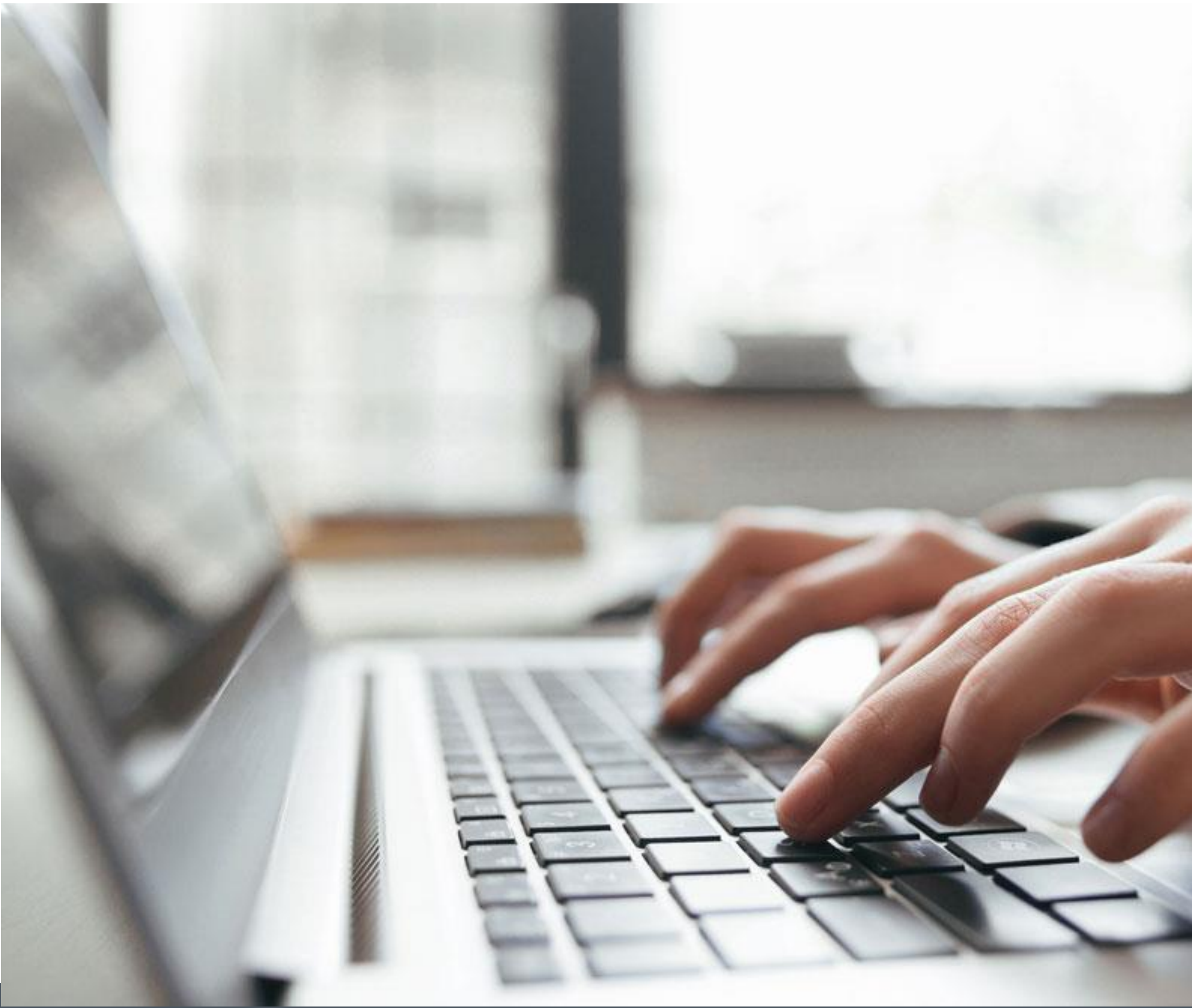

Application Note

Back-EMF protection circuits: Charge capacitor and brake chopper

Version 1.0.0

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Contents

1 What is *back EMF?*

Motor rotation produces back electromotive force (= an electromagnetic force). This Back EMF induces voltage in the motor windings, and the motor works like a generator. Voltage spikes due to rapid deceleration / acceleration damage SMD components in the motor controller.

On the hardware side, you can smooth out unwanted voltage spikes by: (a) charge capacitor or (b) brake chopper. The latter is a resistor connected to the DC link voltage. As real consumers in the DC link, brake choppers absorb excessive generator power from the motor.

The motor generates power bidirectionally. In motor mode, it converts electrical into mechanical power. In generator mode, however, it induces the back EMF voltage on the motor phases. There are thus four scenarios (see right):

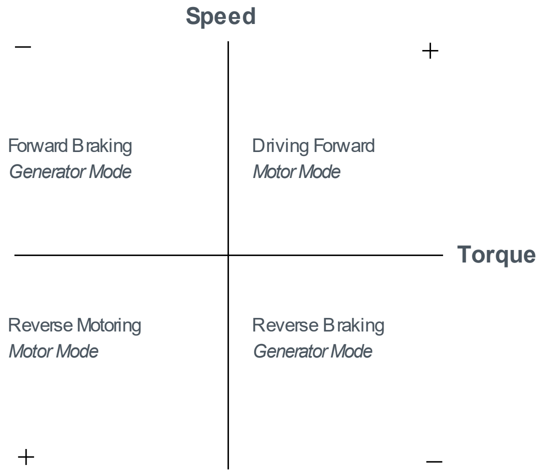

Fig. 1: If the motor runs as a generator, either a charge capacitor or a brake chopper protects the EMF-sensitive components in the motor controller.

2 Protection by charge capacitor

Charge capacitors durably smoothen voltage spikes of the motor-induced back EMF signal. Similarly, with switching power supplies, they also smoothen the pulsating DC current generated when AC voltage is rectified: "wavy" operating voltage turns "smooth".

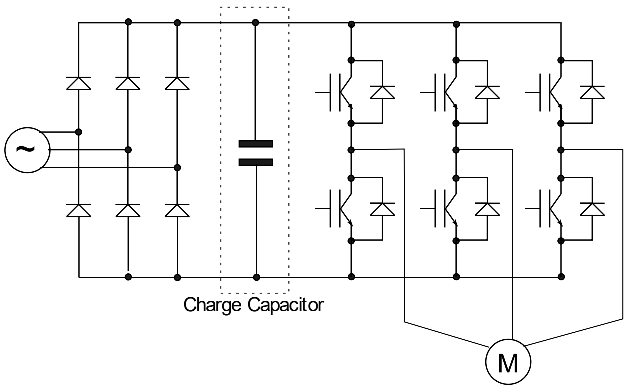

Fig. 2: Charging capacitor position between AC power supply (~) and motor (M).

First, the capacitor smoothens the residual ripple of the supply voltage. The red characteristic shows the curve of the rectified switching network voltage; the blue characteristic shows the voltage curve after being smoothed by the activated capacitor (= filtering).

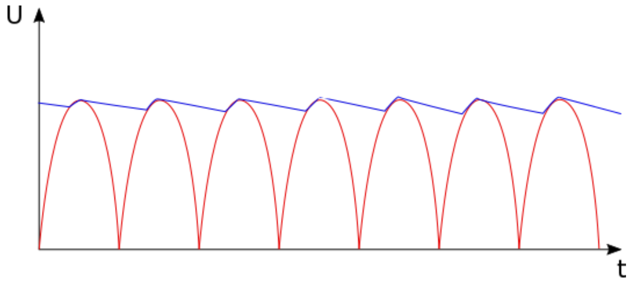

Fig. 3: Filtering lowers the residual ripple of the supply voltage.

Due to line resistance, the capacitor in the DC link also acts as an RC element and low-pass filter. If the motor generates large voltage spikes in the back EMF signal during rapid acceleration or braking ramps, this threatens the dielectric strength of the SMD components on the motor controller board. The filter circuit smoothens voltage spikes to a durable low voltage. This protects SMD components including the controller from back EMF voltage damage.

2.1 Sizing a capacitor

You can connect capacitors in parallel to add up their capacitances. Avoid capacitances higher than the rule of thumb **1A motor current ~ 1000 µF capacitance**. Otherwise capacitors charge / discharge too long and slow down the system. To protect your Nanotec motor controller, we thus recommend:

Electrolytic capacitor Z-K4700/50

4700 µF standard capacitance | Dielectric up to 50 V

Fig. 4: The aluminum cup of the Z-K4700/50 is only 35 mm short and 25 mm in diameter.

Capacitor Z-K10000/100

10,000 µF standard capacitance | Dielectric up to 100 V

Fig. 5: The aluminum cup of the Z-K10000/100 is also easy to install (95 mm long, Ø 40 mm).

2.2 Connecting a capacitor

The charge capacitor has each a positive and negative pole to be connected in parallel in the DC link, between switching power supply and motor controller:

1. Place the capacitor as close as possible to the motor controller.
2. Connect the positive pole to the motor controller supply *UB+.*
3. Connect the negative pole to the motor controller ground *GND.*

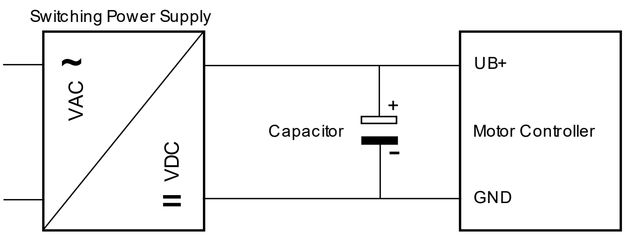

Fig. 6: Charge capacitor in a DC link.

3 Protection by brake chopper

Brake choppers don't work like charging capacitors, but like electronic switches (= chopper) in the DC link.

Whereas capacitors **smoothen** generator voltage spikes from the motor, brake choppers convert excess energy into **heat**. They act as a resistor in the DC link as soon as the induced voltage level threatens the motor controller's SMD components. If the DC link voltage drops below the switch-on but not mains level, the resistor switches off again.

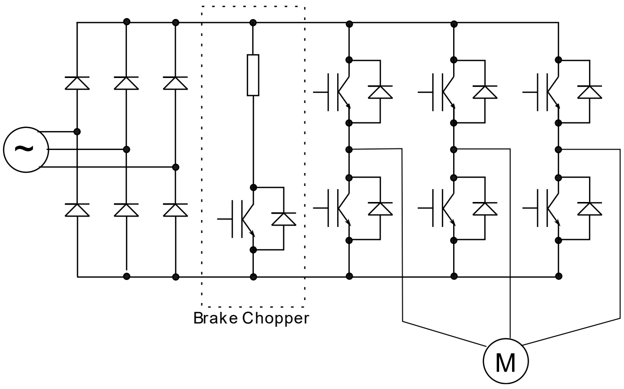

Fig. 7: Brake chopper position between AC power supply (~) and motor (M).

3.1 Nanotec BC72-50 brake chopper: key data

Brake choppers fit applications with high regenerated voltage (12 to 75 V permissible input level).

The internal brake resistor suits for up to 20 watts power in nominal operation with the internal and 100 watts with an external resistor resp. (peak power: 1 kW [max. 1 s]).

Fig. 8: Nanotec BC72-50 with output for monitoring the operating status (far bottom). Just above: two rotary switches for setting the application-specific operating voltage from 12 bis 75 V.

3.2 Connecting a brake chopper

In addition to the supply input, the chopper has each a positive and negative pole to be connected in parallel in the DC link, between switching power supply and motor controller:

1. Place the chopper as close as possible to the motor controller.
2. Connect the positive pole to the motor controller supply *UB+*.
3. Connect the negative pole to the motor controller ground *GND.*

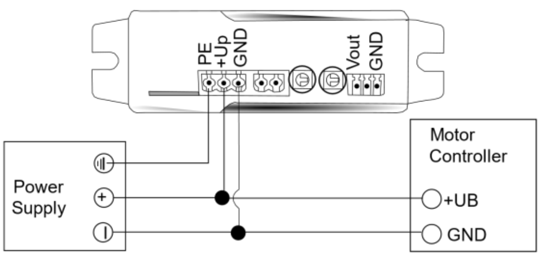

Fig. 9: Brake chopper in a DC link.

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