

## Phase Control Thyristors (Stud Version), 230 A



TO-93 (TO-209AB)

### FEATURES

- Center amplifying gate
- International standard case TO-93 (TO-209AB)
- Hermetic metal case with ceramic insulator
- Compression bonded encapsulation for heavy duty operations such as severe thermal cycling
- Designed and qualified for industrial level
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS**  
COMPLIANT

### PRIMARY CHARACTERISTICS

|                       |                   |
|-----------------------|-------------------|
| $I_{T(AV)}$           | 230 A             |
| $V_{DRM}/V_{RRM}$     | 1400 V, 1600 V    |
| $V_{TM}$              | 1.55 V            |
| $I_{GT}$              | 150 mA            |
| $T_J$                 | -40 °C to +125 °C |
| Package               | TO-93 (TO-209AB)  |
| Circuit configuration | Single SCR        |

### TYPICAL APPLICATIONS

- DC motor controls
- Controlled DC power supplies
- AC controllers

### MAJOR RATINGS AND CHARACTERISTICS

| PARAMETER         | TEST CONDITIONS | VALUES       | UNITS             |
|-------------------|-----------------|--------------|-------------------|
| $I_{T(AV)}$       |                 | 230          | A                 |
|                   | $T_C$           | 85           | °C                |
| $I_{T(RMS)}$      |                 | 360          | A                 |
| $I_{TSM}$         | 50 Hz           | 5700         | A                 |
|                   | 60 Hz           | 5970         |                   |
| $I^2t$            | 50 Hz           | 163          | kA <sup>2</sup> s |
|                   | 60 Hz           | 149          |                   |
| $V_{DRM}/V_{RRM}$ |                 | 1400 to 1600 | V                 |
| $t_q$             | Typical         | 100          | μs                |
| $T_J$             |                 | -40 to +125  | °C                |

### ELECTRICAL SPECIFICATIONS

#### VOLTAGE RATINGS

| TYPE NUMBER | VOLTAGE CODE | $V_{DRM}/V_{RRM}$ , MAXIMUM REPETITIVE PEAK AND OFF-STATE VOLTAGE<br>V | $V_{RSM}$ , MAXIMUM NON-REPETITIVE PEAK VOLTAGE<br>V | $I_{DRM}/I_{RRM}$ MAXIMUM AT $T_J = T_J$ MAXIMUM<br>mA |
|-------------|--------------|------------------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------|
| VS-ST230S   | 14           | 1400                                                                   | 1500                                                 | 30                                                     |
|             | 16           | 1600                                                                   | 1700                                                 |                                                        |



| ABSOLUTE MAXIMUM RATINGS                             |                     |                                                                                                           |                        |                                                                       |            |                    |
|------------------------------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------|------------------------|-----------------------------------------------------------------------|------------|--------------------|
| PARAMETER                                            | SYMBOL              | TEST CONDITIONS                                                                                           |                        |                                                                       | VALUES     | UNITS              |
| Maximum average on-state current at case temperature | I <sub>T(AV)</sub>  | 180° conduction, half sine wave                                                                           |                        |                                                                       | 230        | A                  |
|                                                      |                     |                                                                                                           |                        |                                                                       | 85         | °C                 |
| Maximum RMS on-state current                         | I <sub>T(RMS)</sub> | DC at 78 °C case temperature                                                                              |                        |                                                                       | 360        |                    |
| Maximum peak, one-cycle non-repetitive surge current | I <sub>TSM</sub>    | t = 10 ms                                                                                                 | No voltage reapplied   | Sinusoidal half wave, initial T <sub>J</sub> = T <sub>J</sub> maximum | 5700       | A                  |
|                                                      |                     | t = 8.3 ms                                                                                                |                        |                                                                       | 5970       |                    |
|                                                      |                     | t = 10 ms                                                                                                 | 100 % V <sub>RRM</sub> |                                                                       | 4800       |                    |
|                                                      |                     | t = 8.3 ms                                                                                                | reapplied              |                                                                       | 5000       |                    |
| Maximum I <sup>2</sup> t for fusing                  | I <sup>2</sup> t    | t = 10 ms                                                                                                 | No voltage reapplied   |                                                                       | 163        | kA <sup>2</sup> s  |
|                                                      |                     | t = 8.3 ms                                                                                                |                        |                                                                       | 148        |                    |
|                                                      |                     | t = 10 ms                                                                                                 | 100 % V <sub>RRM</sub> |                                                                       | 115        |                    |
|                                                      |                     | t = 8.3 ms                                                                                                | reapplied              |                                                                       | 105        |                    |
| Maximum I <sup>2</sup> √t for fusing                 | I <sup>2</sup> √t   | t = 0.1 to 10 ms, no voltage reapplied                                                                    |                        |                                                                       | 1630       | kA <sup>2</sup> √s |
| Low level value of threshold voltage                 | V <sub>T(TO)1</sub> | (16.7 % × π × I <sub>T(AV)</sub> ) < I < π × I <sub>T(AV)</sub> , T <sub>J</sub> = T <sub>J</sub> maximum |                        |                                                                       | 0.92       | V                  |
| High level value of threshold voltage                | V <sub>T(TO)2</sub> | (I > π × I <sub>T(AV)</sub> ), T <sub>J</sub> = T <sub>J</sub> maximum                                    |                        |                                                                       | 0.98       |                    |
| Low level value of on-state slope resistance         | r <sub>t1</sub>     | (16.7 % × π × I <sub>T(AV)</sub> ) < I < π × I <sub>T(AV)</sub> , T <sub>J</sub> = T <sub>J</sub> maximum |                        |                                                                       | 0.88       | mΩ                 |
| High level value of on-state slope resistance        | r <sub>t2</sub>     | (I > π × I <sub>T(AV)</sub> ), T <sub>J</sub> = T <sub>J</sub> maximum                                    |                        |                                                                       | 0.81       |                    |
| Maximum on-state voltage                             | V <sub>TM</sub>     | I <sub>pk</sub> = 720 A, T <sub>J</sub> = T <sub>J</sub> maximum, t <sub>p</sub> = 10 ms sine pulse       |                        |                                                                       | 1.55       | V                  |
| Maximum holding current                              | I <sub>H</sub>      | T <sub>J</sub> = 25 °C, anode supply 12 V resistive load                                                  |                        |                                                                       | 600        | mA                 |
| Maximum (typical) latching current                   | I <sub>L</sub>      |                                                                                                           |                        |                                                                       | 1000 (300) |                    |

| SWITCHING                                                |         |                                                                                                                                |        |       |
|----------------------------------------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------|--------|-------|
| PARAMETER                                                | SYMBOL  | TEST CONDITIONS                                                                                                                | VALUES | UNITS |
| Maximum non-repetitive rate of rise of turned-on current | $di/dt$ | Gate drive 20 V, 20 Ω, $t_r \leq 1$ μs<br>$T_J = T_J$ maximum, anode voltage $\leq 80$ % $V_{DRM}$                             | 1000   | A/μs  |
| Typical delay time                                       | $t_d$   | Gate current 1 A, $di_g/dt = 1$ A/μs<br>$V_d = 0.67$ % $V_{DRM}$ , $T_J = 25$ °C                                               | 1.0    | μs    |
| Typical turn-off time                                    | $t_q$   | $I_{TM} = 300$ A, $T_J = T_J$ maximum, $di_F/dt = 20$ A/μs,<br>$V_R = 50$ V, $dV/dt = 20$ V/μs, gate 0 V 100 Ω, $t_p = 500$ μs | 100    |       |

| BLOCKING                                           |                          |                                                      |        |       |
|----------------------------------------------------|--------------------------|------------------------------------------------------|--------|-------|
| PARAMETER                                          | SYMBOL                   | TEST CONDITIONS                                      | VALUES | UNITS |
| Maximum critical rate of rise of off-state voltage | $dV/dt$                  | $T_J = T_J$ maximum linear to 80 % rated $V_{DRM}$   | 500    | V/μs  |
| Maximum peak reverse and off-state leakage current | $I_{RRM}$ ,<br>$I_{DRM}$ | $T_J = T_J$ maximum, rated $V_{DRM}/V_{RRM}$ applied | 30     | mA    |



| TRIGGERING                          |                    |                                                                |                                                                                                                                                       |        |      |       |
|-------------------------------------|--------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|-------|
| PARAMETER                           | SYMBOL             | TEST CONDITIONS                                                |                                                                                                                                                       | VALUES |      | UNITS |
|                                     |                    |                                                                |                                                                                                                                                       | TYP.   | MAX. |       |
| Maximum peak gate power             | P <sub>GM</sub>    | T <sub>J</sub> = T <sub>J</sub> maximum, t <sub>p</sub> ≤ 5 ms |                                                                                                                                                       | 10.0   |      | W     |
| Maximum average gate power          | P <sub>G(AV)</sub> | T <sub>J</sub> = T <sub>J</sub> maximum, f = 50 Hz, d% = 50    |                                                                                                                                                       | 2.0    |      |       |
| Maximum peak positive gate current  | I <sub>GM</sub>    | T <sub>J</sub> = T <sub>J</sub> maximum, t <sub>p</sub> ≤ 5 ms |                                                                                                                                                       | 3.0    |      | A     |
| Maximum peak positive gate voltage  | + V <sub>GM</sub>  | T <sub>J</sub> = T <sub>J</sub> maximum, t <sub>p</sub> ≤ 5 ms |                                                                                                                                                       | 20     |      | V     |
| Maximum peak negative gate voltage  | - V <sub>GM</sub>  |                                                                |                                                                                                                                                       | 5.0    |      |       |
| DC gate current required to trigger | I <sub>GT</sub>    | T <sub>J</sub> = - 40 °C                                       | Maximum required gate trigger/ current/voltage are the lowest value which will trigger all units 12 V anode to cathode applied                        | 180    | -    | mA    |
|                                     |                    | T <sub>J</sub> = 25 °C                                         |                                                                                                                                                       | 90     | 150  |       |
|                                     |                    | T <sub>J</sub> = 125 °C                                        |                                                                                                                                                       | 40     | -    |       |
| DC gate voltage required to trigger | V <sub>GT</sub>    | T <sub>J</sub> = - 40 °C                                       |                                                                                                                                                       | 2.9    | -    | V     |
|                                     |                    | T <sub>J</sub> = 25 °C                                         |                                                                                                                                                       | 1.8    | 3.0  |       |
|                                     |                    | T <sub>J</sub> = 125 °C                                        |                                                                                                                                                       | 1.2    | -    |       |
| DC gate current not to trigger      | I <sub>GD</sub>    | T <sub>J</sub> = T <sub>J</sub> maximum                        | Maximum gate current/voltage not to trigger is the maximum value which will not trigger any unit with rated V <sub>DRM</sub> anode to cathode applied | 10     |      | mA    |
| DC gate voltage not to trigger      | V <sub>GD</sub>    |                                                                |                                                                                                                                                       | 0.25   |      | V     |

| THERMAL AND MECHANICAL SPECIFICATIONS        |              |                                               |                  |                     |
|----------------------------------------------|--------------|-----------------------------------------------|------------------|---------------------|
| PARAMETER                                    | SYMBOL       | TEST CONDITIONS                               | VALUES           | UNITS               |
| Maximum operating junction temperature range | $T_J$        |                                               | -40 to 125       | $^\circ\text{C}$    |
| Maximum storage temperature range            | $T_{Stg}$    |                                               | -40 to 150       |                     |
| Maximum thermal resistance, junction to case | $R_{thJC}$   | DC operation                                  | 0.10             | K/W                 |
| Maximum thermal resistance, case to heatsink | $R_{thC-hs}$ | Mounting surface, smooth, flat and greased    | 0.04             |                     |
| Mounting torque, $\pm 10\%$                  |              | Non-lubricated threads                        | 31<br>(275)      | N · m<br>(lbf · in) |
|                                              |              | Lubricated threads                            | 24.5<br>(210)    |                     |
| Approximate weight                           |              |                                               | 280              | g                   |
| Case style                                   |              | See dimensions - link at the end of datasheet | TO-93 (TO-209AB) |                     |

| $\Delta R_{thJC}$ CONDUCTION |                       |                        |                             |       |
|------------------------------|-----------------------|------------------------|-----------------------------|-------|
| CONDUCTION ANGLE             | SINUSOIDAL CONDUCTION | RECTANGULAR CONDUCTION | TEST CONDITIONS             | UNITS |
| 180°                         | 0.016                 | 0.012                  | $T_J = T_J \text{ maximum}$ | K/W   |
| 120°                         | 0.019                 | 0.020                  |                             |       |
| 90°                          | 0.025                 | 0.027                  |                             |       |
| 60°                          | 0.036                 | 0.037                  |                             |       |
| 30°                          | 0.060                 | 0.060                  |                             |       |

**Note**

- The table above shows the increment of thermal resistance  $R_{thJC}$  when devices operate at different conduction angles than DC

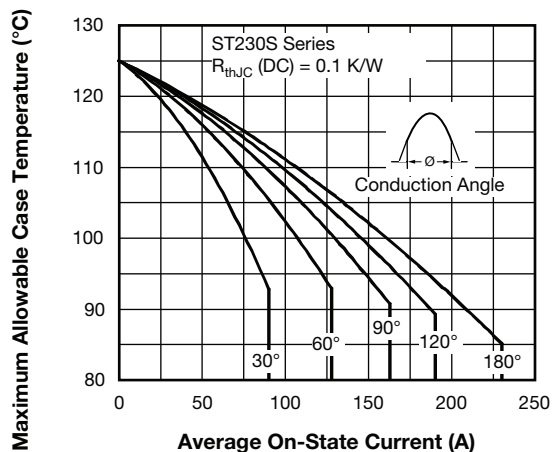


Fig. 1 - Current Ratings Characteristics

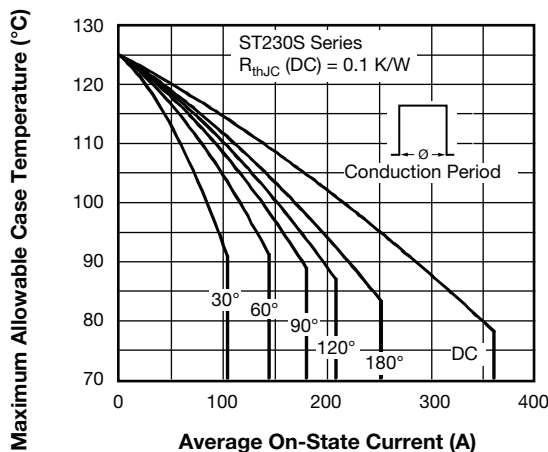


Fig. 2 - Current Ratings Characteristics

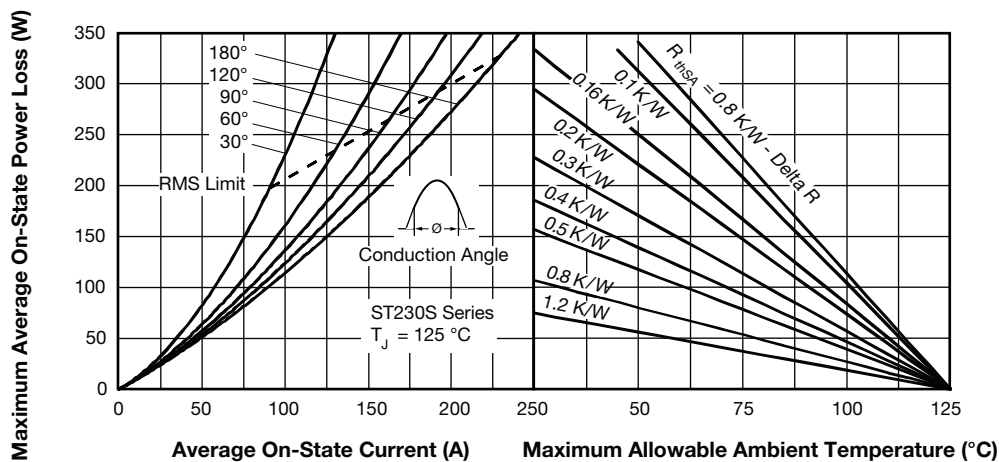


Fig. 3 - On-State Power Loss Characteristics

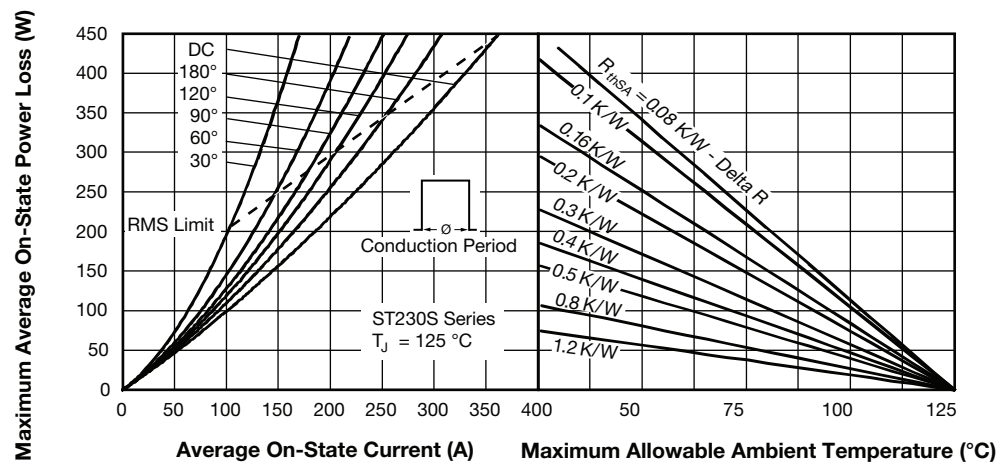


Fig. 4 - On-State Power Loss Characteristics

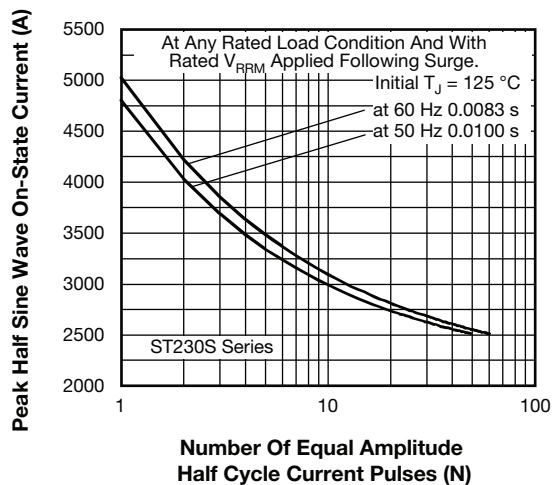


Fig. 5 - Maximum Non-Repetitive Surge Current

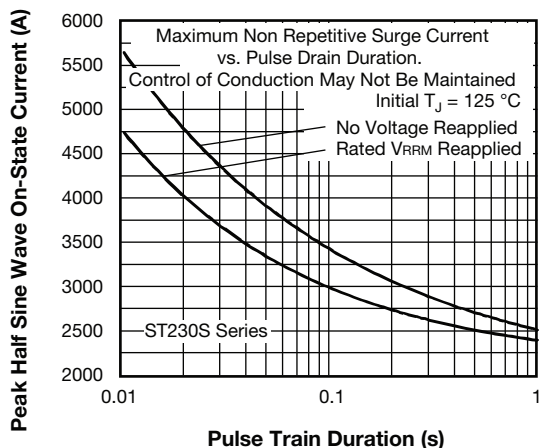


Fig. 6 - Maximum Non-Repetitive Surge Current

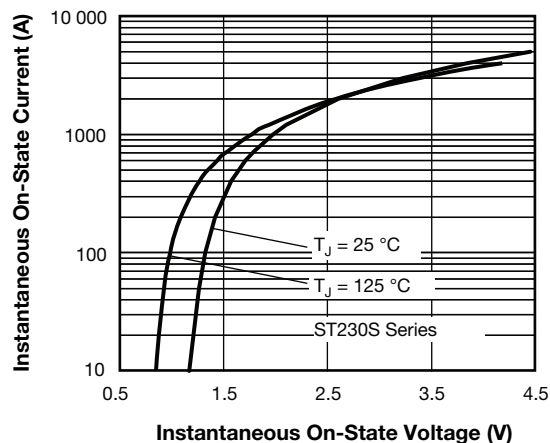


Fig. 7 - On-State Voltage Drop Characteristics

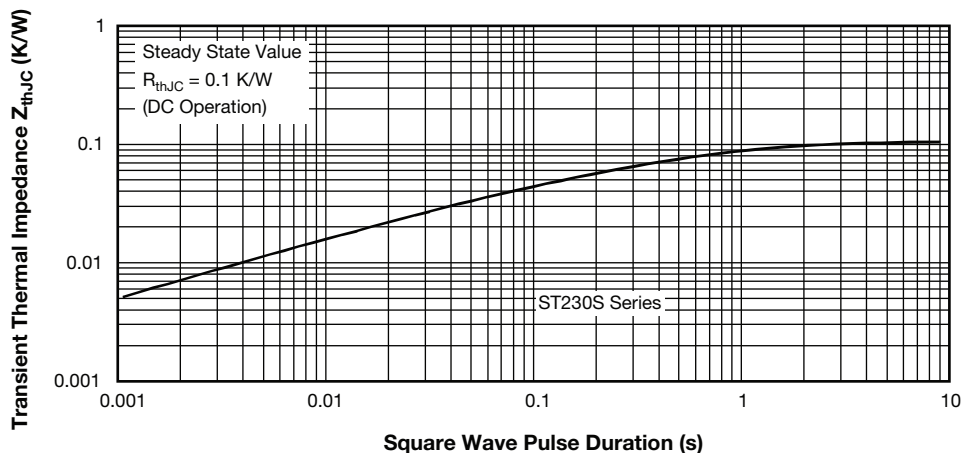


Fig. 8 - Thermal Impedance  $Z_{thJC}$  Characteristics

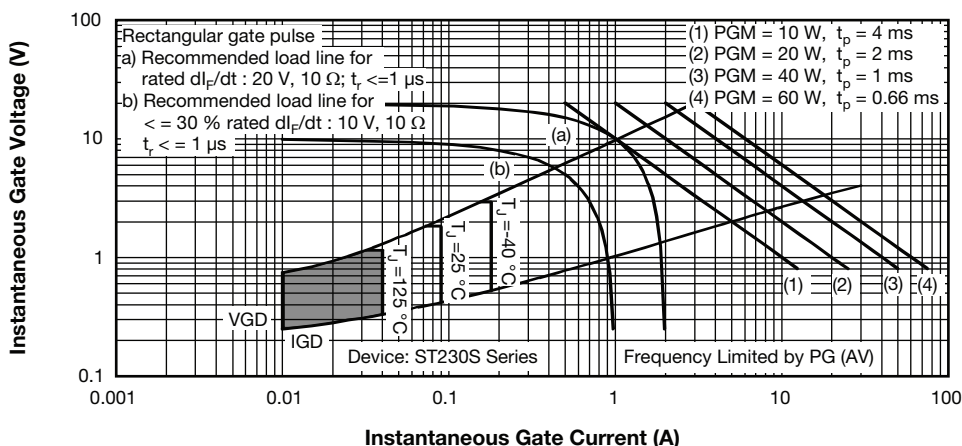


Fig. 9 - Gate Characteristics

## ORDERING INFORMATION TABLE

| Device code | VS- | ST | 23 | 0 | S | 16 | P | 0 | PbF |
|-------------|-----|----|----|---|---|----|---|---|-----|
|             | 1   | 2  | 3  | 4 | 5 | 6  | 7 | 8 | 9   |

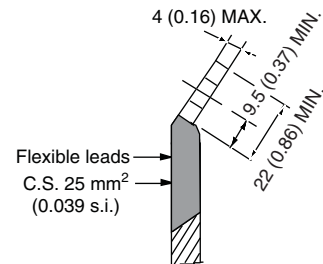
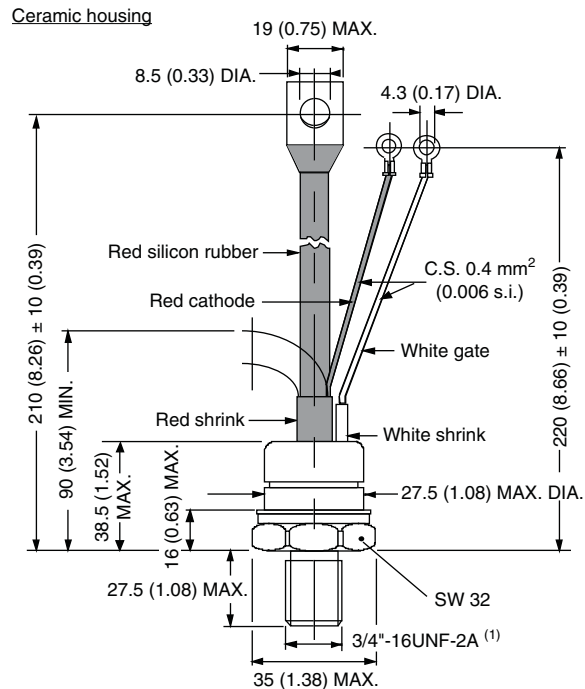
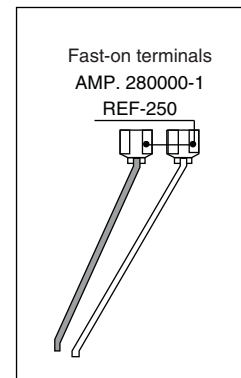
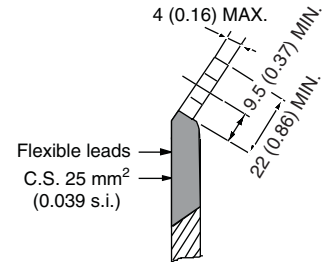
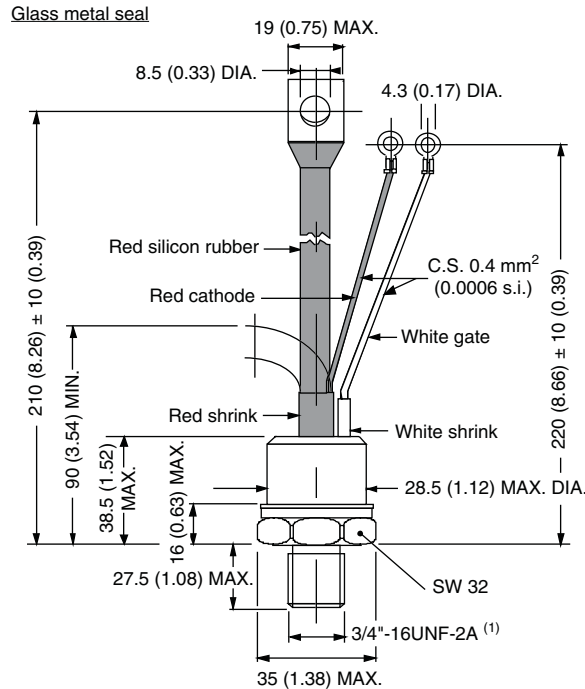
- 1** - Vishay Semiconductors product
- 2** - Thyristor
- 3** - Essential part number
- 4** - 0 = converter grade
- 5** - S = compression bonding stud
- 6** - Voltage code x 100 =  $V_{RRM}$  (see Voltage Ratings table)
- 7** - P = stud base 3/4"-16UNF2A threads
- 8** - 0 = eyelet terminals (gate and auxiliary cathode leads)  
1 = fast-on terminals (gate and auxiliary cathode leads)
- 9** - None = standard production  
PbF = lead (Pb)-free

Note: For metric device M16 x 1.5 contact factory

| LINKS TO RELATED DOCUMENTS |                                                                        |
|----------------------------|------------------------------------------------------------------------|
| Dimensions                 | <a href="http://www.vishay.com/doc?95082">www.vishay.com/doc?95082</a> |

### TO-209AB (TO-93)

**DIMENSIONS** in millimeters (inches)



**Note**

<sup>(1)</sup> For metric device: M16 x 1.5 - length 21 (0.83) maximum



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