of full-bridge transformers.

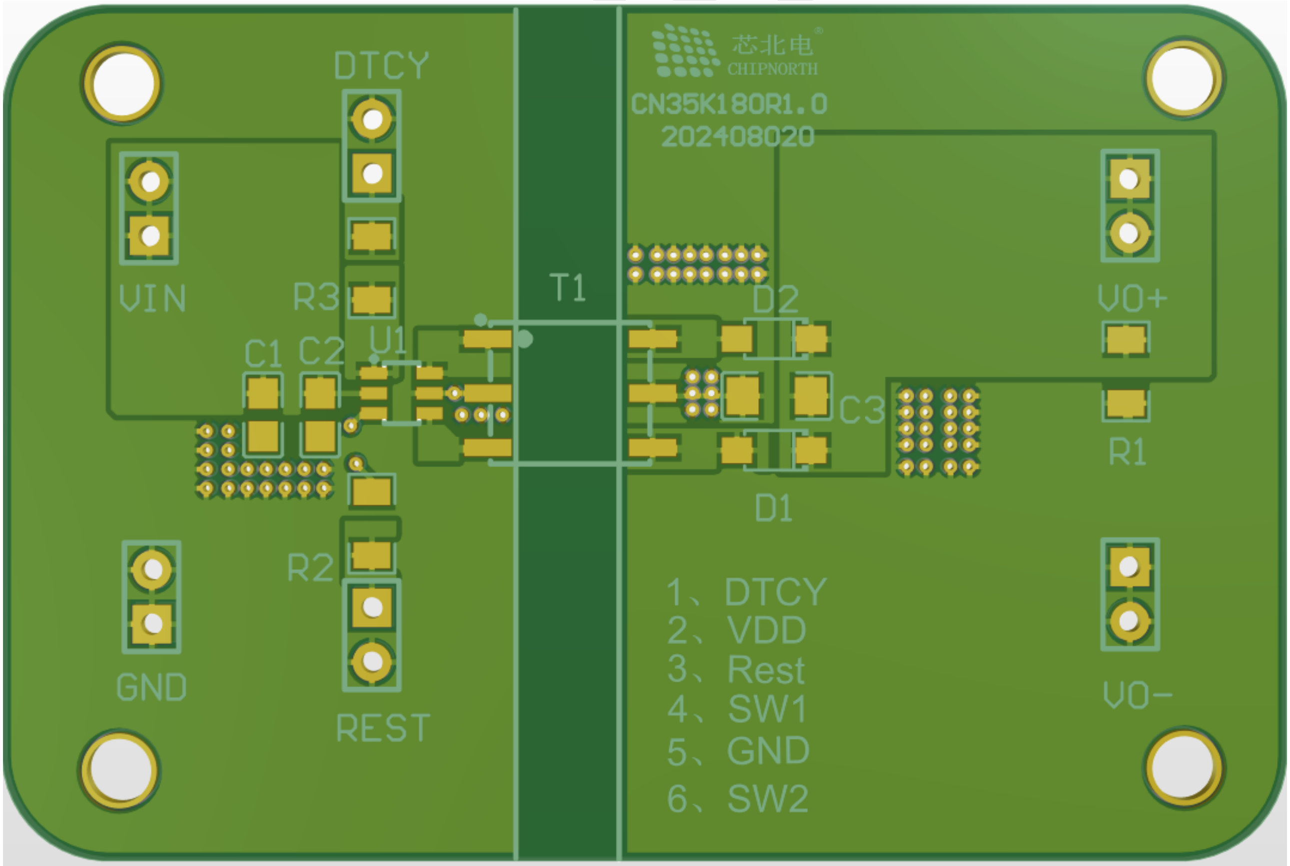
12.3.5 Bill of materials

Symbol	Description	Manufactures	Part Number
T1	N1:N2:N3=1:1.12:1.12		
R1	40K±0.1%,0603,100mW	YAGEO	RT0603BRD0740KL
R2	240K±0.1%,0603,100mW	YAGEO	RT0603BRE07240KL
D1、D2	SOD-123,VF:440mV@2A,VR:30V,IF:2A	ROHM	RB060M-30
C1、C2	4.7uF±10%/50V,0805,X7R	FH	0805B475K500NT

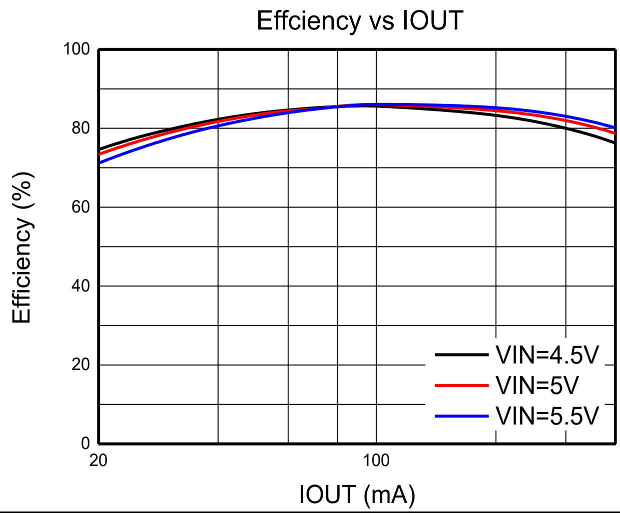
12.3.6 PCB Layout Guide

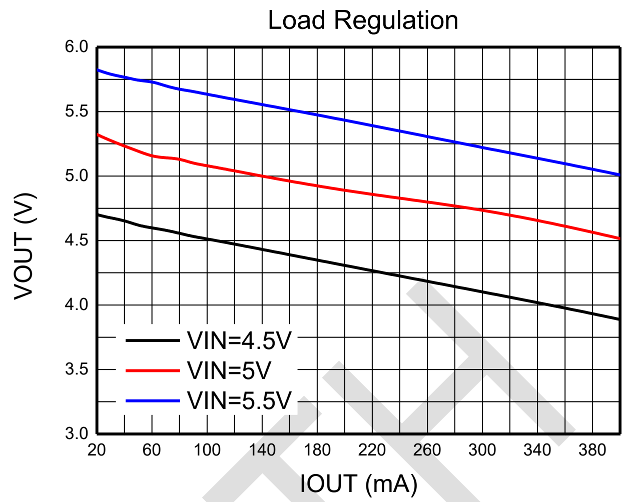
- The VIN capacitor is located as close as possible to the chip VIN and GND pins to minimize the loop area formed by the input capacitance, VIN and GND pins.
- For reliable operation, it is recommended to use a 0.1μf low ESR ceramic bypass capacitor at the VIN pin of the device. The capacitor should be located as close as possible to the power supply pins and on the same layer in the PCB layout. Capacitors must be rated at a voltage greater than the VIN voltage rating.
- The connections between the SW1 and SW2 pins and the transformer primary terminals and between the VIN pin and the transformer center tap must be as short as possible to minimize parasitic inductance.
- The connection between the VIN pin and the center tap of the transformer should be grounded with a low ESR ceramic capacitor. The recommended capacitance range is 1 μF ~ 10 μF, generally 10 μF. The capacitor voltage rating must be greater than the VIN voltage level, and it is recommended to use X5R or X7R material capacitors.
- The device's GND pin is recommended to be connected to the PCB ground plane using two via holes to help minimize inductance.
- Capacitors and other connections to ground planes should use two via holes to minimize inductance.
- Rectifier diodes should be Schottky diodes with low forward voltage and low capacitance to maximize efficiency.
- The VOUT pin must be connected to ISO ground with a low ESR ceramic capacitor. Typical capacitance values are 500 nF ~ 10 μF, 10 μF is recommended.

12.3.7 PCB Layout Reference

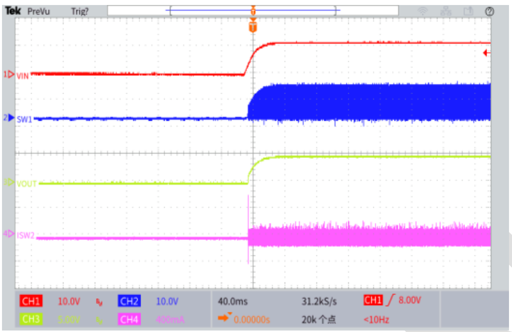


12.4 Basic Performance

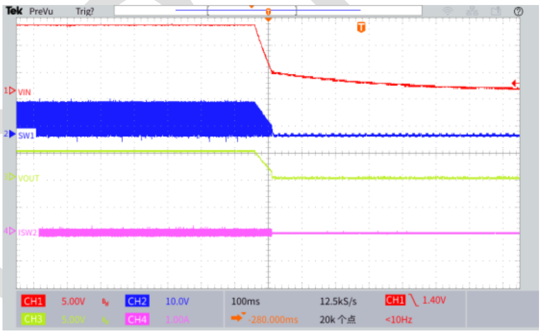




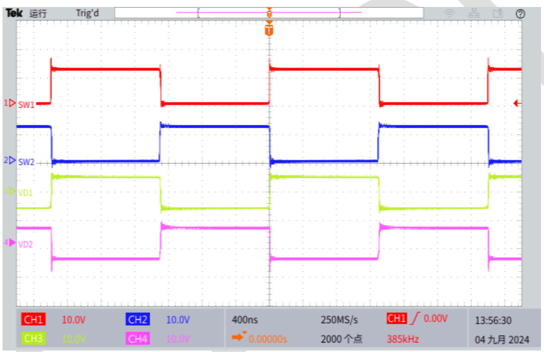
12.5 Operating Waveforms



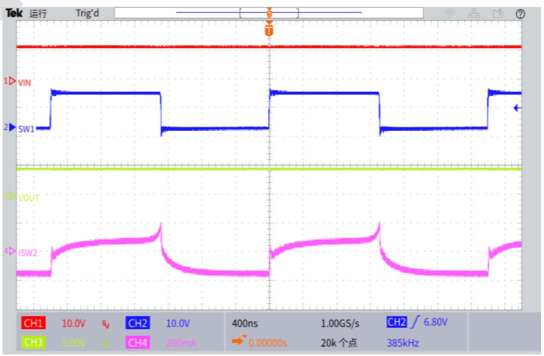
VIN=12V, IOUT=200mA power-on



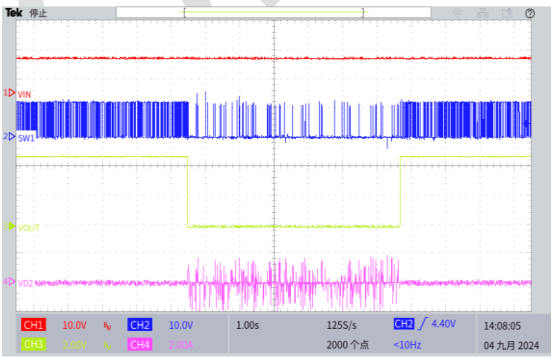
VIN=12V, IOUT=200mA power-down



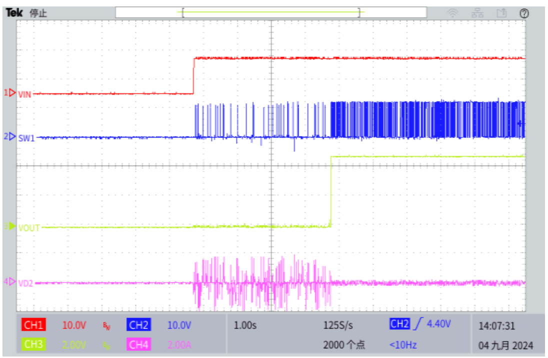
IOUT=200mA, SW1、SW2、D1、D2 waveform



IOUT=200mA, Steady-state operating waveforms



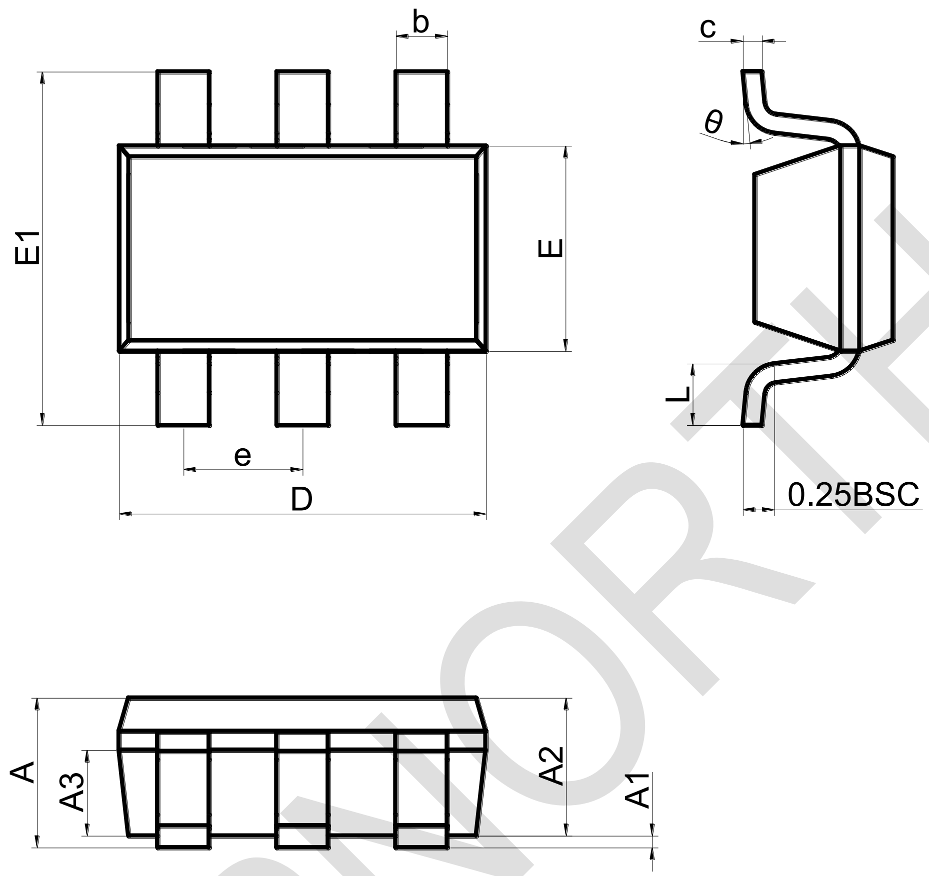
Short circuit after power up



Short circuit before power up

13 Package Information

SOT23-6



Symbol	Size		
	Min.	**Typ.**	**Max**
A	1.050	1.150	1.250
A1	0.000	0.060	0.100
A2	1.000	1.100	1.200
A3	0.550	0.650	0.750
D	2.820	2.920	3.020
E	1.510	1.610	1.700
E1	2.650	2.800	2.950
b	0.300	0.400	0.500
e	0.950BSC		
θ	0°	4°	8°
L	0.300	0.420	0.570
c	0.100	0.152	0.200

14 Important Statement

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