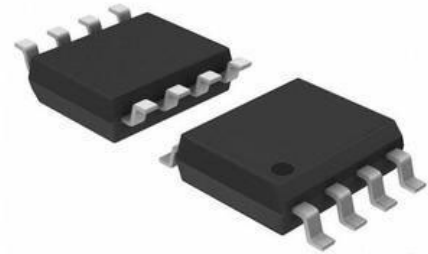


SCM1502A Relay Power Saving Controller

Features

- The input voltage is detected in real time, and the relay operating voltage can be accurately set
- It can work in a wide input voltage range of 2.5:1
- The pick-up current and the holding current can be set separately, and the relay coil design is simpler
- With built-in analog frequency jitter, it is easy to solve EMI problems
- The chip's power supply range is 7V~40V, which meets most of the relay input voltage requirements
- With fast shutdown function, it reduces the relay shutdown delay
- Take power from input to save auxiliary power

Package



Product package: SOP-8.

Please see "Ordering Information" for details

Applications

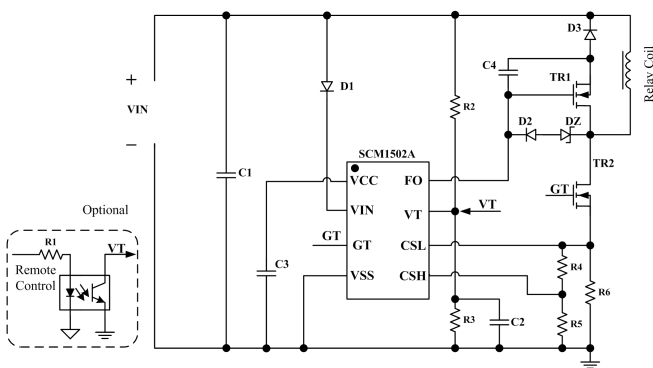
- Power saving transformation of various relays

Functional Description

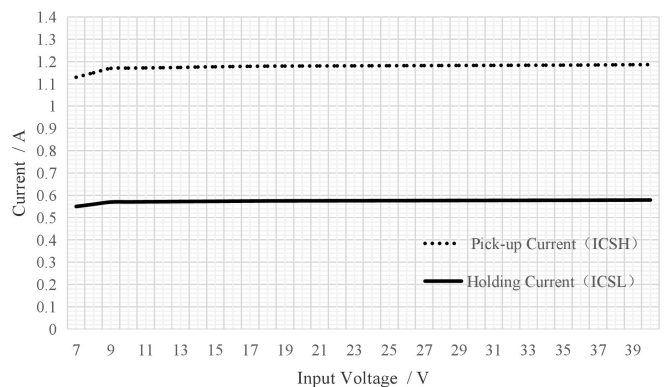
The SCM1502A is a relay power-saving controller that reduces the pick-up and holding power consumption of the relay.

SCM1502A has a built-in startup circuit, which can complete the fast startup of the controller with a charging current greater than 8mA within the input voltage range of 7V ~ 40V, in order to meet the relay operating conditions and respond quickly. In addition, SCM1502A can also control the relay coil to switch between high current pick-up and low current holding. The size of the pick-up and holding current can be independently designed to facilitate the application of different relays. And in the low current holding stage, if the input is under voltage or the user is not enabled, the controller will activate the fast shutdown function to allow the relay to open quickly, so as to reduce the impact of SCM1502A on the relay opening performance.

Typical Application Circuit



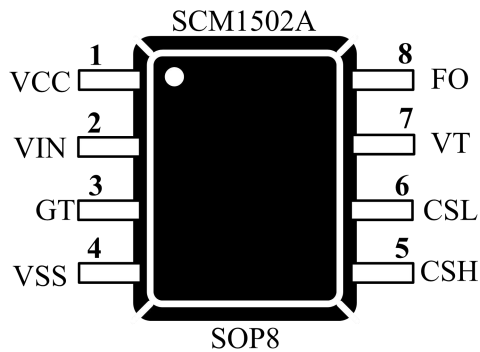
Functional Curve



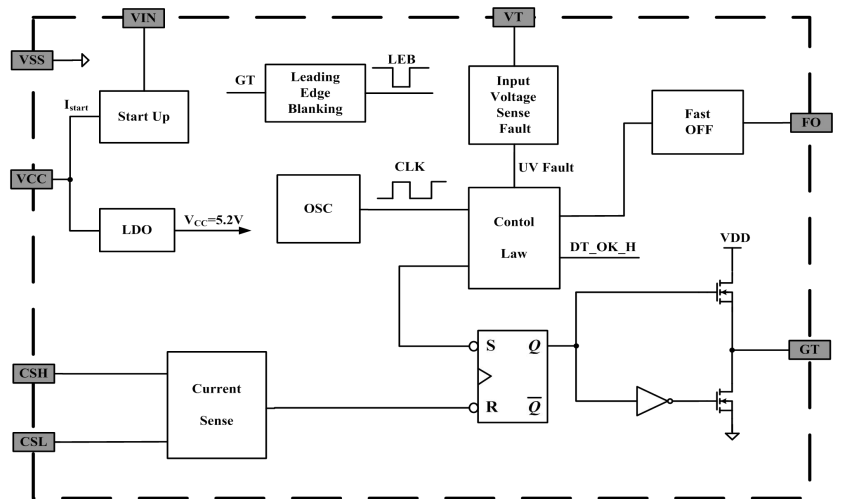
Catalog

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Pins



Internal Block Diagram



Pin Description

NUMBER	NAME	I/O	DESCRIPTION
1	VCC	P	LDO output, external bypass capacitor
2	VIN	P	Chip supply pin
3	GT	O	Power MOSFET drive
4	VSS	P	Chip ground
5	CSH	I	Pickup state current sampling pin
6	CSL	I	Holding state current sampling pin
7	VT	I	Input voltage detection
8	FO	O	Bootstrap drive for fast turn-off transistor

Pin Function Descriptions

VCC (LDO output) : The bypass capacitor port of the controller is externally connected with bypass capacitor C_{VCC} . After power on, the built-in LDO circuit charges the capacitor C_{VCC} , and the VCC voltage rises. When the VCC voltage is charged to the start threshold V_{VCC_ON} , the controller starts to output the drive signal, and the LDO circuit will continue to work, and finally maintain $VCC = 5.2V$.

VIN (input) : The controller's power supply port can be connected to a DC input voltage below 40V. This DC input voltage is stepped down to the VCC pin through the LDO circuit inside VIN, and the VCC pin voltage will eventually stabilize at 5.2V.

GT (drive output): Output a square wave signal with an average frequency of 23.9kHz. In the pickup stage, in order to ensure the pickup, a 100% duty cycle is allowed. However, after entering the holding stage, the controller limits the maximum duty cycle to 75%. During the pickup and holding stage, the square wave frequency has periodic jitter, that is, the frequency jitters within the range of $\pm 6.5\%$ within 6ms.

VSS (ground): Signal reference ground.

CSH (pick-up current detection): The high current detection pin only controls the duty cycle of the square wave signal output by the GT pin during the pickup stage. That is, when the CSH pin voltage is greater than 0.6V, the GT pin outputs low power level.

CSL (holding current detection): A small current detection pin that controls the duty cycle of the square wave signal output from the GT pin only during the holding stage. That is, when the CSL pin voltage is greater than 0.3V, the GT pin outputs low power level.

VT (input voltage detection): The external voltage divider samples the input voltage. When $V_T < 0.6V$, it counts 0.5ms. If V_T is still less than 0.6V, it enters the protection state. At this time, it can exit the input undervoltage protection state only when $V_T > 0.8V$.

FO (quick turn-off tube drive output): In normal operation mode, as long as the GT pin outputs a high level, $V_{FO} = V_{VCC} - 0.6 - V_{CSL}$. In order to charge the FO pin to the maximum value, it is necessary to charge the $V_{VCC} = V_{VCC_HD}$ to $V_{VCC} - 0.6$ when the V_{CSL} is not very large after the first rising edge of the GT pin signal appears, so as to minimize the on-resistance of the fast switch-off transistor. During the holding stage, if the controller enters the input undervoltage protection, the FO will draw 1.45mA, so that the fast turn-off transistor TR1 operates in the sub-threshold region, and the demagnetization current slope of the inductor becomes larger, thereby reducing the delay of relay contact pop-up. See "Fast shut-off" section for details.

Absolute Maximum Ratings

Test conditions: Free-air, normal operating temperature range (unless otherwise specified), voltage reference is ground.

PARAMETER	SYMBOL	MIN	MAX	UNIT
V_{VIN}	Input start voltage	7	40	V
V_{VCC}	Bias supply voltage		6	
V_{GT}	GT pin voltage	-0.6	20	
V_{VT}, V_{CSL}, V_{CSH}	Voltage range	-0.6	6	
T_J	Working junction temperature range	-40	125	°C
T_{STG}	Storage temperature	-40	150	
	Lead temperature of 0.6mm from the outer casing within 10 seconds		260	
V_{ESD}	Electrostatic discharge (ESD) rating, Human body model (HBM)	± 2000		

Note: Permanent damage to the device may occur if the stress values listed in the "Maximum Ratings" table are exceeded. The reliability of the device may be affected by long-term operation under extreme rating conditions. All voltage values are based on the Earth (GND) reference. Current is the positive input and negative output of the specified terminal.

Recommended Operating Conditions

Test conditions: Free-air, normal operating temperature range (unless otherwise specified), voltage reference is ground.

SYMBOL	PARAMETER	MIN	MAX	UNIT
C_3	VCC bypass capacitor	1	10	uF
C_4	Gate capacitance of quick turn-off tube TR1	0.047	0.47	uF

Electrical Characteristics

Unless otherwise stated, the following parameters were tested under normal temperature and pressure and in an unsealed environment.

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{START}	Starting current	$V_{VIN}=20V$ current flowing from the VCC pin	8	18		mA
V_{LK_VIN}	VIN pin leakage current	$V_{VIN}=20V, V_{VCC}=5.6V$			10	uA
V_{VCC_ON}	Drive signal output point VCC pin voltage	$V_{VT}=2V$	2.925	3.9	4.875	V
V_{VCC_OFF}	Drive signal turn-off point VCC pin voltage	$V_{VT}=2V$	2.475	3.3	4.125	V
V_{VCC_HD}	VCC self-power supply sustaining voltage	$V_{VIN}=20V$	4.997	5.26	5.523	V
V_{FO_STATE}	Pick-up, holding stage, FO voltage	$V_{VIN}=20V, V_{VT}=2V$	4	5	5.5	V
I_{FO_LK}	FO leakage current	$V_{VCC}=5V, V_{VT}=2V, V_{FO}=30V$			10	uA
I_{START_OFF}	VT pin undervoltage, VIN bias current	$V_{VIN}=20V, V_{VT}=0V$		220		uA
I_{VIN_RUN}	VIN pin working current under GT pin 1nF load capacitance during the holding stage	$V_{VIN}=20V, V_{VT}=2V, V_{CSL}=1.0V$		570		uA
V_{VT_ON}	VT pin relay operating voltage VT	$V_{VIN}=20V$	0.76	0.8	0.84	V
V_{VT_OFF}	VT pin relay off voltage	$V_{VIN}=20V$	0.57	0.6	0.63	V
T_{D_CHANGE}	Mode switching delay for pick-up and holding	$V_{VIN}=20V$	73.53	85.7	99.48	ms
F_{SW}	Average switching frequency	$V_{VIN}=20V$, normal operation	21.31	23.9	26.05	kHz
F_{SK}	Frequency jitter	Peak-to-peak jitter compared to the average frequency, $T = 27^\circ C$		±6.5		%
T_R	Drive Rise Time with GT Pin 1nF Load Capacitance	$V_{VIN}=20V$, Connect GT to 1nF capacitor		150		ns
T_F	Drive fall time with GT pin 1nF load capacitance	$V_{VIN}=20V$, Connect GT to 1nF capacitor		45		ns
D_{max}	Maximum duty cycle in holding state	$V_{VIN}=20V$	71.25	75	78.75	%
V_{CSHT}	CSH pin pick-up current comparison threshold	$V_{VIN}=20V$, pick-up stage	0.57	0.6	0.63	V
V_{CSLT}	CSL pin holding current comparison threshold	$V_{VIN}=20V$, holding stage	0.285	0.3	0.315	V
T_{ON_MIN}	Minimum on time	$V_{VIN}=20V, V_{VT}=2V, V_{CSL}=1.0V$	357.5	550	742.5	ns
T_{D_STOP}	Shutdown detection delay	$V_{VIN}=20V$		500		us
I_{FO_S}	FO pin source current	$V_{VIN}=20V, V_{VT}=0V$	1.02	1.45	1.89	mA
T_{FO_S}	FO pin current draw time, that is, fast turn-off time	$V_{VIN}=20V, V_{VT}=0V$	73.53	85.7	99.48	ms

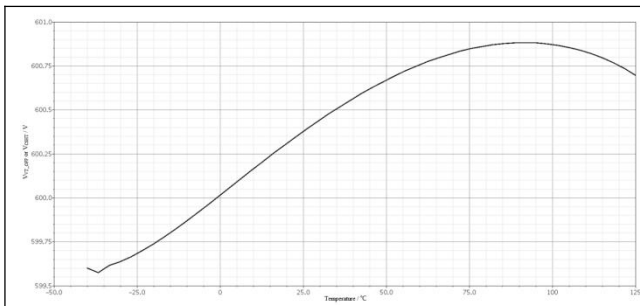


Fig. 1 VT pin relay turn-off voltage (V_{VT_OFF}) VS Temperature or CSH pin pick-up current comparison threshold (V_{CSHT}) VS Temperature

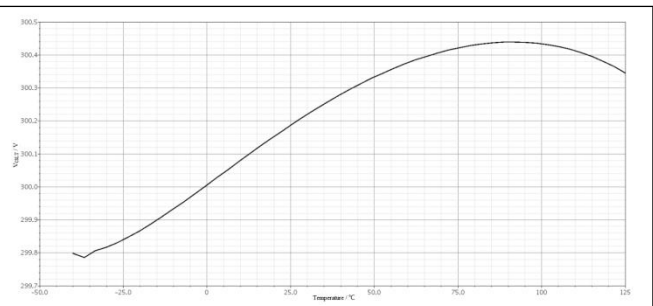


Fig. 2 CSL pin holding current comparison threshold (V_{CSLT}) VS Temperature

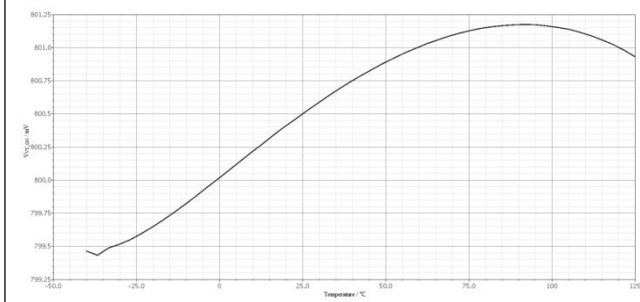


Fig. 3 VT pin relay operating voltage (V_{VT_ON}) VS Temperature

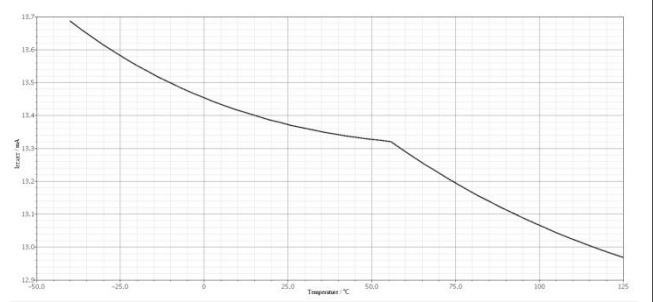


Fig. 4 Starting current (I_{START}) VS Temperature

Functional Application

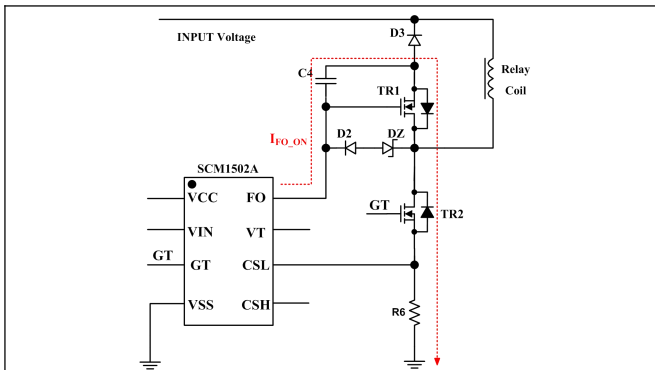


Fig. 5 Start-up circuit schematic

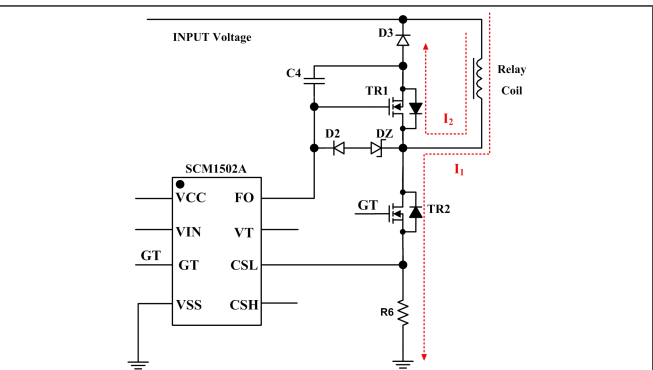


Fig. 6 Equivalent Circuits in the Pick-up and Holding Stages

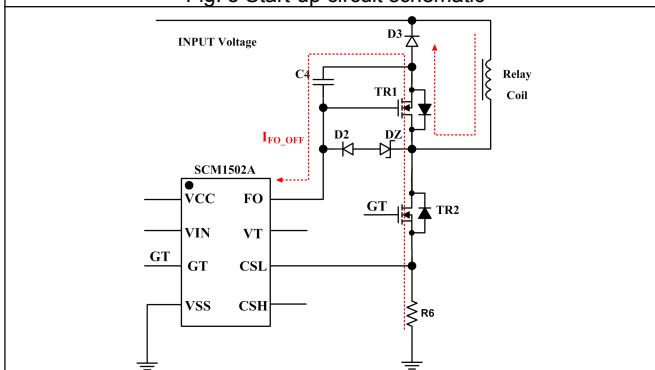


Fig. 7 Circuit schematic diagram of turn-off stage

(1) Figure 5, the working principle of the chip startup, see the working principle diagram of the startup process. After the chip is started, the GT will output a high level, and the FO will continue to output a current-driven MOS transistor TR1. FO charges the gate of MOS transistor TR1, and the current I_{FO_ON} path is as follows: When MOS transistor TR2 is turned on, the FO pin charges capacitor C4 through the body diode of MOS transistor TR1 and MOS transistor TR2. Each time the MOS transistor TR2 is turned on, the FO pin will charge the capacitor C4. Therefore, in the Pick-up and Holding stages, the MOS transistor TR1 is turned on all time.

(2) In Fig. 6, since the MOS transistor TR1 is turned on all time during normal operation, the main power circuit can be equivalent to the equivalent circuit of the Pick-up and Holding stages. When the MOS transistor TR2 is turned on, the relay coil is excited, the coil current is increased, and the

current path is, for example, I_1 , when TR2 is turned off, the relay coil is demagnetized by the diode D3, and the coil current is reduced. The chip detects the current of the relay coil through the CSH and CSL pins, and adjusts the duty cycle in real time to adjust the coil current.

(3) Figure 7, In the turn-off stage, see the circuit schematic of the shutdown phase. The MOS transistor TR2 is not turned on, and the FO will draw the current of the capacitor C4. The path of the current sinking I_{FO_OFF} is as follows: the current of the C4 is drawn through the body diode of the MOS transistor TR2 and the MOS transistor TR1. At this time, the MOS transistor TR1 operates in the sub-threshold state, and the drain terminal voltage of the MOS transistor TR1 is relatively large, and the voltage value is $V_{TH}+V_{DZ}$, wherein V_{TH} is the conduction threshold voltage of TR1, and V_{DZ} is the voltage regulation value of the Zener diode DZ. At this time, the demagnetization voltage of the relay coil becomes large, the coil current is attenuated quickly, and finally the effect of fast turn-off is achieved.

Extended Output Design

The fast turn-off function is not necessary. In the case where the turn-off time is not required, the circuit of the fast turn-off part can be removed, such as circuit expansion one.

Remotely turn off non-essential functions. Without this requirement, the remote shutdown part of the circuit can be removed, and the system can work normally, such as circuit expansion two.

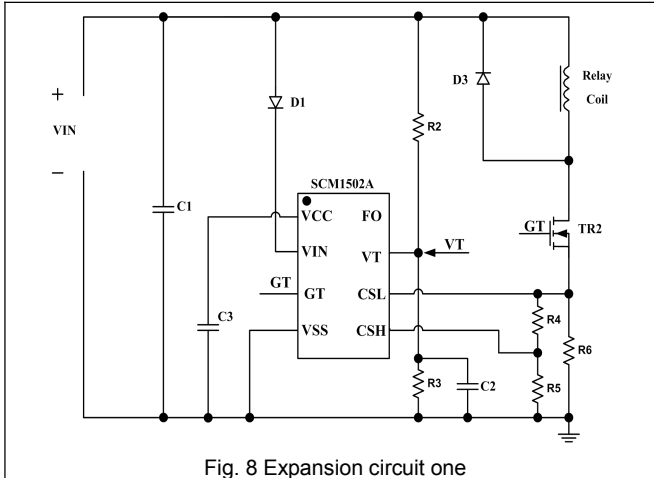


Fig. 8 Expansion circuit one

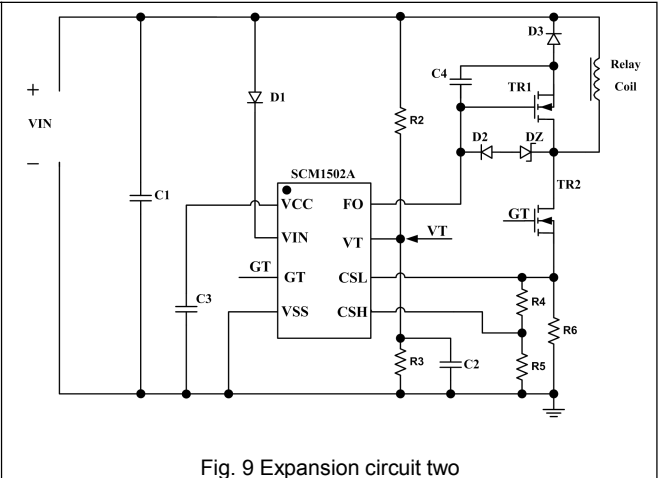


Fig. 9 Expansion circuit two

Application Circuit

The application circuit is a general conventional application and has no remote shutdown function. The circuit can start or turn off the relay by comparing the input voltage with the threshold of VT pin.

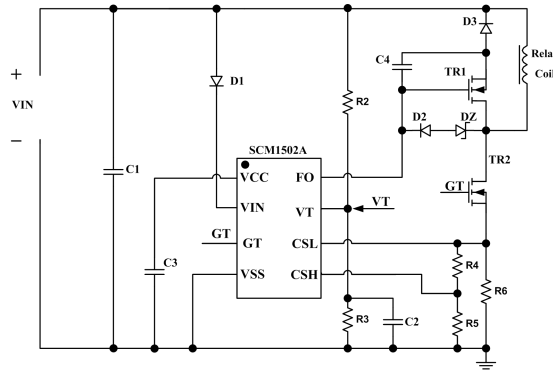


Fig. 10 Application circuit one

For the needs of intelligent control, an optocoupler can be added to achieve remote control, and high and low level signals are used to control the start and shutdown of the relay. When the input is high, the VT pin will be pulled below the off voltage by the optocoupler, and the relay is in the off state. When the input is low and the VT pin voltage reaches the start threshold, the relay will start.

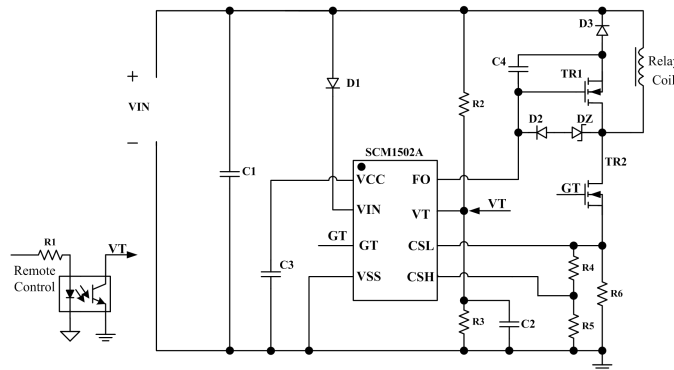


Fig. 11 Application circuit two

Product model overview

The SCM1502A is a relay power-saving controller that reduces the pick-up and holding power consumption of the relay.

SCM1502A has a built-in startup circuit, which can complete the fast startup of the controller with a charging current greater than 8mA within the input voltage range of 7V ~ 40V, in order to meet the relay operating conditions and respond quickly. In addition, SCM1502A can also control the relay coil to switch between high current pick-up and low current holding. The size of the pick-up and holding current can be independently designed to facilitate the application of different relays. And in the low current holding stage, if the input is under voltage or the user is not enabled, the controller will activate the fast shutdown function to allow the relay to open quickly, so as to reduce the impact of SCM1502A on the relay opening performance.

High Voltage Startup Operation

The SCM1502A can take power from the input voltage, charge the VCC bypass capacitor to V_{VCC_ON} with a charging current greater than 8mA to output the GT drive signal, and then the LDO continues to power the VCC bypass capacitor until $V_{VCC} = V_{VCC_HD}$, and finally stabilizes. It should be noted that the chip should be connected in series with a diode on the line that draws power from the input, that is, D1 in the typical application diagram. D1 can prevent the VCC pin from injecting the VIN pin after the input is powered down, making the chip insufficient in power supply and may not complete the quick shutdown action.

Current Design

The SCM1502A uses the CSL and CSH pins to set the peak current in the holding stage and the pick-up stage for programmable design, and the peak current ratio of the two stages ranges from 4 to 20 times wide. As shown in the typical application circuit, the peak currents of these two stages satisfy the following equation:

Peak current I_H during the pick-up stage:

$$I_H = \frac{V_{CSTH} \cdot (R4 + R5)}{R5 \cdot R6}$$

Peak current I_L during the holding stage:

$$I_L = \frac{V_{CSTL}}{R6}$$

It can be seen that by designing the ratio of R4 and R5, the programmable design of the ratio I_H/I_L of the peak current can be realized.

Input Undervoltage Protection

In a typical application, when SCM1502A is just started, if $V_{VT} < 0.6V$, GT does not output a drive signal. When $V_{VT} > 0.8V$ and $V_{VCC} \geq V_{VCC_ON}$, GT starts to output a drive signal and enters the pick-up stage. Here, 0.8V is the operating voltage V_{VT_ON} of the relay. In typical applications, the return difference of V_{VT} is 0.2V, that is, the off voltage of the relay $V_{VT_OFF} = 0.6V$. When $V_{VT} < 0.6V$ and continues for 0.5ms, the input input Pressure protection, turn off the drive signal output of GT. And according to the system status, choose whether to make the fast shutdown tube work in the sub-threshold area. For details, please refer to the "Quick shutdown" section.

Pick-up/holding switchover

Taking typical applications as an example, when $V_{VT} > 0.8V$, start timing for 85.7 ms (if input under-voltage protection is entered during this period, the timing is cleared). SCM1502A transits from the pick-up stage to the holding stage, and from the CSH pin to the CSL pin effectively.

Switching Frequency

To avoid audible noise, the SCM1502A has an average switching frequency of 23.9 kHz. To optimize EMI characteristics, the instantaneous value of the controller's switching frequency is $\pm 6.5\%$ peak-to-peak jitter compared to the average.

Quick Shutdown

As shown in the typical application circuit, when the TR2 is turned on, the FO pin outputs 5 mA of current to charge the FO bootstrap capacitor C4, so that the fast turn-off transistor TR1 operates in a on state, so that to achieve small current slope demagnetization under normal operating conditions.

When the voltage of VT pin is detected to be less than 0.6V up to 0.5ms, and SCM1502A works in the holding stage. The peak slope voltage of CSL is 0.3V, the enable signal switches off the circuit quickly. The FO pin "extracts" 1.45mA current. At this time, the FO bootstrap capacitor C4 discharges until the fast switch-off TR1 works in the sub-threshold region, thus maintaining the slope of the inductance demagnetization current at $(V_Z + 2V_F + V_{TH})/L_M$ to reduce the delay of the relay opening. V_Z is the clamp voltage of the regulator, V_F is the forward voltage of the diodes D1 and D2. It is considered that the forward voltage of D1 and D2 is the same, V_F is the threshold voltage of TR1 and L_M is the inductance of the inductive element L2.

After 85.7ms of the start of the enable signal generation, the fast shutdown circuit stops operating, thereby saving 1.45 mA of current. The 1.2 mA current has a parameter range of 1.02 mA to 1.89 mA due to process variations.

Recommendations

The VCC bypass capacitor C3 should be as close as possible to the VCC pin, and the gate capacitor C4 of the fast turn-off transistor TR1 should be as close as possible to TR1.

Ordering Information

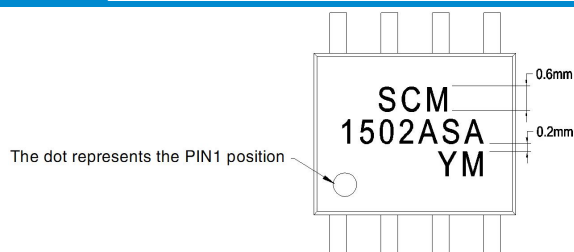
Part Number SCM1502ASA	Package Type SOP-8	No. of Pins 8	Silk Screen Marking SCM 1502ASA YM	Reel information 3K/REEL
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Product marking

SCM1502XYZ:

- (1) SCM1501 = Product designation.
- (2) X= Version information (Letter from A-Z).
- (3) Y = Package definition, (S = SOP package).
- (4) Z = Operating temperature range (C = 0°C to +70°C, I = -40°C to +85°C, A = -40°C to +125°C, M = -55°C to +125°C).
- (5) YM = Date code for product traceability, Y = code for production year, M = code for production month.

Silk Screen Information



Note:

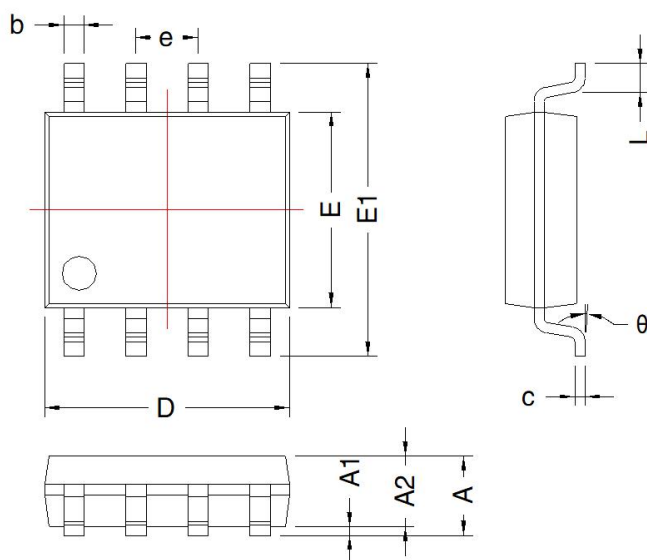
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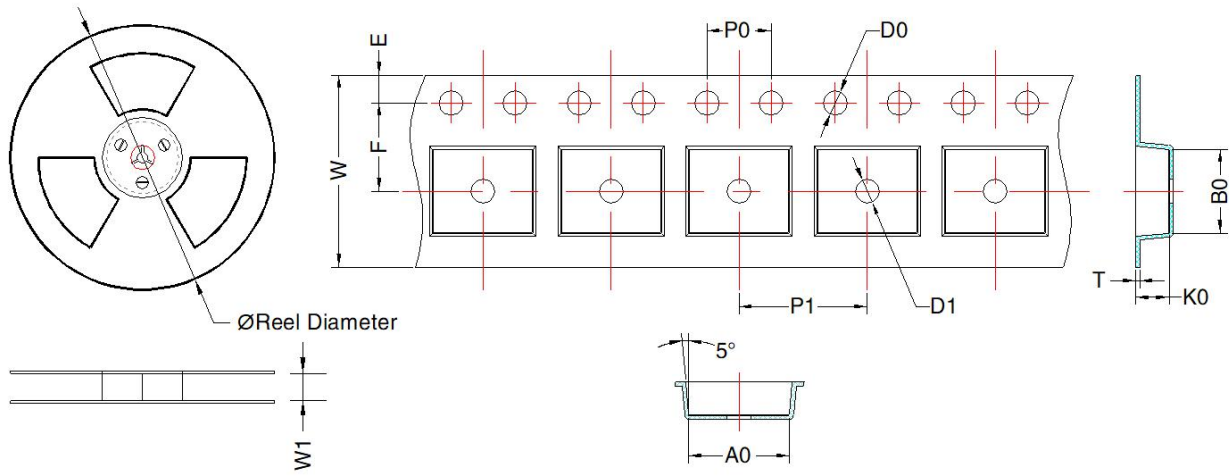
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Mechanical Package Information

THIRD ANGLE PROJECTION

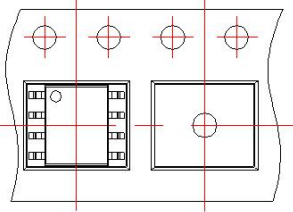


Mark	SOP-8			
	Dimension(mm)		Dimension(inch)	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A1	0.1	0.25	0.004	0.010
A2	1.35	1.55	0.053	0.061
D	4.8	5.0	0.189	0.197
E	3.8	4.0	0.150	0.157
E1	5.8	6.2	0.228	0.244
L	0.4	0.8	0.016	0.032
b	0.33	0.51	0.013	0.020
e	1.27TYP		0.05TYP	
c	0.17	0.25	0.0067	0.001
θ	0°	8°	0°	8°



The orientation of IC in tape

➔
User Direction of Feed



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)
SCM1502ASA	SOP-8	3000	330.0	12.4	6.5 ± 0.2	5.45 ± 0.2	2.0 ± 0.2	0.3 ± 0.05	12.0 ± 0.3	1.75 ± 0.1	5.5 ± 0.1	8.0 ± 0.1	4 ± 0.1	1.5 ± 0.1	1.5 ± 0.1

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