

## Application Note DK9222-0610-0027

### Motion

#### Keywords

Buffer capacitor  
Brake chopper  
Fieldbus  
Drive  
Stepper  
DC motor  
Output stage  
DC link  
Overload  
Recovery  
EtherCAT  
K-Bus  
Bus Terminal  
PLC

# Overvoltage protection and voltage stabilization for Motion Control terminals

**This application example describes how Motion Control applications with the output stages for servo, DC and stepper motors by Beckhoff are optimized by the utilization of buffer capacitors. The buffer capacitor terminals EL9570 for EtherCAT and KL9570 for K-Bus stabilize the voltage supply by absorbing the fed back energy and dumping the energy that the buffer capacitor cannot protect against into an external braking resistor. The buffer capacitor terminal protects the DC power supply and other motor terminals that may be sharing the same DC power source. The buffer capacitor terminal extends the area of application for Beckhoff Motion Control terminals to also include applications with short start/stop ramp times and large inertia. Additional installation space in control cabinets is saved due to the solution's compact design as a double-sized standard terminal block.**

## Electrical drives

Variable-speed electrical drives are used in practically all industrial sectors. They are preferred for the following reasons:

- Good system efficiency
- Good or very good static and dynamic control characteristics
- Communication with higher-level controllers is possible
- Market prices are in line with user expectations.

Electrical drives are also influenced by the control electronics. New servo drives make complete solutions that are compact and energy-saving possible. These exhibit dynamic control behavior, good torque stability, and control capability down to zero speed.

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Servo motors are suitable drives for position control applications. They combine motor, speed and angular position measuring systems. For cost-sensitive applications with low dynamics, stepper motors may be used as an alternative. In the lower capacity range, DC motors offer good control ability with low costs. The suitability of a drive is judged on the basis of the torque produced and the dynamics.

### Motion Control in a very compact form factor

The modular I/O system from Beckhoff also encompasses Motion Control in an exceptionally compact form factor. Motors are driven directly from the PLC with output stages for servo, stepper and DC motors. To have an output stage means that the motor amplifier is built right into the motor terminal. Whether using an EtherCAT or a Bus Terminal, these I/O devices with a built in drive can be integrated into any control environment using Beckhoff Bus Couplers. The TwinCAT System Manager reduces familiarization efforts to a minimum, since TwinCAT enables equal treatment of all motors on the software side. The interfaces are almost identical, and parameterization is quite straightforward.

Overview of Motion Control terminals		
	EtherCAT Terminals	Bus Terminals
Servomotors	EL7201 50 V DC, 4 A	—
DC motors	EL7332 24 V DC, 1 A EL7342 50 V DC, 3.5 A	KL2532 24 V DC, 1 A KL2552 50 V DC, 5 A
Stepper motors	EL7031 24 V DC, 1.5 A EL7041 50 V DC, 5 A	KL2531 24 V DC, 1.5 A KL2541 50 V DC, 5 A

Fig. 1 Overview of the Motion Control terminals

### DC, servo and stepper motors (principle of operation)

The principles of operation for DC motors and stepper motors are fundamentally different. DC motors generate a torque and a rotary motion when a voltage is applied. Stepper motors only generate a torque. A prerequisite for the rotary motor motion is commutation of the current, i.e. inversion of the direction of current flow in the electromagnetic coil during a motor rotation. DC motors with brushes are self-commutating. Stepper motors cannot commute independently. Servo motors do not differ from the aforementioned types of motors in their physical operating principle, but rather in the way they are controlled: they are operated in conjunction with position feedback in a closed control loop.

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## Power supply of electrical drives – problems from real applications

### A Voltage peaks at the power supply unit

In highly dynamic applications, fast decelerations cause the feedback of energy, which will lead to voltage spikes at the power supply unit. The overvoltage spikes can destroy the power supply unit. 'Intelligent' power supplies with overvoltage protection switch themselves off briefly, but this results in the drive losing control. These are all factors that will significantly impair system reliability.

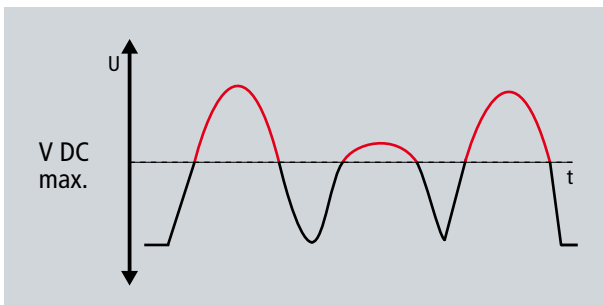


Fig. 2 Voltage spikes at the power supply unit

### B Ripple currents

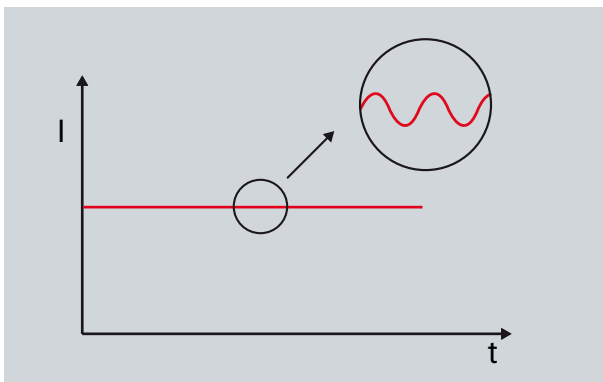


Fig. 3 Occurrence of ripple currents

Ripple currents occur during fast acceleration. The power supply unit can no longer compensate, resulting in voltage drops. Ripple currents additionally occur with the commutation of DC machines, which have a negative influence on synchronization, particularly in the case of short start/stop ramp times of the motors, and appear as torque ripple (rough mechanical operation).

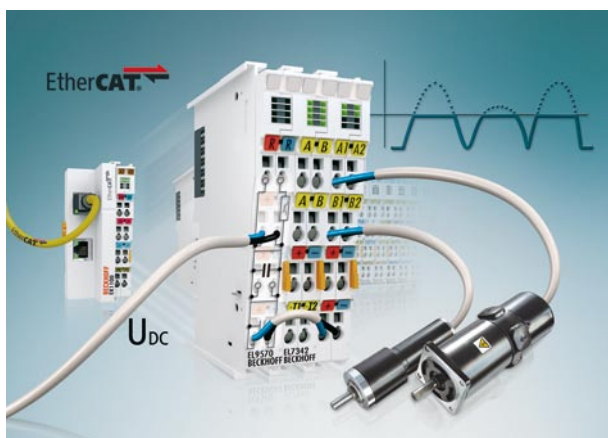
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#### C Braking energy/energy recovery

The faster the deceleration time of the motors, the more negative energy is generated, which appears as a voltage peak at the power supply unit.

See **A Voltage peaks**



#### Optimization potential with the Beckhoff buffer capacitor terminals

The EL9570 and KL9570 buffer capacitor terminals are intended for use with the output stages of stepper motors and DC motors. With a capacitance of 500  $\mu\text{F}$  they stabilize the power supply, feed energy back and protect highly dynamic drives against overvoltage. The 12 mm wide EL9570 and KL9570 buffer capacitor terminals supplement the extensive I/O system kit for Motion Control in miniature format and can be integrated in any control environment via Bus Couplers.

#### Overvoltage protection

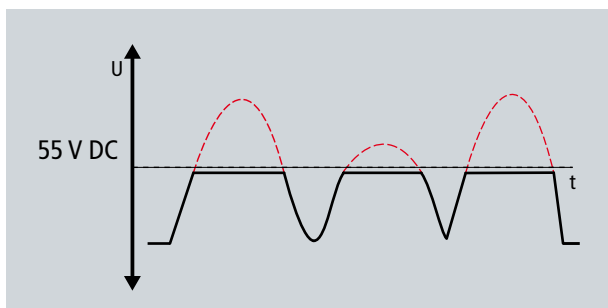


Fig. 5 Prevention of overvoltage

The KL9570 and EL9570 buffer capacitor terminals can absorb the energy generated by highly dynamic drives due to their 500  $\mu\text{F}$  capacitors, which are particularly resistant to ripple current. If the fed-back energy exceeds the capacity of the

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capacitors, an external braking resistor prevents overvoltage. The low internal resistance and the high pulse current capability of up to 10 A enables good buffering parallel to the power supply.

KL9570 in combination with:	EL9570 in combination with:
KL2531   Stepper motor terminal 24 V DC, 1.5 A	EL7031   Stepper motor terminal 24 V DC, 1.5 A
KL2541   Stepper motor terminal 50 V DC, 5 A, with incremental encoder	EL7041   Stepper motor terminal 50 V DC, 5 A, with incremental encoder
KL2532   2-channel DC motor output stage 24 V DC, 1 A	EL7201   Servomotor terminal 50 V DC, 4 A, with resolver, motor brake
KL2552   2-channel DC motor output stage 50 V DC, 5 A	EL7332   2-channel DC motor output stage 24 V DC, 1 A
	EL7342   2-channel DC motor output stage 50 V DC, 3.5 A

Fig. 6 Possible combinations of Beckhoff Motion Control and buffer capacitor terminals

- Buffer capacitor terminal [www.beckhoff.com/KL9570](http://www.beckhoff.com/KL9570)
- Buffer capacitor terminal EtherCAT [www.beckhoff.com/EL9570](http://www.beckhoff.com/EL9570)

#### Bus Terminals

- Stepper motor terminal 24 V DC, 1.5 A [www.beckhoff.com/KL2531](http://www.beckhoff.com/KL2531)
- Stepper motor terminal 50 V DC, 5 A, with incremental encoder [www.beckhoff.com/KL2541](http://www.beckhoff.com/KL2541)
- 2-channel DC motor output stage 24 V DC, 1 A [www.beckhoff.com/KL2532](http://www.beckhoff.com/KL2532)
- 2-channel DC motor output stage 50 V DC, 5 A [www.beckhoff.com/KL2552](http://www.beckhoff.com/KL2552)

#### EtherCAT Terminals

- Servomotor terminal 50 V DC, 4 A EtherCAT [www.beckhoff.com/EL7201](http://www.beckhoff.com/EL7201)
- Stepper motor terminal 24 V DC, 1.5 A EtherCAT [www.beckhoff.com/EL7031](http://www.beckhoff.com/EL7031)
- Stepper motor terminal 50 V DC, 5 A, with incremental encoder EtherCAT [www.beckhoff.com/EL7041](http://www.beckhoff.com/EL7041)
- 2-channel DC motor output stage 24 V DC, 1 A EtherCAT [www.beckhoff.com/EL7332](http://www.beckhoff.com/EL7332)
- 2-channel DC motor output stage 50 V DC, 3.5 A EtherCAT [www.beckhoff.com/EL7342](http://www.beckhoff.com/EL7342)

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