XClampR™ TVS

XMC7K24CA

Explanation of XMC7K24CA the XClampR™ TVS in operation

Rev.006

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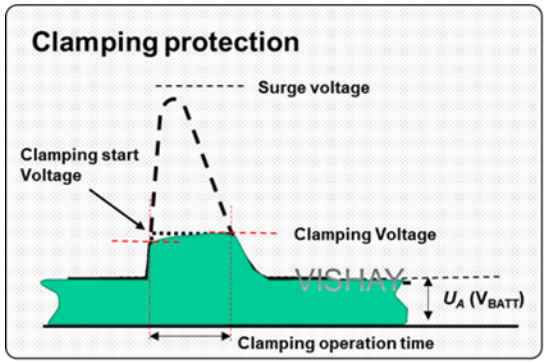
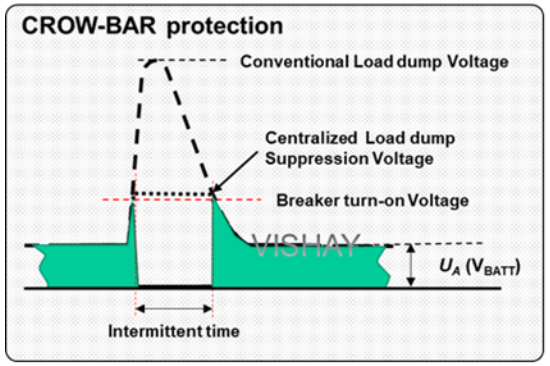
XClampR™ TVS

- Extremely low clamping voltage ratio
- Extremely low clamping voltage
- Extremely stable breakdown voltage (V_{BR}) over a wide operating temperature range
  - (-55 °C to +175 °C)
  - Very low temperature coefficient (αT)
- Extremely stable clamping voltage (V_C) over a wide operating temperature range
- High clamping current capability
- Low leakage
- Bi-directional
- Snapback operation
- Variable clamping voltage by conventional TVS combination

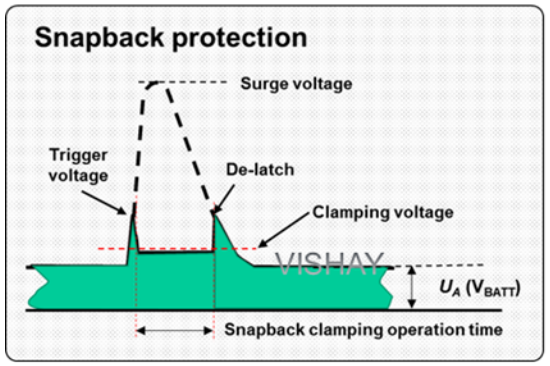
Overvoltage Protection Types



Circuit type	ABD TVS, Zener, MOV
Advantage	No electrical short Accurate voltage protection control
Disadvantage	High power rating device required



Circuit type	Gas Discharge Tube type surge Arrestor , Thyristor , Load switch
Advantage	No electrical short (Load switch type) Simple and small device required (GDT , Thyristor)
Disadvantage	Intermittence time Fuse blowout (Thyristor type) Circuit reset Big capacitor and polarity protection diode required for power backup (Load switch)

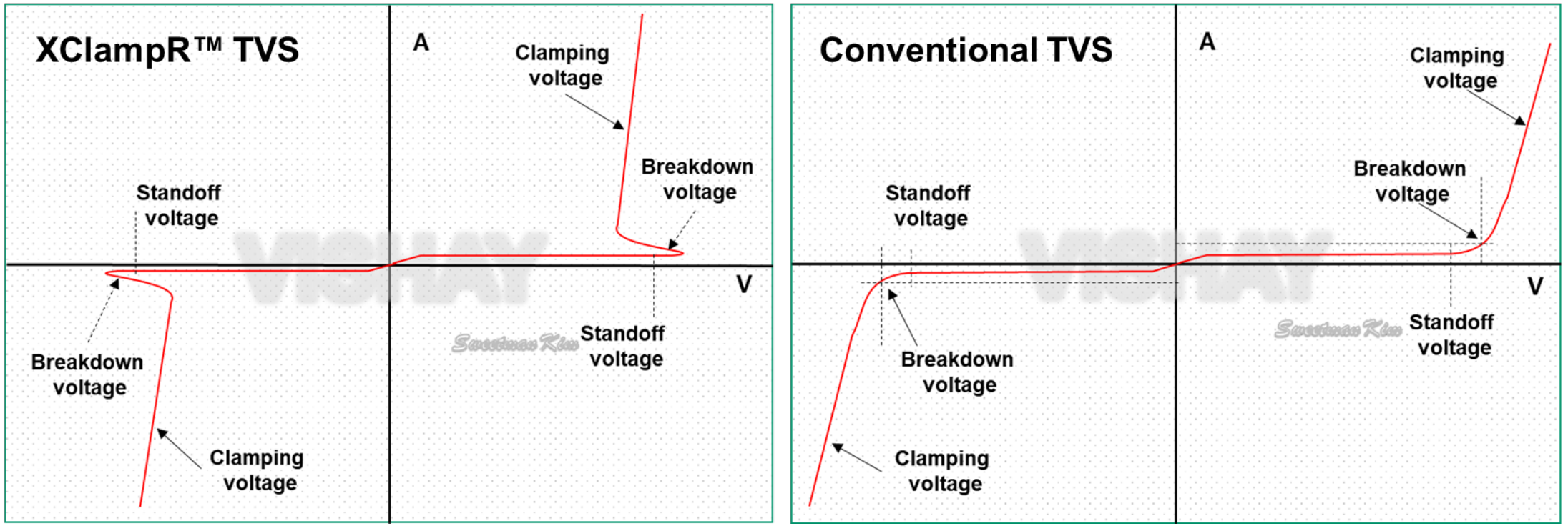


Circuit type	VISHAY XClampR™ TVS
Advantage	No electrical short No intermittent time Accurate voltage protection control
Disadvantage	NOTHING

Snapback Clamping Operation

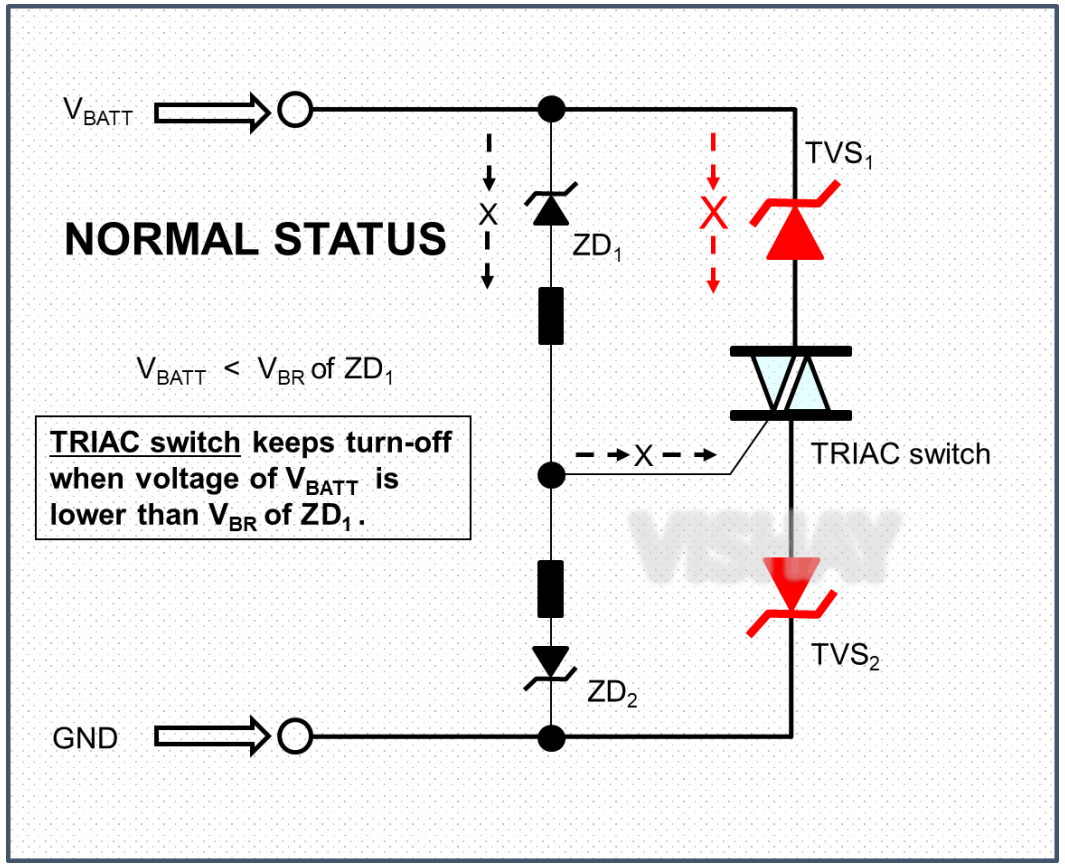
- The XMC7K24CA is a snapback type TVS with an extremely low clamping voltage ratio for suppressing transient voltage to a lower clamping voltage than conventional TVS
- Datasheet : XMC7K24CA

Typical operation curve of XClampR™ TVS and conventional TVS

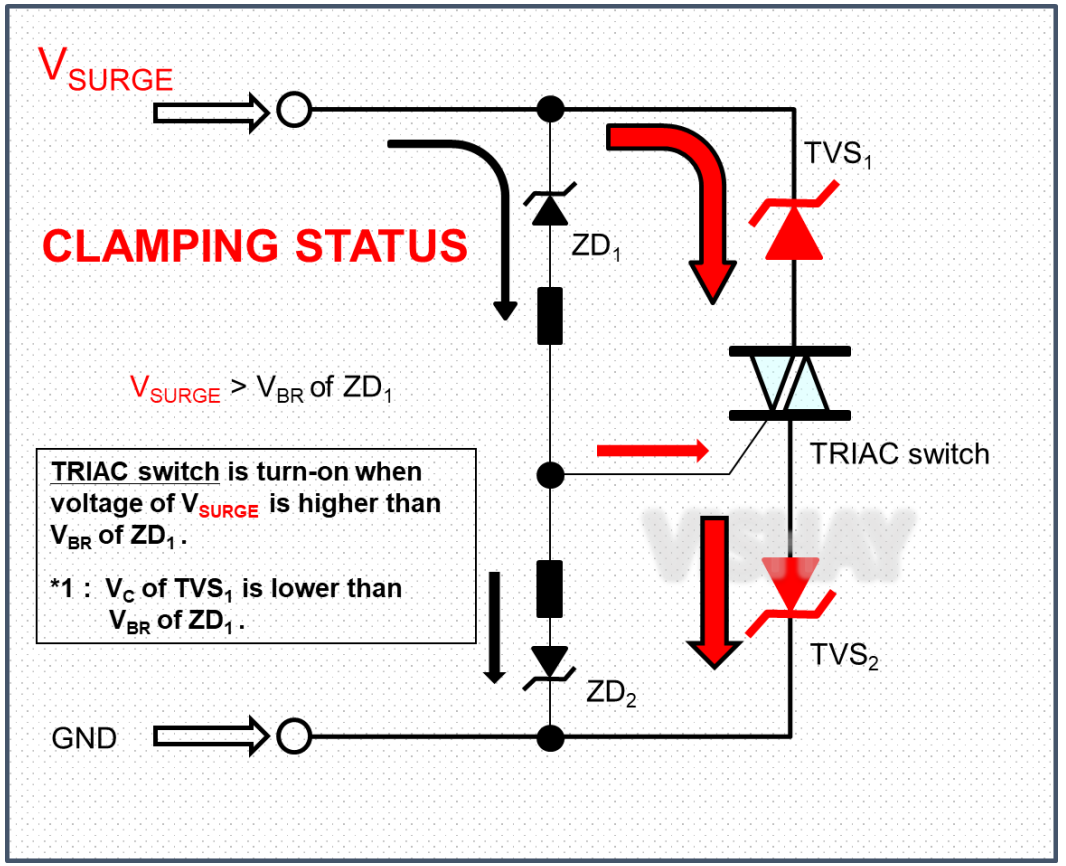


Equivalent Circuit and Operation of XClampR™ TVS (Concept Only)

- XClampR™ TVS does not operate until input voltage over V_{BR} (V_Z)



- XClampR™ TVS operates at input voltage over V_{BR} (V_Z)

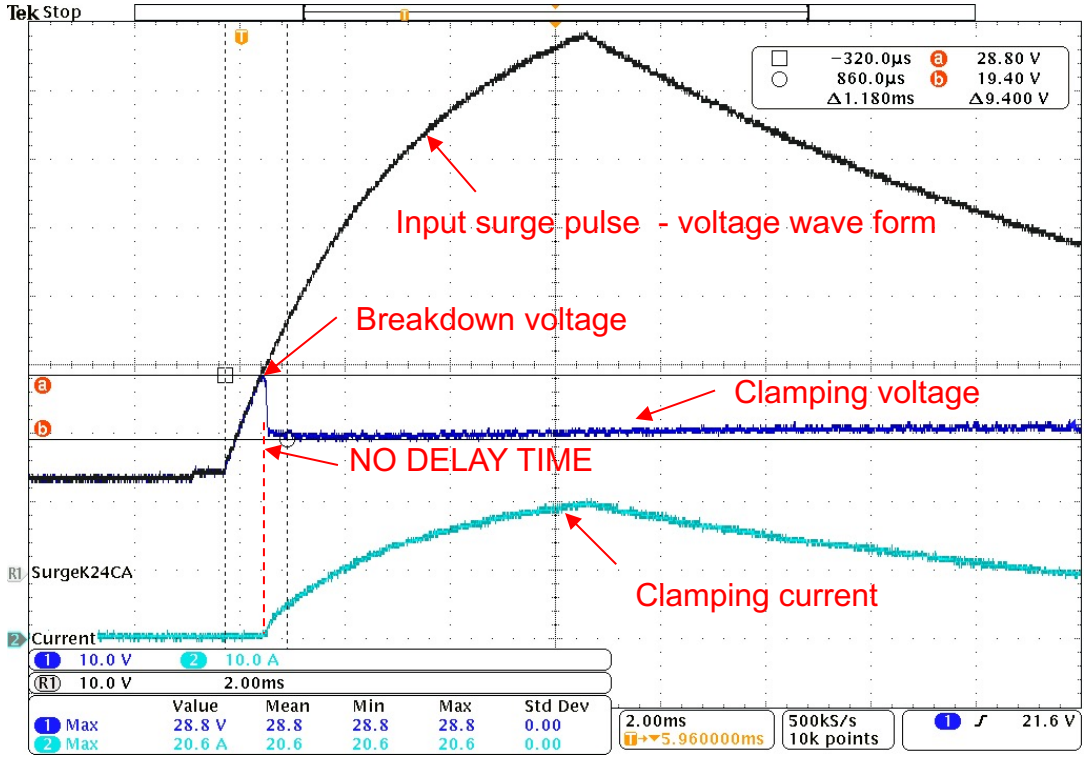


***1 : By this reason, Clamping voltage is lower than V_{BR}**

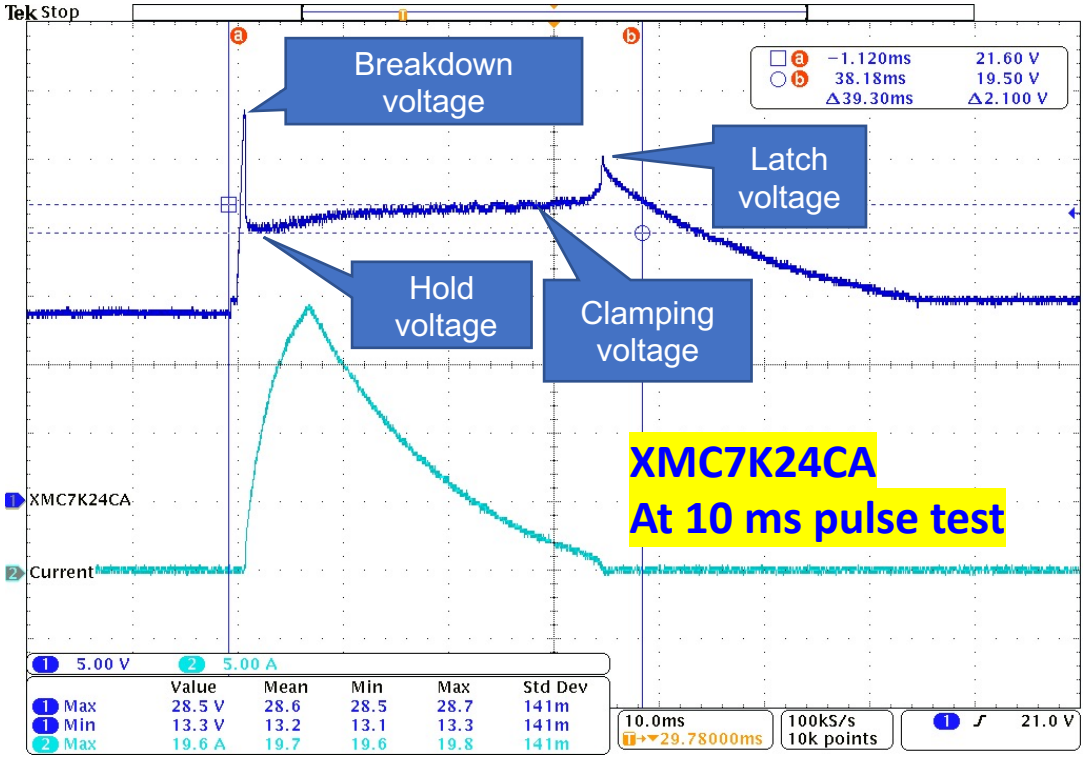
XClampR™ TVS Characteristics in Operation

- Trigger voltage, hold voltage, clamping voltage, and latch voltage

Comparison of surge pulse and clamping operation form

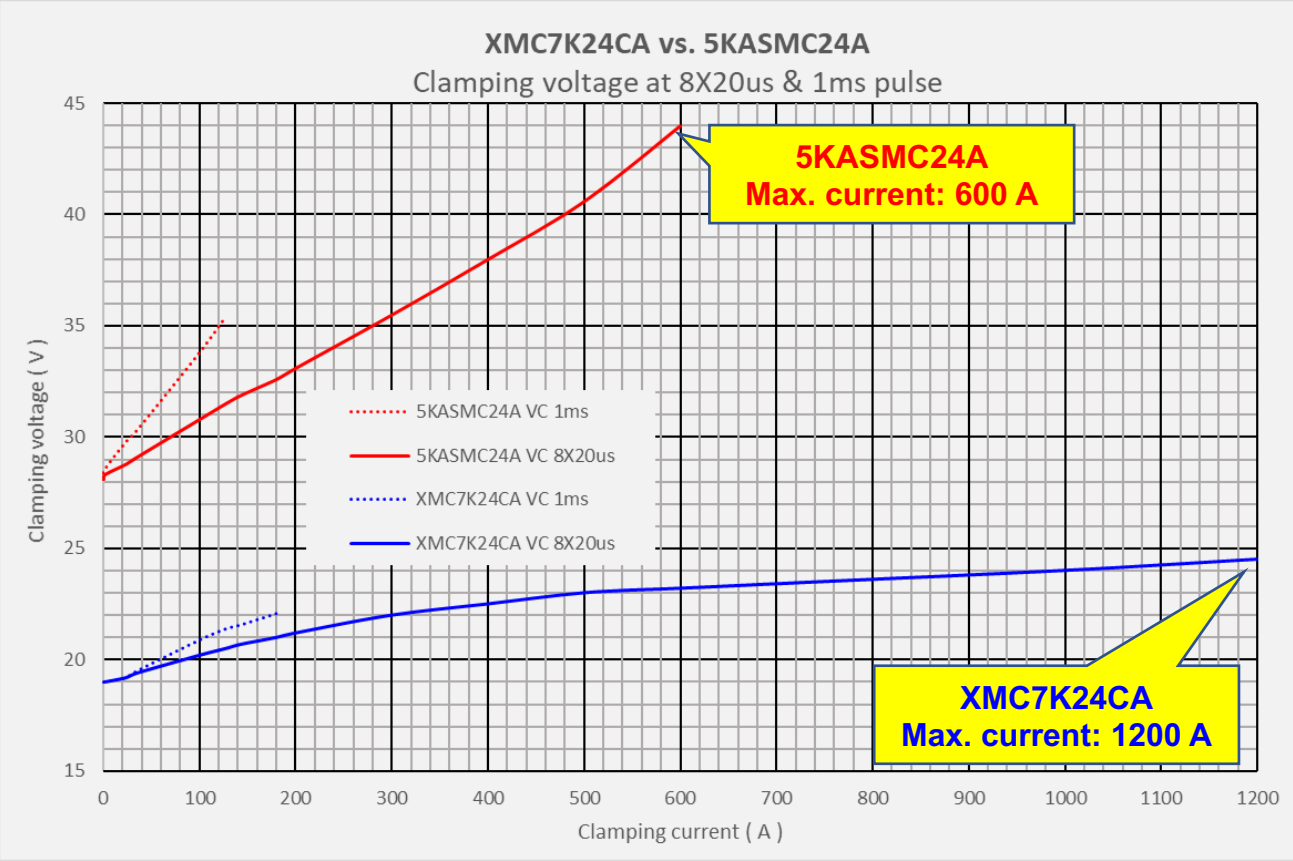


Total clamping operation form comparison



Extremely Low Clamping Ratio

- Compare to **5KASMC24A**

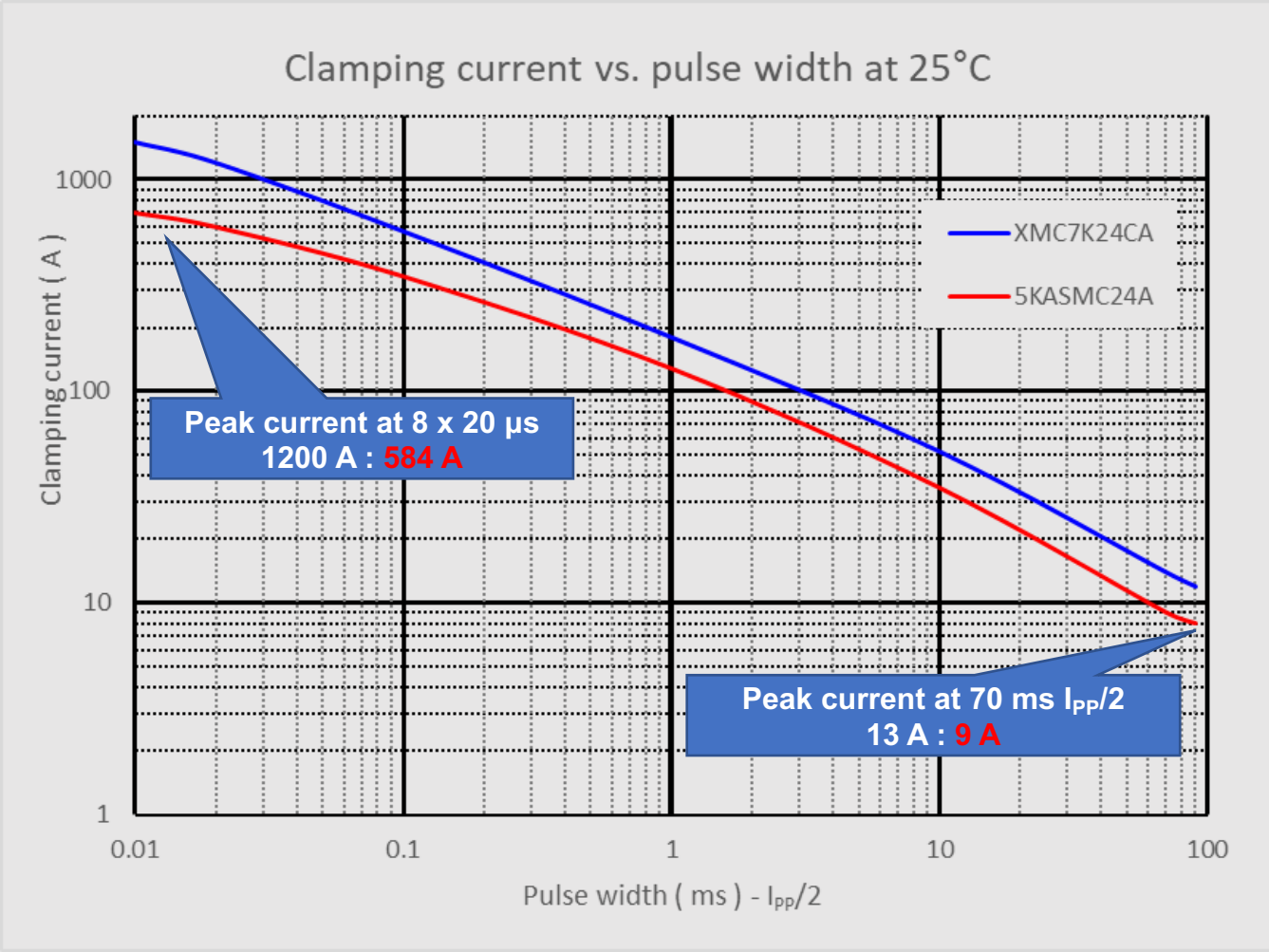


Clamping voltage at 8/20 µs test				
Current (A)	1	100	600	1200
XMC7K24CA (Clamping ratio: 1.22 at 600 A)				
Clamping voltage	19.0	20.2	23.2	24.5
5KASMC24A (Clamping ratio: 1.54)				
Clamping voltage	28.5	31.0	44.0	

Clamping voltage at 1 ms test				
Current (A)	1	100	144	180
XMC7K24CA (Clamping ratio: 1.13 at 144 A)				
Clamping voltage	19.0	21.0	21.5	22.5
5KASMC24A (Clamping ratio: 1.27)				
Clamping voltage	28.5	33.8	36.2	

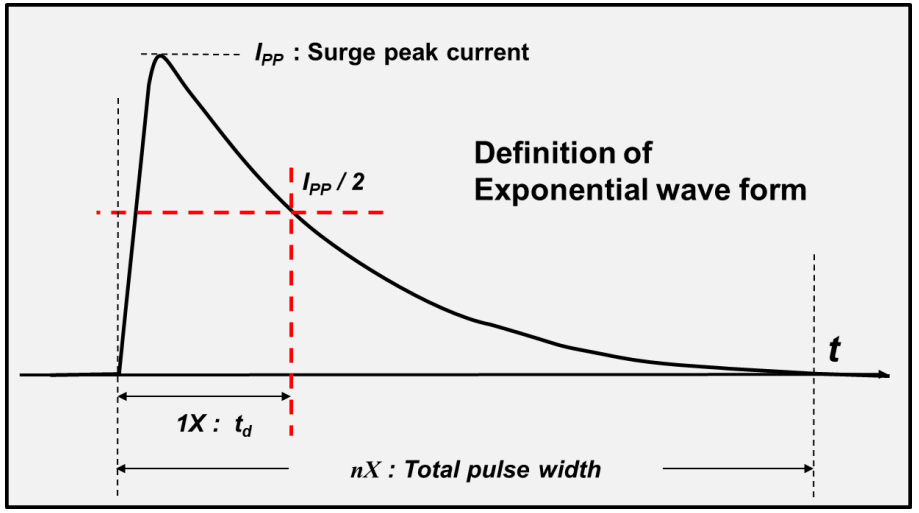
High Clamping Current Capability

- Compare to **5KASMC24A**



	8 x 20 µs	70 ms $I_{PP}/2$
XMC7K24CA	1200 A	13 A
5KASMC24A	584 A	9 A

Definition of $I_{PP}/2$ pulse width



Extremely Stable Breakdown Voltage (V_{BR})

- Total 1.7 V difference only over a wide operating temperature range (-55 °C to +175 °C)

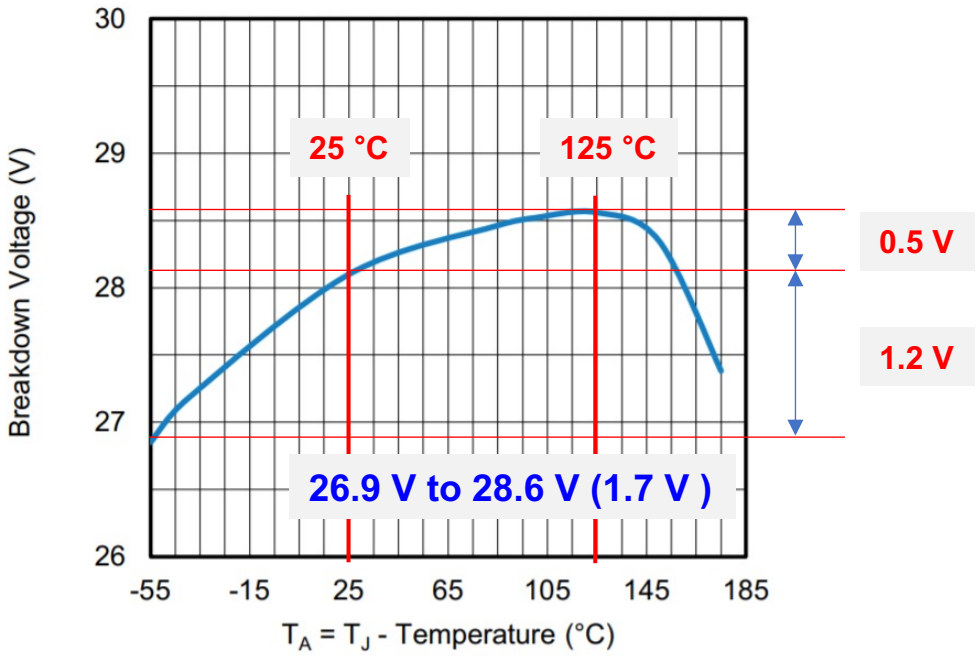
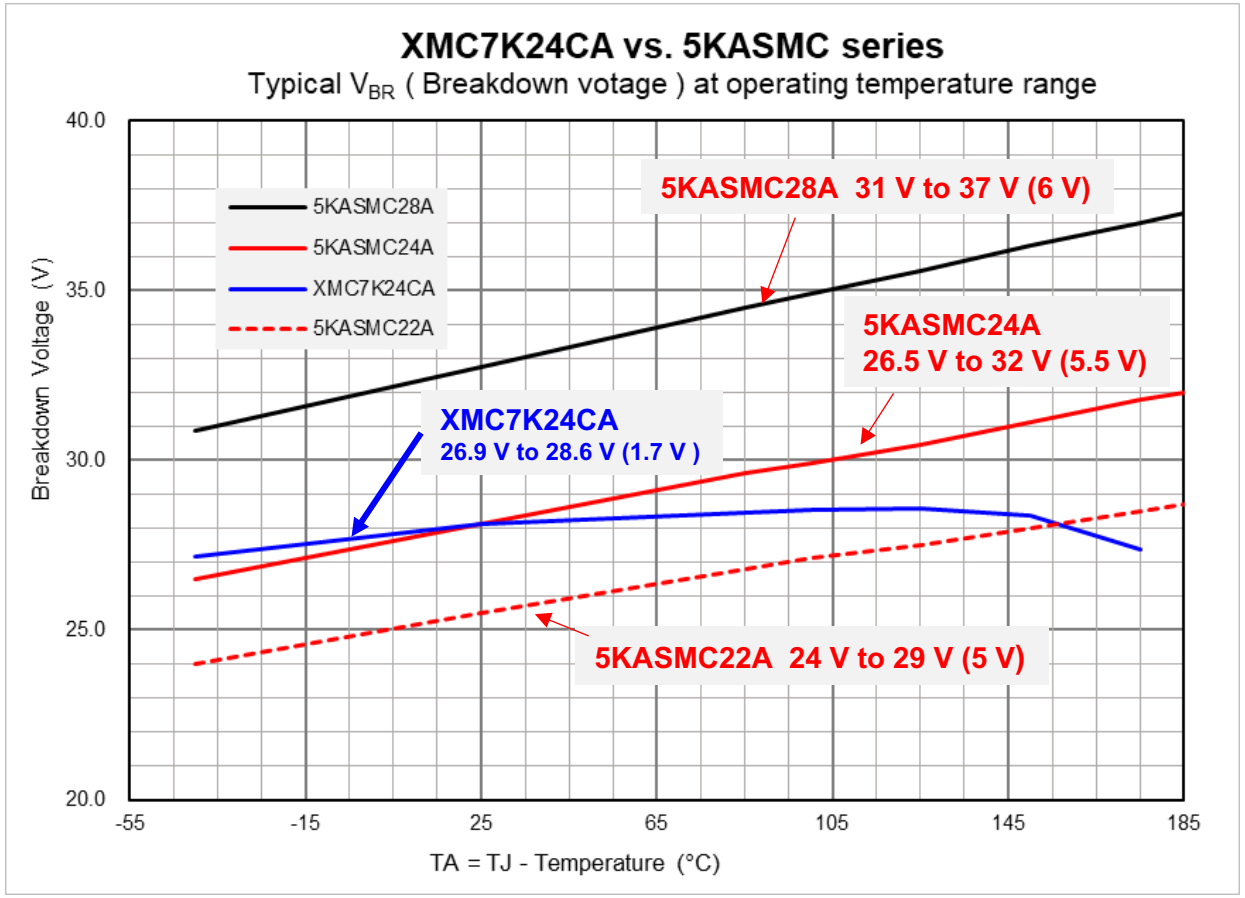


Fig. 5 - Typical Breakdown Voltage vs. Temperature Curve

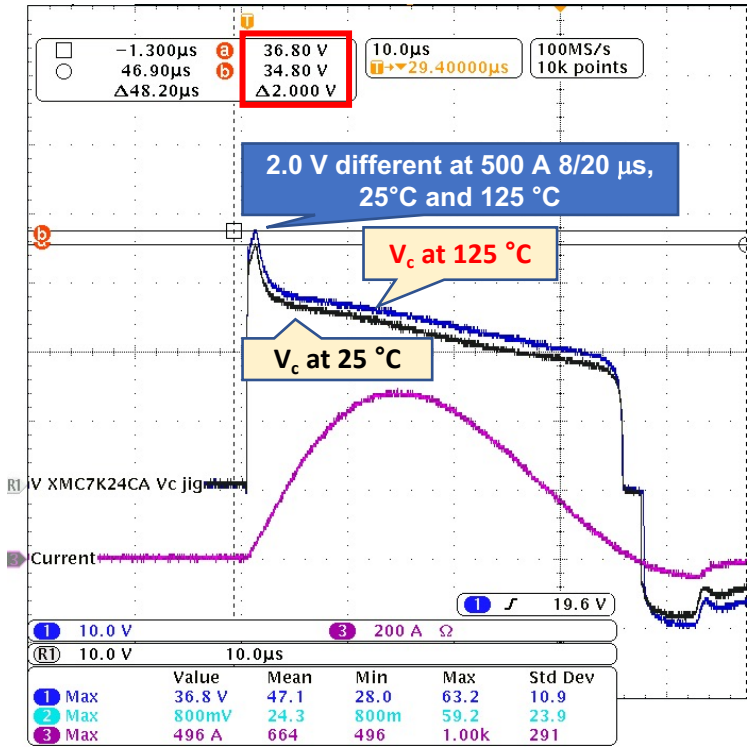


Extremely Stable Clamping Voltage (V_C)

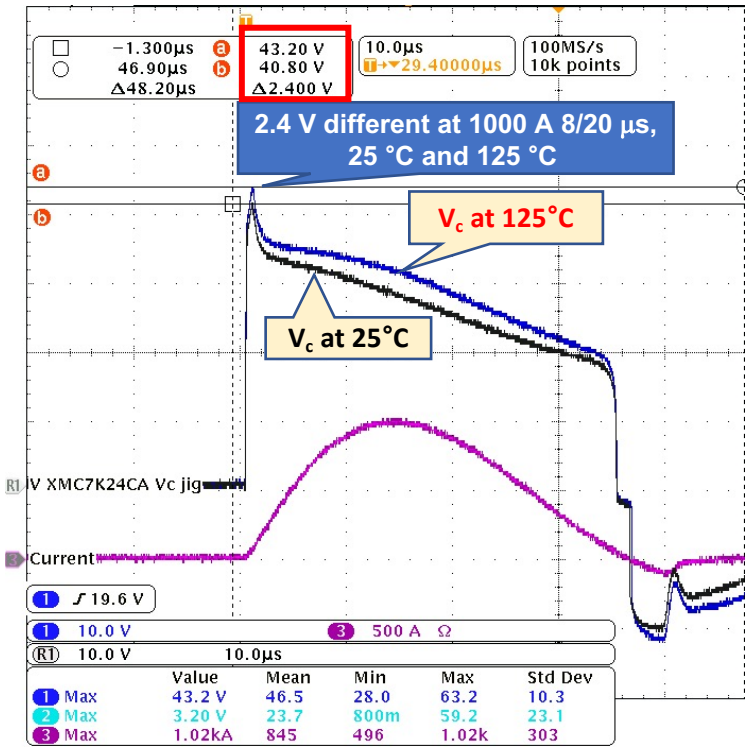
Over a Wide Operating Temperature Range

- 2.4 V difference only at 25 °C and 125 °C of a 1000 A 8/20 µs surge test

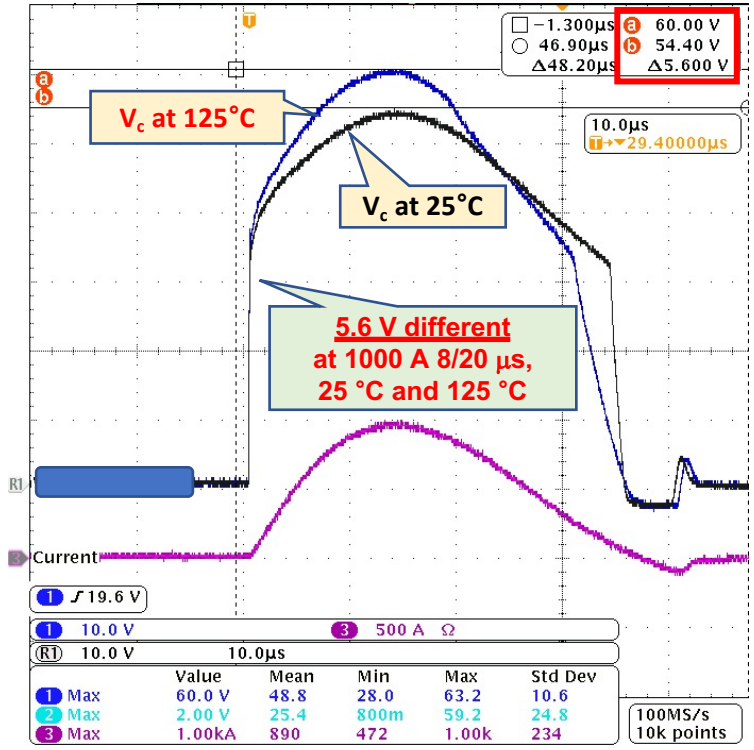
XMC7K24CA at 500 A



XMC7K24CA at 1000 A



Conventional 5 kW TVS at 1000 A



Variable Clamping Voltage With Conventional TVS Combination for:

- **12 V powertrain**
  - Flywheel or freewheeling diode of motor / solenoid drive circuit
  - Secondary protection or anti-parallel function

- **24 V powertrain**
  - Able to meet ISO 16750-2 Pulse b condition (central load dump test) with
    - 48 V stand-off voltage
    - Clamping under 58 V or 65 V at Pulse 1, Pulse 2a, and Pulse 3a/b of ISO 7637-2 : 2011

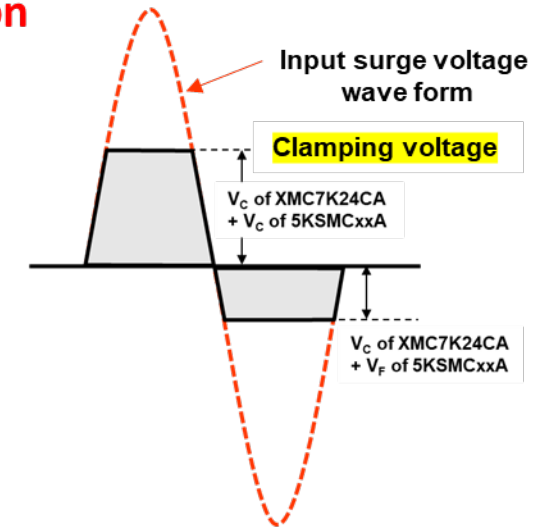
- **48 V powertrain**
    - 50 V to 70 V stand-off voltage
    - Clamping voltages under 70 V to 100 V at various transient pulses

Variable Clamping Voltages With Conventional TVS Combination

Asymmetrical combination

XMC7K24CA

5KSMCxxA



- **Positive clamping voltage**

  = V_C of XMC7K24CA + V_C of 5KSMCxxA
- **Negative clamping voltage**

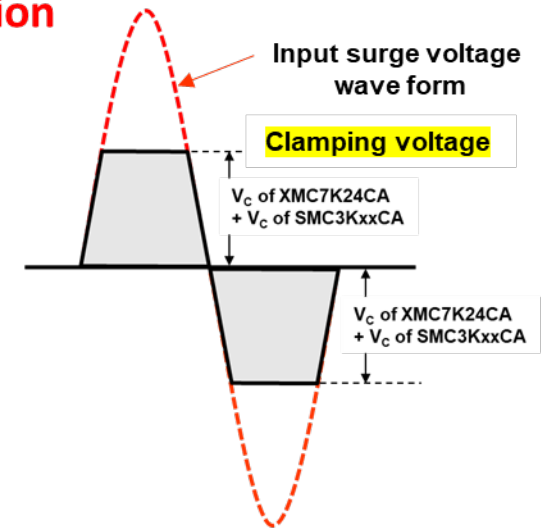
  = V_C of XMC7K24CA + V_F of 5KSMCxxA
- **Clamping current limit**

  = Fix by smaller side of two devices

Symmetrical combination

XMC7K24CA

SMC3KxxCA



- **Positive clamping voltage**

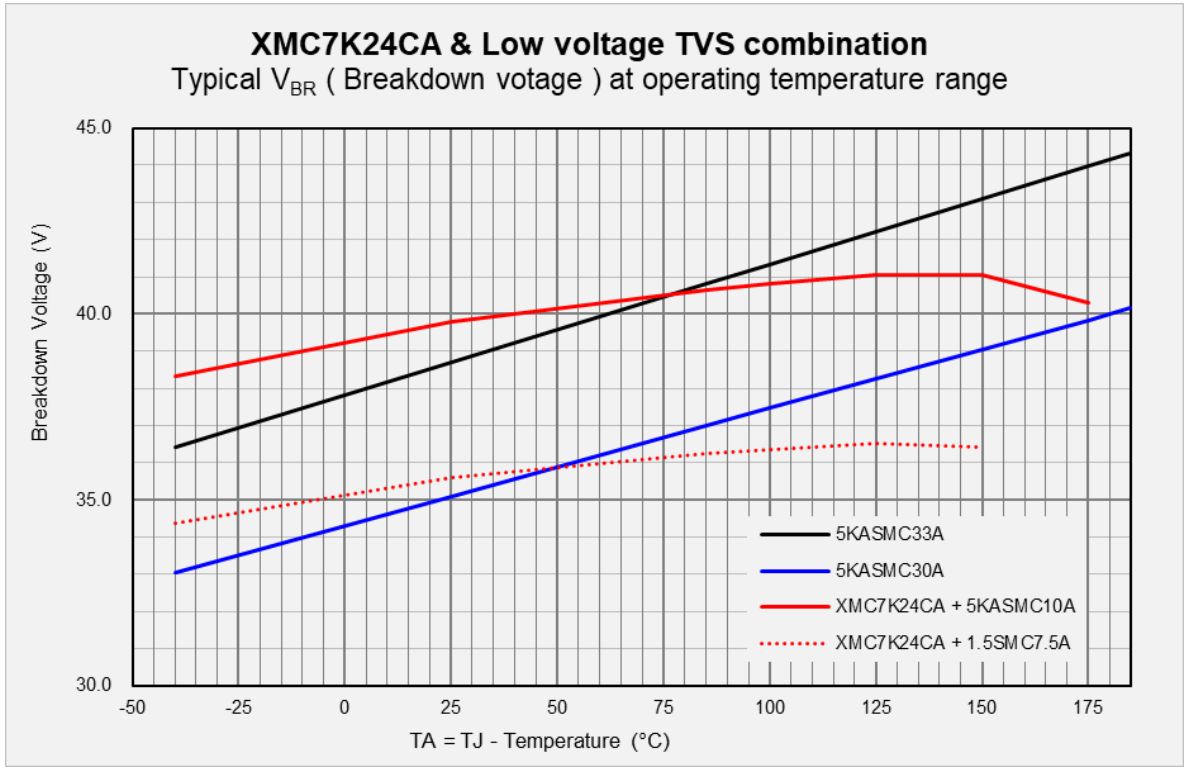
  = V_C of XMC7K24CA + V_C of SMC3KxxA
- **Negative clamping voltage**

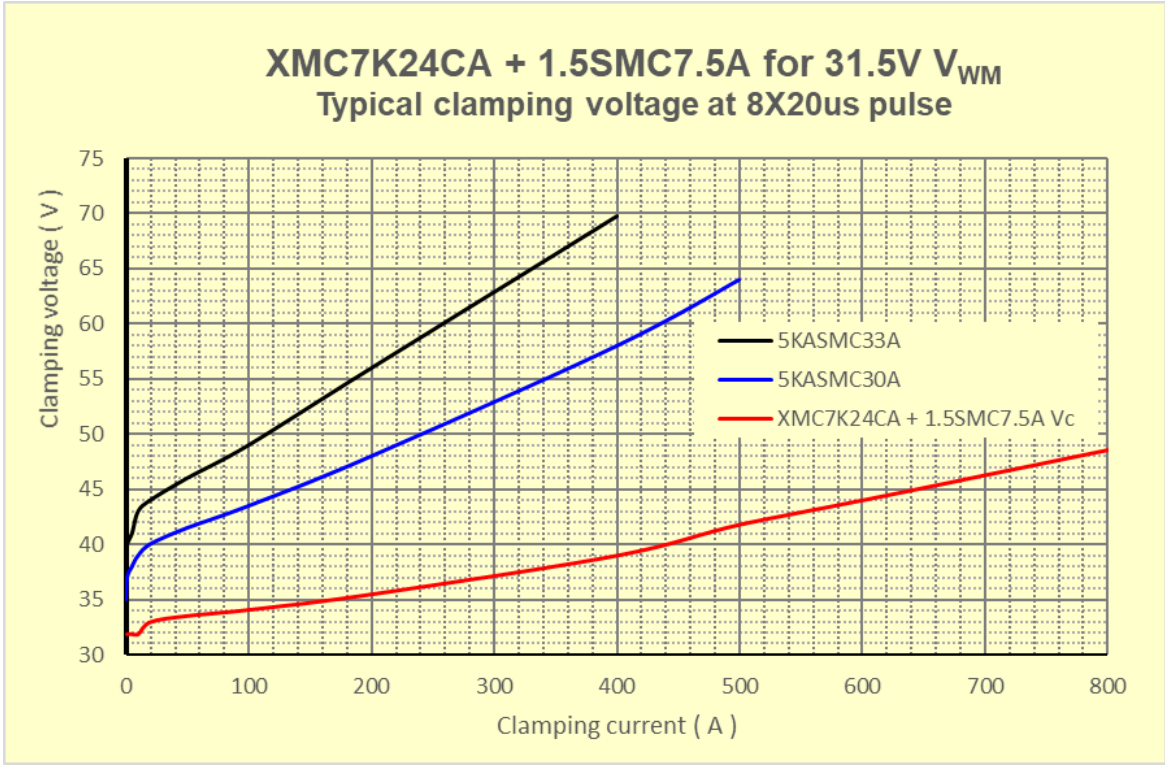
  = V_C of XMC7K24CA + V_C of SMC3KxxA
- **Clamping current limit**

  = Fix by smaller side of two devices

Advantage of XClampR™ and Conventional TVS Combination (1)

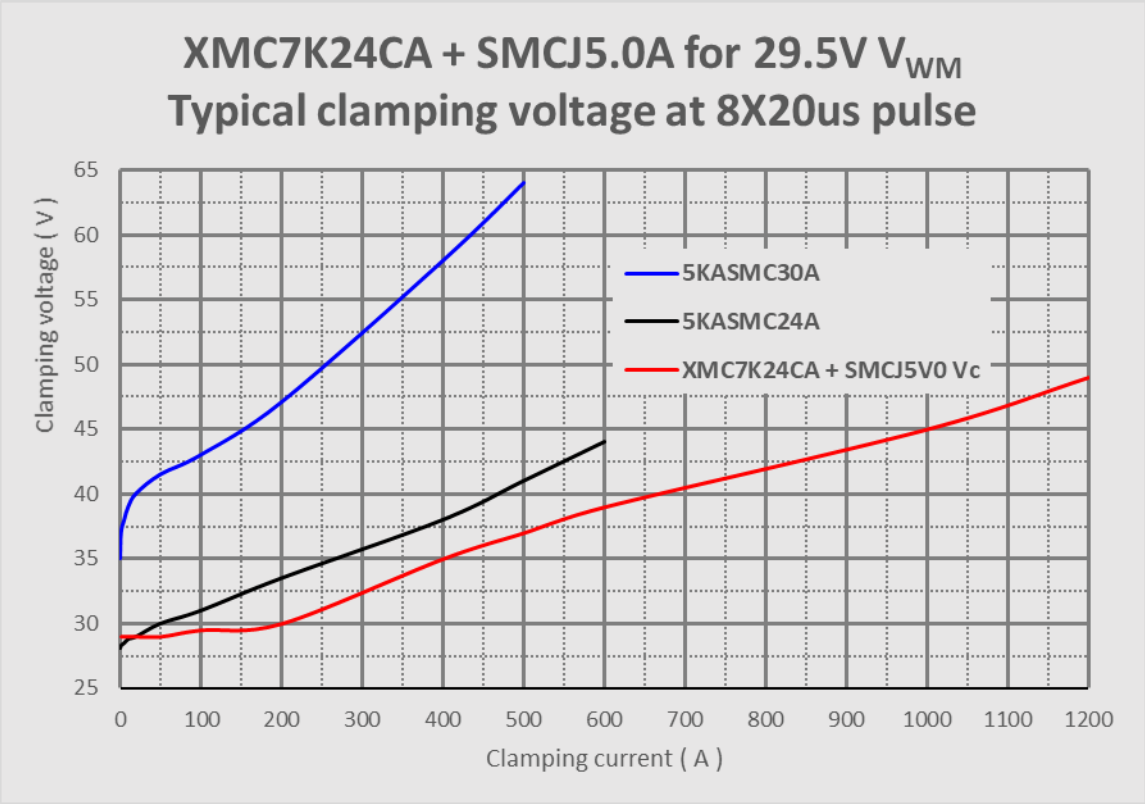
- Flexible clamping voltages
- Stable V_{BR} and clamping voltage over a wide operating temperature range

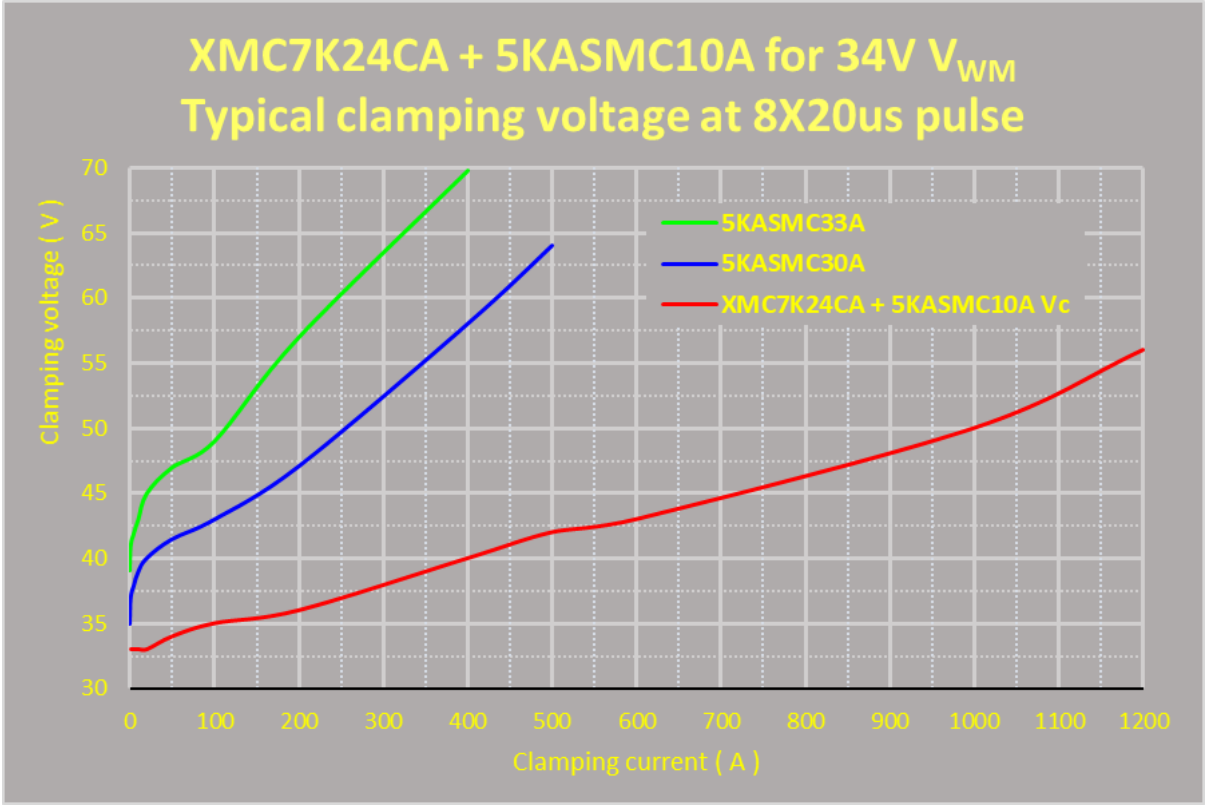




Advantage of XClampR™ and Conventional TVS Combination (2)

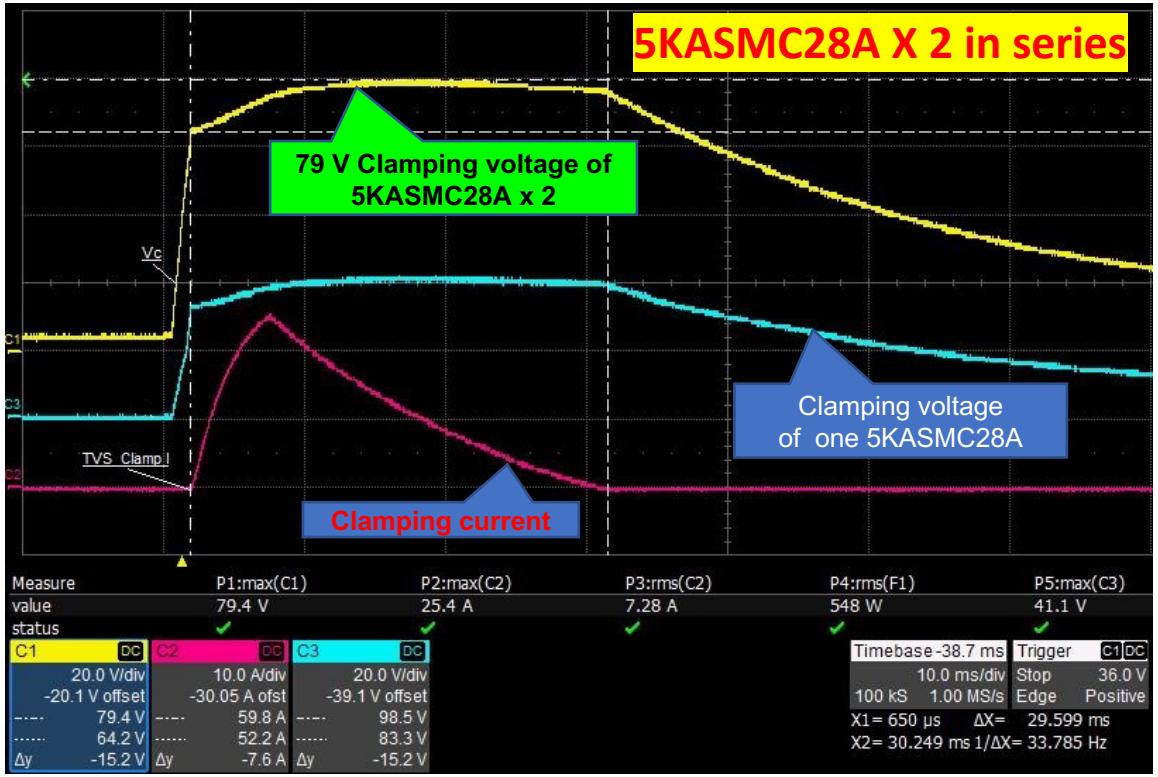
- Higher current capability

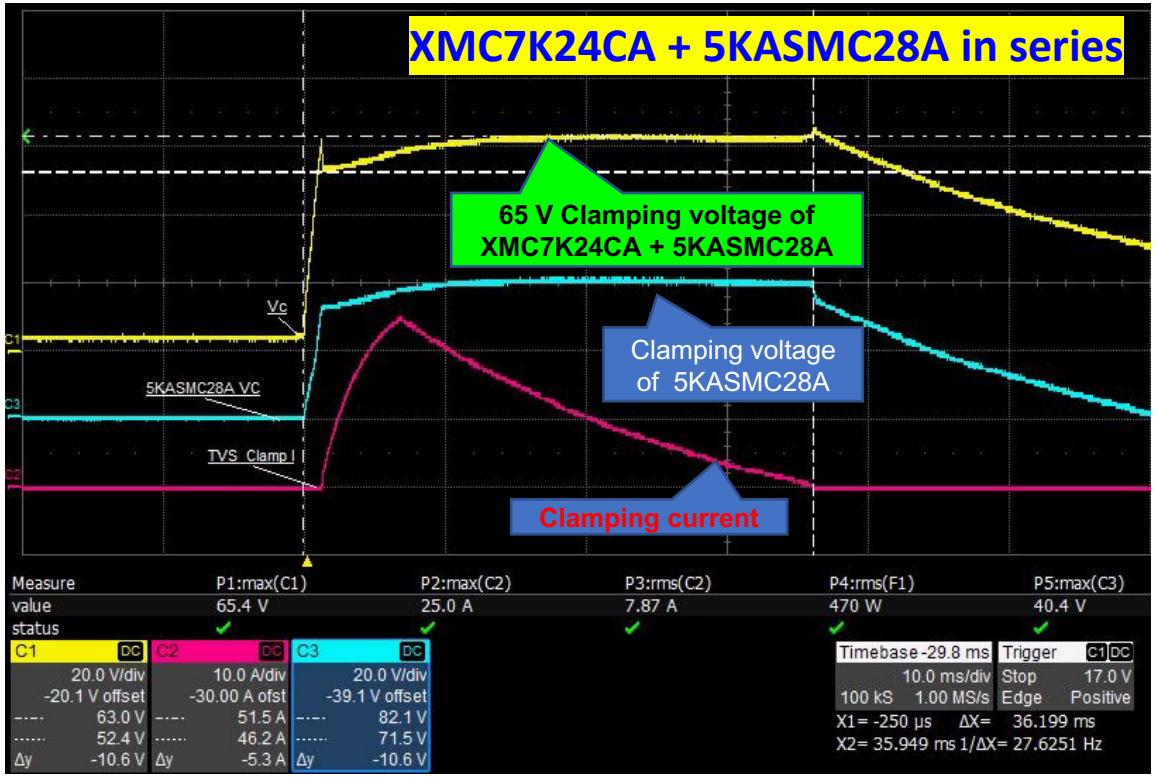




Clamping Operation Comparison of 5KASMC28A X 2 in series vs. XMC7K24CA + 5KASMC28A

- at 10 ms I_{PP}/2 exponential pulse, 25 °C T_A condition





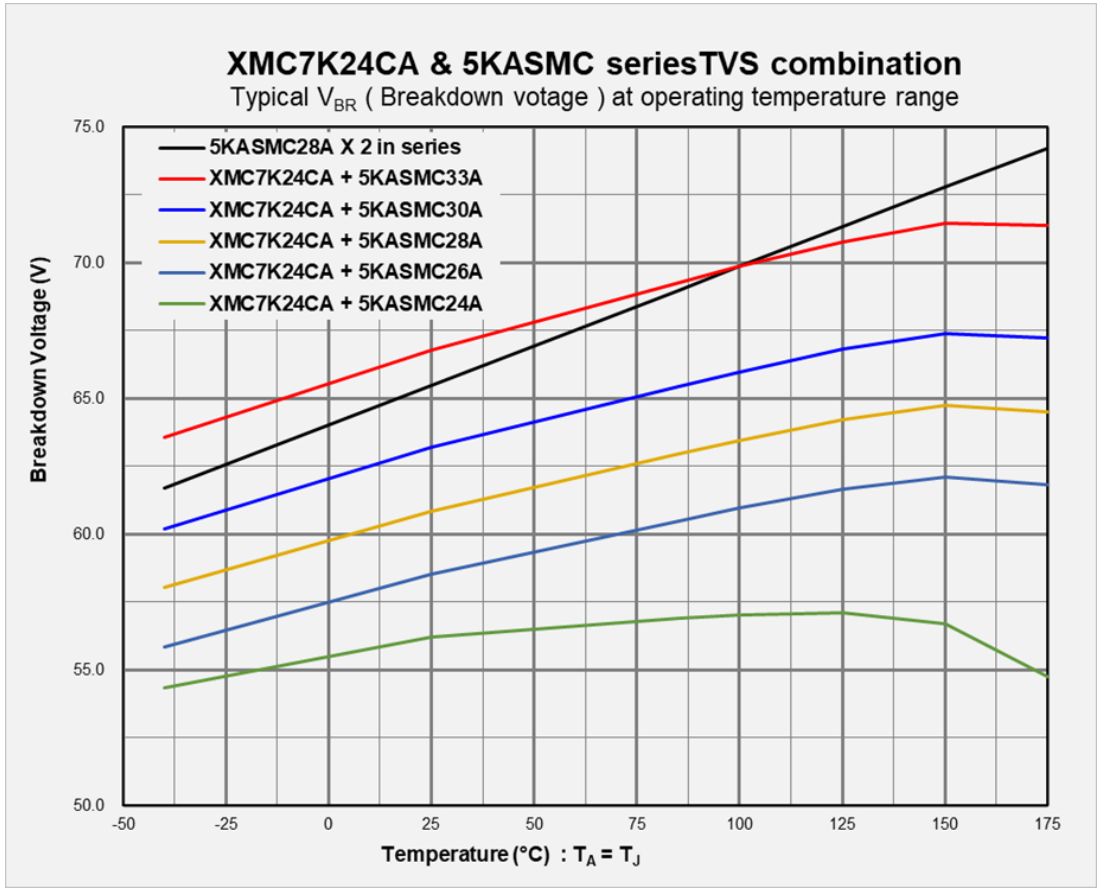
- Clamping peak voltage: **79 V** +/-4 V
- Clamping start voltage: 64 V +/- 4 V

- Clamping peak voltage: **65 V** +/-2 V
- Clamping start voltage: 63 V +/- 2 V

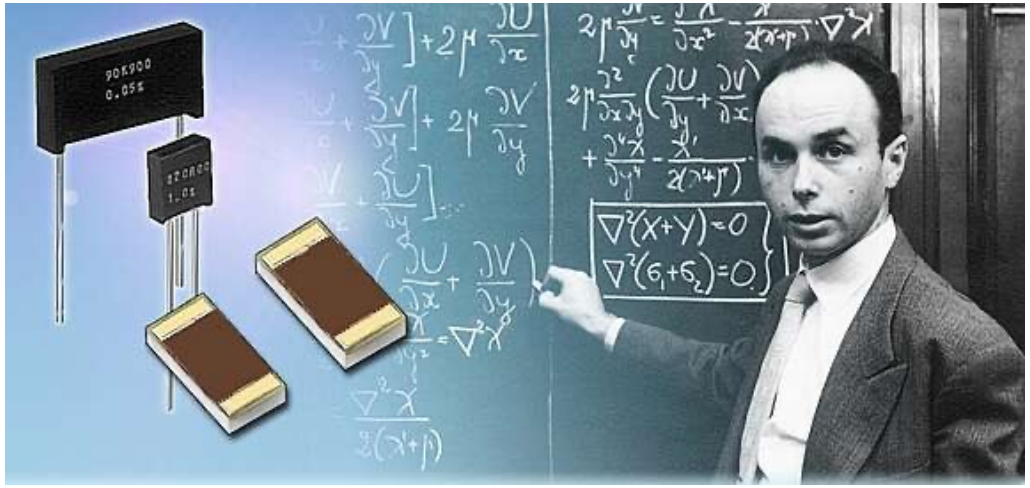
TVS Combination for Various Stand-Off and Clamping Voltage

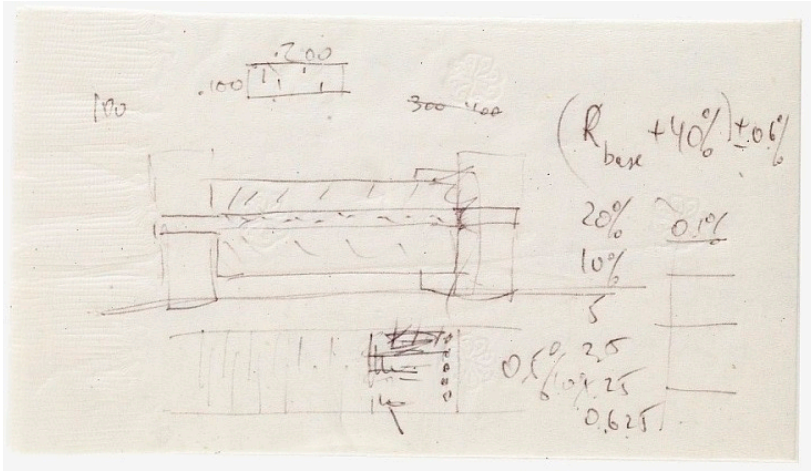
- XMC7K24CA with 5KASMC series
  - Stable V_{BR} over a wide temperature range
  - Stable clamping voltage (V_C)
  - Low clamping voltage ratio

P/N	Stand-off voltage (V)	Clamping voltage (V) at 30 A, 25 °C T_A t_d = 10 ms I_{PP}/2
5KASMC28A X 2 in series	56	83.0
XMC7K24CA + 5KASMC33A	57	72.0
XMC7K24CA + 5KASMC30A	54	68.0
XMC7K24CA + 5KASMC28A	52	65.0
XMC7K24CA + 5KASMC26A	50	62.0
XMC7K24CA + 5KASMC24A	48	60.0



DNA OF ULTRA STABILITY - VISHAY





Dr. Felix Zandman applied principles to electronic resistors for new breakthroughs in resistor precision, stability over temperature excursions, and long-term operation.

Vishay Power Metal Strip® Resistor

Original sketch (ballpoint pen on paper napkin) by Dr. Felix Zandman, 1996

Image courtesy of National Museum of American History, Behring Center (Washington, D.C.)

ACKNOWLEDGEMENTS

- I would like to express my deep gratitude to Vincent Lin for his guidance
- I would like to thank KS Foo, Dinah Liu and Fany Fan at Product Marketing and Engineering for providing necessary support
- I would like to thank Warren Chiang, Johnny Chiang and Kevin Yang at Research and Development team for their expertise

FIN

THANK YOU

Other package types will be available soon