AN302
Application note

Thyristors and TRIACs: holding current - an important parameter

Introduction

The purpose of this note is to familiarize the users of TRIACs or thyristors with the hypostatic current parameter, I_H, also known as the holding current parameter.

The importance of this parameter is illustrated by some typical examples. Then a description is given of how to measure it and on its variation with the conditions of use and the sensitivity of the components.

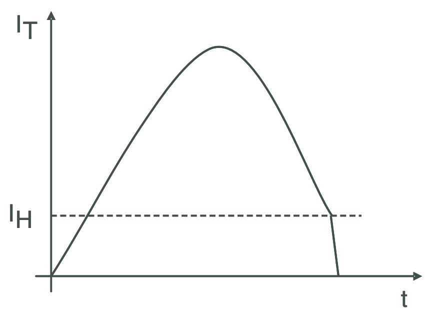
This application note discusses only the TRIAC; however, the concepts are also valid for SCRs.

Definition

To keep an electromechanical relay turned on, it is necessary to have a minimum current circulating in its coil. If the current falls too low the relay would turn off. The same phenomenon can be observed in a TRIAC. This minimum current which keeps the TRIAC conducting is called the hypostatic or holding current, I_H. (see *Figure 1*).

Figure 1 below shows the holding current and the gate current pulse, I_G, which is applied to the basic TRIAC circuit. After the TRIAC is turned on, a current, I_T, flows through it.When the TRIAC current falls below the holding current the TRIAC is blocked and requires another gate pulse before it can turn on again.

Figure 1. Current control



1 Application examples

The importance of the holding current is highlighted by the following application examples.

1.1 Example 1: light dimmer

Figure 2. Dimmer with interference suppression filter (coil and capacitor)

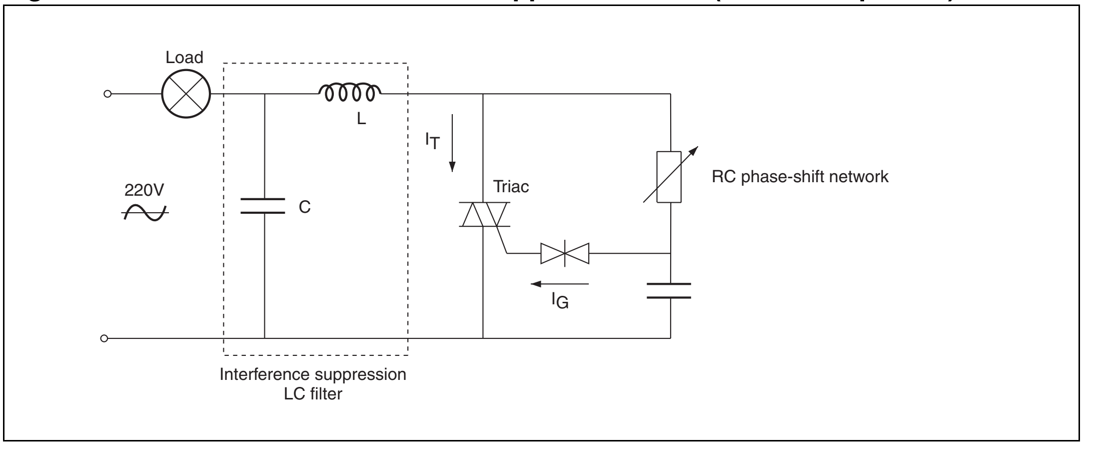
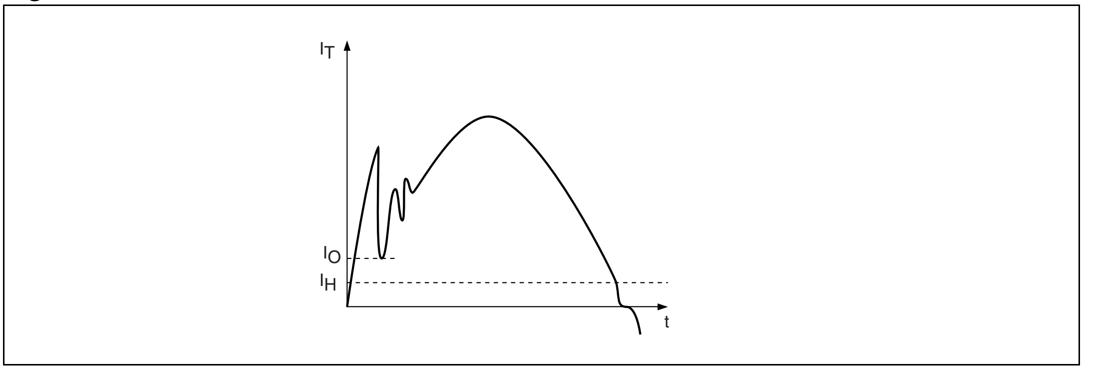


Figure 3. Current in the dimmer TRIAC



In the dimmer circuit of *Figure 2* the interference suppression filter can produce oscillations. If the minimum current during these oscillations is higher than the holding current, that is, if $I_O > I_H$ in *Figure 3*, the TRIAC remains turned on. But if I_O falls below I_H, the TRIAC will be blocked.

It is possible, if the coil is the incorrect type or of poor quality, that the oscillation is insufficiently damped and the TRIAC current falls below the holding current. This results in untimely blocking of the TRIAC. However, it is turned on again at the next gate current pulse; but the oscillations again prevent continuous conduction and the lamp flickers. Hence this is known as the flicker effect.

How to prevent the flicker effect

The flicker effect can be prevented by using an appropriate interference suppression filter which does not produce extensive oscillations, and then by choosing a TRIAC with a lower holding current.

1.2 Example 2: motor control (1)

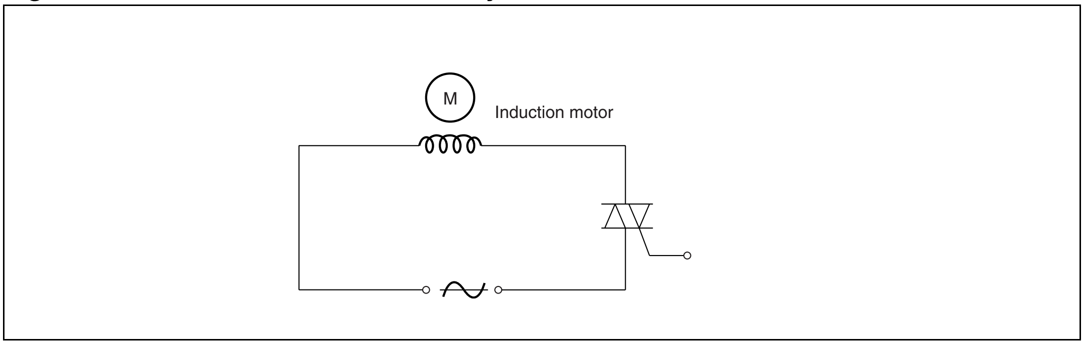


Figure 4. Control of a small motor by TRIAC

The designer wishes to control a small high-impedance motor (2500 Ω, for example) by a TRIAC. He obtains the parts and an operating manual and carries out some tests. The circuit, based on that in *Figure 4*, operates as expected at first. However, after one year of production, the manufacturer complains of low torque in the motor and blames the TRIAC.

What's happened?

The circuit was designed with a type of TRIAC whose maximum specified holding current I_H was 50 mA. But the TRIACs used for the tests were not worst-case, they were more sensitive, having I_{H+} = 13 mA and I_{H-} = 8 mA. The designer based his choice on these results.

After a year of delivery, the component manufacturer continues to deliver parts which are in conformity with the specification but less sensitive than before, in fact now I_{H+} = 40 mA and I_{H-} = 20 mA, typically.

With these different values the conduction time decreases, the asymmetry is greater as shown in *Figure 5*, and the resulting DC component of current causes the motor to gradually lose torque.

To prevent this kind of difficulty, one must, when designing the circuit, take into account not the typical value of the sample used but the worst-case value specified by the component manufacturer.

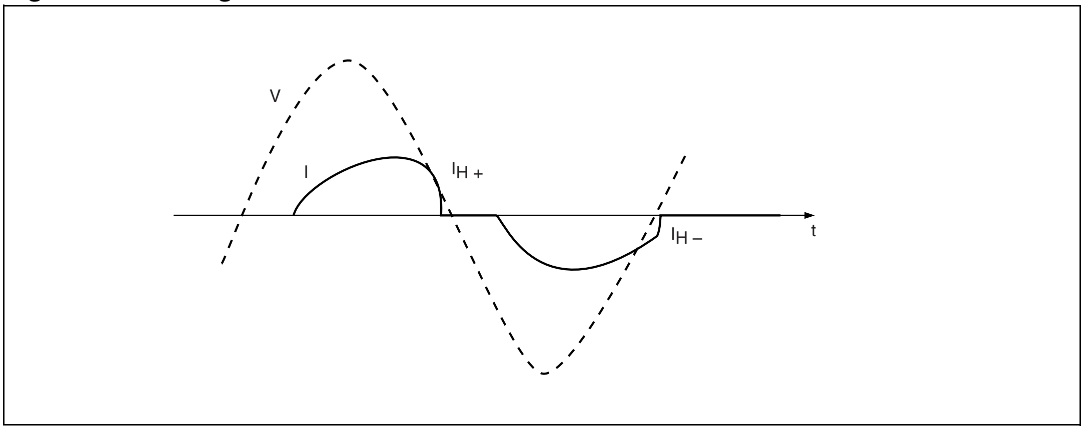


Figure 5. Voltage across the TRIAC and current for the motor control

1.3 Example 3: motor control (2)

This time, the designer selects a TRIAC with a lower maximum specified holding current, I_H. The small high-impedance motor (*Figure 4*) seems to operate without problems. However, the motor is intended for mounting on out-door equipment. It is installed in summer and works well. But in winter, the fault described above occurs.

What has happened?

The designer studied the operation of his circuit at an ambient temperature of 25 °C. But the holding current varies inversely with the temperature. Thus, as the temperature decreases, the holding current increases and the phenomenon described in example 2 occurs.

Again, it is essential to take into account the temperature effects on the device parameters for circuits which have to operate at extremes of temperature. It is not sufficient to use the values given for an ambient temperature of 25 °C.

2 Holding current - the details

The three examples in the previous chapter illustrate the importance of the holding current parameter and the different problems it can cause if it is not taken into account at an early stage in the design cycle.

If the device is to remain in the conducting state, it is imperative that the circuit in which it is used ensures an operating current sufficiently high.

In our data sheets, for all types of TRIACs, the holding current, I_H, is specified as a maximum value. Then, corrections must be made to compensate for temperature variations.

2.1 Measuring the holding current

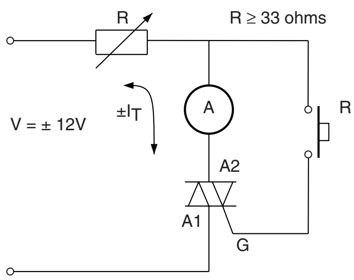
In *Figure 6* push button R is used to fire the TRIAC. The value of the conducting current I_T is set to be much higher than the latching current I_L. Increasing the resistance R causes the current I_T to decrease. The value of the holding current I_H is the value of I_T just before the TRIAC is blocked.

The holding current is always measured with the gate unconnected, that is disconnected from the trigger circuit and without bias. However, sensitive SCRs, that is, those with a gate trigger current I_{GT} of 200 µA or less, are measured with a 1 kΩ resistor connected between gate and cathode.

For repeatable results, the TRIAC should be suitably turned on. The following guidelines must be applied.

- The initial value of current I_T must be more than five times the latching current I_L before the test can begin.
- If the holding current is measured by pulses (by an automatic tester, for example), the TRIAC should be conducting for at least 500 µs before starting the test.

Figure 6. Circuit for measurement of the holding current I_H



Example:

BTA/BTB12-600C: I_L (QI - QIII and QIV) = 40 mA,
so choose I_T = 500 mA, I_H maximum = 25 mA

For a TRIAC, I_H has two values; I_{H+}, when electrode A2 is positive with respect to electrode A1, and I_{H-}, when electrode A2 is negative with respect to electrode A1. In the documentation only one maximum value is given for both quadrants. This value is always the higher value.

Depending on the production batch, the holding current can vary. However, the dispersion always remains below the limits specified in the data sheet. For a better perspective, here are some figures:

- sensitive TRIAC: I_{GT} (QI): 5 mA (type TW), 2 mA < I_H < 8 mA (specified I_H max: 10 mA)
- standard TRIAC: I_{GT} (QI): 50 mA (type B), 8 mA < I_H < 40 mA (specified I_H max: 50 mA)

The minimum value of the I_H parameter is not specified in the data sheets.

2.2 Variation of the holding current

2.2.1 Typical variation of I_H with device sensitivity and direction of commutation

The holding current, I_H, is related to the gate firing current, I_{GT} as shown in *Table 1*.

Table 1. Ratio between I_{H+} and I_{GT} (QI) for sensitive and standard TRIACs

Triac	I_{H+} / I_{GT} (QI)
Sensitive TRIAC 12 Arms (TW type)	2.5 (approx.)
Standard TRIAC 12 Arms (C type)	1.4 (approx.)

Example:

BTA/BTB12-600TW: if I_{GT} (QI) = 1.5 mA then I_{H+} = 3.8 mA.

BTA/BTB12-600C: if I_{GT} (QI) = 10 mA then I_{H+} = 14 mA.

In the case of the TRIAC (as opposed to the thyristor), it is important to note that current I_{H-} (electrode A2 negative with respect to A1) can be higher or lower than I_{H+} according to the rated current and the device technology.

Table 2. Ratio between I_{H+} and I_{H-} for sensitive and standard TRIACs

Triac	I_{H+} / I_{H-}
Sensitive TRIAC 12 Arms (TW type)	0.9 (approx.)
Standard TRIAC 12 Arms (C type)	1.8 (approx.)

Example:

BTA/BTB06-600TW: if I_{H+} = 4.3 mA, I_{H-} = 4.8 mA.

BTA/BTB12-600C: if I_{H+} = 15 mA, I_{H-} = 8.3 mA.

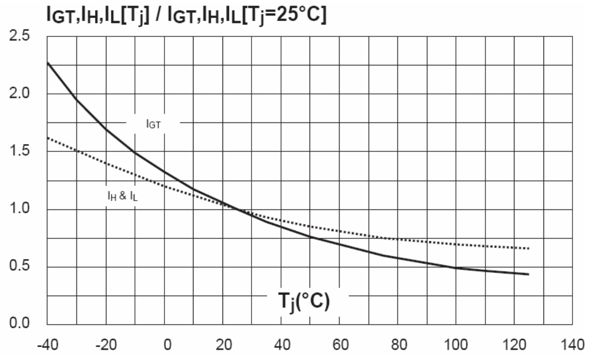
2.2.2 Variation of I_H with junction temperature

The holding current is physically related to the firing current, I_{GT}. These two parameters vary with the junction temperature as shown in *Figure 7*.

Example:

Triac TO-220AB, type BTA/BTB12-600C: I_H = 20 mA at T_j = 25 °C and 14 mA at 110 °C.

Figure 7. Relative variation of I_H, with the junction temperature, T_j

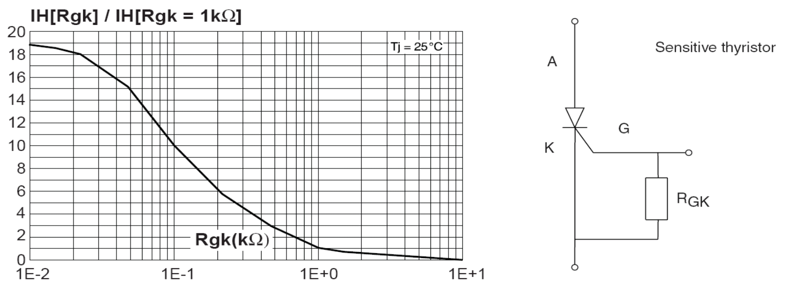


2.2.3 Effect of reapplied voltage

The rise time and the level of the reapplied reverse voltage across the TRIAC after blocking have no effect on the value of its holding current, I_H.

2.2.4 Influence of the external gate cathode resistor

Figure 8. Variation of I_H, of a sensitive thyristor with R_{GK}



Note: The hypostatic current for sensitive thyristors is always specified for R_{GK} = 1000ohms.

Some applications require a resistor, R_{GK}, to be connected between the gate and the cathode of the component, either to improve its behavior under voltage at high junction temperatures (by-pass for leakage current) in the case of sensitive thyristors or because it forms part of the firing circuit. The value of this resistor, as well as the sensitivity of the component, affects the holding current as shown in *Figure 8*.

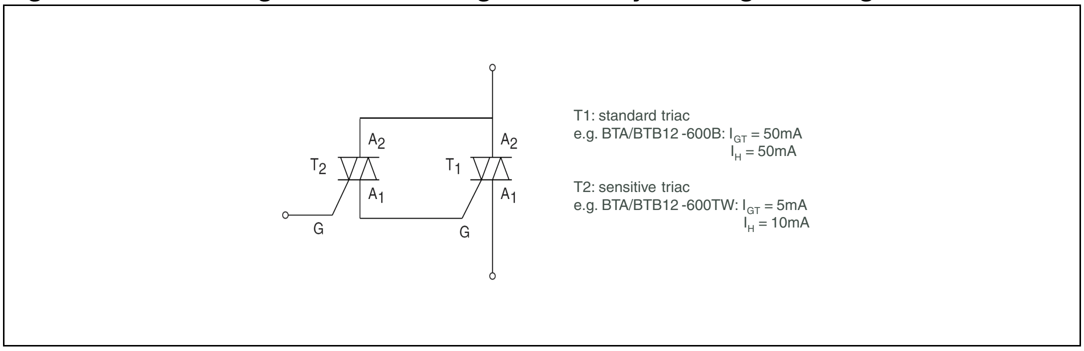
Sensitive thyristors (I_{GT} < 200 µA)

For sensitive thyristors R_{GK} has a large influence on the holding current as shown by *Figure 9*. Thus, in certain applications, the designer may want to use a high-impedance control circuit.

Standard thyristors, sensitive and standard TRIACs

Here, R_{GK} has no significant effect on the holding current provided that it is not too low, that is, R_{GK} should be greater than 20 Ω.

Figure 9. A Darlington TRIAC for high sensitivity with high holding current



2.3 Combining characteristics

We have seen that the more sensitive the TRIAC (lower I_G), the lower the value of the holding current, I_H.

Now, in certain applications a sensitive TRIAC with a high holding current, I_H (or I_L), may be required. In this case, two TRIACs, a sensitive one and a standard one, connected as a “Darlington” pair could be used as shown in *Figure 9*. The assembly is sensitive but has a higher holding current.

3 Conclusions

The choice of a thyristor or a TRIAC does not depend only on the voltage, the rated current and the sensitivity. Other parameters must be taken into account to ensure reliability.

The holding or hypostatic current, I_H, plays an important role in many circuits. The value of this parameter varies with:

- dispersion of the characteristics at manufacture
- temperature
- control circuit (in the case of sensitive thyristors)
- direction of current flow.

Taking into account these elements, the designer can obtain satisfactory operation of his circuit in industrial real-life applications.

4 Revision history

Table 3. Document revision history

Date	Revision	Changes
Feb-1989	1	First issue
30-Mar-2004	2	Stylesheet update. No content change.
10-Mar-2008	3	Reformatted to current standards. Complete technical review