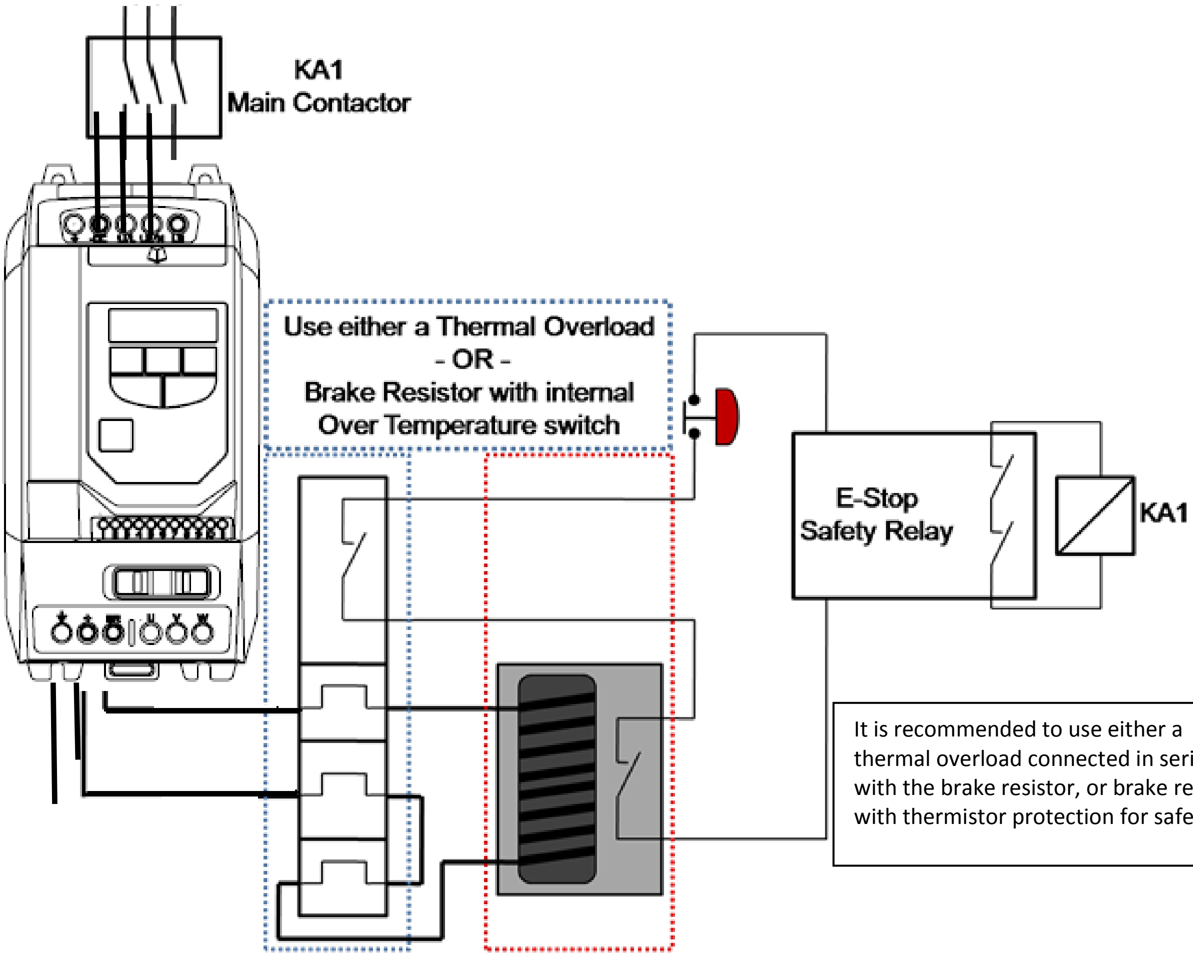
Optidrive Applications Support Library

Application Note	**AN-ODE-2-017**
Title	**Using the Brake Circuit**
Related Products	**Optidrive E2**
Level **2**	1 – Fundamental - No previous experience necessary 2 – Basic – Some Basic drives knowledge recommended 3 – Advanced – Some Basic drives knowledge required 4 – Expert – Good experience in topic of subject matter recommended

Overview

Optidrive E2 has a built-in braking (power dump) circuit (except frame size 1 drives), which when used together with an external braking resistor can be used to dissipate the re-generated energy from the motor that results from decelerating a high inertia load, or lowering a load against gravity. Using a braking resistor can provide faster deceleration rate when controlling high load inertia. This document describes how to connect the braking resistor to the Optidrive E2 and how to enable the brake circuit inside the drive.

Connection Diagram



It is recommended to use either a thermal overload connected in series with the brake resistor, or brake resistor with thermistor protection for safety.

Installation Notes

	The Optidrive E2 internal software has Over-Current and Thermal Overload protection to prevent possible failure or damage to the braking resistor, however in safety critical applications and hoisting applications, it is strongly recommended that an external independent thermal overload protection device suitable for the resistor in use is installed. In less critical applications, this may be omitted at the installers own discretion and risk.
	When connecting a braking resistor, it is important that the minimum permissible resistance value is observed. Refer to the User guide rating tables for recommended resistance values.
	When connecting cables to the power terminal connections of the Optidrive, always ensure the power has been removed / isolated from the drive, and that a suitable time period (minimum 5 minutes) has elapsed to allow the stored charge to dissipate.

Invertek Drives Braking Resistors

A range of specially developed braking resistors are available from Invertek, suitable for general purpose use, which have the following advantages

- Mounts to the Optidrive heatsink for optimum cooling
- Needs no additional enclosure space
- Thermal overload protection in Optidrive
- In-built thermal fuse for secondary level protection

Braking Circuit Operation

Optidrive E2 units Frame Size 2 and above have an integrated brake chopper circuit to which an external brake resistor can be connected. The brake chopper connects to the DC Bus of the drive, and thereby operates on a high DC voltage, so extreme care should always be used when working with brake resistors. The operating voltage of the brake circuit depends upon the voltage rating of the Optidrive; values are shown in the table below.

Drive Rated Supply Voltage	DC Bus Voltage Level (Volts DC)				
	Brake Chopper On	Brake Chopper Off	Under Voltage Trip	Minimum Operating	Over Voltage Trip
200 – 240 Volts AC	390	378	160	239	418
380 – 480 Volts AC	780	756	320	478	835

Example Braking Resistor Values

For advice on how to select the correct braking resistor, please refer to the table below.

Recommended Brake Resistance (ohms)					
ODE-2, 230 Volts Drives					
kW	**HP**	**Minimum**	**5% Duty, 2 Seconds**	**10% Duty, 60 Seconds**	**Higher / Continuous Duty**
1.5	2	47	58	68	101
2.2	3	47	47	47	69
4	5	22	22	25	38
ODE-2, 400 Volts Drives					
kW	**HP**	**Minimum**	**5% Duty, 2 Seconds**	**10% Duty, 60 Seconds**	**Higher / Continuous Duty**
1.5	2	100	232	270	406
2.2	3	100	158	184	277
4	5	100	100	101	152
5.5	7.5	50	63	74	111
7.5	10	50	50	54	81
11	15	50	50	50	55

To prevent a possible failure of the Optidrive, the minimum braking resistance values must be observed.

Note that two or more resistors can be connected in series or parallel, provided the minimum resistance value remains to be observed.

Parameters

P-34 Brake circuit enable

This parameter controls the functionality of the brake circuit.

Par.	Description	Range	Units	Default	Explanation
P-34	Brake Circuit Enable	0 : Disabled 1: Enabled With Thermal Protection 2: Enabled Without Thermal Protection	-	0	Enables the internal brake chopper on Size 2 and above drives. Setting 1 provides software monitoring of the braking power consumption, and the drive will trip if the loading exceeds the maximum capability of the optional Invertek resistor. Setting 2 disables the protection, and external thermal monitoring and protection must be used.

Thermal Overload Protection

When using setting 1 in P-34, software thermal protection is enabled to protect the brake resistor against overheating. The software function is intended to provide a basic level of protection for the resistor however it is always preferable to use an external thermal protection circuit with a failsafe design.

The thermal protection is based on the following parameters

P-34 Setting	Frame Sizes	Resistance	Continuous Braking Power
1	2 & 3	100Ω	200W

The internal software protection monitors the time for which the braking resistor is activated, and calculates the dissipated power based on the resistance shown in the table above and the midpoint DC Bus Voltage between the switch on and switch off control points of the brake chopper, e.g. 768 Volts DC for a 380 – 480 Volt drive. This means that providing that it is possible to connect multiple resistors in parallel to the drive, and the Braking Power figure shown above will then become per resistor.

For example, if 2 x 100Ω resistors are connected in parallel to a size 3 Optidrive, and P-34 = 1, the braking power allowed will be 2 x 200W = 400W.

Selecting Suitable Resistor Values

There are three separate parameters to consider when selecting a Braking Resistor for an application.

Resistance

The resistance should **never** be less than the minimum value suitable for the drive in use as shown in the User Guide. Using a lower value can cause damage to the drive. The resistance value effectively controls the maximum braking torque that the drive can achieve. A higher resistance value reduces the maximum available braking torque.

Power Rating & Duty

Braking resistor power levels are usually given as the power level the resistor can dissipate continuously. Most resistors can typically dissipate many times this power level for a reduced time period and duty cycle. The power rating required for a resistor should be calculated based on the expected loading and duty cycle of the intended application. Multiple resistors can be connected in Series and Parallel to achieve a higher power level and duty, providing that the minimum resistance value of the drive is observed.

Example Calculation – Flywheel type application

Where an application has high inertia, but very infrequent stops, the duty cycle of the braking resistor is low. For example, consider a motor driving a large grinding wheel via a belt drive system.

Grinding Wheel Diameter = 1 Metre
Grinding Wheel Mass = 500 Kg
Flywheel Speed = 500 Rpm
Motor Speed = 1500 Rpm
Motor & Optidrive rated Power = 7.5kW
Required Stopping Time = 30 Seconds
Stopping Frequency = 2 Times per hour

Firstly, calculate the inertia of the driven load. The grinding wheel is effectively a solid flywheel, so the inertia, J is

$$J = ½ \times M \times r^2$$

Where M = Mass, r = radius
So in this example, J = ½ x 500 x 0.5 x 0.5 = 62.5 Kgm^2
Secondly, convert the speeds to radians per second

$$\text{Flywheel Speed} = \frac{(500 \times 2 \times \pi)}{60} = 52.4\ rads^{-1}$$

$$\text{Motor Speed} = \frac{(1500 \times 2 \times \pi)}{60} = 157.1\ rads^{-1}$$

The braking energy is transferred to the motor from the driven load, so the *reflected inertia* at the motor shaft should be considered. Reflected inertia is calculated by dividing by the square of the drive ratio. In this case

$$\text{Drive Ratio} = \frac{\text{Motor Speed}}{\text{Load Speed}} = 3$$

$$\text{Reflected Inertia} = \frac{62.5}{9} = 6.9\ Kgm^2$$

NOTE It is important when carrying out actual calculations to consider the *total* reflected inertia. This would include the inertia of the motor, the pulleys and belts and any other components. This becomes more important when considering dynamic applications with short stopping times, where the small differences in inertia can have a dramatic effect on the system performance. Additionally, frictional losses and inefficiencies in the mechanical system can also assist in reducing the overall braking requirements, and can be considered in calculations.

Now, calculate the braking torque

$$\text{Braking Torque} = \frac{\text{Total Inertia x Angular Velocity}}{\text{Required Stopping Time}} = \frac{6.9 \times 157.1}{30} = 36.13\ \text{Nm}$$

Peak Braking Power will always occur at the highest speed, so the braking power can be calculated as follows

Power = Torque x Angular Velocity = 36.13 x 157.1 = 5676 Watts

Assuming a linear deceleration rate, the average braking power during stopping

$$\text{Average Braking Power} = \frac{\text{Peak Braking Power}}{2} = 2838\ \text{Watts}$$

Based on the repeat cycle time, this power rating is required twice per hour for 30 seconds, so the duty is 1.7%. In this case, a brake resistor capable of 5.7kW peak, 2.8kW for 30 seconds at 1.7% duty is required.

The resistance value to use, if required, can be determined from the peak braking power

Peak Braking Power = 5676 Watts

This must be dissipated across the resistor from the DC Bus. Assuming a 400 Volt supply, the brake chopper operating voltages from the tables above will be as follows

Switch on Voltage = 780 Volts

Switch Off Voltage = 756 Volts

The resistance required can then be determined using

$R = V^2$ / Power = (780 x 780) / 5676 = 107Ω

Checking the minimum resistance for the drive shows this value to be higher than the minimum allowed. Using a higher resistance simply limits the maximum braking torque available, and hence providing it is never planned to reduce the stopping time, this resistance will work well in the application.

An alternative approach sometimes required is to calculate the minimum possible stopping time for a given application using a selected drive and motor combination. In this case, the first step is to determine the braking torque available. Using the same data from the example above, we can calculate the peak braking power and torque as follows:-

The drive rating is 7.5kW, therefore the maximum continuous braking power is 7.5kW, however the Optidrive has an overload capacity of 150% for 60 seconds, thereby providing the minimum stopping time is less than 60 seconds, the overload capacity can be utilised, giving a peak braking power of

7.5kW x 150% = 11250 Watts

As we have already calculated, the motor speed is 157.1 Rads^{-1}, therefore peak braking torque can be calculated

Power = Torque x Speed, therefore Torque = Power / Speed = 11250 / 157.1 = 71.6Nm

The Deceleration Rate can then be calculated based on this torque

Angular Deceleration = Braking Torque / Load Inertia = 71.6 / 6.9 = 10.4 Rads^{-2}

The actual Stopping Time can then be calculated

Stopping Time = Operating Speed / Deceleration Rate = 157.1 / 10.4 = 15.1 Seconds

Appendix

Revision History			
Version	Comments	Author	Date
01	Document Creation	KB	03/10/11
02	Revised to new format, added calculation example & info	KB	24/04/14