

FAQ of Phototriacs

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1. What is “static dV/dt”?

Static dV/dt is a measure of the ability of a triac to retain a blocking state under the influence of a voltage transient.

Static dV/dt turn-on is non-destructive when series impedance limits the surge current. The triac turns off after a half cycle of conduction.

The symbol for static dV/dt is dV/dtcr or dV/dt(s). Unit is KV/ μ s.

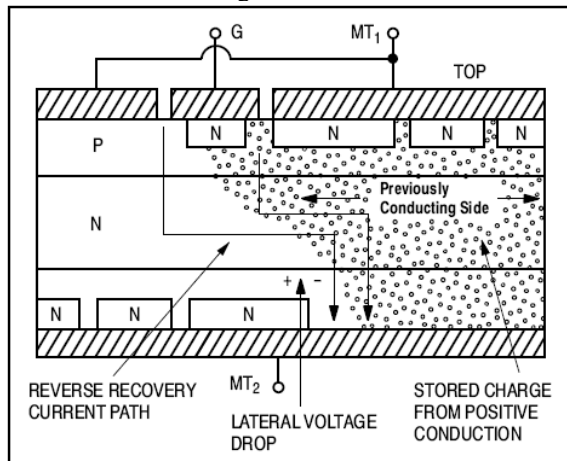
2. What are “commutating dV/dt” and “commutating di/dt”?

The commutating dV/dt and commutating di/dt rating apply when a TRIAC has been conducting and attempts to turn-off when the trigger current is off and the current drops below the holding value. Successful turn-off requires the voltage across the TRIAC to rise or the current through the TRIAC drops at a rate slow enough to prevent the device from retriggering on.

The symbol of commutating dV/dt is dV/dtcrq or dV/dt(c). Unit is V/ μ s.

The symbol of commutating di/dt is di/dtcrq or di/dt(c). Unit is A/ms.

Normally the commutating dV/dt of a triac is much less than its static dV/dt for its special functional structure. A TRIAC functions like two inverse-parallel SCRs combined in one chip. There is charge within the crystal’s volume because of prior conduction. The charge at the boundaries of the collector junction depletion layer responsible for dV/dtcr is also present. TRIACs have lower dV/dtcrq than dV/dtcr because of this additional charge.





To get higher commutating dV/dt and di/dt two discrete SCRs in inverse parallel may be used instead of one TRIAC chip. Because each SCR will have an entire half-cycle of reverse polarity voltage applied to it, turn-off of the SCRs is assured, no matter what the character of the load.

Vishay's IL410/IL420/IL4108/IL4208/IL4118/IL4218 and BRT series use **two discrete SCRs** resulting in a commutating dV/dt of greater than 9 V/ μ s. It can drive a load directly up to 300 mA (room temperature, resistive load).

Another solution is the power phototriac VO3526. Its commutating dV/dt is 5 V/ μ s (typ.) and can drive a load directly up to 1 A (room temperature, resistive load).

The triacs with low commutating dV/dt or di/dt should not be used to drive a load directly. They are intended to be a trigger device only. The maximum direct load current is limited by its commutating performance and may be less than its on-state current. Following are the formulas:

$$dV/dtcrq = 8.9 * f * V_{rms} \quad (2-1)$$

$$di/dtcrq = 8.9 * f * I_{rms} \quad (2-2)$$

or

$$di/dtcrq = 8.9 * f * V_{rms} / R_{load} \quad (2-3)$$

then

$$I_{rms} = di/dtcrq / (8.9 * f) \quad (2-4)$$

For example, VO4158 $di/dtcrq = 0.02$ A/ms @85 C. When the power supply freq = 60 Hz, use function 2-4
 $I_{rms(max)} = 0.02 / (8.9 * 60) = 37$ mA

To calculate from $dV/dtcrq$ one needs to know the test condition. The test current of $dV/dtcrq$ should be close to the proposed direct load current. For example the test condition of VO4158 is 120 Vrms, R_{load} is 2400 Ohm, @85 C. The typical value of $dV/dtcrq$ is 0.05 V/us. Then use function 2-3

$$di/dtcrq = 8.9 * f * V_{rms} / R_{load} = dV/dtcrq / R_{load} = 0.05 / 2.4 = 0.02$$
 A/ms

3. Trigger current 2 (I_{FT2}) of IL410

Question1:

What is the difference between Trigger current 1 and Trigger current 2 listed on the IL410 datasheet?

Answer:

The test condition of I_{FT1} is

Ambient temperature $T_{amb} = 25$ °C, operating voltage V_D ($mt1$ - $mt2$) = 5 VDC

The test condition of I_{FT2} is

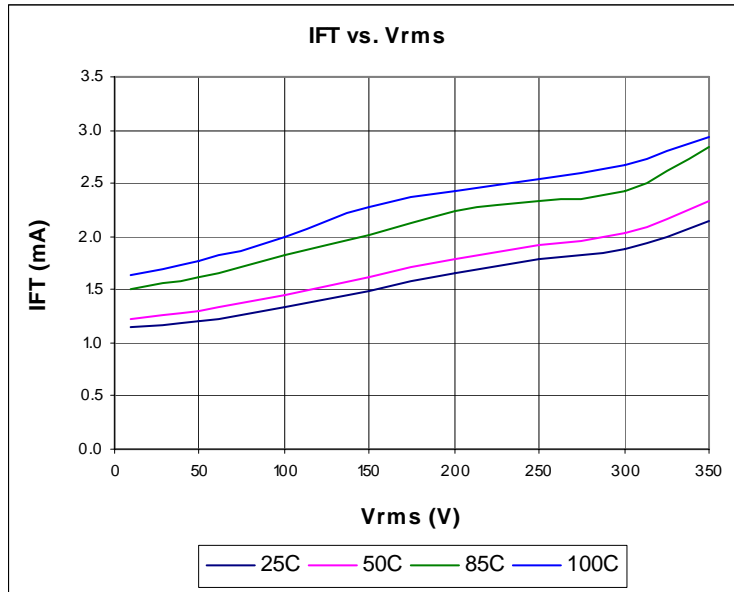
$T_{amb} = 100$ °C, $V_D = 220$ V (RMS), freq = 50 Hz

Question2:

How do you determine the minimum current required to guarantee that the output turns on over the temperature range -40 to 85 °C and supply voltage is 250 V (RMS)?

Answer:

The trigger current threshold I_{FT} of IL410 is getting higher when operating voltage or temperature is higher, as shown in the following figure. The same characteristics apply to the IL4116/7/8 and VO4157/8 series.



IL410 Trigger current vs. temperature and operating voltage (50 Hz)

For the operating voltage 250 V (RMS) over the temperature range -40 to 85 °C, the I_F should be at least 2.3 x of the I_{FT1} (2 mA, max.).

Considering -30% degradation over time, the trigger current minimum is

$$I_F = 2 \times 2.3 \times 130\% = 6 \text{ mA}$$

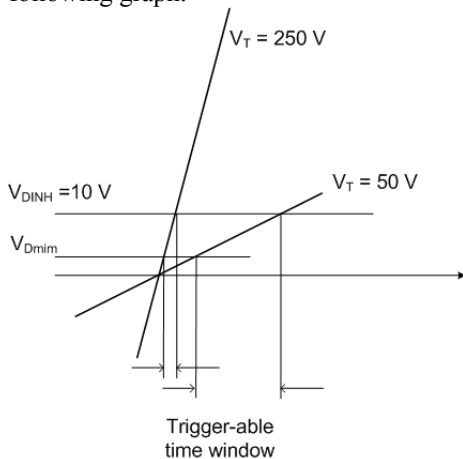
Remark: Same rules apply to other Zero-crossing phototriacs, e.g. IL4116, IL4117, IL4118, VO4157, VO4158 and BRTs.

Question3:

Why the I_{FT} is dependent on the terminal voltage?

Answer:

The ZC triac has an inhibit circuit (or called ZC Circuit) to inhibit the triac from being triggered on when the main power supply voltage (V_T) is not close to zero even if the trigger current (I_F) is high. The actual trigger-able time window is between the minimum trigger voltage and the Inhibit Voltage (V_{DINH}) specified in the datasheet. The trigger time window becomes narrow when V_T or frequency is high, shown as following graph.





4. Direct Driven Load Current

Question:

The on-state current (I_{TM}) of VO4x5x series is 300 mA but why can not it drive a 50 mA load directly? What does the 300 mA on-state current mean here? Do you have other phototriacs that can drive a load 100 mA or more directly?

Answer:

VO4157/8 and VO4257/8 should not be used to drive a load directly. It is intended to be a trigger device only. The load current cannot be more than 30 mA when driving a load directly because VO4x5x use only one triac die resulting in a low commutating dV/dt (0.07 V/ μ s, typ.)¹

The VO4x5x on-state current is 300 mA, this is good for driving a high power triac which requires larger trigger current.

IL410/IL4108/IL4118 and BRT series use two discrete SCRs resulting in a commutating dV/dt of greater than 9 V/ μ s. It can drive a load directly up to 300 mA (room temperature, resistive load) and high frequency of power supply up to 3000 Hz. The following tables are test results of these parts for comparison and reference.

IL410/IL4108/IL4118 Commutating dV/dt and di/dt

Test condition: $V_{bias} = 230V_{rms}$, $R_L = 767 \text{ Ohm}$ ($I_{rms} = 300 \text{ mA}$)						
	At 25C			At 85C		
	freq	(dv/dt)c	di/dt	freq	(dv/dt)c	di/dt
	KHz	(V/ μ s)	(A/ms)	KHz	(V/ μ s)	(A/ms)
Average	4.5	9.2	12.0	3.7	7.5	9.8

VO4158 Commutating dV/dt and di/dt

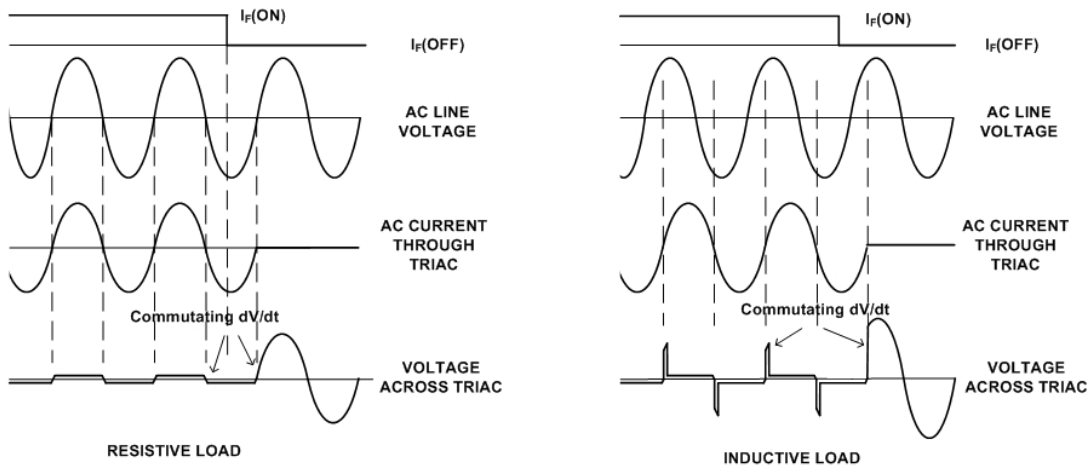
Test condition: $V_{bias} = 120V_{rms}$, $R_L = 2.4 \text{ kOhm}$ ($I_{rms} = 50 \text{ mA}$)						
	At 25C			At 85C		
	freq	(dv/dt)c	di/dt	freq	(dv/dt)c	di/dt
	Hz	(V/ μ s)	(A/ms)	Hz	(V/ μ s)	(A/ms)
Average	70	0.075	0.031	47	0.050	0.022

5. Inductive and Resistive Loads

Question: Why does the ZC phototriac need higher trigger current when the load is inductive than resistive?

The ZC triac has an inhibit circuit (or called ZC Circuit) to inhibit the triac from being triggered on when the main power supply voltage (V_T) is not close to zero. When the load is inductive the commutating dV/dt spikes can inhibit one half of the TRIAC from turning on. If the spike potential exceeds the inhibit voltage of the zero cross detection circuit, half of the TRIAC will be held-off and not turn-on. The half-off condition also can be eliminated by providing a higher level of LED drive current. Another solution is add a RC snubber or a single capacitor directly across the device to damp the peak commutating dV/dt spike.

¹ For the maximum load current calculation please refer to question #2.



Example:

-- IL410 (ZC Phototriac) --

I_{FT} : 1 mA ($V_D = 5$ VDC)

Test condition: $V_T = 120.7$ V, 60 Hz

Resistive Load: 29.4 W, 0.242 Arms, PF = 1.00, $I_{FT} = 1.5$ mA

Inductive Load (AC Relay): 9.4 W, 0.241 Arms, PF = 0.33, $I_{FT} = 2.2$ mA

-- IL420 (NZC Phototriac) --

I_{FT} : 0.9 mA ($V_D = 5$ VDC)

Test condition: $V_T = 120.7$ V, 60 Hz

Resistive Load: 28.4 W, 0.237 Arms, PF = 1.00, $I_{FT} = 1.0$ mA

Inductive Load (AC Relay): 9.0 W, 0.237 Arms, PF = 0.33, $I_{FT} = 1.1$ mA

Remarks: The I_{FT} of a ZC phototriac is dependent on the terminal voltage and the power factor, but NZC is not.

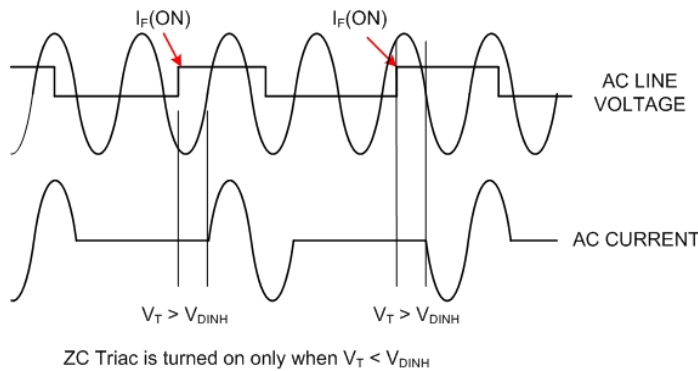
6. What is "inhibit voltage"?

Question

There is a parameter "inhibit voltage" in the Electrical Characteristics table of Zero-crossing phototriac datasheet. What does it mean?

Answer:

The ZC triac has an inhibit circuit (or called ZC Circuit) to inhibit the triac from being triggered on when the main power supply voltage (V_T) is not close to zero even if the trigger current (I_T) is high.



7. What does “Inhibit Current I_{DINH} ” means?

I_{DINH} is Off-state current in inhibit state of a zero-crossing phototriac, in short “Inhibit current”. Its test condition is $V_D = V_{DRM}$, $I_F = I_{FT1}$, $T_{amb} = 25\text{ C}$.

The inhibit current I_{DINH} is a function of the LED forward current I_F , shown as Figure 10 of its datasheet.

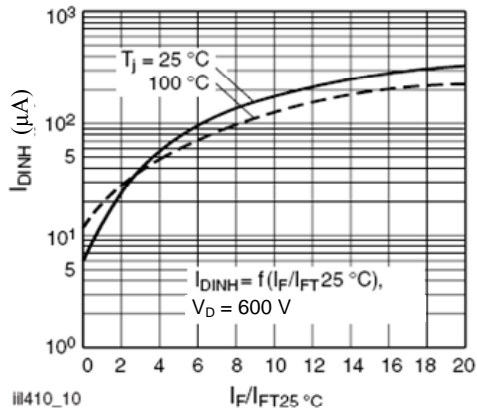


Fig. 10 - Inhibit current vs. I_F/I_{FT25C}

For example, $V_D = 600\text{ V}$, $T_{amb} = 25\text{ C}$, $I_{FT1(max)} = 2.0\text{ mA}$

Suppose

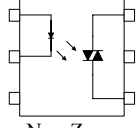
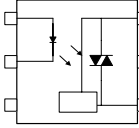
$$I_F = 4 * I_{FT1} = 8\text{ mA}$$

then

$$I_{DINH} = 60\text{ }\mu\text{A (typical)}$$

When a sensitive power triac is triggered by the ZC phototriac a gate resistor R_G may be required to avoid error triggering by the inhibit current.

Phototriac Selector Guide

	Device Number	Trigger Current (mA)	On-state Voltage V_{TM}		Blocking Voltage V_{DRM} (V)	Static dV/dt	Commutating di/dt (A/ms) (typ.)	Isolation Voltage V_{ISO} (V)
			Max (V)	@ I_{TM} (mA)				
 <p>Non-Zero-Crossing Switching</p>	K3010P(G) series	5 to 15	3.0	100	250	10 V/us	0.05	5300
	K3020P(G) series	5 to 30			400			
	IL440-4	15	3.0	100	400	50 V/us	0.11	
	IL440-5	10						
	IL440-6	5						
	VO3052	10	3.0	100	600	1.5 KV/us	0.03	
	VO3053	5						
	VO4257 series	1.6 to 3	3.0	300	700	5 KV/us	0.03	
	VO4258 series				800			
	IL420	2.0	3.0	300	600	10 KV/us	12	
IL4208	800							
IL4216/7/8	1.3	600-800						
 <p>Zero-Crossing Switching</p>	VO3062	10	3.0	100	600	1.5 KV/us	0.03	
	VO3063	5						
	VO4157 series	1.6 to 3	3.0	300	700	5 KV/us	0.03	
	VO4158 series				800			
	IL410	2.0	3.0	300	600	10 KV/us	12	
	IL4108				800			
	IL4116/7/8	1.3			600-800			

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