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1 How to Read this Design Guide

1.1.1 How to Read this Design Guide

This Design Guide will introduce all aspects of Brake Resistors for your VLT® FC Series Drive; From choosing the right Brake Resistor for the application to instructions about how to install it and how to programme the Frequency converter.

Danfoss Drives technical literature is also available online at www.danfoss.com/BusinessAreas/DrivesSolutions/Documentations/Technical+Documentation.

1.1.2 Symbols

Symbols used in this manual:

NB!
Indicates something to be noted by the reader.

Indicates a general warning.

Indicates a high-voltage warning.

*	Indicates default setting

1

1.1.3 Abbreviations

Alternating current	AC
American wire gauge	AWG
Ampere/AMP	A
Automatic Motor Adaptation	AMA
Current limit	I_{LIM}
Degrees Celsius	°C
Direct current	DC
Drive Dependent	D-TYPE
Electro Magnetic Compatibility	EMC
Electronic Thermal Relay	ETR
Drive	FC
Gram	g
Hertz	Hz
Kilohertz	kHz
Local Control Panel	LCP
Meter	m
Millihenry Inductance	mH
Milliampere	mA
Millisecond	ms
Minute	min
Motion Control Tool	MCT
Nanofarad	nF
Newton Meters	Nm
Nominal motor current	$I_{M,N}$
Nominal motor frequency	$f_{M,N}$
Nominal motor power	$P_{M,N}$
Nominal motor voltage	$U_{M,N}$
Parameter	par.
Protective Extra Low Voltage	PELV
Printed Circuit Board	PCB
Rated Inverter Output Current	I_{INV}
Revolutions Per Minute	RPM
Regenerative terminals	Regen
Second	s
Synchronous Motor Speed	n_s
Torque limit	T_{LIM}
Volts	V
The maximum output current	$I_{VLT,MAX}$
The rated output current supplied by the frequency converter	$I_{VLT,N}$

2 Safety and Conformity

2.1 Safety Precautions

Equipment containing electrical components may not be disposed of together with domestic waste.
It must be separately collected with electrical and electronic waste according to local and currently valid legislation.

MCE 101/102

Design Guide

2.1.1 CE Conformity and Labelling

What is CE Conformity and Labelling?

The purpose of CE labelling is to avoid technical trade obstacles within EFTA and the EU. The EU has introduced the CE label as a simple way of showing whether a product complies with the relevant EU directives. The CE label says nothing about the specifications or quality of the product. Frequency converters are regulated by three EU directives:

The low-voltage directive (73/23/EEC)

Frequency converters must be CE labelled in accordance with the low-voltage directive of January 1, 1997. The directive applies to all electrical equipment and appliances used in the 50 - 1000 V AC and the 75 - 1500 V DC voltage ranges. Danfoss CE-labels in accordance with the directive and issues a declaration of conformity upon request.

2

Warnings

When in use the brake resistor surface temperature rises. DO NOT touch the brake resistor during operation.

Never work on a brake resistor in operation.

NB!
Never attempt to repair a defective brake resistor.

3 Introduction

3.1.1 Description of the Brake System

When the speed reference of a frequency converter is reduced, the motor acts as a generator and brakes. When a motor acts as a generator, it supplies energy to the frequency converter which is collected in the intermediate circuit. The function of the brake resistor is to provide a load on the intermediate circuit during braking, thereby ensuring that the braking power is absorbed by the brake resistor.

If a brake resistor was not used, the intermediate circuit voltage of the frequency converter would continue to increase, until it cuts out for protection. The advantage of using a brake resistor is it enables braking of a heavy load quickly, e.g. on a conveyor belt.

Danfoss has chosen a solution in which the brake resistor does not form an integral part of the frequency converter.
This offers the user the following advantages:

- The resistor time cycle can be selected as required
- The heat developed during braking can be conveyed beyond the panel cabinet to allow the energy to be used
- There is no overheating of the electronic components, even if the brake resistor is overloaded

Danfoss offers a range of brake resistors for frequency converters, VLT FC-Series, 2800 and FCD 300.

This Design Guide describes how to choose the right brake resistor for an application. Alternative to using a brake resistor there are other braking methods which can be applied depending on the braking profile of the application. The alternative braking methods can be found in the chapter *Alternative Braking Methods.*

4 How to Choose a Brake Resistor

The Danfoss brake resistor programme consists of two types of resistors, flat packs and wire wound - see pictures below.

Illustration 4.1: Wire Wound

Illustration 4.2: Flat Pack

4.1.1 Flat Packs

The flat pack brake resistors (see Illustration 4.2) for the VLT FC series is a safe and compact solution for the customer. At a constant load and free convection the resistor is self protecting as a fuse. This means short circuit proof, no fault to frame, no melting of casing and self extinguishing. The casing is made of anodized aluminum and is IP65 tight.
With the compact flat pack resistor, it is possible to mount the resistor on the rear of a VLT FC-series frequency converter.

The flat pack resistor portfolio covers the lower power range from 0.75 - 7.5 kW (both T2, T4 and T5) - and intended for horizontal applications (conveyors).

4.1.2 Wire Wound

The Danfoss wire wound resistor (see Illustration 4.1) consist of fully welded wire wound ceramic resistors. The base material is a very high temperature (up to 700°C) resistant ceramic, called Corderite. This ensures a resistor which is suitable for pulse loads between 10 - 20 times or more compared to the nominal load, which is used in frequent braking applications such as cranes, hoists and elevators.

To simplify the selection of the wire wound brake resistor Danfoss has chosen to offer two sizes for each drive across the power range, from 0.37 kW to 355 kW (T5).
The overall sizes are based on the duty cycle (10% and 40%) which is the proportion between the process time and the braking time. Thus if a 10% duty cycle resistor is applied it is able to absorb/brake away the peak power for 10% of the period. The remaining 90% of the period will be used to deflect excess heat. Depending on the size the periods for the wire wound resistors are 120, 300 and 600 seconds.

The following chapter lists the 10% and 40% brake resistors available for the VLT FC-Series drives.

If the optimum brake resistor must be selected it is necessary to know how often and how much the motor is to brake. How to calculate this and application examples can be found in chapter 6 and 7.

The enclosures comply with IP20.

As rule of thumb the 10% resistors are used for horizontal loads (e.g. conveyors, gantry cranes) and the 40% for vertical loads (e.g. cranes, hoists and elevators).
However to help choose the right sized brake resistor for an application the flow chart (illustration 4.3) provides guidance. Answer the questions in the diamond shaped boxes and you are guided to either tables for selection of brake resistors or chapters about how to calculate inertia or duty cycle.

4

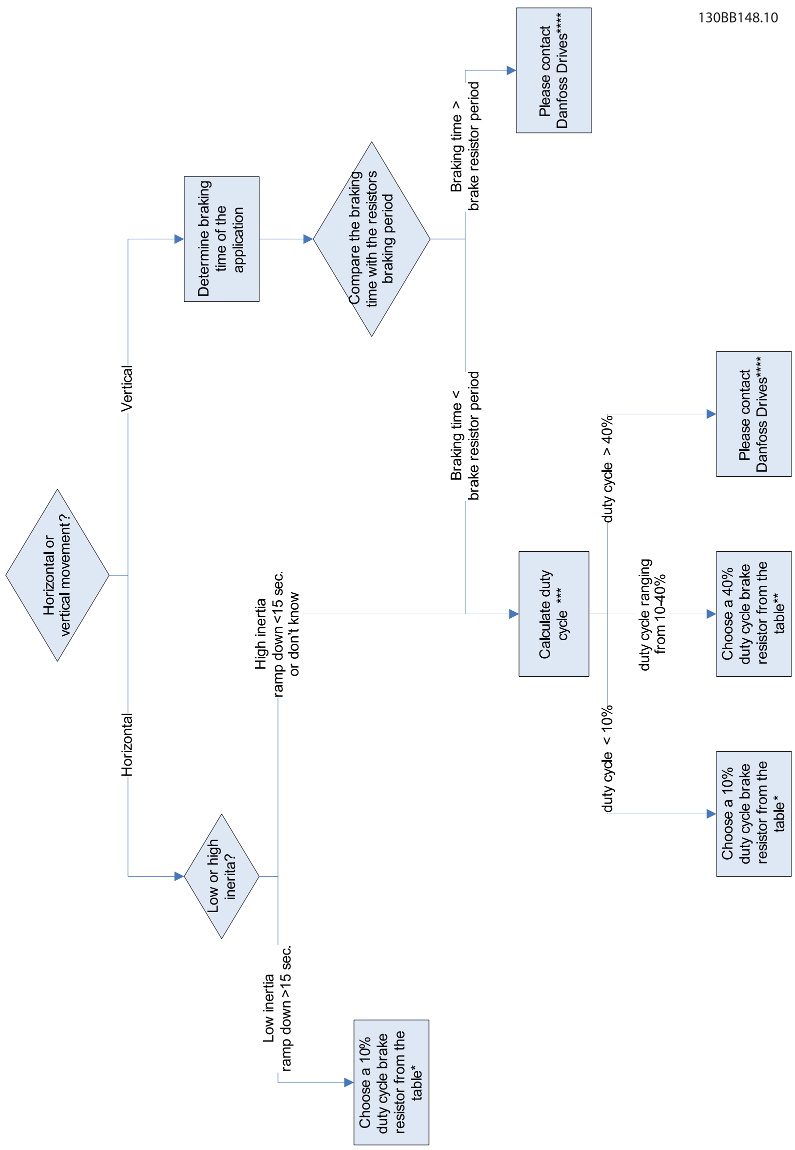

Illustration 4.3: Brake Resistor Selection Flow Chart

*) 40% (same as **)

**) See 10% tables in chapter *Brake Resistor Overview*.

***) See the chapter *Calculation of the Brake Resistor*.

****) Please provide the following info:

- Nominal power 100%
- Max. power during brake cycle
- Braking time / Duty cycle
- Supply voltage (max. DC)
- Resistance (Ω-value)
- With or without thermswitch
- IP enclosure rating

5 Brake Resistor Overview

5.1 Wire Wound

5.1.1 Abbreviations for the Tables

*) Resulting max. brake torque when using R_{rec}. Using the $R_{br,nom}$ will result in maximum brake torque e.g. 160%. The value in brackets is the drives max. brake torque

2*) All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper (60/75°C) conductors are recommended.

3*) Order the specified amount of Brake Resistors (e.g. 2 x 1062 = 2 pieces of 175U1062). See table header for the first four characters (175U or 130B).

4*) Rating for each thermistor relay (using one thermistor relay per resistor).

5*) Parallel star connection (see the *Installation* chapter.)

6*) Please contact Danfoss for further info.

7*) With Klixon Switch

P_m	: Rated motor size for VLT type
R_{min}	: Minimum permissible brake resistor - by drive
R_{rec}	: Recommended brake resistor (Danfoss)
$P_{b, max}$	: Brake resistor rated power as stated by supplier
Therm. relay	: Brake current setting of thermal relay
Code number	: Order numbers for Danfoss Brake Resistors
Cable cross section	: Recommended minimum value based upon PVC insulated copper cable, 30 degree Celsius ambient temperature with normal heat dissipation
$P_{pbr,avg}$	: Brake Resistor average rated power as stages by
$R_{br,avg}$	: The nominal (recommended) resistor value to ensure a brake power on motor shaft of 160%/110% for 1 minute

5.1.2 VLT AutomationDrive 10 %

AutomationDrive FC 301 - Mains: 200-240V (T2) - 10 % Duty Cycle

AutomationDrive FC 301	$P_{m (HO)}$	R_{min}	$R_{br, nom}$	R_{rec}	$P_{br avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with Rrec*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK25	0.25	368	408	425	0.095	1841	120	1.5	0.5	154 (160)
PK37	0.37	248	276	310	0.25	1842	120	1.5	0.9	142 (160)
PK55	0.55	166	185	210	0.285	1843	120	1.5	1.2	141 (160)
PK75	0.75	121	135	145	0.065	1820	120	1.5	0.7	149 (160)
P1K1	1.1	81	91.4	90	0.095	1821	120	1.5	1	160 (160)
P1K5	1.5	58.5	66.2	65	0.25	1822	120	1.5	2	160 (160)
P2K2	2.2	40.2	44.6	50	0.285	1823	120	1.5	2.4	143 (160)
P3K0	3	29.1	32.4	35	0.43	1824	120	1.5	2.5	148 (160)
P3K7	3.7	22.5	25.9	25	0.8	1825	120	1.5	5.7	160 (160)

AutomationDrive FC 302 - Mains: 200-240V (T2) - 10% Duty Cycle

AutomationDriven FC 302	$P_{m (HO)}$	R_{min}	$R_{br, nom}$	R_{rec}	$P_{br avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with Rrec*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK25	0.25	382	467	425	0.095	1841	120	1.5	0.5	160 (160)
PK37	0.37	279	315	310	0.25	1842	120	1.5	0.9	160 (160)
PK55	0.55	189	211	210	0.285	1843	120	1.5	1.2	160 (160)
PK75	0.75	130	154	145	0.065	1820	120	1.5	0.7	160 (160)
P1K1	1.1	81	104	90	0.095	1821	120	1.5	1	160 (160)
P1K5	1.5	58.5	75.7	65	0.25	1822	120	1.5	2	160 (160)
P2K2	2.2	45	51	50	0.285	1823	120	1.5	2.4	160 (160)
P3K0	3	31.5	37	35	0.43	1824	120	1.5	2.5	160 (160)
P3K7	3.7	22.5	29.6	25	0.8	1825	120	1.5	5.7	160 (160)

AutomationDrive FC 301/302 - Mains: 200-240V (T2) - 10% Duty Cycle

AutomationDrive FC 301/302	$P_{m (HO)}$	R_{min}	$R_{br. nom}$	R_{rec}	$P_{br avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with R_{rec}*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P5K5	5.5	18	20	20	1	1826	120	1.5	7.1	158 (160)
P7K5	7.5	13	14	15	2	1827	120	1.5	11	153 (160)
P11K	11	9	10	10	2.8	1828	120	2.5	17	154 (160)
P15K	15	6	7	7	4	1829	120	4	24	150 (150)
P18K	18.5	5.1	6	6	4.8	1830	120	4	28	150 (150)
P22K	22	4.2	5	4.7	6	1954	300	10	36	150 (150)
P30K	30	3	3.7	3.3	8	1955	300	10	49	150 (150)
P37K	37	2.4	3	2.7	10	1956	300	16	61	150 (150)

AutomationDrive FC 301 - Mains: 380-480V (T4) - 10% Duty Cycle

AutomationDrive FC 301	$P_{m\ (HO)}$	R_{min}	$R_{br.\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with R_{rec}*
T4	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK37	0.37	620	1098	620	0.065	1840	120	1.5	0.3	160 (160)
PK55	0.55	620	739	620	0.065	1840	120	1.5	0.3	160 (160)
PK75	0.75	485	539	620	0.065	1840	120	1.5	0.3	139 (160)
P1K1	1.1	329	366	425	0.095	1841	120	1.5	0.5	138 (160)
P1K5	1.5	240	266	310	0.25	1842	120	1.5	0.9	138 (160)
P2K2	2.2	161	179	210	0.285	1843	120	1.5	1.2	137 (160)
P3K0	3	117	130	150	0.43	1844	120	1.5	1.7	139 (160)
P4K0	4	87	97	110	0.6	1845	120	1.5	2.3	140 (160)
P5K5	5.5	63	69	80	0.85	1846	120	1.5	3.3	139 (160)
P7K5	7.5	45	50	65	1	1847	120	1.5	3.9	124 (160)
P11K	11	34.9	38.8	40	1.8	1848	120	1.5	7.1	155 (160)
P15K	15	25.3	28.1	30	2.8	1849	120	1.5	9.7	150 (160)
P18K	18.5	20.3	22.6	25	3.5	1850	120	1.5	12	144 (160)
P22K	22	16.9	18.8	20	4	1851	120	1.5	14	150 (160)
P30K	30	13.2	14.7	15	4.8	1852	120	2.5	18	147 (150)
P37K	37	11	12	12	5.5	1853	120	2.5	21	147 (150)
P45K	45	9	10	9.8	15	2008	120	10	39	148 (150)
P55K	55	7	8	7.3	13	0069	120	10	42	150 (150)
P55K	55	6.6	7.9	5.7	14	1958	300	10	50	150 (150)
P75K	75	6.6	5.7	6.3	15	0067	120	10	49	150 (150)
P75K	75	4.2	5.7	4.7	18	1959	300	16	62	150 (150)
P75K	75	4.2	5.7	4.7	29	0077	600	16	79	150 (150)

5

AutomationDrive FC 302 - Mains: 380-500V (T5) - 10% Duty Cycle

Automation-Drive FC 302	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section[2]*	Therm. relay	Max. brake torque with R_{rec}*
T5	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK37	0.37	620	1360	620	0.065	1840	120	1.5	0.3	160 (160)
PK55	0.55	620	915	620	0.065	1840	120	1.5	0.3	160 (160)
PK75	0.75	620	668	620	0.065	1840	120	1.5	0.3	160 (160)
P1K1	1.1	425	453	425	0.095	1841	120	1.5	0.5	160 (160)
P1K5	1.5	310	330	310	0.25	1842	120	1.5	0.9	160 (160)
P2K2	2.2	210	222	210	0.285	1843	120	1.5	1.2	160 (160)
P3K0	3	150	161	150	0.43	1844	120	1.5	1.7	160 (160)
P4K0	4	110	120	110	0.6	1845	120	1.5	2.3	160 (160)
P5K5	5.5	80	86	80	0.85	1846	120	1.5	3.3	160 (160)
P7K5	7.5	65	62	65	1	1847	120	1.5	3.9	160 (160)
P11K	11	40	42.1	40	1.8	1848	120	1.5	7.1	160 (160)
P15K	15	30	30.5	30	2.8	1849	120	1.5	9.7	160 (160)
P18K	18.5	25	24.5	25	3.5	1850	120	1.5	12	160 (160)
P22K	22	20	20.3	20	4	1851	120	1.5	14	150 (160)
P30K	30	15	15.9	15	4.8	1852	120	2.5	18	150 (150)
P37K	37	12	13	12	5.5	1853	120	2.5	21	150 (150)
P45K	45	10	10	9.8	15	2008	120	10	39	150 (150)
P55K	55	7	9	7.3	13	0069	120	10	42	150 (150)
P55K	55	7.3	8.6	7.3	14	1958	300	10	50	150 (150)
P75K	75	4.7	6.2	4.7	15	0067	120	10	49	150 (150)
P75K	75	4.7	6.2	4.7	18	1959	300	16	62	150 (150)
P75K	75	4.7	6.2	4.7	29	0077	600	16	79	150 (150)
P90K	90	3.8	5.2	3.8	22	1960	300	25	76	150 (150)
P90K	90	3.8	5.2	3.8	36	0078	600	35	97	150 (150)
P110	110	3.2	4.2	3.2	27	1961	300	35	92	150 (150)
P110	110	3	4	3.2	42	0079	600	50	115	150 (150)
P132	132	3	3.5	2.6	32	1962	300	50	111	150 (150)
P160	160	2	2.9	2.1	39	1963	300	70	136	150 (150)
P200	200	2	3	6.6 / 2 = 3.3	28 x 2 = 56	2 x 1061 [3]*	300	2 x 50[5]*	130[4]*	106 (150)
P200	200	1.6	2.3	6.6 / 3 = 2.2	28 x 3 = 84	3 x 1061 [3]*	300	3 x 50 [5]*	130[4]*	150 (150)
P250	250	2.6	1.9	5.2 / 2 = 2.6	36 x 2 = 72	3 x 1062 [3]*	300	3 x 70 [5]*	166[4]*	108 (150)
P250	250	2.6	1.9	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	150 (150)
P315	315	2.3	1.5	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	97 (150)
P315	315	2.3	1.5	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	150 (150)
P355	355	2.1	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	94 (150)
P355	355	2.1	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	150 (150)
P400	400	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	135 (135)
P450	450	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	120 (120)
P500	500	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	108 (108)
P560	560	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	96 (96)
P630	630	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	85 (85)
P710	710	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	76 (76)
P800	800	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	67 (67)
P1M0	1000	1.2	1.3	4.2 / 3 = 1.4	50 x 3 = 150	3 x 1064 [3]*	300	3 x 120 [5]*	218[4]*	54 (54)

AutomationDrive FC 302 - Mains: 525-600V (T6) - 10% Duty Cycle

Automation-Drive FC 302	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with R_{rec}*
T6	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK75	0.75	620	904	620	0.1	1840	120	1.5	0.3	160 (160)
P1K1	1.1	550	613	620	0.1	1840	120	1.5	0.3	160 (160)
P1K5	1.5	380	447	425	0.1	1841	120	1.5	0.5	160 (160)
P2K2	2.2	270	301	310	0.3	1842	120	1.5	0.9	160 (160)
P3K0	3	189	218	210	0.3	1843	120	1.5	1.2	160 (160)
P4K0	4	135	162	150	0.4	1844	120	1.5	1.7	160 (160)
P5K5	5.5	99	116	110	0.6	1845	120	1.5	2.3	160 (160)
P7K5	7.5	72	84.5	80	0.9	1846	120	1.5	3.3	160 (160)
P11K	11	40	57	40	2	1848	120	1.5	3.9	160 (160)
P15K	15	36	41.3	40	2	1848	120	1.5	7.1	160 (160)
P18K	18.5	27	33.2	30	2.8	1849	120	1.5	9.7	160 (160)
P22K	22	22.5	27.6	25	3.5	1850	120	1.5	12	150 (150)
P30K	30	18	21.6	20	4	1851	120	1.5	14	150 (150)
P37K	37	13.5	17.3	15	4.8	1852	120	2.5	18	150 (150)
P45K	45	10.8	14.2	12	5.5	1853	120	2.5	21	150 (150)
P55K	55	8.8	11.6	9.8	15	2008	120	10	39	150 (150)
P75K	75	6.6	8.4	7.3	13	0069	120	10	42	150 (150)
P90K	90	4.7	7	4.7	18	1959	300	16	62	150 (150)
P110	110	4.7	5.8	4.7	18	1959	300	16	62	150 (150)
P132	132	4.2	4.8	4.7	18	1959	300	16	62	150 (150)
P160	160	3.4	4	3.8	22	1960	300	25	76	150 (150)
P200	200	2.7	3.2	5.2 / 2 = 2.6	36 x 2 = 72	2 x 1062	300	2 x 705*	166	150 (150)
P250	250	2.2	2.5	5.2 / 2 = 2.6	36 x 2 = 72	2 x 1062	300	2 x 705*	166	146 (150)
P315	315	1.7	2							(150)
P355	355	1.6	1.8							(150)
P400	400	1.4	1.6							(150)
P450	450	1.2	1.3							(150)
P500	500	1.2	1.3							(150)
P560	560	1.2	1.3							(130)
P670	670	1.2	1.3							(116)
P750	750	1.2	1.3							(103)
P850	850	1.2	1.3							(91)
P1M0	1000	1.2	1.3							(73)
P1M1	1100	1.2	1.3							

AutomationDrive FC 302 - Mains: 525-690V (T7) - 10% Duty Cycle

Automation-Drive FC 302	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section	Max. brake torque with R_{rec}*
T7	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[%]
P400	400	1.9	2.2	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	150 (150)
P500	500	1.5	1.7	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	123 (150)
P560	560	1.4	1.5	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	118 (150)
P630	630	1.2	1.4	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	98 (150)
P710	710	1.2	1.3	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	87 (140)
P800	800	1.2	1.3	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	77 (124)
P900	900	1.2	1.3	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	68 (110)
P1M1	1000	1.2	1.3	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	61 (99)
P1M2	1200	1.2	1.3	4.2 / 2 = 2.1	50 x 2 = 100	2 x 1064	300	2 x 120	51 (83)

5.1.3 VLT AutomationDrive 40%

AutomationDrive FC 301 - Mains: 200-240V (T2) - 40% Duty Cycle

AutomationDrive FC 301	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section[2]*	Therm. relay	Max. brake torque with R_{rec}*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK25	0.25	368	408	425	0.43	1941	120	1.5	1	154 (160)
PK37	0.37	248	276	310	0.80	1942	120	1.5	1.6	142 (160)
PK55	0.55	166	185	210	1.35	1943	120	1.5	2.5	141 (160)
PK75	0.75	121	135	145	0.26	1920	120	1.5	1.3	149 (160)
P1K1	1.1	81	91.4	90	0.43	1921	120	1.5	2.2	160 (160)
P1K5	1.5	58.5	66.2	65	0.80	1922	120	1.5	3.5	160 (160)
P2K2	2.2	40.2	44.6	50	1.00	1923	120	1.5	4.5	143 (160)
P3K0	3	29.1	32.4	35	1.35	1924	120	1.5	6.2	148 (160)
P3K7	3.7	22.5	25.9	25	3.00	1925	120	1.5	11	160 (160)

AutomationDrive FC 302 - Mains: 200-240V (T2) - 40% Duty Cycle

AutomationDrive FC 302	$P_{m\,(HO)}$	R_{min}	$R_{br,\,nom}$	R_{rec}	$P_{br\,avg}$	Order no.	Period	Cable cross section^{2}*	Therm. relay	Max. brake torque with R_{rec}*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK25	0.25	382	467	425	0.43	1941	120	1.5	1.0	160 (160)
PK37	0.37	279	315	310	0.80	1942	120	1.5	1.6	160 (160)
PK55	0.55	189	211	210	1.35	1943	120	1.5	2.5	160 (160)
PK75	0.75	130	154	145	0.26	1920	120	1.5	1.3	160 (160)
P1K1	1.1	81	104	90	0.43	1921	120	1.5	2.2	160 (160)
P1K5	1.5	58.5	75.7	65	0.80	1922	120	1.5	3.5	160 (160)
P2K2	2.2	45	51	50	1.00	1923	120	1.5	4.5	160 (160)
P3K0	3	31.5	37	35	1.35	1924	120	1.5	6.2	160 (160)
P3K7	3.7	22.5	29.6	25	3.00	1925	120	1.5	11	160 (160)

AutomationDrive FC 301/302 - Mains: 200-240V (T2) - 40% Duty Cycle

AutomationDrive FC 301/302	$P_{m\,(HO)}$	R_{min}	$R_{br,\,nom}$	R_{rec}	$P_{br\,avg}$	Order no.	Period	Cable cross section	Therm. relay	Max. brake torque with R_{rec}*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P5K5	5.5	18	20	20	3.5	1926	120	1.5	13	(160)
P7K5	7.5	13	14	15	5	1927	120	2.5	18	(160)
P11K	11	9	10	10	9	1928	120	10	30	(160)
P15K	15	6	7	7	10	1929	120	16	38	(150)
P18K	18.5	5.1	6	6	12.7	1930	120	16	46	(150)
P22K	22	4.2	5							(150)
P30K	30	3	3.7							(150)
P37K	37	2.4	3							(150)

AutomationDrive FC 301 - Mains: 380-480V (T4) - 40% Duty Cycle

AutomationDrive FC 301	$P_{m (HO)}$	R_{min}	$R_{br, nom}$	R_{rec}	$P_{br avg}$	Order no.	Period	Cable cross section²*	Therm. relay	Max. brake torque with R_{rec}*
T4	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK37	0.37	620	1098	620	0.26	1940	120	1.5	0.6	160 (160)
PK55	0.55	620	739	620	0.26	1940	120	1.5	0.6	160 (160)
PK75	0.75	485	539	620	0.26	1940	120	1.5	0.6	139 (160)
P1K1	1.1	329	366	425	0.43	1941	120	1.5	1	138 (160)
P1K5	1.5	240	267	310	0.80	1942	120	1.5	1.6	138 (160)
P2K2	2.2	161	179	210	1.35	1943	120	1.5	2.5	137 (160)
P3K0	3	117	130	150	2.00	1944	120	1.5	3.7	139 (160)
P4K0	4	87	97	110	2.40	1945	120	1.5	4.7	140 (160)
P5K5	5.5	63	69	80	3.00	1946	120	1.5	6.1	139 (160)
P7K5	7.5	45	50	65	4.50	1947	120	1.5	8.3	124 (160)
P11K	11	34.9	38.8	40	5.00	1948	120	1.5	11	155 (160)
P15K	15	25.3	28.1	30	9.30	1949	120	2.5	18	150 (160)
P18K	18.5	20.3	22.6	25	12.70	1950	120	4	23	144 (160)
P22K	22	16.9	18.8	20	13.00	1951	120	4	25	150 (160)
P30K	30	13.2	14.7	15	15.60	1952	120	10	32	147 (150)
P37K	37	10.6	12	12	19.00	1953	120	10	40	147 (150)
P45K	45	8.7	10	9.8	38.00	2007	120	16	62	148 (150)
P55K	55	6.6	8	7.3	38.00	0068	120	25	72	150 (150)
P55K	55	6.6	7.9	5.7						150 (150)
P75K	75	6.6	5.7	6.3	45.00	0066	120	25	87	150 (150)
P75K	75	4.2	5.7	4.7						150 (150)
P75K	75	4.2	5.7	4.7						150 (150)

AutomationDrive FC 302 - Mains: 380-500V (T5) - 40% Duty Cycle

AutomationDrive FC 302	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section²*	Therm. relay	Max. brake torque with R_{rec}*
T5	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK37	0.37	620	1360	620	0.26	1940	120	1.5	0.6	160 (160)
PK55	0.55	620	915	620	0.26	1940	120	1.5	0.6	160 (160)
PK75	0.75	620	668	620	0.26	1940	120	1.5	0.6	160 (160)
P1K1	1.1	425	453	425	0.43	1941	120	1.5	1	160 (160)
P1K5	1.5	310	330	310	0.80	1942	120	1.5	1.6	160 (160)
P2K2	2.2	210	222	210	1.35	1943	120	1.5	2.5	160 (160)
P3K0	3	150	161	150	2	1944	120	1.5	3.7	160 (160)
P4K0	4	110	120	110	2.4	1945	120	1.5	4.7	160 (160)
P5K5	5.5	80	86	80	3	1946	120	1.5	6.1	160 (160)
P7K5	7.5	65	62	65	4.5	1947	120	1.5	8.3	160 (160)
P11K	11	40	42.1	40	5	1948	120	1.5	11	160 (160)
P15K	15	30	30.5	30	9.3	1949	120	2.5	18	160 (160)
P18K	18.5	25	24.5	25	12.7	1950	120	4	23	160 (160)
P22K	22	20	20.3	20	13	1951	120	4	25	150 (160)
P30K	30	15	15.9	15	15.6	1952	120	10	32	150 (150)
P37K	37	12	13	12	19	1953	120	10	40	150 (150)
P45K	45	10	10	9.8	38	2007	120	16	62	150 (150)
P55K	55	7	9	7.3	38	0068	120	25	72	150 (150)
P55K	55	7.3	8.6							150 (150)
P75K	75	4.7	6.2	4.7	45	0066	120	25	87	150 (150)
P75K	75	4.7	6.2							150 (150)
P75K	75	4.7	6.2							150 (150)
P90K	90	3.8	5.2	7.6 / 2 = 3.8	38 x 2 = 75	2 x 0072 ³*	600	2 x 70⁵*	140⁴*	150 (150)
P90K	90	3.8	5.2							150 (150)
P110	110	3.2	4.2	6.4 / 2 = 3.2	45 x 2 = 90	2 x 0073³*	600	2 x 70⁵*	168⁴*	150 (150)
P110	110	3	4							150 (150)
P132	132	3	4	5.8 / 2 = 2.6	56 x 2 = 112	2 x 0074³*	600	2 x 25⁵	186⁴	150 (150)
P160	160	2	3	6.3 / 3 = 2.1	45 x 3 = 135	3 x 0075³*	600	3 x 25⁵	252⁴	150 (150)
P200	200	2	3							106 (150)
P200	200	1.6	2.3							150 (150)
P250	250	2.6	1.9							108 (150)
P250	250	2.6	1.9							150 (150)
P315	315	2.3	1.5							97 (150)
P315	315	2.3	1.5							150 (150)
P355	355	2.1	1.3							94 (150)
P355	355	2.1	1.3							150 (150)
P400	400	1.2	1.3							135 (135)
P450	450	1.2	1.3							120 (120)
P500	500	1.2	1.3							108 (108)
P560	560	1.2	1.3							96 (96)
P630	630	1.2	1.3							85 (85)
P710	710	1.2	1.3							76 (76)
P800	800	1.2	1.3							67 (67)
P1M0	1000	1.2	1.3							54 (54)

AutomationDrive FC 302 - Mains: 525-600V (T6) - 40 % Duty Cycle

AutomationDrive FC 302	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section[2]*	Therm. relay	Max. brake torque with R_{rec}*
T6	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK75	0.75	620	905	620	0.26	1940	120	1.5	0.6	160 (160)
P1K1	1.1	550	614	620	0.26	1940	120	1.5	0.6	160 (160)
P1K5	1.5	380	448	425	1	1941	120	1.5	1	160 (160)
P2K2	2.2	270	302	310	1.6	1942	120	1.5	1.6	160 (160)
P3K0	3	189	219	210	2.5	1943	120	1.5	2.5	160 (160)
P4K0	4	135	162	150	3.7	1944	120	1.5	3.7	160 (160)
P5K5	5.5	99	117	110	4.7	1945	120	1.5	4.7	160 (160)
P7K5	7.5	72	84.5	80	6.1	1946	120	1.5	6.1	160 (160)
P11K	11	40	57	40	11	1948	120	1.5	8.3	160 (160)
P15K	15	36	41.3	40	11	1948	120	1.5	11	160 (160)
P18K	18.5	27	33.2	30	18	1949	120	2.5	18	160 (160)
P22K	22	22.5	27.6	25	23	1950	120	4	23	150 (150)
P30K	30	18	21.6	20	25	1951	120	4	25	150 (150)
P37K	37	13.5	17.3	15	32	1952	120	10	32	150 (150)
P45K	45	10.8	14.2	12	40	1953	120	10	40	150 (150)
P55K	55	8.8	11.6	9.8	62	2007	120	16	62	150 (150)
P75K	75	6.6	8.4	7.3	72	0068	120	25	72	150 (150)
P90K	90	4.7	7							150 (150)
P110	110	4.7	5.8							150 (150)
P132	132	4.2	4.8							150 (150)
P160	160	3.4	4							150 (150)
P200	200	2.7	3.2							150 (150)
P250	250	2.2	2.5							146 (150)
P315	315	1.7	2							(150)
P355	355	1.6	1.8							(150)
P400	400	1.4	1.6							(150)
P450	450	1.2	1.3							(150)
P500	500	1.2	1.3							(150)
P560	560	1.2	1.3							(130)
P670	670	1.2	1.3							(116)
P750	750	1.2	1.3							(103)
P850	850	1.2	1.3							(91)
P1M0	1000	1.2	1.3							(73)
P1M1	1100	1.2	1.3							

AutomationDrive FC 302 - Mains: 525-690V (T7) - 40% Duty Cycle

AutomationDrive FC 302	$P_{m\ (HO)}$	R_{min}	$R_{br.\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section	Therm. Relay	Max. brake torque with R_{rec}*
T7	[kW]	[Ω]	[Ω]	[Ω]	[kW]	130Bxxxx	[s]	[mm2]	[A]	[%]
P37K	37	18	23.5	22	28	2118	600	6	35	150 (150)
P45K	45	13.5	19.3	18	33	2119	600	10	42	150 (150)
P55K	55	13.5	15.8	15	42	2120	600	16	52	150 (150)
P75K	75	8.8	11.5	11	56	2121	600	25	71	150 (150)
P90K	90	8.8	9.6	9.1	66	2122	600	35	85	146 (150)
P110	110	6.6	7.8	7.5	78	2123	600	50	102	150 (150)
P132	132	4.2	6.5	6.2	96	2124	600	50	124	150 (150)
P160	160	4.2	5.4	5.1	120	2125	600	70	198	150 (150)
P200	200	3.4	4.3	7.8 / 2 = 3.9	2 x 78	2 x 2126 3*	600	2 x 25	200	150 (150)
P250	250	2.3	3.4	6.6 / 2 = 3.3	2 x 90	2 x 2127 3*	600	2 x 35	234	150 (150)
P315	315	2.3	2.7	5.4 / 2 = 2.7	2 x 112	2 x 2128 3*	600	2 x 50	288	150 (150)

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5.1.4 VLT HVAC Drive 10%

HVAC Drive FC 102 - Mains: 200-240V (T2) - 10% Duty Cycle

HVAC Drive FC 102	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with Rrec*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P1K1	1.1	130	152	145	0.065	1820	120	1.5	0.7	110 (110)
P1K5	1.5	81	110	90	0.095	1821	120	1.5	1	110 (110)
P2K2	2.2	58	74.2	65	0.25	1822	120	1.5	2	110 (110)
P3K0	3	45	53.8	50	0.285	1823	120	1.5	2.4	110 (110)
P3K7	3.7	31.5	43.1	35	0.43	1824	120	1.5	2.5	110 (110)
P5K5	5.5	22.5	28.7	25	0.8	1825	120	1.5	5.7	110 (110)
P7K5	7.5	18	20.8	20	1	1826	120	1.5	7.1	110 (110)
P11K	11	12.6	14	15	2	1827	120	1.5	11	103 (110)
P15K	15	9	10.2	10	2.8	1828	120	2.5	17	110 (110)
P18K	18.5	6.3	8.2	7	4	1829	120	4	24	110 (110)
P22K	22	5.4	6.9	6	4.8	1830	120	4	28	110 (110)
P30K	30	4.2	5	4.7	6	1954	300	10	36	110 (110)
P37K	37	2.9	4	3.3	8	1955	300	10	49	110 (110)
P45K	45	2.4	3.3	2.7	10	1956	300	16	61	110 (110)

HVAC Drive FC 102 - Mains: 380-480V (T4) - 10% Duty Cycle

HVAC Drive FC 102	$P_{m\ (HO)}$	R_{min}	$R_{br.\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section	Therm. relay	Max. brake torque with Rrec*
T4	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P1K1	1.1	329	608	620	0.065	1840	120	1.5	0.3	110 (110)
P1K5	1.5	240	443	425	0.095	1841	120	1.5	0.5	110 (110)
P2K2	2.2	161	299	310	0.25	1842	120	1.5	0.9	110 (110)
P3K0	3	117	217	210	0.285	1843	120	1.5	1.2	110 (110)
P4K0	4	86.9	161	150	0.43	1844	120	1.5	1.7	110 (110)
P5K5	5.5	62.5	115	110	0.6	1845	120	1.5	2.3	110 (110)
P7K5	7.5	45.3	83.7	80	0.85	1846	120	1.5	3.3	110 (110)
P11K	11	34.9	56.4	40	2	1848	120	1.5	7.1	110 (110)
P15K	15	25.3	40.9	40	2	1848	120	1.5	7.1	110 (110)
P18K	18.5	20.3	32.8	30	2.8	1849	120	1.5	9.7	110 (110)
P22K	22	16.9	27.3	25	3.5	1850	120	1.5	12	110 (110)
P30K	30	13.2	20	20	4	1851	120	1.5	14	110 (110)
P37K	37	10.6	16.1	15	4.8	1852	120	2.5	18	110 (110)
P45K	45	8.7	13.2	12	5.5	1853	120	2.5	21	110 (110)
P55K	55	6.6	10.8	9.8	15	2008	120	10	39	110 (110)
P75K	75	6.6	7.8	7.3	13	0069	120	10	42	110 (110)
P90K	90	3.6	6.5	4.7	18	1959	300	16	62	110 (110)
P110	110	3	5.3	4.7	18	1959	300	16	62	110 (110)
P132	132	2.5	4.5	3.8	22	1960	300	25	76	110 (110)
P160	160	2	3.7	3.8	22	1960	300	25	76	106 (110)
P200	200	1.6	2.9	2.6	32	1962	300	50	111	110 (110)
P250	250	1.2	2.4	2.1	39	1963	300	70	136	110 (110)
P315	315	1.2	1.9	2.1	39	1963	300	70	136	98 (110)
P355	355	1.2	1.7							(110)
P400	400	1.2	1.5							(110)
P450	450	1.2	1.3							(110)
P500	500	1.2	1.3							(100)
P560	560	1.2	1.3							(89)
P630	630	1.2	1.3							(79)
P710	710	1.2	1.3							(70)
P800	800	1.2	1.3							(62)
P1M0	1000	1.2	1.3							(50)

HVAC Drive FC 102 - Mains: 525-600V (T6) - 10% Duty Cycle

HVAC Drive FC 102	$P_{m (HO)}$	R_{min}	$R_{br, nom}$	R_{rec}	$P_{br avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with Rrec*
T6	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK75	0.75	620	1316	620	0.065	1840	120	1.5	0.3	110 (110)
P1K1	1.1	620	893	620	0.065	1840	120	1.5	0.3	110 (110)
P1K5	1.5	558	651	620	0.065	1840	120	1.5	0.3	110 (110)
P2K2	2.2	380	439	425	0.095	1841	120	1.5	0.5	110 (110)
P3K0	3	279	318	310	0.25	1842	120	1.5	0.9	110 (110)
P4K0	4	189	236	210	0.285	1843	120	1.5	1.2	110 (110)
P5K5	5.5	135	170	150	0.43	1844	120	1.5	1.7	110 (110)
P7K5	7.5	99	123	110	0.6	1845	120	1.5	2.3	110 (110)
P11K	11	73.8	82.9	80	0.85	1846	120	1.5	3.3	110 (110)
P15K	15	48.6	60.1	40	2	1848	120	1.5	7.1	110 (110)
P18K	18.5	35.1	48.2	40	2	1848	120	1.5	7.1	110 (110)
P22K	22	27.9	40.1	40	2	1848	120	1.5	7.1	110 (110)
P30K	30	23.4	29.4	25	3.5	1850	120	1.5	12	110 (110)
P37K	37	17.1	23.6	20	4	1851	120	1.5	14	110 (110)
P45K	45	13.5	19.4	20	4	1851	120	1.5	14	107 (110)
P55K	55	11.7	15.9	15	5	1852	120	2.5	18	110 (110)
P75K	75	9.9	11.5	12	6	1853	120	2.5	21	106 (110)
P90K	90	8.6	9.6	9.8	15	2008	120	10	39	108 (110)
P110	110	6.6	7.9	7.3	13	0069	120	10	42	110 (110)
P132	132	4.2	6.5	4.7	18	1959	300	16	62	110 (110)
P160	160	4.2	5.4	4.7	18	1959	300	16	62	110 (110)
P200	200	3.4	4.3	3.8	22	1960	300	25	76	110 (110)
P250	250	2.3	3.5	5.3 / 2 = 2.6	36 x 2 = 72	2 x 1062	300	70	166	110 (110)
P315	315	2.3	2.7	5.3 / 2 = 2.6	36 x 2 = 72	2 x 1062	300	70	166	110 (110)
P355	355	2.2	2.4	5.3 / 2 = 2.6	36 x 2 = 72	2 x 1062	300	70	166	103 (110)
P400	400	1.9	2.2							(110)
P450	450	1.6	1.7							(110)
P500	500	1.4	1.5							(110)
P560	560	1.2	1.4							(110)
P670	670	1.2	1.3							(103)
P750	750	1.2	1.3							(91)
P850	850	1.2	1.3							(81)
P1M0	1000	1.2	1.3							(73)

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5.1.5 VLT HVAC Drive 40 %

HVAC Drive FC 102 - Mains: 200-240V (T2) - 40 % Duty Cycle

HVAC Drive FC 102	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section²*	Therm. relay	Max. brake torque with Rrec*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P1K1	1.1	130	152	145	0.26	1920	120	1.5	1.3	110 (110)
P1K5	1.5	81	110	90	0.43	1921	120	1.5	2.2	110 (110)
P2K2	2.2	58	74.2	65	0.80	1922	120	1.5	3.5	110 (110)
P3K0	3	45	53.8	50	1.00	1923	120	1.5	4.5	110 (110)
P3K7	3.7	31.5	43.1	35	1.35	1924	120	1.5	6.2	110 (110)
P5K5	5.5	22.5	28.7	20	3	1925	120	1.5	11	110 (110)
P7K5	7.5	18	20.8							110 (110)
P11K	11	12.6	14							103 (110)
P15K	15	9	10.2							110 (110)
P18K	18.5	6.3	8.2							110 (110)
P22K	22	5.4	6.9							110 (110)
P30K	30	4.2	5							110 (110)
P37K	37	2.9	4							110 (110)
P45K	45	2.4	3.3							110 (110)

HVAC Drive FC 102 - Mains: 380-480V (T4) - 40% Duty Cycle

HVAC Drive FC 102	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section2*	Therm. relay	Max. brake torque with Rrec*
T4	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P1K1	1.1	329	608	620	0.26	1940	120	1.5	0.6	110 (110)
P1K5	1.5	240	443	425	1	1941	120	1.5	1	110 (110)
P2K2	2.2	161	299	310	1.6	1942	120	1.5	1.6	110 (110)
P3K0	3	117	217	210	2.5	1943	120	1.5	2.5	110 (110)
P4K0	4	86.9	161	150	3.7	1944	120	1.5	3.7	110 (110)
P5K5	5.5	62.5	115	110	4.7	1945	120	1.5	4.7	110 (110)
P7K5	7.5	45.3	83.7	80	6.1	1946	120	1.5	6.1	110 (110)
P11K	11	34.9	56.4	40	11	1948	120	1.5	11	110 (110)
P15K	15	25.3	40.9	40	11	1948	120	1.5	11	110 (110)
P18K	18.5	20.3	32.8	30	18	1949	120	2.5	18	110 (110)
P22K	22	16.9	27.3	25	23	1950	120	4	23	110 (110)
P30K	30	13.2	20	20	25	1951	120	4	25	110 (110)
P37K	37	10.6	16.1	15	32	1952	120	10	32	110 (110)
P45K	45	8.7	13.2	12	40	1953	120	16	40	110 (110)
P55K	55	6.6	10.8	9.8	62	2007	120	16	62	110 (110)
P75K	75	6.6	7.8	7.3	72	0068	120	25	72	110 (110)
P90K	90	3.6	6.5							(110)
P110	110	3	5.3							(110)
P132	132	2.5	4.5							(110)
P160	160	2	3.7							(110)
P200	200	1.6	2.9							(110)
P250	250	1.2	2.4							(110)
P315	315	1.2	1.9							(110)
P355	355	1.2	1.7							(110)
P400	400	1.2	1.5							(110)
P450	450	1.2	1.3							(110)
P500	500	1.2	1.3							(100)
P560	560	1.2	1.3							(89)
P630	630	1.2	1.3							(79)
P710	710	1.2	1.3							(70)
P800	800	1.2	1.3							(62)
P1M0	1000	1.2	1.3							(50)

HVAC Drive FC 102 - Mains: 525-600V (T6) - 40% Duty Cycle

HVAC Drive FC 102	$P_{m (HO)}$	R_{min}	$R_{br, nom}$	R_{rec}	$P_{br avg}$	Order no.	Period	Cable cross section	Therm. relay	Max. brake torque with Rrec*
T6	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK75	0.75	620	1316	620	0.26	1940	120	1.5	0.6	110 (110)
P1K1	1.1	620	893	620	0.26	1940	120	1.5	0.6	110 (110)
P1K5	1.5	558	651	620	0.26	1940	120	1.5	0.6	110 (110)
P2K2	2.2	380	439	425	1	1941	120	1.5	1	110 (110)
P3K0	3	279	318	310	1.6	1942	120	1.5	1.6	110 (110)
P4K0	4	189	236	210	2.5	1943	120	1.5	2.5	110 (110)
P5K5	5.5	135	170	150	3.7	1944	120	1.5	3.7	110 (110)
P7K5	7.5	99	123	110	4.7	1945	120	1.5	4.7	110 (110)
P11K	11	73.8	82.9	80	6.1	1946	120	1.5	6.1	110 (110)
P15K	15	48.6	60.1	40	11	1948	120	1.5	11	110 (110)
P18K	18.5	35.1	48.2	40	11	1948	120	1.5	11	110 (110)
P22K	22	27.9	40.1	40	11	1948	120	1.5	11	110 (110)
P30K	30	23.4	29.4	25	23	1950	120	4	23	110 (110)
P37K	37	17.1	23.6	20	25	1951	120	4	25	110 (110)
P45K	45	13.5	19.4	20	25	1951	120	4	25	107 (110)
P55K	55	11.7	15.9	15	32	1952	120	10	32	110 (110)
P75K	75	9.9	11.5	12	40	1953	120	16	40	106 (110)
P90K	90	8.6	9.6	9.8	62	2007	120	16	62	108 (110)
P110	110	6.6	7.9	7.3	72	0068	120	25	72	110 (110)
P132	132	4.2	6.5							110 (110)
P160	160	4.2	5.4							110 (110)
P200	200	3.4	4.3							110 (110)
P250	250	2.3	3.5							110 (110)
P315	315	2.3	2.7							110 (110)
P355	355	2.2	2.4							103 (110)
P400	400	1.9	2.2							(110)
P450	450	1.6	1.7							(110)
P500	500	1.4	1.5							(110)
P560	560	1.2	1.4							(110)
P670	670	1.2	1.3							(103)
P750	750	1.2	1.3							(91)
P850	850	1.2	1.3							(81)
P1M0	1000	1.2	1.3							(73)

5.1.6 VLT AQUA Drive 10 % Duty Cycle

AQUA Drive FC 202 - Mains: 200-240V (T2) - 10 % Duty Cycle

AQUA Drive FC 202	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section²*	Therm. relay	Max. brake torque with Rrec*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK25	0.25	380	425	679	0.095	1841	120	1.5	0.5	110 (110)
PK37	0.37	380	425	459	0.095	1841	120	1.5	0.5	110 (110)
PK55	0.55	275	310	307	0.25	1842	120	1.5	0.9	109 (110)
PK75	0.75	188	210	224	0.285	1843	120	1.5	1.2	110 (110)
P1K1	1.1	130	145	152	0.065	1820	120	1.5	0.7	110 (110)
P1K5	1.5	81	90	110	0.095	1821	120	1.5	1	110 (110)
P2K2	2.2	58	65	74.2	0.25	1822	120	1.5	2	110 (110)
P3K0	3	45	50	53.8	0.285	1823	120	1.5	2.4	110 (110)
P3K7	3.7	31.5	35	43.1	0.43	1824	120	1.5	2.5	110 (110)
P5K5	5.5	22.5	25	28.7	0.8	1825	120	1.5	5.7	110 (110)
P7K5	7.5	18	20	20.8	1	1826	120	1.5	7.1	110 (110)
P11K	11	12.6	15	14	2	1827	120	1.5	11	103 (110)
P15K	15	9	10	10.2	2.8	1828	120	2.5	17	110 (110)
P18K	18.5	6.3	7	8.2	4	1829	120	4	24	110 (110)
P22K	22	5.4	6	6.9	4.8	1830	120	4	28	110 (110)
P30K	30	4.2	4.7	5	6	1954	300	10	36	110 (110)
P37K	37	2.9	3.3	4	8	1955	300	10	49	110 (110)
P45K	45	2.4	2.7	3.3	10	1956	300	16	61	110 (110)

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AQUA Drive FC 202 - Mains: 380-480V (T4) - 10% Duty Cycle

AQUA Drive FC 202	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section[2]*	Therm. relay	Max. brake torque with Rrec*
T4	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK37	0.37	620	1825	620	0.065	1840	120	1.5	0.3	110 (110)
PK55	0.55	620	1228	620	0.065	1840	120	1.5	0.3	110 (110)
PK75	0.75	485	896	620	0.065	1840	120	1.5	0.3	110 (110)
P1K1	1.1	329	608	620	0.065	1840	120	1.5	0.3	110 (110)
P1K5	1.5	240	443	425	0.095	1841	120	1.5	0.5	110 (110)
P2K2	2.2	161	299	310	0.25	1842	120	1.5	0.9	110 (110)
P3K0	3	117	217	210	0.285	1843	120	1.5	1.2	110 (110)
P4K0	4	86.9	161	150	0.43	1844	120	1.5	1.7	110 (110)
P5K5	5.5	62.5	115	110	0.6	1845	120	1.5	2.3	110 (110)
P7K5	7.5	45.3	83.7	80	0.85	1846	120	1.5	3.3	110 (110)
P11K	11	34.9	56.4	40	2	1848	120	1.5	7.1	110 (110)
P15K	15	25.3	40.9	40	2	1848	120	1.5	7.1	110 (110)
P18K	18.5	20.3	32.8	30	2.8	1849	120	1.5	9.7	110 (110)
P22K	22	16.9	27.3	25	3.5	1850	120	1.5	12	110 (110)
P30K	30	13.2	20	20	4	1851	120	1.5	14	110 (110)
P37K	37	10.6	16.1	15	4.8	1852	120	2.5	18	110 (110)
P45K	45	8.7	13.2	12	5.5	1853	120	2.5	21	110 (110)
P55K	55	6.6	10.8	10	15	2008	120	10	39	110 (110)
P75K	75	6.6	8	7	13	0069	120	10	42	110 (110)
P90K	90	3.6	7	5	18	1959	300	16	62	110 (110)
P110	110	3	5	5	18	1959	300	16	62	110 (110)
P132	132	2.5	5	4	22	1960	300	25	76	110 (110)
P160	160	2	4	3.8	22	1960	300	25	76	106 (110)
P200	200	1.6	2.9	2.6	32	1962	300	50	111	110 (110)
P250	250	1.2	2.4	2.1	39	1963	300	70	136	110 (110)
P315	315	1.2	1.9	2.1	39	1963	300	70	136	98 (110)
P355	355	1.2	1.7							(110)
P400	400	1.2	1.5							(110)
P450	450	1.2	1.3							(110)
P500	500	1.2	1.3							(100)
P560	560	1.2	1.3							(89)
P630	630	1.2	1.3							(79)
P710	710	1.2	1.3							(70)
P800	800	1.2	1.3							(62)
P1M0	1000	1.2	1.3							(50)

AQUA Drive FC 202 - Mains: 525-690V (T7) - 10% Duty Cycle

AQUA Drive FC 202	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section	Max. brake torque with Rrec*
T7	[kW]	[Ω]	[Ω]	[Ω]	[kW]	130Bxxxx	[s]	[mm2]	[%]
P500	500	2.1	2.3	2.3	90	2 x 1063 [3]*	300		110 (110)
P560	560	1.9	2.1	2.1	100	2 x 1064 [3]*	300		110 (110)
P630	630	1.7	1.9	2.1	100	2 x 1064 [3]*	300		98 (110)
P710	710	1.5	1.7	2.1	100	2 x 1064 [3]*	300		87 (110)
P800	800	1.3	1.5	2.1	100	2 x 1064 [3]*	300		77 (110)
P900	900	1.2	1.3	2.1	100	2 x 1064 [3]*	300		68 (110)
P1M0	1000	1.2	1.3	2.1	100	2 x 1064 [3]*	300		61 (110)
P1M2	1200	1.2	1.3	2.1	100	2 x 1064 [3]*	300		51 (110)
P1M4	1400	1.2	1.3	2.1	100	2 x 1064 [3]*	300		44 (110)

5.1.7 VLT AQUA Drive 40 % Duty Cycle

AQUA Drive FC 202 - Mains: 200-240V (T2) - 40 % Duty Cycle

AQUA Drive FC 202	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section[2]*	Therm. re-lay	Max. brake torque with Rrec*
T2	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK25	0.25	380	425	679	0.43	1941	120	1.5	1.0	110 (110)
PK37	0.37	380	425	459	0.43	1941	120	1.5	1.0	110 (110)
PK55	0.55	275	310	307	0.8	1942	120	1.5	1.6	109 (110)
PK75	0.75	188	210	224	1.35	1943	120	1.5	2.5	110 (110)
P1K1	1.1	130	145	152	0.26	1920	120	1.5	1.3	110 (110)
P1K5	1.5	81	90	110	0.43	1921	120	1.5	2.2	110 (110)
P2K2	2.2	58	65	74.2	0.8	1922	120	1.5	3.5	110 (110)
P3K0	3	45	50	53.8	1	1923	120	1.5	4.5	110 (110)
P3K7	3.7	31.5	35	43.1	1.35	1924	120	1.5	6.2	110 (110)
P5K5	5.5	22.5	25	28.7	3	1925	120	1.5	11	110 (110)
P7K5	7.5	18	20	20.8						110 (110)
P11K	11	12.6	15	14						103 (110)
P15K	15	9	10	10.2						110 (110)
P18K	18.5	6.3	7	8.2						110 (110)
P22K	22	5.4	6	6.9						110 (110)
P30K	30	4.2	4.7	5						110 (110)
P37K	37	2.9	3.3	4						110 (110)
P45K	45	2.4	2.7	3.3						110 (110)

AQUA Drive FC 202 - Mains: 380-480V (T4) - 40% Duty Cycle

AQUA Drive FC 202	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section²*	Therm. re-lay	Max. brake torque with Rrec*
T4	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
PK37	0.37	620	1825	620	0.26	1940	120	1.5	0.6	110 (110)
PK55	0.55	620	1228	620	0.26	1940	120	1.5	0.6	110 (110)
PK75	0.75	485	896	620	0.26	1940	120	1.5	0.6	110 (110)
P1K1	1.1	329	608	620	0.26	1940	120	1.5	0.6	110 (110)
P1K5	1.5	240	443	425	1	1941	120	1.5	1	110 (110)
P2K2	2.2	161	299	310	1.6	1942	120	1.5	1.6	110 (110)
P3K0	3	117	217	210	2.5	1943	120	1.5	2.5	110 (110)
P4K0	4	86.9	161	150	3.7	1944	120	1.5	3.7	110 (110)
P5K5	5.5	62.5	115	110	4.7	1945	120	1.5	4.7	110 (110)
P7K5	7.5	45.3	83.7	80	6.1	1946	120	1.5	6.1	110 (110)
P11K	11	34.9	56.4	40	11	1948	120	1.5	11	110 (110)
P15K	15	25.3	40.9	40	11	1948	120	1.5	11	110 (110)
P18K	18.5	20.3	32.8	30	18	1949	120	2.5	18	110 (110)
P22K	22	16.9	27.3	25	23	1950	120	4	23	110 (110)
P30K	30	13.2	20	20	25	1951	120	4	25	110 (110)
P37K	37	10.6	16.1	15	32	1952	120	10	32	110 (110)
P45K	45	8.7	13.2	12	40	1953	120	16	40	110 (110)
P55K	55	6.6	10.8	10	62	2007	120	16	62	110 (110)
P75K	75	6.6	8	7	72	0068	120	25	72	110 (110)
P90K	90	3.6	7							110 (110)
P110	110	3	5							110 (110)
P132	132	2.5	5							110 (110)
P160	160	2	4							106 (110)
P200	200	1.6	2.9							110 (110)
P250	250	1.2	2.4							110 (110)
P315	315	1.2	1.9							98 (110)
P355	355	1.2	1.7							(110)
P400	400	1.2	1.5							(110)
P450	450	1.2	1.3							(110)
P500	500	1.2	1.3							(100)
P560	560	1.2	1.3							(89)
P630	630	1.2	1.3							(79)
P710	710	1.2	1.3							(70)
P800	800	1.2	1.3							(62)
P1M0	1000	1.2	1.3							(50)

AQUA Drive FC 202 - Mains: 525-690V (T7) - 40% Duty Cycle

AQUA Drive FC 202	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	R_{rec}	$P_{br\ avg}$	Order no.	Period	Cable cross section	Therm. relay	Max. brake torque with Rrec*
T7	[kW]	[Ω]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm2]	[A]	[%]
P45K	45	22.5	26.4	22	28	2118	600	6	35	110 (110)
P55K	55	18	21.6	18	33	2119	600	10	42	110 (110)
P75K	75	13.5	15.6	15	42	2120	600	16	52	110 (110)
P90K	90	8.8	13	11	56	2121	600	25	71	110 (110)
P110	110	8.8	10.7	9.1	77	2122	600	35	85	110 (110)
P132	132	6.6	8.9	7.5	93	2123	600	50	102	110 (110)
P160	160	6.6	7.3	6.2	113	2124	600	50	124	110 (110)
P200	200	4.2	5.9	5.1	137	2125	600	70	198	110 (110)
P250	250	4.2	4.7	7.8 / 2 = 3.9	89.5 x 2 = 179	2 x 2126[3]*	600	2 x 25	200	110 (110)
P315	315	3.4	3.7	6.6 / 2 = 3.3	106 x 2 = 212	2 x 2127[3]*	600	2 x 35	234	108 (110)
P400	355	2.3	3.3							110 (110)
P450	400	2.3	2.9							110 (110)
P500	500	2.1	2.3							110 (110)
P560	560	1.9	2.1							110 (110)
P630	630	1.7	1.9							98 (110)
P710	710	1.5	1.7							87 (110)
P800	800	1.3	1.5							77 (110)
P900	900	1.2	1.3							68 (110)
P1M0	1000	1.2	1.3							61 (110)

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5.1.8 VLT 2800 40 % Duty Cycle

VLT type	P_{motor}	R_{min}	R_{rec}	$P_{b, max}$	Order no.	Period	Cable cross section[2]*	Therm.relay
	[kW]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm²]	[A]
2803 (200 V)	0.37	297	330	0.16	1900[7]*	120	1.5	0.7
2805 (200 V)	0.55	198	220	0.25	1901[7]*	120	1.5	1.1
2807 (200 V)	0.75	135	150	0.32	1902[7]*	120	1.5	1.5
2811 (200 V)	1.1	99	110	0.45	1975[7]*	120	1.5	2
2815 (200 V)	1.5	74	82	0.85	1903[7]*	120	1.5	3.2
2822 (200 V)	2.2	50	56	1.00	1904[7]*	120	1.5	4.2
2840 (200 V)	3.7	22	25	3.00	1925	120	1.5	11
2805 (400 V)	0.55	747	830	0.45	1976[7]*	120	1.5	0.7
2807 (400 V)	0.75	558	620	0.32	1910[7]*	120	1.5	0.7
2811 (400 V)	1.1	387	430	0.85	1911[7]*	120	1.5	1.4
2815 (400 V)	1.5	297	330	0.85	1912[7]*	120	1.5	1.6
2822 (400 V)	2.2	198	220	1.00	1913[7]*	120	1.5	2.1
2830 (400 V)	3.0	135	150	1.35	1914[7]*	120	1.5	3
2840 (400 V)	4	99	110	1.60	1979[7]*	120	1.5	3.8
2855 (400 V)	5.5	80	80	2.00	1977[7]*	120	1.5	5
2875 (400 V)	7.5	56	56	3.00	1978[7]*	120	1.5	6.8
2880 (400 V)	11	40	40	5.00	1997[7]*	120	1.5	11.2
2881 (400 V)	15	30	30	10	1998	120	2.5	18.3
2882 (400 V)	18.5	25	25	13	1999	120	4	22.8

5.1.9 VLT FCD300 40 % Duty Cycle

VLT type	P_{motor}	R_{min}	R_{rec}	$P_{b, max}$	Order no.[7]*	Period	Cable cross section[2]*	Therm.relay
	[kW]	[Ω]	[Ω]	[kW]	175Uxxxx	[s]	[mm²]	[A]
303 (400 V)	0.37	520	830	0.45	1976	120	1.5	0.7
305 (400 V)	0.55	405	830	0.45	1976	120	1.5	0.7
307 (400 V)	0.75	331	620	0.32	1910	120	1.5	0.7
311 (400 V)	1.1	243	430	0.85	1911	120	1.5	1.4
315 (400 V)	1.5	197	330	0.85	1912	120	1.5	1.6
322 (400 V)	2.2	140	220	1.00	1913	120	1.5	2.1
330 (400 V)	3	104	150	1.35	1914	120	1.5	3
335 (400 V)	3.3	104	150	1.35	1914	120	1.5	3

5.2 Flat Packs

5.2.1 Abbreviations for the Tables

P_m	: Rated motor size for VLT type
R_{min}	: Minimum permissible brake resistor - by drive
R_{rec}	: Recommended brake resistor (Danfoss)
$P_{b, max}$	: Brake resistor rated power as stated by supplier
Therm. relay	: Brake current setting of thermal relay
Code number	: Order numbers for Danfoss Brake Resistors
Cable cross section	: Recommended minimum value based upon PVC insulated copper cable, 30 degree Celsius ambient temperature with normal heat dissipation
$P_{pbr,avg}$	: Brake Resistor average rated power as stages by
$R_{br,avg}$	: The nominal (recommended) resistor value to ensure a brake power on motor shaft of 160%/110% for 1 minute

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5.2.2 VLT AutomationDrive

AutomationDrive FC 301 - Mains: 200-240V (T2)

AutomationDrive FC 301				Flatpack IP65 for horizontal conveyors		
	$P_{m\ (HO)}$	R_{min}	$R_{br,\ nom}$	Rrec per item	Duty Cycle	Order no.
T2	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
PK25	0.25	368	408	430/100	40	1002
PK37	0.37	248	276	330/100 or 310/200	27 or 55	1003 or 0984
PK55	0.55	166	185	220/100 or 210/200	20 or 37	1004 or 0987
PK75	0.75	121	135	150/100 or 150/200	14 or 27	1005 or 0989
P1K1	1.1	81.0	91.4	100/100 or 100/200	10 or 19	1006 or 0991
P1K5	1.5	58.5	66.2	72/200	14	0992
P2K2	2.2	40.2	44.6	50/200	10	0993
P3K0	3	29.1	32.4	35/200 or 72/200	7 or 14	0994 or 2 x 0992
P3K7	3.7	22.5	25.9	60/200	11	2 x 0996

AutomationDrive FC 302 Mains: 200-240V (T2)

AutomationDrive FC 302				Flatpack IP65 for horizontal conveyors		
	$P_{m (HO)}$	R_{min}	$R_{br. nom}$	Rrec per item	Duty Cycle	Order no.
T2	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
PK25	0.25	382	467	430/100	40	1002
PK37	0.37	279	315	330/100 or 310/200	27 or 55	1003 or 0984
PK55	0.55	189	211	220/100 or 210/200	20 or 37	1004 or 0987
PK75	0.75	130	154	150/100 or 150/200	14 or 27	1005 or 0989
P1K1	1.1	81.0	104.4	100/100 or 100/200	10 or 19	1006 or 0991
P1K5	1.5	58.5	75.7	72/200	14	0992
P2K2	2.2	45.0	51.0	50/200	10	0993
P3K0	3	31.5	37.0	35/200 or 72/200	7 or 14	0994 or 2 x 0992
P3K7	3.7	22.5	29.6	60/200	11	2 x 0996

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AutomationDrive FC 301 Mains: 380-480V (T4)

AutomationDrive FC 301				Flatpack IP65 for horizontal conveyors		
	$P_{m (HO)}$	R_{min}	$R_{br. nom}$	Rrec per item	Duty Cycle	Order no.
T4	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
PK37	0.37	620	1098	830/100	30	1000
PK55	0.55	620	739	830/100	20	1000
PK75	0.75	485	539	620/100 or 620/200	14 or 27	1001 or 0982
P1K1	1.1	329	366	430/100 or 430/200	10 or 20	1002 or 0983
P1K5	1.5	240.0	266.7	310/200	14	0984
P2K2	2.2	161.0	179.7	210/200	10	0987
P3K0	3	117.0	130.3	150/200 or 300/200	7 or 14	0989 or 2 x 0985
P4K0	4	87	97	240/200	10	2 x 0986
P5K5	5.5	63	69	160/200	8	2 x 0988
P7K5	7.5	45	50	130/200	6	2 x 0990
P11K	11	34.9	38.8	80/240	5	2 x 0090
P15K	15	25.3	28.1	72/240	4	2 x 0091

AutomationDrive FC 302 Mains: 380-500V (T5)

AutomationDrive FC 302				Flatpack IP65 for horizontal conveyors		
	$P_{m (HO)}$	R_{min}	$R_{br. nom}$	Rrec per item	Duty Cycle	Order no.
T5	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
PK37	0.37	620	1360	830/100	30	1000
PK55	0.55	620	915	830/100	20	1000
PK75	0.75	620	668	620/100 or 620/200	14 or 27	1001 or 0982
P1K1	1.1	425	453	430/100 or 430/200	10 or 20	1002 or 0983
P1K5	1.5	310.0	330.4	310/200	14	0984
P2K2	2.2	210.0	222.6	210/200	10	0987
P3K0	3	150.0	161.4	150/200 or 300/200	7 or 14	0989 or 2 x 0985
P4K0	4	110	120	240/200	10	2 x 0986
P5K5	5.5	80	86	160/200	8	2 x 0988
P7K5	7.5	65	62	130/200	6	2 x 0990
P11K	11	40.0	42.1	80/240	5	2 x 0090
P15K	15	30.0	30.5	72/240	4	2 x 0091

5.2.3 VLT HVAC Drive

HVAC Drive FC 102 Mains: 200-240V (T2)

HVAC Drive FC 102	Pm (HO)	Rmin	Rbr. nom	Flatpack IP65 for horizontal conveyors Rrec per item	Duty Cycle	Order no.
T2	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
P1K1	1.1	130	152	100/100 or 100/200	10 or 19	1006 or 0991
P1K5	1.5	81	110	72/200	14	0992
P2K2	2.2	58	74.2	50/200	10	0993
P3K0	3	45	53.8	35/200 or 72/200	7 or 14	0994 or 2 x 0992
P3K7	3.7	31.5	43.1	60/200	11	2 x 0996

HVAC Drive FC 102 Mains: 380-480V (T4)

HVAC Drive FC 102	$P_{m\ (HO)}$	R_{min}	$R_{br.\ nom}$	Flatpack IP65 for horizontal conveyors Rrec per item	Duty Cycle	Order no.
T4	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
P1K1	1.1	329	608	630		
P1K5	1.5	240	443	430/100 or 430/200	10 or 20	1002 or 0983
P2K2	2.2	161	299	320/200	14	0984
P3K0	3	117	217	215/200	10	0987
P4K0	4	86.9	161	150/200 or 300/200	7 or 14	0989 or 2 x 0985
P5K5	5.5	62.5	115.0	120/200	6	2 x 0990
P7K5	7.5	45.3	83.7	82/240	5	2 x 0090

5.2.4 VLT AQUA Drive

AQUA Drive FC 202 Mains: 200-240V (T2)

AQUA Drive FC 202				Flatpack IP65 for horizontal conveyors		
	$P_{m\ (HO)}$	R_{min}	$R_{br.\ nom}$	Rrec per item	Duty Cycle	Order no.
T2	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
PK25	0.25	380	679	430/100	40	1002
PK37	0.37	380	459	430/100	40	1002
PK55	0.55	275	307	330/100 or 310/200	27 or 55	1003 or 0984
PK75	0.75	188	224	220/100 or 210/200	20 or 37	1004 or 0987
P1K1	1.1	130	152	150/100 or 150/200	14 or 27	1005 or 0989
P1K5	1.5	81	110	100/100 or 100/200	10 or 19	1006 or 0991
P2K2	2.2	58	74.2	72/200	14	0992
P3K0	3	45	53.8	50/200	10	0993
P3K7	3.7	31.5	43.1	35/200 or 72/200	7 or 14	0994 or 2 x 0992
P5K5	5.5	22.5	28.7	60/200	11	2 x 0996

AQUA Drive FC 202 Mains: 200-240V (T2)

AQUA Drive FC 202				Flatpack IP65 for horizontal conveyors		
	$P_{m\ (HO)}$	R_{min}	$R_{br.\ nom}$	Rrec per item	Duty Cycle	Order no.
T4	[kW]	[Ω]	[Ω]	[Ω / W]	%	175Uxxxx
PK37	0.37	620	1825	830/100	30	1000
PK55	0.55	620	1228	830/100	20	1000
PK75	0.75	485	896	830/100	20	1000
P1K1	1.1	329	608	630		
P1K5	1.5	240	443	430/100 or 430/200	10 or 20	1002 or 0983
P2K2	2.2	161	299	320/200	14	0984
P3K0	3	117	217	215/200	10	0987
P4K0	4	86.9	161.0	150/200 or 300/200	7 or 14	0989 or 2 x 0985
P5K5	5.5	62.5	115.0	120/200	6	2 x 0990
P7K5	7.5	45.3	83.7	82/240	5	2 x 0090

6 Application Examples

6.1 Examples

6.1.1 Example 1 - Conveyor Belt

Illustration 6.1 (see next page) shows the relation between the braking power and the acceleration/braking of a conveyor belt. As can be seen, the motor power during braking is negative, since the torque on the motor shaft is negative. The braking power, i.e. the power to be dissipated to the brake resistor, corresponds almost to the negative motor power, taking the losses in the motor and the frequency converter into account. The example also shows that the motor power is time-dependent.

Kinetic energy (E) in conveyor belt + motor:

$$E = 0.5 \times m \times v^2 + 0.5 \times j \times \omega^2 [Ws]$$

m = mass with linear movement [kg]
v = speed of mass with linear movement [m/s]
j = inertia of motor and gear box [kgm²]

$$\omega = motor\ speed = \frac{n \times 2}{60} [rad / s]$$

This formula may also be expressed as follows:

$$E = 0.50 \times m \times v^2 + 0.0055 \times j \times n^2 [Ws]$$

However, not all of the energy is to be dissipated to the brake resistor. The friction of the conveyor belt and the power loss of the motor also contribute to the braking function. Consequently, the formula for energy dissipation (E_b) to the brake resistor is as follows:

$$E_b = \left(0.5 \times m \times v^2 + 0.5 \times j \times \omega^2 - 0.5 \times M_f \times \omega\right) \times \eta_{MOTOR} [Ws]$$

M_f = Friction torque [Nm]
η_M = Motor efficiency

When:

$$\omega = \frac{n \times 2}{60}$$

is inserted, the result is as follows:

$$E_b = \left(0.5 \times m \times v^2 + 0.0055 \times j \times n^2 - 0.052 \times n \times M_f\right) \times \eta_M [Ws]$$

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The relation between braking power and acceleration/braking of a conveyor belt.

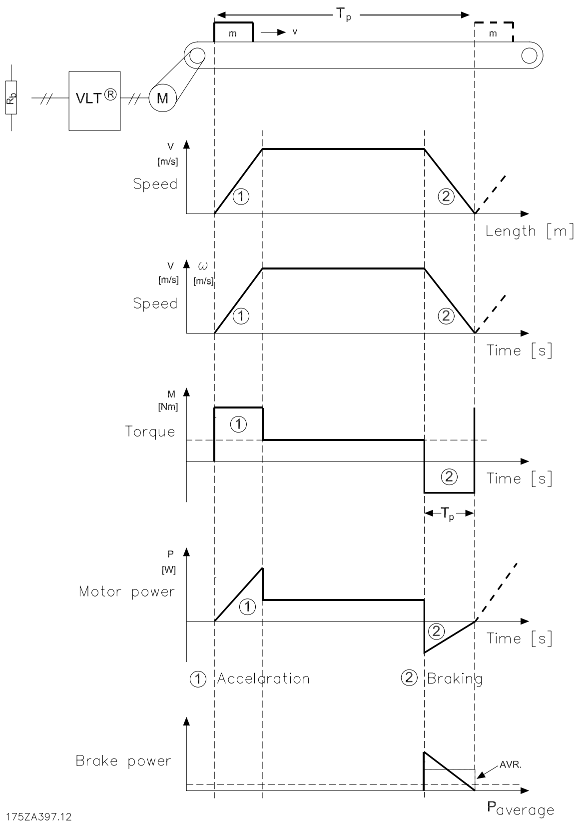
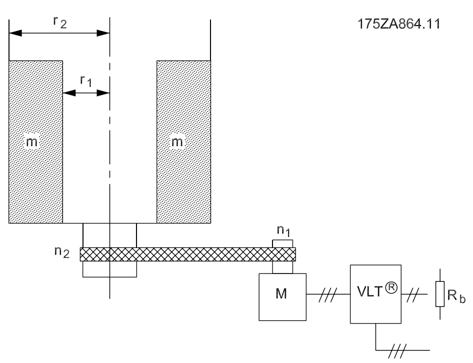


Illustration 6.1:

6.1.2 Example 2 - Centrifuge

Another typical application in which braking can be required on centrifuges. The weight of the centrifuge content is m.



j_C =	centrifuge inertia = ½ x m x ($r_1{}^2$ + $r_2{}^2$) [kgm^2]
j_M =	Gear motor inertia [kgm^2]
η_M =	Gear motor efficiency
n_1 =	max. motor speed [rpm]
n_2 =	max. centrifuge speed [rpm]

$$E_b = \left(0.0055 \times j_c \times n2^2 + 0.0055 \times j_M \times n1^2\right) \times \eta_M [Ws]$$

6.1.3 Continuous Braking

For continuous braking, select a brake resistor in which the constant braking power does not exceed the average power P_{avg} of the brake resistor.

NB!
Please contact your Danfoss distributor for further information.

7 Calculation of the Brake Resistor

To ensure the optimal choice of the brake resistor for a given application, its inertia and braking profile, some calculations must be carried out.
This chapter (along with examples in the previous) provides guidance through the necessary calculations to determine the values needed for Danfoss to design the optimal brake resistor for a given application.

7.1.1 Brake Setup

Illustration 7.1 shows a brake set-up using a frequency converter.

The following sections use expressions and abbreviations with respect to a brake set-up that can be seen from illustration 7.1.

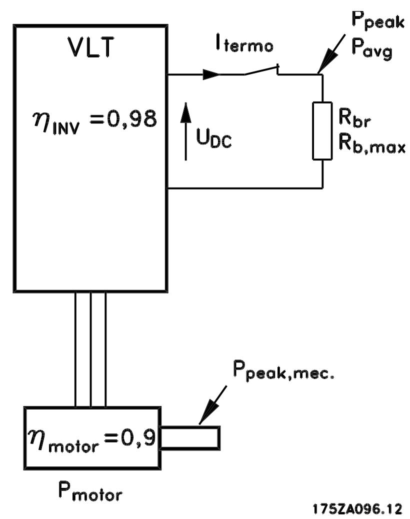


Illustration 7.1: Brake Setup

7.1.2 Calculation of Brake Resistor Values

To keep the VLT frequency converter from cutting out for protection when the motor brakes, the resistor values are to be selected on the basis of the peak braking power and the intermediate circuit voltage:

$$R_{br} = \frac{Udc^2}{P_{peak}} [\Omega]$$

As can be seen, the brake resistor depends on the intermediate circuit voltage (Udc).

Udc is the voltage, where the brake is activated. The FC-Series brake function is settled in 5 areas of mains:

Size	Brake active	Warning before cut out	Cut out (trip)
FC 301 / FC 302 3 x 200-240 V	390 V	405 V	410 V
FC 301 3 x 380-480 V	778 V	810 V	820 V
FC 302 3 x 380-500 V	810 V	840 V/ 828 V*	855 V
FC 302 3 x 525-600 V	943 V	965 V	975 V
FC 302 3 x 525-690 V	1099 V	1109 V	1130 V
*) 840 V Frame size A, B, C 828 V Frame size D, E, F			

NB!
Check that the brake resistor can handle voltages of 410 V, 820 V, 850 V, 975 V or 1130 V - unless Danfoss brake resistors are used.

Danfoss recommends the brake resistance R_{rec}, i.e. one that guarantees that the frequency converter is able to brake at the highest braking torque ($M_{br(\%)}$) of 160%. The formula can be written as:

$$R_{rec}\,[\Omega] = \frac{U_{dc}^2 \times 100}{P_{motor} \times M_{br\,(\%)} \times \eta_{VLT} \times \eta_{motor}}$$

η_{motor} is typically at 0.90
η_{VLT} is typically at 0.98

For 200 V, 480 V, 500 V and 600 V frequency converters, R_{rec} at 160% braking torque is written as:

$$200V : R_{rec} = \frac{107780}{P_{motor}}\,[\Omega]$$

$$480V : R_{rec} = \frac{375300}{P_{motor}}\,[\Omega]\ 1)$$

$$480V : R_{rec} = \frac{428914}{P_{motor}}\,[\Omega]\ 2)$$

$$500V : R_{rec} = \frac{464923}{P_{motor}}\,[\Omega]$$

$$600V : R_{rec} = \frac{630137}{P_{motor}}\,[\Omega]$$

$$690V : R_{rec} = \frac{832664}{P_{motor}}\,[\Omega]$$

1) For frequency converters Frame Size A
2) For frequency converters Frame Size B + C

If a higher brake resistor resistanse is selected, 160% / 150% / 110% braking torque cannot be obtained, and there is a risk that the frequency converter will cut out for protection.

If braking is only e.g. at 80% torque, it is possible to install a smaller brake resistor, the size of which can be calculated using the formula R_{rec}, no. 1.

NB!
The resistor brake resistance selected should not be higher than that recommended by Danfoss. If a brake resistor with a higher ohmic value is selected, the 160% braking torque may not be achieved because there is a risk that the frequency converter cuts out for safety reasons.

NB!
If a short circuit in the brake transistor occurs, power dissipation in the brake resistor is only prevented by using a mains switch or contactor to disconnect the mains for the frequency converter. (The contactor can be controlled by the frequency converter).

NB!
Do not touch the brake resistor as it can get very hot while/after braking. The brake resistor must be placed in a secure environment to avoid fire risk

7.1.3 Calculation of Braking Power

When calculating the braking power, it is to be ensured that the brake resistor is able to handle the average power as well as the peak power. The average power is determined by the process period time, i.e. the length of the braking time in relation to the process period time. The peak power is determined by the braking torque, which means that as braking progresses, the brake resistor must be able to dissipate the energy input.

The illustration below shows the relation between the average power and the peak power.

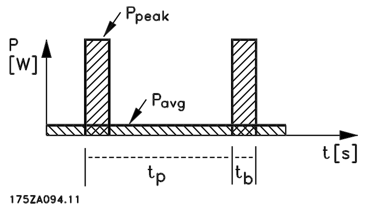


Illustration 7.2: Relation between average power and the peak power.

7.1.4 Calculation of the Brake Resistor Peak Power

$P_{peak,\ mec}$ is the peak power by which the motor brakes on the motor shaft. It is calculated as follows:

$$P_{peak,\ mec} = P_{motor} \times M_{BR(\%)} \quad [W]$$

P_{peak} is the name used for the braking power dissipated to the brake resistor when the motor brakes.

P_{peak} is lower than $P_{peak,mec}$ since the power is reduced by the efficiencies of the motor and the VLT frequency converter.

The peak power is calculated as follows:

$$P_{peak} = P_{motor} \times M_{BR(\%)} \times \eta_{motor} \times \eta_{vlt} \ [W]$$

If the brake resistor recommended by Danfoss is selected (R_{rec}) on the basis of the tables further on in this instruction, the brake resistor will be certain to provide a braking torque of 160% / 150% / 110% on the motor shaft.

7.1.5 Calculation of the Brake Resistor Average Power

The average power is determined by the process period time, i.e. the length of the braking time in relation to the process period time.

If the amount of kinetic energy (Eb) transferred to the resistor in each braking sequence (see examples 1 and 2 in the chapter *Application Examples*) is known, the average power of the resistor can be calculated as follows:

$$P_{avg} = \frac{E_b}{T_p} \quad [W]$$

T_p = period time in seconds (see drawing on page 3).

If the amount of kinetic energy transferred to the resistor in each braking sequence is not known, the average power can be calculated on the basis of the process period time and the braking time.

The duty-cycle for the braking sequence is calculated as follows:

$$Duty\ cycle = \frac{T_b \times 100}{T_p} \quad [\%]$$

T_p = process period time in seconds.
T_b = braking time in seconds.

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Danfoss offers brake resistors with a duty-cycle of max. 10% and 40%, respectively (some drives are only available with a duty-cycle of max. 10%). If a 10% duty-cycle is applied, the brake resistors are able to absorb Ppeak for 10% of the period time. The remaining 90% of the period time will be used on deflecting excess heat.

The average power with 10% duty-cycle can be calculated as follows: $P_{avg} = P_{peak} \times 10\% \quad [W]$

The average power with 40% duty-cycle can be calculated as follows: $P_{avg} = P_{peak} \times 40\% \quad [W]$

The calculations apply to intermittent braking using a period time of 120/300/600 seconds (to define whether it is 120, 300 or 600 seconds. Please see the tables further on).

NB!
Longer time than the specified intermittent braking period time may result in overheating of the resistor.

7.1.6 Braking of Inertia

In the case of braking of high inertia values on the motor shaft, the brake resistor values can be based on the inertia, Δω, Δt. See the illustration 7.3 below.

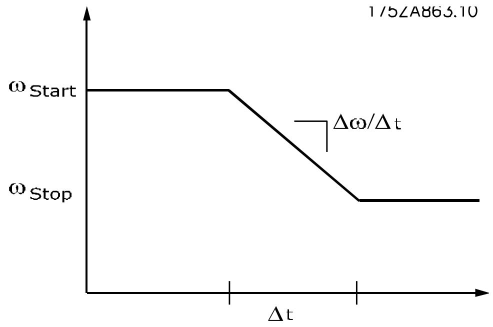


Illustration 7.3:

Δt is determined by the ramp-down time.

NB!
The ramp-down time goes from the rated motor frequency to 0 Hz.

P_{peak} can be calculated as:

$$P_{peak} = \eta_{motor} \times w_{start} \times j \times \frac{\Delta w}{\Delta t}$$

$$P_{peak} = \eta_{motor} \times \eta_{vlt} \times \eta_{start} \times j \times \left(\frac{2 \times \pi}{60}\right)^2 \times \frac{\Delta n}{\Delta t}$$

j is the inertia of the motor shaft.
Calculate the value on the brake resistor as described under the preceding paragraphs.

8 Installation

8.1.1 Brake Cable

Max. length [m]: 20 m screened cable.

The connection cable to the brake resistor is to be screened/armoured. Connect the screen/armouring to the conductive back plate at the VLT frequency converter and to the brake resistor metal cabinet by means of cable clamps.

NB!
If Danfoss brake resistors are not used, make sure that the brake resistors used are induction-free.

8.1.2 Protective Functions During Installation

When installing a brake resistor, every measure should be taken to avoid the risk of overloading, since a fire hazard may arise owing to the heat generated in the heat resistor.

NB!
The brake resistor is to be fitted on a non-flammable material.

For protection of the installation, a thermal relay should be fitted that cuts off the frequency converter if the brake current becomes too high.

Calculate the brake current setting of the thermal relay as follows:

$$I_{therm\ relay} = \sqrt{\frac{P_{brakeresistor\ max}}{R_{brakeresistor}}}$$

R_{br} is the current brake resistor value calculated in the section on "Calculation of brake resistor values". Illustration 8.1 shows an installation with a thermal relay.

The brake current setting of thermal relay for Danfoss brake resistors can be found in the chapter *Brake Resistor Overview.*

8

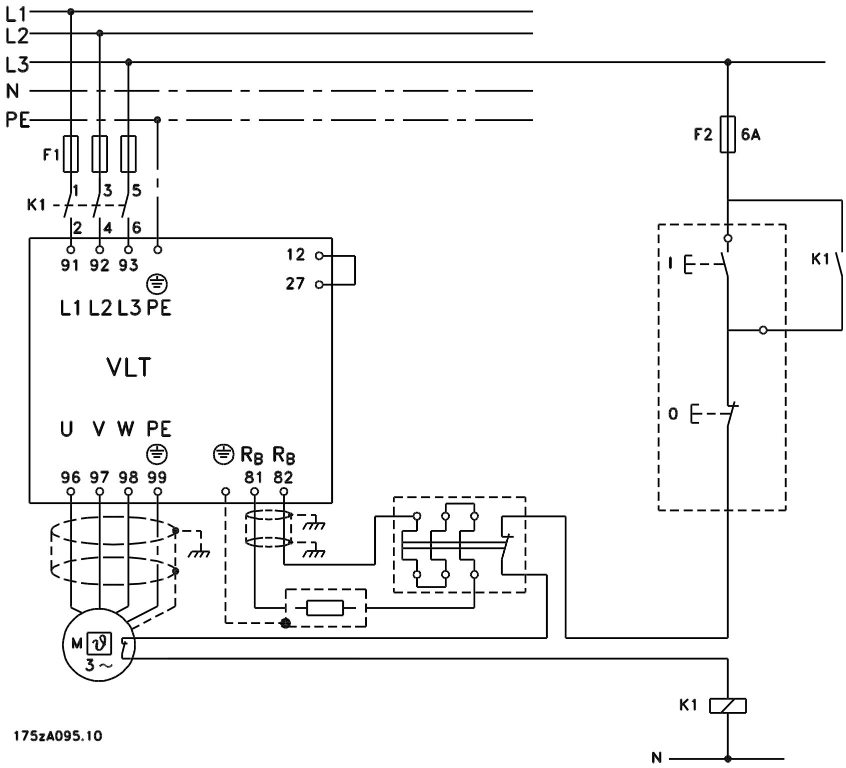


Illustration 8.1:

8

Some of the Danfoss Brake resistors contain a thermal switch (see tables in chapter *Brake Resistor Overview*). This switch is NC (normally closed) and can be used e.g. coasting stop reverse between terminal 12 and 27. The drive will then coast, if the thermal switch is opened.
The thermal switch must comply with PELV.

The brake is protected against short-circuiting of the brake resistor, and the brake transistor is monitored to ensure that short-circuiting of the transistor is detected. A relay/digital output can be used for protecting the brake resistor against overloading in connection with a fault in the frequency converter. In addition, the brake makes it possible to read out the momentary power and the mean power for the latest 120 seconds. The brake can also monitor the power energizing and make sure it does not exceed a limit selected in par. 2-12 *Brake Power Limit (kW)*. In par. 2-13 *Brake Power Monitoring*, select the function to carry out when the power transmitted to the brake resistor exceeds the limit set in par. 2-12 *Brake Power Limit (kW)*.

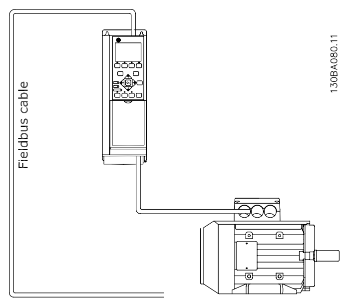
NB!
Monitoring the brake power is not a safety function; a thermal switch is required for that purpose. The brake resistor circuit is not earth leakage protected.

Over voltage control (OVC) (exclusive brake resistor) can be selected as an alternative brake function in par. 2-17 *Over-voltage Control*. This function is active for all units. The function ensures that a trip can be avoided if the DC link voltage increases. This is done by increasing the output frequency to limit the voltage from the DC link. It is a very useful function, e.g. if the ramp-down time is too short since tripping of the frequency converter is avoided. In this situation the ramp-down time is extended.

8.1.3 EMC Precautions

The following EMC precautions are recommended in order to achieve interference-free operation of the RS-485 network.

NB!
Relevant national and local regulations, for example regarding protective earth connection, must be observed. The RS-485 communication cable must be kept away from motor and brake resistor cables to avoid coupling of high frequency noise from one cable to another. Normally a distance of 200 mm (8 inches) is sufficient, but keeping the greatest possible distance between the cables is generally recommended, especially where cables run in parallel over long distances. When crossing is unavoidable, the RS-485 cable must cross motor and brake resistor cables at an angle of 90 degrees.

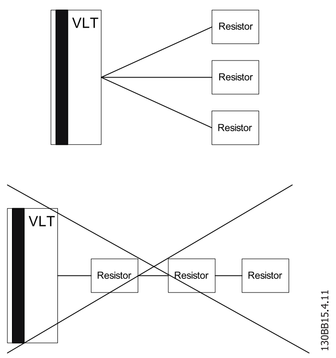


8

8.1.4 Cable Connection

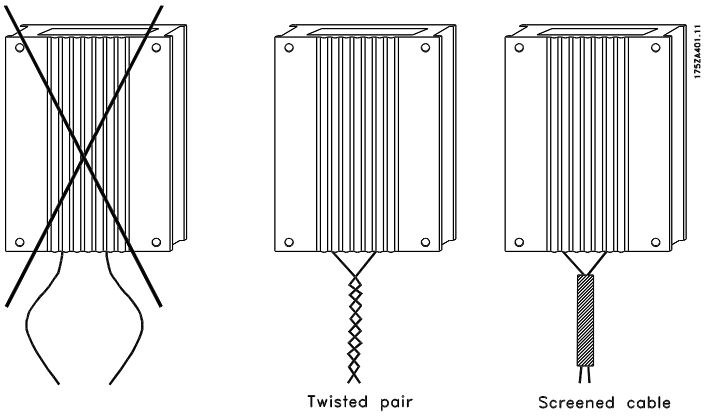
NB!
Cables General: All cabling must comply with national and local regulations on cable cross-sections and ambient temperature. Copper (60/75°C) conductors are recommended.

How to connect more than one resistor
Star parallel connection to ensure load is shared evenly between two or more resistors.



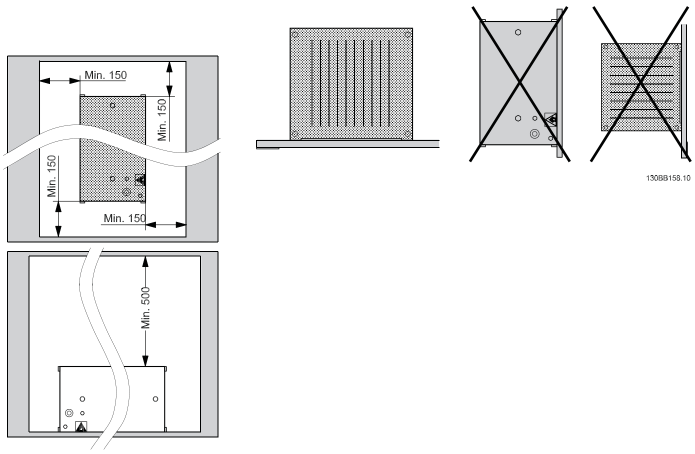
Flat Pack

To reduce the electrical noise from the wires between the brake resistor and the VLT frequency converter, the wires must be twisted.
For enhanced EMC performance a metal screen can be used.



Wire Wound

Follow the instructions shown in illustration below to ensure needed cooling of the resistor.



Mounting the resistor so the lamellas are horizontal will course overheating of the resistor.

9 Programming

9.1.1 VLT FC 301/302 AutomationDrive Parameters

The following is a list of parameters for the FC-Series which are important or relevant for braking with a Brake Resistor.

Parameter	Suggestion of settings
2-00 DC Hold Current	This parameter holds the motor function (holding torque) or pre-heats the motor.
2-01 DC Brake Current	Depends on the desired braking torque
2-02 DC Braking Time	Set the desired DC braking time
2-03 DC Brake Cut In Speed [RPM]	Set the desired DC Brake Cut In Speed
2-04 DC Brake Cut In Speed [Hz]	Set the desired DC brake cut-in frequency

Table 9.1: DC Braking

Parameter	Suggestion of settings
2-10 Brake Function	Resistor brake
2-16 AC Brake Max. Current	Enter the maximum permissible current when using AC brake to avoid overheating of motor windings. The AC brake function is available in Flux mode only (FC 302 only).

Table 9.2: AC Braking

Parameter	Suggestion of settings		
2-10 Brake Function	Resistor brake		
2-11 Brake Resistor (ohm)	Depends on the unit, see the tables in chapter *Brake Resistor Overview.*		
2-12 Brake Power	Depends on the unit, see the tables in chapter *Brake Resistor Overview.*		
2-13 Brake Power Monitoring	Warning or trip		
2-15 Brake Check	Warning or trip		
2-17 Over-voltage Control	Over-voltage control (OVC) reduces the risk of the drive tripping due to an over voltage on the DC link caused by generative power from the load. - Must not be enabled in hoisting applications.		
4-17 Torque Limit Generator Mode	160%		
5-01 Output (Terminal 27)	Brake no warning Brake ready no fault or Brake fault		
5-02 Output (Terminal 29)	Same as 5-01		
5-3 Output relay	[21]	Thermal warning	The thermal warning turns on when the temperature exceeds the limit in the motor, the frequency converter, the brake resistor, or the thermistor.
	[28]	Brake, no brake warning	Brake is active and there are no warnings.
	[29]	Brake ready, no fault	Brake is ready for operation and there are no faults.
	[30]	Brake fault (IGBT)	Output is Logic '1' when the brake IGBT is short-circuited. Use this function to protect the frequency converter if there is a fault on the brake modules. Use the output/relay to cut out the main voltage from the frequency converter.

Table 9.3: Dynamic Braking

9.1.2 VLT 2800 Parameters

The following is a list of parameters for the VLT 2800 Series which are important or relevant for the dynamic brake and the DC brake.

Parameter	Suggestion of settings
126 DC braking time	Set the desired DC braking time
127 DC brake engaging frequency	Set the desired DC brake engaging frequency
132 DC brake voltage	Depends on the desired braking torque
400 Brake function	Resistor or AC brake
456 Brake voltage reduce	0 should only be used if there are problems with overvoltage in the intermediate circuit

9.1.3 FCD 300 Parameters

The following is a list of parameters for the VLT FCD 300 Series which are important or relevant for the dynamic brake and the DC brake.

Parameter	Suggestion of settings
126 DC braking time	Set the desired DC braking time
127 DC brake engaging frequency	Set the desired DC brake engaging frequency
132 DC brake voltage	Depends on the desired braking torque
400 Brake function	Resistor or AC brake
456 Brake voltage reduce	0 should only be used if there are problems with overvoltage in the intermediate circuit

10 Brake Resistor Dimension Data

10.1.1 Brake Resistor for VLT FC-Series 10 % Duty-Cycle, Cablegland, Weight and Drawing no.

Code number 175Uxxxx	Cablegland	Weight [kg]	Drawing No.
1820	PG 9	1,1	1*
1821	PG 9	1,1	1 *
1822	PG 9	2,1	3*
1823	PG 9	2,1	3*
1824	PG 9	2,2	4*
1825	PG 9	3,0	6*
1826	PG 9	3,5	7*
1827	PG 16	5,8	9*
1828	PG 21	13,5	12
1829	PG 21	15,0	12
1830	PG 21	16,5	12
1954	PG 21	19,0	12
1955	PG 21	20,0	13
1956	PG 21	32,0	14
1840	PG 9	1,1	1*
1841	PG 9	1,2	2*
1842	PG 9	2,1	3*
1843	PG 9	2,1	3*
1844	PG 9	2,2	4*
1845	PG 9	2,4	5*
1846	PG 9	3,0	6*
1847	PG 9	3,5	7*
1848	PG 16	5,8	9*
1849	PG 16	13,5	12
1850	PG 16	15,0	12
1851	PG 16	15,0	12
1852	PG 21	16,5	12
1853	PG 21	19,0	12
2008	PG 21	36,0	15
0069	PG 21	40,0	15
1958	PG 21	49,0	15
0076	PG 29	65,0	17
1959	PG 21	52,0	15
0077	PG 36	67,0	17
0067	PG 21	40,0	15
1960	PG 29	56,0	16
0078	PG 36	90,0	18
1961	PG 29	66,0	17
0079	PG 36	94,0	18
1962	PG 36	72,0	17
1963	PG 36	125,0	18
2 x 1061	PG 36	70/pcs	2 x 17
2 x 1062	PG 36	90/pcs	2 x 18
2 x 1063	PG 36	90/pcs	2 x 18
2 x 1064	PG 42	125/pcs	2 x 19

Thermostat kit available (175 U2306)

10

10.1.2 Brake Resistor for VLT FC-Series 40 % Duty-Cycle, Cablegland, Weight and Drawing no.

Code number 175Uxxxx	Cablegland	Weight [kg]	Drawing No.
1920	PG 9	2,1	3*
1921	PG 9	2,2	4*
1922	PG 9	3,0	6*
1923	PG 9	3,5	7*
1924	PG 16	4,6	8*
1925	PG 16	13,5	12
1926	PG 16	15,0	12
1927	PG 21	16,5	12
1928	PG 21	25,0	14
1929	PG 21	25,0	14
1930	PG 21	32,0	15
1940	PG 9	2,1	3*
1941	PG 9	2,2	4*
1942	PG 9	3,0	6*
1943	PG 16	4,6	8*
1944	PG 16	5,8	9*
1945	PG 16	7,2	10*
1946	PG 16	7,6	11*
1947	PG 16	16,5	12
1948	PG 16	17,0	12
1949	PG 21	25,0	14
1950	PG 21	32,0	15
1951	PG 21	34,0	15
1952	PG 21	35,0	15
1953	PG 29	47,0	16
2007	PG 36	95,0	18
0068	PG 36	125	18
0066	PG 36	150	18
2 x 0072	PG 36	90/pcs	2 x 18
2 x 0073	PG 36	95/pcs	2 x 18

Thermostat kit available (175 U2306)

10

10.1.3 Brake Resistor for VLT 2803-2882 40 % Duty-cycle, Cablegland, Weight and Drawing no.

Code number 175Uxxxx	Cablegland	Weight [kg]	Drawing No.
1900	PG 7 (Thermo) / PG 9 (power)	1,2	2*
1901	PG 7 (Thermo) / PG 9 (power)	2,1	3*
1902	PG 7 (Thermo) / PG 9 (power)	2,1	3*
1975	PG 7 (Thermo) / PG 9 (power)	2,2	4*
1903	PG 7 (Thermo) / PG 9 (power)	2,4	5*
1904	PG 7 (Thermo) / PG 9 (power)	3,5	7*
1925	PG 16	13,5	12
1976	PG 7 (Thermo) / PG 9 (power)	2,2	4*
1910	PG 7 (Thermo) / PG 9 (power)	2,2	4*
1911	PG 7 (Thermo) / PG 9 (power)	2,4	5*
1912	PG 7 (Thermo) / PG 9 (power)	3,0	6*
1913	PG 7 (Thermo) / PG 9 (power)	3,5	7*
1914	PG 7 (Thermo) / PG 16 (power)	4,6	8*
1979	PG 7 (Thermo) / PG 16 (power)	4,6	8*
1977	PG 7 (Thermo) / PG 16 (power)	5,8	9*
1978	PG 7 (Thermo) / PG 16 (power)	7,6	11
1997	PG 21	17	12
1998	PG 21	25	14
1999	PG 21	34	15

Thermostat kit available (175 U2306)

10.1.4 Brake Resistor for VLT FCD 303-335 40 % Duty-cycle, Cablegland, Weight and Drawing no.

Code number 175Uxxxx	Cablegland	Weight [kg]	Drawing No.
1976	PG 7 (Thermo) / PG 9 (power)	2,2	4*
1976	PG 7 (Thermo) / PG 9 (power)	2,2	4*
1910	PG 7 (Thermo) / PG 9 (power)	2,2	4*
1911	PG 7 (Thermo) / PG 9 (power)	2,4	5*
1912	PG 7 (Thermo) / PG 9 (power)	3,0	6*
1913	PG 7 (Thermo) / PG 9 (power)	3,5	7*
1914	PG 7 (Thermo) / PG 16 (power)	4,6	8*
1914	PG 7 (Thermo) / PG 16 (power)	4,6	8*

Thermostat kit available (175 U2306)

10

11 Alternative Braking Methods

11.1.1 DC Injection Braking

If the three-phase winding of the stator is fed with direct current, a stationary magnetic field Φ will be set up in the stator bore causing a voltage to be induced in the bars of the cage rotor as long as the rotor is in motion. Since the electrical resistance of the rotor cage is very low, even small induced voltages can create a high rotor current. This current will produce a strong braking effect on the bars and hence on the rotor. As the speed falls, the frequency of the induced voltage falls and with it the inductive impedance. The ohmic resistance of the rotor gradually becomes dominant and so increases the braking effect as the speed comes down. The braking torque generated falls away steeply just before standstill and finally ceases when there is no further movement. Direct current injection braking is therefore not suitable for actually holding a load at rest.

FC-Series:
An over-modulated DC current added to the AC current works as an eddy current brake (par. 2-02 ≠ 0 s).

11.1.2 AC-braking

When the motor acts as a brake the DC-link voltage will increase because energy is fed back to the DC-link. The principle in AC-brake is to increase the magnetisation during the braking and thereby increase the thermal losses of the motor.

FC-Series:
The brake energy is distributed in the motor by changing the loss conditions in the motor. The AC brake function cannot be used in applications with high cycling frequency since this will overheat the motor (par. 2-10 = [2]). Using factory settings it is possible to brake with about 50 % of rated torque below 2/3 of rated speed and with about 25 % at rated speed. The function is not working at low speed (below 1/3 of nominal motor speed).

VLT 2800 and FCD 300
Using par. 144 in VLT 2800 and FCD 300 it is possible to adjust the size of the generator torque that can be applied to the motor without the intermediate circuit voltage exceeding the warning level.

The braking torque depends on the speed. With the AC-brake function enabled and parameter 144 = 1,3 (factory setting) it is possible to brake with about 50 % of rated torque below 2/3 of rated speed and with about 25 % at rated speed. The function is not working at low speed (below 1/3 of nominal motor speed). It is only possible to run for about 30 seconds with parameter 144 greater than 1.2.

NB!
If the value in parameter 144 is increased, the motor current will simultaneously increase significantly when generator loads are applied. The parameter should therefore only be changed if it is guaranteed during measurement that the motor current in all operating situations will never exceed the maximum permitted current in the motor. Please note: The current can not be read out from the display.

11.1.3 Mechanical Holding Brake

A mechanical holding brake mounted directly on the motor shaft normally performs static braking. In some applications the static holding torque is working as static holding of the motor shaft (usually synchronous permanent motors). A holding brake is either controlled by a PLC or directly by a digital output from the frequency converter (relay or solid state).

NB!
When the holding brake is included in a safety chain:
A frequency converter cannot provide a safe control of a mechanical brake. A redundancy circuitry for the brake control must be included in the total installation.

11.1.4 Optimum Braking

Dynamic braking is useful from max. speed down to a certain frequency. Below this frequency DC braking is to be applied as required. The most efficient way of doing this is to use a combination of dynamic and DC braking. See illustration 11.1. The parameters can be found further on in this instruction in the chapter *Programming*.

For further information about DC Braking see section 11.1.1

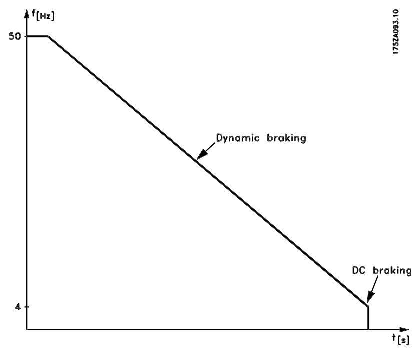


Illustration 11.1:

NB!
When changing from dynamic to DC braking, there will be a short period (2-6 milliseconds) with very low braking torque.

How to calculate optimum DC-brake cut in frequency:

Slip $S = \frac{n_O - n_n}{n_O} \times 100\,[\%]$

Synchronous speed $n_0 = \frac{f \times 60}{p}$ [1/min]

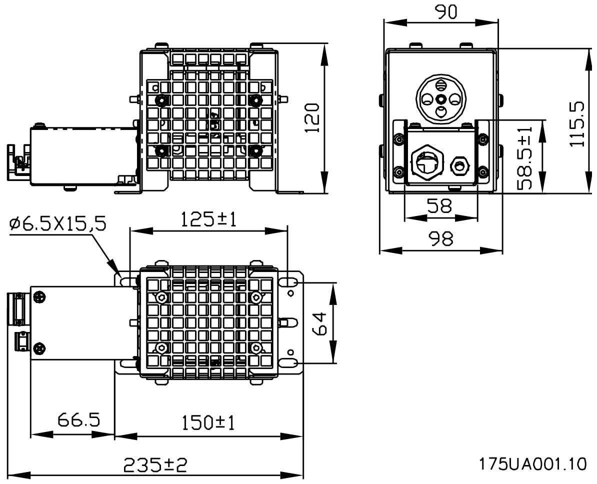
f = frequency
p = no. of pole pairs
n_n = speed of the rotor

DC-brake cut in frequency = $2 \times \frac{S \times f}{100}\,[Hz]$

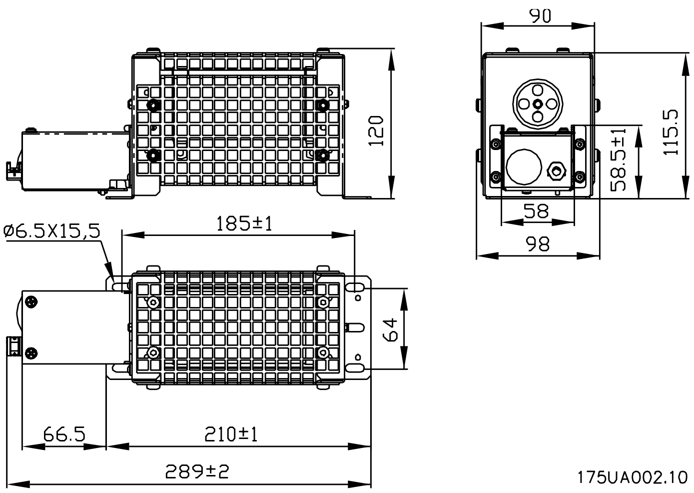
12 Drawings 1-19

12.1 Drawings

12.1.1 Drawing 1



12.1.2 Drawing 2



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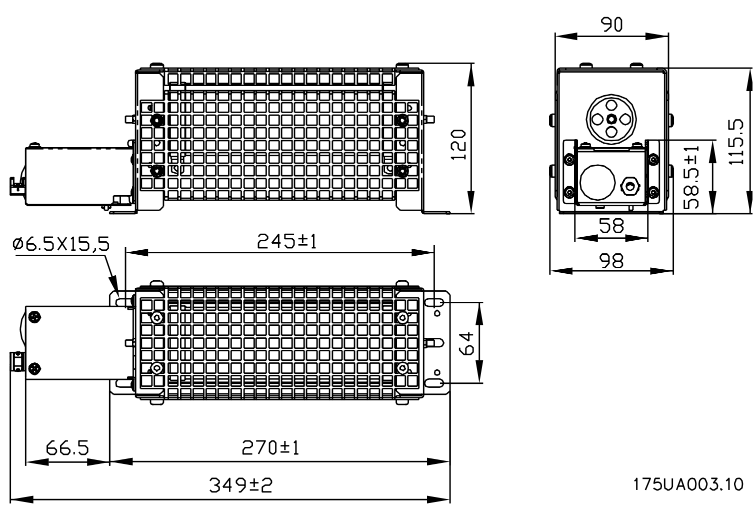
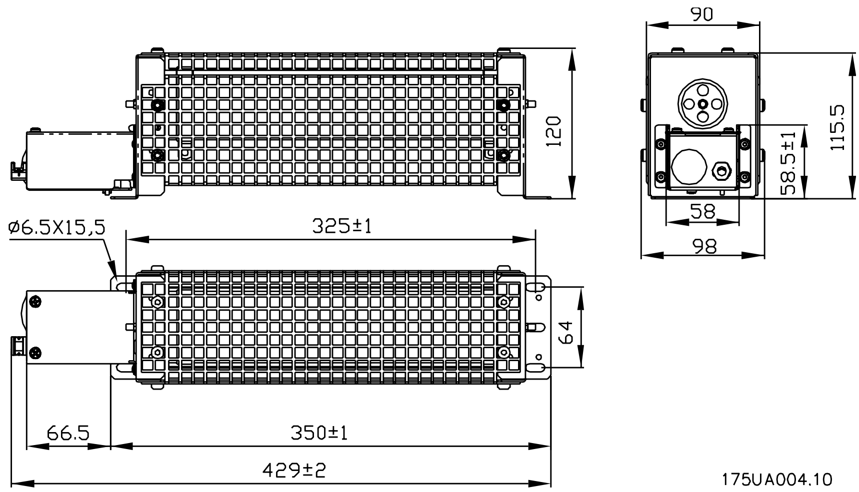
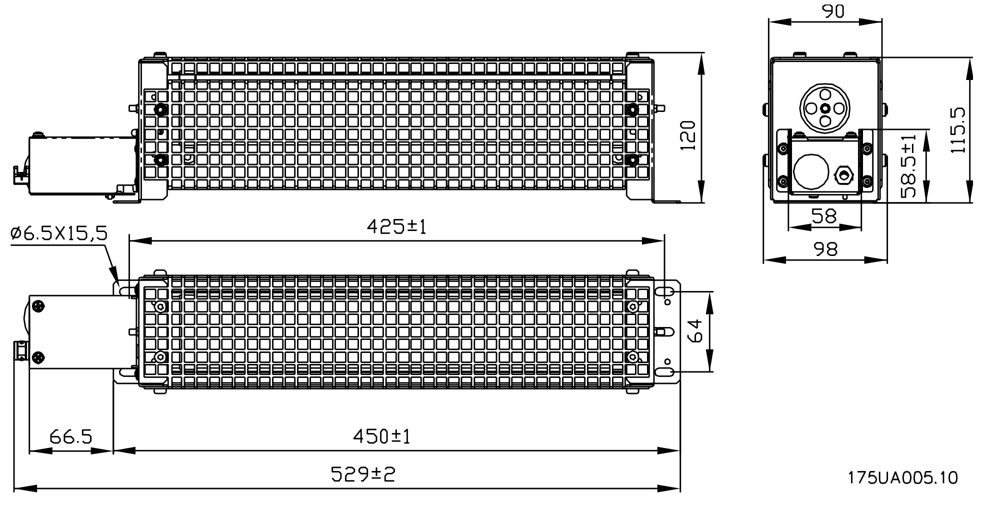
12.1.3 Drawing 3



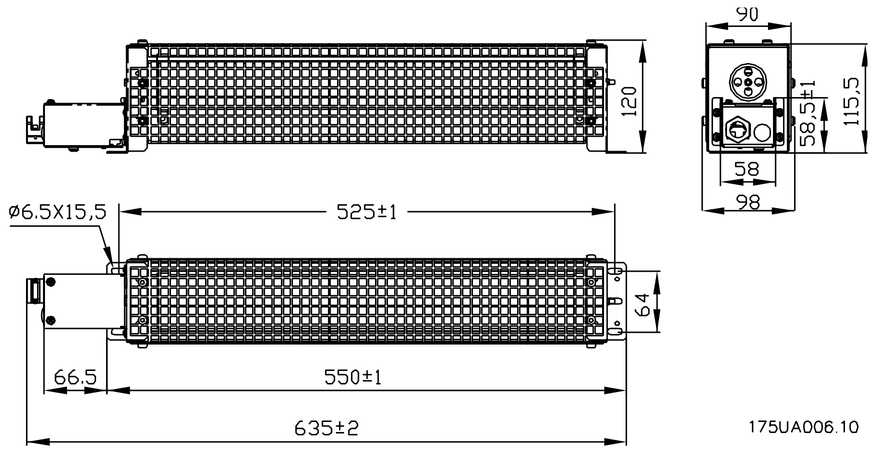
12.1.4 Drawing 4



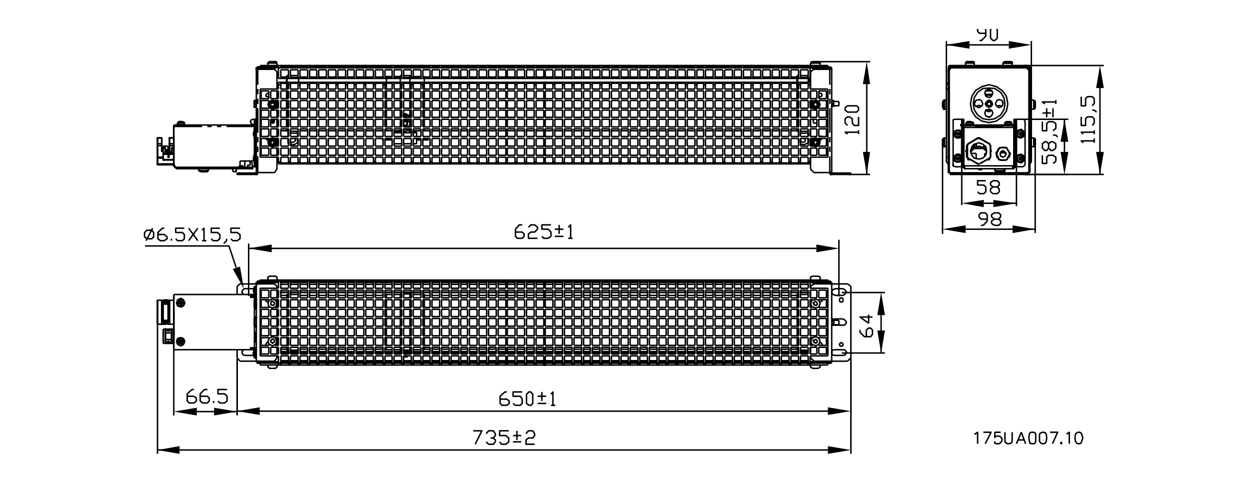
12.1.5 Drawing 5



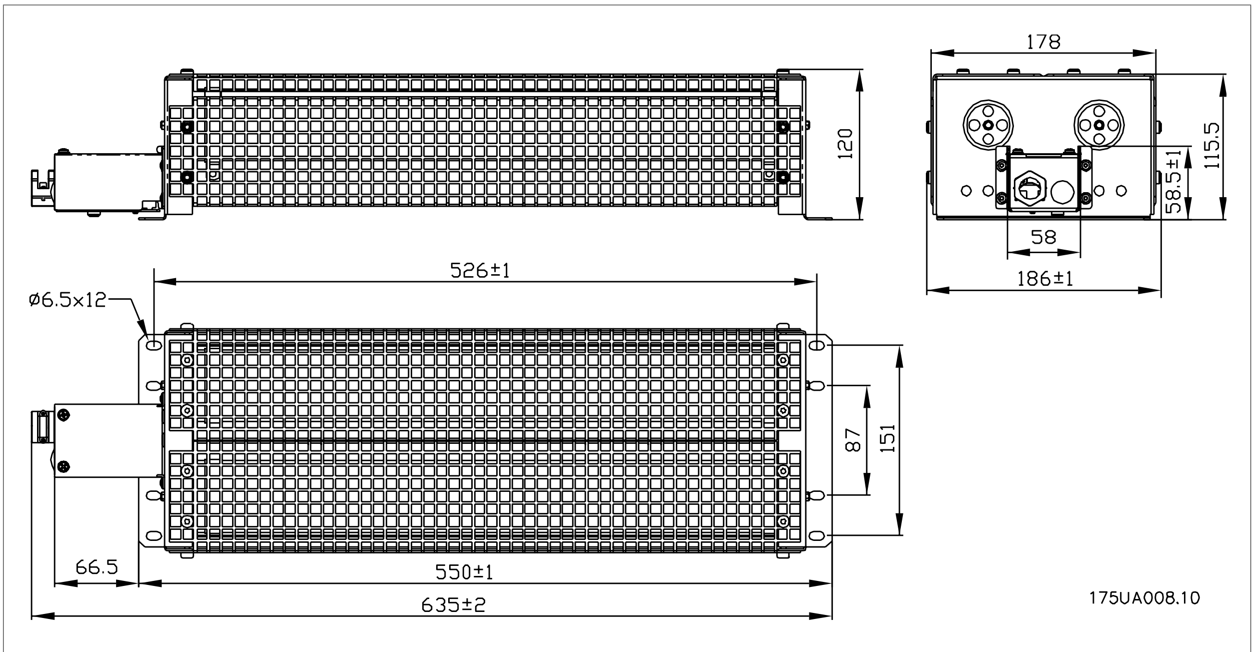
12.1.6 Drawing 6



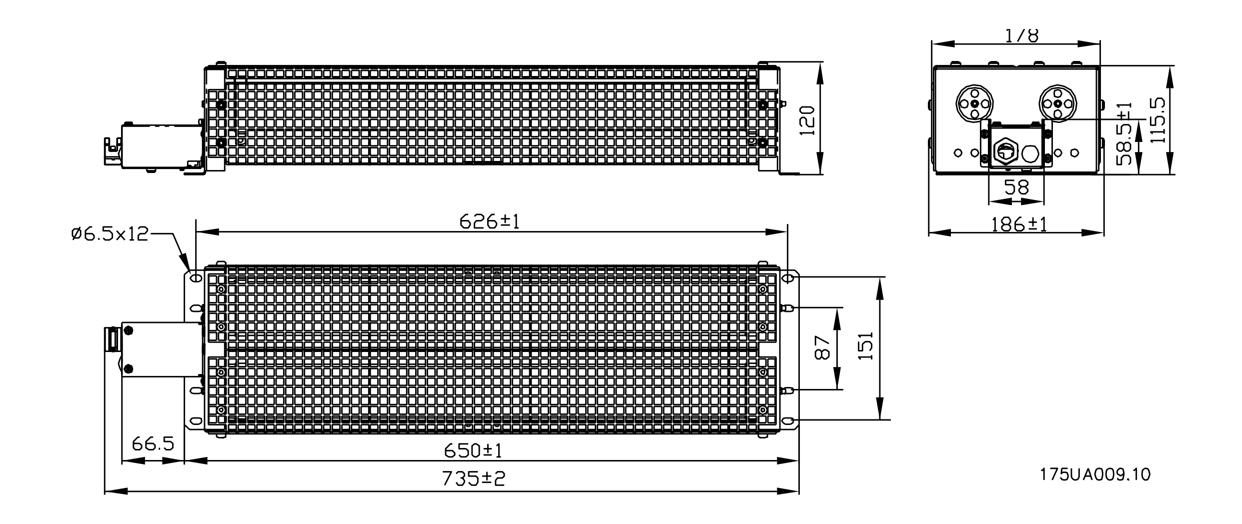
12.1.7 Drawing 7



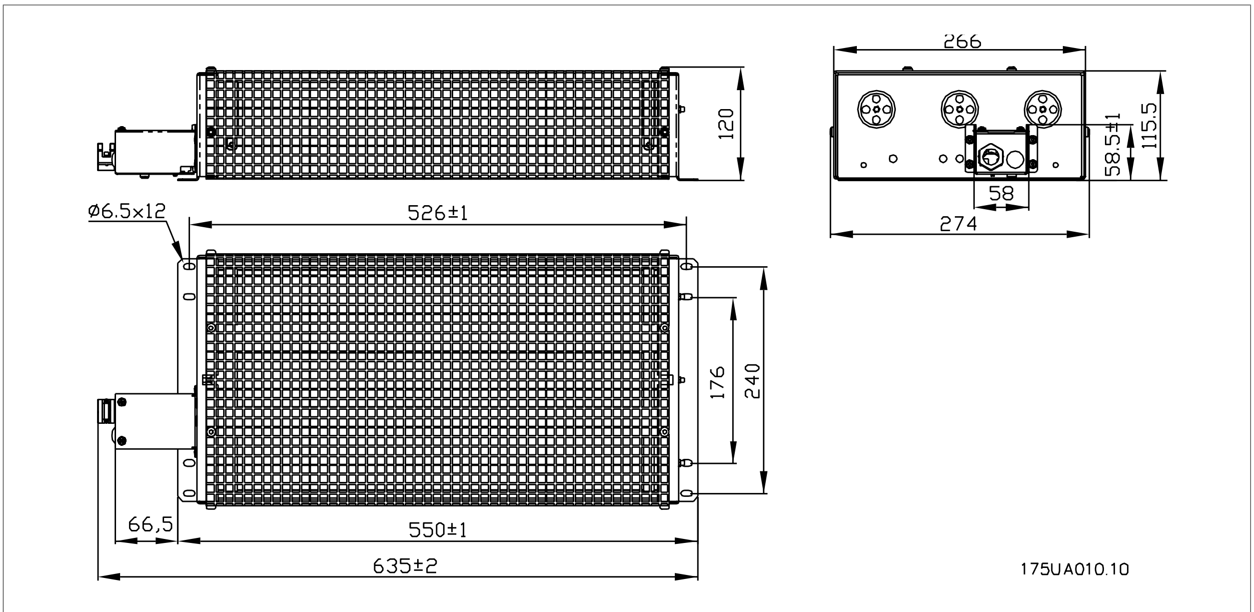
12.1.8 Drawing 8



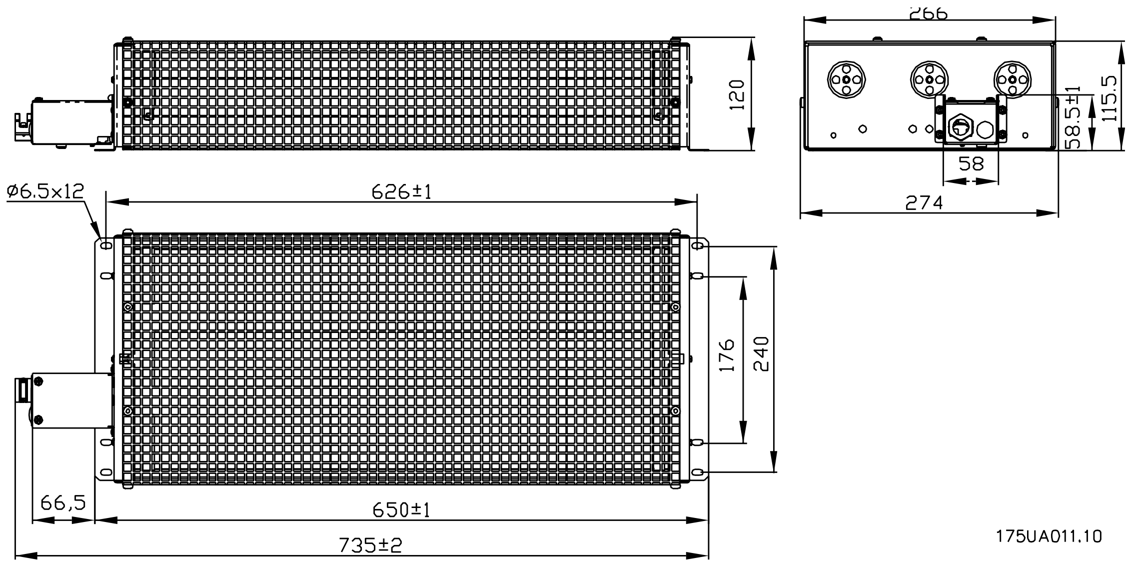
12.1.9 Drawing 9



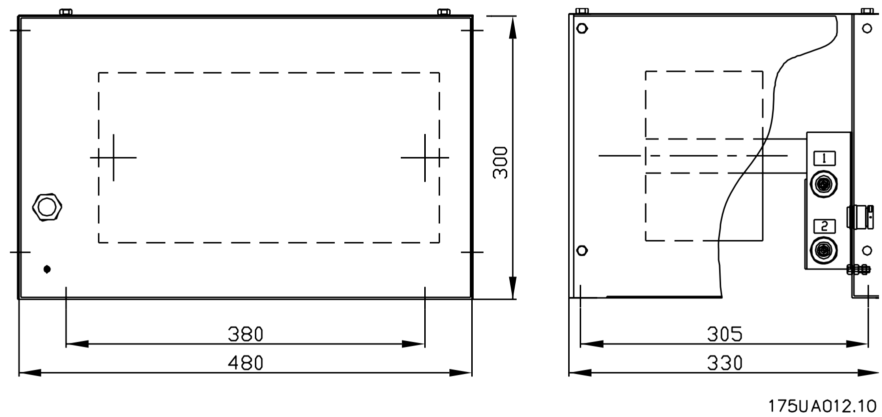
12.1.10 Drawing 10



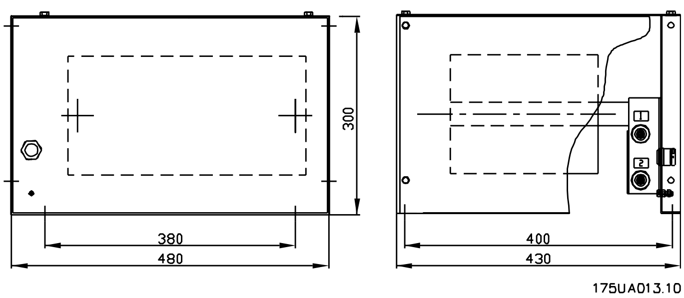
12.1.11 Drawing 11



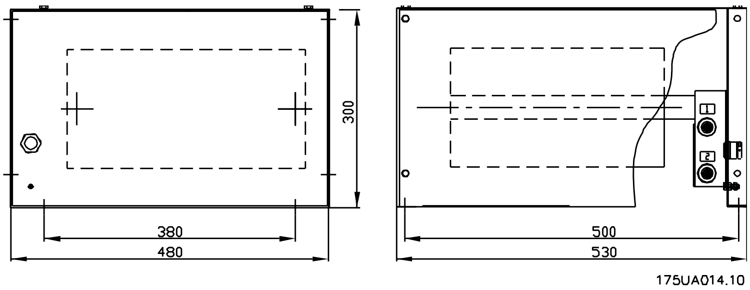
12.1.12 Drawing 12



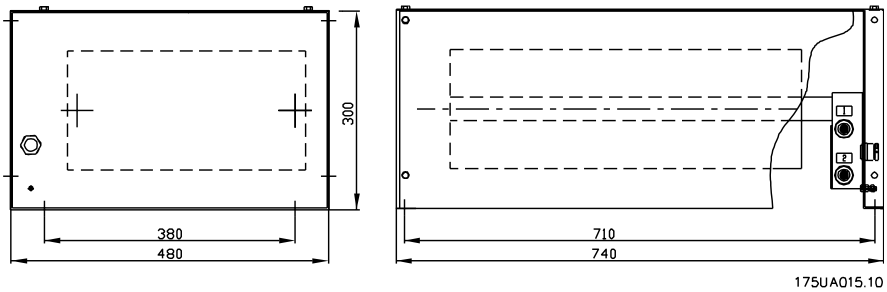
12.1.13 Drawing 13



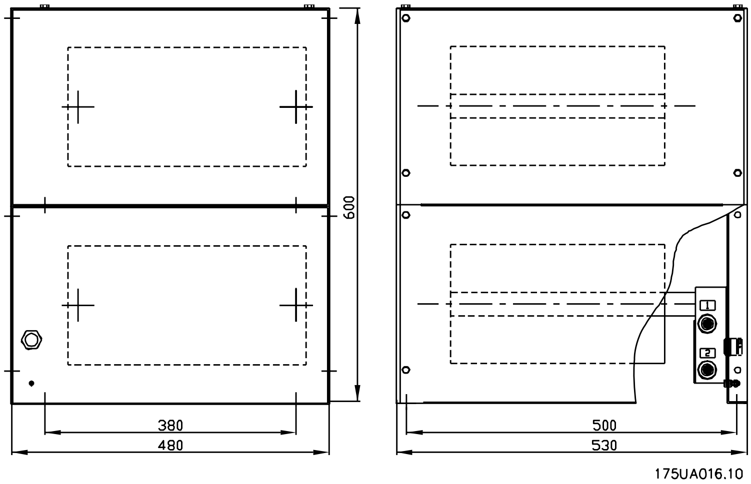
12.1.14 Drawing 14



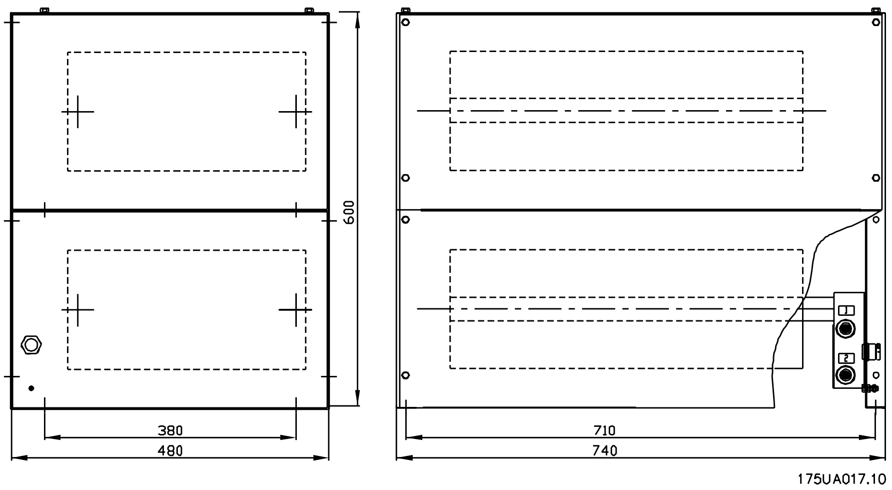
12.1.15 Drawing 15



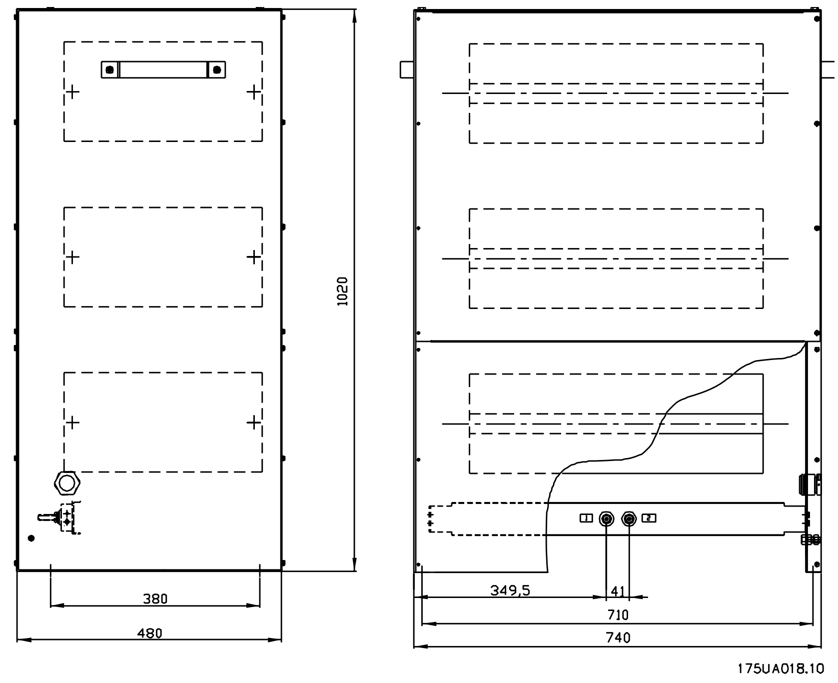
12.1.16 Drawing 16



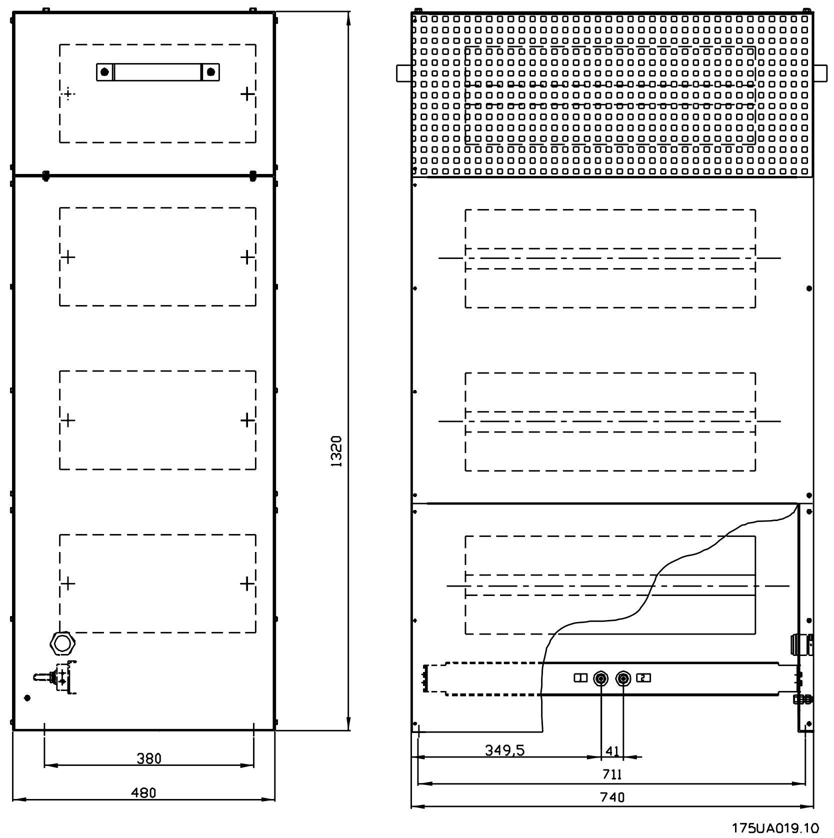
12.1.17 Drawing 17



12.1.18 Drawing 18



12.1.19 Drawing 19



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