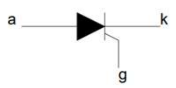
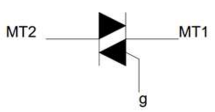
Thyristors & Triacs

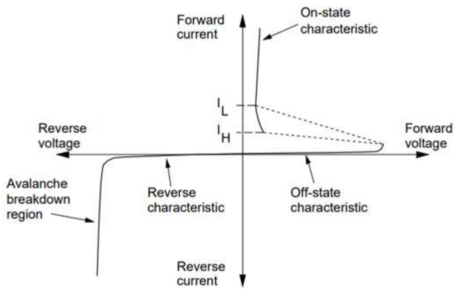
Thiristor



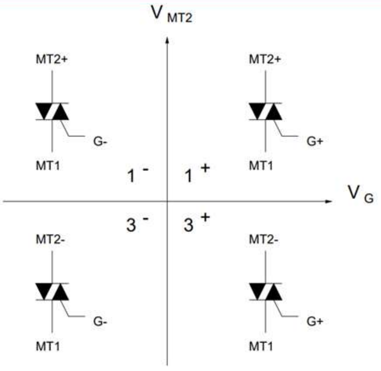
Triac



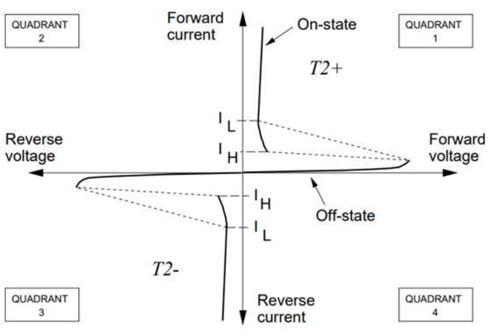
Thyristor V/I characteristic



Triac



Triac characteristic



Rule 1:
To turn a thyristor (or triac) ON, a gate current

$\geq I_{GT}$ must be applied until the load current is

$\geq I_L$.
This condition must be met at the lowest

expected operating temperature.

Rule 2:
To turn off (commutate) a thyristor (or triac),
the load current must be
$< I_H$ for sufficient time
to allow a return to the blocking state.
This condition must be met at the highest
expected operating temperature.

BT139-600 parameters

Static characteristics

I_{GT}	gate trigger current	V_D = 12 V; I_T = 0.1 A; T2+ G+; T_j = 25 °C; Fig. 7		-	5	35	mA
		V_D = 12 V; I_T = 0.1 A; T2+ G-; T_j = 25 °C; Fig. 7		-	8	35	mA
		V_D = 12 V; I_T = 0.1 A; T2- G-; T_j = 25 °C; Fig. 7		-	10	35	mA
		V_D = 12 V; I_T = 0.1 A; T2- G+; T_j = 25 °C; Fig. 7		-	22	70	mA
I_L	latching current	V_D = 12 V; I_G = 0.1 A; T2+ G+; T_j = 25 °C; Fig. 8		-	7	40	mA
		V_D = 12 V; I_G = 0.1 A; T2+ G-; T_j = 25 °C; Fig. 8		-	20	60	mA
		V_D = 12 V; I_G = 0.1 A; T2- G-; T_j = 25 °C; Fig. 8		-	8	40	mA
		V_D = 12 V; I_G = 0.1 A; T2- G+; T_j = 25 °C; Fig. 8		-	10	60	mA
I_H	holding current	V_D = 12 V; T_j = 25 °C; Fig. 9		-	6	45	mA

Dynamic BT139 parameters

dV_D/dt	rate of rise of off-state voltage	V_{DM} = 402 V; T_j = 125 °C; (V_{DM} = 67% of V_{DRM}); exponential waveform; gate open circuit		200	250	-	V/µs
dV_{com}/dt	rate of change of commutating voltage	V_D = 400 V; T_j = 95 °C; dI_{com}/dt = 7.2 A/ms; I_T = 16 A; gate open circuit		10	20	-	V/µs
t_{gt}	gate-controlled turn-on time	I_{TM} = 20 A; V_D = 600 V; I_G = 0.1 A; dI_G/dt = 5 A/µs		-	2	-	µs

BT139-600 parameters

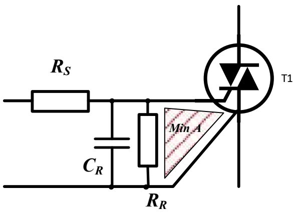
Rule 3:
When designing a triac triggering circuit,

avoid triggering in the 3+ quadrant (MT2-, G+) where possible

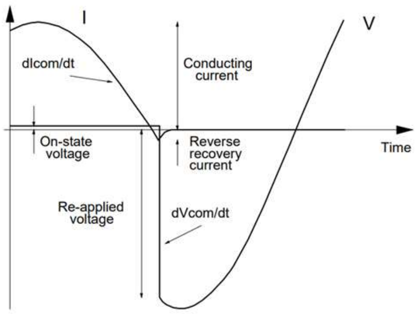
Unwonted commutation

Rule 4:
To minimise noise pickup, keep gate connection length to a minimum. Take the return directly to MT1 (or cathode). If hard wired, use twisted pair or shielded cable. Fit a resistor of 1kΩ or less between gate and MT1. Fit a bypass capacitor in conjunction with a series resistor to the gate. Alternatively, use an insensitive series H triac

Reduction of noise in gate loop



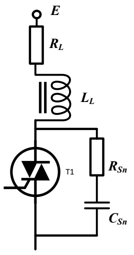
Unwonted commutation Triac dV_{COM}/dt



Dynamic BT139 parameters

dV_D/dt	rate of rise of off-state voltage	V_{DM} = 402 V; T_j = 125 °C; (V_{DM} = 67% of V_{DRM}); exponential waveform; gate open circuit		200	250	-	V/µs
dV_{com}/dt	rate of change of commutating voltage	V_D = 400 V; T_j = 95 °C; dI_{com}/dt = 7.2 A/ms; I_T = 16 A; gate open circuit		10	20	-	V/µs
t_{gt}	gate-controlled turn-on time	I_{TM} = 20 A; V_D = 600 V; I_G = 0.1 A; dI_G/dt = 5 A/µs		-	2	-	µs

$dV_{com}/dt = (dV/dt)_{com}$

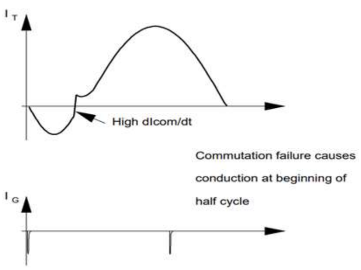


$$C_{Sn} \approx (1-4) * \left(E^2 \Big/ \left(L_L * \left(\frac{dV}{dt}\right)_c^2 \right) \right)$$

$$R_{Sn} \approx (1-2) * \left(\sqrt{\frac{L_L}{C_{Sn}}} - R_L \right)$$

$$P_{R_{Sn}} \approx C_{Sn} E^2 f_s$$

Unwonted commutation Triac dI_{COM}/dt



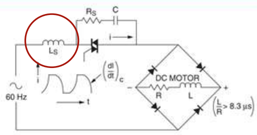
no benefit in adding a snubber across the triac because dV_{COM}/dt is not the problem…..

T5035H-8PI

Symbol	Test conditions		Quadrants		Value	Unit
I_{GT}	V_D = 12 V, R_L = 30 Ω		I - II - III	Min.	5	mA
	V_D = 12 V, R_L = 30 Ω		I - II - III	Max.	35	mA
V_{GT}	V_D = 12 V, R_L = 30 Ω		I - II - III	Max.	1.3	V
V_{GD}	V_D = V_{DRM}, R_L = 3.3 kΩ	T_j = 150 °C	I - II - III	Min.	0.15	V
I_L	I_G = 1.2 x I_{GT}		I - III	Max.	75	mA
			II	Max.	90	mA
I_H (1)	I_T = 500 mA, gate open			Max.	60	mA
dV/dt (1)	V_D = 536 V, gate open		T_j = 150 °C	Min.	2000	V/µs
(dI/dt)c (1)	Without snubber network		T_j = 150 °C	Min.	40	A/ms

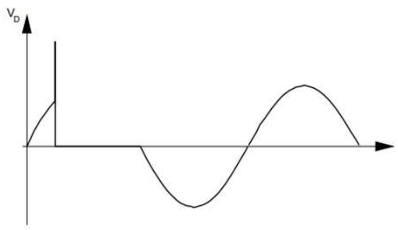
1. For both polarities of A2 referenced to A1.

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



no benefit in adding a snubber across the triac because dV_{COM}/dt is not the problem….add Ls [a few mH can be saturated].

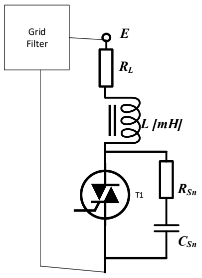
Triac turn-on by exceeding dV_D/dt



Dynamic BT139 parameters

dV_D/dt	rate of rise of off-state voltage	V_{DM} = 402 V; T_j = 125 °C; (V_{DM} = 67% of V_{DRM}); exponential waveform; gate open circuit		200	250	-	V/µs
dV_{com}/dt	rate of change of commutating voltage	V_D = 400 V; T_j = 95 °C; dI_{com}/dt = 7.2 A/ms; I_T = 16 A; gate open circuit		10	20	-	V/µs
t_{gt}	gate-controlled turn-on time	I_{TM} = 20 A; V_D = 600 V; I_G = 0.1 A; dI_G/dt = 5 A/µs		-	2	-	µs

Snubber; L[mH]; filter



T5035H-8PI

Symbol	Test conditions		Quadrants		Value	Unit
I_{GT}	V_D = 12 V, R_L = 30 Ω		I - II - III	Min.	5	mA
	V_D = 12 V, R_L = 30 Ω		I - II - III	Max.	35	mA
V_{GT}	V_D = 12 V, R_L = 30 Ω		I - II - III	Max.	1.3	V
V_{GD}	V_D = V_{DRM}, R_L = 3.3 kΩ	T_j = 150 °C	I - II - III	Min.	0.15	V
I_L	I_G = 1.2 x I_{GT}		I - III	Max.	75	mA
			II	Max.	90	mA
I_H (1)	I_T = 500 mA, gate open			Max.	60	mA
dV/dt (1)	V_D = 536 V, gate open		T_j = 150 °C	Min.	2000	V/µs
(dI/dt)c (1)	Without snubber network		T_j = 150 °C	Min.	40	A/ms

1. *For both polarities of A2 referenced to A1.*

T5035H-8PI

- 50 A RMS Snubberless Triac
- 800 V symmetrical blocking voltage
- 150 °C maximum junction temperature Tj
- Three triggering quadrants
- High noise immunity - static dV/dt
- Robust dynamic turn-off commutation - (dI/dt)c

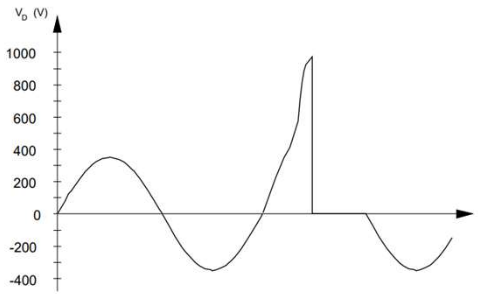
Rule 5:

Where high dV_D/dt or dV_{COM}/dt are likely to cause a problem, fit an RC snubber across MT1 and MT2.

Where high dI_{COM}/dt is likely to cause a problem, fit an inductor of a few mH (saturated !?) in series with the load.

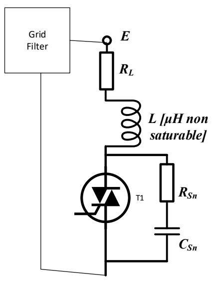
Alternatively, use a Hi-Com triac

Triac turn-on by exceeding V_{DRM}



BT139

Symbol	Parameter	Conditions	Min	Max	Unit
V_{DRM}	repetitive peak off-state voltage		-	600	V



dI_T/dt - burn out

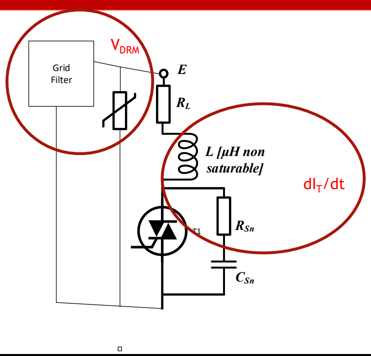
Rule 6.

If the triac's V_{DRM} is likely to be exceeded during severe mains transients, employ one of the following measures:

- Limit high dI_T/dt with a non saturable inductor of a few μH in series with the load;
- Use a MOV (Metal Oxide Varistor) across the mains in combination with filtering on the supply side

dI_T/dt prevent

Rule 8:
If the triac's dI_T/dt is likely to be exceeded, an air cored inductor of a few μH or an NTC thermistor should be fitted in series with the load.
Alternatively, employ zero voltage turn-on for resistive loads.



Rule 7:
Healthy gate drive and avoiding 3+ (IV quadrant) operation maximises the triac's dI_T/dt capability.

BT139

dI_T/dt	rate of rise of on-state current	I_T = 20 A; I_G = 0.2 A; dI_G/dt = 0.2 A/µs; T2+ G+		-	50	A/µs
		I_T = 20 A; I_G = 0.2 A; dI_G/dt = 0.2 A/µs; T2+ G-		-	50	A/µs
		I_T = 20 A; I_G = 0.2 A; dI_G/dt = 0.2 A/µs; T2- G-		-	50	A/µs
		I_T = 20 A; I_G = 0.2 A; dI_G/dt = 0.2 A/µs; T2- G+		-	10	A/µs

Rule 9:

Avoid mechanical stress to the triac when fitting it to the heatsink.

Fix, then solder.

Never pop rivet with the rivet mandrel on the tab side.

Rule 10:

For longterm reliability, ensure that the Rth j-a. is low enough to keep the junction temperature within Tj max for the highest expected ambient temperature.

$$R_{th\ j\text{-}a} = R_{th\ j\text{-}mb} + R_{th\ mb\text{-}h} + R_{th\ h\text{-}a} \quad [K/W]$$

Test problems

- Prąd załączania (gate current I_{GT})
- Prąd właczania (latch current I_L)
- Prąd wyłączania (holding current I_H)
- Niekontrolowane włączenia triaka:
  - Szumy w obwodzie bramki (odfiltrować i zbocznikować bramkę)
  - Przekroczenie dV_{COM}/dt (w czasie wyłaczania obc. indukcyjnego- snubber)
  - Przekroczenie dI_{COM}/dt (nieoczekiwane wyłączenie prądu – indukcyjność uH bez nasycenia)
  - Przekroczenie chwilowe dV_D/dt (bez przekroczenia trwałego V_{DRM} – filtracja sieci; MOV)
  - Chwilowe przekroczenie V_{DRM} (powtarzalne – filtracja sieci;MOV)
- Rola układu tłumiącego (snubber)