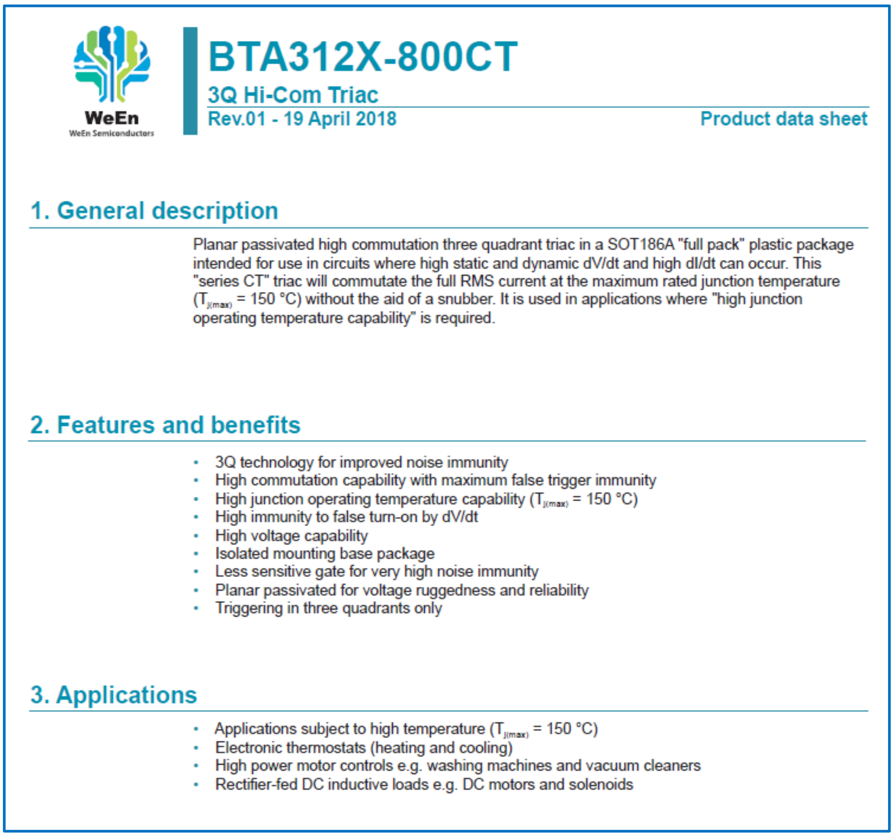
1. Introduction

Datasheets are not required to be created to a fixed international standard. This means datasheets must be read and interpreted carefully to ensure that parameter descriptions and values are correctly understood.

This datasheet note looks at the parameters defined and described in WeEn datasheets for triacs.

2. Datasheet product profile

All WeEn's datasheets have the product name and type, revision number and publication date as the first page heading. This is followed by three sections, "General description", "Features and benefits" and "Applications". These sections describe the product to allow the reader to quickly understand its technology, main advantages and uses.


WeEn
WeEn Semiconductors

BTA312X-800CT
3Q Hi-Com Triac
Rev.01 - 19 April 2018 Product data sheet

1. General description

Planar passivated high commutation three quadrant triac in a SOT186A "full pack" plastic package intended for use in circuits where high static and dynamic dV/dt and high dI/dt can occur. This "series CT" triac will commutate the full RMS current at the maximum rated junction temperature ($T_{j(max)}$ = 150 °C) without the aid of a snubber. It is used in applications where "high junction operating temperature capability" is required.

2. Features and benefits

- 3Q technology for improved noise immunity
- High commutation capability with maximum false trigger immunity
- High junction operating temperature capability ($T_{j(max)}$ = 150 °C)
- High immunity to false turn-on by dV/dt
- High voltage capability
- Isolated mounting base package
- Less sensitive gate for very high noise immunity
- Planar passivated for voltage ruggedness and reliability
- Triggering in three quadrants only

3. Applications

- Applications subject to high temperature ($T_{j(max)}$ = 150 °C)
- Electronic thermostats (heating and cooling)
- High power motor controls e.g. washing machines and vacuum cleaners
- Rectifier-fed DC inductive loads e.g. DC motors and solenoids

Fig. 1 Example of a datasheet product profile (BTA312X-800CT)

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The “Quick reference data” section highlights some important parameters for the product found in the main body of the datasheet.

4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Values	Unit
Absolute maximum rating				
V_{DRM}	repetitive peak off-state voltage		800	V
$I_{T(RMS)}$	RMS on-state current	full sine wave; $T_h \leq 84$ °C; Fig. 1; Fig. 2; Fig. 3	12	A
I_{TSM}	non-repetitive peak on-state current	full sine wave; t_p = 20 ms; $T_{j(init)}$ = 25 °C; Fig. 4; Fig. 5	100	A
		full sine wave; t_p = 16.7 ms; $T_{j(init)}$ = 25 °C	110	A
T_j	junction temperature		150	°C

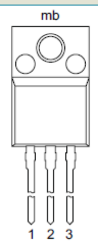
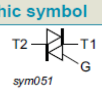
Fig. 2 Example of a datasheet product profile (BTA312X-800CT)

“Pinning information” contains a table and diagram to aid the correct identification of the product’s electrical terminals and package type. Pin “mb” is isolated in this TO220F package example. For non-isolated devices with a metal tab package, “mb” is connected to T2 (main terminal 2).

“Ordering information” gives the product’s part number and package version. Sometimes there is a “Marking information” section which gives data on the labelling printed on the device and sometimes the packing method.

5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	T1	main terminal 1		
2	T2	main terminal 2		
3	G	gate		
mb	n.c.	mounting base; isolated		

6. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
BTA312X-800CT	TO-220F	Plastic single-ended package; isolated heatsink mounted; 1 mounting hole; 3-lead TO-220 'full pack'	SOT186A

7. Marking

Table 4. Marking codes

Type number	Marking codes
BTA312X-800CT	BTA312X-800CT

Fig. 3 Example of a datasheet product profile (BTA312X-800CT)

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3. Datasheet “Limiting Values”

8. Limiting values

Table 5. Limiting values
In accordance with the Absolute Maximum Rating System (IEC 60134).

Fig. 4 Example of “Limiting Values” table heading

“Limiting Values” describe the the limiting conditions that can be applied by a circuit without risk of damage to the triac, and these limiting values reflect the triac’s capability. These are the absolute maximum ratings for *the operating and environmental conditions* and circuit designers should ensure these are not exceeded. These values may be maximum or minimum.

“Limiting” means that the value specified in the table must not be exceeded otherwise the product may malfunction, or “lose control” or even be damaged permanently. A limiting value is defined in accordance with the IEC-60134 international standard, known as the “Absolute Maximum Rating System”.

3.1 V_{DRM}

8. Limiting values

Table 4. Limiting values
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Values	Unit
V_{DRM}	repetitive peak off-state voltage		800	V

Fig. 5 Example of voltage rating

V_{DRM} is the maximum allowable instantaneous repetitive peak off-state voltage (including transients) that the circuit can apply to the triac when the gate is open circuit. “DRM” describes the voltage as “off-state” or “blocking”, “Repetitive” and “Maximum”.

If V_{DRM} is exceeded the triac *may* turn on without an applied gate current for either voltage direction. Both situations could cause damage to a triac depending on the circuit conditions if the rate of rise of load current (dI_T/dt) is too fast.

The rated value of $V_{DRM(max)}$ may be applied continuously over the entire operating junction temperature range, provided that the thermal resistance between junction and ambient is low enough to avoid the possibility of thermal runaway.

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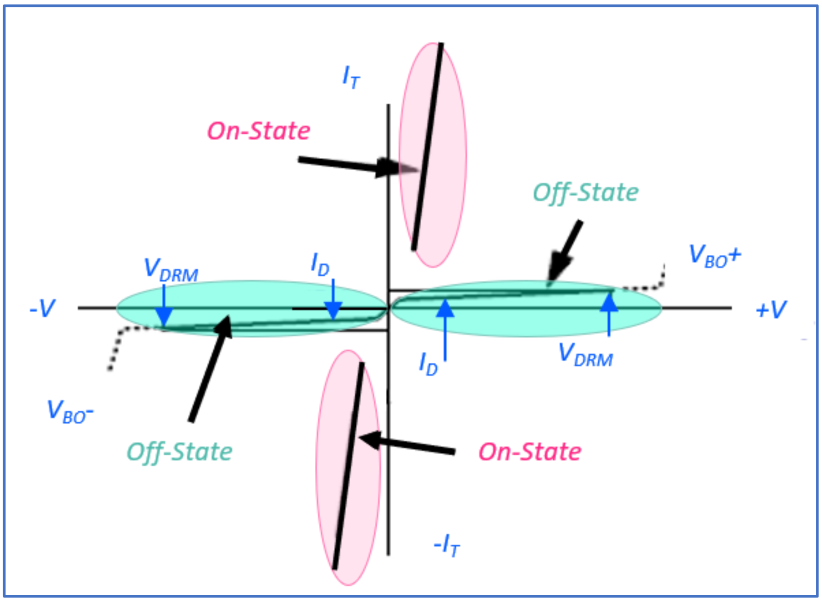

Fig. 6 Blocking off-state voltage and on-state conduction operating regions

3.2 $I_{T(RMS)}$

$I_{T(RMS)}$	RMS on-state current	full sine wave; $T_h \leq 84$ °C; Fig. 1; Fig. 2; Fig. 3	12	A

Fig. 7 Example of current rating

$I_{T(RMS)}$ is the value of current for the triac which under steady state conditions results in the rated temperature $T_{j(max)}$ being reached for a given package-related temperature condition. This temperature condition is specified as T_{mb} for “mounting-base” or “tab” type packages, T_h for plastic packages for “heatsink” mounting, T_{lead} for smaller plastic packages that cannot be heatsink mounted or T_{sp} for the solder point of surface mounted packages.

$I_{T(AV)}$ is related to the $I_{T(RMS)}$ current parameter by the equation, $I_{T(RMS)} / I_{T(AV)}$ = form factor.

The $I_{T(RMS)}$ rating of 12A in the example shown (Fig 7) applies to steady state operation but for short durations (e.g. less than 2 seconds), it is allowable to operate the triac at a higher current. This means the RMS current within that shorter duration can exceed the steady-state rating of 12A. This is shown in the “RMS current versus surge duration graphic” in the datasheet (see Fig 8).

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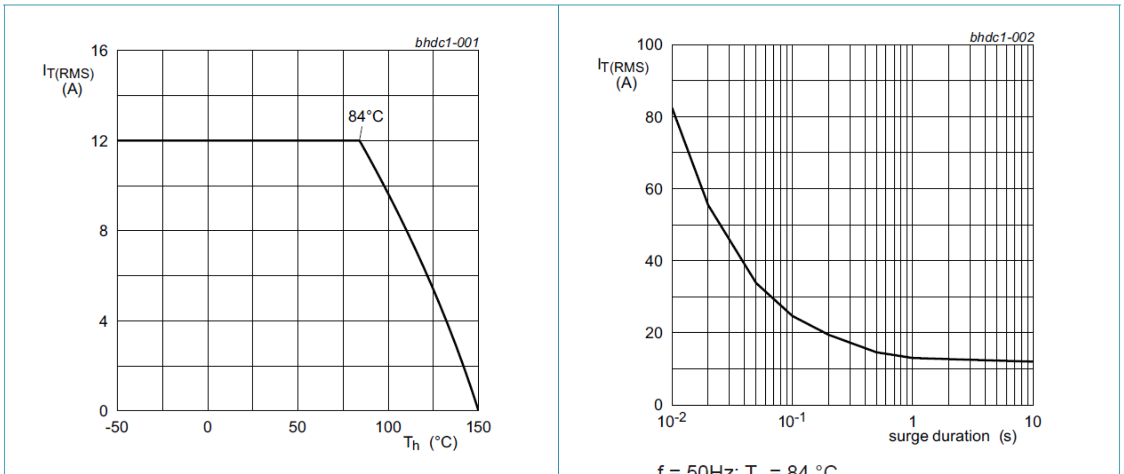

Fig. 1. RMS on-state current as a function of heatsink temperature; maximum values

Fig. 2. RMS on-state current as a function of surge duration; maximum values

Fig. 8 Example of current graphics

The limiting value specified depends on the thermal resistance and size of any heatsink (for the package type in this example). As also mentioned, the allowable $I_{T(RMS}$ limiting value rises as the conduction duration reduces below about 2 seconds (see Fig. 8). A derating graph (Fig. 8) also indicates the reduction of the maximum current recommended for temperatures that may exceed T_h = 84 °C (for this BTA312X-800CT example).

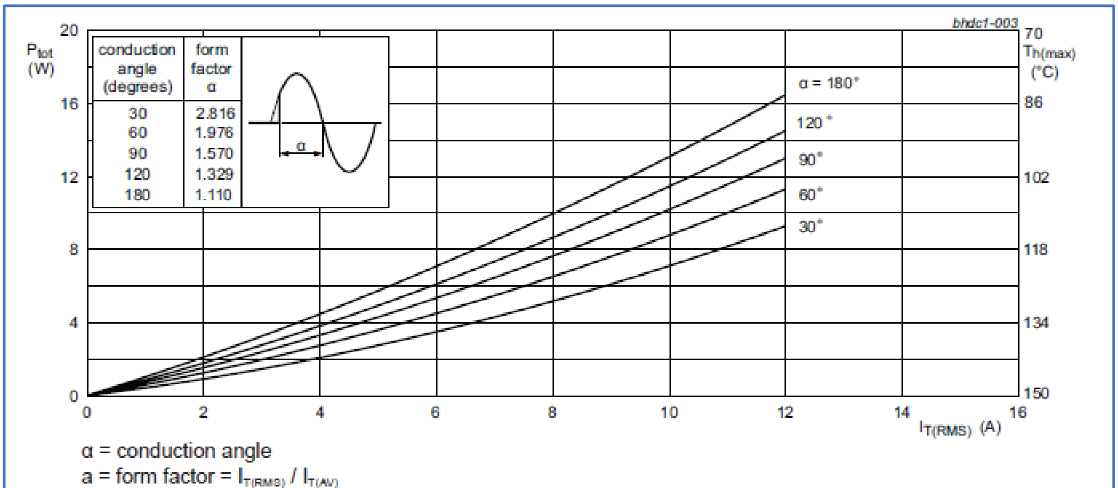

Fig. 3. Total power dissipation as a function of RMS on-state current; maximum values

Fig. 9 Example of power dissipation graphic

The power dissipation of the triac is directly proportional to the current and conduction angle. With the aid of the $T_{h(max)}$ values on the right-hand vertical axis, the maximum allowable power and $I_{T(RMS)}$ for any given heatsink temperature is shown. For a given $I_{T(RMS)}$, the power dissipated at small conduction angles is lower than at large conduction angles. This is because of the higher $I_{T(RMS)}$ at higher conduction angles. Operating

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the triac at $I_{T(RMS)}$ values above the rated limiting value is likely to result in rapid thermal cycling which may affect the internal assembly of the triac and lead to reliability issues.

3.3 I_{TSM}

I_{TSM}	non-repetitive peak on-state current	full sine wave; t_p = 20 ms; $T_{j(init)}$ = 25 °C; Fig. 4; Fig. 5	100	A
		full sine wave; t_p = 16.7 ms; $T_{j(init)}$ = 25 °C	110	A

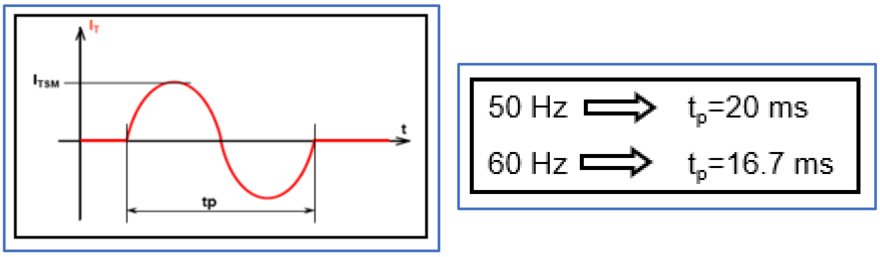

Fig. 10 Example of non-repetitive peak on state current rating

I_{TSM} is the maximum non-repetitive peak on-state surge current that may be applied to the triac. It is specified for a one full-sine wave pulse at an initial junction temperature of 25 °C before surge with an AC mains frequency of 50 or 60Hz. The shorter the time period of the surge (higher frequency) the higher the I_{TSM} capability, but at very short durations the allowable I_{TSM} starts to decrease, as the rate of rise of current, dI_T/dt, becomes an additional limiting factor (see Fig. 11). Exceeding the I_{TSM} rating may damage the triac.

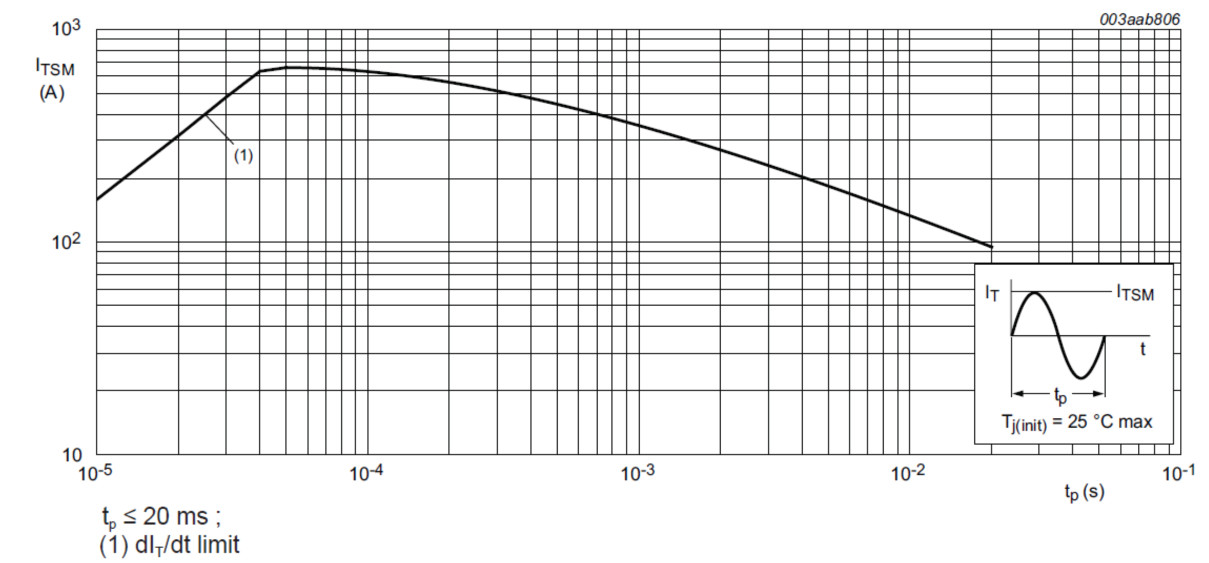

Fig. 5. Total power dissipation as a function of RMS on-state current; maximum values

Fig. 11 Example of I_{TSM} versus pulse width

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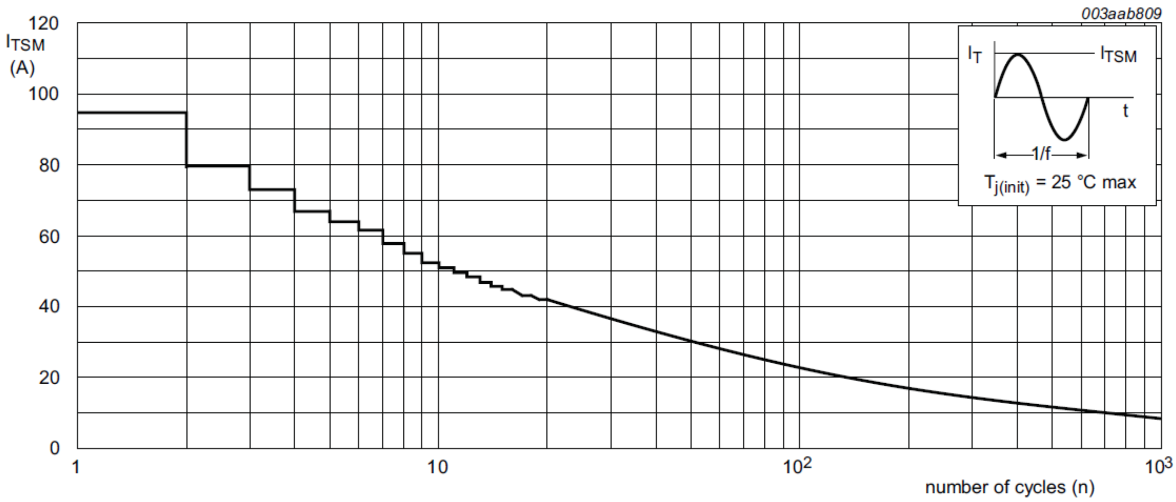
The I_{TSM} parameter is important because triacs are often used to control motor loads Some motors, especially high-power carbon brush “universal” motors, have a very low impedance at start-up or when stalling and the surge current can be high. This will cause rapid heating and destruction of the triac if the current does not reduce quickly and remain within the limits of the I_{TSM} rating curves.



f = 50 Hz

Fig. 4. Non-repetitive peak on-state current as a function of the number of sinusoidal current cycles; maximum values

Fig. 12 Example of I_{TSM} versus number of pulses

The I_{TSM} rating value decreases as the number of pulses increases and this is also shown in a graphic in the WeEn datasheet (see Fig. 12). For a very high number of cycles the I_{TSM} value reduces to the continuous $I_{T(RSM)}$ rating value.

3.4 I^2t

I^2t	I^2t for fusing	t_p = 10ms; sine wave	50	A^2s

Fig. 13 Example of I^2t rating

For correct circuit protection the I^2t of a protective fuse in series with the device must be less than the specified I^2t rating value of the device. This rating is numerically linked with the I_{TSM} rating by the equation:

$$I^2t = (I_{TSM}^2/2) \times t_p \equiv I_{TSM}^2/200$$

This is for t_p = 10ms (50Hz half-sine duration) fusing time.

The same value for I^2t is calculated when t_p = 8.33ms (60Hz half-sine duration) with the corresponding I_{TSM} rating at 60Hz.

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3.5 dI_T/dt

dI_T/dt	rate of rise of on-state current	I_G = 70mA	100	A/µs

Fig. 14 Example of rate of rise of on-state current rating

Maximum allowable rate of rise of on-state current after gate triggering is to limit local hot-spot heating close to the gate region of the triac. After the gate is triggered and the triac rapidly turns-on, such local heating takes place because of the triacs' internal structure and this can lead to degradation or complete failure. When a triac is triggered by exceeding the breakdown voltage or by a high rate of rise of off-state voltage dV_D/dt, it is also important to consider limiting the dI_T/dt by good circuit design.

In the rating for the datasheet, a simple gate trigger condition is used. In fact, the magnitude of the gate current, rate of rise of the gate current, gate current pulse width and the peak load current limit are also important in determining the absolute rating for dI_T/dt.

3.6 P_{GM}, $P_{G(AV)}$, I_{GM}, V_{RGM}

I_{GM}	peak gate current		2	A
P_{GM}	peak gate power		5	W
$P_{G(AV)}$	average gate power	over any 20 ms period	0.5	W

Fig. 15 Example of gate ratings

The intention of these gate ratings is to reassure the circuit designer that the gate structure can handle the power that any real circuit may apply to it. The "average gate power" rating is intended to reflect designs where continuous gate current is applied, while the "peak gate power" rating is meant to apply to circuits where gate pulses are applied at the start of desired conduction.

For pulsed gate current, it is considered that the gate drive may be from a capacitor discharge with peak of current significantly higher than the pulse average. Hence, the peak gate power rating value is a factor of 10 above the average value. Provided the peak of those pulses does not exceed the peak gate current of 2A or peak gate power of 5W, then there is no risk of damage to the triac gate structure.

It should be noted that these values of average and peak power are chosen to give a very good safety margin and reassurance to designers. They do not reflect the actual failure point of WeEn's triacs. In fact, the true capability of the gate structure of these triacs is much higher than these values in the datasheet. However, it is WeEn's judgement that these numbers are entirely adequate to cover all eventualities in design.

The gate structure of a triac is robust but when its capability to handle power is exceeded the triac may degrade gradually or fail completely.

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3.7 T_{stg}, T_j

T_{stg}	storage temperature		-40 to 150	°C
T_j	junction temperature		150	°C

Fig. 16 Example of temperature ratings

T_{stg} gives the values for the range of temperature allowable for storage (dispatching, handling, warehousing) of the triac.

$T_{j(max)}$ is the maximum operating junction temperature for the triac in the on-state or off-state. Although the junction temperature may transiently exceed $T_{j(max)}$ without damage, (e.g. during exceptional, brief, non-repetitive overload or fault conditions), for repetitive operation the peak junction temperature must remain below the absolute maximum rating.

3.8 V_{isol}, C_{isol}

Table 6. Isolation characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$V_{isol(RMS)}$	RMS isolation voltage	from all terminals to external heatsink; sinusoidal waveform; clean and dust free; 50 Hz ≤ f ≤ 60 Hz; RH ≤ 65 %; T_h = 25 °C		-	-	2500	V
C_{isol}	isolation capacitance	from main terminal 2 to external heatsink; f = 1 MHz; T_h = 25 °C		-	10	-	pF

Fig. 17 Example of isolation ratings

The isolation voltage in this example is for the T0220F package. The capacitance value is a characteristic and is given as a typical value.

4. Datasheet “Characteristics”

“Characteristics” are the inherent measurable parameters for the triac and are often stated with minimum or maximum values or both. Sometimes typical values are given. The limits define a range of values for the triac’s inherent parameter characteristics. These values are useful to the designer for optimizing the circuit and ensuring reliable operation.

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4.1 Thermal characteristics

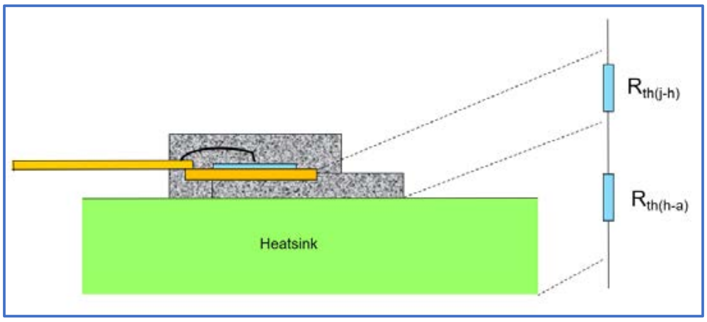


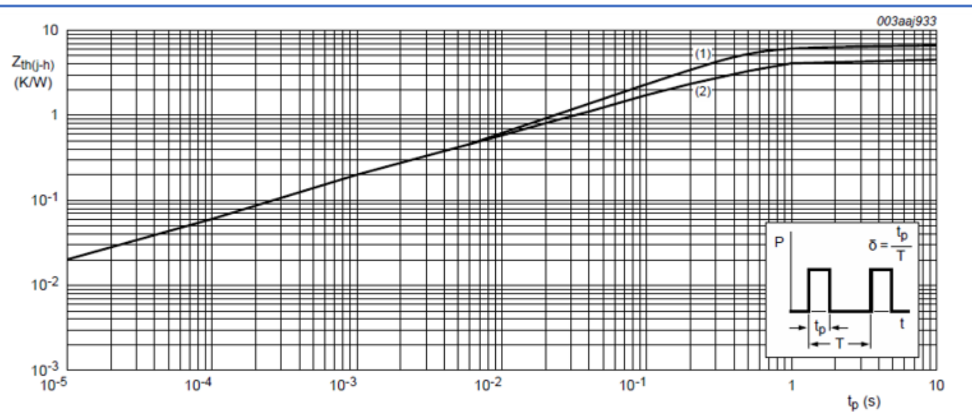
Table 5. Thermal characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
$R_{th(j-h)}$	thermal resistance from junction to heatsink	with heatsink compound; Fig. 6		-	-	4	K/W
		without heatsinkcompound; Fig. 6		-	-	5.5	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient free air	in free air		-	55	-	K/W

Fig. 18 Example of thermal characteristics

Maximum steady-state thermal resistance values are given in the datasheet and are used to specify the triac's current and power ratings. The average junction temperature rise for a given dissipation is the mathematical product of the average power dissipation and the thermal resistance.

A typical value of junction to ambient thermal resistance is given which assumes that through-hole leaded devices are mounted vertically on a PCB in free air. The value for surface mount packages is for a device soldered to a pad area on a given PCB material.



(1) Without heatsink compound
(2) With heatsink compound

Fig. 6. Transient thermal impedance from junction to heatsink as a function of pulse width

Fig. 19 Example of transient thermal impedance graphic

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Although average junction temperature rise may be calculated from the thermal resistance value, the peak junction temperature calculation requires knowledge of the current waveform and the transient thermal impedance curve. This curve in the datasheet is based on rectangular power pulses. Increasing the pulse duration results in higher transient thermal impedance (Z_{th}) until the steady-state, thermal resistance (R_{th}) is reached. If the application operates under transient (pulse) conditions, Z_{th} instead of R_{th} should be considered since R_{th} is applicable only to steady state, continuous operation. The temperature rise is calculated as the mathematical product of peak dissipation during the pulse by the thermal impedance for the given pulse width.

In practice, a power device frequently must handle composite waveforms rather than a simple rectangular pulse. This type of pulse can be simulated by superimposing several rectangular pulses which have a common time period but with both positive and negative amplitudes. Similarly, a burst of pulses can be treated as a composite waveform. Triangular, trapezoidal and sinusoidal waveforms can also be approximated by a series of rectangles. This analysis is covered elsewhere.

4.2 I_{GT}, I_L, I_H

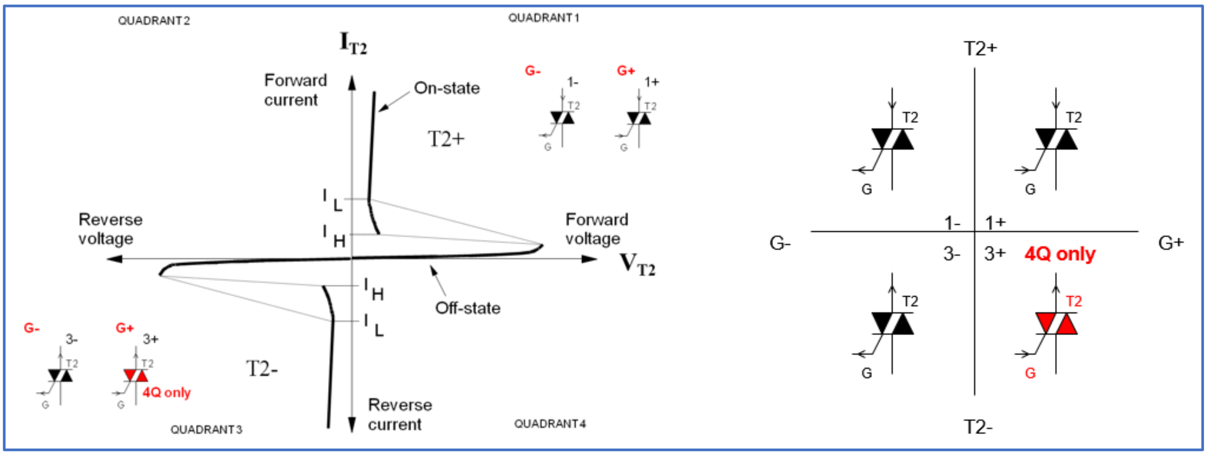

Fig. 20 Triac operating characteristic and triggering options

Table 7. Characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
Static characteristics							
I_{GT}	gate trigger current	V_D = 12 V; I_T = 0.1 A; T2+ G+; T_j = 25 °C; Fig. 7		2	-	35	mA
		V_D = 12 V; I_T = 0.1 A; T2+ G-; T_j = 25 °C; Fig. 7		2	-	35	mA
		V_D = 12 V; I_T = 0.1 A; T2- G-; T_j = 25 °C; Fig. 7		2	-	35	mA

Fig. 21 Static characteristics, I_{GT} (BTA312-800CT)

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I_L	latching current	V_D = 12 V; I_T = 0.1 A; T2+ G+; T_j = 25 °C; Fig. 8		-	-	50	mA
		V_D = 12 V; I_T = 0.1 A; T2+ G-; T_j = 25 °C; Fig. 8		-	-	60	mA
		V_D = 12 V; I_T = 0.1 A; T2- G-; T_j = 25 °C; Fig. 8		-	-	50	mA
I_H	holding current	V_D = 12 V; T_j = 25 °C; Fig. 9		-	-	35	mA

Fig. 22 Static characteristics, I_L, I_H (BTA312-800CT)

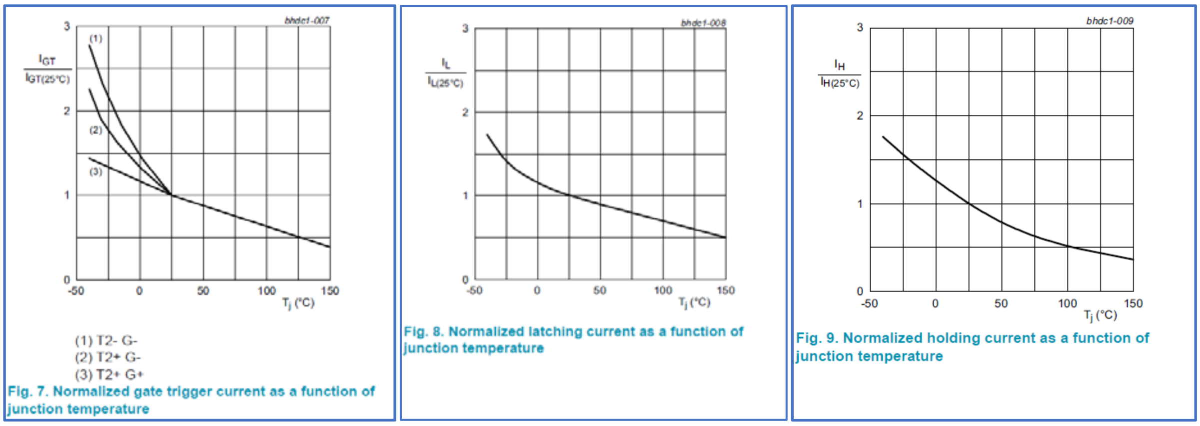

Fig. 23 I_{GT}, I_L, and I_H temperature dependency graphics (BTA312-800CT)

The maximum gate trigger current, $I_{GT\,(max)}$, means that the triggering circuit must apply at least this value of gate current to guarantee triggering the triac. If a minimum value is given in the datasheet, this indicates that below this value electrical noise on the gate will not trigger the triac.

It is important to understand these values are stated for 25 °C. I_{GT} increases as junction temperature decreases and so in order to guarantee reliable triggering of the triac the designer needs set the gate drive current for the lowest operating temperature for the application. The minimum recommended gate pulse width for reliable triggering is 10µs.

Latching current, I_L is the minimum current through the main terminals to keep the triac "latched-on" after the gate current has been removed. I_L is also temperature dependent (see Fig. 18) and maximum and minimum operating temperatures must be considered when designing an optimal trigger circuit.

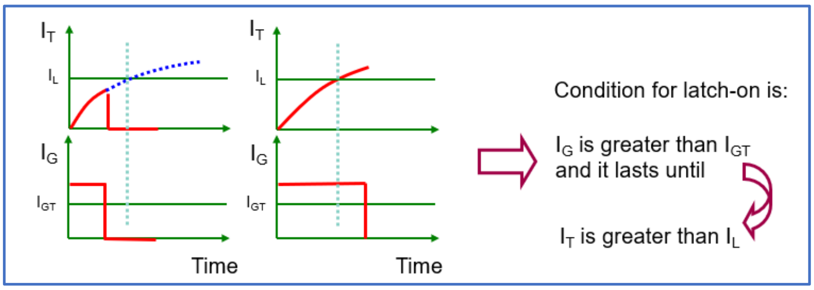

Fig. 24 Graphic showing interaction of I_{GT} and I_L

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I_H is the value of holding current. The triac will only turn off (commutate) when the current through the main terminals drops below this value. This current must remain below I_H for enough time to allow return to the off-state.

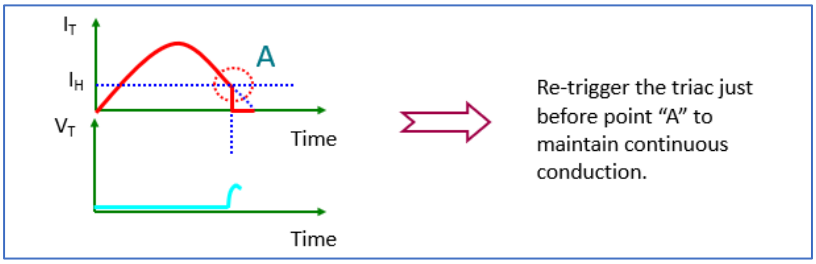

Fig. 25 Graphic showing interaction of I_T and I_H

I_H is also temperature dependent (see Fig. 18) and maximum and minimum operating temperatures must be considered to ensure conditions for safe commutation are met.

4.3 V_{GT}

V_{GT}	gate trigger voltage	V_D = 12 V; I_T = 0.1 A; T_j = 25 °C; Fig. 11		-	0.8	1	V
		V_D = 400 V; I_T = 0.1 A; T_j = 150 °C; Fig. 11		0.25	0.4	-	V

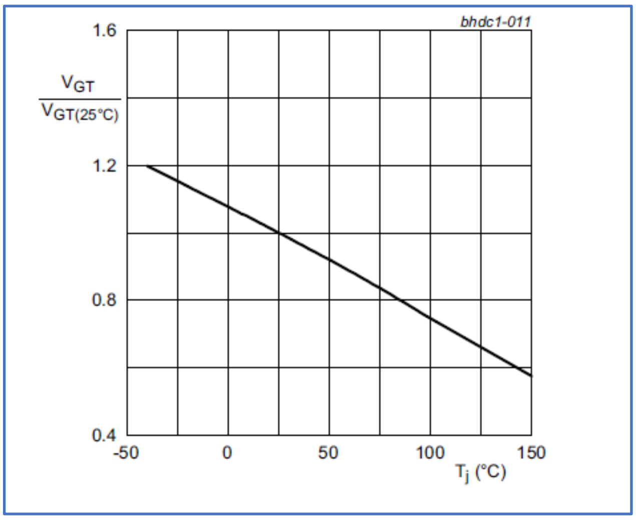

Fig. 26 Normalized V_{GT} versus junction temperature

The datasheet shows values for the typical and maximum gate trigger voltage at a gate current equal to I_{GT} at 25 °C. The graph shows the dependency on temperature.

The maximum gate trigger voltage is the gate voltage required to trigger the triac. The trigger circuit must be able to supply at least the maximum V_{GT} in order to drive current into the gate to cause triggering. To ensure

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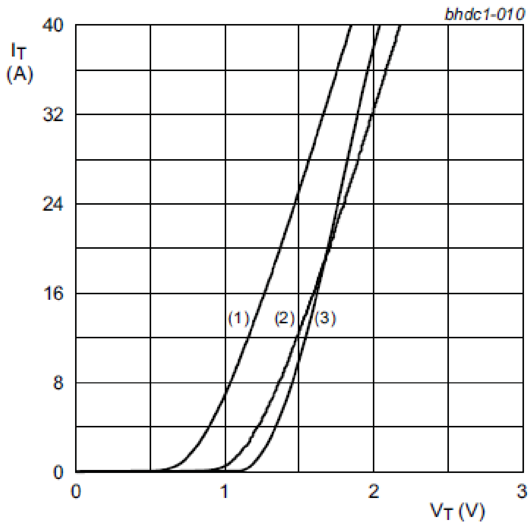
that the triac will not trigger, the gate voltage must be held below the minimum gate trigger voltage. The datasheet gives the minimum V_{GT} at the maximum junction temperature (150 °C in this example) and the maximum off-state voltage, V_{DRM}.

Because of the temperature dependency characteristics of I_{GT} and V_{GT}, the higher the junction temperature the easier it will be for the triac to be wrongly triggered.

4.4 V_T

V_T	on-state voltage	I_T = 15 A; T_j = 25 °C; Fig. 10		-	1.3	1.6	V



V_o = 1.097 V; R_s = 0.0321 Ω
(1) T_j = 150 °C; typical values
(2) T_j = 150 °C; maximum values
(3) T_j = 25 °C; maximum values

Fig. 10. On-state current as a function of on-state voltage

Fig. 27 Example of static characteristic V_T and graphic

V_T is the on-state voltage for the triac at 25 °C for a specified load current condition. This is the maximum instantaneous on-state voltage measured under pulse conditions to avoid excessive power dissipation.

The datasheet contains a graph with maximum and typical curves measured at the rated operating temperature (150 °C in this example) and at 25 °C. The maximum curve is used to calculate the power dissipation for a given average current. V_0 is the "knee voltage" and R_s is the slope resistance. If values for V_0 and R_s are not given in the data sheet, these can be generated manually as demonstrated in the graphic example (see Fig. 28).

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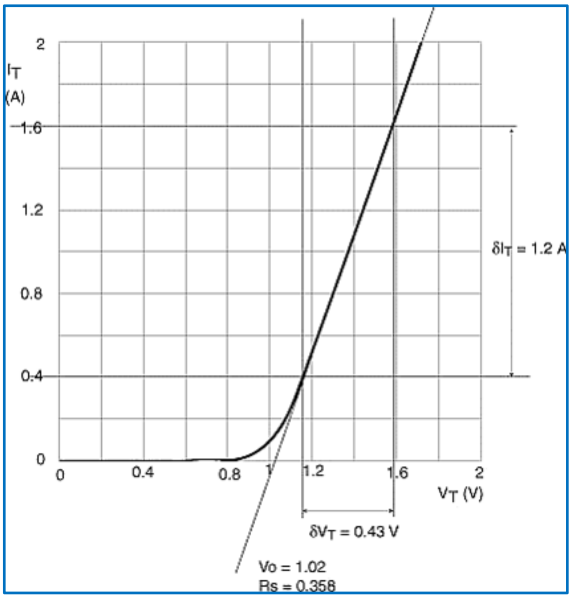

Fig. 28 Example graphic showing V_0 and R_s derivation

The on-state characteristic may be approximated by a linear model and the on-state voltage is then given by the equation: $V_T = V_0 + I_T.R_s$ and the instantaneous power dissipation is given by $P_T = V_0. I_T + I_T^2.R_s$ where I_T is the instantaneous on-state current.

It can be shown mathematically that the average on-state dissipation for any current waveform is given by the equation, $P_{T(AV)} = V_0. I_{T(AV)} + I_{T(RMS)}^2 .R_s$, where $I_{T(AV)}$ is the on-state average current and $I_{T(RMS)}$ is the RMS value of the on-state current.

Therefore, in triac datasheets, the graph for on-state dissipation can be calculated as a function of RMS current. Sinusoidal waveforms are assumed, and the graphs show the dissipation over a range of conduction angles. (See Fig. 9).

The derivation of V_0 and Rs and the power calculations are presented in WeEn Application Note WAN004.

4.5 I_D

I_D	off-state current	V_D = 800 V; T_j = 25 °C		-	-	10	µA
		V_D = 800 V; T_j = 150 °C		-	-	1	mA

Fig. 29 Example of static characteristics, I_D and I_R

The maximum off-state leakage values are at maximum operating junction temperature and maximum blocking voltage. Very high I_D leakage current can lead to false triggering of the triac, especially if it is a sensitive gate design.

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4.6 Dynamic characteristics: dV_D/dt

dV_D/dt	rate of rise of off-state voltage	V_{DM} = 536 V; T_j = 125 °C; (V_{DM} = 67% of V_{DRM}); exponential waveform; gate open circuit		500	-	-	V/µs
		V_{DM} = 536 V; T_j = 150 °C; (V_{DM} = 67% of V_{DRM}); exponential waveform; gate open circuit		300	-	-	V/µs

Fig. 30 Triac dynamic characteristics, dV_D/dt (BTA312X-800CT)

Dynamic characteristics show how the triac copes with fast-changing conditions in a circuit. These are not to be mistakenly understood as limiting values. "Dynamic" means continuous changes in voltage and current. Such characteristics are important when a triac experiences a fast voltage transient while in the off-state. These characteristics are measured under specified conditions and often at maximum operating junction temperature.

The rate of change of blocking voltage (dV_D/dt) indicates a triac's ability to withstand a fast-changing voltage without causing spontaneous, unwanted turn-on of the triac.

By convention this characteristic is tested with blocking voltage, V_D set at 67% V_{DRM} and "dt" measured between 10% - 63% of V_D for a given junction temperature: In this example T_j = 125°C and T_j = 150°C with gate open circuit are shown.

There is internal junction capacitance between T2 and gate and the larger the junction area and the closer the geometries, the larger the capacitance. Consequently, very high dV_D/dt can generate or induce enough internal gate current to spontaneously trigger the triac ($I_G = C.dV_D/dt$).

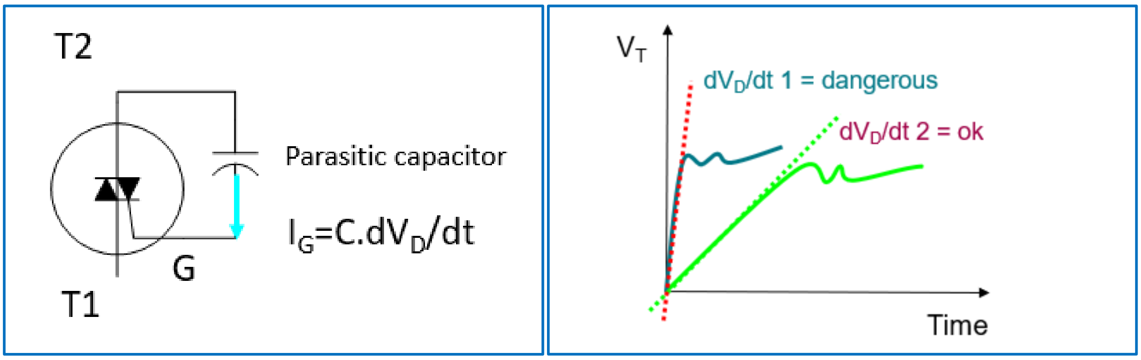

Fig. 31 dV_D/dt illustration

If in the circuit the maximum dV_D/dt is exceeded, the triac may be triggered wrongly into conduction.

This event may not itself damage the triac or adversely affect an application as this depends on the circuit, but such lack of control and susceptibility to electrical noise is not advisable. The higher the temperature and the lower the I_{GT}, the lower triac's withstand capability and noise immunity.

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If for a 4-quadrant triac an improved immunity is required, an RC snubber may be added between T1 and T2 to reduce the rate of rise of blocking voltage below the critical value. A resistance value of at least 47Ω, typically 100Ω, and a capacitance value in the range 4.7nF to 100nF is suitable for the RC snubber. For 3-quadrant triacs this may also be the case - if very high immunity is required.

Larger capacitance and lower resistances cause greater stress to the triac when triggering at non-zero volts and the designer needs to consider this. A fast discharge of the snubber capacitor can cause dI_T/dt damaging effects to the triac if the resistance is too low.

4.7 Dynamic characteristics: commutation capability

dI_{com}/dt	rate of change of commutating current	V_D = 400 V; T_j = 150 °C; $I_{T(RMS)}$ = 16 A; dV_{com}/dt = 20 V/µs; gate open circuit; snubberless condition		12	-	-	A/ms
		V_D = 400 V; T_j = 150 °C; $I_{T(RMS)}$ = 16 A; dV_{com}/dt = 10 V/µs; gate open circuit		15	-	-	A/ms
		V_D = 400 V; T_j = 150 °C; $I_{T(RMS)}$ = 16 A; dV_{com}/dt = 1 V/µs; gate open circuit		20	-	-	A/ms

dV_{com}/dt	rate of change of commutating voltage	V_D = 400 V; T_j = 95 °C; I_T = 16 A; dI_{com}/dt = 7.2 A/ms; gate open circuit		10	20	-	V/µs

Fig. 32 Triac dynamic characteristics, dI_{com}/dt (BTA312X-800CT) and dVcom/dt (BT139X-800)

Commutation capability of a triac (the ability of the triac to always turn off correctly) is usually guaranteed as a minimum value of dI_{com}/dt or in some cases dV_{com}/dt at a specified junction temperature. These parameters are interdependent and must always be considered together. An increase in the value of any one parameter always causes a decrease in the other two for a triac design.

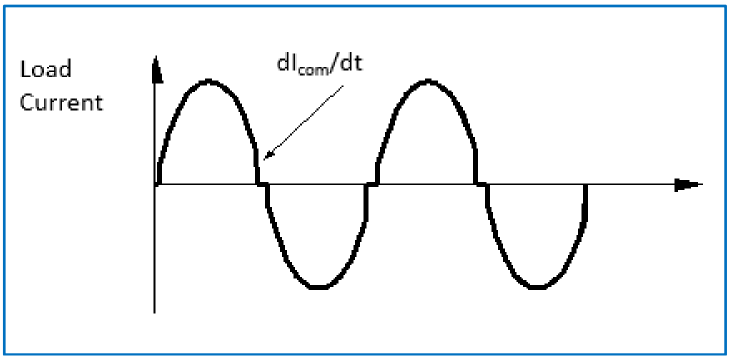

Fig. 33 dI_{com}/dt illustration for a rectifier fed inductive load

The dI_{com}/dt parameter is defined as the rate-of-rise of current as the current approaches turn-off (commutation) and is always specified for a value of dV_{com}/dt and junction temperature. This parameter is particularly important when the triac switches non-linear loads, especially rectified DC inductive loads because fast fall of the commutating current can cause false triggering of the triac. WeEn "3-Quadrant" triacs do not normally require a series dI_{com}/dt limiting inductor in series with the load.

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This parameter is temperature dependent and is specified at maximum rated junction temperature. It is also dependent on dVcom/dt, peak reapplied voltage (line voltage) and is specified at rated current and 400V.

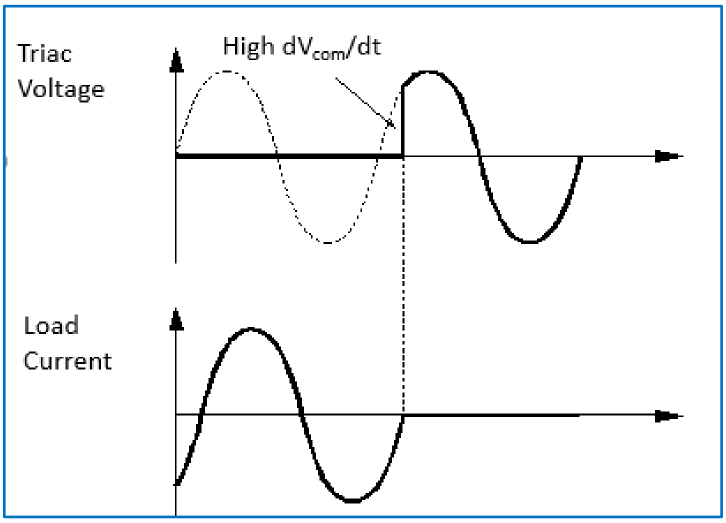

Fig. 34 dV_{com}/dt illustration for an inductive load

The dV_{com}/dt parameter is defined as the rate-of-rise of voltage across the main terminals that a triac can block without spontaneously switching back on again when turning off (commutating) from the on-state in one half-cycle to the off-state in the opposite half-cycle.

This dV_{com}/dt parameter is temperature dependent and is specified at maximum rated junction temperature. It is is also dependent on dI_{com}/dt, peak reapplied voltage (line voltage) and is normally specified at rated current and 400V. With inductive loading, when the voltage is out of phase with the load current, there will be a voltage stress (dV_{com}/dt) across the main terminals of the triac during the zero-current crossing. This is caused by the fast rise in reapplied voltage following commutation caused by phase shift between voltage and current. This fast rise of dV_{com}/dt can cause the triac to false trigger.

A snubber (series RC across the triac) may be used with inductive loads to decrease this dV_{com}/dt to an amount below the minimum value which the triac can be guaranteed to turn off each half-cycle, although for WeEn "3Q Hi-COM" triacs this is not usually necessary. A resistance value of at least 47Ω, typically 100Ω, and a capacitance value in the range 4.7nF to 100nF is suitable for the RC snubber.

All devices are guaranteed to commutate rated current with a resistive load at 50 to 60 Hz. Commutation of rated current is not guaranteed at higher frequencies, and no direct relationship can be made about current and temperature derating for higher-frequency operation.

Commutation failure (failure to turn off at the end of a half cycle) is not necessarily damaging to the triac

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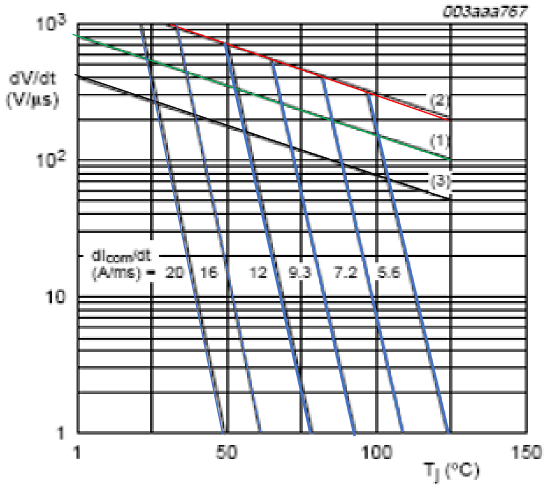

The triac should commutate when dI_T/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

(1) BT139X-600; BT139X-800.

(2) BT139X-600G.

(3) BT139X-600F.

Fig 12. Critical rate of change of commutating voltage as a function of junction temperature; minimum values

Fig. 35 Illustration of interdependent relationship between dI_{com}/dt, dV_{com}/dt and T_j

Fig. 32 shows that dV_{com}/dt decreases as the temperature increases, dV_{com}/dt decreases as dI_{com}/dt increases. The higher the I_{GT}, the higher the dV_{com}/dt which means better immunity to false triggering.

4.8 Dynamic characteristics: t_{gt}

t_{gt}	gate-controlled turn-on time	V_D = 800 V; I_{TM} = 20 A; I_G = 0.1 A; dI_G/dt = 5 A/µs		-	2	-	µs

Fig. 36 Triac dynamic characteristics, t_{gt} (BT139X-800)

t_{gt} is the gate-controlled turn-on time and has a typical value of 2µs. The 1+ quadrant (Q1) has the smallest turn-on delay compared to the other quadrants. This parameter is most often shown in older datasheets.

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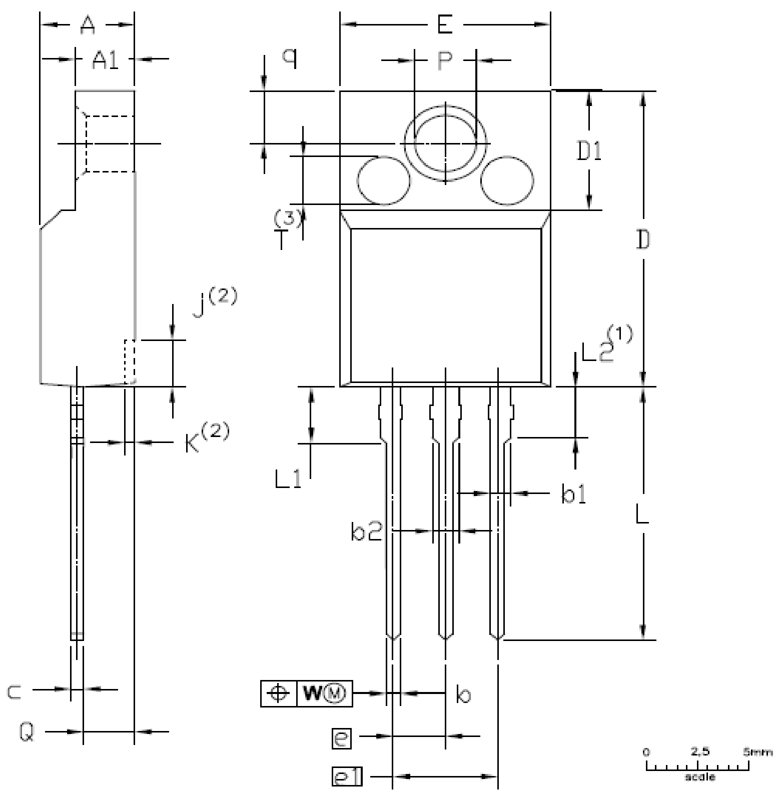
5. Package outline drawing

The datasheet contains a package outline drawing of the device. if a surface mount package is described a soldering pad drawing may also be included.

11. Package outline

Plastic single–ended package; isolated heatsink mounted; 1 mounting hole; 3–lead TO–220 "full pack" SOT186A



UNIT	A	A_1	b	b_1	b_2	c	D	D_1	E	e	e_1	j(2)	K(2)	L	L_1	L_2(1) max.	P	Q	q	W	T(3)
mm	4.6 4.0	2.9 2.5	0.9 0.7	1.1 0.9	1.4 1.0	0.7 0.4	15.8 15.2	6.5 6.3	10.3 9.7	2.54	5.08	2.7 1.7	0.6 0.4	14.4 13.5	3.30 2.79	3	3.2 3.0	2.6 2.3	3.0 2.6	0.4	2.5

Notes
1. Terminal dimensions within this zone are uncotrolled
2. Dot lines area designs may vary
3. Eject pin mark is for reference only

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT186A		3 LEADS TO220F				2013–11–14

Fig. 13. Package outline TO-220F (SOT186A)

Fig. 37 Example package outline drawing

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Revision history

Rev	Date	Description
v.01	20190915	initial version

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