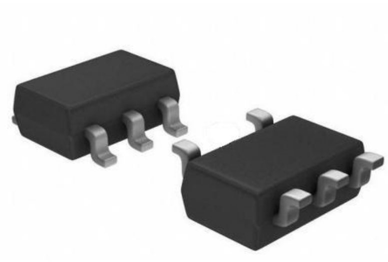
MORNSUN®

SCM1212BTA-Q 3.3 -5V Transformer Driver for Isolated Power Supplies

Features

- Comply with AEC-Q100 standard and adopt automotive grade process
- Third-party AEC-Q100 automotive approval (Report number : R202210148135-01E)
- With ±3% buffeting function, reduced conduction and radiation EMI
- Push-Pull driver controller
- 2.7-5.5V wide input voltage
- Low conduction resistance 200mΩ
- Built-in two power NMOS, highly symmetrical quasi-complementary drive
- Limited MOSFET's current when power on
- Over-current and short circuit protection
- Over temperature protection
- Under voltage protection
- Increase the dead time under light load

Packaging



Optional Packaging of Product: SOT-23-5 please refer to "Order Information" for details of silk screen.

Application

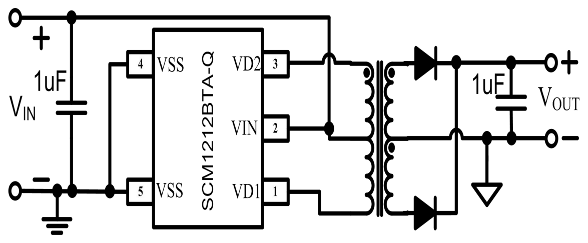
- Isolated power supply for CAN, RS485, RS232 and on-board system of controller area network

Description

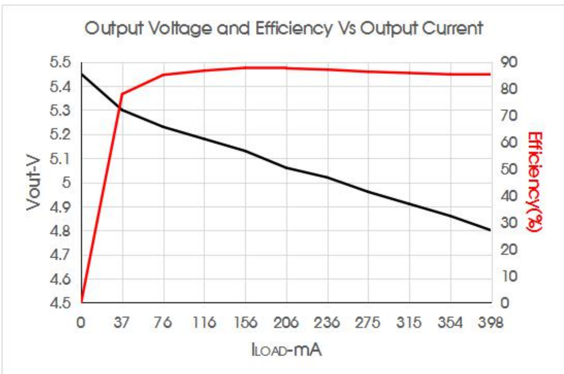
The SCM1212B-Q is a push-pull power primary side controller integrated with power MOSFET. The chip can work normally under the low input voltage of 3V, and it will not be damaged under the impact of high input voltage of 9V for 1S. There are two drivers inside the chip, which respectively control one flow direction of the current of the primary side winding. Alternately selecting the two drivers can realize the push-pull control of the primary side of the transformer. The driving symmetry of the power MOS inside the chip is high, thereby reducing the bias degree of the push-pull topology.

The chip also integrates three key technologies to improve reliability. The first is the soft-start function, which limits the power tube current to avoid damage to the device due to high current impact at startup, and quantitatively guarantees the startup with capacitive load under CC load mode. The second is to integrate the output over-current and short-circuit protection. On the one hand, the judgment and timing of over-current and short-circuit protection are distinguished to control the short-circuit temperature rise while ensuring the capacitive load. On the other hand, the protection threshold is adjusted according to the input voltage and temperature, so that the protection consistency is good, and it is not affected by input changes and temperature changes; the third is over-temperature protection. When the temperature exceeds the specified range, the chip will automatically enter the sleep state, and it will automatically recover when the temperature drops to the set value again.

Typical Application Circuit

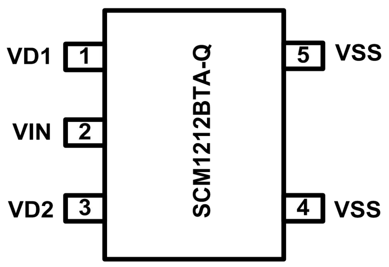


Function Curves



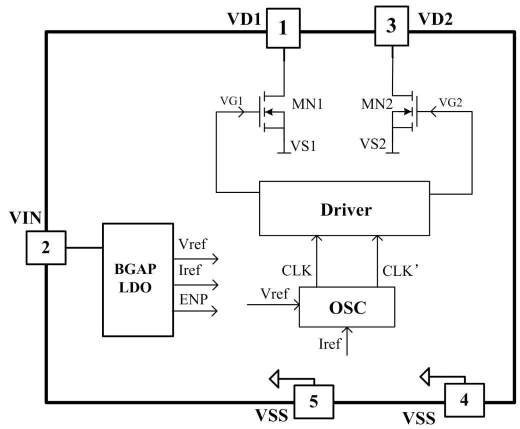
Contents

Pin Configuration



SOT-23-5 Package

Inter Block Diagram



Pin Description

No.	Name	I/O	Description
1	VD1	I/O	Built-in power LDMOSFET's drain.
3	VD2	I/O	
2	VIN	P	Supply voltage input
4	VSS	P	Device ground. Connect this pin to board ground.
5	VSS	P	Power ground

Absolute Maximum Ratings

General test conditions:Free-air, normal operating temperature range(unless otherwise specified).

Parameters		Min	Max	Unit
Input Voltage	V_{VIN}	-0.4	9	V
Drain Voltage of MOSFET	V_{VD1}/V_{VD2}	-0.7	26	V
Operation Junction Temperature Range	T_J	-40	150	℃
Storage Temperature	T_{STG}	-55	150	
Soldering Temperature (Allowable reflow soldering temperature of chip within 10 seconds)			260	
Moisture Sensitivity Level	MSL	MSL3		
Rated Value of ESD	Human-body model(HBM),per AEC Q100-002(1) HBM ESD Classification Level 3A		5000	V
	Charged-device model(CDM),per AEC Q100-011 CDM ESD Classification Level C6		1000	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.
Note: if the value exceeds the stress value listed in the table's "Absolute Maximum Ratings", it may cause permanent damage to the components.If the product operates in the maximum rated condition for a long time, the reliability of the components may be affected.All voltage values take GND as basis reference.The current refers to the current between positive input and negative output of the specified terminal.

Recommended Operating Conditions

Unless otherwise specified, the following parameters are measured in the conditions of V_{VIN}= 5V.

Parameters		Min	Max	Unit
Input Voltage	V_{VIN}	2.5	6	V
Drain Voltage of MOSFET	V_{VD1}/V_{VD2}	-0.7	18	V
Output Switching Current of Primary Winding	I_{D1}, I_{D2}	50	600	mA
Operation Junction Temperature	T_J	-40	150	℃

Electrical Characteristics

Unless otherwise specified, V_{VIN}= 5V and the environment temperature is 25°C.

Symbol	Corresponding Parameters	Test Conditions	Min	Typ	Max	Unit
Supply Section (VIN Pin)						
V_{VIN}	Operating Voltage range		2.5		6	V
I_{RUN}	Operating Current of Chip	V_{VIN}=5V, No connection to VD1 and VD2		1.5	2	mA
I_{START}	I_{VIN} when V_{VIN} is in under-voltage lockout	V_{VIN}=2V		200		uA
V_{VIN_ON}	Start-up Voltage	V_{VIN} voltage increasing		2.5	2.7	V
V_{VIN_OFF}	Voltage when V_{VIN} is in under-voltage lockout	V_{VIN} voltage decreasing	2	2.2		V
V_{VIN_OVP}	Voltage when VIN is in over voltage	V_{VIN} voltage increasing		10.5		V
V_{OVP_OFF}	Voltage when VIN is in over voltage recovery	V_{VIN} voltage decreasing		6.2		V
T_{OTP}	Temperature of Over-temperature Protection	Environment temperature increasing		165		℃
T_{OTPH}	Return Difference of Over-temperature Protection	Environment temperature decreasing		141		℃
Drain Port of MOSFET (VD1/VD2 Pin)						
B_{VDSS}	Breakdown Voltage of MOS Transistor	V_{GATE}=0V，I_{DS}=100uA	26	35		V
R_{DS_ON}	NMOS On Resistance	V_{VIN}=3V,I_{DS}=0.5A		200	500	mΩ
		V_{VIN}=5V,I_{DS}=0.5A		150	400	
I_{SOFT}	Current of Soft Start	V_{VIN}=3V,T_J=25℃,V_{VD1}=V_{VD2}=3V		1000		mA
		V_{VIN}=5V,T_J=25℃,V_{VD1}=V_{VD2}=3V	600	800		
Switch Characteristics						
F_{OSC}	Operating Frequency	No connection to VD1 and VD2	195	220	245	kHz
T_{DEAD}	Maximum dead time	VD1,VD2 is in series with 200Ω/1W power resistance ,to VIN,V_{VIN}=5V		210		ns
	Minimum dead time	VD1,VD2 is in series with 50Ω/1W power resistance to VIN,V_{VIN}=5V		120		ns
T_{D_OSP}	Delay Time of Short Circuit Protection	F_{OSC}=220kHz	28	150		ms
T_{SLEEP}	Sleep Time of Short Circuit Protection	F_{OSC}=220kHz		1.5		s

Typical Performance Curves

Unless otherwise specified, the following typical characteristic curves are obtained in the conditions of V_{VIN}=5V and T=25℃.Typical performance curves are obtained by testing the test circuit shown in Figure 5.

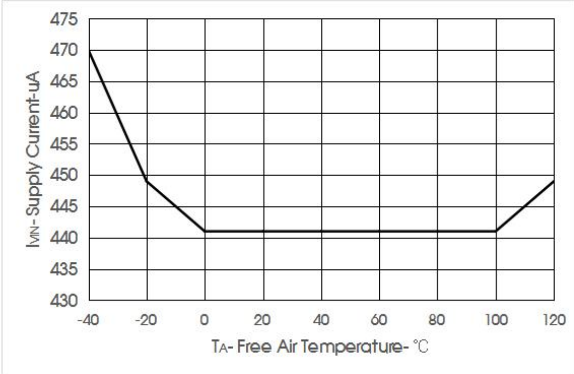


Figure 1 Supply average current of VIN VS Free-air temperature

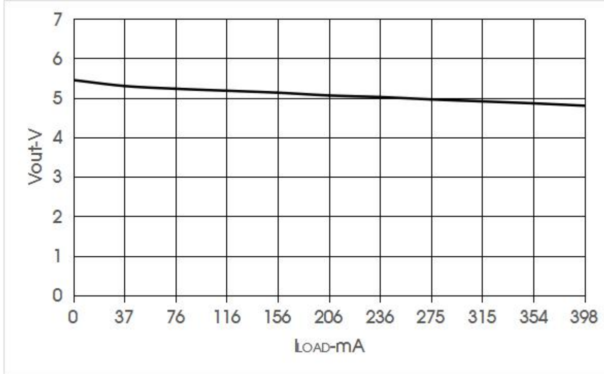


Figure 2 Output voltage VS Load current

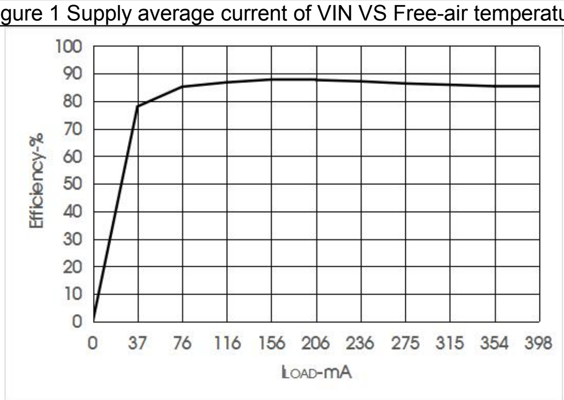


Figure 3 Efficiency VS Load Current

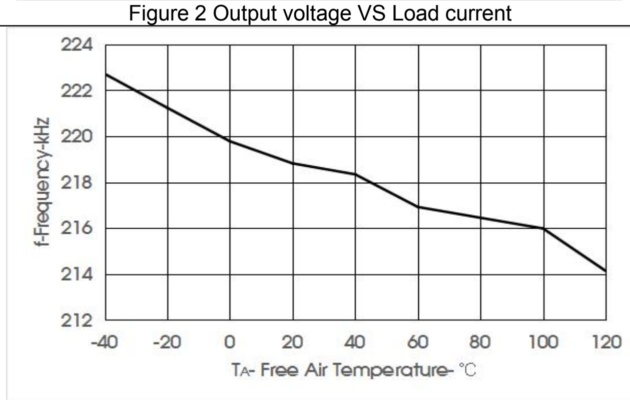


Figure 4 Switching Frequency of MOS Transistor VS Free-air Temperature

Parameter Measurement Information

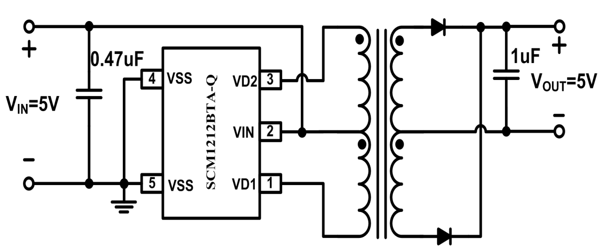


Figure 5 Schematic Diagram of Test Circuit for Function Curve

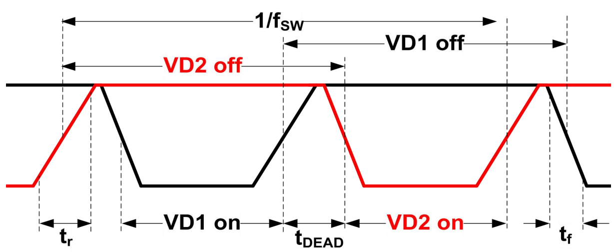


Figure 6 Circuit Sequence Diagram

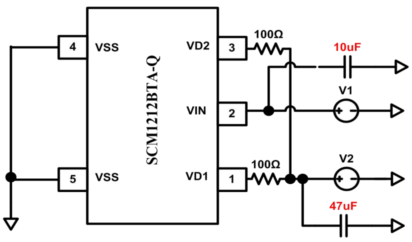


Figure 7 Schematic Diagram of Test Circuit for Switch Characteristics

(1) Push-pull Converter

As shown in Figure 8 and Figure 9, the push-pull converter is a transformer with center tap, which can achieve the transmission of energy from the primary winding to secondary winding.

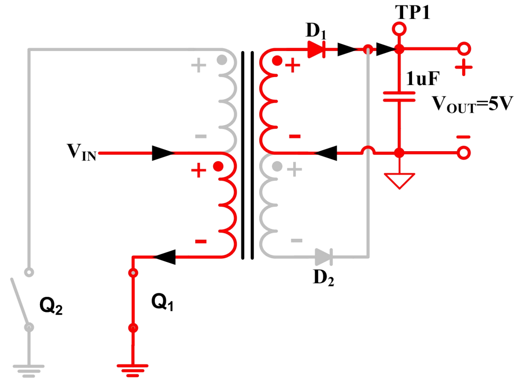


Figure 8 Switching Period 1 of Push-pull Converter

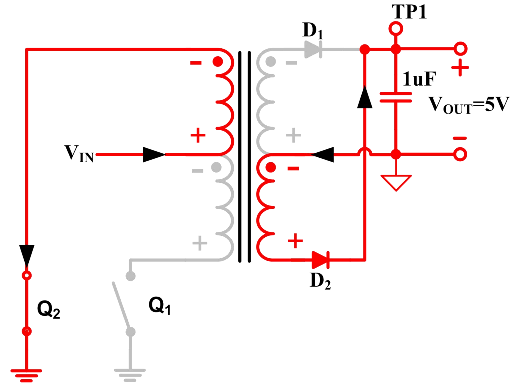


Figure 9 Switching Period 2 of Push-pull Converter

The drive waveform of drains VD_1 and VD_2 of two MOSFETs Q_1 and Q_2 are shown in Figure 6.Two MOS transistors are on alternatively and the times of the breakover periods of two transistors are equal, and there is a short period t_{BBM} between the two breakover periods that the two power transistors are not on. The driving levels of the two MOS transistores are quasi complementary in timing. When one pipe is opened, the other pipe is closed. There is a short dead time at the intersrction of switching to ensure that the two pipes are not connected at the same time and the current is reversed. As shown in red highlighted parts in Figure 8, when Q_1 is on, input voltage V_{IN} drives a current which arrives at the reference ground through the lower half of primary winding of transformer and Q1, and at the same time, the induced electromotive force of side winding charges output capacitor through diode D_1.Similarly, as shown in Figure 9, when Q_2 is on, the induced electromotive force charges output capacitor through diode D_2.As continuously repeating the above process, the secondary winding of power converter obtain the needed power supply.

(2) Magnetization of Magnetic Core

Figure 10 is the ideal magnetization curve of push-pull converter, and the vertical axis represents magnetic flux density B and the horizontal axis represents magnetic field intensity H.When Q1 is on, the magnetic flow is pushed to point A' from point A.Similarly, when Q2 is on, the magnetic flow is then pulled back to point A from point A'.The magnetic flux density B is proportional to the product of voltage of primary winding V_{LP} and breakover time of MOS transistors $t_{ON,}$ which can be described in the following formula:

$B \approx V_{Lp} \times t_{ON}$

The volt-second product $V_{Lp} \times t_{ON}$ defines the magnetization degree of each switching period. If the volt-second products in the above "push" and "pull" periods are not identical, a small direct current component may be generated to cause the deviation of magnetic flow. If balance cannot be restored, the deviation of magnetic flow will gradually increase in the each of the following switching period, making magnetic core become saturated gradually. The phenomenon of the deviation of magnetic flow is usually caused by the unequal on resistance or switching speed of two power switching components. Although the on resistance or switching speed of the two power components are approximately equal through integrating them into the same wafer with the help of high matching advantage of semiconductor integrated circuit technology, the manufacturing error still exists, causing the small deviation for the breakover time.

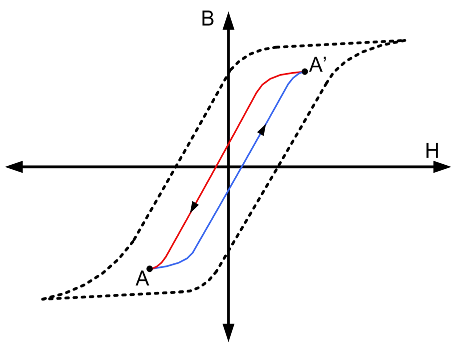


Figure 10 Magnetization Curve

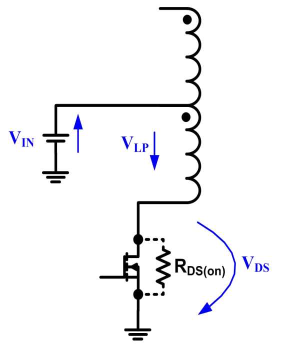


Figure 11 Self-adapting Positive Temperature Coefficient Rds(on)

Fortunately, the breakover resistance $R_{DS(on)}$ of MOSFET has positive temperature coefficient, the SCM1212B-Q has the self-correcting effect to restrain the imbalance of volt-second based on this feature. Under the condition that there is small deviation between the breakover time of two MOS transistors, the transistor which has longer breakover time t_{ON} generates more quantity of heat, and the temperature of the transistor rises to improve $R_{DS(on)}$, then in the breakover period when the load remains unchanged, the drain-source voltage of this transistor V_{DS} is relatively high, as shown in Figure 13, the voltage of primary winding V_{LP} conforms to the formula $V_{LP}=V_{IN}-V_{DS}$, thus the V_{LP} of the transistor which has larger t_{ON} will gradually decrease to make volt-second recover balance.

Product Operation Mode

The SCM1212B-Q has three operating modes, namely start mode, push-pull steady state mode and short circuit protection mode.

In the startup mode, the chip is judged by short circuit first. At this time, the MOS tube is always in the current limiting drive state, and a short timing time is selected for judgment.

After the system short circuit is eliminated, the SCM1212B-Q enters the starting mode. The SCM1212B-Q provides enough charging time for the output capacitor to avoid being mistaken for the output short circuit when the output capacitor voltage is too low, which will lead to abnormal starting. At the same time, the MOS tube is always in the current limiting drive state in the startup mode.

Start-up Mode

The voltage of output capacitor is zero when the converter is just started, and the converter will firstly determine the system's state. The flow diagram is shown in Figure 12 . It can be described in the following form. Start → Drive the selected MOS transistor in current-limiting drive method → detect the switch-on voltages of MOS transistors(V_{VD1}, V_{VD2}) → judge whether the voltages (V_{VD1}, V_{VD2}) are more than the set value.

If (V_{VD1}, V_{VD2}) are more than the set value 1, then calculate the duration of over-voltage→ judge whether the duration is more than T_{D_OSP1} (28ms, typ). If yes, then the system turns into short circuit mode, if no, then the above process is repeated.

If (V_{VD1}, V_{VD2}) are less than the set value 1and more than the set value 2, then the cumulative duration of exceeding set value 1 →judge whether the duration is more than T_{D_OSP2} (150ms, typ). If not exceeded, enter start-up mode. If exceed, select the current limiting drive again and continue the cycle.

If (V_{VD1}, V_{VD2}) are not greater than the set value 1, then the system turns into push-pull steady state mode.

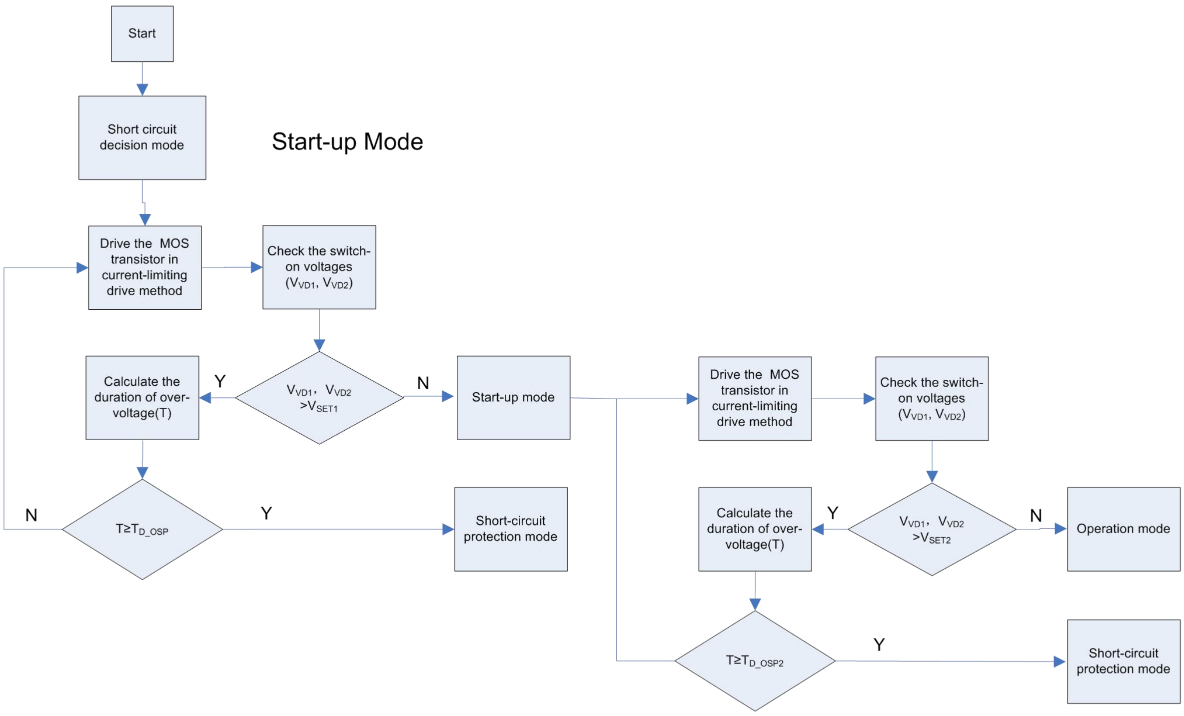


Figure 12 Flow Diagram of Start-up Mode

Operation Mode

If the output of converter has no short circuit, the voltage of output capacitor, in start-up mode, will gradually increase during the continuously circular charging.When the breakover voltage of MOS transistor is less than or equal to the set value, the converter will turn into operation mode.The flow diagram is shown in Figure 13, that is, determine that the breakover voltage of MOS transistor is less than or equal to the set value→ drive the selected MOS transistor with full drive→ check the switch-on voltage of MOS transistors→ judge whether the voltages (V_{VD1}, V_{VD2}) are more than the set value.

If the breakover voltage of MOS transistor is more than the set value, then the system goes into time-counting cycle of start-up mode, otherwise, the system turns back to the step “drive the selected MOS transistor with full drive”, and the above processes are repeated, which is the normal operation of the converter after the product is started.In the operation, MOS transistor is fully driven, that is the MOS transistor is operating in switching status and the on resistance is low, resulting in low energy consumption and high efficiency.

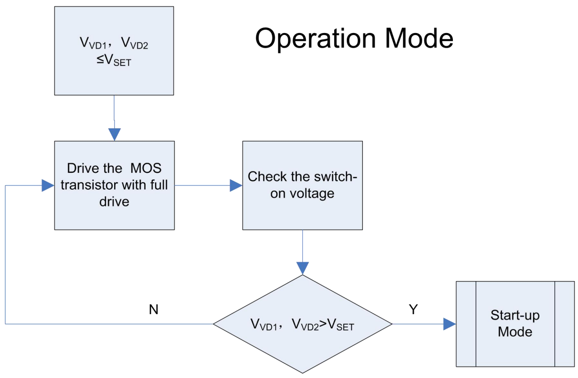


Figure 13 Flow Diagram of Operation Mode

Short -circuit Protection Mode

If the output of the converter is in short-circuit state, the chip will detect in start-up mode that the breakover voltage of MOS transistor is always more than the set value, then it will accumulate over-voltage time until the time exceeds T_{D_OSP} (150ms, typ.).At this time, SCM1212B-Q will stop to drive the MOS transistor and begin to count the dormancy time of MOS transistor .When the time is counted to T_{SLEEP} (1500ms, typ.), the product resumes operation and turns into start-up mode.

The flow diagram of short-circuit protection mode is shown as Figure 14: determine the duration of over-voltage exceeding T_{D_OSP} → stop driving and begin to count time (dormancy mode) → finish counting time → turn back to start-up mode.We can see that if the converter is always in output short circuit status, it will operate in the short-circuit protection mode and start-up mode alternately.

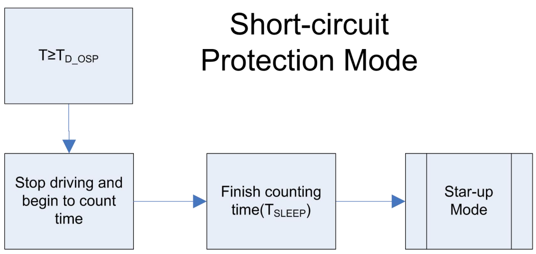


Figure 14 Flow Diagram of Short-circuit Protection Mode

Extended Output Design

SCM1212B-Q is used to drive the push-pull circuit, which can make output voltage become higher.

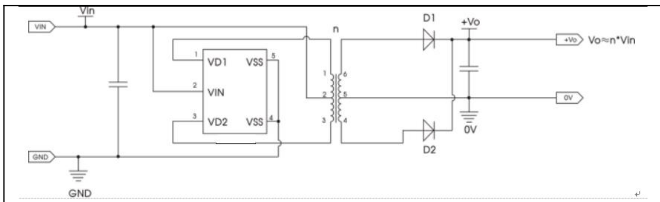


Figure 15 Extended Circuit I

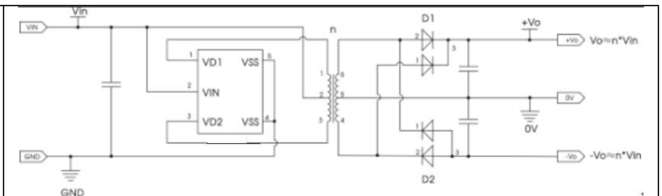


Figure 16 Extended Circuit II

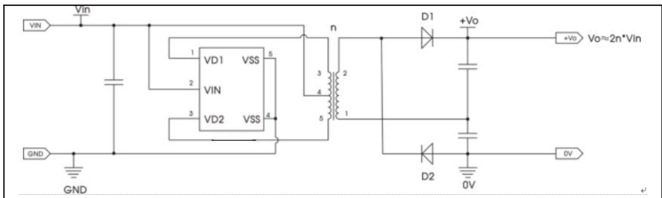


Figure 17 Extended Circuit III

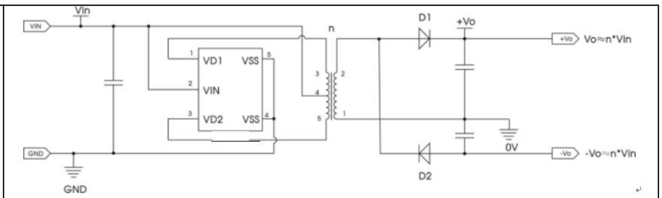


Figure18 Extended Circuit IV

Extended Circuit I and Extended Circuit II use a full-wave rectification method. The Extended Circuit I is a single output, and the Extended Circuit II is a two-way output. The full-wave rectification topology's side winding is complex, but its output ripple is smaller than the double-pressure rectification.

Extended Circuit III and Extended Circuit IV use a double-pressure rectification method. The Extended Circuit III is a single output, the Extended Circuit IV is a two-way output. the double-pressure rectification topology's side winding is simple, but its output ripple is larger than the full-wave rectification.

Application Circuit

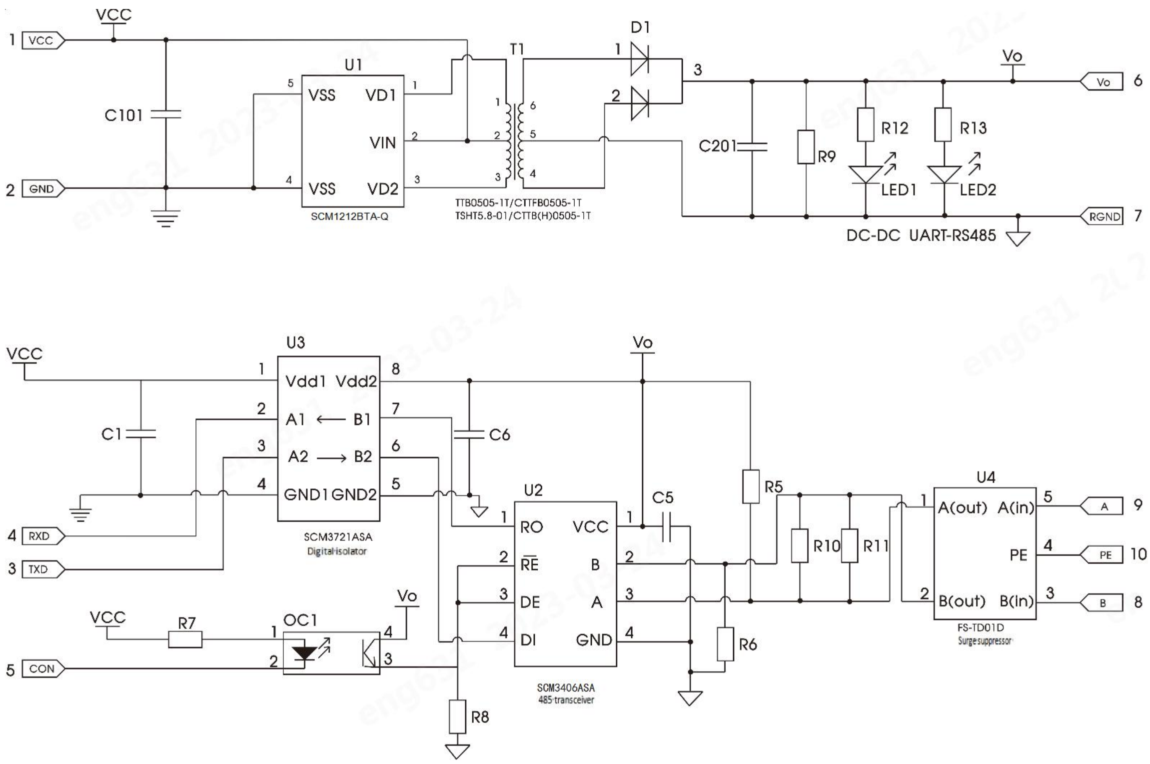


Figure 19 Application Circuit I

(1) Introduction of CTTH0505-1T Transformer

With the voltage of primary winding and secondary winding of 5000VAC/6000VDC, the allowable operating temperature of -40℃~+125℃ and the packaging size of 13.20*12.70*7.62mm, combined with design of our ICSCM1212B-Q product, TTB05xx-1T transformer can be used for electrical isolation scenario which is applicable to 5VDC input and output power less than 1W, such as digital circuit, analog acquisition circuit and data exchange circuit. Please log in the official website of Mornsun and contact the salespeople to obtain the specific specification.

(2) Introduction of TSHT5.8-01 Transformer

TSHT5.8-01 transformer, with the packaging size of 12.50 x 8.70 x 5.90mm, is specially designed for use with IC.It is mainly used for the electrical isolation scenario which is applicable to 5VDC input and 5VDC output power less than 1W, such as digital circuit, analog acquisition circuit and data exchange circuit.

Using Suggestions

If the input power is not stable enough, it is suggested to add 1uF capacitor in the first section of IC SCM1212B-Q, if there is high requirement to EMI performance, add capacitor and inductor in the first section of the module to filter noise, if there is high requirement to no-load voltage, add resistor after the filtering capacitor of the module as dummy load, it is suggested that the connecting wire of pin 1 and pin 3 to the transformer is as short as possible.

Ordering information

Product Model	Packaging	Quantity of Pin	Silk Screen	Packing
SCM1212BTA-Q	SOT-23-5	5	1212-QYM	3K/tray

Description of Product Model

SCM1212XYZ-Q:

(1) SCM1212, product code.

(2) X = A-Z, version code.

(3) Y = T, packaging code, T: SOT packaging.

(4) Z = C, I, A, M, code of temperature rangeC: 0℃-70℃, I: -40℃-85℃, A: -40℃-125℃, M: -55℃-125℃.

(5) Q=Automobile grade.

Description of Silk Screen

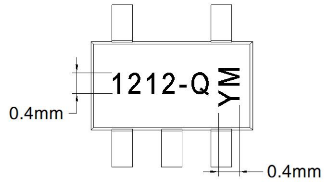
1212-QYM:

(1) 1212, code of product silk screen in 4 digits.

(2) YM, Product Traceability Code.

(3) Q, Automobile grade.

Silk Screen Information

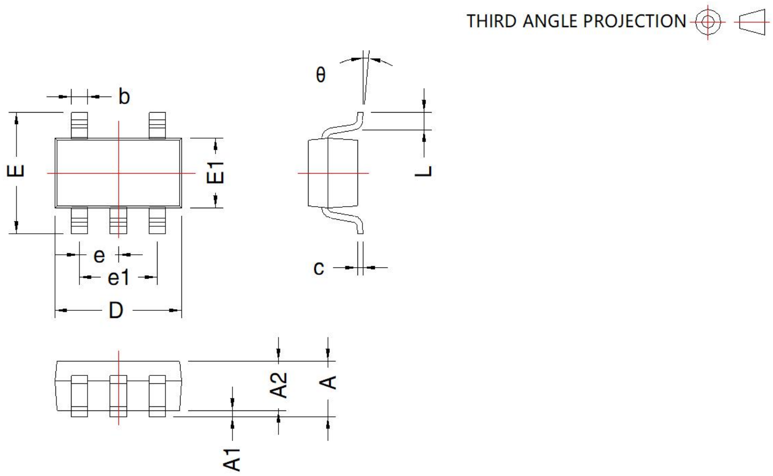


Note：

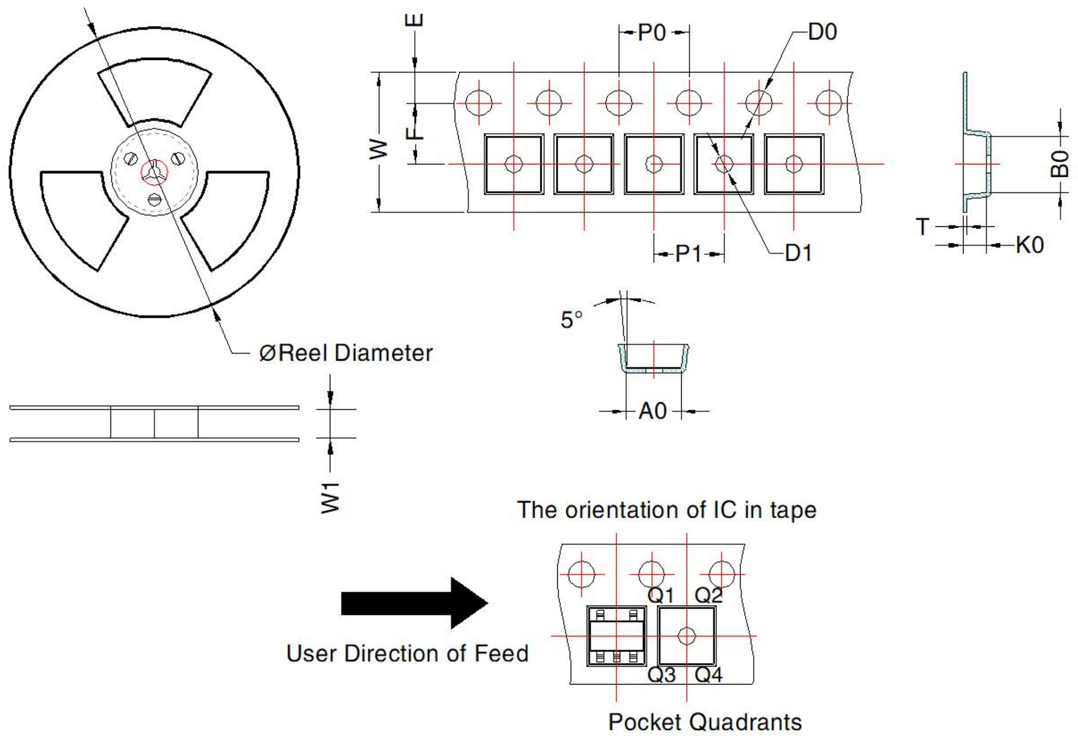
1、Typeface：Arial；

2、Character size：Height：0.4mm，Spacing：0.1mm

Package Information



SOT−23−5				
Mark	Dimension(mm)		Dimension(inch)	
	Min	Max	Min	Max
A	1.05	1.25	0.041	0.049
A1	0	0.10	0	0.004
A2	1.05	1.15	0.041	0.045
D	2.82	3.02	0.111	0.119
E1	1.50	1.70	0.059	0.067
E	2.65	2.95	0.104	0.116
L	0.30	0.60	0.012	0.024
b	0.30	0.50	0.012	0.020
e	0.95 BSC		0.037 BSC	
e1	1.80	2.00	0.071	0.079
c	0.10	0.20	0.004	0.008
θ	0°	8°	0°	8°



Device	Package Type	MPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	T (mm)	W (mm)	E (mm)	F (mm)	P1 (mm)	P0 (mm)	D0 (mm)	D1 (mm)	Pin1 Quadrant
SCM1212BTA-Q	SOT-23-5	3000	180.0	8.5	3.17 ± 0.1	3.23 ± 0.1	1.37 ± 0.1	0.25 ± 0.03	8.0 ± 0.3	1.75 ± 0.1	3.5 ± 0.1	4 ± 0.1	4 ± 0.1	1.5 ± 0.1	1.0 ± 0.1	Q3

Note: The minimum order quantity is the minimum packing quantity, and the order quantity shall be an integral multiple of MPQ.

Mornsun Guangzhou Science & Technology Co.,Ltd.

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