Minimizing the Effects of Voltage Notching

General Application

Line side of VFD

Suppression of voltage notches

Elimination of extra zero crosses

Protection of motor drive electronics

This application note offers advice about reducing the depths of voltage notches which are typically associated with Silicon Controlled Rectifier (SCR) circuits. Another name for the SCR is Thyristor. SCRs are commonly used in DC drives, battery chargers, induction heating equipment and some lighting control equipment.

Notches appearing in the voltage waveform at the input side of the SCR controllers are a natural phenomenon. They can have an adverse effect on timing circuits, zero cross switching circuits and any equipment sensitive to the zero crossings of the voltage waveform.

This paper explains simple ways to reduce the adverse effects of voltage notching.

Approvals / Standards

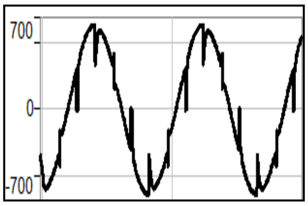
UL Listed (E173113)

IEC/EN60076-6 VDE0532-76-6

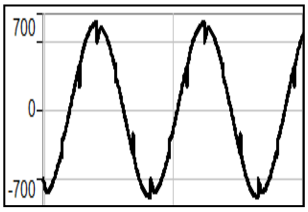
RoHS 2011/65/EU

c UL us LISTED

Voltage Waveforms



Without input line reactor



With input line reactor

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Silicon Controlled Rectifiers (SCRs) control their output voltage through a gating signal applied to their gate terminal. The signal commands the SCR when to begin conducting, which in turn controls what portion of the voltage waveform is applied to a load. This capability permits them to control the speed of a DC motor, by controlling the area under the curve for a voltage waveform.

Each time one SCR is turned on, another is being turned off. This is referred to as SCR commutation. During this momentary transition of states, a short circuit occurs. At this instant, the current rises, limited by the upstream impedance, and the instantaneous voltage goes to zero. Very quickly, the transition is accomplished and current reduces to a normal value. At this instant, the voltage also resumes. This pattern repeats for a total of six times per cycle (one for each diode in a 6-pulse rectifier).

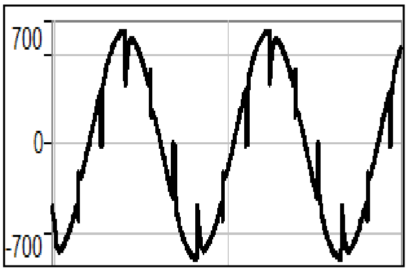

Fig. 1a Voltage notching in AC waveform

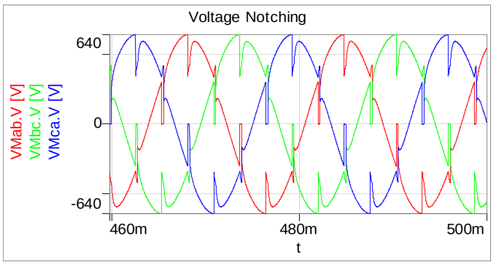

Fig. 1ab Voltage notching in AC waveform (3-phases)

Fig. 1a and Fig. 1b above illustrate typical notches in a voltage waveform for a SCR controller. Six notches per cycle are evident. As can be seen above, some of the notches are touching the zero axis – these are clearly creating extra zero crosses. The extra (false) zero crosses give will false signals to zero cross sensitive circuits.

As a result, zero cross switching devices may switch at the wrong time, causing malfunction or damage to themselves or other electronic equipment. They may also cause timing errors in devices that rely upon natural zero crosses as timing indicators (i.e.: normally from one zero cross to the next is 8.35 msec).

From experience, when multiple DC drives are supplied from the same voltage source, they may cause miss-fires of SCRs and gate firing board failures. Essentially, the extra zero crosses caused by one DC drive creates signals for another drive to turn on an SCR. Doing so at the wrong instant, can cause it to turn on into a short circuit, resulting in possible SCR or gate firing board failures. A six-pulse SCR (Thyristor) rectifier circuit is shown in Fig. 2 below.

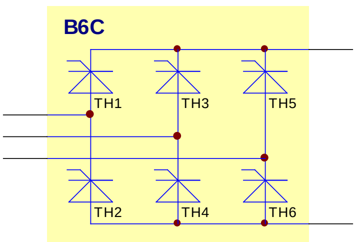

Fig. 2 6-pulse SCR Rectifier

The simplest remedy for voltage notching is to add a line reactor in series with the input terminals of the SCR controller. Fig. 3 illustrates a DC drive that includes an AC line reactor.

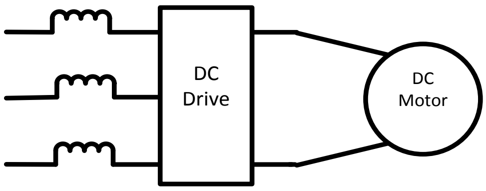

Fig. 3 DC Drive with AC Input Line Reactor

The line reactors absorb much of the notch voltage resulting in less notch depth, which generally keeps the notches far enough away from the zero axes. Typically, this prevents the miss-fires when multiple DC drives share a common power source and prevents other malfunctions that were caused by false zero crosses.

In most cases, this problem is solved by using 3% impedance line reactors. In rare cases, it may be necessary to use 5% impedance. The line reactor provides commutating reactance to limit the current during the transition (commutation) period. The extra impedance reduces the commutation current, preventing a short circuit and thereby reducing voltage notch depth.

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