SOLID STATE OPTRONICS



# SP946-X

Zero Cross
800V / 1.2A
AC Solid State Relay

## Description

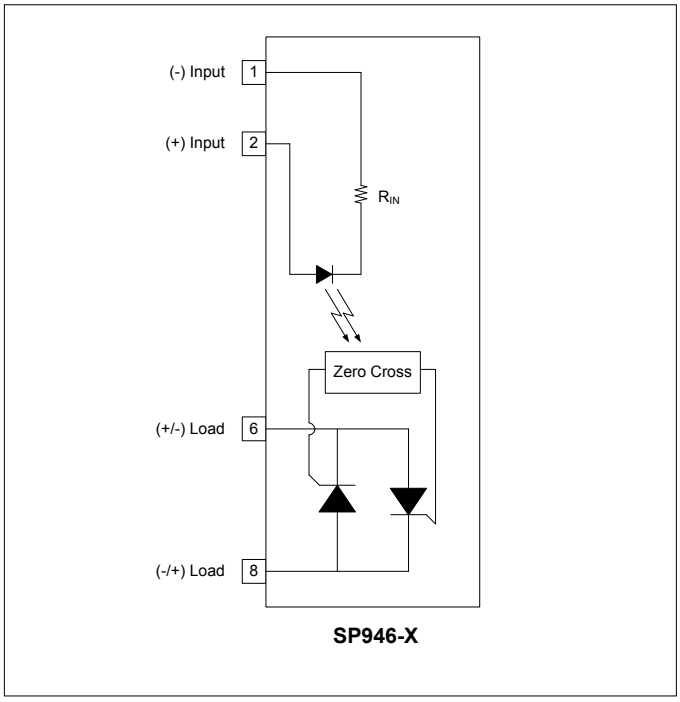
The SP946-X is a bi-directional, single-pole, single-throw, normally open multipurpose solid-state relay. The circuit is composed of one input IR LED with a series limiting resistor which activates an optically coupled IC on the output that controls the firing angle of two back-to-back SCRs. This circuit assures no false triggering under most adverse conditions, and a tight zero-volt switching window not exceeding 5V. The SP946-X provides high peak load voltage (800V+) and high input-to-output isolation voltage (up to $5kV_{RMS}$).

The SP946-X comes in a compact 4 pin SIP package, making it ideal for high-density board applications.

## Applications

- Valve Control
- Solenoid Control
- Home Appliances
- Metering Equipment
- Heating Elements
- Gas Pump Control Circuitry

## Schematic Diagram




**SP946-X**

## Features

- Zero-Volt Cross Switching
- Input Series Limiting Resistor (300Ω TYP)
- High Blocking Voltage (800V MIN)
- High Transient Immunity
- 1.2A Maximum Continuous Current
- Low Input Control Current
- Long Life / High Reliability
- RoHS / Pb-Free / REACH Compliant

## Agency Approvals

| | |
|---|---|
| UL/C-UL: | File # E90096 |
| VDE: | File # 40035191 (EN 60747-5-2) |

## Absolute Maximum Ratings

The values indicated are absolute stress ratings. Functional operation of the device is not implied at these or any conditions in excess of those defined in electrical characteristics section of this document. Exposure to absolute Maximum Ratings may cause permanent damage to the device and may adversely affect reliability.

| | |
|---|---|
| Storage Temperature | -55 to +125°C |
| Operating Temperature | -40 to +85°C |
| Continuous Input Current | 50mA |
| Transient Input Current | 500mA |
| Reverse Input Control Voltage | 5V |
| Input Power Dissipation | 40mW |
| Total Power Dissipation | 1.2W |
| Solder Temperature – Wave (10sec) | 260°C |
| Solder Temperature – IR Reflow (10sec) | 260°C |

## Ordering Information

| Part Number | Description |
|---|---|
| SP946-X | 4 pin SIP, (25/Tube) |
| SP946-XH | $5kV_{RMS}$ $V_{ISO}$, 4 pin SIP, (25/Tube) |

**NOTE: Suffixes listed above are not included in marking on device for part number identification**

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**Electrical Characteristics,** $T_A$ = 25°C (unless otherwise specified)

| Parameter | Symbol | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| **Input Specifications** | | | | | | |
| LED Forward Voltage | $V_F$ | - | 1.2 | 1.5 | V | $I_F$ = 10mA |
| LED Reverse Voltage | $BV_R$ | 5 | - | - | V | $I_R$ = 10µA |
| Input Resistor | $R_{IN}$ | - | 300 | - | Ω | |
| Trigger (Must Operate) Current[1] | $I_F$ | - | 3 | 5 | mA | $I_O = I_{O(MAX)}$ [Resistive Load] |
| Junction Capacitance | $C_J$ | - | 5 | - | pF | $I_F$=0mA |
| **Output Specifications** | | | | | | |
| Blocking Voltage | $V_B$ | 800 | - | - | V | $I_F$ = 0mA, $I_O$ = 1µA |
| Continuous Load Current | $I_{O(MAX)}$ | - | - | 1.2 | A | $I_F$ = 5mA |
| Surge Current | $I_{(SURGE)}$ | - | - | 10 | A | T ≤ 16mS |
| Holding Current | $I_{HOLD}$ | - | - | 10 | mA | $I_F$ = 5mA |
| On Voltage | $V_{ON}$ | - | - | 1.2 | V | $I_F$ = 5mAV, $I_O$ = 1.2A |
| Voltage Across Load at Turn On | - | - | - | 5 | V | $I_F$ = 5mA |
| Leakage Current | $I_{Oleak}$ | - | 100 | 250 | µA | $I_F$ = 0mA, $V_O$ = 250V |
| Thermal Resistance | - | - | 80 | - | °C/W | |
| Power Factor[2] | - | - | 0.3 | - | - | |
| Critical Rate of Rise (dV/dt)[3] | dV/dt | 400 | - | - | V/µS | |
| **Coupled Specifications** | | | | | | |
| Turn-On Time | $T_{ON}$ | - | - | 0.5 | Cycles | $I_F$ = 5mA |
| Turn-Off Time | $T_{OFF}$ | - | - | 0.5 | Cycles | $I_F$ = 5mA |
| Coupled Capacitance | $C_{COUPLED}$ | - | 2 | - | pF | |
| Contact Transient Ratio | - | 2,000 | 7,000 | 0 | V/µS | dV = 50V |
| **Isolation Specifications** | | | | | | |
| Isolation Voltage | $V_{ISO}$ | 3750 | - | - | $V_{RMS}$ | RH ≤ 50%, t=1min |
| (-H Option) | | 5000 | - | - | | |
| Input-Output Resistance | $R_{I-O}$ | - | $10^{12}$ | - | Ω | $V_{I-O}$ = 500$V_{DC}$ |

**NOTES**:

1) Resistive load. For inductive loads, higher drive current is recommended
2) Snubber circuits may be required for lower power factors
3) This is for static dV/dt.

**SP946-X Performance & Characteristics Plots,** $T_A$ = 25°C (unless otherwise specified)

**Figure 1:** *Typical Blocking Voltage Distribution*
(N = 100, Ta = 25ºC)

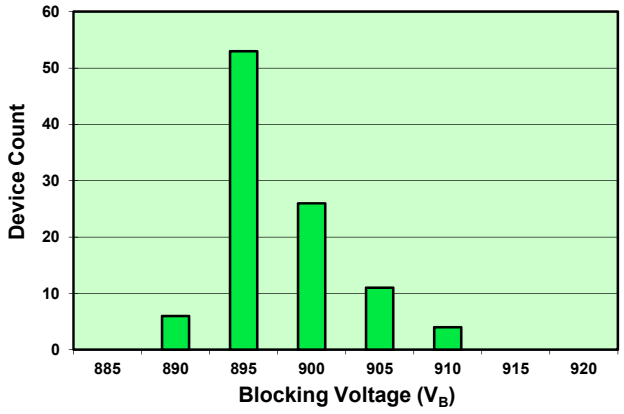
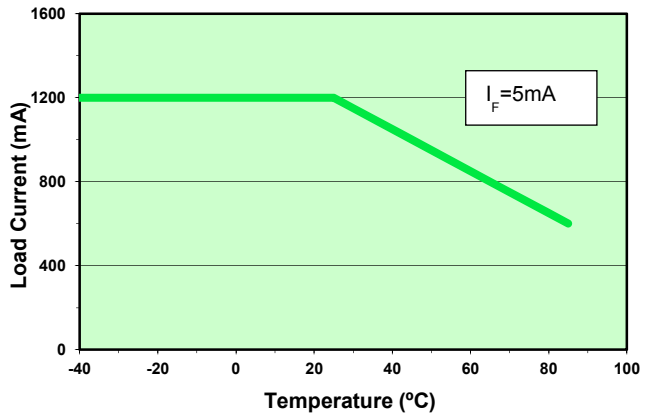



**Figure 2:** *Maximum Load Current vs. Temperature*




## *ZERO-VOLT SWITCHING*

This solid state relay has been designed with a driver circuit that controls the operation of two back-to-back silicon controlled rectifiers (SCRs), each responsible for one half of the AC cycle. If an AC signal is examined, the turn on, turn off and zero-volt switching can be seen. Figure 3 shows a typical 60 HZ, 120VAC signal with a corresponding relay input signal:

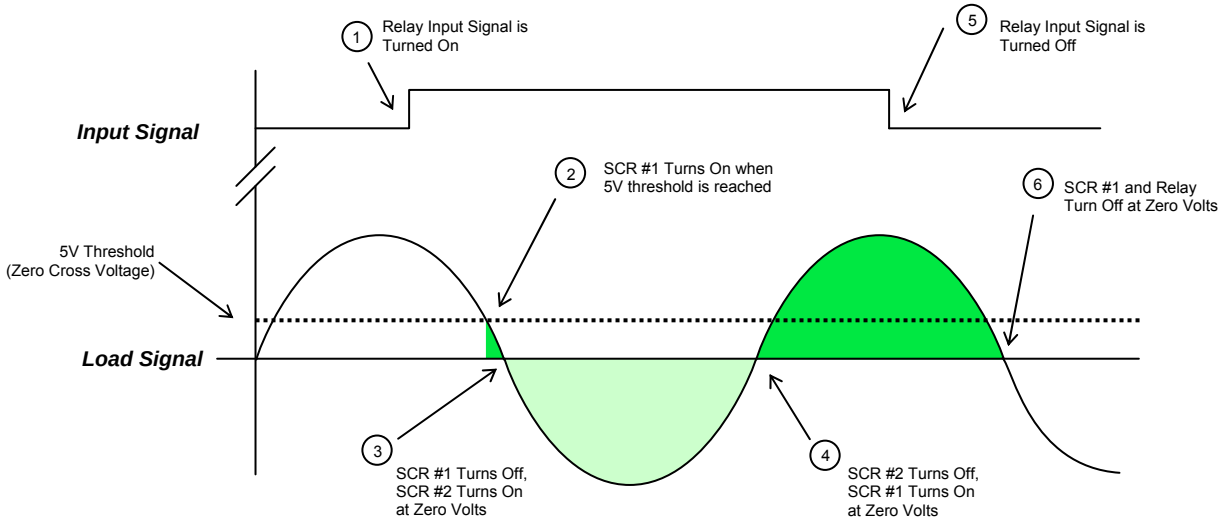



Figure 3: *Zero-Volt Switching Cycle*

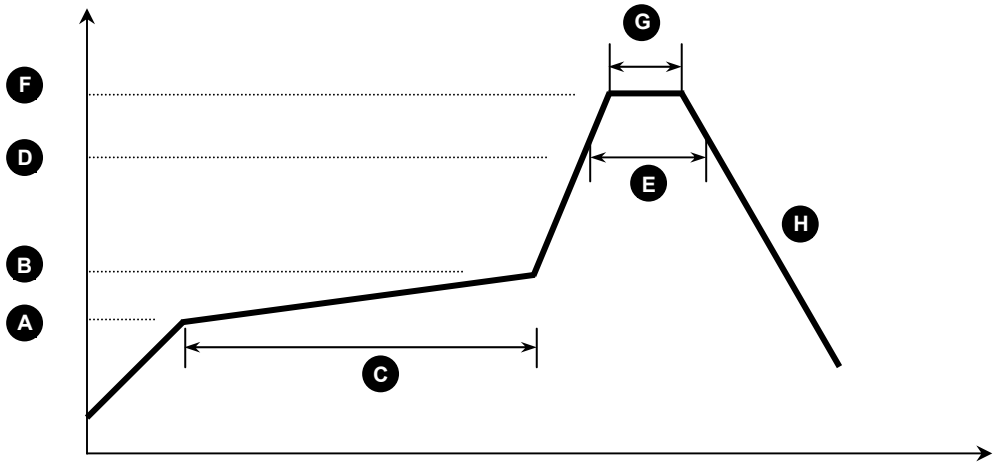
Figure 3 shows the sequence of zero-volt switching operation. At Stage 1, an input signal is applied to the relay. The relay will not turn on until the threshold voltage of 5V is reached. Once this point is reached (Stage 2), SCR #1 (designated as the SCR which controls positive AC voltage) turns on. However, SCR #1 only conducts for an instant, as the cycle quickly crosses zero. At this point (Stage 3), SCR #1 will turn off and SCR #2 (negative AC voltage) turns on. Likewise, at the next zero cross (Stage 4), SCR #2 will turn off and SCR #1 conducts again. Even though the input signal is terminated at Stage 5, the relay will continue to conduct (typical SCR behavior) until Stage 6, when SCR #1 crosses zero and ceases to conduct. Please note that turn on can likewise begin on the negative phase of the AC cycle with a -5V threshold, though only the positive phase is shown here.

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## SP946-X Solder Reflow Temperature Profile Recommendations

**(1)** *Infrared Reflow:*

Refer to the following figure as an example of an optimal temperature profile for single occurrence infrared reflow. Soldering process should not exceed temperature or time limits expressed herein. Surface temperature of device package should not exceed 250ºC:




| Process Step | Description | Parameter |
|---|---|---|
| A | Preheat Start Temperature (ºC) | 150ºC |
| B | Preheat Finish Temperature (ºC) | 180ºC |
| C | Preheat Time (s) | 90 - 120s |
| D | Melting Temperature (ºC) | 230ºC |
| E | Time above Melting Temperature (s) | 30s |
| F | Peak Temperature, at Terminal (ºC) | 260ºC |
| G | Dwell Time at Peak Temperature (s) | 10s |
| H | Cool-down (ºC/s) | <6ºC/s |

**(2)** *Wave Solder:*

| | |
|---|---|
| Maximum Temperature: | 260ºC (at terminal) |
| Maximum Time: | 10s |
| Pre-heating: | 100 - 150ºC (30 - 90s) |
| Single Occurrence | |

**(3)** *Hand Solder:*

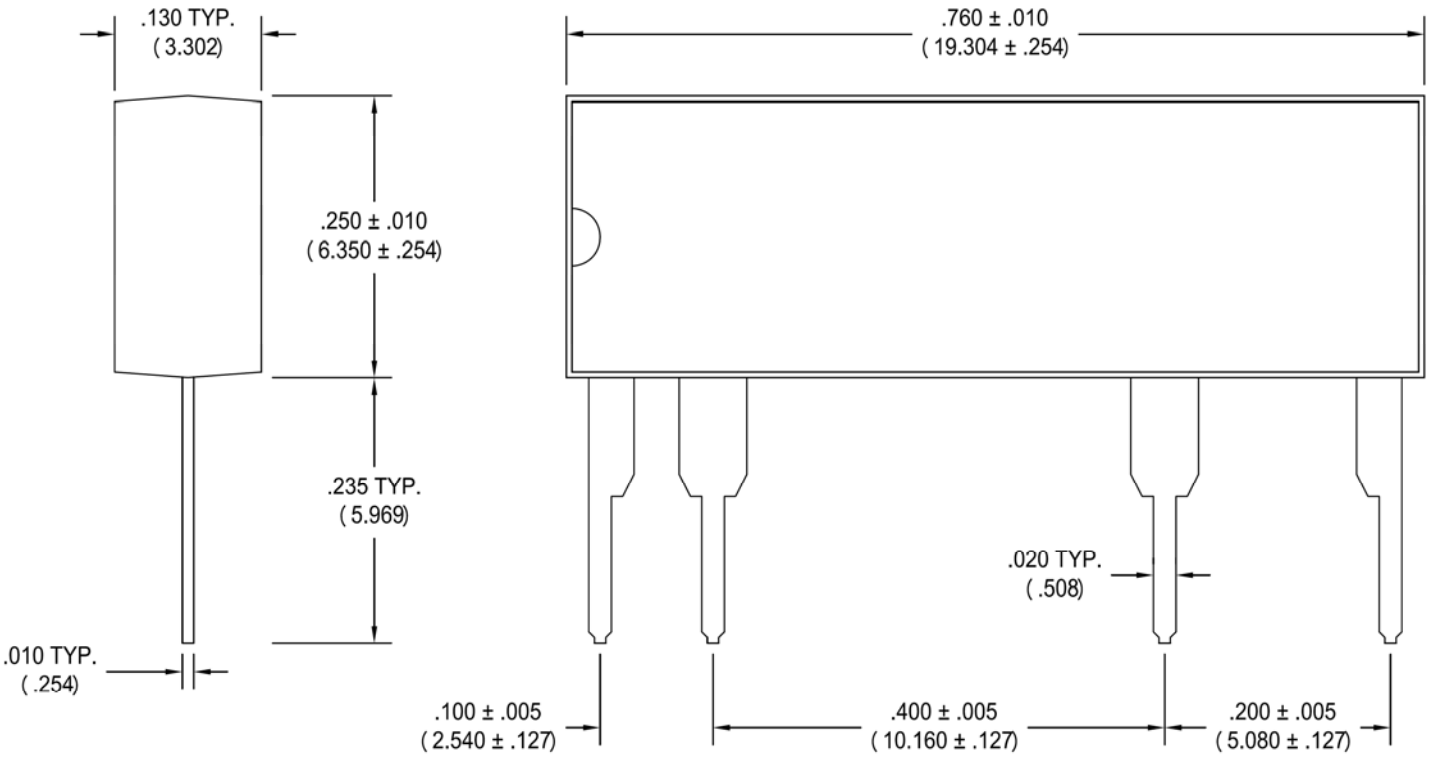
| | |
|---|---|
| Maximum Temperature: | 350ºC (at tip of soldering iron) |
| Maximum Time: | 3s |
| Single Occurrence | |

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## SP946-X Package Dimensions

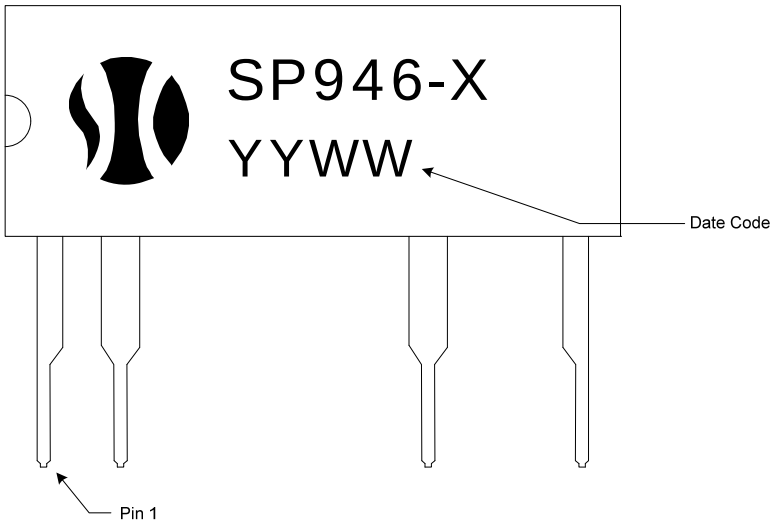
*4 PIN SIP Package*

***Note:*** *All dimensions in inches ["] with millimeters in parenthesis ()*




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### SP946-X Package Marking




### SP946-X Package Weights

| Device | Single Unit | Full Tube (25pcs) | Full Pouch (10 tubes) |
|---|---|---|---|
| SP946-X(H) | 0.88 | 35 | 370 |

***Note:*** *All weights above are in GRAMS, and include packaging materials where applicable*

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