VLT 2800 Engineering Data – Output Protection

In the VLT 2800 drive intermediate circuit, a DC link inductor significantly improves overall efficiency by increasing the power factor and lowering the ripple current in the bus voltage for an almost threefold increase in capacitor and drive life. Because there are minimal ripple currents, motor operation is smooth and quiet at all speeds. Since there is less temperature rise, longer motor life can be expected as well.

Multiple Motors – Parallel Connection of Motors

The VLT 2800 (with optional LC filter) Series are able to control several motors connected in parallel. If the motors are to have different rpm values, the motors must have different rated base speed values. Motor rpm is changed simultaneously, which means that the ratio between the rated rpm values is maintained across the range.

The total current consumed by all of the motors may not exceed the maximum output current of the drive.

The individual motors can be switched and reversed an unlimited amount on the output of the VLT 2800 (with optional LC filter) without tripping or damaging the drive.

If the total starting current of the motors is higher than the maximum output current of the drive, the output frequency falls. The output current of the drive can exceed the rated current of the individual motor, making it necessary to protect each motor as if it were connected to the AC line.

If the motor sizes deviate very much, problems may arise during starting and low speed operation. This is due to the fact that small motors have a relatively large ohmic resistor in the stator, therefore, they demand more compensation voltage during starting and low speeds.

Often, it will be possible to increase the start voltage and find an acceptable start condition for all the motors. If this is not possible, it may be necessary to replace the small motor with a larger one. This does not necessarily demand a bigger drive, as the mechanical power output of the motor is unchanged.

In systems with motors connected in parallel, the ETR (electronic thermal relay) of the drive cannot be used as motor protection for the individual motor. Consequently, additional motor protection is required, such as thermistors in each motor (or individual thermal relays).

Also, the individual motor cable for each motor must be summed and is not to exceed the total motor cable length permitted.

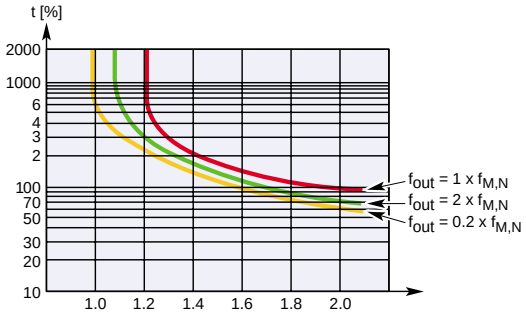
Thermal Motor Protection

The VLT 2800 Series feature integrated electronic, thermal motor protection (ETR function). The drive calculates the motor temperature on the basis of current, frequency and time.

As opposed to the traditional bimetallic protection, electronic protection takes into account the reduction in cooling at low frequencies that comes from reduced fan speed (motors with internal ventilation).

Thermal motor protection is comparable to a normal motor thermistor, and is UL listed as a Class 20 overload. To obtain maximum protection against overheating, thermistors can be integrated in the motor and connected to the thermistor input of the VLT 2800 drives (terminals 53/54).

The motor temperature is calculated on the basis of motor current, output frequency and time.

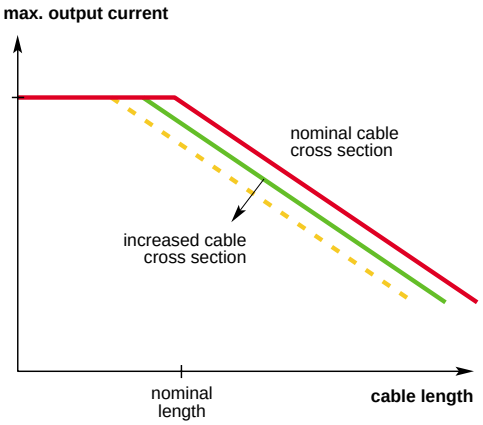


Long Motor Cables

If the length or the gauge of the motor cables exceeds the maximum values, the maximum allowable continuous output decreases.

The longer the cable length or the larger the gauge, the lower the capacitive reactance. High capacitive reactance will increase the losses in the cable. The resulting output current must be reduced by about 5% for each step the wire gauge increases (see figure below). The current is reduced linearly, when the cable length exceeds the maximum for which the drive has been designed.

The typical mode of operation for the drive causes short voltage rise times in the motor cable. This may damage the insulation of the motor windings. The problem intensifies as the switching frequency of the inverter increases.



The maximum output current of the drive depends on the length and gauge of the motor cable. All VLT 2800 units allow for a maximum 250 ft. of motor cable and 1,000 ft. with the optional LC module.

dV/dt and Peak Voltage on the Motor

When a transistor in the inverter is opened, the voltage applied to the motor will rise by a dV/dt ratio (voltage rise/time is referred to as dV/dt). The dV/dt is determined by:

- The motor cable (type, cross-section, length, shielded/armored/unshielded/unarmored)
- Inductors

The self-inductance will cause an overshoot V_{PEAK} for the motor voltage before it stabilizes at a level determined by the voltage in the intermediate circuit.

Both the dV/dt ratio and the peak voltage V_{PEAK} influence the lifetime of the motor. Too high values affect primarily motors without phase coil isolation paper.

If the motor cable is short (a few feet or meters), the dV/dt ratio will be quite high, but the peak voltage quite low.

If the motor cable is long 330 ft. (100 m), for example, dV/dt will decrease and V_{PEAK} will increase.

If motors without phase isolation paper are used, it is recommended to use an LC filter on the output of the drive.

The chart below shows typical values for dV/dt and peak voltage V_{PEAK} measured on the terminals of the motor between two phases at different cable lengths. With the patented Danfoss "soft turn on", the IGBT transistors produce one of the lowest dV/dt in the industry.

VLT 2805-2840, 380-480 V

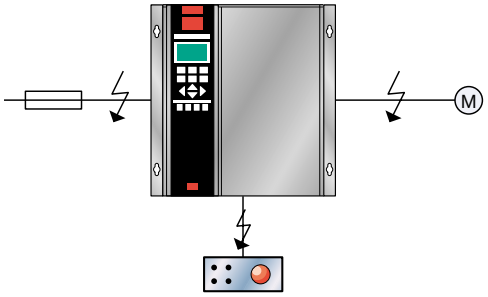
Cable Length	AC Line Voltage	Rise Time	Peak Voltage*
50 ft (15 m)	380 VAC	0.2 µsec	940 V
50 ft (15 m)	460 VAC	0.2 µsec	1170 V
140 ft (40 m)	380 VAC	0.3 µsec	980 V
140 ft (40 m)	460 VAC	0.3 µsec	1230 V

* 380-480 VAC class is worst case scenario for Peak Voltage; 200-240 VAC units operate with lower Peak Voltage.

No Motor Derating

The VLT 2800 drives are optimized for constant or variable torque operation so that motors do not need to be derated. When the RMS current from the drives is taken, the motor sees a near perfect sine wave and full AC line voltage. This waveform helps to overcome torque pulsation, cogging or ripple problems, and delivers smooth running at low speeds.

The rated output currents of Danfoss VLT 2800 Series drives correspond to typical rated motor current values in standard 4-pole asynchronous motors. So, if you know the motor power, you simply select the corresponding VLT model.



Where there is risk of short circuits

Short Circuit and Ground Faults

Short circuits and ground faults may occur on the supply side, on the motor side or in the control leads.

Any short-circuits or ground faults on the supply side will cause the prefuses in the installation to fail. The VLT 2800 will seldom cause short-circuits and it will not be damaged because of faults on the supply side.

As a rule motor faults arise because of missing insulation that causes short-circuits between two phases or between phase and ground. The VLT 2800 are protected against short circuits by means of current measurement in each of the three motor phases. A short circuit between two output phases will cause an overcurrent in the inverter which will turn off each IGBT individually when the short circuit current exceeds the permitted value.

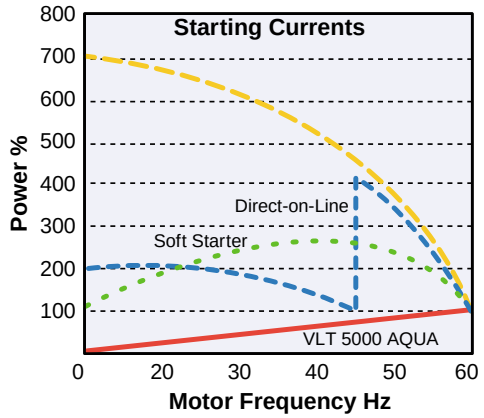
Grounding can also cause the VLT 2800 to trip out. The internal voltage supply is therefore protected by a fuse. The drive turns off within 100 ms in case of a ground fault on a motor phase, depending on impedance and motor frequency.

Motor-Generated Overvoltage

The voltage in the intermediate circuit is increased when the motor acts as a generator. This occurs in two cases:

- The load overspeeds the motor
- During deceleration "ramp-down", if the moment of inertia is high, the load is low and the ramp-down time is too short for the energy to be dissipated internally in the VLT 2800, the motor, and the installation.

The unit attempts to correct the ramp if possible. If not, the inverter turns off to protect the transistors and the intermediate circuit capacitors when a predetermined voltage level is reached.



Building Load

Using a VLT 2800 drive eliminates a power in-rush at start-up. The current starts from zero and rises as the load accelerates with no danger of exceeding full load current.

This has two major benefits. The first is that it doesn't matter when the units are switched on, as maximum demand will not be exceeded. The second is that as the current is properly controlled, the installation doesn't require a sequenced start. This removes the need for additional capital equipment.

LC Filter Modules

When the speed of a motor is controlled by a drive, resonance noise from the motor will occur occasionally. This is due to the construction of the motor and the noise occurs whenever one of the IGBTs of the drive is activated. The frequency of the resonance will correspond to the switching frequency.

The filter reduces the voltage rise time dV/dt, the peak voltage V_{PEAK} and the ripple current to the motor. So the current and the voltage are near sinusoidal. That reduces the acoustic motor noise to a minimum.

Because of the ripple current in the coils, there will be some noise from the coils. However, if the filter is built into a cabinet or similar, the coil noise will be no problem.

For the VLT 2800 Series, Danfoss offers an LC filter which dampens the acoustic motor noise. To use the filters properly, it must be ensured that:

- they fit the VLT Series drive
- the current ratings are observed
- the mains supply is 200-480 VAC
- parameter 412, Output Frequency Dependent Switching, is set to LC-filter fitted [3]
- the output frequency is max. 120 Hz.