

Auxiliary Switch Diodes for Snubber SARS01, SARS05

Description

The SARS01/05 is an auxiliary switch diode especially designed for snubber circuits, which are used in the primary sides of flyback switched-mode power supplies.

Being capable of reducing the ringing voltage generated at power MOSFET turn-off, the SARS01/05-incorporated snubber circuits allow better cross regulation of multiple outputs.

The SARS01/05 can also improve power supply efficiency by partially transferring such ringing voltage into the secondary side of a power supply unit.

Features

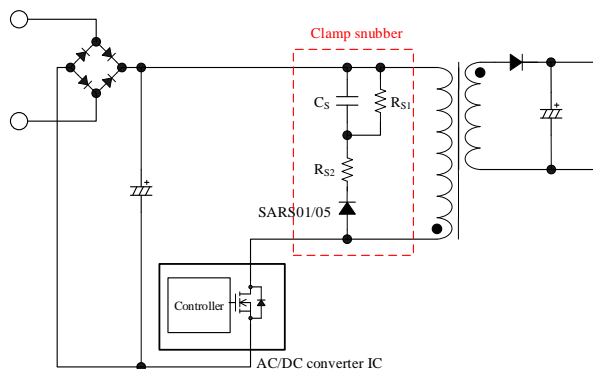
- Improves Cross Regulation
- Reduces Noise
- Improves Efficiency

Applications

For switched-mode power supplies (SMPS) with flyback topology such as:

- White Goods
- Adaptor
- Industrial Equipment

Typical Application

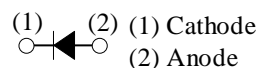
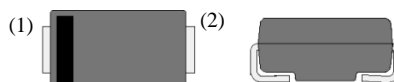


Package

- SARS01
Axial ($\phi 2.7 \times 5.0L / \phi 0.6$)



- SARS05
SJP ($4.5 \text{ mm} \times 2.6 \text{ mm}$)



Not to scale

Selection Guide

Part Number	$I_{F(AV)}$	$V_F(\text{max.})$	Package
SARS01	1.2 A	0.92 V	Axial
SARS05	1.0 A	1.05 V	SJP

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SARS01, SARS05

Absolute Maximum Ratings

Unless otherwise specified, $T_A = 25\text{ }^{\circ}\text{C}$.

Parameter	Symbol	Conditions	Rating	Unit	Remarks
Transient Peak Reverse Voltage	V_{RSM}		800	V	
Peak Repetitive Reverse Voltage	V_{RM}		800	V	
Average Forward Current ⁽¹⁾	$I_{F(AV)}$		1.2	A	SARS01
			1.0		SARS05
Surge Forward Current	I_{FSM}	Half cycle sine wave, positive side, 10 ms, 1 shot	110	A	SARS01
			30		SARS05
I^2t Limiting Value	I^2t	$1\text{ ms} \leq t \leq 10\text{ ms}$	60.5	A^2s	SARS01
			4.5		SARS05
Junction Temperature	T_J		-40 to 150	$^{\circ}\text{C}$	
Storage Temperature	T_{STG}		-40 to 150	$^{\circ}\text{C}$	

Electrical Characteristics

Unless otherwise specified, $T_A = 25\text{ }^{\circ}\text{C}$.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	Remarks
Forward Voltage Drop	V_F	$I_F = 1.2\text{ A}$	—	—	0.92	V	SARS01
		$I_F = 1.5\text{ A}$	—	—	1.05		SARS05
Reverse Leakage Current	I_R	$V_R = V_{RM}$	—	—	10	μA	SARS01
			—	—	5		SARS05
Reverse Leakage Current under High Temperature	$H \cdot I_R$	$V_R = V_{RM}$, $T_J = 100\text{ }^{\circ}\text{C}$	—	—	50	μA	
Reverse Recovery Time	t_{rr}	$I_F = I_{RP} = 100\text{ mA}$, $T_J = 25\text{ }^{\circ}\text{C}$, 90% recovery point	2	—	18	μs	SARS01
			2	—	19		SARS05
Thermal Resistance	$R_{th(J-L)}$	⁽²⁾	—	—	20	$^{\circ}\text{C/W}$	SARS01
			—	—	20		SARS05

⁽¹⁾ See the derating curves of each product.

⁽²⁾ $R_{th(J-L)}$ is thermal resistance between junction and lead.

SARS01 Rating and Characteristic Curves

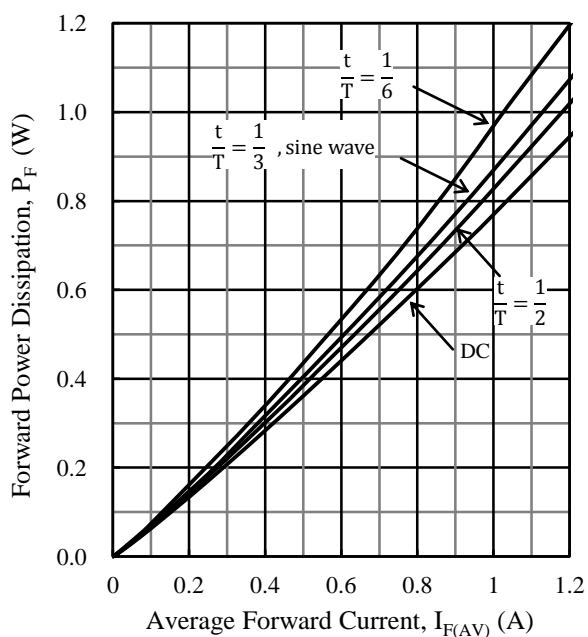


Figure 1. SARS01 $I_{F(AV)}$ vs. P_F Power Dissipation Curves ($T_J = 150\text{ }^{\circ}\text{C}$)

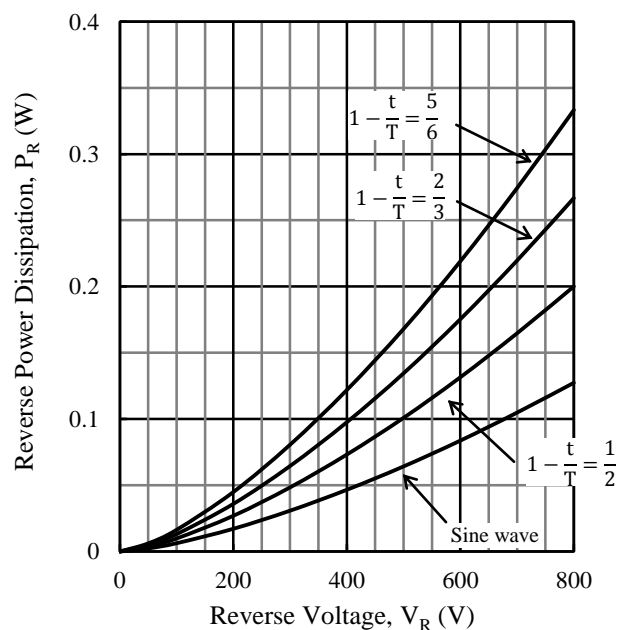


Figure 2. SARS01 V_R vs. P_R Power Dissipation Curves ($T_J = 150\text{ }^{\circ}\text{C}$)

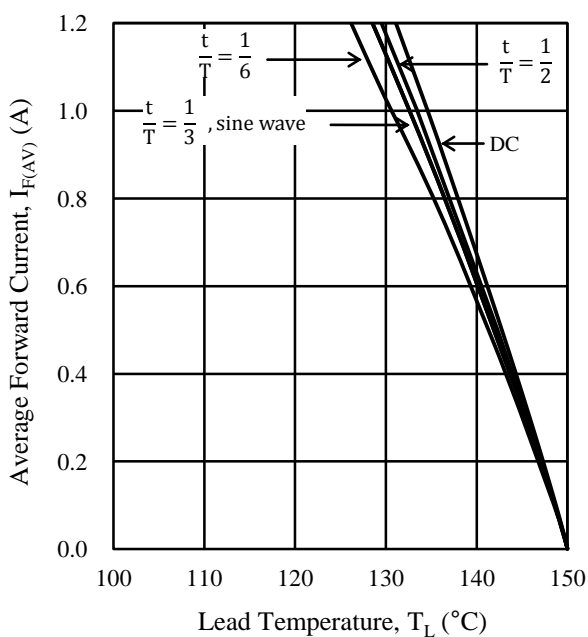


Figure 3. SARS01 T_L vs. $I_{F(AV)}$ Derating Curves ($V_R = 0\text{ V}$, $T_J = 150\text{ }^{\circ}\text{C}$)

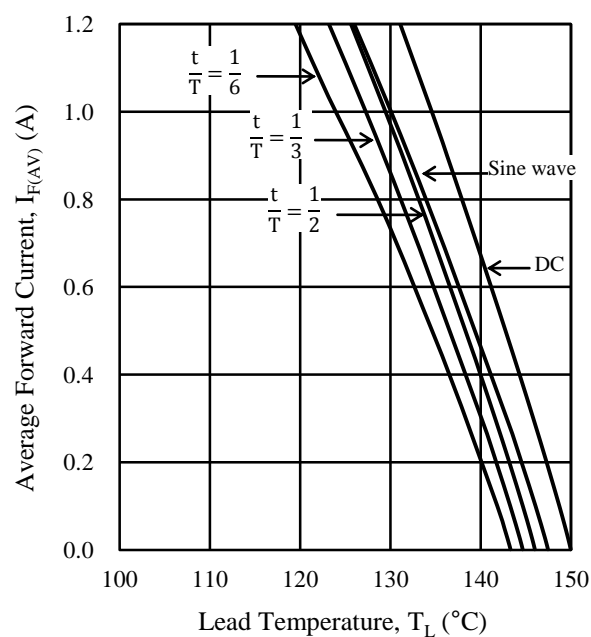


Figure 4. SARS01 T_L vs. $I_{F(AV)}$ Derating Curves ($V_R = 800\text{ V}$, $T_J = 150\text{ }^{\circ}\text{C}$)

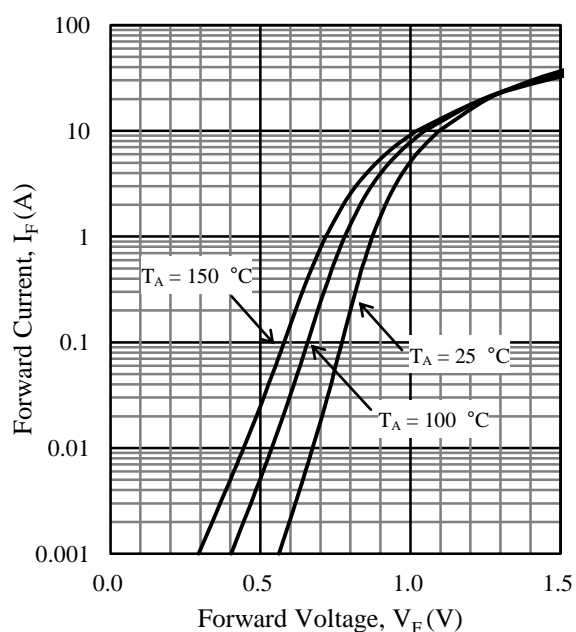


Figure 5. SARS01 V_F vs. I_F Typical Characteristics

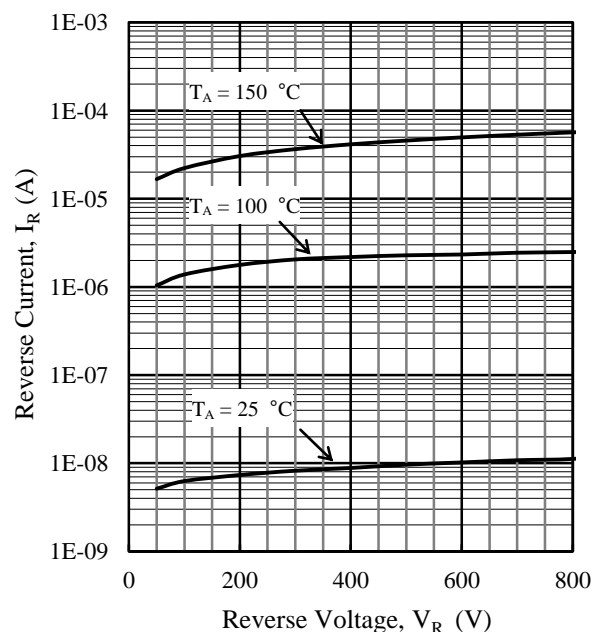


Figure 6. SARS01 V_R vs. I_R Typical Characteristics

SARS05 Rating and Characteristic Curves

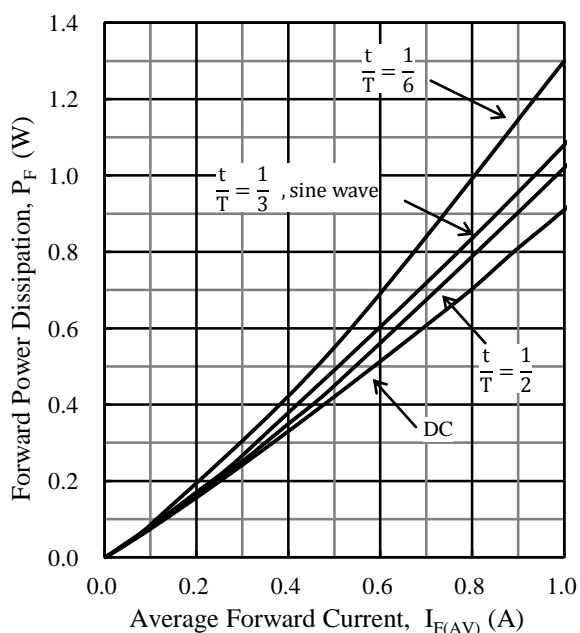


Figure 7. SARS05 $I_{F(AV)}$ vs. P_F Power Dissipation Curves ($T_J = 150\text{ °C}$)

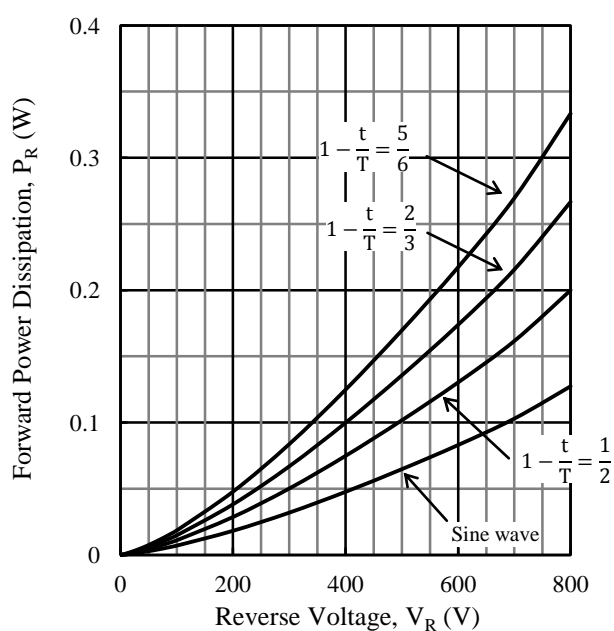


Figure 8. SARS05 V_R vs. P_R Power Dissipation Curves ($T_J = 150\text{ °C}$)

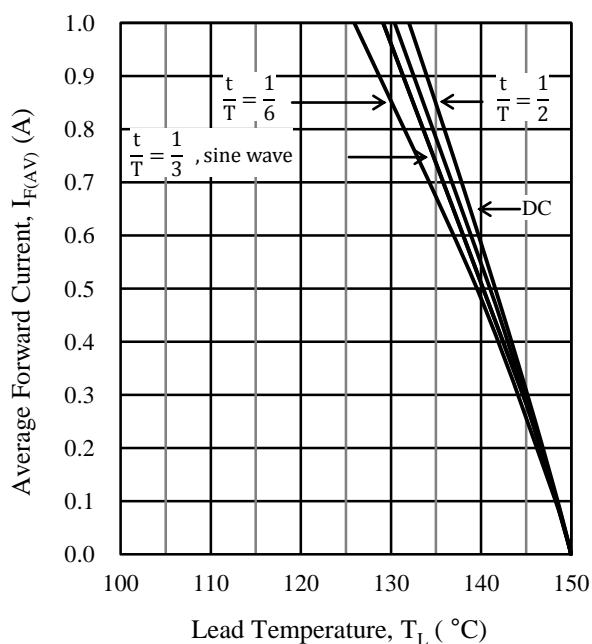


Figure 9. SARS05 T_L vs. $I_{F(AV)}$ Derating Curves ($V_R = 0$ V, $T_J = 150$ °C)

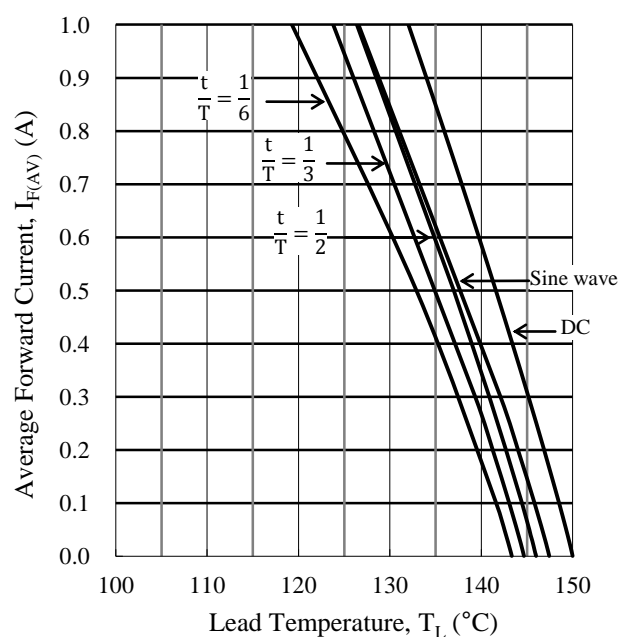


Figure 10. SARS05 T_L vs. $I_{F(AV)}$ Derating Curves ($V_R = 800$ V, $T_J = 150$ °C)

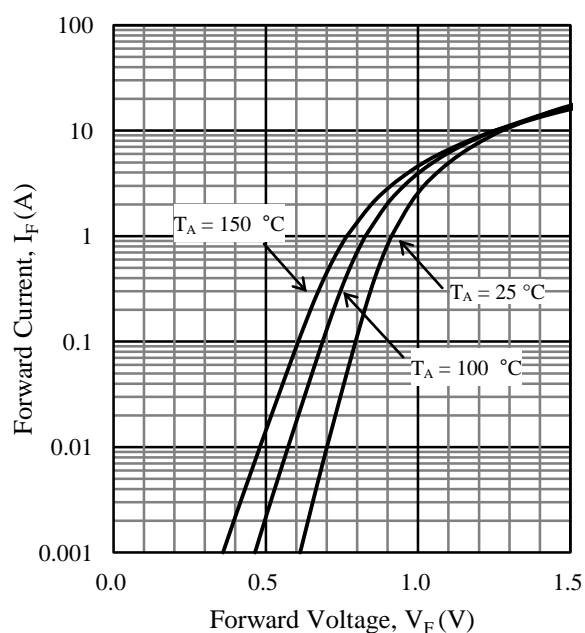


Figure 11. SARS05 V_F vs. I_F Typical Characteristics

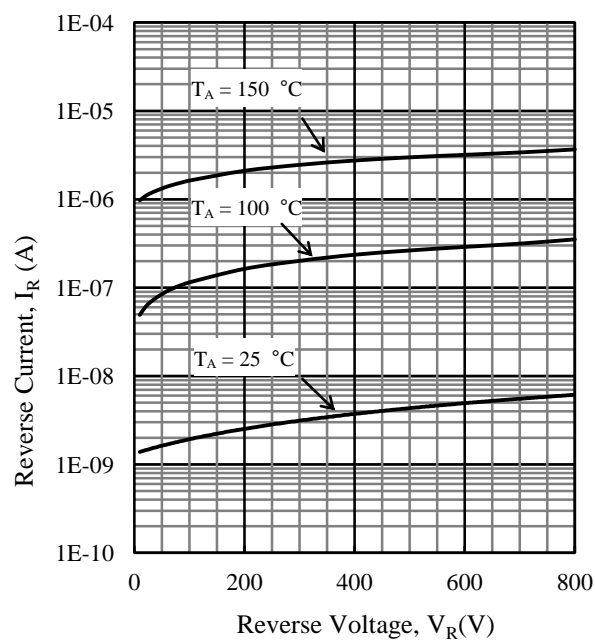
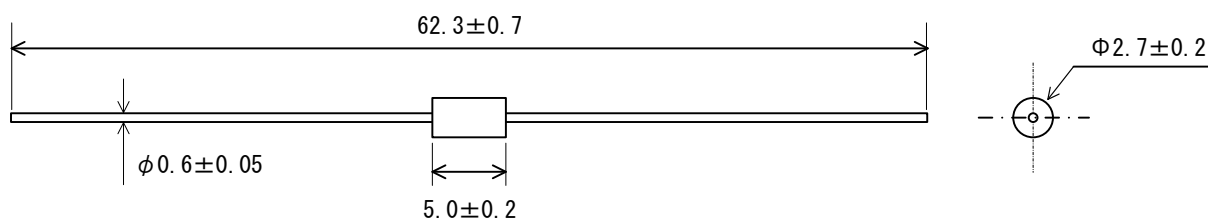


Figure 12. SARS05 V_R vs. I_R Typical Characteristics

SARS01 Physical Dimensions and Marking Diagram

• SARS01 Physical Dimensions

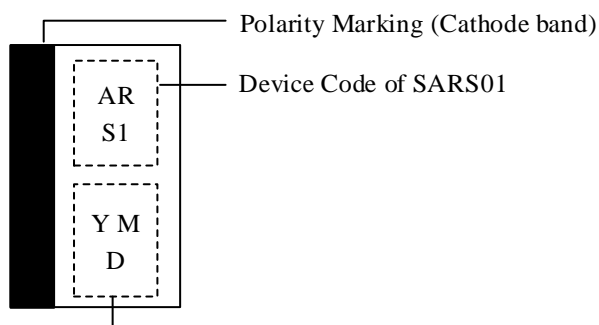
Axial ($\phi 2.7 \times 5.0L / \phi 0.6$)



NOTES:

- Dimensions in millimeters
- Bare leads: Pb-free (RoHS compliant)
- When soldering the products, it is required to minimize the working time, within the following limits:
 - Flow: 260 ± 5 °C / 10 ± 1 s, 2 times
 - Soldering Iron: 380 ± 10 °C / 3.5 ± 0.5 s, 1 time (Soldering should be at a distance of at least 1.5 mm from the body of the product.)

• SARS01 Marking Diagram



Lot Number:

Y is the last digit of the year of manufacture (0 to 9)

M is the month of the year (1 to 9, O, N, or D)

D is a period of days:

“.” is the first 10 days of the month (1st to 10th)

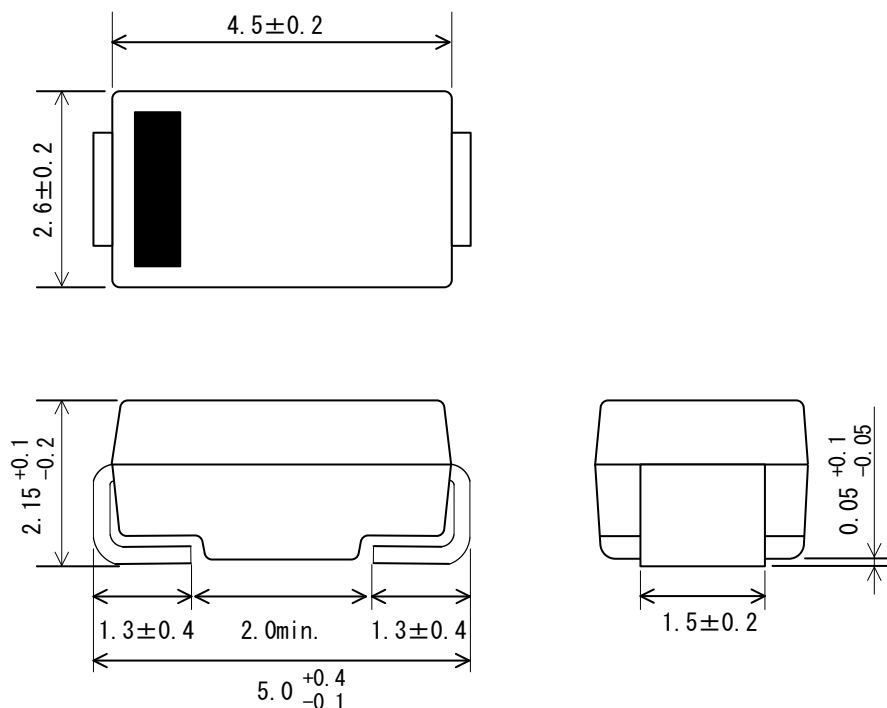
“..” is the second 10 days of the month (11th to 20th)

“...” is the last 10–11 days of the month (21st to 31st)

SARS05 Physical Dimensions and Marking Diagram

- SARS05 Physical Dimensions

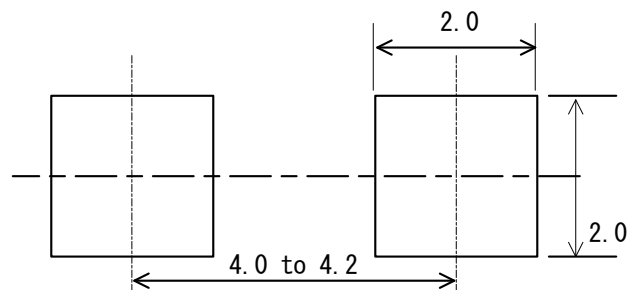
- SJP Physical Dimensions



NOTES:

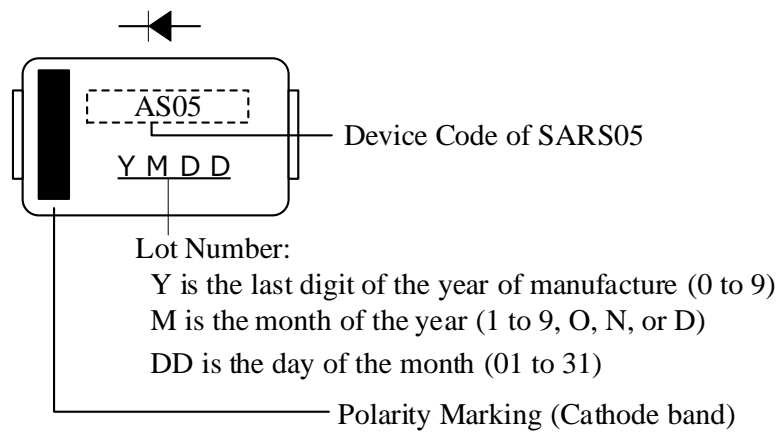
- Dimensions in millimeters
- Bare lead frame: Pb-free (RoHS compliant)
- When soldering the products, it is required to minimize the working time, within the following limits:
Reflow (MSL 3)
Preheat: $180\text{ }^{\circ}\text{C} / 90 \pm 30\text{ s}$
Solder heating: $250\text{ }^{\circ}\text{C} / 10 \pm 1\text{ s}$, 2 times ($260\text{ }^{\circ}\text{C}$ peak)
Soldering iron: $380 \pm 10\text{ }^{\circ}\text{C} / 3.5 \pm 0.5\text{ s}$, 1 time

- SARS05 Land Pattern Example



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- SARS05Marking Diagram



Operational Comparison of Clamp Snubber Circuits

Figure 13 shows a general clamp snubber circuit. In the circuit, the surge voltage at tuning off a power MOSFET is charged to C_S through the surge absorb loop, and is consumed by R_{S1} through the energy discharge loop. All the consumed energy becomes loss in R_{S1} . In addition, the ringing of surge voltage results in poor cross regulation of multi-outputs.

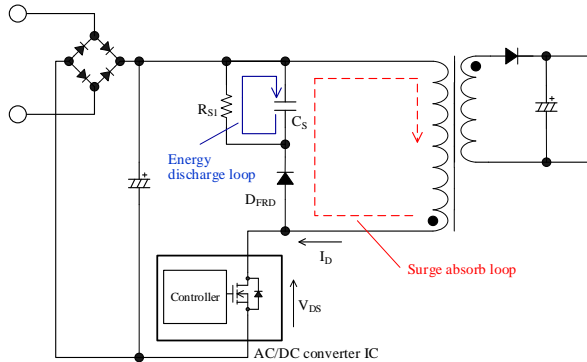


Figure 13. General Clamp Snubber Circuit

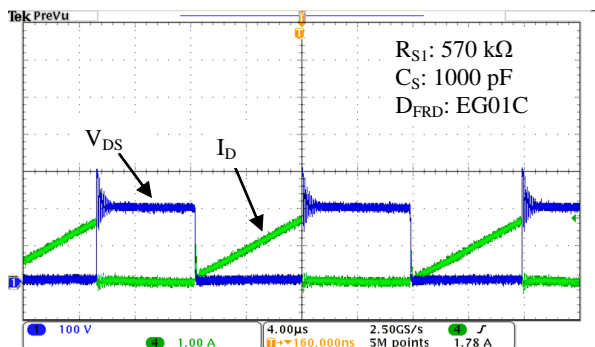


Figure 14. Waveforms of General Clamp Snubber Circuit

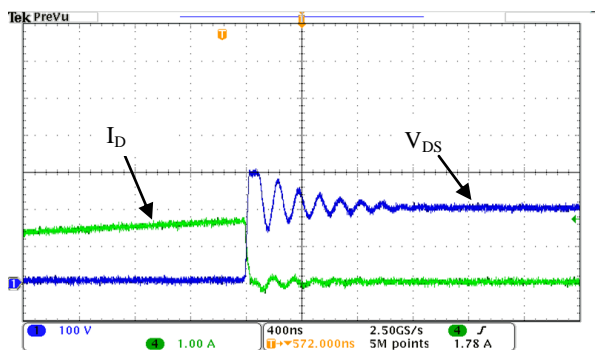


Figure 15. Enlarged View of Figure 14

Figure 16 shows the clamp snubber circuit using the SARS01/05. The surge voltage at tuning off a power MOSFET is charged to C_S through the surge absorb loop. Since the reverse recovery time, t_{rr} , of the SARS01/05 is a relatively long period, the energy charged to C_S is discharged to the reverse direction of the surge absorb loop until C_S voltage is equal to the flyback voltage. Some discharged energy is transferred to secondary side. Thus, the power supply efficiency improves.

In addition, the power supply using the SARS01/05 reduces the ringing voltage. Thus, the cross regulation of multi-outputs can be improved.

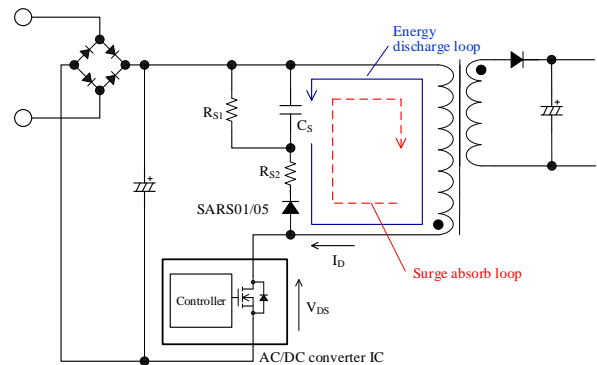


Figure 16. Clamp Snubber Circuit using SARS01/05

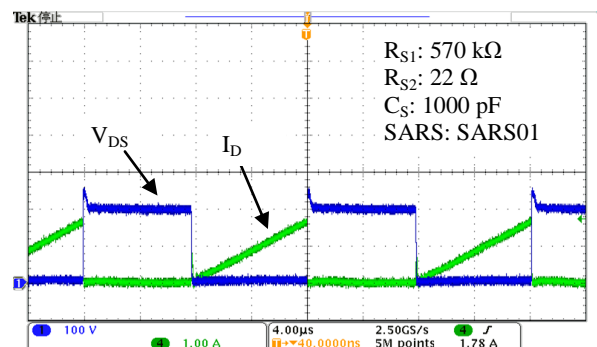


Figure 17. Waveforms of Clamp Snubber Circuit using SARS01

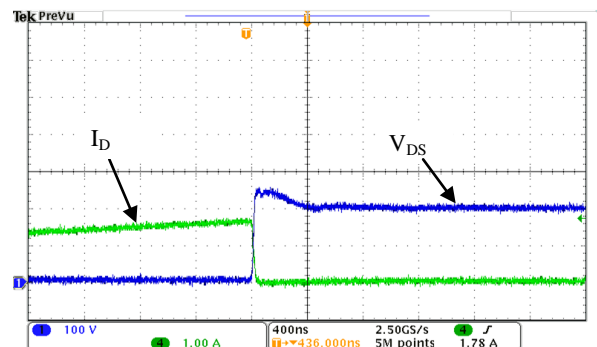


Figure 18. Enlarged View of Figure 17

Power Dissipation and Junction Temperature Calculation

Figure 19 shows a typical application using the SARS01/05. Figure 20 shows the operating waveforms of the SARS01/05. The power dissipation of the SARS01/05 is calculated as follows:

- 1) The waveforms of the SARS01/05 voltage, V_{SARS} , and the SARS01/05 current, I_{SARS} , are measured in actual application operation. $V_{SARS} \times I_{SARS}$ is calculated by the math function of oscilloscope.
- 2) The each average energy ($P_1, P_2 \dots P_k$) is measured at period of each polarity of $V_{SARS} \times I_{SARS}$ ($t_1, t_2, \dots t_k$) as shown in Figure 19 by the automatic measurement function of the oscilloscope.
- 3) The power dissipation of the SARS01/05, P_{SARS} , is calculated by Equation (1):

$$P_{SARS} = \frac{1}{T} (|P_1 \times t_1| + |P_2 \times t_2| + \dots |P_k \times t_k|) \quad (1)$$

where:

P_{SARS} is power dissipation of the SARS01/05,
 T is switching cycle of power MOSFET (s), and
 P_k is average energy of period t_k (W).

A differential probe is recommended to use for the measurement of V_{SARS} . Please conform to the oscilloscope manual about power dissipation measurement including the delay compensation of probe. In addition, by using the temperature of the SARS01/05 in actual application operation, the estimated junction temperature of the SARS01/05 is calculated by Equation (2). It should be enough lower than T_J of the absolute maximum rating.

$$T_{J(SARS)} = T_L + \theta_{J-L} \times P_{SARS} \text{ (}^\circ\text{C)} \quad (2)$$

where:

$T_{J(SARS)}$ is junction temperature of the SARS01/05,
 T_L is lead temperature of the SARS01/05, and
 θ_{J-L} is thermal resistance between junction to lead.

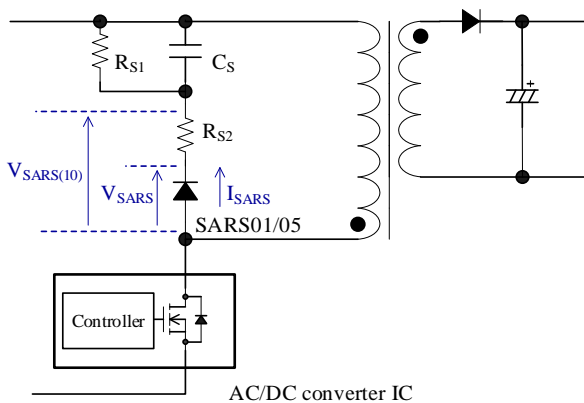


Figure 19. Typical Application

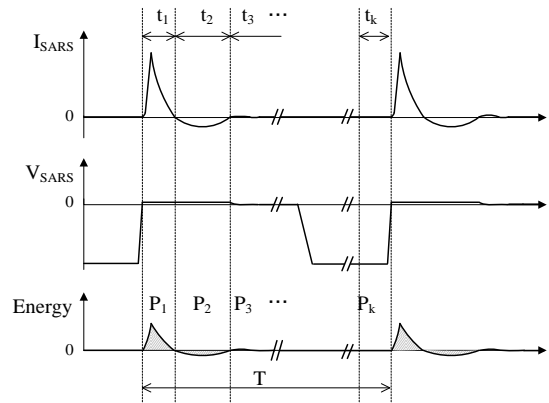


Figure 20. SARS01/05 Current

Parameter Setting of Snubber Circuit using SARS01/05

The temperature of the SARS01/05 and peripheral components should be measured in actual application operation.

The reference values of snubber circuit using the SARS01/05 are as follows:

- C_S
 680 pF to 0.01 μ F.
 The voltage rating is selected according to the voltage subtracted the input voltage from the peak of V_{DS} .
- R_{S1}
 R_{S1} is the bias resistance to turn off the SARS01/05, and is 100 k Ω to 1 M Ω .
 Since a high voltage is applied to R_{S1} that has high resistance, the following should be considered according to the requirement of the application:
 - Select a resistor designed for electromigration, or
 - Connect more resistors in series so that the applied voltages of individual resistors can be reduced.
 The power rating of resistor should be selected from the measurement of the effective current of R_{S1} based on actual operation in the application.
- R_{S2}
 R_{S2} is the limited resistance in the energy discharging. The value of 22 Ω to 220 Ω is connected to the SARS01/05 in series.
 The power rating of resistor should be selected from the measurement of the effective current of R_{S2} based on actual operation in the application.

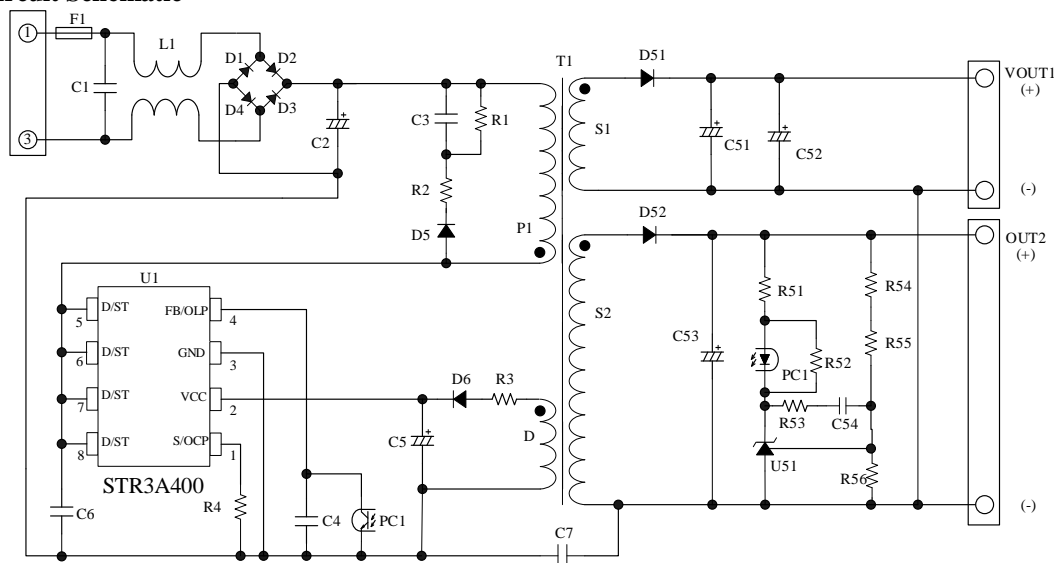
Reference Design of Power Supply

This section provides the information on a reference design, including power supply specifications, a circuit diagram, the bill of materials, and transformer specifications.

Power Supply Specifications

Item	Specification
Input Voltage	85 VAC to 265 VAC
Output Power	34.8 W (40.4 W peak)
Output 1	8 V / 0.5 A
Output 2	14 V / 2.2 A (2.6 A peak)

Circuit Schematic



Bill of Materials

Symbol	Ratings ⁽¹⁾	Recommended Part No.	Symbol	Ratings ⁽¹⁾	Recommended Part No.
C1 ⁽²⁾	Film, 0.1 μ F, 275 V		D52	Schottky, 100 V, 10 A	SPEN-210A
C2 ⁽²⁾	Electrolytic, 150 μ F, 400 V		F1	Fuse, 250 V AC, 3 A	
C3	Ceramic, 1000 pF, 1 kV		L1 ⁽²⁾	CM inductor, 3.3 mH	
C4	Ceramic, 0.01 μ F		PC1	Optocoupler, PC123 or equiv.	
C5	Electrolytic, 22 μ F, 50 V		R1 ⁽³⁾	Metal oxide, 330 k Ω , 1 W	
C6 ⁽²⁾	Ceramic, 15 pF / 2 kV		R2	47 Ω , 1 W	
C7 ⁽²⁾	Ceramic, 2200 pF, 250 V		R3	10 Ω	
C51 ⁽²⁾	Electrolytic, 680 μ F, 25 V		R4 ⁽²⁾	0.47 Ω , 1/2 W	
C52	Electrolytic, 680 μ F, 25 V		R51	1 k Ω	
C53	Electrolytic, 470 μ F, 16 V		R52	1.5 k Ω	
C54 ⁽²⁾	Ceramic, 0.1 μ F, 50 V		R53 ⁽²⁾	100 k Ω	
D1	600 V, 1 A	EM01A	R54 ⁽²⁾	6.8 k Ω	
D2	600 V, 1 A	EM01A	R55	$\pm 1\%$, 39 k Ω	
D3	600 V, 1 A	EM01A	R56	$\pm 1\%$, 10 k Ω	
D4	600 V, 1 A	EM01A	T1	See the Transformer Specification	
D5	800 V, 1.0 A	SARS05	U1	IC	STR3A453D
D6	Fast recovery, 200 V, 1.5A	SJPX-F2	U51	Shunt regulator, $V_{REF} = 2.5$ V	(TL431 or equiv.)
D51	Schottky, 60 V, 1.5 A	SJPW-F6			

⁽¹⁾ Unless otherwise specified, the voltage rating of capacitor is 50 V or less and the power rating of resistor is 1/8 W or less.

⁽²⁾ Refers to a part that requires adjustment based on operation performance in an actual application.

⁽³⁾ High voltage is applied to this resistor that has high resistance. To meet your application requirements, it is required to select resistors designed for electromigration, or to connect more resistors in series so that the applied voltages of individual resistors can be reduced.

SARS01, SARS05

• Transformer Specifications

Item	Specification
Primary Inductance, L_P	518 μ H
Core Size	EER-28
AL Value	245 nH/N ² (with a center gap of about 0.56 mm)
Winding Specification	See Table 1
Winding Structure	See Figure 21

Table 1. Winding Specification

Winding	Symbol	Number of Turns (turns)	Wire Diameter (mm)	Structure
Primary Winding	P1	18	$\phi 0.23 \times 2$	Single-layer, solenoid winding
Primary Winding	P2	28	$\phi 0.30$	Single-layer, solenoid winding
Auxiliary Winding	D	12	$\phi 0.30 \times 2$	Solenoid winding
Output 1 Winding	S1-1	6	$\phi 0.4 \times 2$	Solenoid winding
Output 1 Winding	S1-2	6	$\phi 0.4 \times 2$	Solenoid winding
Output 2 Winding	S2-1	4	$\phi 0.4 \times 2$	Solenoid winding
Output 2 Winding	S2-2	4	$\phi 0.4 \times 2$	Solenoid winding

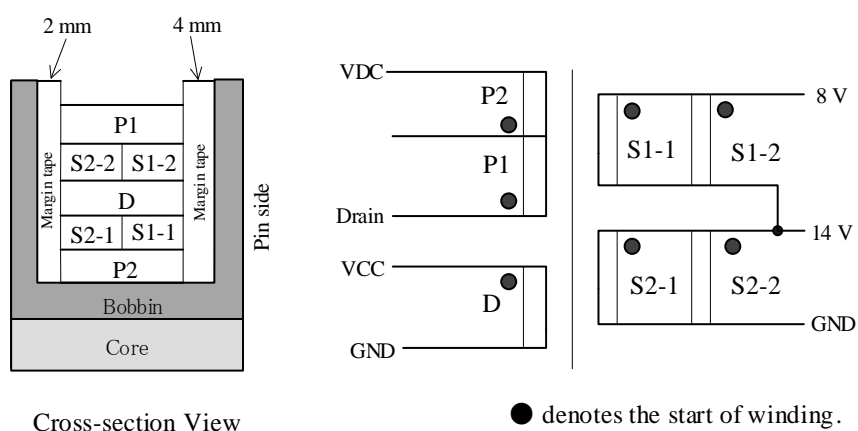


Figure 21. Winding Structure

Important Notes

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