

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Features

1. Qualification based on AEC-Q200 Rev-D
2. High surge suppression capability for automotive application (load dump)
3. No temperature derating up to 125 °C
4. Bidirectional and symmetrical V/I characteristics
5. Stability in high-temperature and high-humidity environment
6. RoHS & Halogen Free (HF) compliant



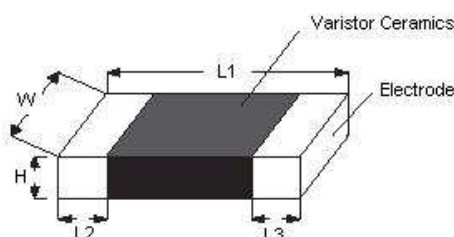
### ■ Recommended Applications

Transient overvoltage protection in automotive applications: engine management, airbag, control units, electro hydraulic brake, ABS/ESP, sunroof

### ■ Part Number Code

| T                                                                                                                               | V                                       | M            | 3                                      | C   | 1                                      | 6                                                                                                                                                                                                                                                                                      | 0 | K         | 1  | 0  | 2    | R  | V    |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------|----------------------------------------|-----|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----------|----|----|------|----|------|----|------|---|------|---|------|---|------|---|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------------------------------------------|--|-----|------|-----|-----------------------|-----|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------|--|------|---------------------------------------|------|-----------------------------------------|----------------------------------------------------------------------------------------|--|-----------|--|---|------|--------------------------------------------------------------------------------------------------|--|-----------------|--|---|----------|
| 1                                                                                                                               | 2                                       | 3            | 4                                      | 5   | 6                                      | 7                                                                                                                                                                                                                                                                                      | 8 | 9         | 10 | 11 | 12   | 13 | 14   | 15 | 16   |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| <table><tr><th colspan="2">Product Type</th></tr><tr><td>TVM</td><td>THINKING<br/>SMD Varistor<br/>TVM Series</td></tr></table> |                                         | Product Type |                                        | TVM | THINKING<br>SMD Varistor<br>TVM Series | <table><tr><th colspan="2">Size(EIA)</th></tr><tr><td>0</td><td>0402</td></tr><tr><td>1</td><td>0603</td></tr><tr><td>2</td><td>0805</td></tr><tr><td>3</td><td>1206</td></tr><tr><td>4</td><td>1210</td></tr><tr><td>5</td><td>1812</td></tr><tr><td>6</td><td>2220</td></tr></table> |   | Size(EIA) |    | 0  | 0402 | 1  | 0603 | 2  | 0805 | 3 | 1206 | 4 | 1210 | 5 | 1812 | 6 | 2220 | <table><tr><th colspan="2">Max. Continuous Voltage(V<sub>DC</sub>)</th></tr><tr><td>5R5</td><td>5.5V</td></tr><tr><td>090</td><td>9x10<sup>0</sup>=9V</td></tr><tr><td>330</td><td>33x10<sup>0</sup>=33V</td></tr></table> |  | Max. Continuous Voltage(V <sub>DC</sub> ) |  | 5R5 | 5.5V | 090 | 9x10 <sup>0</sup> =9V | 330 | 33x10 <sup>0</sup> =33V | <table><tr><th colspan="2">Typical Capacitance</th></tr><tr><td>M330</td><td>33x10<sup>0</sup>pF=33pF<br/>(@1MHz)</td></tr><tr><td>K102</td><td>10x10<sup>2</sup>pF=1000pF<br/>(@1KHz)</td></tr></table> |  | Typical Capacitance |  | M330 | 33x10 <sup>0</sup> pF=33pF<br>(@1MHz) | K102 | 10x10 <sup>2</sup> pF=1000pF<br>(@1KHz) | <table><tr><th colspan="2">Packaging</th></tr><tr><td>R</td><td>Reel</td></tr></table> |  | Packaging |  | R | Reel | <table><tr><th colspan="2">Optional Suffix</th></tr><tr><td>V</td><td>V Series</td></tr></table> |  | Optional Suffix |  | V | V Series |
|                                                                                                                                 |                                         | Product Type |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         | TVM          | THINKING<br>SMD Varistor<br>TVM Series |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         | Size(EIA)    |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         | 0            | 0402                                   |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         | 1            | 0603                                   |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         | 2            | 0805                                   |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 3                                                                                                                               | 1206                                    |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 4                                                                                                                               | 1210                                    |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 5                                                                                                                               | 1812                                    |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 6                                                                                                                               | 2220                                    |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| Max. Continuous Voltage(V <sub>DC</sub> )                                                                                       |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 5R5                                                                                                                             | 5.5V                                    |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 090                                                                                                                             | 9x10 <sup>0</sup> =9V                   |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| 330                                                                                                                             | 33x10 <sup>0</sup> =33V                 |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| Typical Capacitance                                                                                                             |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| M330                                                                                                                            | 33x10 <sup>0</sup> pF=33pF<br>(@1MHz)   |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| K102                                                                                                                            | 10x10 <sup>2</sup> pF=1000pF<br>(@1KHz) |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| Packaging                                                                                                                       |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| R                                                                                                                               | Reel                                    |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| Optional Suffix                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| V                                                                                                                               | V Series                                |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
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|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
|                                                                                                                                 |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |
| </                                                                                                                              |                                         |              |                                        |     |                                        |                                                                                                                                                                                                                                                                                        |   |           |    |    |      |    |      |    |      |   |      |   |      |   |      |   |      |                                                                                                                                                                                                                            |  |                                           |  |     |      |     |                       |     |                         |                                                                                                                                                                                                          |  |                     |  |      |                                       |      |                                         |                                                                                        |  |           |  |   |      |                                                                                                  |  |                 |  |   |          |

### ■ Structures and Dimensions



(Unit: mm)

| Part No. | Size (EIA) | L1         | W         | H max. | L2 and L3 |
|----------|------------|------------|-----------|--------|-----------|
| TVM0     | 0402       | 1.00±0.15  | 0.50±0.10 | 0.60   | 0.20±0.10 |
| TVM1     | 0603       | 1.60 ±0.15 | 0.80±0.15 | 0.95   | 0.35±0.15 |
| TVM2     | 0805       | 2.00 ±0.20 | 1.25±0.20 | 1.20   | 0.40±0.20 |
| TVM3     | 1206       | 3.20 ±0.30 | 1.60±0.20 | 1.50   | 0.50±0.20 |
| TVM4     | 1210       | 3.20 ±0.30 | 2.50±0.25 | 1.50   | 0.50±0.20 |
| TVM5     | 1812       | 4.50 ±0.40 | 3.20±0.30 | 2.00   | 0.60±0.30 |
| TVM6     | 2220       | 5.70±0.40  | 5.00±0.30 | 2.50   | 0.60±0.30 |

Hmax: TVM6C160K453RV = 3.00

W: TVM6C160K453RV = 5.00 ±0.40

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Electrical Characteristics

#### ● 0402 Series

| Part No.      | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance |        | Operating Temp. Range |
|---------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|--------|-----------------------|
|               | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | 1MHz   | (°C)                  |
|               | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                | (pF)   |                       |
| TVM0C140K800R | 16~21            | 11                      | 14              | 35                             | 1              | 10                          | 0.05                    | 80±30%              | --     | -55~+125              |
| TVM0C180M120R | 22~28            | 14                      | 18              | 55                             | 1              | 2                           | 0.03                    | --                  | 12±30% |                       |
| TVM0C180M400R | 22~28            | 14                      | 18              | 50                             | 1              | 20                          | 0.05                    | --                  | 40±30% |                       |
| TVM0C180M500R | 22~28            | 14                      | 18              | 50                             | 1              | 20                          | 0.05                    | --                  | 50±30% |                       |
| TVM0C180M600R | 22~28            | 14                      | 18              | 50                             | 1              | 20                          | 0.05                    | --                  | 60±30% |                       |
| TVM0C180M650R | 22~28            | 14                      | 18              | 50                             | 1              | 20                          | 0.05                    | --                  | 65±30% |                       |

#### ● 0603 Series

| Part No.      | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance |         | Operating Temp. Range |
|---------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|---------|-----------------------|
|               | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | 1MHz    | (°C)                  |
|               | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                | (pF)    |                       |
| TVM1C090M491R | 11~16            | 7                       | 9               | 29                             | 1              | 30                          | 0.1                     | --                  | 490±30% | -55~+125              |
| TVM1C160K561R | 21.6~26.4        | 12                      | 16              | 45                             | 1              | 30                          | 0.1                     | 560±30%             | --      |                       |
| TVM1C180K300R | 23~30            | 14                      | 18              | 52                             | 1              | 4                           | 0.03                    | 30±30%              | --      |                       |
| TVM1C180M300R | 23~30            | 14                      | 18              | 52                             | 1              | 4                           | 0.03                    | --                  | 30±30%  |                       |
| TVM1C180M900R | 23~30            | 14                      | 18              | 48                             | 1              | 30                          | 0.1                     | --                  | 90±30%  |                       |
| TVM1C180K101R | 23~30            | 14                      | 18              | 48                             | 1              | 30                          | 0.1                     | 100±30%             | --      |                       |
| TVM1C180K431R | 23~30            | 14                      | 18              | 45                             | 1              | 50                          | 0.1                     | 430±30%             | --      |                       |
| TVM1C220K530R | 25~40            | 17                      | 22              | 50                             | 1              | 30                          | 0.1                     | 53±30%              | --      |                       |
| TVM1C220K101R | 25~33            | 17                      | 22              | 50                             | 1              | 30                          | 0.1                     | 100±30%             | --      |                       |
| TVM1C260M111R | 31~38            | 20                      | 26              | 60                             | 1              | 30                          | 0.1                     | --                  | 110±30% |                       |
| TVM1C310K900R | 35.1~42.9        | 25                      | 31              | 67                             | 1              | 30                          | 0.3                     | 90±30%              | --      |                       |
| TVM1C320M100R | 51.9~70.1        | 25                      | 32              | 120                            | 1              | 5                           | 0.05                    | --                  | 10±30%  |                       |

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Electrical Characteristics

#### ● 0805 Series

| Part No.       | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance | V <sub>jump</sub> (5min) | W <sub>LD</sub> (10x) | Operating Temp. Range |
|----------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|--------------------------|-----------------------|-----------------------|
|                | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | (V)                      | (J)                   | (°C)                  |
|                | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                |                          |                       |                       |
| TVM2C160K651R  | 21.6~26.4        | 12                      | 16              | 40                             | 1              | 120                         | 0.3                     | 650±20%             | 24.5                     | 1                     | -55~+125              |
| TVM2C180K651RV | 23~28            | 14                      | 18              | 44                             | 1              | 120                         | 0.3                     | 650±20%             | 24.5                     | 1                     |                       |
| TVM2C180K751R  | 23~28            | 14                      | 18              | 44                             | 1              | 120                         | 0.3                     | 750±20%             | 24.5                     | 1                     |                       |
| TVM2C260K501R  | 29.7~36.3        | 20                      | 26              | 56                             | 1              | 80                          | 0.3                     | 500±20%             | 27                       | 1                     |                       |
| TVM2C310K251RV | 35.1~42.9        | 25                      | 31              | 67                             | 1              | 80                          | 0.3                     | 250±30%             | 29                       | 0.5                   |                       |

#### ● 1206 Series

| Part No.       | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance | V <sub>jump</sub> (5min) | W <sub>LD</sub> (10x) | Operating Temp. Range |
|----------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|--------------------------|-----------------------|-----------------------|
|                | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | (V)                      | (J)                   | (°C)                  |
|                | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                |                          |                       |                       |
| TVM3C160K102R  | 21.6~26.4        | 12                      | 16              | 40                             | 1              | 200                         | 0.6                     | 1000±20%            | 24.5                     | 1.5                   | -55~+125              |
| TVM3C160K242RV | 21.6~26.4        | 12                      | 16              | 38                             | 1              | 400                         | 0.6                     | 2400 (max.)         | 24.5                     | 2                     |                       |
| TVM3C180K102RV | 22.95~28.05      | 14                      | 18              | 42                             | 1              | 150                         | 0.6                     | 1000 (max.)         | 24.5                     | 1.5                   |                       |
| TVM3C260K801RV | 29.7~36.3        | 20                      | 26              | 54                             | 1              | 200                         | 0.7                     | 800±20%             | 27.5                     | 1.2                   |                       |
| TVM3C260K132R  | 29.7~36.3        | 20                      | 26              | 54                             | 1              | 250                         | 0.7                     | 1300±20%            | 27.5                     | 1.5                   |                       |
| TVM3C340K551R  | 42.3~51.7        | 26                      | 34              | 77                             | 1              | 200                         | 0.4                     | 550±20%             | 50                       | 1.5                   |                       |
| TVM3C450K301R  | 50.4~61.6        | 35                      | 45              | 90                             | 1              | 100                         | 0.4                     | 300±20%             | 59                       | 1.2                   |                       |
| TVM3C480K271RV | 55.8~68.2        | 37                      | 48              | 100                            | 1              | 100                         | 0.4                     | 270±20%             | 59                       | 1.2                   |                       |
| TVM3C560K251RV | 61.2~74.8        | 40                      | 56              | 110                            | 1              | 100                         | 0.5                     | 250±20%             | 65                       | 1.5                   |                       |

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Electrical Characteristics

#### ● 1210 Series

| Part No.       | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance | V <sub>jump</sub> (5min) | W <sub>LD</sub> (10x) | Operating Temp. Range |
|----------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|--------------------------|-----------------------|-----------------------|
|                | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | (V)                      | (J)                   | (°C)                  |
|                | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                |                          |                       |                       |
| TVM4C160K242R  | 21.6~26.4        | 12                      | 16              | 40                             | 2.5            | 400                         | 1.6                     | 2400±20%            | 24.5                     | 3                     | -55~+125              |
| TVM4C180K312RV | 22.95~28.05      | 14                      | 18              | 42                             | 2.5            | 500                         | 1.6                     | 3100 (max.)         | 27.5                     | 3                     |                       |
| TVM4C260K152RV | 29.7~36.3        | 20                      | 26              | 54                             | 2.5            | 400                         | 1.9                     | 1500±20%            | 27                       | 3                     |                       |
| TVM4C310K122RV | 35.1~42.9        | 25                      | 31              | 65                             | 2.5            | 300                         | 1.7                     | 1200±20%            | 29                       | 3                     |                       |
| TVM4C340K112R  | 42.3~51.7        | 26                      | 34              | 75                             | 2.5            | 300                         | 2.3                     | 1100±20%            | 50                       | 3                     |                       |
| TVM4C380K901RV | 42.3~51.7        | 30                      | 38              | 77                             | 2.5            | 300                         | 2                       | 900±20%             | 50                       | 3                     |                       |
| TVM4C450K601R  | 50.4~61.6        | 35                      | 45              | 90                             | 2.5            | 250                         | 2                       | 600±20%             | 60                       | 1.5                   |                       |

#### ● 1812 Series

| Part No.       | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance | V <sub>jump</sub> (5min) | W <sub>LD</sub> (10x) | Operating Temp. Range |
|----------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|--------------------------|-----------------------|-----------------------|
|                | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | (V)                      | (J)                   | (°C)                  |
|                | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                |                          |                       |                       |
| TVM5C160K452R  | 21.6~26.4        | 12                      | 16              | 40                             | 5              | 800                         | 2.4                     | 4500±20%            | 24.5                     | 6                     | -55~+125              |
| TVM5C260K322R  | 29.7~36.3        | 20                      | 26              | 54                             | 5              | 800                         | 3                       | 3200±20%            | 30                       | 6                     |                       |
| TVM5C300K172R  | 35~43            | 23                      | 30              | 77                             | 5              | 600                         | 3.8                     | 1700±20%            | 45                       | 6                     |                       |
| TVM5C300K302RV | 35~43            | 23                      | 30              | 77                             | 5              | 800                         | 3.8                     | 3000 (max.)         | 45                       | 6                     |                       |
| TVM5C380K302RV | 42.3~51.7        | 30                      | 38              | 77                             | 5              | 1200                        | 4.2                     | 3000 (max.)         | 50                       | 6                     |                       |

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Electrical Characteristics

#### ● 2220 Series

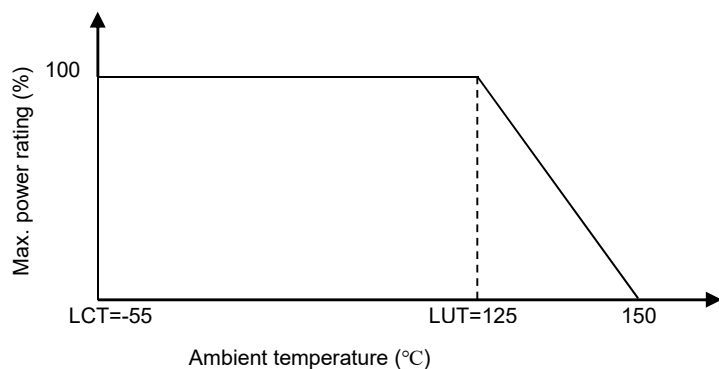
| Part No.       | Varistor Voltage | Max. Continuous Voltage |                 | Max. Clamping Voltage (8/20μs) |                | Max. Surge Current (8/20μs) | Max. Energy (10/1000μs) | Typical Capacitance | V <sub>jump</sub> (5min) | W <sub>LD</sub> (10x) | Operating Temp. Range |
|----------------|------------------|-------------------------|-----------------|--------------------------------|----------------|-----------------------------|-------------------------|---------------------|--------------------------|-----------------------|-----------------------|
|                | V <sub>1mA</sub> | V <sub>AC</sub>         | V <sub>DC</sub> | V <sub>P</sub>                 | I <sub>P</sub> | I <sub>max</sub>            | W <sub>max</sub>        | 1KHz                | (V)                      | (J)                   | (°C)                  |
|                | (V)              | (V)                     | (V)             | (V)                            | (A)            | (A)                         | (J)                     | (pF)                |                          |                       |                       |
| TVM6C160K103R  | 21.6~26.4        | 12                      | 16              | 42                             | 10             | 1200                        | 5.8                     | 10000±20%           | 24.5                     | 12                    | -55~+125              |
| TVM6C160K203R  | 21.6~26.4        | 12                      | 16              | 42                             | 10             | 1200                        | 10                      | 20000±20%           | 24.5                     | 25                    |                       |
| TVM6C160K303RV | 21.6~26.4        | 12                      | 16              | 45                             | 10             | 1500                        | 10                      | 30000(max.)         | 24.5                     | 35                    |                       |
| TVM6C160K453RV | 21.6~26.4        | 12                      | 16              | 40                             | 10             | 5000                        | 10                      | 45000(max.)         | 24.5                     | 50                    |                       |
| TVM6C240K203RV | 32~39            | 18                      | 24              | 60                             | 10             | 1000                        | 7.8                     | 20000(max.)         | 24.5                     | 15                    |                       |
| TVM6C340K652RV | 42.3~51.7        | 26                      | 34              | 77                             | 10             | 1200                        | 12                      | 6500±20%            | 50                       | 12                    |                       |
| TVM6C380K302R  | 42.3~51.7        | 30                      | 38              | 77                             | 10             | 1000                        | 12                      | 3000±20%            | 50                       | 12                    |                       |

# Varistor for Automotive: TVM-C Series

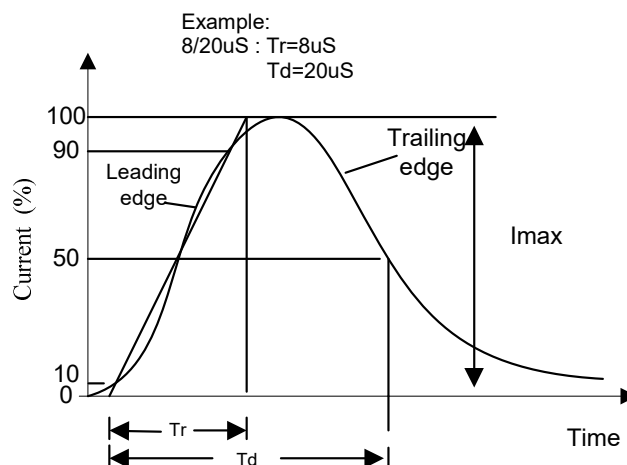
## SMD Type for Transient Overvoltage Protection



### Power Derating Curve

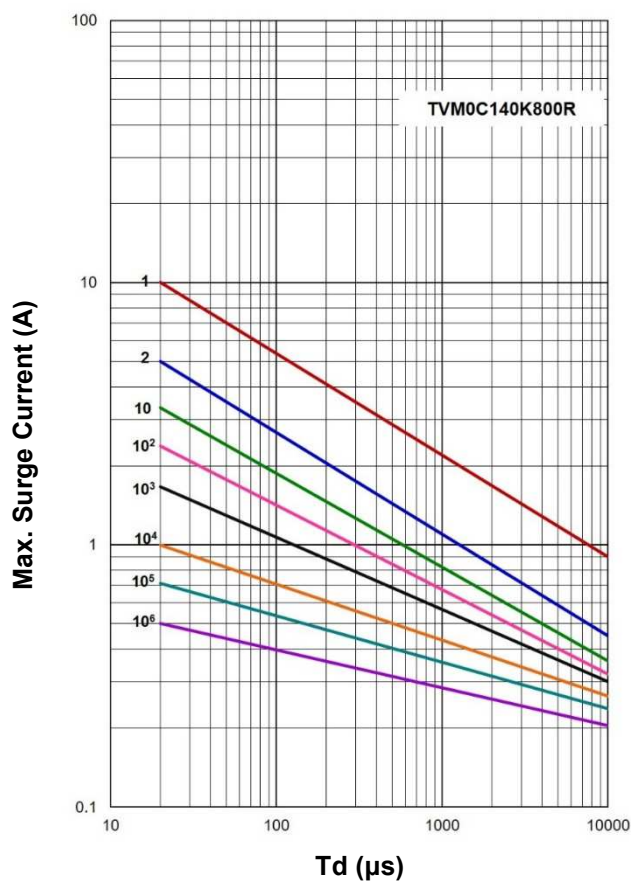


### Surge Current Standard Waveform

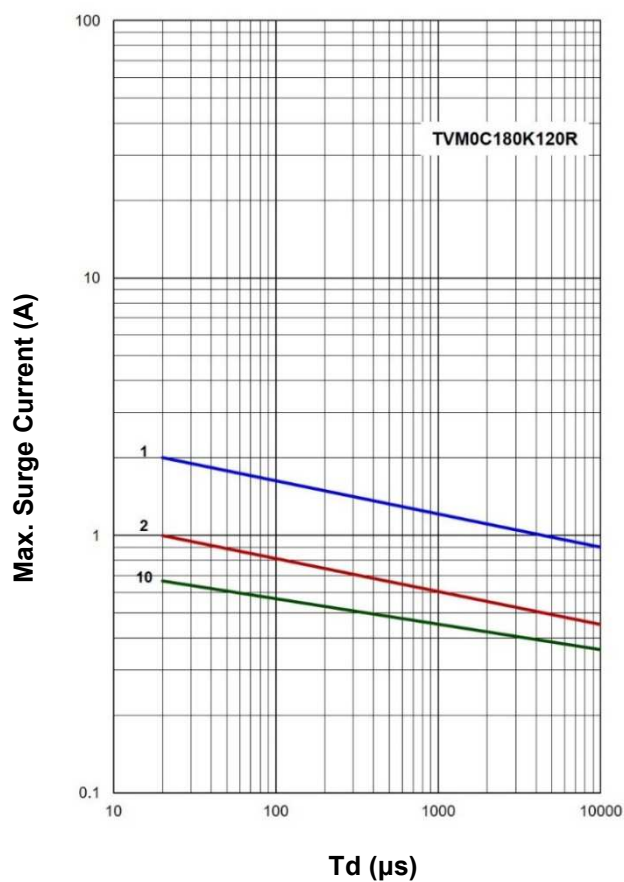


### Max. Surge Current Derating Curves

TVM0C140K800R



TVM0C180M120R



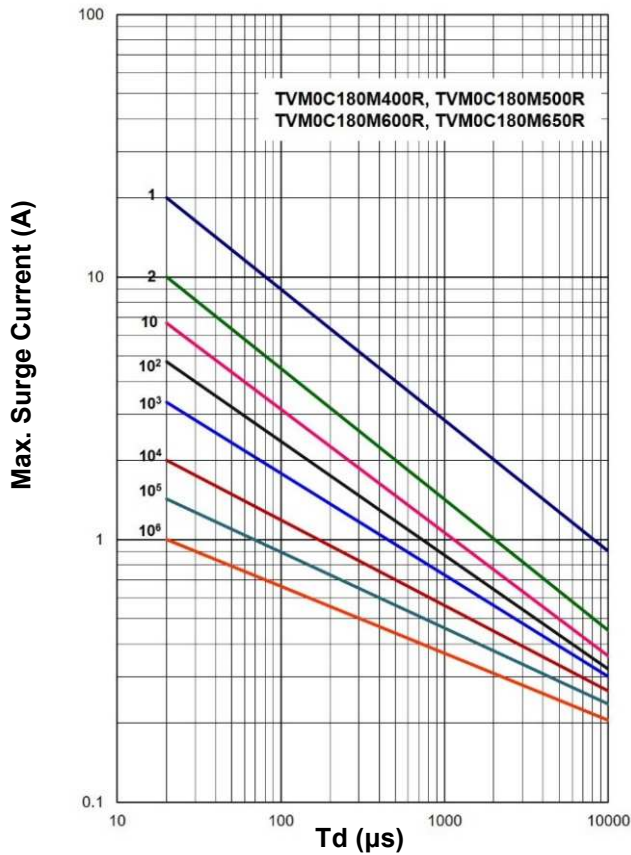
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

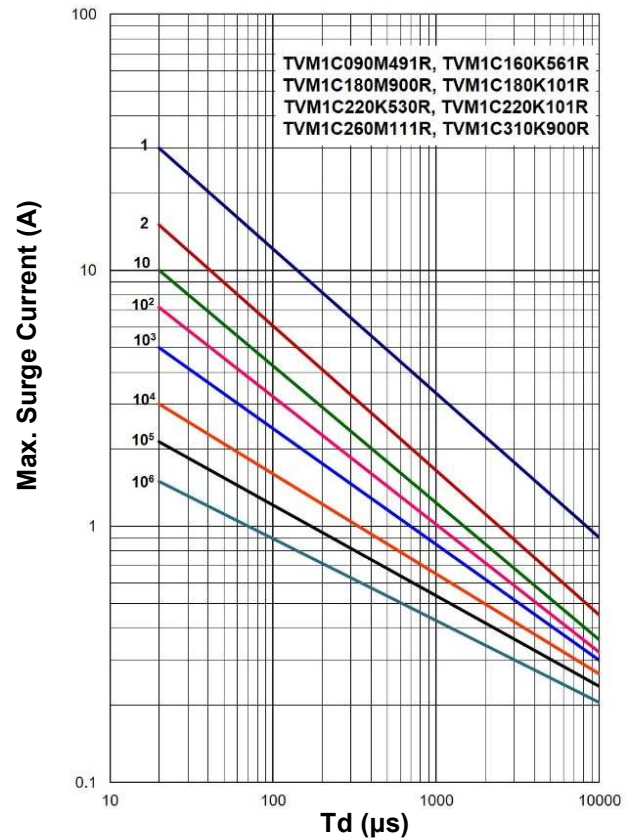


### Max. Surge Current Derating Curves

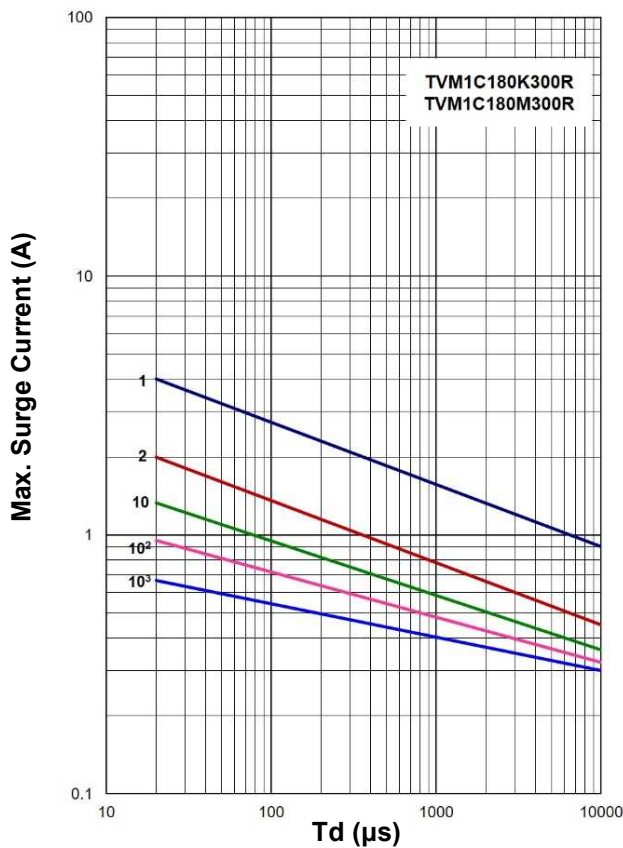
TVM0C180M400R, TVM0C180M500R  
TVM0C180M600R, TVM0C180M650R



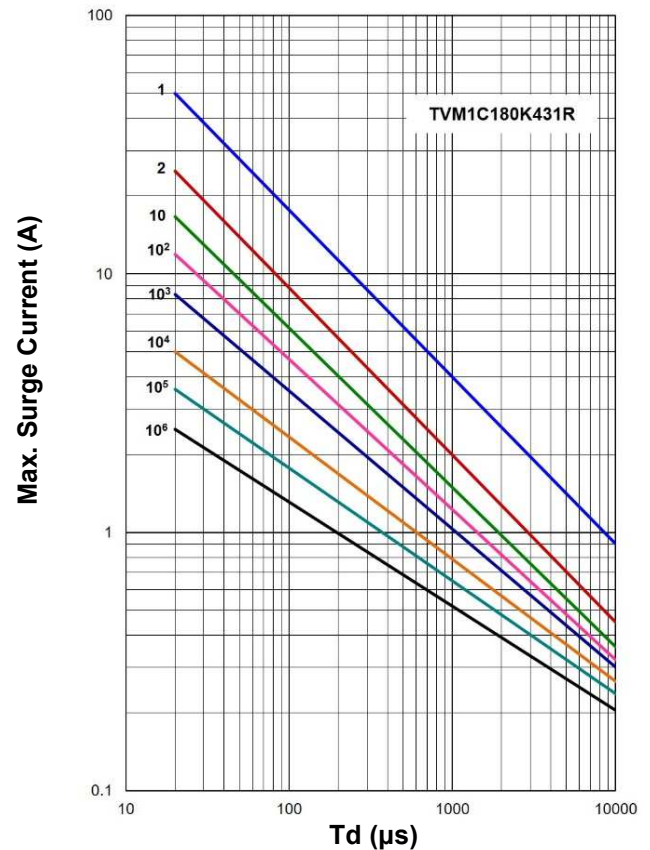
TVM1C090M491R, TVM1C160K561R  
TVM1C180M900R, TVM1C180K101R  
TVM1C220K530R, TVM1C220K101R  
TVM1C260M111R, TVM1C310K900R



TVM1C180K300R, TVM1C180M300R



TVM1C180K431R



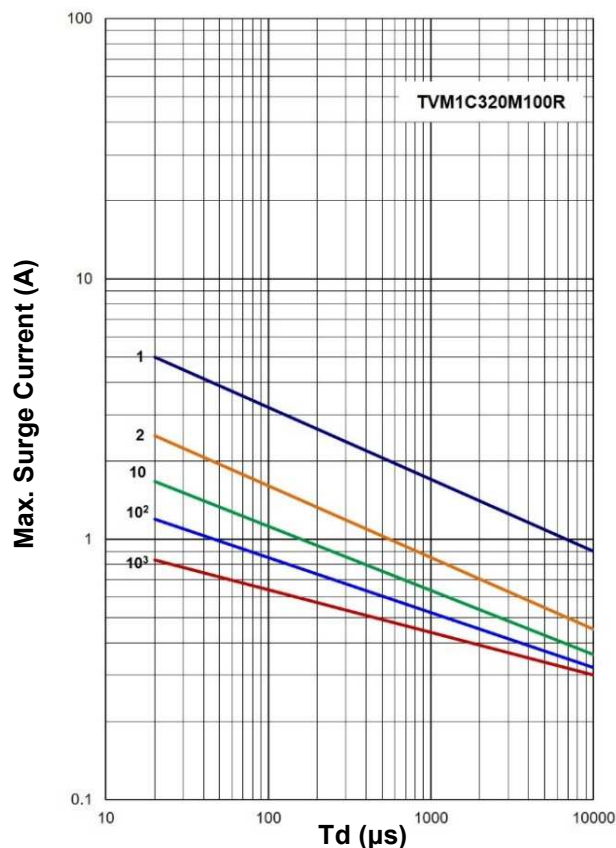
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

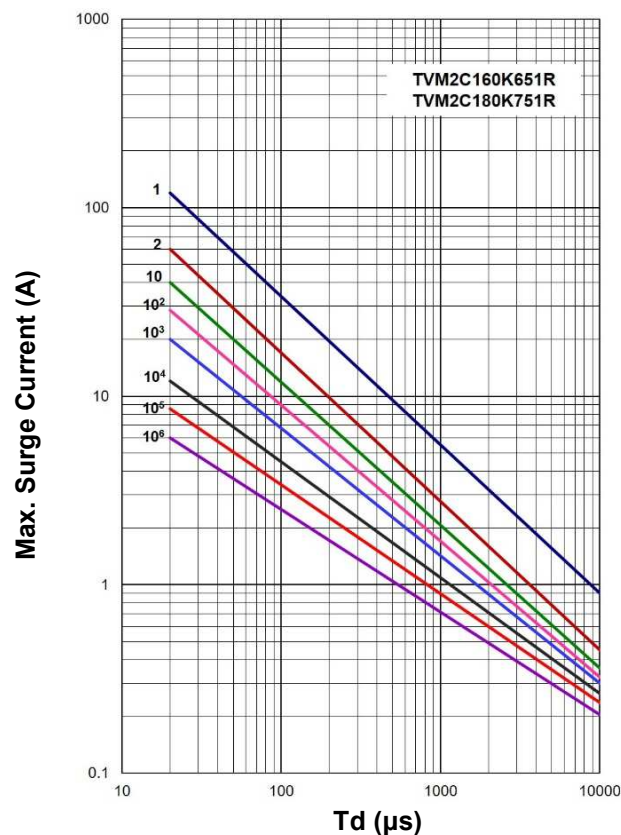


### ■ Max. Surge Current Derating Curves

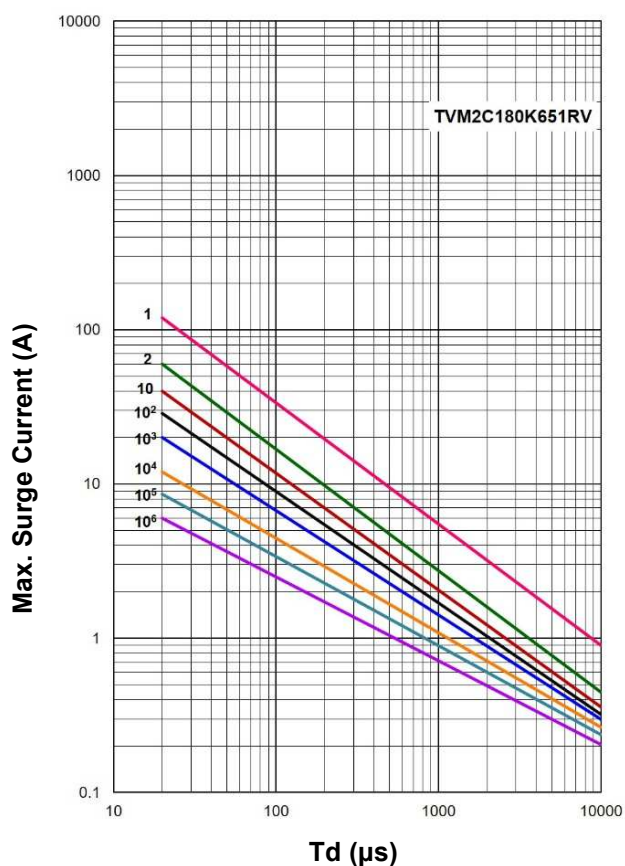
TVM1C320M100R



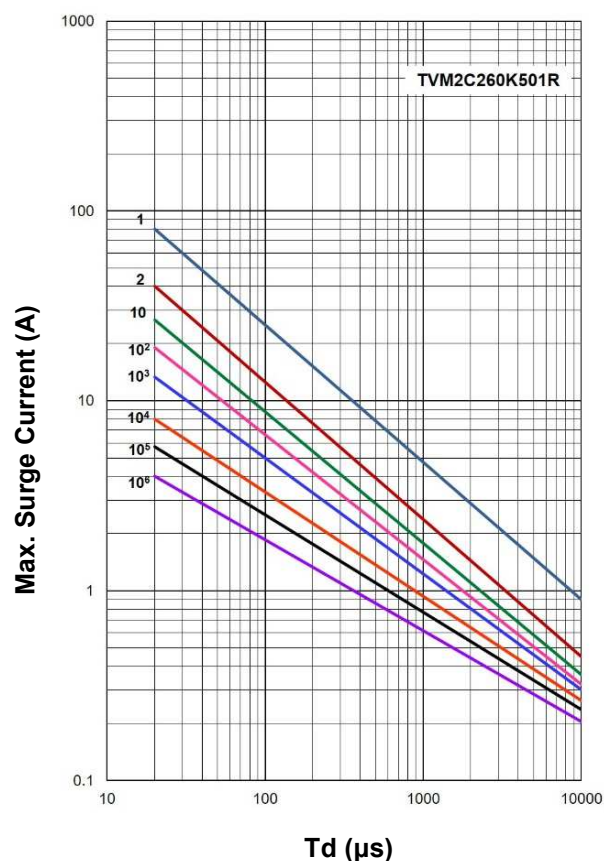
TVM2C160K651R, TVM2C180K751R



TVM2C180K651RV



TVM2C260K501R



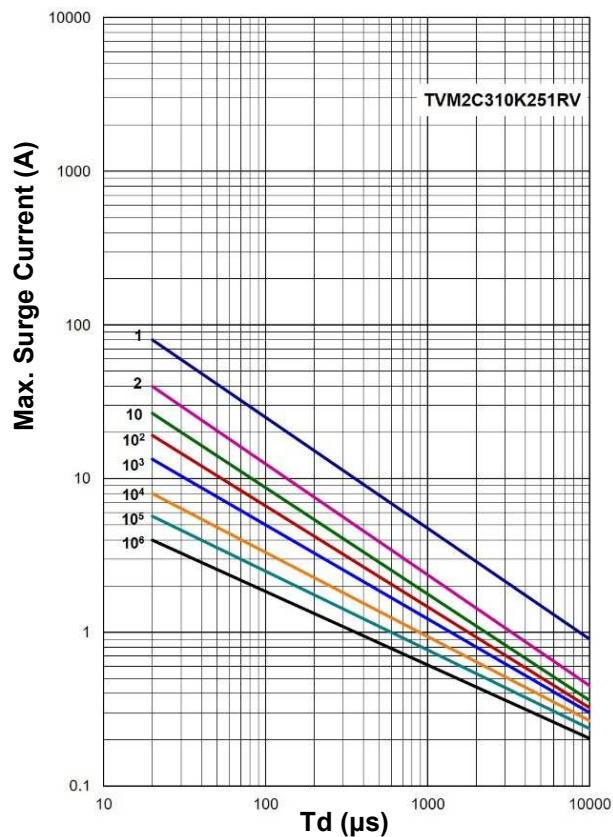
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

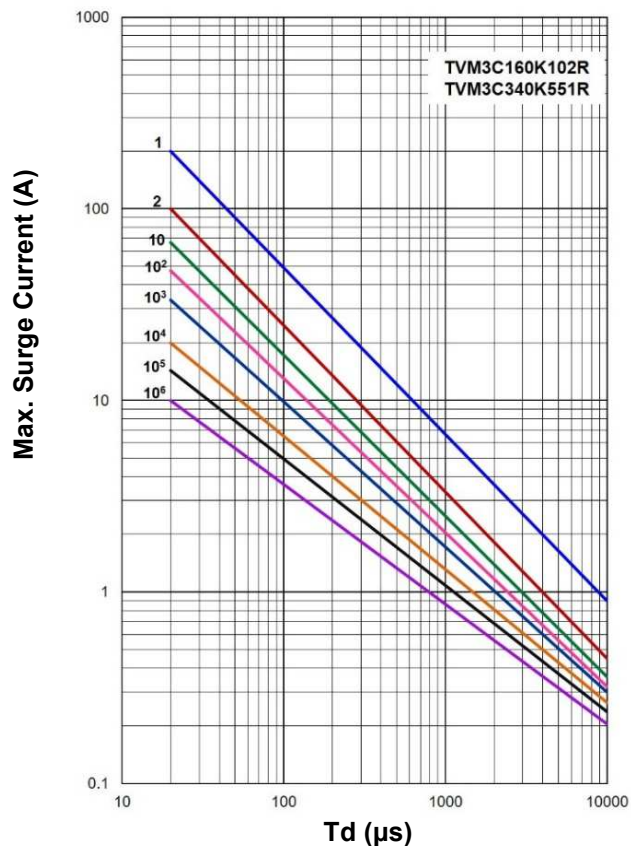


### ■ Max. Surge Current Derating Curves

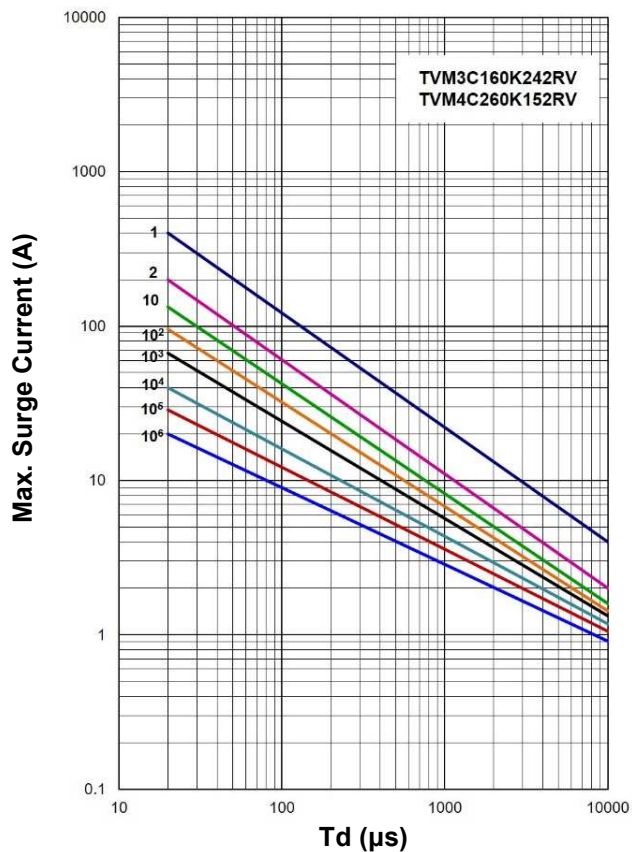
TVM2C310K251RV



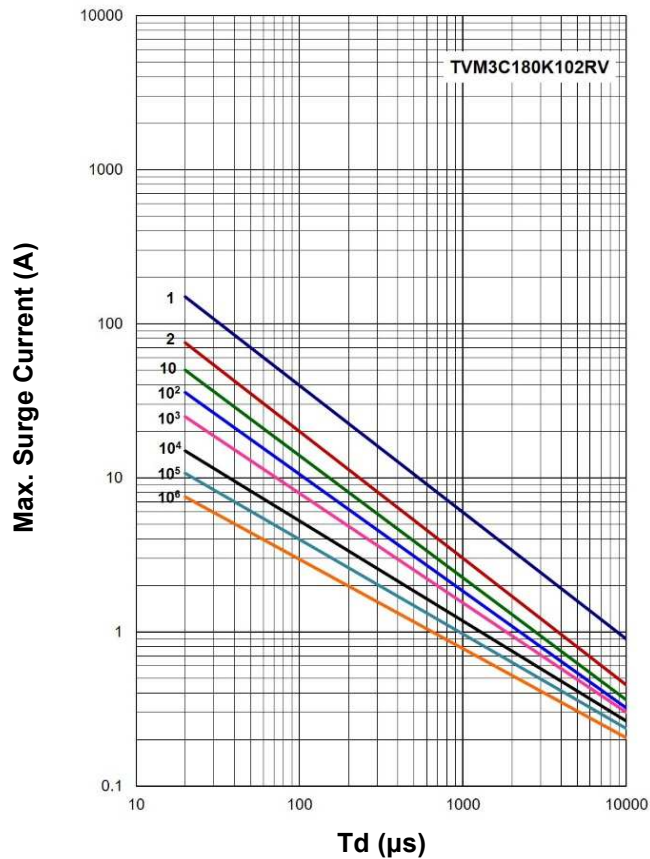
TVM3C160K102R, TVM3C340K551R



TVM3C160K242RV, TVM4C260K152RV



TVM3C180K102RV

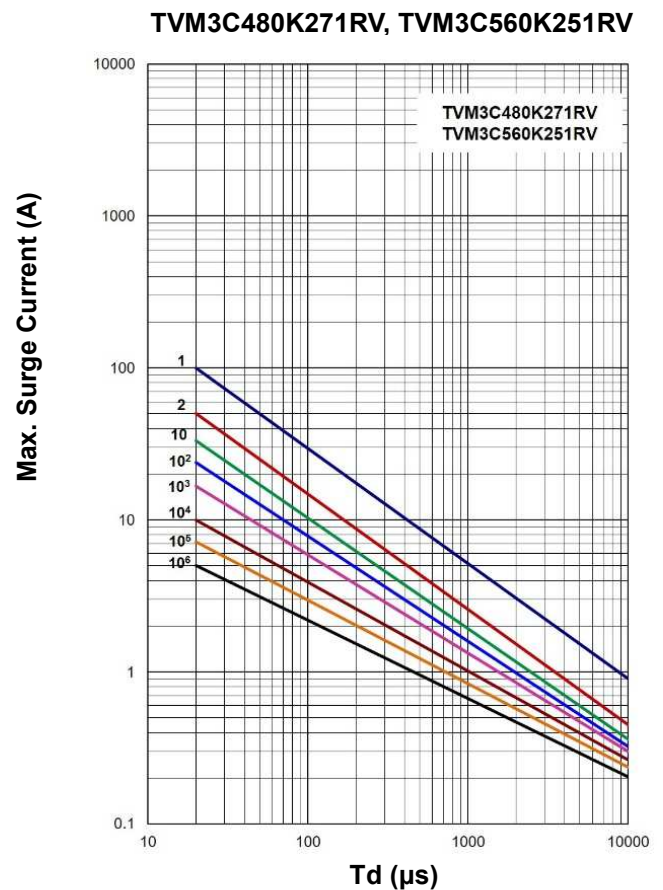
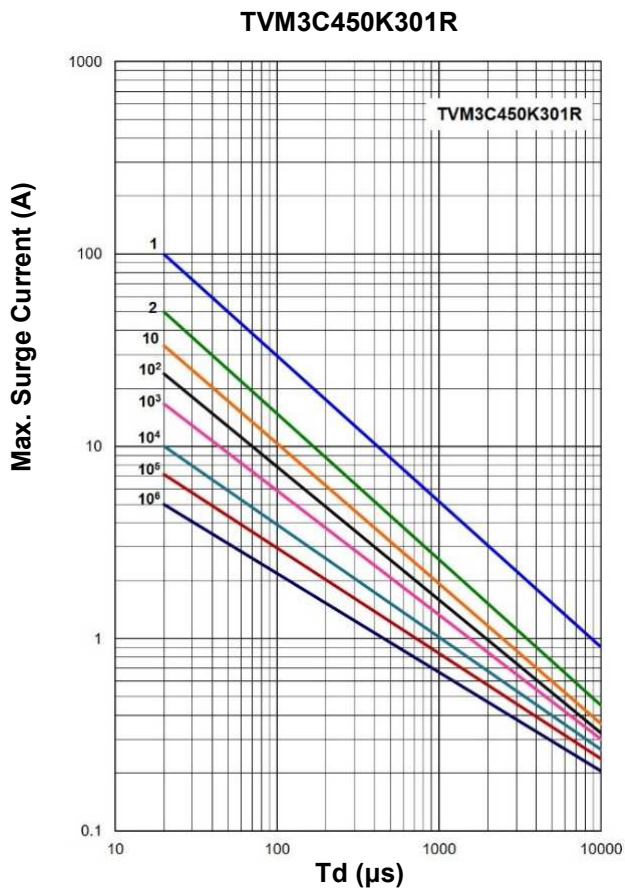
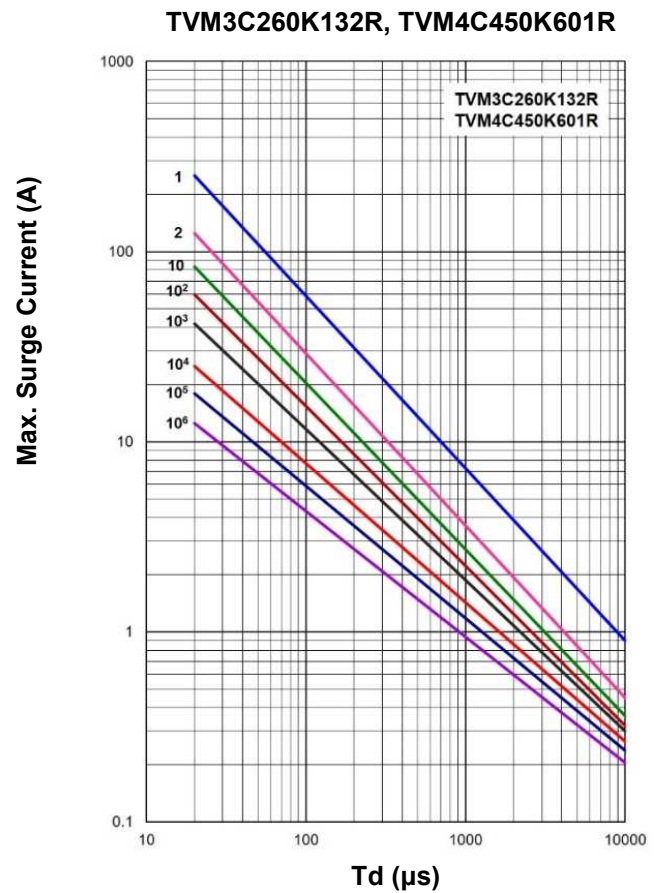
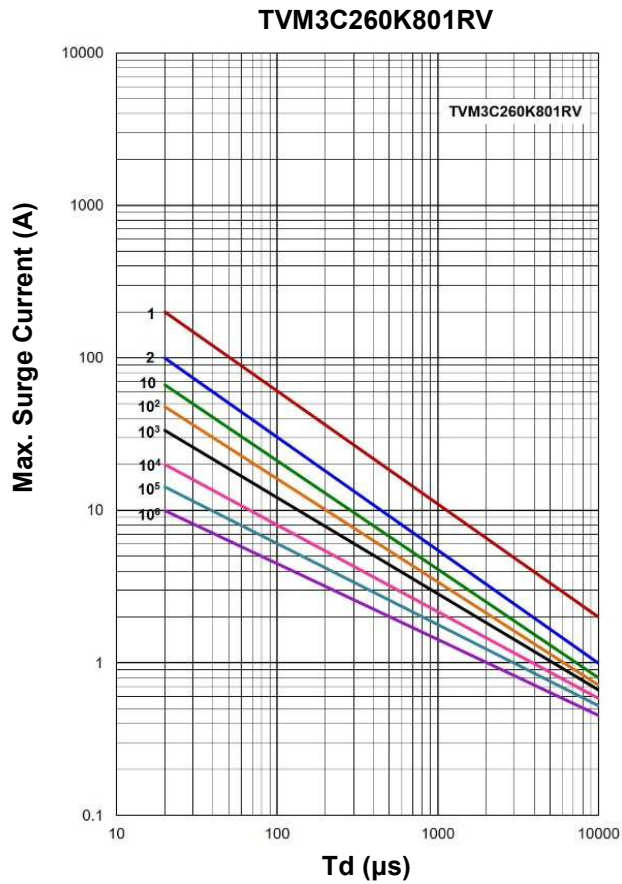


# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Max. Surge Current Derating Curves

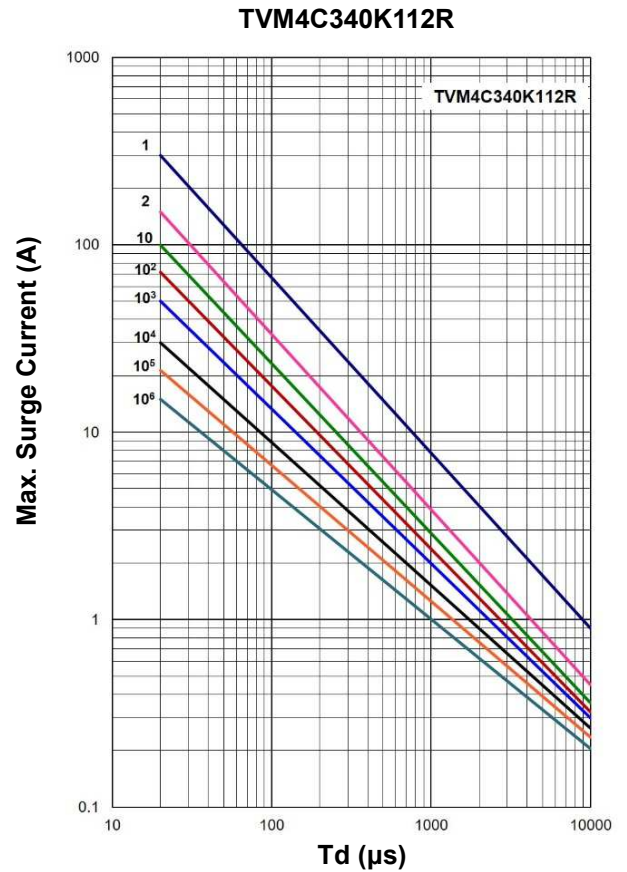
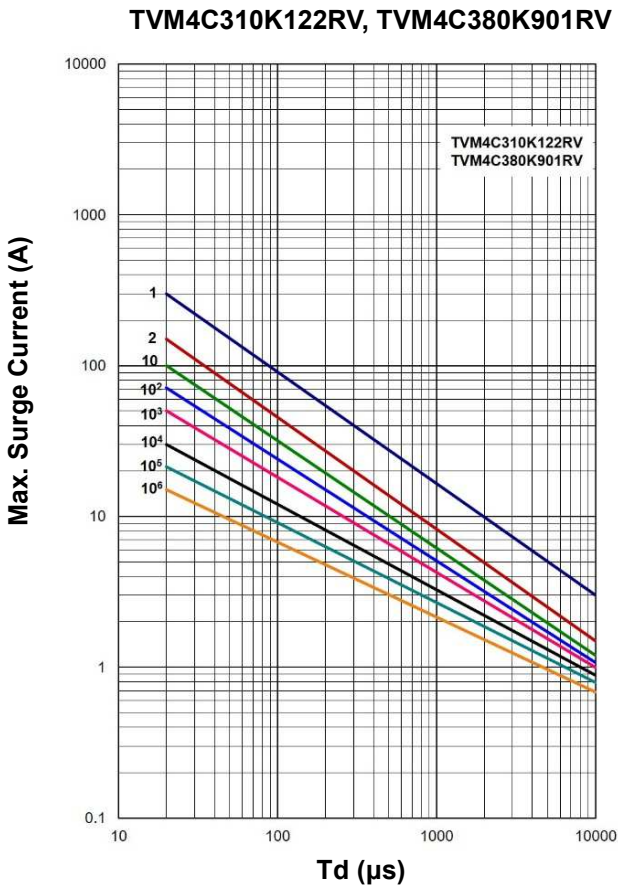
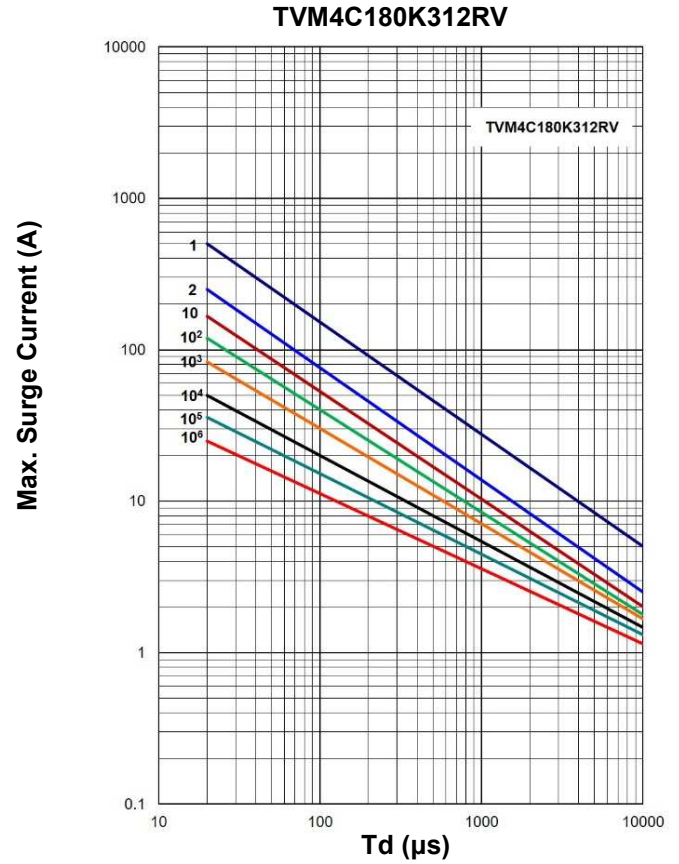
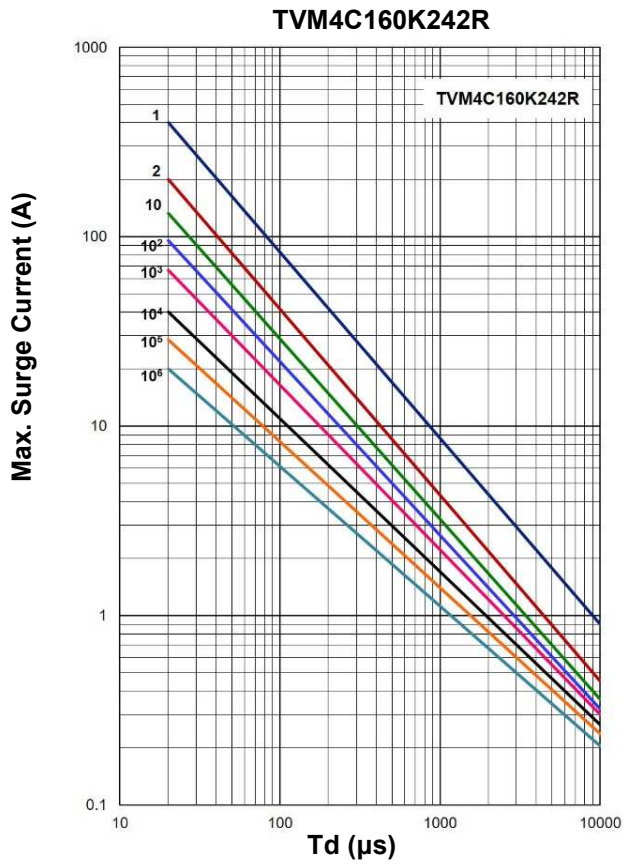


# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Max. Surge Current Derating Curves



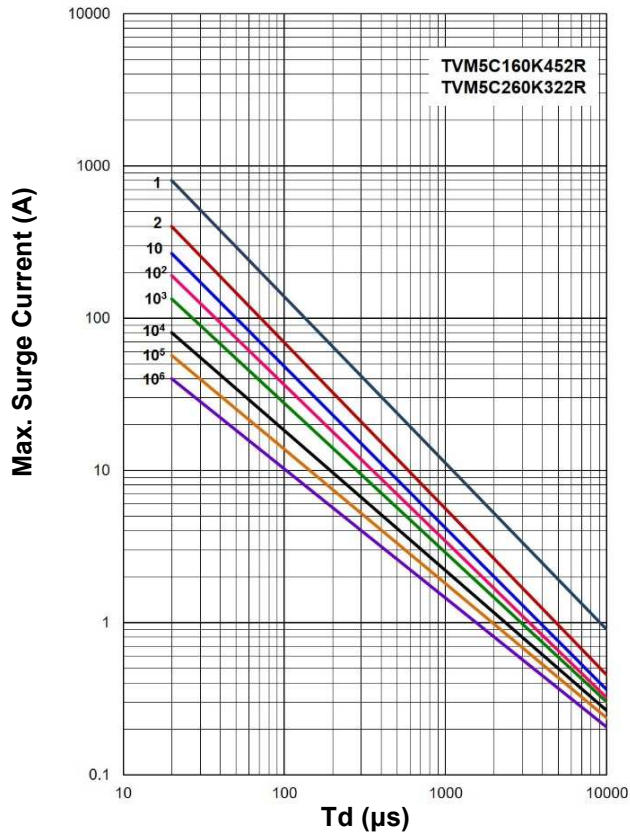
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

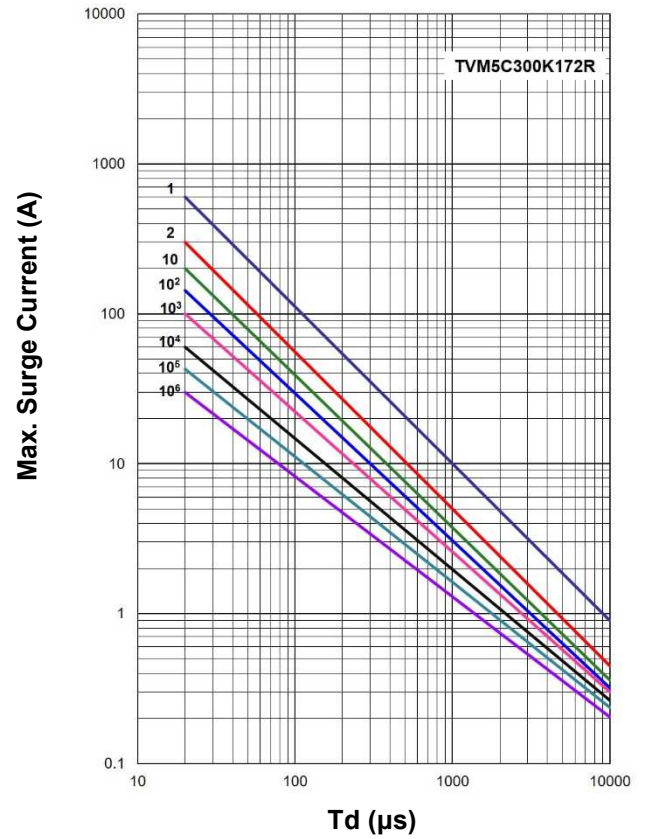


### ■ Max. Surge Current Derating Curves

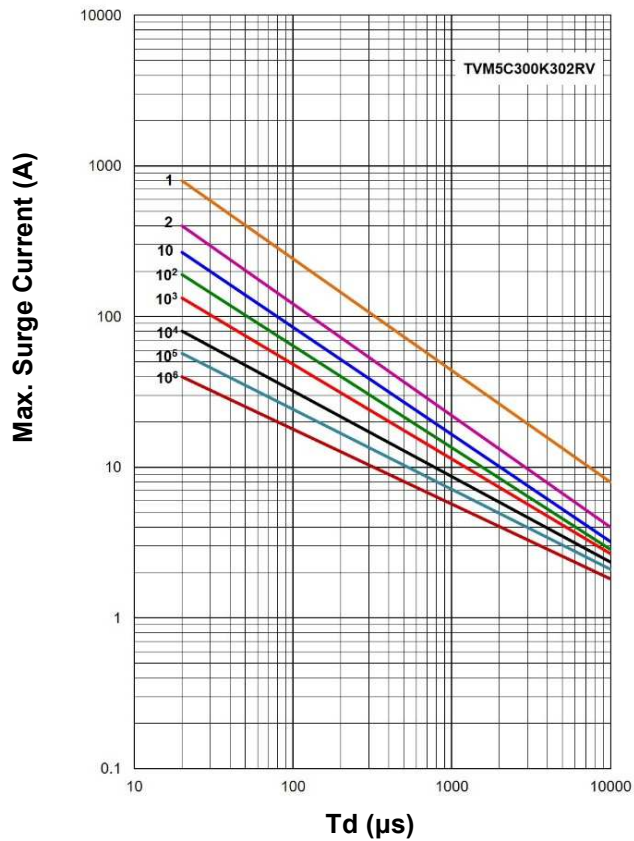
TVM5C160K452R, TVM5C260K322R



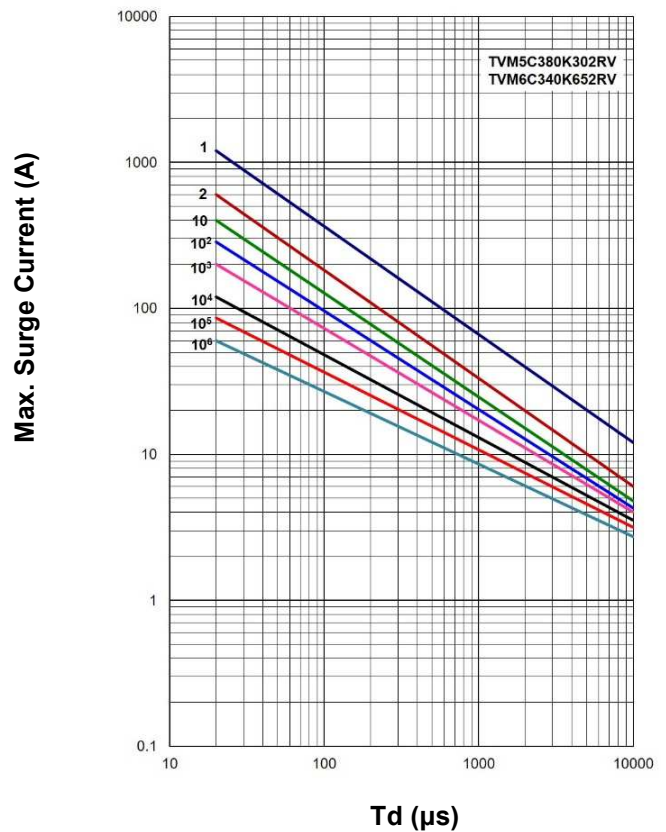
TVM5C300K172R



TVM5C300K302RV



TVM5C380K302RV, TVM6C340K652RV

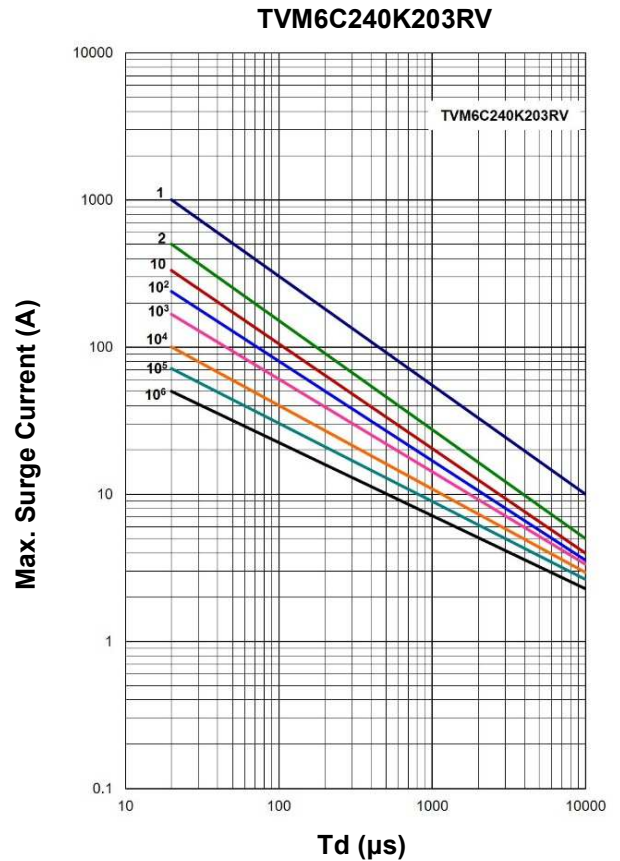
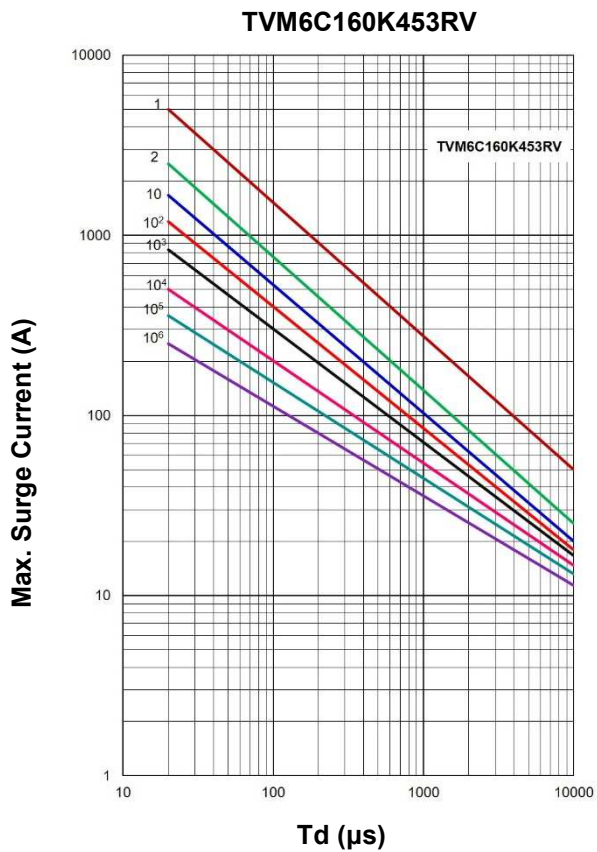
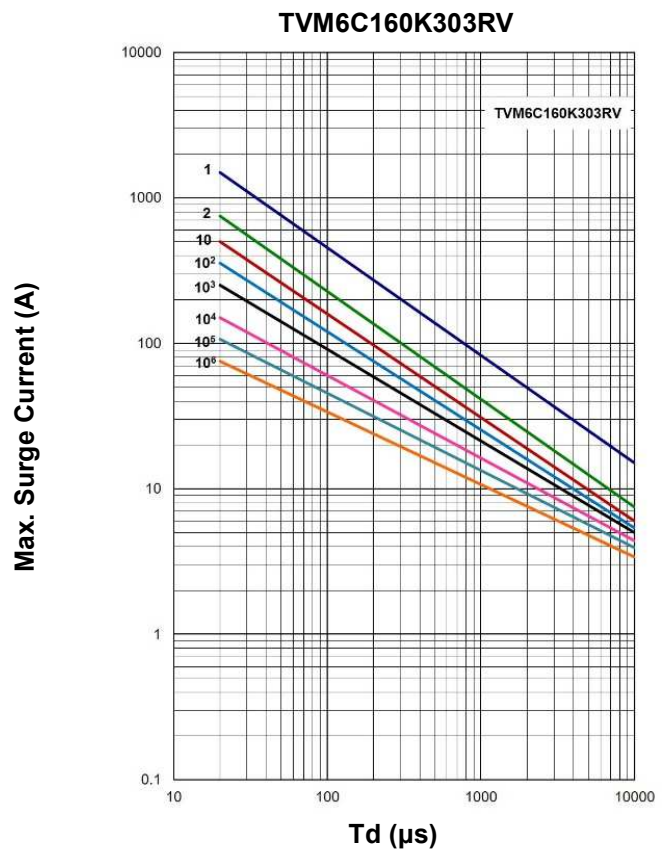
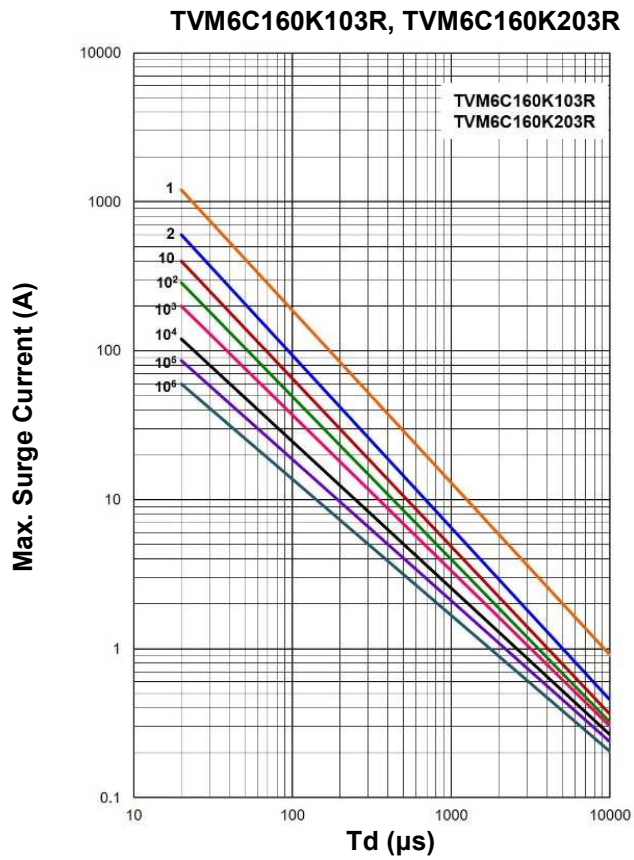


# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Max. Surge Current Derating Curves



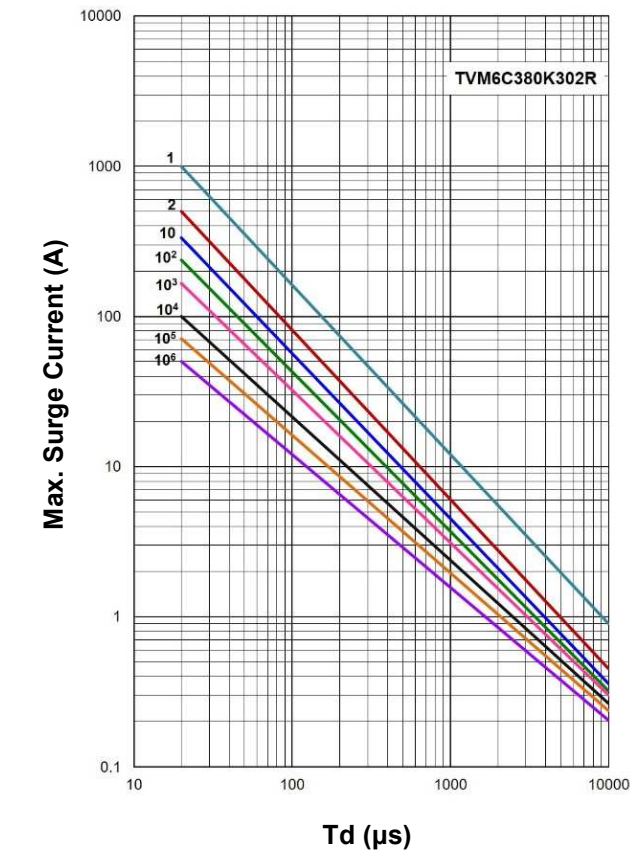
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



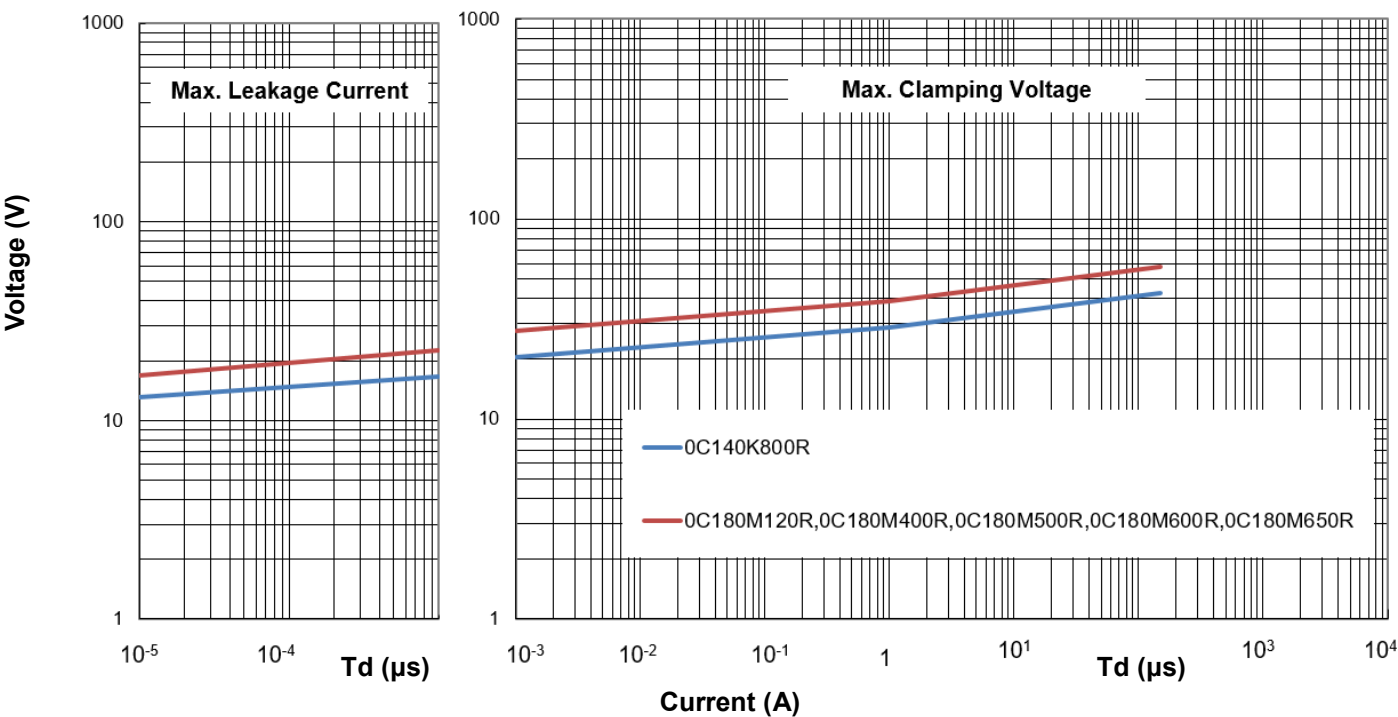
### ■ Max. Surge Current Derating Curves

TVM6C380K302R



### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM0C140K800R~TVM0C180M650R)



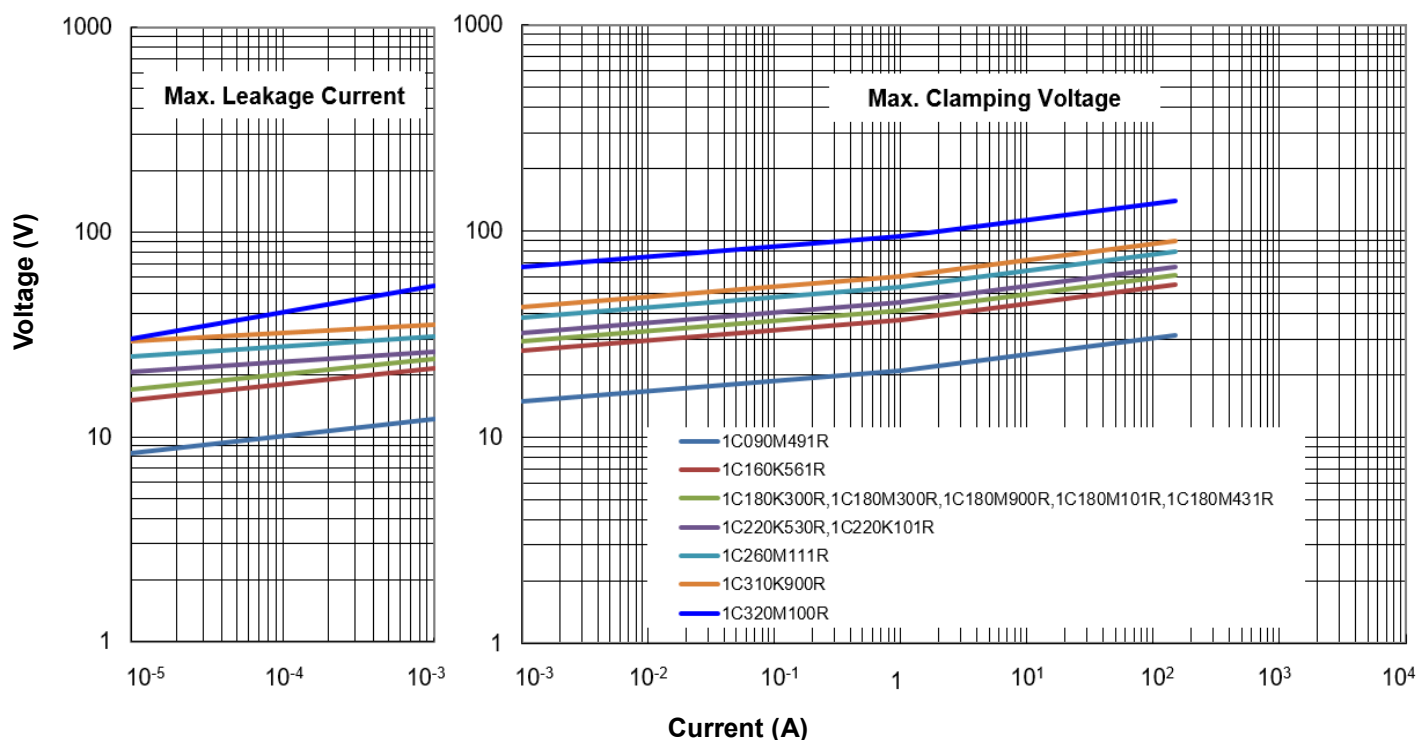
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

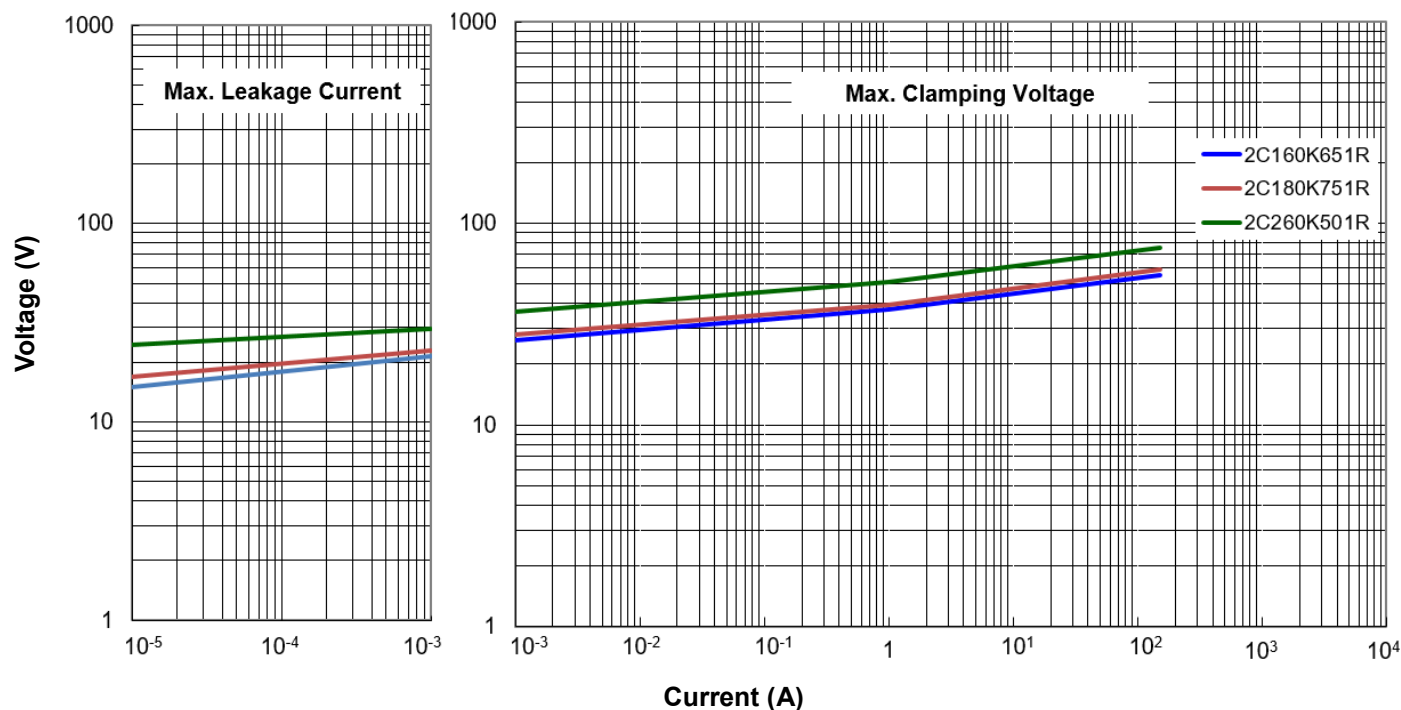


### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM1C090M491R~TVM1C320M100R)



Max. Leakage Current and Max. Clamping Voltage Curves (TVM2C160K651R~TVM2C260K501R)



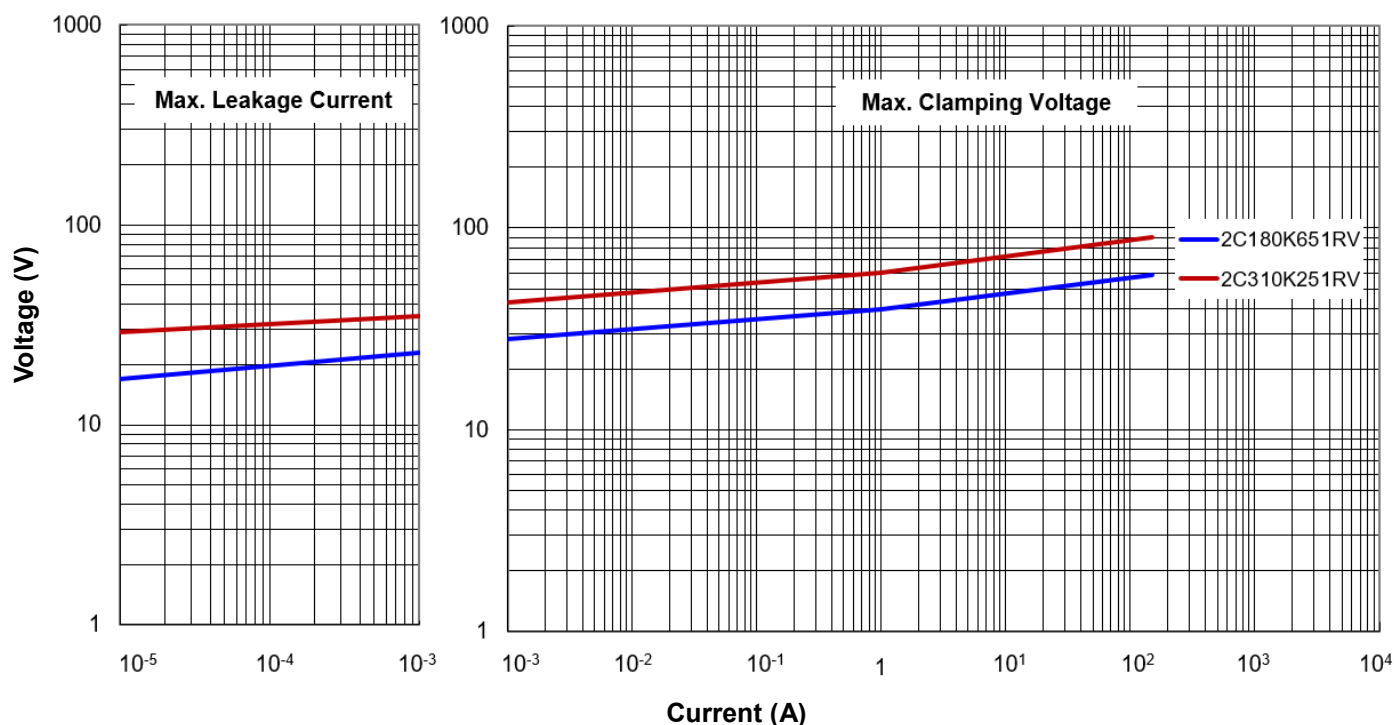
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

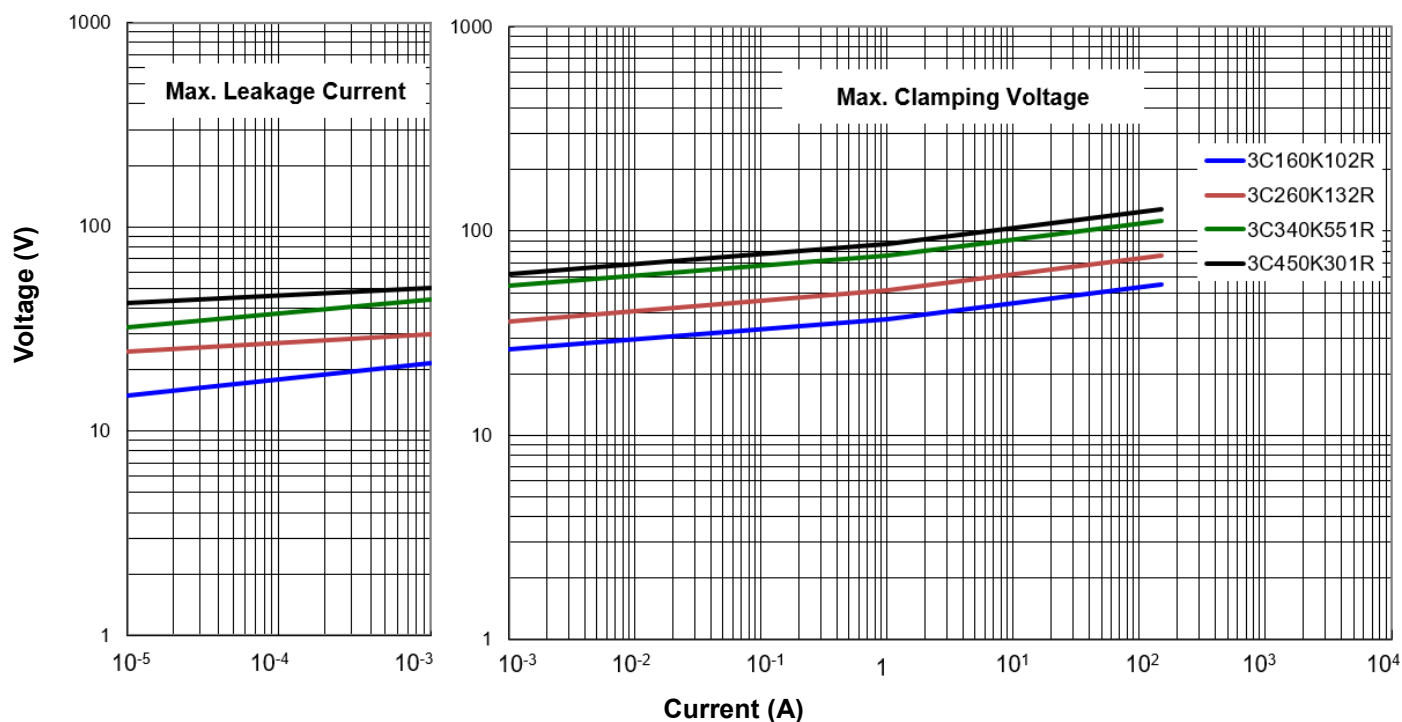


### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM2C180K651RV, TVM2C310K251RV)



Max. Leakage Current and Max. Clamping Voltage Curves (TVM3C160K102R~TVM3C450K301R)



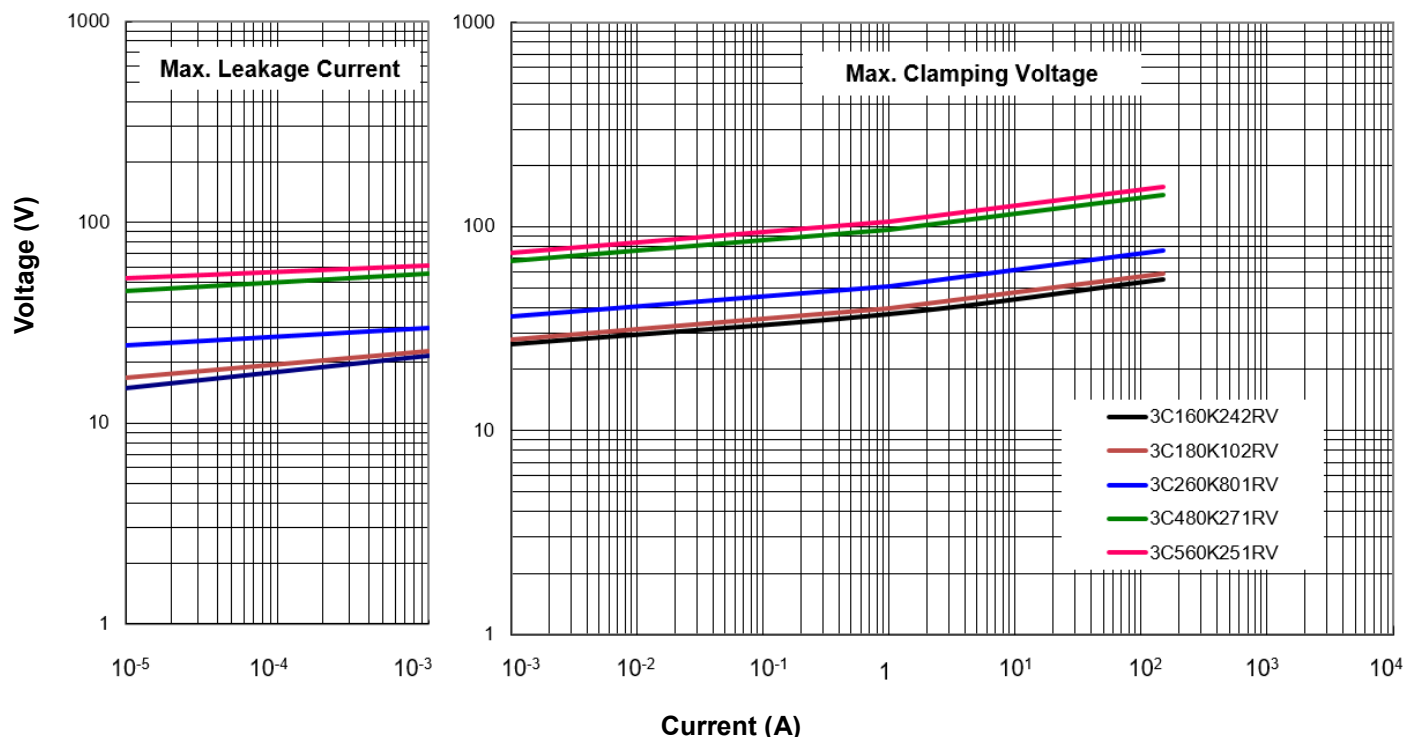
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

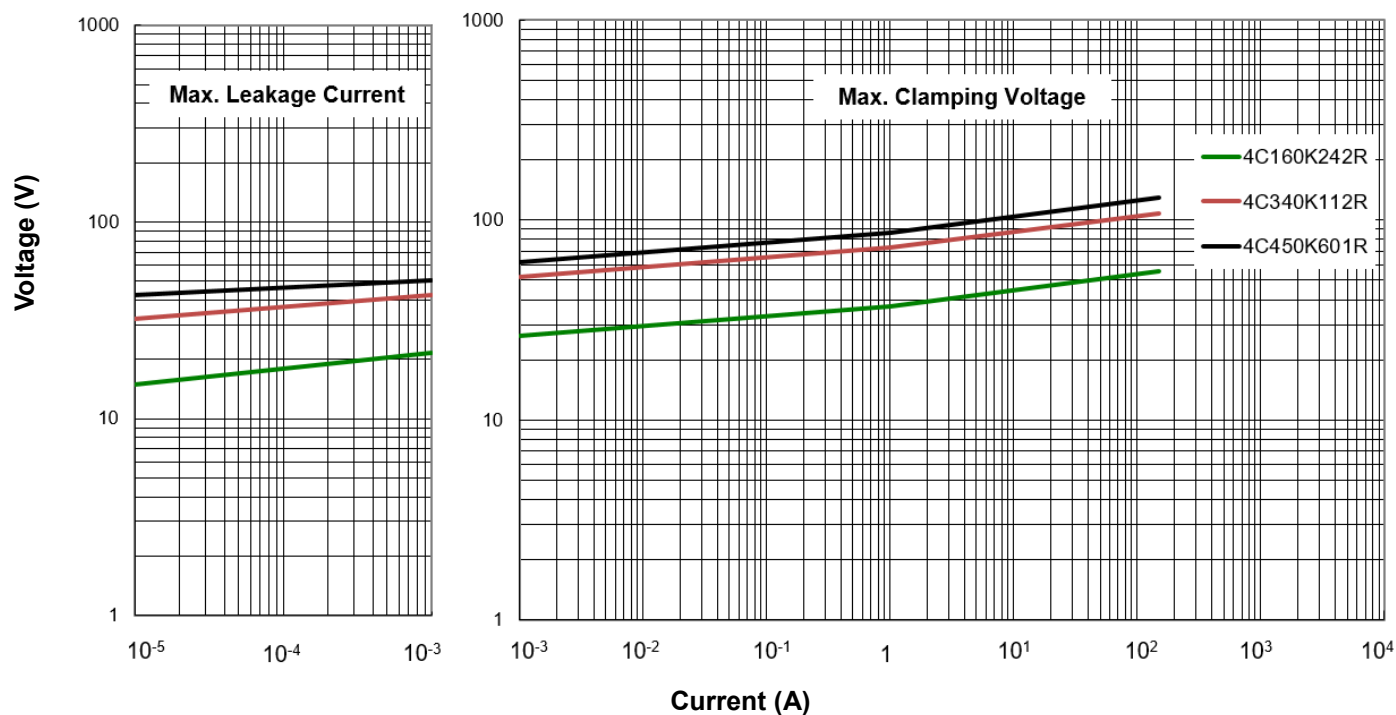


### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM3C160K242RV~TVM3C560K251RV)



Max. Leakage Current and Max. Clamping Voltage Curves (TVM4C160K242R~TVM4C450K601R)



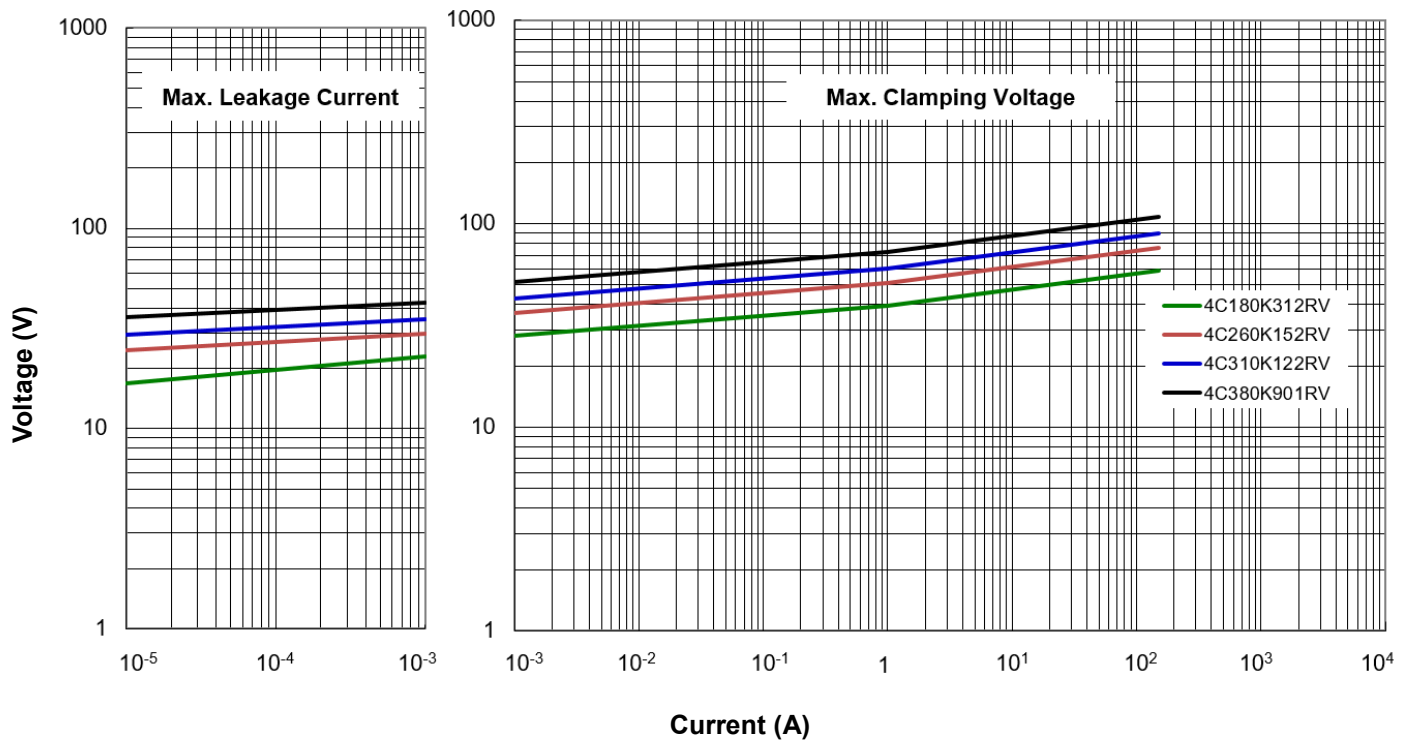
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

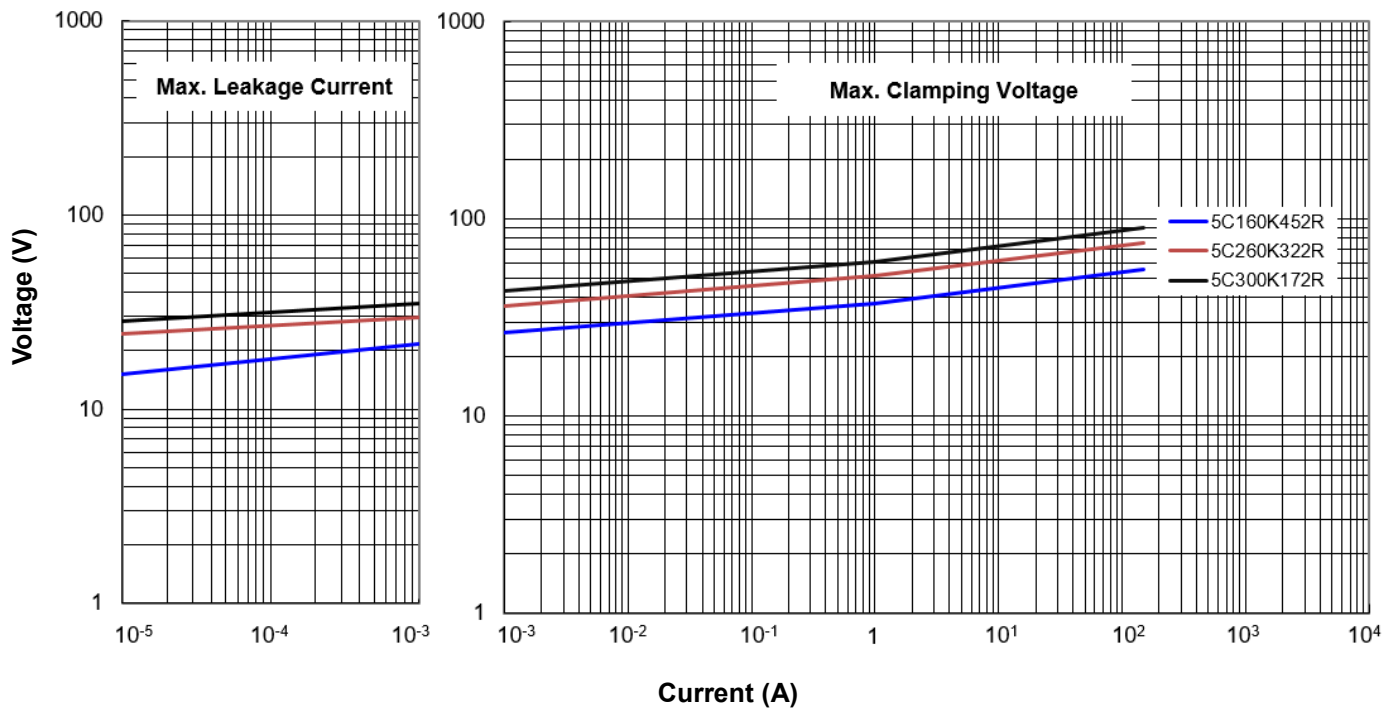


### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM4C180K312RV~TVM4C380901RV)



Max. Leakage Current and Max. Clamping Voltage Curves (TVM5C160K452R~TVM5C300K172R)



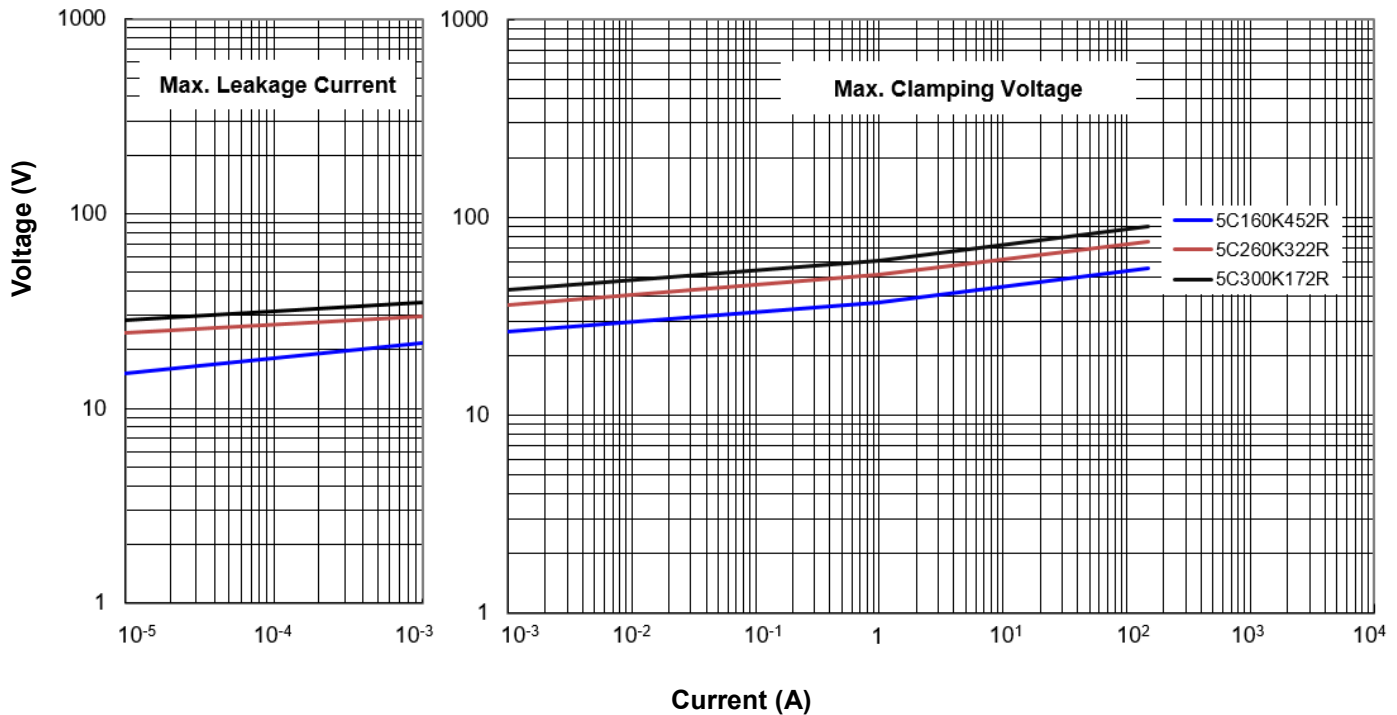
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

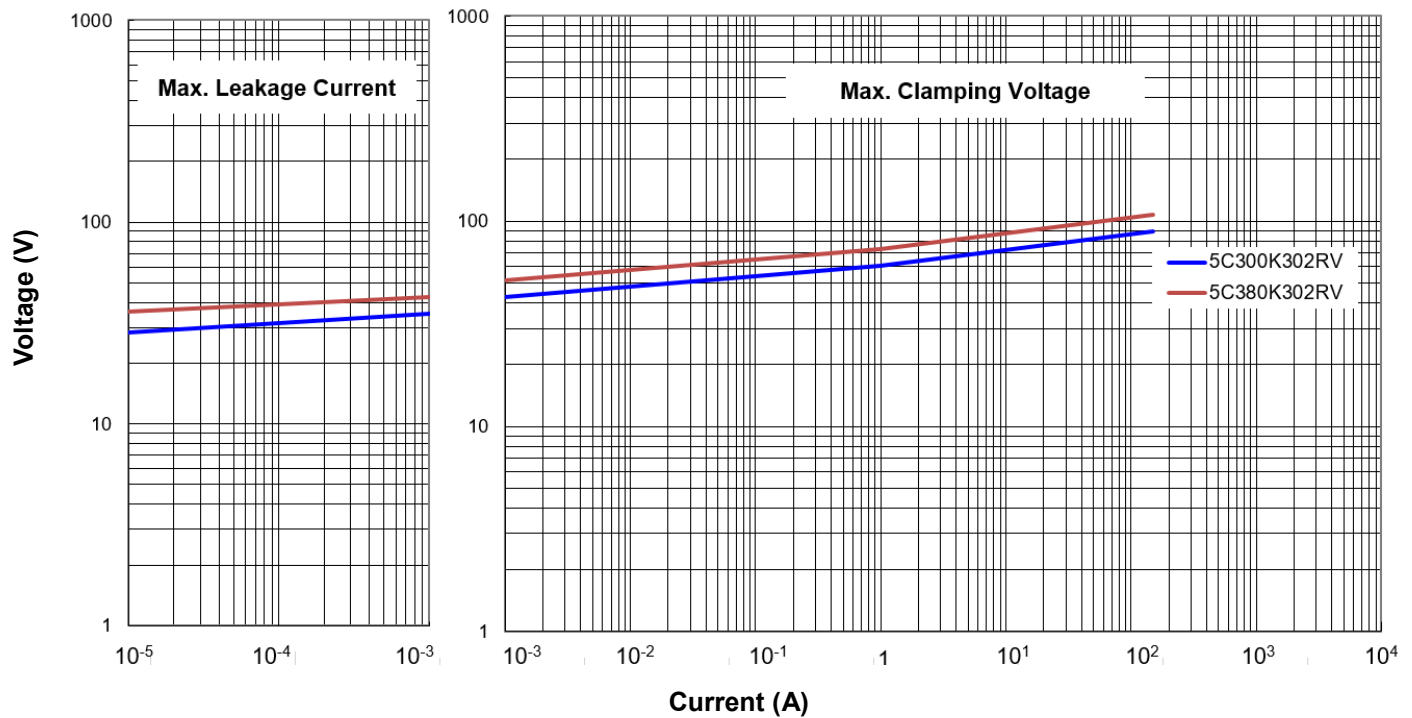


### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM5C160K452R~TVM5C300K172R)



Max. Leakage Current and Max. Clamping Voltage Curves (TVM5C300K302RV, TVM5C380K302RV)



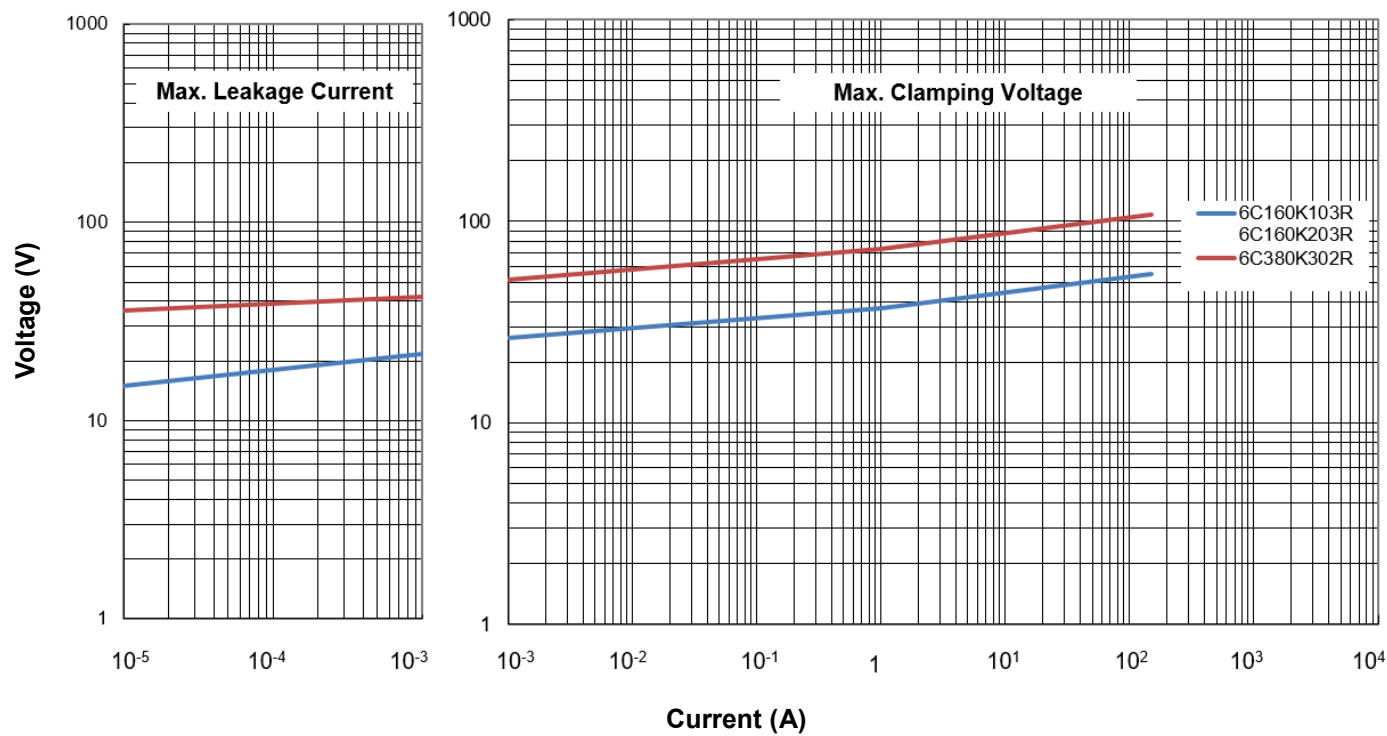
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection

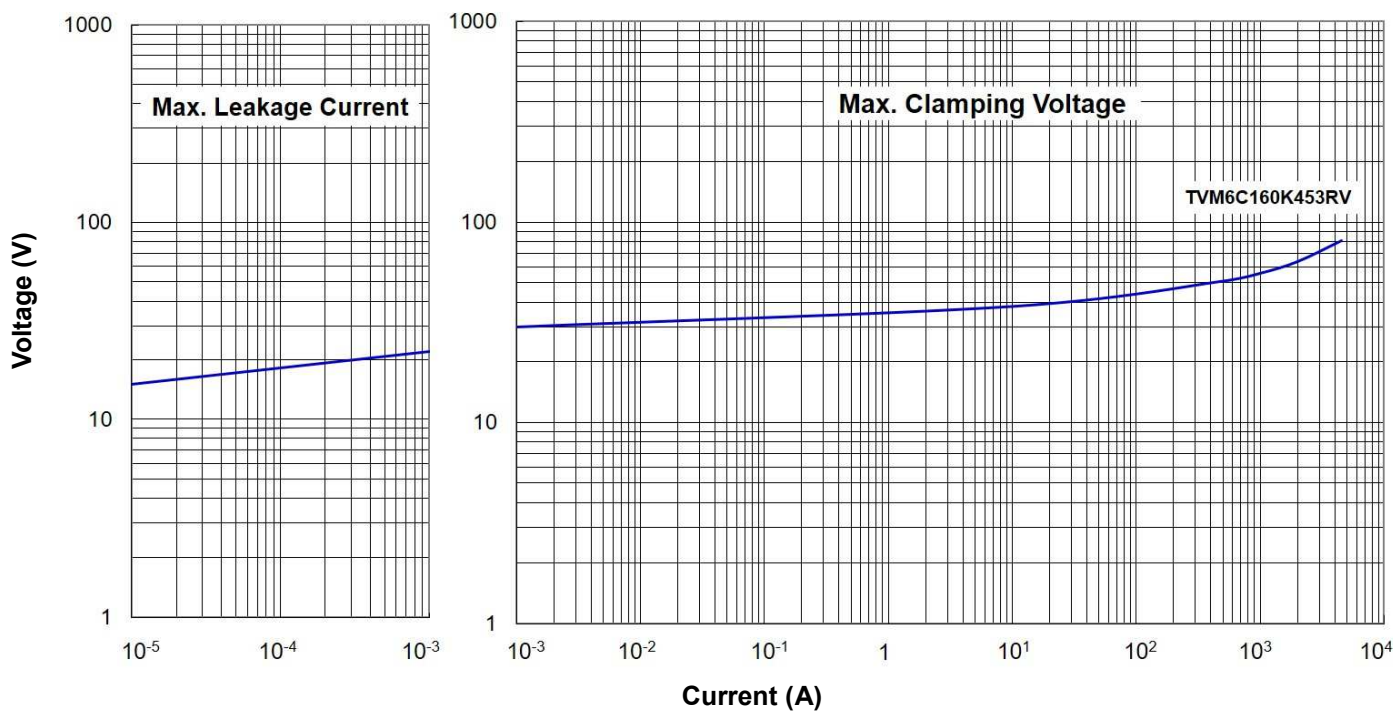


### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM6C160K103R~TVM6C380K302R)



Max. Leakage Current and Max. Clamping Voltage Curves (TVM6C160K453RV)



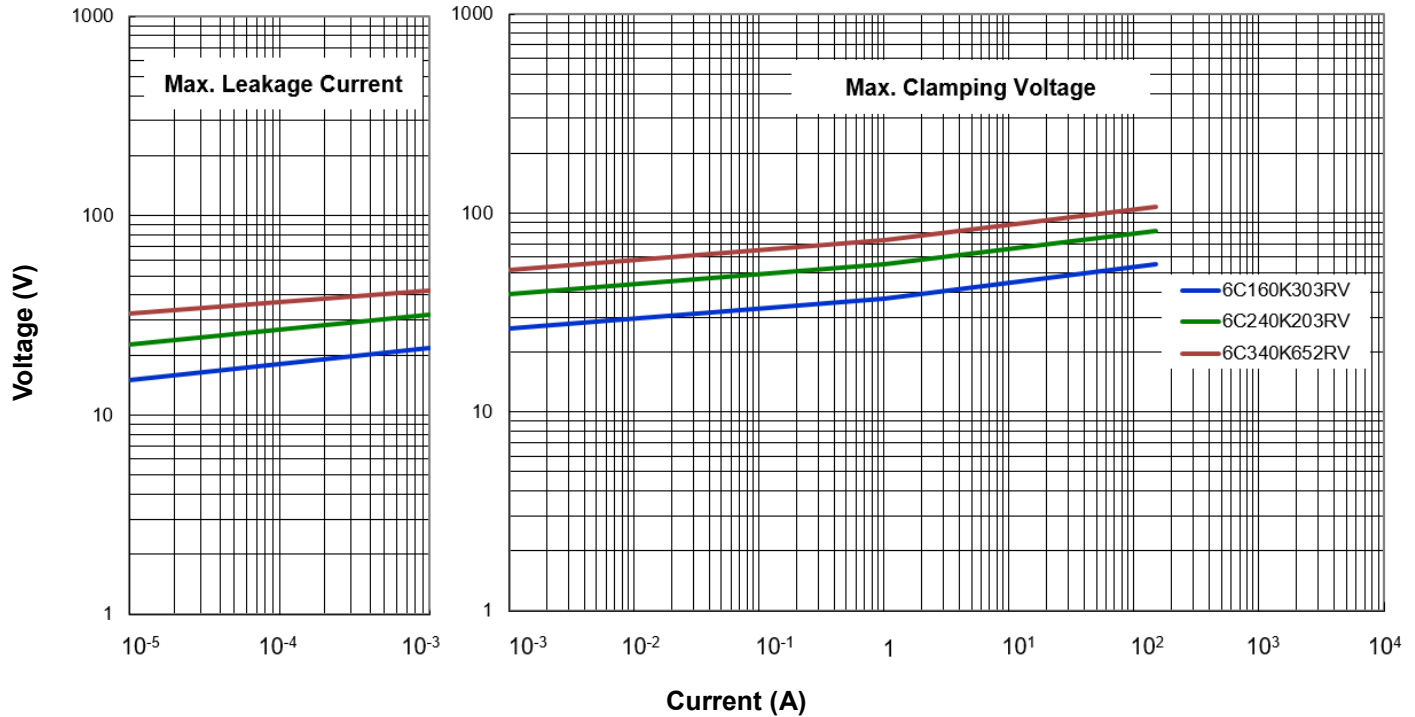
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



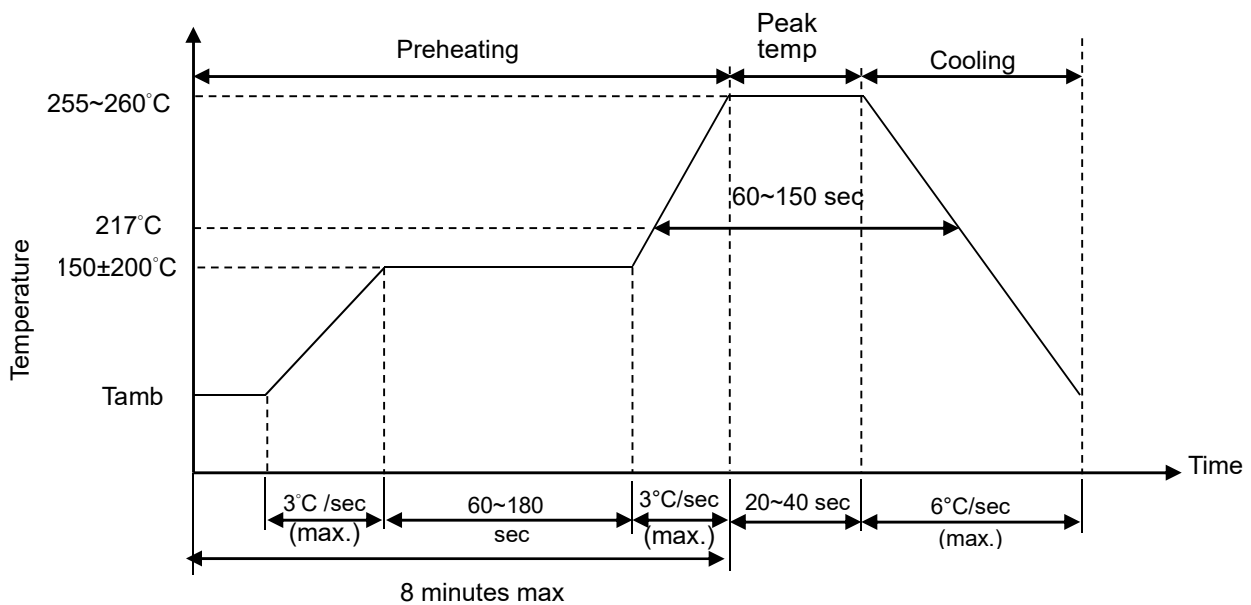
### ■ Max. Leakage Current and Max. Clamping Voltage Curves

Max. Leakage Current and Max. Clamping Voltage Curves (TVM6C160K303RV~TVM6C340K652RV)



### ■ Soldering Recommendation

#### ● IR-Reflow Soldering Profile



# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



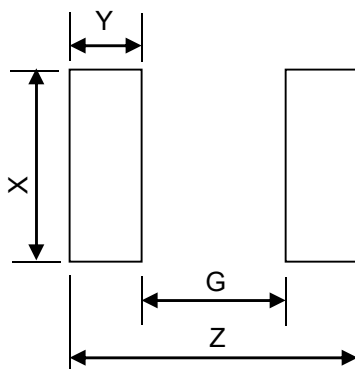
### ■ Soldering Recommendation

#### ● Reworking Conditions with Soldering Iron

| Item                              | Conditions   |
|-----------------------------------|--------------|
| Temperature of Soldering Iron-tip | 360°C (max.) |
| Soldering Time                    | 3 sec (max.) |
| Diameter of Soldering Iron-tip    | Φ 3mm (max.) |

Caution: Do not touch the component surface with soldering iron directly to prevent it from damage.

### ■ Recommended Soldering Pad Dimensions



| Size | Z (mm) | G (mm) | X (mm) | Y (mm) |
|------|--------|--------|--------|--------|
| 0402 | 1.4    | 0.4    | 0.5    | 0.5    |
| 0603 | 2.8    | 0.8    | 1.0    | 1.0    |
| 0805 | 3.4    | 1.0    | 1.4    | 1.2    |
| 1206 | 4.5    | 2.1    | 1.8    | 1.2    |
| 1210 | 4.5    | 2.1    | 2.8    | 1.2    |
| 1812 | 6.0    | 3.0    | 3.6    | 1.5    |
| 2220 | 7.2    | 4.2    | 5.5    | 1.5    |

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Reliability (based on AEC-Q200 Rev-D)

| Item                                | Standard                   | Test conditions / Methods                                                                                                                                                                                                     | Specifications                                            |
|-------------------------------------|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| High Temperature Exposure (Storage) | MIL-STD-202<br>Method 108  | Test temp.: 150 +3/-0°C<br>Duration: 1000 h Unpowered<br>Measurement at 24±2 hours after test conclusion.                                                                                                                     | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Temperature Cycling                 | JESD22<br>Method JA-104    | Lower test temp.: -55 +0/-3°C<br>Upper test temp.: 125 +3/-0°C<br>Soak Time at Lower or Upper Temp. : 30 min<br>Maximum transition time: 1 min.<br>Number of cycles: 1000<br>Measurement at 24±4 hours after test conclusion. | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Biased Humidity                     | MIL-STD-202<br>Method 103  | Test temp: 85°C<br>Rel. humidity of air: 85% +5/-0%<br>Duration: 1000 h<br>Bias at Working Voltage $V_{DC}$ .<br>Measurement at 24±4 hours after test conclusion.                                                             | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Operational Life                    | MIL-STD-202<br>Method 108  | Test temp.: 125 +3/-0°C<br>Duration: 1000 h<br>Bias at Working Voltage $V_{DC}$<br>Measurement at 24±4 hours after test conclusion.                                                                                           | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| External Visual                     | MIL-STD-883<br>Method 2009 | Inspect device construction, marking and workmanship.                                                                                                                                                                         | No visible damage                                         |
| Physical Dimension                  | JESD22<br>Method JB-100    | Verify physical dimensions to the applicable device specification.                                                                                                                                                            | Within the specified values                               |
| Resistance to Solvents              | MIL-STD-202<br>Method 215  | Per MIL-STD-202 Method 215<br>Solvent 1:1 part (by volume) of isopropyl alcohol 3 part (by volume) of mineral spirits.                                                                                                        | No visible damage                                         |
| Mechanical Shock                    | MIL-STD-202<br>Method 213  | Test Condition F<br>Peak value: 1500g's<br>Half sine Waveform<br>Normal duration (D): 0.5ms<br>In 3 directions perpendicularly intersecting each other (total 18 times).                                                      | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Reliability (based on AEC-Q200 Rev-D)

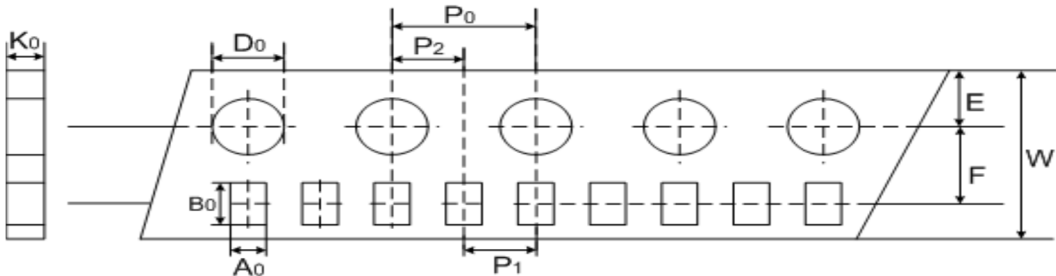
| Item                            | Standard                    | Test conditions / Methods                                                                                                                       | Specifications                                            |
|---------------------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| Vibration                       | MIL-STD-202<br>Method 204   | Acceleration: 5 g's<br>Sweep time: 20 min<br>Frequency range: 10 to 2000 Hz<br>3×12 cycles                                                      | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Resistance to Soldering Heat    | MIL-STD-202<br>Method 210   | Condition B No pre-heat of samples.<br>Temperature: 260±5°C, Time: 10±1s<br>Immersion and emersion rate: 25±6 mm/s<br>Number of heat cycles : 1 | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 5\%$  |
| ESD                             | AEC-Q200-002                | Discharge capacitance: 150 pF<br>Test from 6KV DC to 25KV AD<br>1 pulse in each polarity<br>(DC=Direct Contact Discharge, AD=Air Discharge)     | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Solderability                   | IEC 60068-2-58<br>J-STD-002 | a) 4 h @ 155°C dry heat<br>Dip @245±5°C 3±0.3sec<br>b) Steam aging 8h±15min @93±3°C<br>Dip @260±5°C 7±0.5sec                                    | 95% of termination wetted                                 |
| Electrical Characterization     | Specifications              | V1mA(-55°C), V1mA(25°C), V1mA(125°C)                                                                                                            | Within the specified values                               |
| Board Flex                      | AEC-Q200-005                | Bend the board: 2mm (Min.)<br>Duration: 60 (+5) Sec                                                                                             | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Terminal Strength               | AEC-Q200-006                | Apply force:<br>0201=0.15kg (1.5 N)<br>0402=0.5kg (5 N)<br>0603=1.0kg (10 N)<br>≥ 0805=1.8kg (17.7 N)<br>Duration: 60 (+1) Sec                  | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 10\%$ |
| Electrical Transient Conduction | ISO-7637-2                  | Test pulses 5a<br>Number of pulses: 10<br>Test Energy: W <sub>LD</sub> (Load dump )                                                             | No visible damage<br>$ \Delta V_{1mA}/V_{1mA}  \leq 15\%$ |

# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



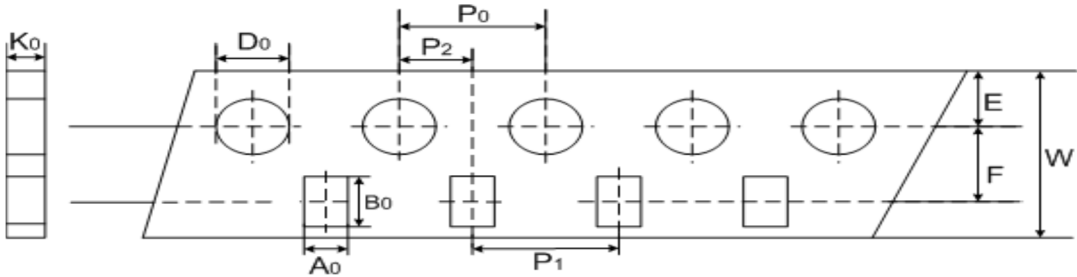
- Packaging
  - Taping Specification (SMD 0402)



(Unit: mm)

| Index<br>Size | $A_0$      | $B_0$      | $W$       | $E$       | $F$        | $P_1$     | $P_2$      | $P_0$     | $D_0$     | $K_0$     |
|---------------|------------|------------|-----------|-----------|------------|-----------|------------|-----------|-----------|-----------|
| 0402          | $\pm 0.05$ | $\pm 0.12$ | $\pm 0.2$ | $\pm 0.1$ | $\pm 0.05$ | $\pm 0.1$ | $\pm 0.05$ | $\pm 0.1$ | $\pm 0.1$ | $\pm 0.1$ |

- Taping Specification (SMD 0603 & 0805)



(Unit: mm)

| Index<br>Size | $A_0$ | $B_0$ | $W$ | $E$  | $F$ | $P_1$ | $P_2$ | $P_0$ | $D_0$ | $K_0$ |
|---------------|-------|-------|-----|------|-----|-------|-------|-------|-------|-------|
| 0603          | 1.1   | 1.9   | 8   | 1.75 | 3.5 | 4     | 2     | 4     | 1.55  | 0.95  |
| 0805          | 1.5   | 2.3   | 8   | 1.75 | 3.5 | 4     | 2     | 4     | 1.55  | 1.0   |

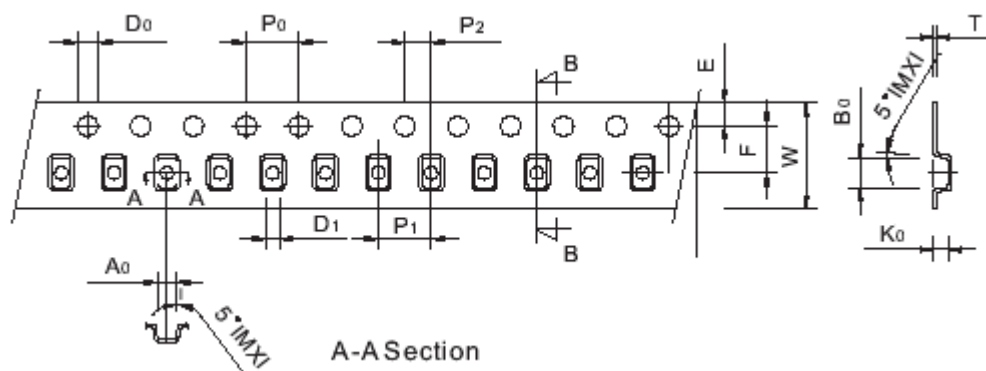
# Varistor for Automotive: TVM-C Series

## SMD Type for Transient Overvoltage Protection



### ■ Packaging

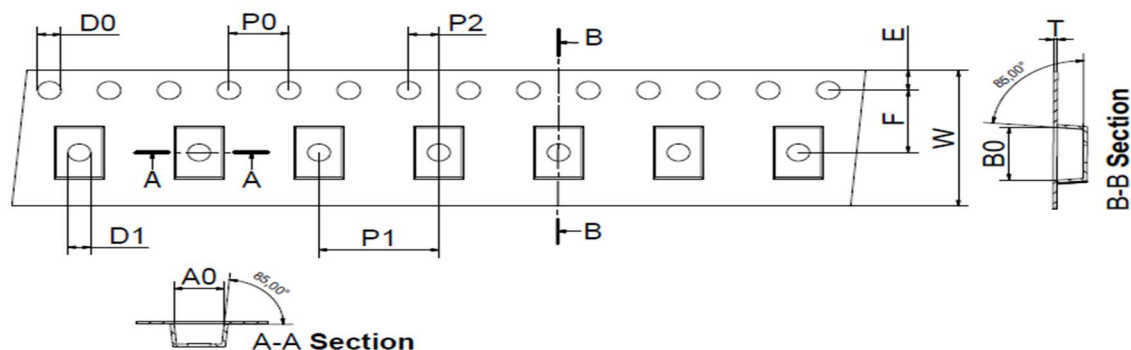
#### ● Taping Specification (SMD 1206 & 1210)



(Unit: mm)

| Index<br>Size | A <sub>0</sub> | B <sub>0</sub> | W    | E    | F     | P <sub>1</sub> | P <sub>2</sub> | P <sub>0</sub> | D <sub>0</sub> | D <sub>1</sub> | T    |
|---------------|----------------|----------------|------|------|-------|----------------|----------------|----------------|----------------|----------------|------|
| 1206          | ±0.2           | ±0.2           | ±0.2 | ±0.1 | ±0.05 | ±0.1           | ±0.05          | ±0.1           | ±0.1           | ±0.1           | ±0.1 |
| 1210          | 1.85           | 3.45           | 8    | 1.75 | 3.5   | 4              | 2              | 4              | 1.55           | 1              | 0.25 |
| 1210          | 2.75           | 3.55           | 8    | 1.75 | 3.5   | 4              | 2              | 4              | 1.55           | 1              | 0.25 |

#### ● Taping Specification(SMD 1812 & 2220)



(Unit: mm)

| Index<br>Size | A <sub>0</sub> | B <sub>0</sub> | W    | E    | F     | P <sub>1</sub> | P <sub>2</sub> | P <sub>0</sub> | D <sub>0</sub> | D <sub>1</sub> | T    |
|---------------|----------------|----------------|------|------|-------|----------------|----------------|----------------|----------------|----------------|------|
| 1812          | ±0.2           | ±0.2           | ±0.3 | ±0.1 | ±0.05 | ±0.1           | ±0.05          | ±0.1           | ±0.1           | ±0.1           | ±0.1 |
| 2220          | 3.65           | 4.96           | 12   | 1.75 | 5.5   | 8              | 2              | 4              | 1.55           | 1.5            | 0.25 |
| 2220          | 5.50           | 6.25           | 12   | 1.75 | 5.5   | 8              | 2              | 4              | 1.55           | 1.5            | 0.25 |

# Varistor for Automotive: TVM-C Series

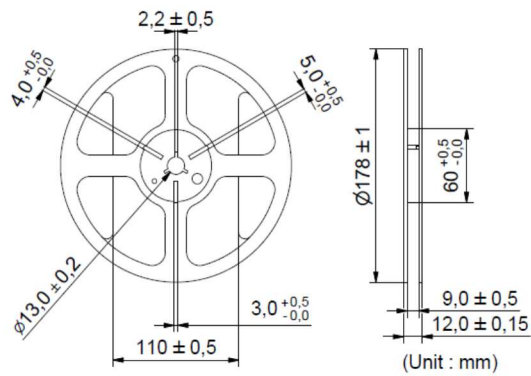
## SMD Type for Transient Overvoltage Protection



### ■ Packaging

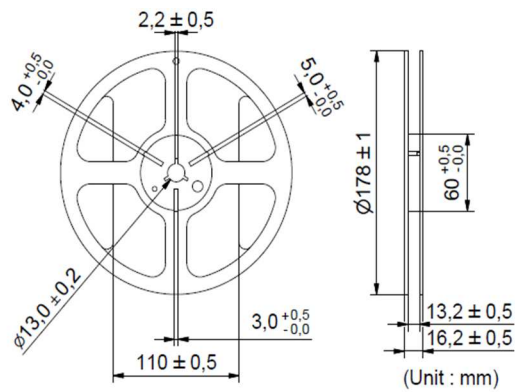
#### ● Quantity

##### ◆ 0402 ~ 1210



| Type | Quantity (pcs/reel) |
|------|---------------------|
| 0402 | 10,000              |
| 0603 | 4,000               |
| 0805 | 3,000               |
| 1206 | 2,000               |
| 1210 | 2,000               |

##### ◆ 1812~2220



| Type | Quantity (pcs/reel) |
|------|---------------------|
| 1812 | 1,000               |
| 2220 | 800                 |

### ■ Warehouse Storage Conditions of Products

- Storage Conditions :
  1. Storage Temperature: -10°C~+40°C
  2. Relative Humidity: ≤75%RH
  3. Keep away from corrosive atmosphere and sunlight.
- Period of Storage : 1 year