



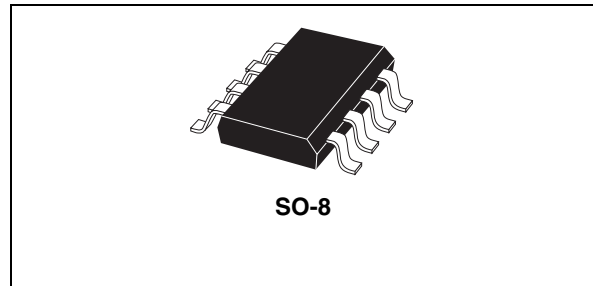
## AC switch failure mode detector

**Features**

- 3.3 V and 5 V power supply compatible
- ACS, ACST, TRIAC compatible
- Gate driver output: 28 mA max sink current
- Adjustable gate drive current
- Sense the AC switch voltage in both AC line polarities
- Diode mode failure detection for solid state AC switches
- Short circuit failure detection for AC switches, relays, electromechanical switches
- Open AC switch detection for AC switches, relays, electromechanical switches
- SO-8 SMD package

**Benefits**

- Enable appliances to meet IEC 60335-1 and IEC 60730-1 standards
- Enable appliances to meet IEC 61000-4-4 standard
- Eliminates high DC current in inductive load, by detecting the diode mode failure
- Improve system safety monitoring open switch failure with critical loads such as door locks
- Enable MCU to sense all AC switch failure modes and protect the appliance
- Less MCU pin allocated to AC failure detection multiple STCC08 designed with resistor dividers uses one I/O
- Easy to drive with MCU directly connected or through an opto coupler
- Highly compact with integrated solution in SMD version

**Applications**

- Home appliances
- ACS, ACST, TRIAC drive
- AC switch failure modes detection
- Zero voltage synchronization

**Description**

The STCC08 is an AC switch failure mode detector and an AC power switch driver. It drives the AC switch and informs the MCU of switch failure. The MCU takes the appropriate actions to put the system in a secure state.

Diode-mode, short circuit detection and open switch in both AC line polarities are detected.

The STCC08 helps home appliances to meet the IEC 60335-1 safety standard.

The STCC08 can be easily interfaced to an MCU with its CMOS input AC switch driver and CMOS compatible output for the failure mode detector.

# 1 Characteristics

Figure 1. Circuit block diagram

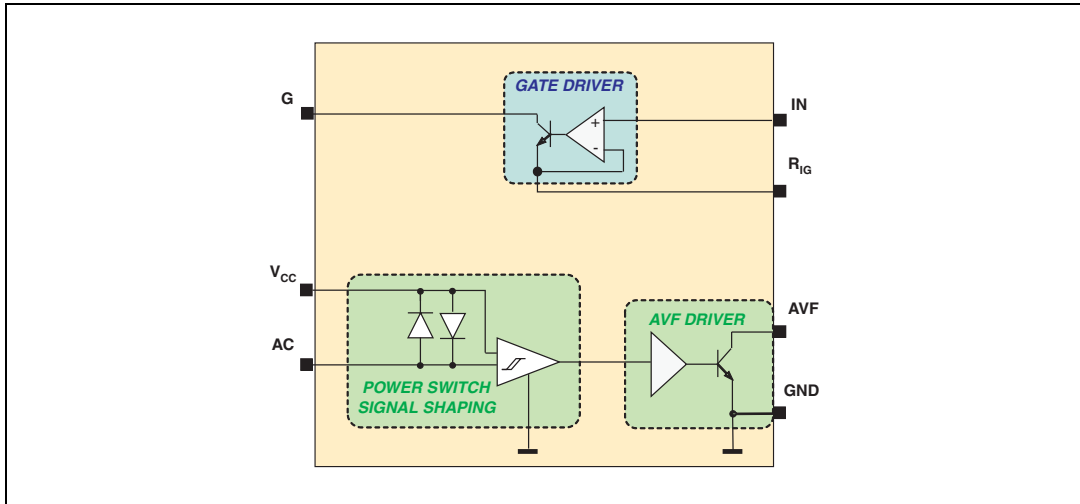
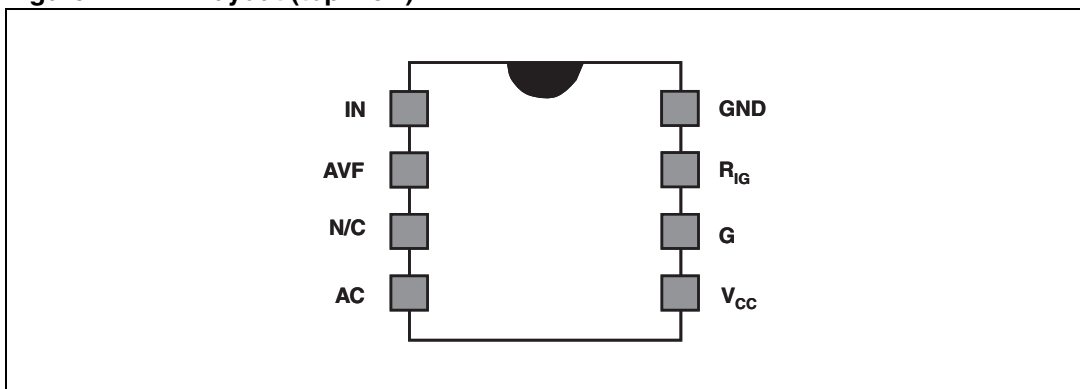


Table 1. Circuit pin descriptions

| Symbol          | Type   | Description   |
|-----------------|--------|---|
| IN              | SIGNAL | Logic AC switch drive                                 |
| AVF             | SIGNAL | Alternating voltage feedback: AC switch status output |
| AC              | SIGNAL | AC switch status sense input                          |
| V <sub>CC</sub> | POWER  | Positive power supply                                 |
| G               | SIGNAL | AC switch gate driver output                          |
| R <sub>IG</sub> | SIGNAL | AC switch gate current setting                        |
| GND             | POWER  | Power supply reference                                |

Figure 2. Pin layout (top view)



**Table 2. Pin allocations**

| Pin # | Name            | Description   |
|-------|-----------------|---|
| 1     | IN              | Logic AC switch drive                                 |
| 2     | AVF             | Alternating voltage feedback: AC switch status output |
| 3     | N/C             | Not connected   |
| 4     | AC              | AC switch status sense input                          |
| 5     | V <sub>CC</sub> | Positive power supply                                 |
| 6     | G               | AC switch gate driver output                          |
| 7     | R <sub>IG</sub> | AC switch gate current setting                        |
| 8     | GND             | Power supply reference                                |

**Table 3. Absolute ratings (T<sub>amb</sub> = 25 °C unless otherwise stated, respect to GND)**

| Symbol           | Pin             | Parameter name and conditions      | Value                         | Unit |
|------------------|-----------------|------------------------------------|-------------------------------|------|
| V <sub>CC</sub>  | V <sub>CC</sub> | Power supply voltage               | 0 to 6                        | V    |
| V <sub>IN</sub>  | IN              | Switch activation voltage          | -0.3V to V <sub>CC</sub> +0.3 | V    |
| I <sub>G</sub>   | G               | Sunk driver current                | 30                            | mA   |
| I <sub>AC</sub>  | AC              | Input sense current peak           | 2.2                           | mA   |
| V <sub>AVF</sub> | AVF             | Alternative feedback voltage       | -0.3 to V <sub>CC</sub> +0.3  | V    |
| I <sub>AVF</sub> | AVF             | Maximum feedback current           | 5                             | mA   |
| T <sub>J</sub>   | All             | Junction temperature range         | -20 to 125                    | °C   |
|                  |                 | Storage junction temperature range | -40 to 150                    | °C   |

**Table 4. Recommended operating conditions**

| Symbol             | Pin             | Parameter name and conditions             | Value       | Unit |
|--------------------|-----------------|---|-------------|------|
| V <sub>CC</sub>    | V <sub>CC</sub> | Power supply voltage respect to GND       | 2.97 to 5.5 | V    |
| I <sub>G</sub>     | G               | Max. sunk driver gate current             | 28          | mA   |
| R <sub>IG</sub>    | RIG             | Gate current setting resistor             | 30          | Ω    |
| R <sub>AC</sub>    | AC              | Detector resistance for AC line = 120 V   | 100         | kΩ   |
|                    |                 | Detector resistance for AC line = 230 V   | 300         | kΩ   |
| R <sub>SHUNT</sub> | -               | HV biasing resistance for AC line = 120 V | 100         | kΩ   |
|                    |                 | HV biasing resistance for AC line = 230 V | 300         | kΩ   |
| T <sub>AMB</sub>   | All             | Operating ambient temperature range       | -20 to 85   | °C   |
| T <sub>J</sub>     | All             | Operating junction temperature range      | -20 to 125  | °C   |

**Table 5. Electrical characteristics**

| Symbol   | Pin             | Name                               | Conditions  | Min                       | Typ | Max                       | Unit          |
|--|-----------------|------------------------------------|---|---------------------------|-----|---------------------------|---------------|
| Switch drive (respect to GND, $T_j=25\text{ }^\circ\text{C}$ unless otherwise specified, $R_{IG}=30\ \Omega$ ) |                 |                                    |   |                           |     |                           |               |
| $I_{\text{QUIESCENT}}$   | $V_{\text{CC}}$ | Quiescent current                  | $I_N = \text{GND}$  |                           |     | 2                         | mA            |
| $V_{\text{ON}}$  | IN              | On-state switch activation voltage |   | $0.7 \cdot V_{\text{CC}}$ |     |                           | V             |
| $V_{\text{OFF}}$   | IN              | Off-state switch release voltage   |   |                           |     | $0.3 \cdot V_{\text{CC}}$ | V             |
| $I_{\text{IN}}$  | IN              | Input drive current                | $V_{\text{in}} > V_{\text{on}}$                                 |                           |     | 50                        | $\mu\text{A}$ |
| $I_{\text{G}}$   | G               | Gate drive current                 | $V_{\text{in}} > V_{\text{on}}$                                 | 20                        |     | 28                        | mA            |
| $I_{\text{AC}}$  | AC              | Detection threshold                |   | 82                        |     | 236                       | $\mu\text{A}$ |
| Status output (respect to GND, $T_j=25\text{ }^\circ\text{C}$ unless otherwise specified)                      |                 |                                    |   |                           |     |                           |               |
| $V_{\text{OH}}$  | AVF             | Minimum output voltage             | $I_{\text{AVF}} = 50\ \mu\text{A}$                              | $0.7 \cdot V_{\text{CC}}$ |     |                           | V             |
| $V_{\text{OL}}$  | AVF             | Maximum drop voltage               | $I_{\text{AVF}} = 50\ \mu\text{A}$<br>(CMOS Compatible)         |                           |     | $0.3 \cdot V_{\text{CC}}$ | V             |
|  |                 |                                    | $I_{\text{AVF}} = 5\ \text{mA}$<br>(Opto-transistor compatible) |                           |     | 1                         | V             |

**Table 6. Thermal resistance**

| Symbol                | Parameter name and conditions              | Value | Unit               |
|-----------------------|--|-------|--------------------|
| $R_{\text{TH (j-a)}}$ | SMD Thermal resistance Junction to Ambient | 140   | $^\circ\text{C/W}$ |

**Table 7. System related electromagnetic compatibility ratings**

| Symbol           | Node    | Pin             | Parameter name and conditions   | Value   | Unit |
|------------------|---------|-----------------|---|---------|------|
| $V_{\text{ESD}}$ | Neutral | $V_{\text{CC}}$ | ESD protection, IEC 61000-4-2, per input, against air discharge   | $\pm 8$ | kV   |
|                  |         | G               | Gate through ACS; ESD protection, IEC 61000-4-2, pin to ground, against air discharge   |         |      |
|                  | Line    | AC              | Alternating current through $R_{\text{AC}} = 300\ \text{k}\Omega$ ; ESD protection, IEC 61000-4-2, pin to ground, against air discharge |         |      |
| $V_{\text{ESD}}$ | Neutral | $V_{\text{CC}}$ | ESD protection, IEC 61000-4-2, pin to ground, for contact discharge <sup>(1)</sup>  | $\pm 6$ | kV   |
| $V_{\text{PPB}}$ | Neutral | $V_{\text{CC}}$ | Total Peak Pulse Voltage Burst, IEC 61000-4-4 <sup>(1)</sup>  | $\pm 4$ | kV   |
|                  |         | G               | Gate through ACS; Total Peak Pulse Voltage Burst, IEC 61000-4-4 <sup>(1)</sup>  |         |      |
|                  | Line    | AC              | Alternating current through $R_{\text{AC}}$ ; Total Peak Pulse Voltage Burst, IEC 61000-4-4 <sup>(1)</sup>                              |         |      |

1. System oriented test circuits - see Application note AN2716

## 2 Functional description

### STCC08 functional description

The STCC08 is a power circuit designed to drive up to 10 mA  $I_{GT}$  AC switches and to detect AC switch failure modes through MCU diagnostic.

It embeds a logic switch driver, an AC switch diode mode detection, a short circuit detection and an AC switch open detection.

STCC08 can be powered by a 3.3 V or 5 V power supply voltage.

### Switch driver

This driver is a logic level buffer (CMOS compatible) interfacing directly with the AC switch and the microcontroller.

The AC switch must be driven in negative polarity: AC switch COM =  $A_1 = V_{CC}$

The drive Boolean rule is:

$V_{in} > V_{on}$ : switch = ON

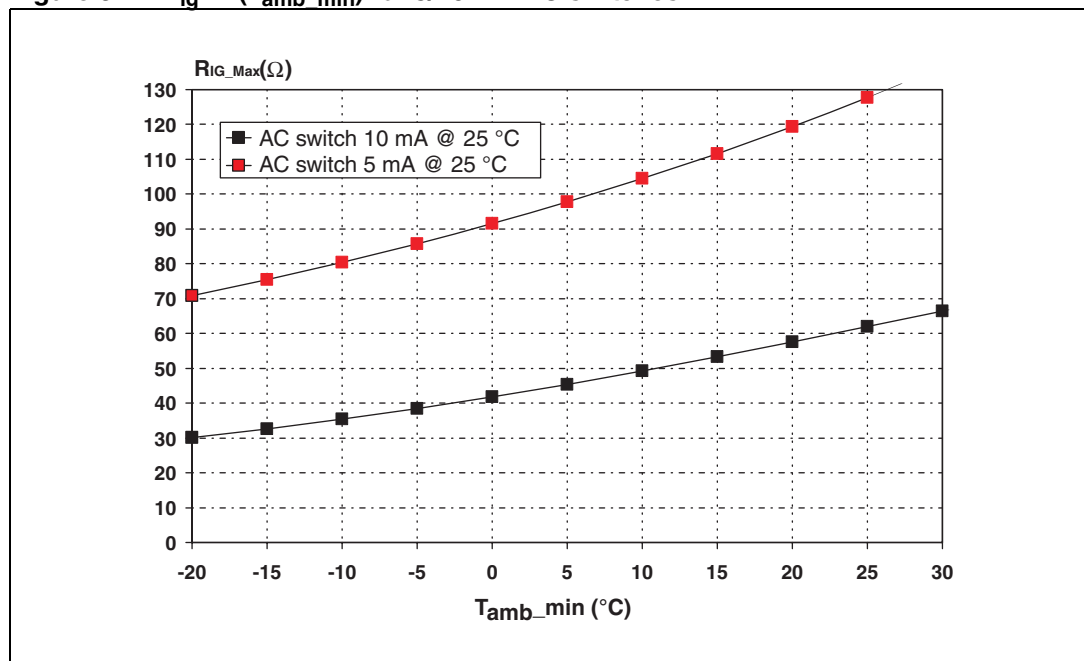
$V_{in} < V_{on}$ : switch = OFF

The AC switch can be driven in continuous, pulsed or angle phase modes.

In insulated applications, the input can be driven through an opto-coupler powered with a non-insulated auxiliary power supply.

$R_{IG}$  pin allows the AC switch gate current to be set. A resistor must be connected between this pin and the ground GND. This resistor is defined according to the minimum ambient temperature and the AC switch  $I_{GT}$  (see [Figure 3](#)). This optimizes the consumption of the application.

**Figure 3.  $R_{ig} = f(T_{amb\_min})$  for 5/10 mA AC switches**



**Failure mode detection**

This function detects AC switch failure modes required by the IEC 60335 standard:

- The AC switch diode mode failure in both negative and positive AC line polarities  
This failure is simulated with a diode placed in parallel with the power switch according to the IEC 60335-1 standard.
- The AC switch short-circuit failure mode, any external shorting and any spurious power switch turn-on
- The open AC switch failure mode

This function improves the system safety. A diode mode failure, a short circuit or an AC switch open can lead to dangerous situations for the system or the user.

The AVF block monitors the state of the AC switch in both AC polarities. Its output AVF is transmitted to the MCU for failure detection.

The MCU detects the failure according to the following truth table:

**Table 8. STCC08 status truth table with R<sub>SHUNT</sub> in parallel with the load**

| IN (MCU generated) | AVF                        | MCU DIAGNOSTIC  |
|--------------------|----------------------------|-----------------|
| 0                  | Open collector             | AC switch OK    |
| 0                  | Open collector to 0 toggle | Diode mode      |
| 0                  | 0                          | Short AC switch |
| 1                  | 0                          | AC switch OK    |
| 1                  | Open collector             | Open AC switch  |

For a diode mode, the AVF output toggles from open collector to GND each the half of the AC mains. Therefore, the AVF output is a pulsed signal during a diode mode failure.

The MCU can put the system in a safe configuration, switching off the front end relay already existing in home appliance designs.

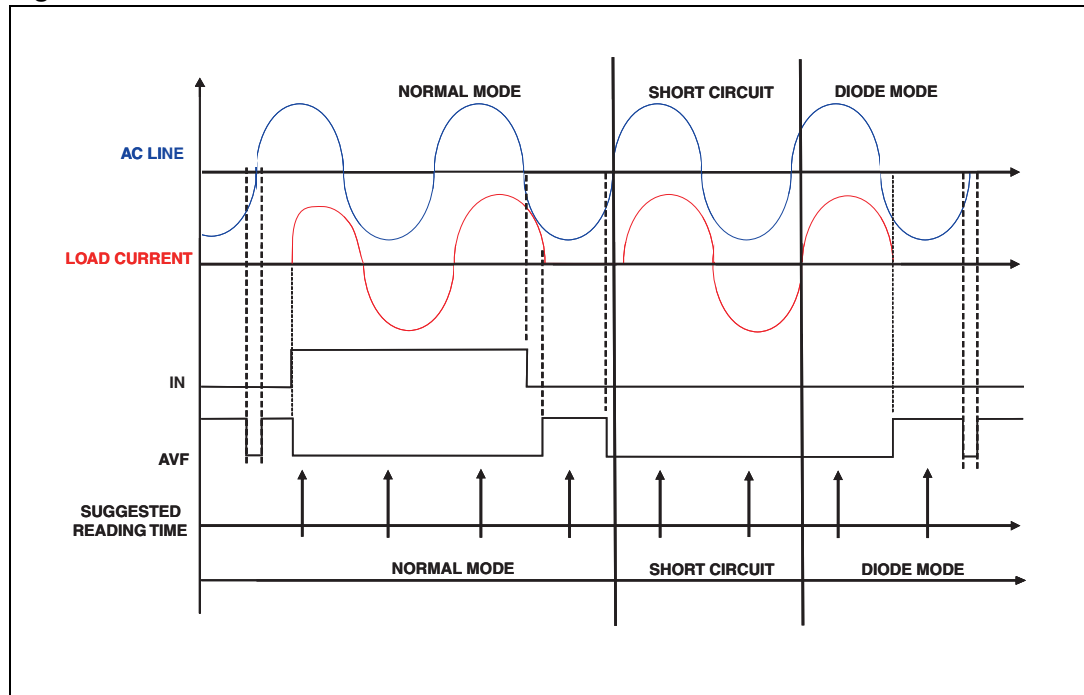
**Status reading**

The AVF output is an open collector, active at low level. It can either be connected to a MCU input, in pull up input configuration, or through an opto-coupler in insulated designs.

For inductive loads, there is a phase shift between load current and AC line voltage. When the ACS control is removed:

- The AC switch - latch structure - still conducts and the AVF is at low level until the next zero current crossing.
- The AVF is at low level until next zero current crossing.
- In the worst case, the load current crosses zero close to peak mains voltage. Then the AVF signal should be read at peak mains voltage.

Figure 4. Failure mode detection for inductive loads in DC control mode



The microcontroller can store the AC switch drive signal in a RAM register when it is driving the STCC08 input. Therefore it can save gate energy while determining conduction state from this RAM register and multiplexing this information with AVF signal.

AC LINE: High voltage between AC line and neutral

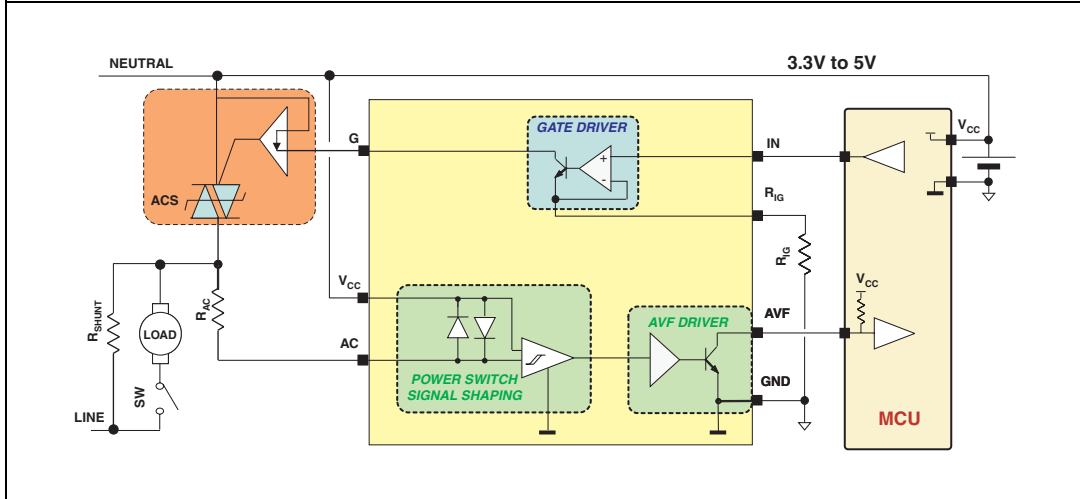
LOAD CURRENT: Current through the AC load

IN: MCU output driving the STCC08 IN input.

AVF: Alternating voltage feedback, output of the STCC08

### 3 Application information

Figure 5. Application example with an MCU direct drive + ACS



The placement of a 100 nF capacitor between V<sub>CC</sub> and GND close to the STCC08 is advised. SW is an electromechanical switch that is part of the application design, for example, the water sensor in a washing machine.

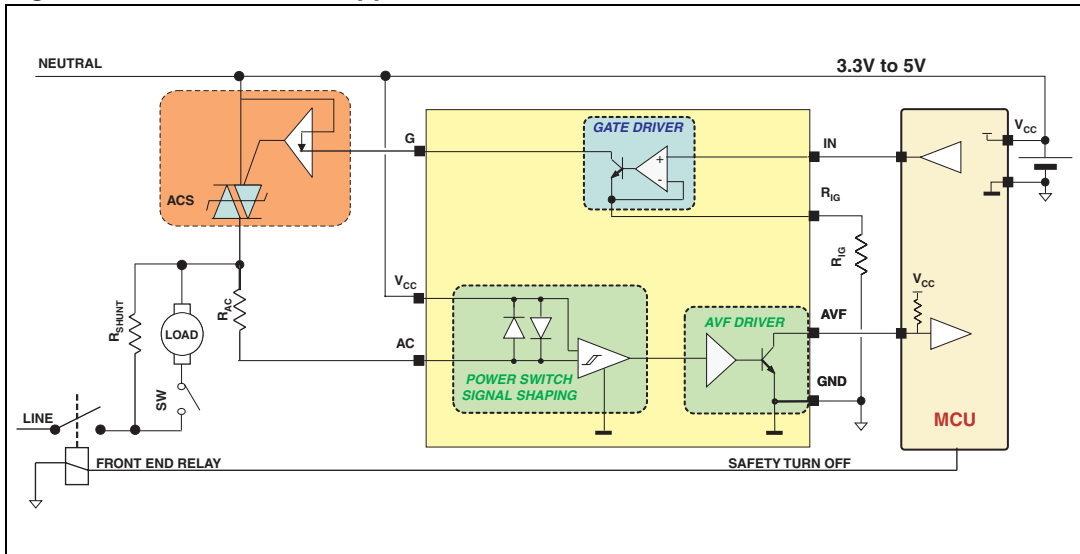
#### 3.1 Recommendations

The STCC08 is designed for 5 and 10 mA ACSs, ACSTs and TRIACs.

##### STCC08 basic application

The microcontroller reads the AC switch state from the AVF output of the STCC08. The microcontroller can power-off the application driving a front-end relay.

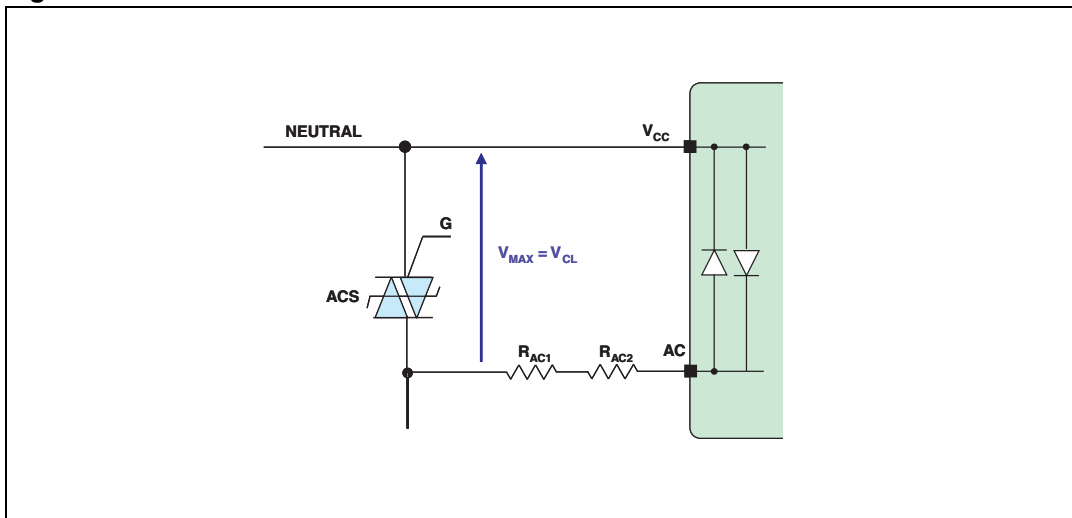
Figure 6. Non-insulated application





This function is effective whatever the drive and the nature of the load.

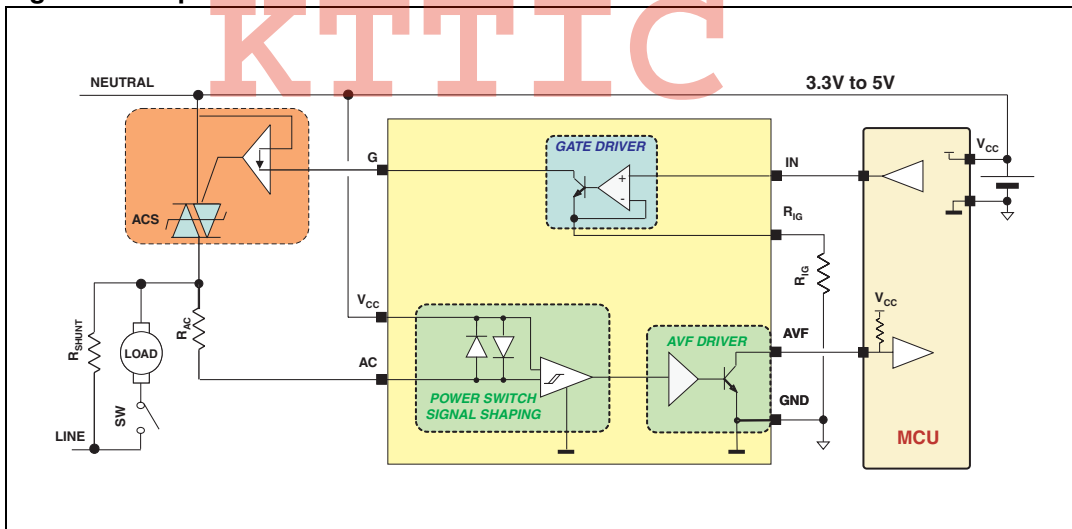
**Figure 7. ACS benefits**



The ACS clamping capability, from 800 V to 1100 V reduces the stress across  $R_{AC}$  resistors during an AC line over-voltage. This provides a robust solution and allows setting high voltage resistors  $R_{AC}$  to withstand the ACS clamping voltage instead of the AC line maximum over-voltage.

**STCC08 AVF alarms configuration**

**Figure 8. Open load and Short circuit ACS discrimination**



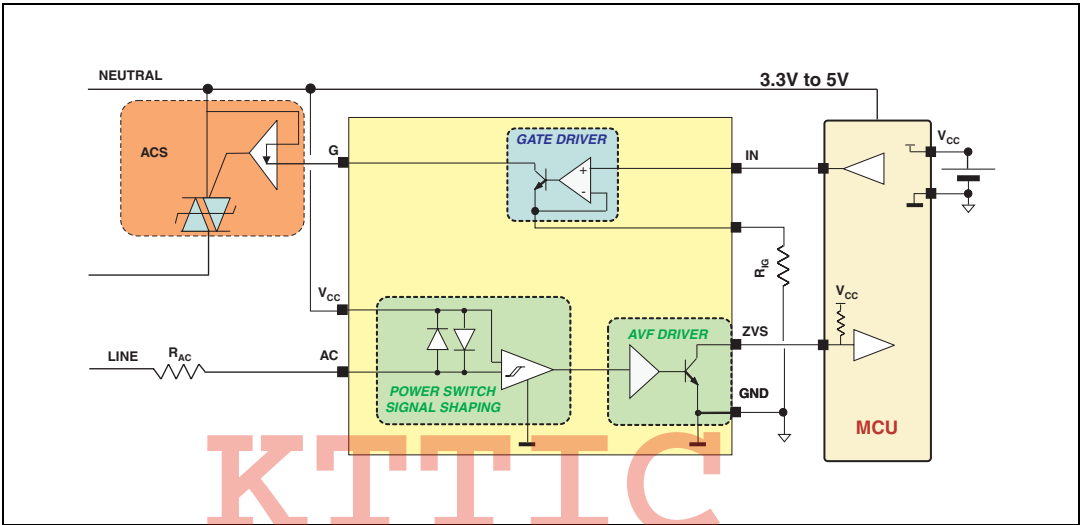
When  $R_{SHUNT}$  is removed, the MCU cannot discriminate between an ACS short circuit and open load failure. See [Table 9](#).

Table 9. STCC08 status truth table with R<sub>SHUNT</sub> removed

| IN (MCU generated) | AVF                        | MCU DIAGNOSTIC             |
|--------------------|----------------------------|----------------------------|
| 0                  | Open collector             | AC switch OK               |
| 0                  | Open collector to 0 toggle | Diode mode                 |
| 0                  | 0                          | Short circuit or open lead |
| 1                  | 0                          | AC switch OK               |
| 1                  | Open collector             | Open AC switch             |

STCC08 ZVS application

Figure 9. ZVS application schematic



The gate driver drives an ACS while the failure detector is used independently for ZVS detection

## 4 Package information

- Epoxy meets UL94, V0

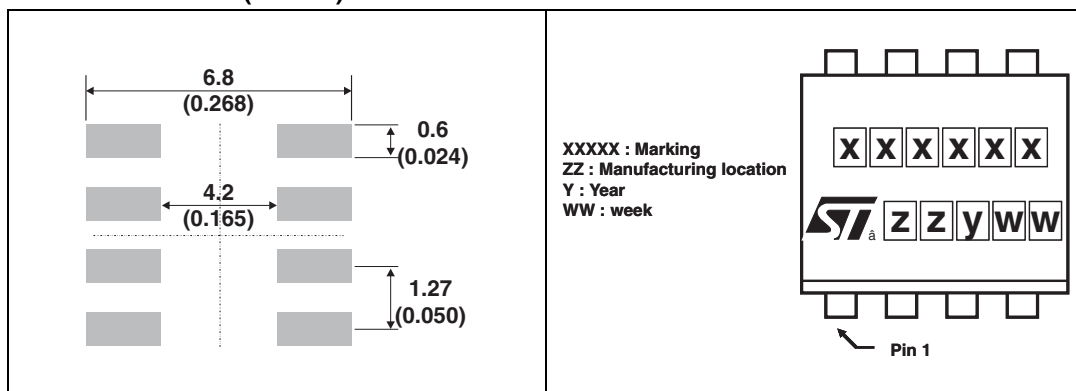
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Table 10. SO-8 dimensions

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.069 |
| A1   | 0.1         |      | 0.25 | 0.004  |       | 0.010 |
| A2   | 1.25        |      |      | 0.049  |       |       |
| b    | 0.28        |      | 0.48 | 0.011  |       | 0.019 |
| C    | 0.17        |      | 0.23 | 0.007  |       | 0.009 |
| D    | 4.80        | 4.90 | 5.00 | 0.189  | 0.193 | 0.197 |
| E    | 5.80        | 6.00 | 6.20 | 0.228  | 0.236 | 0.244 |
| E1   | 3.80        | 3.90 | 4.00 | 0.150  | 0.154 | 0.157 |
| e    |             | 1.27 |      |        | 0.050 |       |
| h    | 0.25        |      | 0.50 | 0.010  |       | 0.020 |
| L    | 0.40        |      | 1.27 | 0.016  |       | 0.050 |
| L1   |             | 1.04 |      |        | 0.041 |       |
| k    | 0°          |      | 8°   | 0°     |       | 8°    |
| ppp  |             |      | 0.10 |        |       | 0.004 |

Figure 10. Footprint dimensions in mm(inches)

Figure 11. Marking



## 5 Ordering information

Table 11. Ordering information

| Order code | Marking | Weight | Base Qty | Delivery Mode     |
|------------|---------|--------|----------|-------------------|
| STCC08     | STCC08  | 0.08 g | 100      | Tube              |
| STCC08RL   | STCC08  | 0.08 g | 2500     | Tape and reel 13" |

## 6 Revision history

Table 12. Document revision history

| Date        | Revision | Changes          |
|-------------|----------|------------------|
| 20-Mar-2008 | 1        | Initial release. |

# KTTIC

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