PRODRIVE TECHNOLOGIES MOTION & MECHATRONICS

LINEAR MOTOR CATALOGUE

PHOENIX

Ironless motors

January 2022

Linear motors
integrated in a custom mechatronic system

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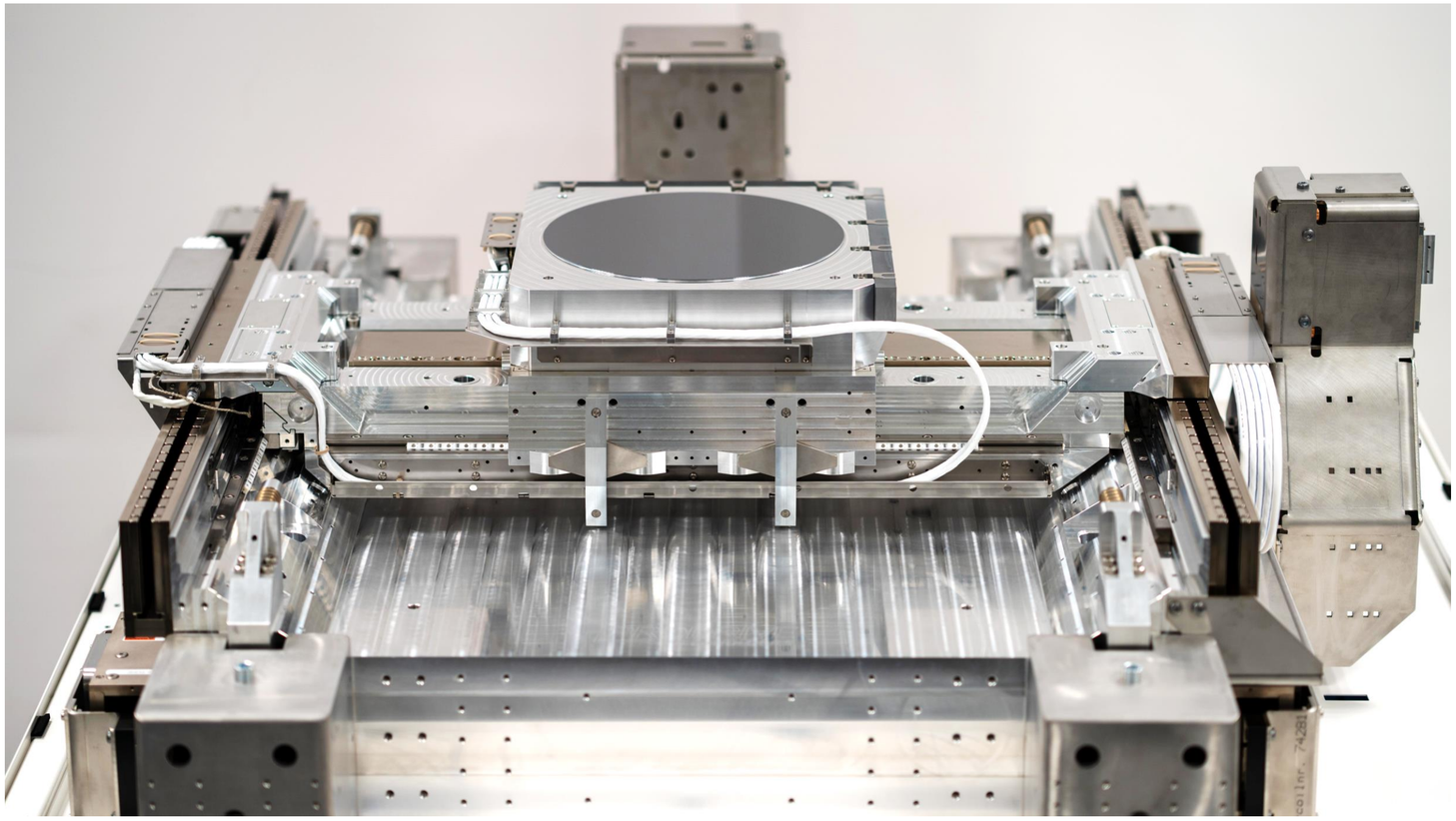


Linear motors integrated in a motion stage

A PASSION FOR TECHNOLOGY

Knowledge

Engineering excellence is the driving force behind linear motor innovation in both design and manufacturing. Prodrive has a highly skilled group of (electro-)mechanical engineers capable of customizing linear motor technology towards your needs.

Quality

Quality is in the DNA of Prodrive Technologies. With a long history in electronics manufacturing, Prodrive continues in the area of linear motor manufacturing with the same philosophy and processes, setting a new standard within the linear motor market.

Automation

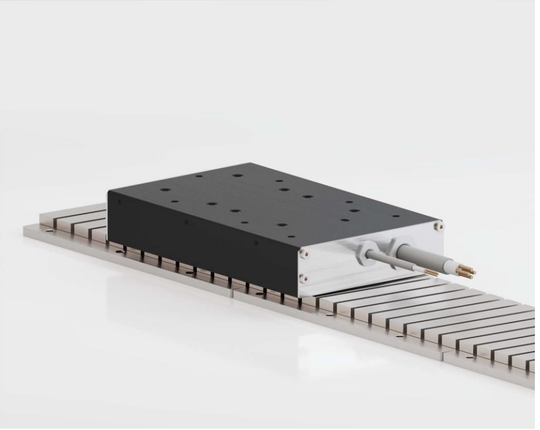
Design for manufacturing is key to reduce cost and guarantee quality. Winding, assembly, vacuum potting and magnet gluing are highly automated processes which guarantees a constant quality at minimum cost.

Time to market

Due to the agility of Prodrive Technologies' large development department, customization can be performed in a very short time, providing a short time to market for challenging mechatronic applications.

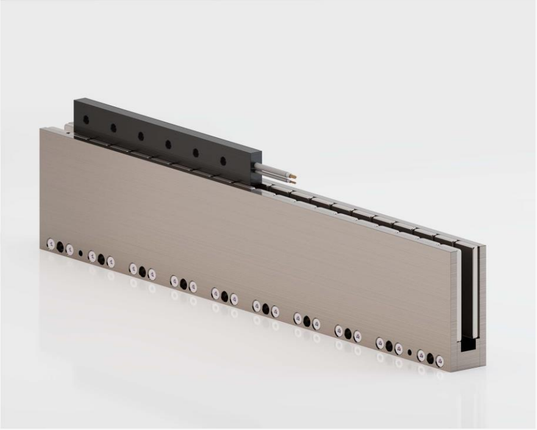
Prodrive Technologies HQ Campus, The Netherlands

OVERVIEW



Chiron

The Chiron line offers iron core linear motors which are optimized for high force and high efficiency. Find the optimal fit for your application due to the many different available form factors.

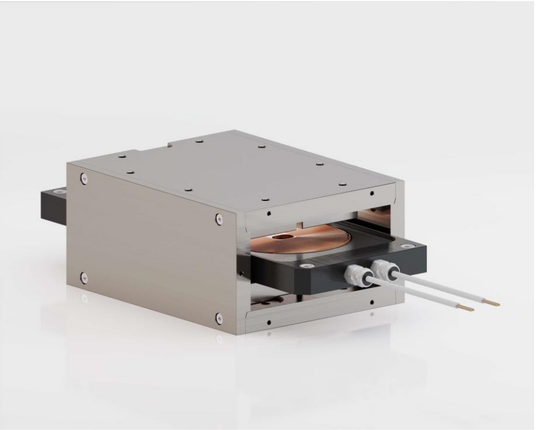


Phoenix

The Phoenix line offers ironless linear motors, for applications requiring an extremely low force ripple for excellent servo performance without attraction forces. Available in a large range of sizes.

Gryphon

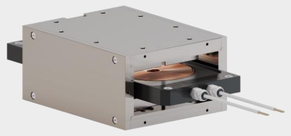
The Gryphon line offers a cost-effective solution for vacuum-compatible ironless linear motors. These motors also contain features providing magnetic shielding.



Iris

For short stroke applications requiring a relatively large displacement in three directions, the Iris line provides a high force density with zero attraction forces in a rectangular form factor.

OVERVIEW



Chiron-S-050
03
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Chiron-S-080
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Chiron-S-100
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Chiron-S-130
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Phoenix-S
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Phoenix-M
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Phoenix-L
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Phoenix-X
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Phoenix-U
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Gryphon-M
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Gryphon-L
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Iris-M
Iris-L
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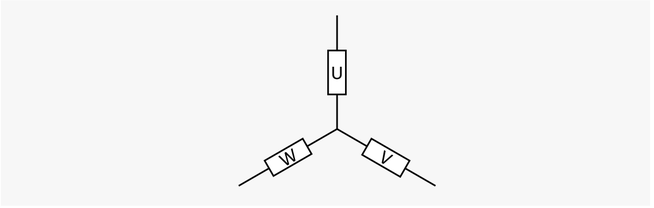
100
1000
10000
Motor constant [N2/W]

WINDING CONFIGURATIONS

The phases of all three-phase linear motors are star-connected.

The Chiron, Phoenix and Gryphon line can be selected with different winding configurations to create an optimal fit for your application.



Phase connection chart

Winding configuration A

The windings are configured such that independent of the number of coils, the force constant remains equal, and the maximum velocity remains unchanged. The maximum current increases with the number of coils.

Winding configuration B

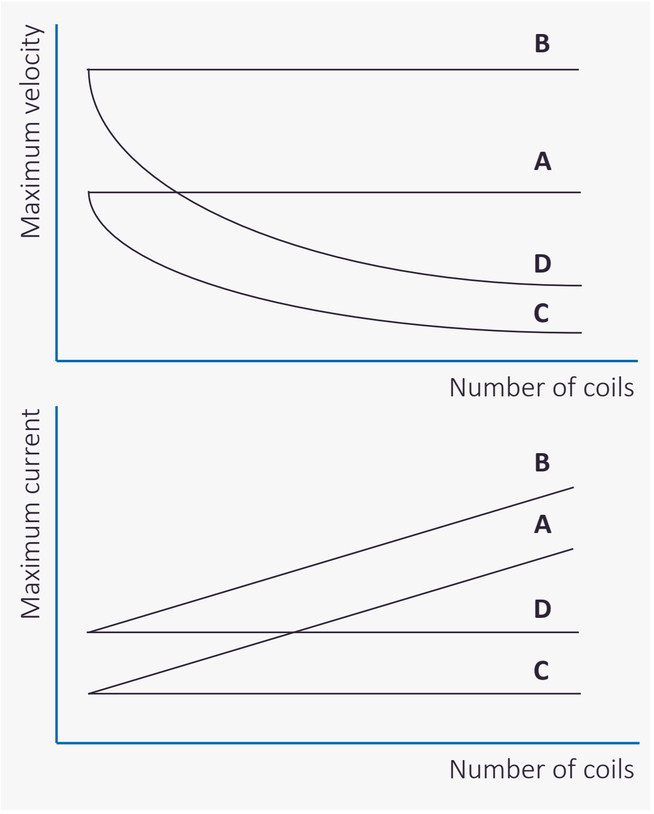
The windings are configured like winding configuration A, but this winding configuration can reach higher velocities at the expense of a lower force constant.

Winding configuration C

The windings are configured such that the current remains constant with increasing number of coils at the expense of reducing the maximum velocity. For the Chiron, Phoenix and Gryphon line, this configuration allows moving magnet applications with partial coil unit overlap.

Winding configuration D

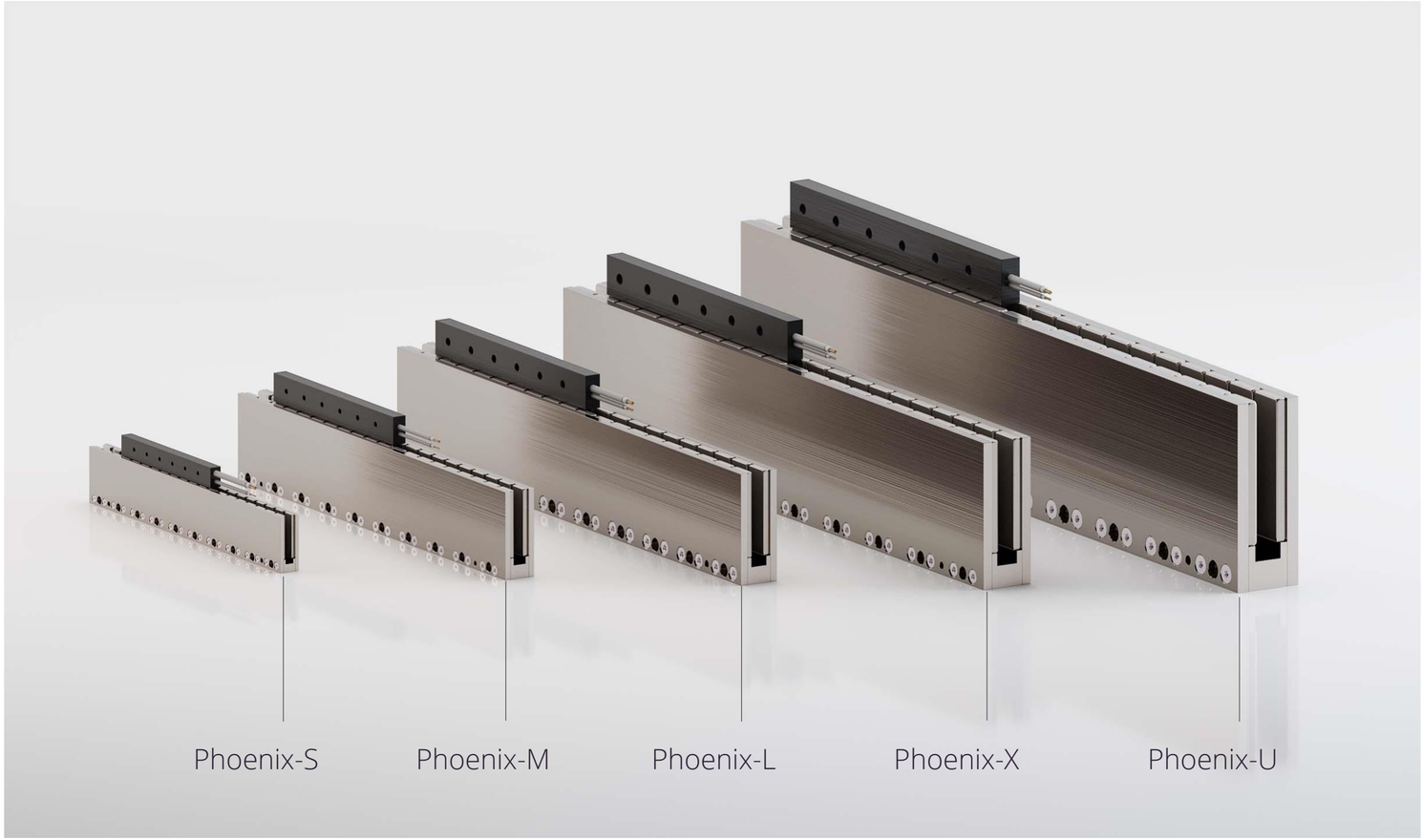
The windings are configured such that the current remains constant with increasing number of coils at the expense of reducing the maximum velocity. This configuration has a higher maximum velocity compared to winding configuration C. For the Phoenix line, this configuration allows moving magnet applications with partial coil unit overlap.



Winding configurations chart

PHOENIX LINE

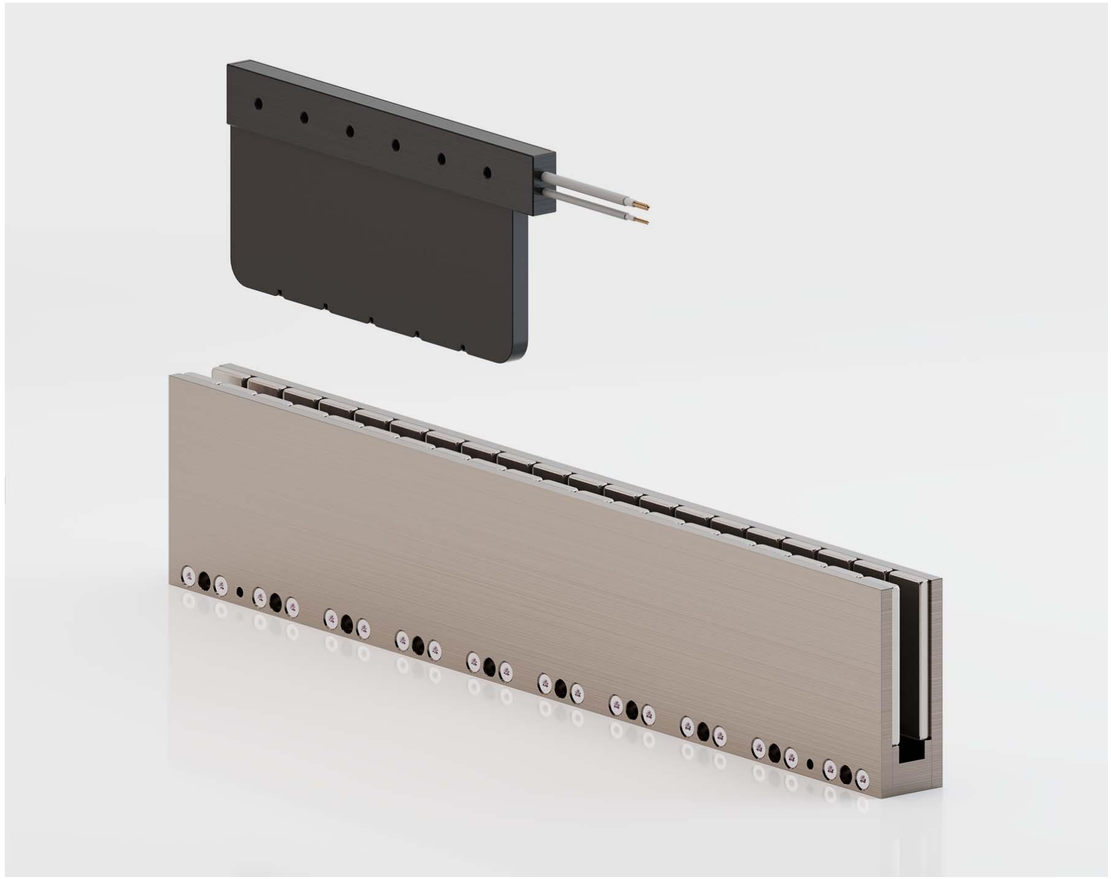
The Phoenix line offers ironless linear motors, for applications requiring an extremely low force ripple for excellent servo performance without attraction forces. Available in a large range.



Phoenix line linear motors in different sizes

* Performance and mechanical specifications of Phoenix T are available on request

PHOENIX LINE - FEATURES



Phoenix in exploded view

Phoenix-CU-M-12-A-N

- Thermal interface (N = none / B = PTC+PT1000)
- Winding configuration (A / B / C / D)
- # of coils
- Size (T* / S / M / L / X / U)
- Coil unit

Phoenix-MY-M-20

- # of poles
- Size (T / S / M / L / X / U)
- Magnet yoke

- Multiple sizes for optimal mechanical integration
- Multiple winding configurations for optimal current/velocity matching
- Coil units have an optional temperature protection (PTC) and sensor (PT1000)
- Magnet yokes can be butted together
- Extremely low force ripple due to ironless coil unit
- No attraction force

* Performance and mechanical specifications of Phoenix T are available on request

PHOENIX-S PERFORMANCE SPECIFICATIONS

	Parameter	Symbol	Unit	T_{coil} (°C)	CU-S-03		CU-S-06				CU-S-09				CU-S-12			
	Winding configuration	-	-	-	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	60		120				175				235			
	Continuous force, interface at 20°C	F_c	N	100	20		45				65				85			
	Attraction force (I = 0)	F_{att}	N	-	0		0				0				0			
	Motor constant	S	N^2/W	20	20		35				55				70			
	Force constant	K_f	N/A_{rms}	-	33	16	33	16	65	33	33	16	98	49	33	16	131	65
	Maximum velocity (F = 0)	v_m	m/s	-	15	30	15	30	7.5	15	15	30	5.0	10	15	30	3.8	7.5
	Maximum velocity (F = F_p)	v_l	m/s	20	12	27	12	27	4.2	12	12	27	1.7	6.7	12	27	0.5	4.2
Electrical	Maximum dc bus voltage	V_{dc}	V	-	400		400				400				400			
	Phase resistance	$R_{ph,20}$	Ohm	20	20	5.0	10	2.5	39	10	6.5	1.7	59	15	4.9	1.2	78	20
	Phase inductance	L_{ph}	mH	20	4.3	1.1	2.1	0.5	8.5	2.1	1.4	0.4	13	3.2	1.1	0.3	17	4.2
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	27	13	27	13	53	27	27	13	80	40	27	13	107	53
	Maximum rms current	I_p	A_{rms}	20	1.8	3.6	3.6	7.2	1.8	3.6	5.5	11	1.8	3.6	7.3	14	1.8	3.6
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	0.7	1.3	1.3	2.7	0.7	1.3	2.0	4.0	0.7	1.3	2.7	5.3	0.7	1.3
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	35		69				104				138			
	Thermal resistance	R_{th}	K/W	-	2.3		1.2				0.77				0.58			
	Coil unit heat capacity	C_{th}	J/K	-	10		19				29				39			
	Thermal time constant, interface at 20°C	τ_{th}	s	-	23		23				23				23			

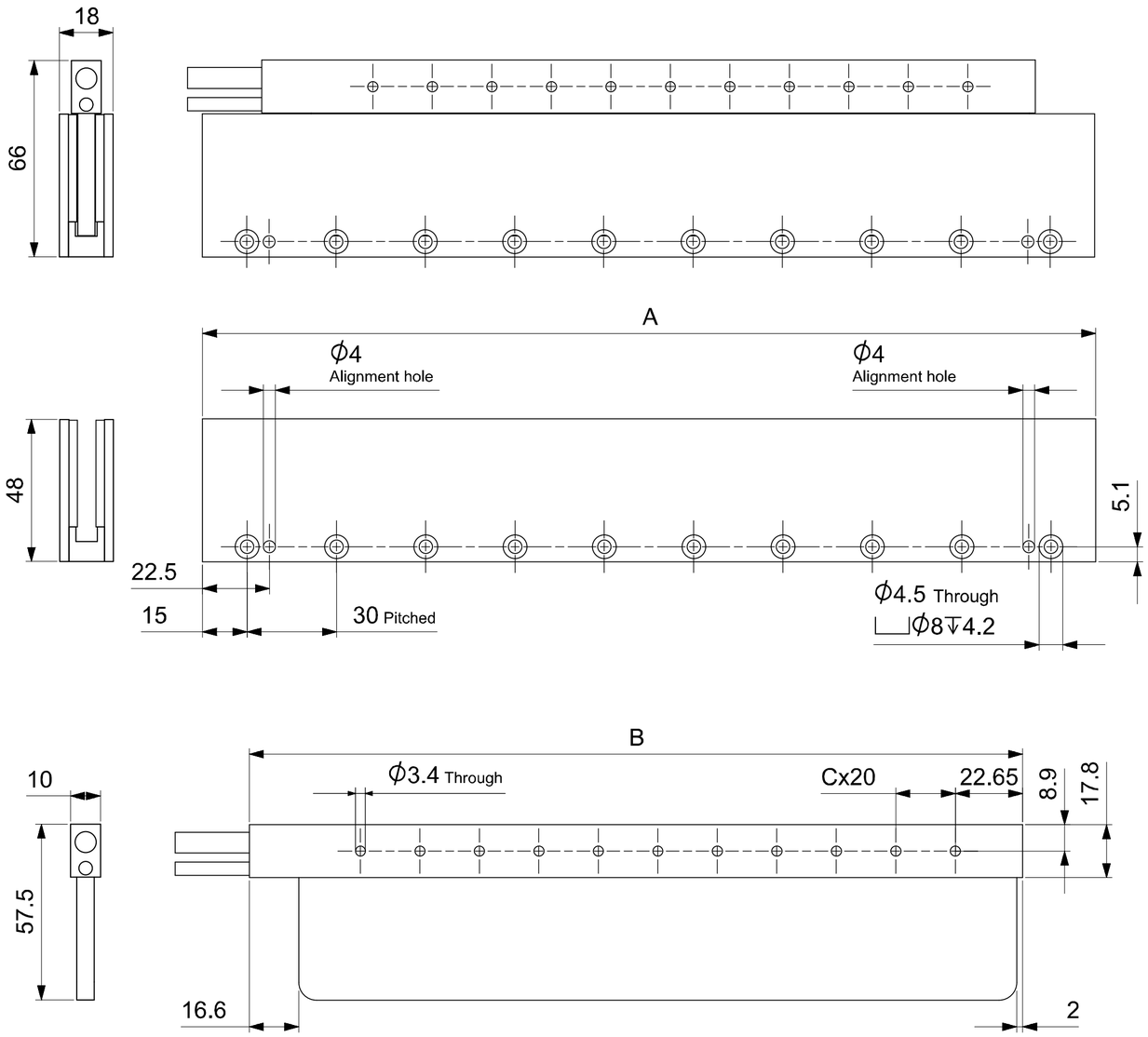
Notes

- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Thermal resistance is defined from average coil temperature to the mounting interface

Product marking / approvals

CE

PHOENIX-S MECHANICAL SPECIFICATIONS



Magnet Yokes

	Parameter	Symbol	Unit	MY-S-08	MY-S-10	MY-S-12	MY-S-20	MY-S-28
Magnet Yokes	Number of poles	N_p	-	8	10	12	20	28
	Pole pitch (N-N)	$2\tau_p$	mm	30	30	30	30	30
	Width	A	mm	120	150	180	300	420
	Mass	M_{my}	kg	0.4	0.5	0.6	1.0	1.4

Coil Units

	Parameter	Symbol	Unit	CU-S-03	CU-S-06	CU-S-09	CU-S-12
Coil Units	Number of coils	N_{coil}	-	3	6	9	12
	Coil pitch	τ_{coil}	mm	20	20	20	20
	Width	B	mm	80	140	200	260
	Number of hole pitches	C	-	1	4	7	10
	Mass	M_{cu}	kg	0.10	0.19	0.27	0.36
	Standard cable length	L_{cable}	m	1	1	1	1

PHOENIX-M PERFORMANCE SPECIFICATIONS

	Parameter	Symbol	Unit	T_{coil} (°C)	CU-M-03		CU-M-06				CU-M-09				CU-M-12				CU-M-15			
	Winding configuration	-	-	-	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	300		600				850		750	850	1150		750	1150	1450		750	1450
	Continuous force, interface at 20°C	F_c	N	100	60		130				190				250				310			
	Attraction force (I = 0)	F_{att}	N	-	0		0				0				0				0			
	Motor constant	S	N^2/W	20	100		190				290				390				490			
	Force constant	K_f	N/A_{rms}	-	61	31	61	31	122	61	61	31	183	92	61	31	244	123	61	31	305	153
	Maximum velocity (F = 0)	v_m	m/s	-	8.0	16	8.0	16	4.0	8.0	8.0	16	2.7	5.3	8.0	16	2.0	4.0	8.0	16	1.6	3.2
	Maximum velocity (F = F_p)	v_l	m/s	20	4.9	13	4.9	13	1.0	4.9	4.9	13	0.0	2.4	4.9	13	0.0	1.0	4.9	13	0.0	0.3
Electrical	Maximum dc bus voltage	V_{dc}	V	-	400		400				400				400				400			
	Phase resistance	$R_{ph,20}$	Ohm	20	13	3.2	6.4	1.6	26	6.3	4.3	1.1	39	10	3.2	0.8	52	13	2.6	0.6	64	16
	Phase inductance	L_{ph}	mH	20	7.7	2.0	3.9	1.0	15	3.9	2.6	0.7	23	5.9	1.9	0.5	31	7.8	1.5	0.4	39	10
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	50	25	50	25	100	50	50	25	149	75	50	25	199	100	50	25	249	125
	Maximum rms current	I_p	A_{rms}	20	4.7	9.5	9.4	19	4.7	9.5	14	28	4.2	9.5	19	38	3.2	9.5	23	47	2.5	9.5
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.0	2.1	2.0	4.1	1.0	2.1	3.1	6.2	1.0	2.1	4.1	8.3	1.0	2.1	5.1	10	1.0	2.1
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	53		106				160				213				266			
	Thermal resistance	R_{th}	K/W	-	1.5		0.75				0.50				0.38				0.30			
	Coil unit heat capacity	C_{th}	J/K	-	45		85				130				170				215			
	Thermal time constant, interface at 20°C	τ_{th}	s	-	64		64				64				64				64			

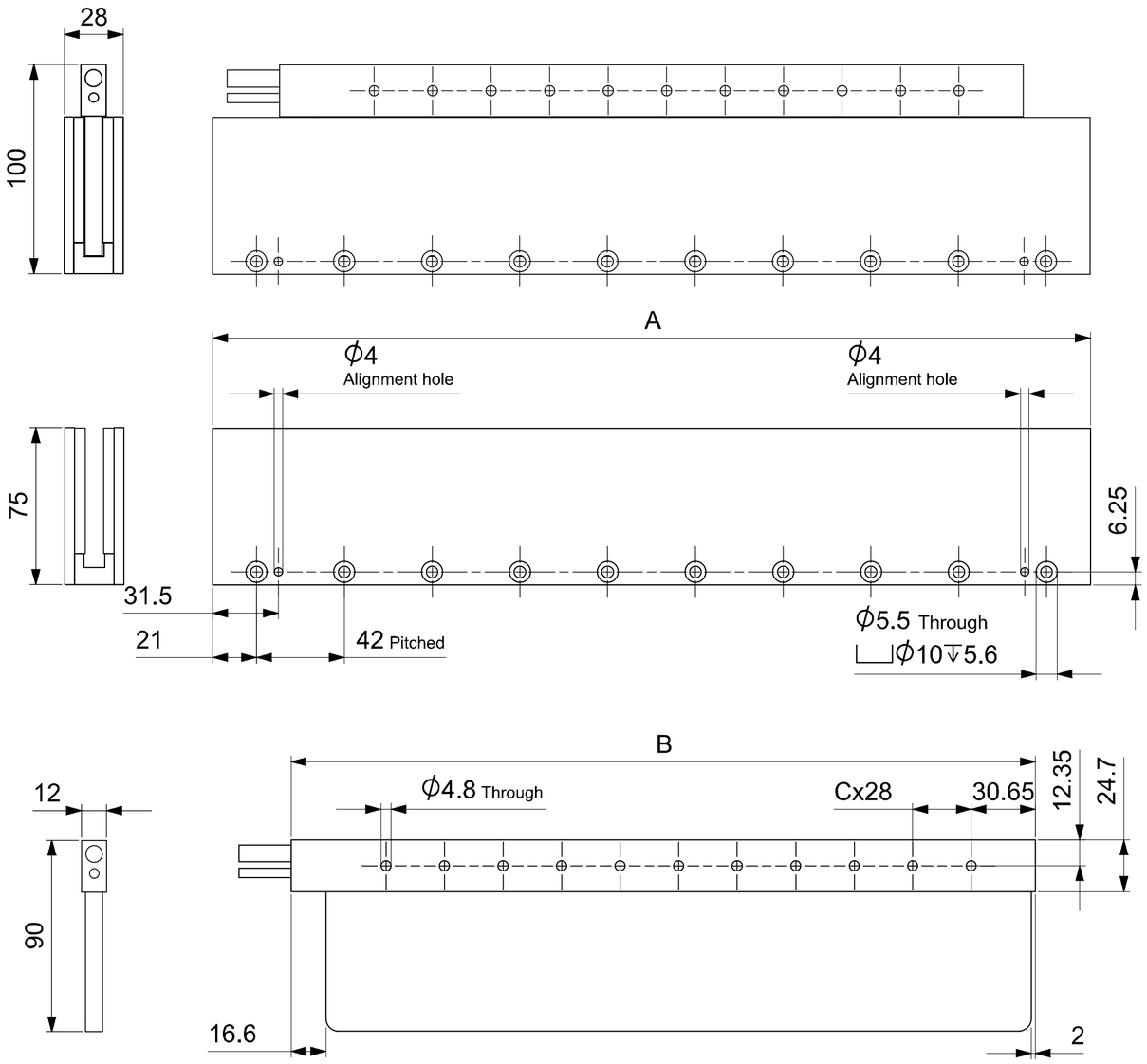
Notes

- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Thermal resistance is defined from average coil temperature to the mounting interface

Product marking / approvals

CE

PHOENIX-M MECHANICAL SPECIFICATIONS



Magnet Yokes

	Parameter	Symbol	Unit	MY-M-08	MY-M-10	MY-M-12	MY-M-20	MY-M-48
Magnet Yokes	Number of poles	N_p	-	8	10	12	20	48
	Pole pitch (N-N)	$2\tau_p$	mm	42	42	42	42	42
	Width	A	mm	168	210	252	420	1008
	Mass	M_{my}	kg	1.5	1.9	2.3	3.8	9.2

Coil Units

	Parameter	Symbol	Unit	CU-M-03	CU-M-06	CU-M-09	CU-M-12	CU-M-15
Coil Units	Number of coils	N_{coil}	-	3	6	9	12	15
	Coil pitch	τ_{coil}	mm	28	28	28	28	28
	Width	B	mm	104	188	272	356	440
	Number of hole pitches	C	-	1	4	7	10	13
	Mass	M_{cu}	kg	0.33	0.64	0.95	1.3	1.6
	Standard cable length	L_{cable}	m	1	1	1	1	1

PHOENIX-L PERFORMANCE SPECIFICATIONS

	Parameter	Symbol	Unit	T_{coil} (°C)	CU-L-03		CU-L-06				CU-L-09				CU-L-12				CU-L-15				CU-L-18			
	Winding configuration	-	-	-	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	600		1250				1850		1800	1850	2450		1800	2450	3100		1800	3100	3700		1800	3700
	Continuous force, interface at 20°C	F_c	N	100	110		220				330				440				550				660			
	Attraction force (I = 0)	F_{att}	N	-	0		0				0				0				0				0			
	Motor constant	S	N^2/W	20	220		440				660				880				1100				1320			
	Force constant	K_f	N/A_{rms}	-	103	46	103	46	206	92.7	103	46	309	139	103	46	411	185	103	46	514	232	103	46	617	278
	Maximum velocity (F = 0)	v_m	m/s	-	8.2	18	8.2	18	4.1	9.1	8.2	18	2.7	6.1	8.2	18	2.1	4.6	8.2	18	1.6	3.6	8.2	18	1.4	3.0
	Maximum velocity (F = F_p)	v_i	m/s	20	5.2	14.7	5.2	15	1.3	6.1	5.2	15	0.0	3.2	5.2	15	0.0	1.7	5.2	15	0.0	0.8	5.2	15	0.0	0.2
Electrical	Maximum dc bus voltage	V_{dc}	V	-	690		690				690				690				690				690			
	Phase resistance	$R_{ph,20}$	Ohm	20	16	3.3	8.1	1.6	32	6.5	5.4	1.1	48	10	4.0	0.8	64	13	3.2	0.7	81	16	2.7	0.5	97	20
	Phase inductance	L_{ph}	mH	20	17	3.4	8.3	1.7	33	7	5.6	1.1	50	10	4.2	0.8	67	14	3.3	0.7	83	17	2.8	0.6	100	20
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	84	38	84	38	168	76	84	38	252	113	84	38	336	151	84	38	420	189	84	38	504	227
	Maximum rms current	I_p	A_{rms}	20	6.0	13	12	27	6.0	13	18	40	5.8	13	24	53	4.4	13	30	66	3.5	13	36	80	2.9	13
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.1	2.4	2.1	4.8	1.1	2.4	3.2	7.1	1.1	2.4	4.3	9.5	1.1	2.4	5.3	12	1.1	2.4	6.4	14	1.1	2.4
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	73		145				218				290				363				435			
	Thermal resistance	R_{th}	K/W	-	1.10		0.55				0.37				0.28				0.22				0.18			
	Coil unit heat capacity	C_{th}	J/K	-	90		170				260				350				430				520			
	Thermal time constant, interface at 20°C	τ_{th}	s	-	95		95				95				95				95				95			

Notes

- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Thermal resistance is defined from average coil temperature to the mounting interface

Product marking / approvals

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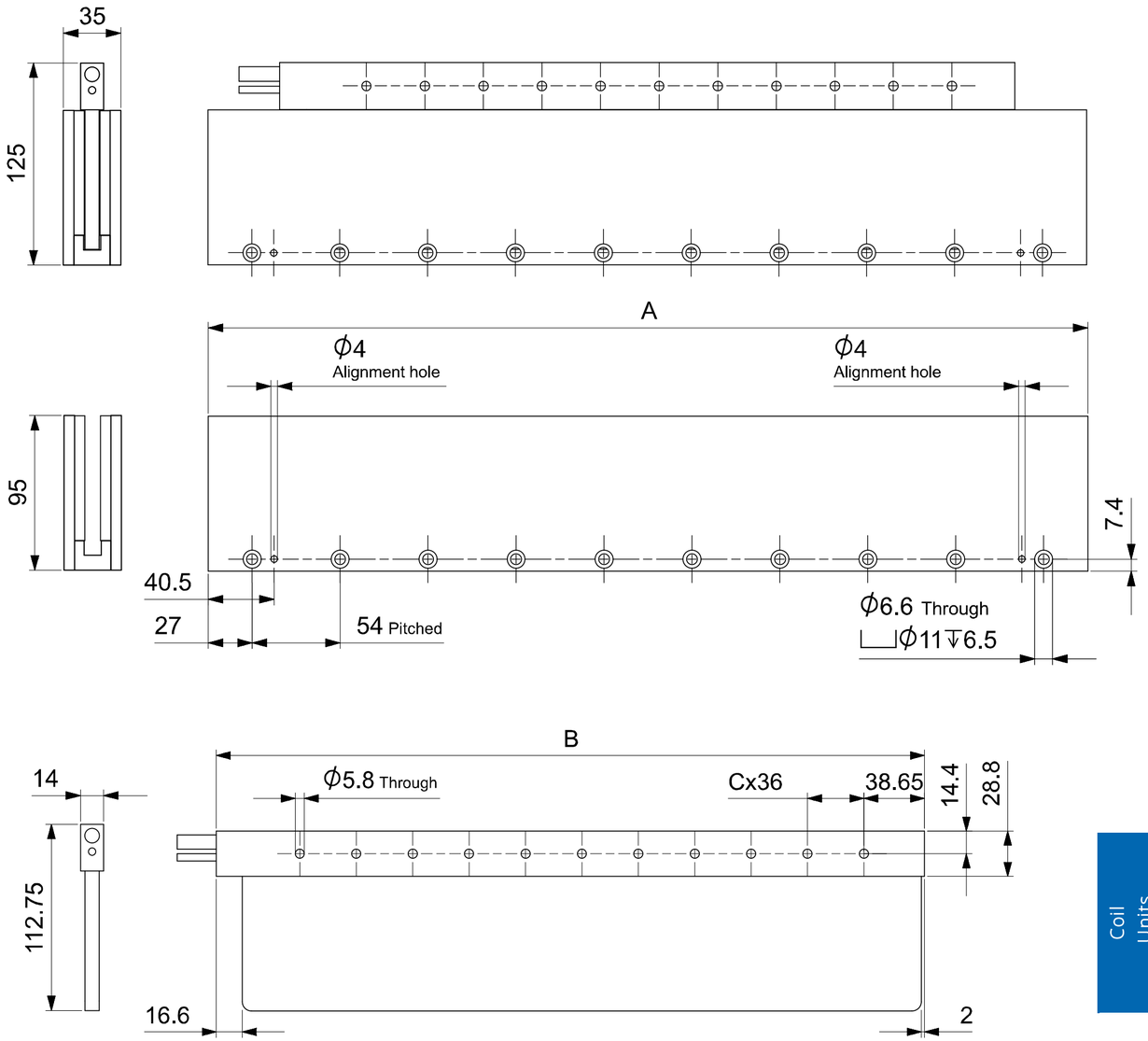
PHOENIX-L MECHANICAL SPECIFICATIONS



Magnet Yokes

	Parameter	Symbol	Unit	MY-L-08	MY-L-10	MY-L-12	MY-L-20	MY-L-36
Magnet Yokes	Number of poles	N_p	-	8	10	12	20	36
	Pole pitch (N-N)	$2\tau_p$	mm	54	54	54	54	54
	Width	A	mm	216	270	324	540	972
	Mass	M_{my}	kg	3.2	4.0	4.8	8.0	14.4

Coil Units

	Parameter	Symbol	Unit	CU-L-03	CU-L-06	CU-L-09	CU-L-12	CU-L-15	CU-L-18
Coil Units	Number of coils	N_{coil}	-	3	6	9	12	15	18
	Coil pitch	τ_{coil}	mm	36	36	36	36	36	36
	Width	B	mm	128	236	344	452	560	668
	Number of hole pitches	C	-	1	4	7	10	13	16
	Mass	M_{cu}	kg	0.56	1.2	1.8	2.4	3.1	3.7
	Standard cable length	L_{cable}	m	1	1	1	1	1	1

PHOENIX-X PERFORMANCE SPECIFICATIONS

	Parameter	Symbol	Unit	T_{coil} (°C)	CU-X-03		CU-X-06				CU-X-09				CU-X-12				CU-X-15				CU-X-18			
	Winding configuration	-	-	-	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	1450		2850				4300		3800	4300	5700		3800	5750	7150		3800	7150	8600		3800	7650
Electromechanical	Continuous force, interface at 20°C	F_c	N	100	200		400				600				800				1000				1200			
Electromechanical	Attraction force (I = 0)	F_{att}	N	-	0		0				0				0				0				0			
Electromechanical	Motor constant	S	N^2/W	20	550		1090				1640				2180				2730				3270			
Electromechanical	Force constant	K_f	N/A_{rms}	-	120	60	120	60	241	121	120	60	361	181	120	60	481	242	120	60	601	302	120	60	722	363
Electromechanical	Maximum velocity (F = 0)	v_m	m/s	-	7.0	14	7.0	14	3.5	7.0	7.0	14	2.3	4.7	7.0	14	1.8	3.5	7.0	14	1.4	2.8	7.0	14	1.2	2.3
Electromechanical	Maximum velocity (F = F_p)	v_l	m/s	20	4.2	11	4.2	11	0.9	4.1	4.2	11	0.0	2.0	4.2	11	0.0	0.9	4.2	11	0.0	0.2	4.2	11	0.0	0.0
Electrical	Maximum dc bus voltage	V_{dc}	V	-	690		690				690				690				690				690			
Electrical	Phase resistance	$R_{ph,20}$	Ohm	20	8.9	2.2	4.4	1.1	18	4.4	3.0	0.7	27	6.7	2.2	0.6	36	8.9	1.8	0.4	44	11	1.5	0.4	53	13
Electrical	Phase inductance	L_{ph}	mH	20	15	3.8	7.6	1.9	30	7.6	5.0	1.3	45	11	3.8	1.0	60	15	3.0	0.8	76	19	2.5	0.6	91	23
Electrical	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	98	49	98	49	196	99	98	49	295	148	98	49	393	197	98	49	491	247	98	49	589	296
Electrical	Maximum rms current	I_p	A_{rms}	20	12	24	24	47	12	24	36	71	11	24	47	95	7.9	24	59	119	6.3	24	71	142	5.3	21
Electrical	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.7	3.3	3.3	6.6	1.7	3.3	5.0	10.0	1.7	3.3	6.6	13	1.7	3.3	8.3	17	1.7	3.3	10.0	20	1.7	3.3
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	96		193				289				386				482				578			
Thermal	Thermal resistance	R_{th}	K/W	-	0.83		0.42				0.28				0.21				0.17				0.14			
Thermal	Coil unit heat capacity	C_{th}	J/K	-	190		370				560				750				940				1120			
Thermal	Thermal time constant, interface at 20°C	τ_{th}	s	-	156		156				156				156				156				156			

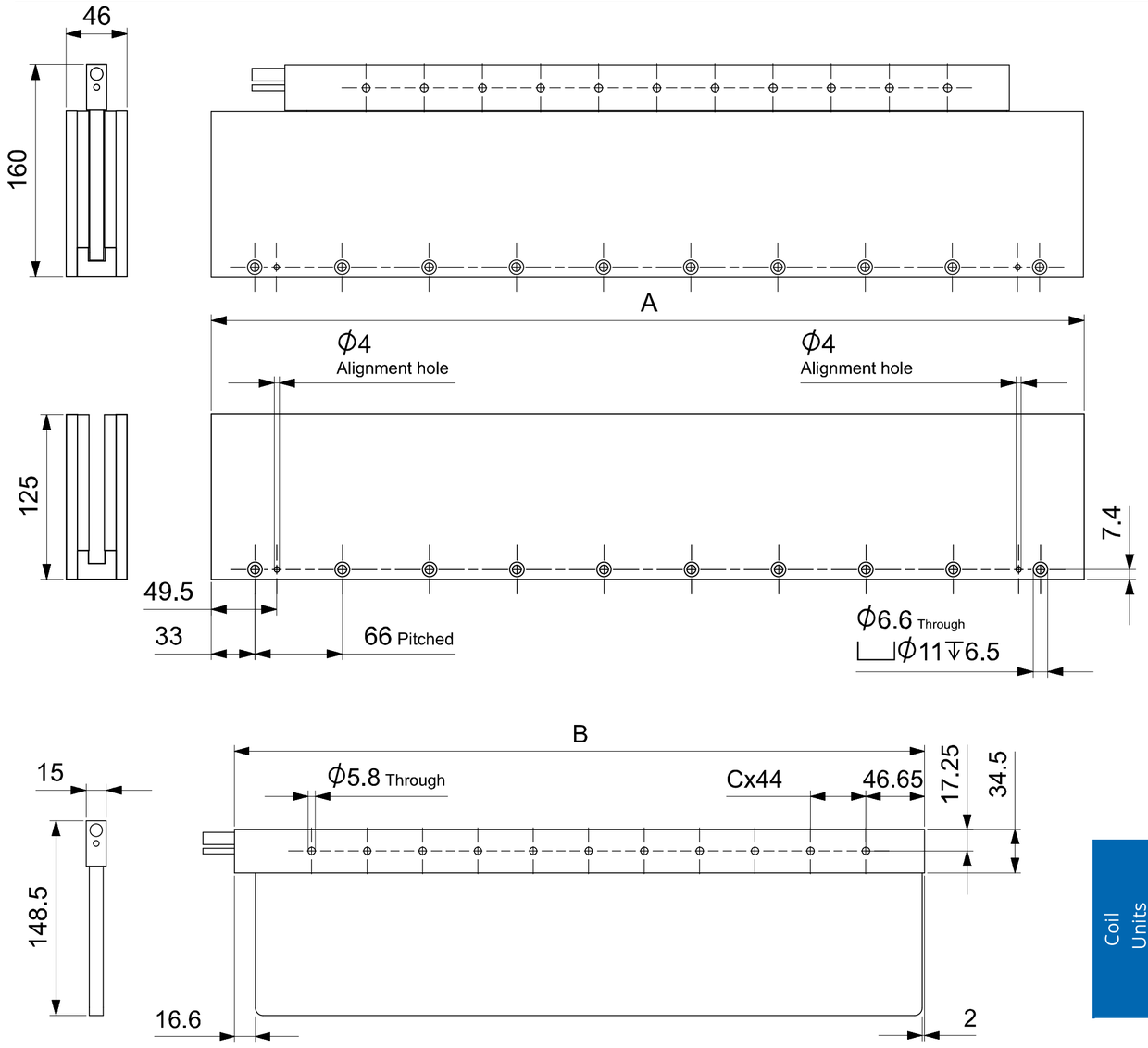
Notes

- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Thermal resistance is defined from average coil temperature to the mounting interface

Product marking / approvals

CE

PHOENIX-X MECHANICAL SPECIFICATIONS



Magnet Yokes

	Parameter	Symbol	Unit	MY-X-08	MY-X-10	MY-X-12	MY-X-20
Magnet Yokes	Number of poles	N_p	-	8	10	12	20
	Pole pitch (N-N)	$2\tau_p$	mm	66	66	66	66
	Width	A	mm	264	330	396	660
	Mass	M_{my}	kg	7.2	9.0	10.8	18.0

Coil Units

	Parameter	Symbol	Unit	CU-X-03	CU-X-06	CU-X-09	CU-X-12	CU-X-15	CU-X-18
Coil Units	Number of coils	N_{coil}	-	3	6	9	12	15	18
	Coil pitch	τ_{coil}	mm	44	44	44	44	44	44
	Width	B	mm	152	284	416	548	680	812
	Number of hole pitches	C	-	1	4	7	10	13	16
	Mass	M_{cu}	kg	1.1	2.2	3.2	4.3	5.4	6.4
	Standard cable length	L_{cable}	m	1	1	1	1	1	1

PHOENIX-U PERFORMANCE SPECIFICATIONS

	Parameter	Symbol	Unit	T_{coil} (°C)	CU-U-03		CU-U-06				CU-U-09				CU-U-12				CU-U-15				CU-U-18			
	Winding configuration	-	-	-	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	3100		6250		5850	6200	9350		5850	9350	12500		5850	11950	15600		5850	11950	18750		5850	11950
	Continuous force, interface at 20°C	F_c	N	100	330		660				990				1320				1650				1980			
	Attraction force (I = 0)	F_{att}	N	-	0		0				0				0				0				0			
	Motor constant	S	N^2/W	20	1150		2350				3500				4650				5800				7000			
	Force constant	K_f	N/A_{rms}	-	169	82	169	82	337	163	169	82	506	245	169	82	674	326	169	82	843	408	169	82	1011	489
	Maximum velocity (F = 0)	v_m	m/s	-	5.0	10	5.0	10	2.5	5.2	5.0	10	1.7	3.5	5.0	10	1.3	2.6	5.0	10	1.0	2.1	5.0	10	0.8	1.7
	Maximum velocity (F = F_p)	v_i	m/s	20	2.1	6.8	2.1	6.8	0.0	2.3	2.1	6.8	0.0	0.7	2.1	6.8	0.0	0.0	2.1	6.8	0.0	0.0	2.1	6.8	0.0	0.0
Electrical	Maximum dc bus voltage	V_{dc}	V	-	690		690				690				690				690				690			
	Phase resistance	$R_{ph,20}$	Ohm	20	8.1	1.9	4.0	1.0	16	3.8	2.7	0.6	24	5.8	2.0	0.5	32	7.7	1.6	0.4	40	10	1.3	0.3	48	12
	Phase inductance	L_{ph}	mH	20	24	5.6	12	2.8	48	11	8.0	1.9	72	17	6.0	1.4	96	22	4.8	1.1	119	28	4.0	0.9	143	34
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	138	67	138	67	275	133	138	67	413	200	138	67	550	266	138	67	688	333	138	67	825	399
	Maximum rms current	I_p	A_{rms}	20	19	38	37	76	17	38	56	114	12	38	74	153	9	37	93	191	7.0	29	112	229	5.8	24
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	2.0	4.0	3.9	8.1	2.0	4.0	5.9	12	2.0	4.0	7.9	16	2.0	4.0	10	20	2.0	4.0	12	24	2.0	4.0
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	123		247				370				494				617				740			
	Thermal resistance	R_{th}	K/W	-	0.65		0.32				0.22				0.16				0.13				0.11			
	Coil unit heat capacity	C_{th}	J/K	-	420		840				1260				1680				2100				2520			
	Thermal time constant, interface at 20°C	τ_{th}	s	-	272		272				272				272				272				272			

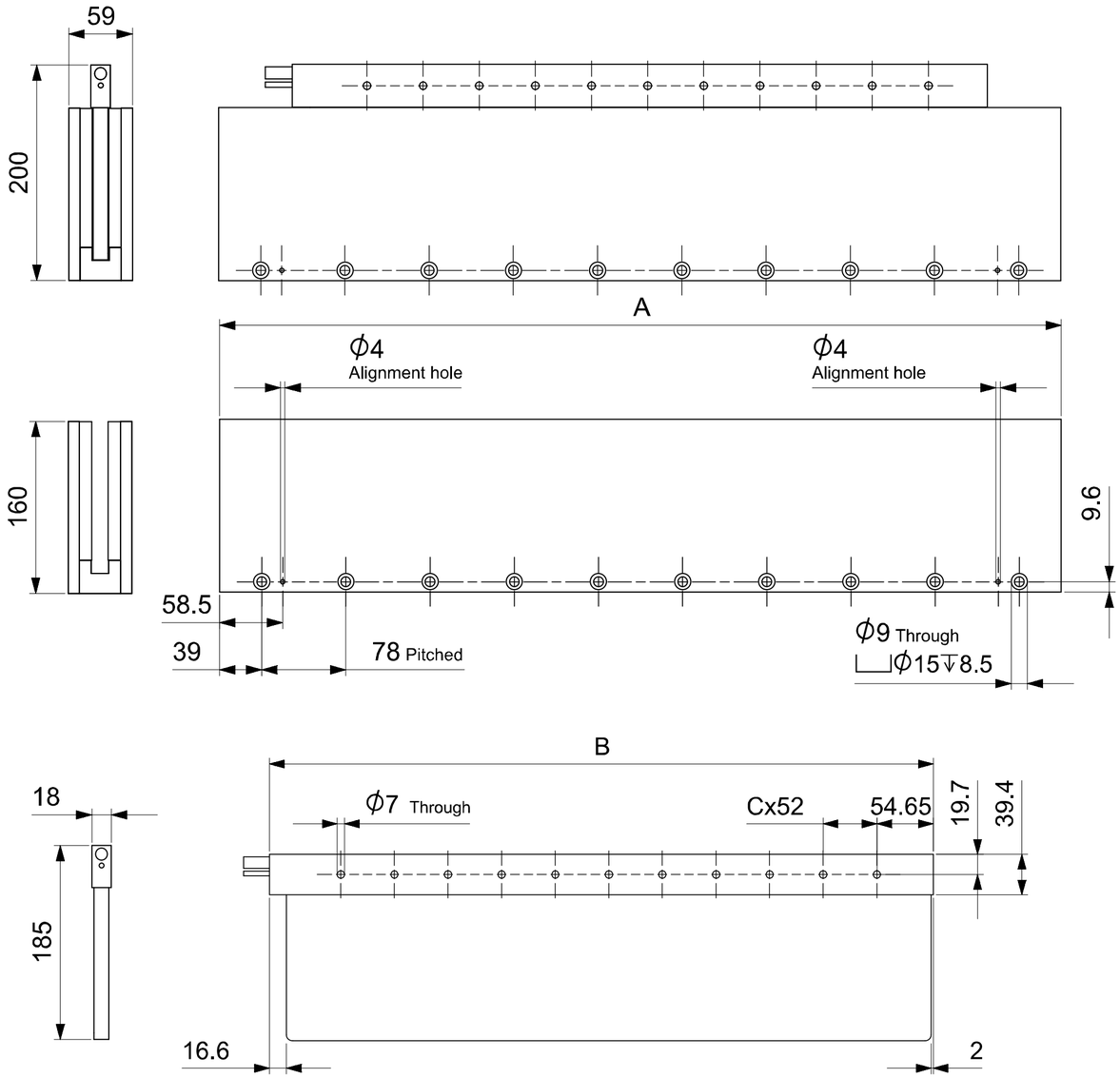
Notes

- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Thermal resistance is defined from average coil temperature to the mounting interface

Product marking / approvals

CE

PHOENIX-U MECHANICAL SPECIFICATIONS



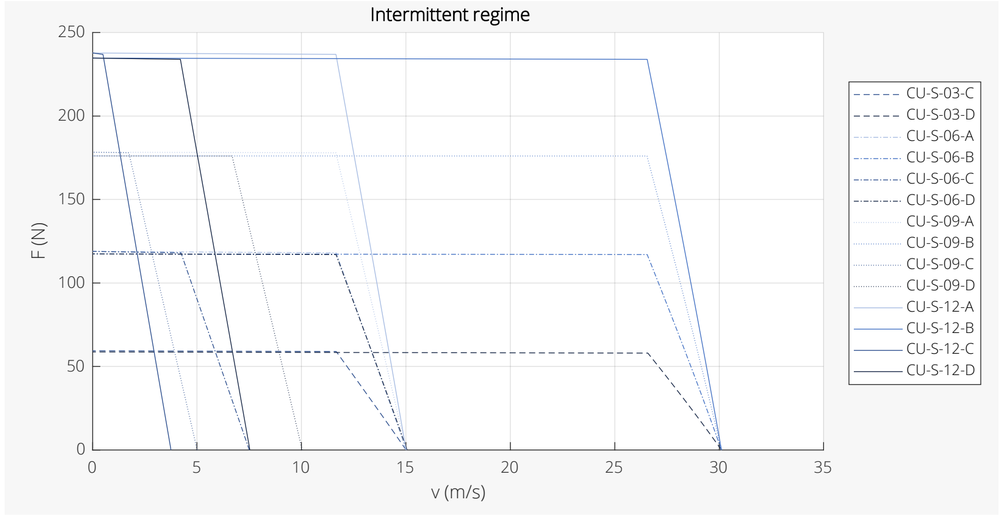
Magnet Yokes

	Parameter	Symbol	Unit	MY-U-08	MY-U-10	MY-U-12	MY-U-18
Magnet Yokes	Number of poles	N_p	-	8	10	12	18
	Pole pitch (N-N)	$2\tau_p$	mm	78	78	78	78
	Width	A	mm	312	390	468	702
	Mass	M_{my}	kg	13.3	16.7	20.0	30.0

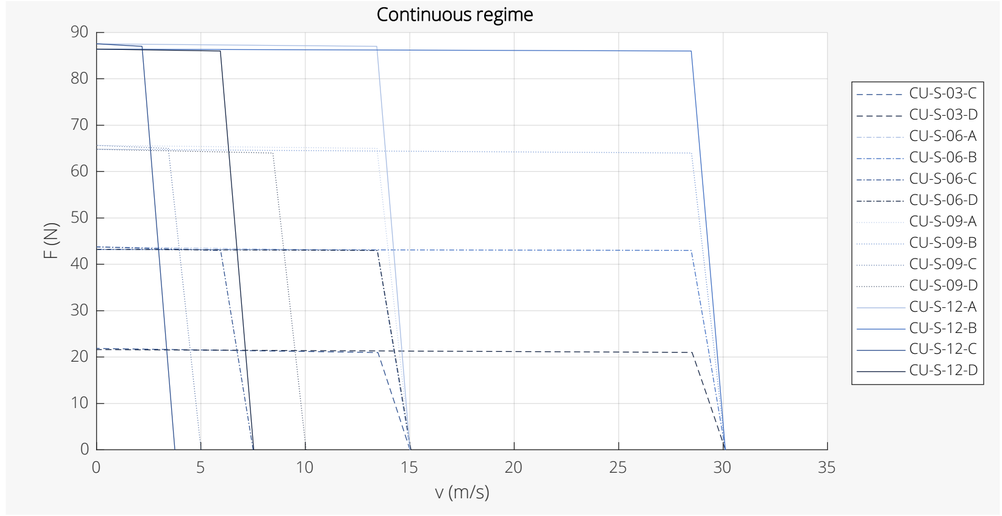
Coil Units

	Parameter	Symbol	Unit	CU-U-03	CU-U-06	CU-U-09	CU-U-12	CU-U-15	CU-U-18
Coil Units	Number of coils	N_{coil}	-	3	6	9	12	15	18
	Coil pitch	τ_{coil}	mm	52	52	52	52	52	52
	Width	B	mm	176	332	488	644	800	956
	Number of hole pitches	C	-	1	4	7	10	13	16
	Mass	M_{cu}	kg	2.2	4.4	6.5	8.7	10.9	13.0
	Standard cable length	L_{cable}	m	1	1	1	1	1	1

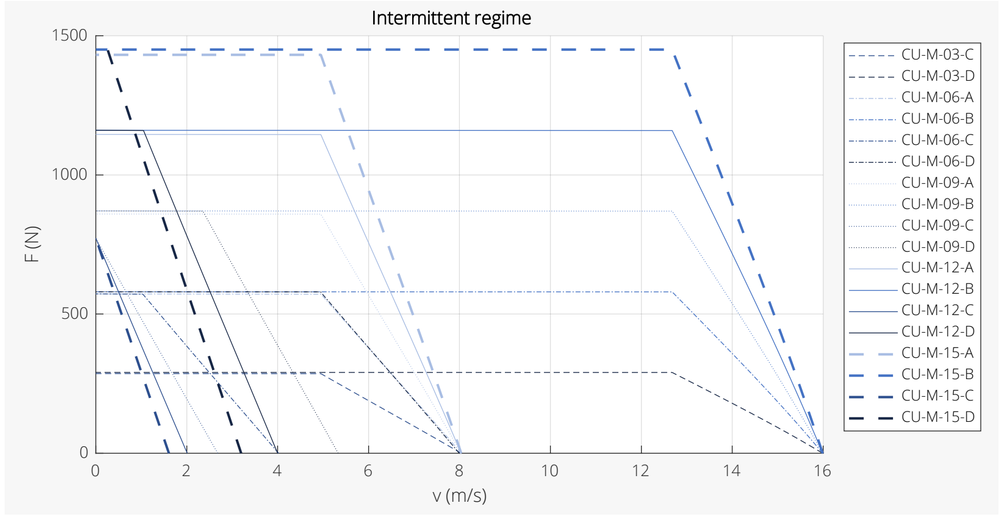
PHOENIX-S/M FORCE-VELOCITY DIAGRAMS



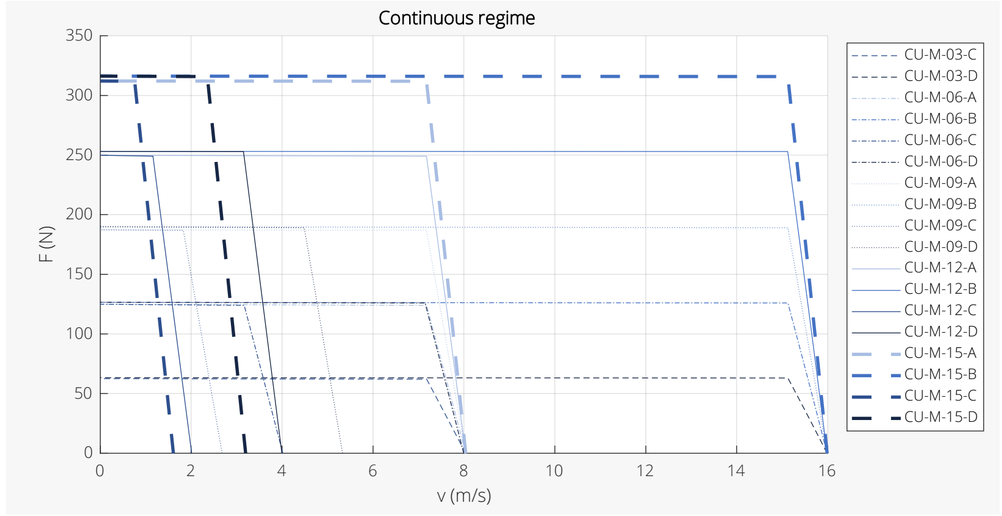
Force-Velocity Diagrams S Size Intermittent Regime



Force-Velocity Diagrams S Size Continuous Regime

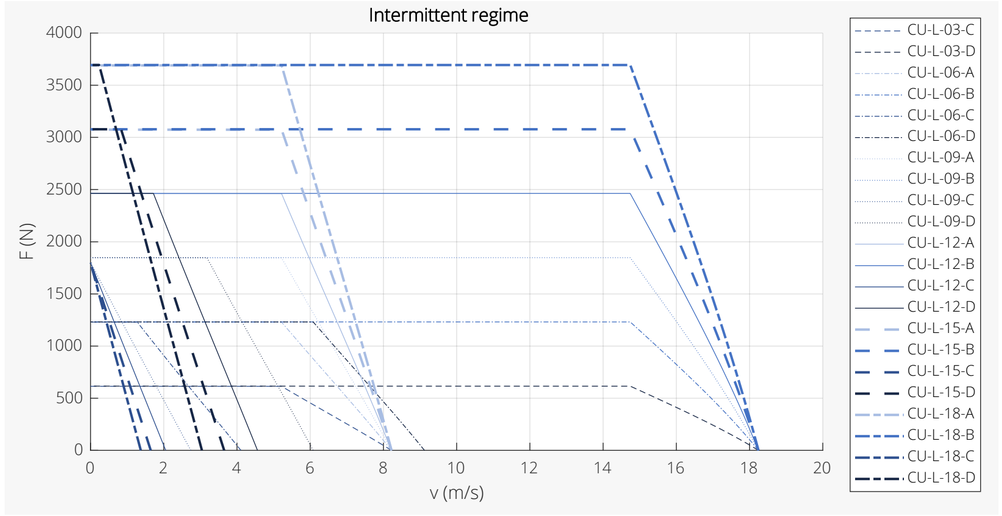


Force-Velocity Diagrams M Size Intermittent Regime

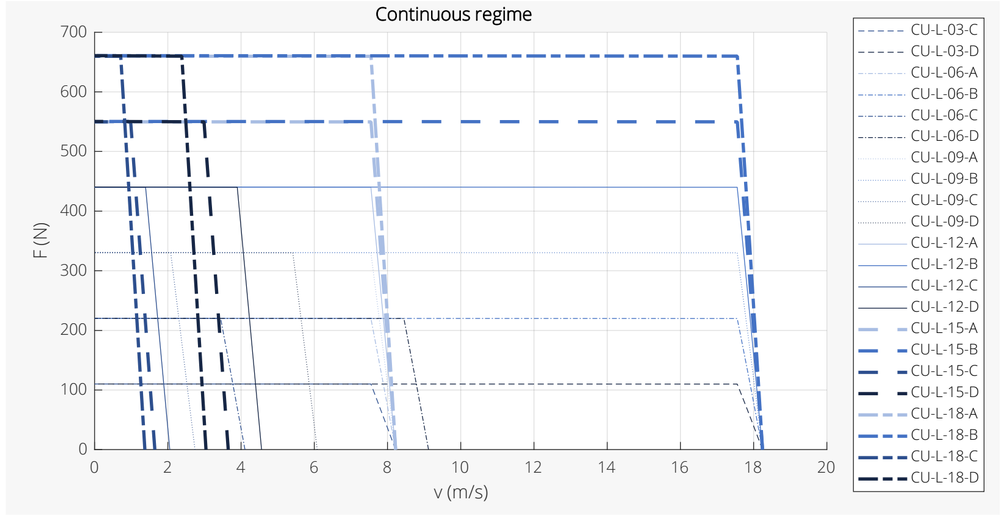


Force-Velocity Diagrams M Size Continuous Regime

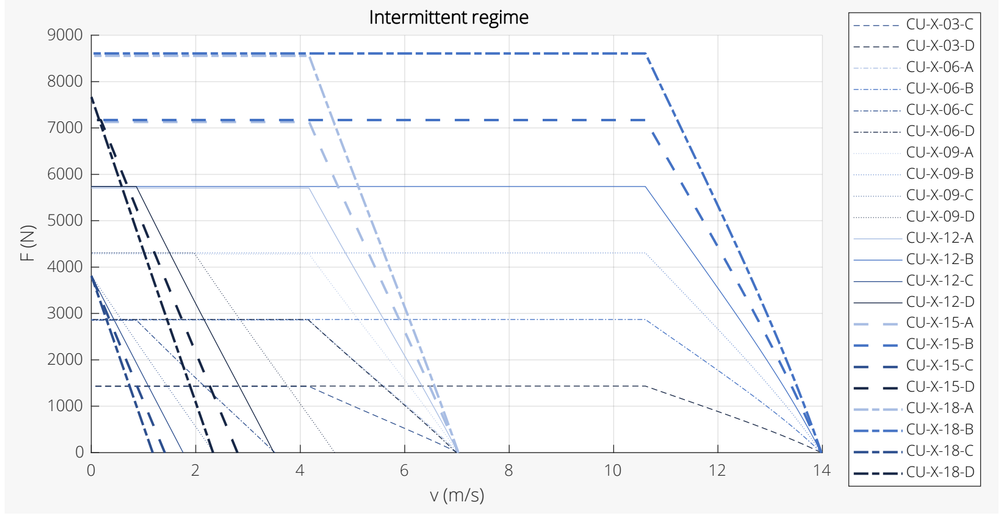
PHOENIX-L/X FORCE-VELOCITY DIAGRAMS



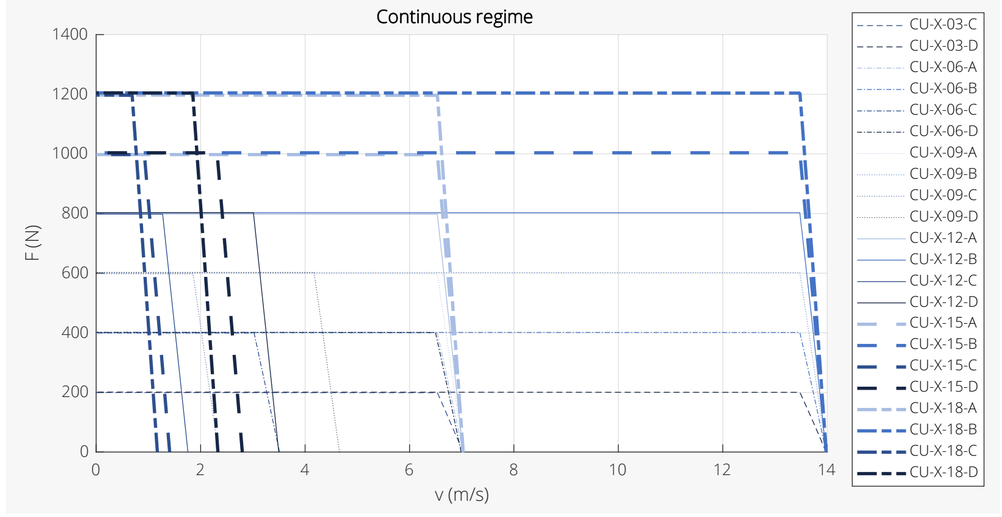
Force-Velocity Diagrams L Size Intermittent Regime



Force-Velocity Diagrams L Size Continuous Regime

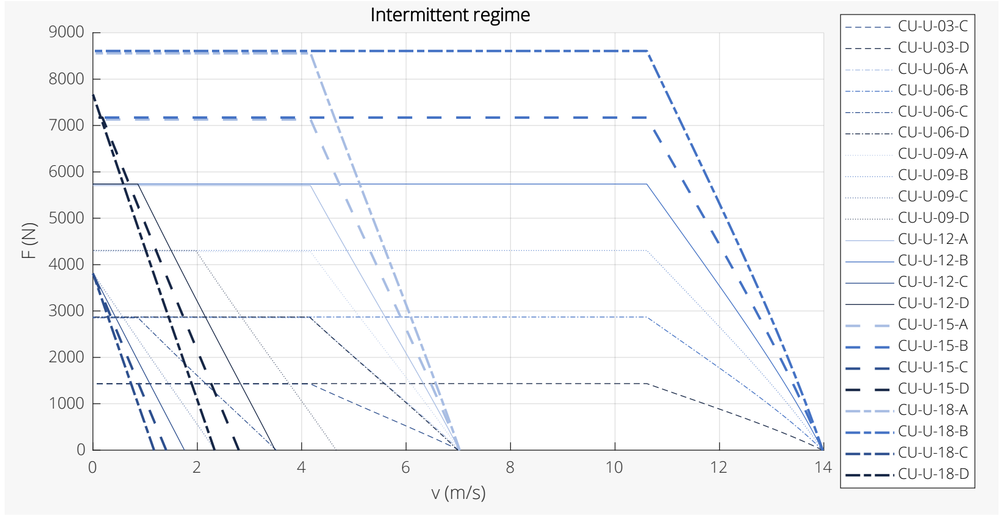


Force-Velocity Diagrams X Size Intermittent Regime

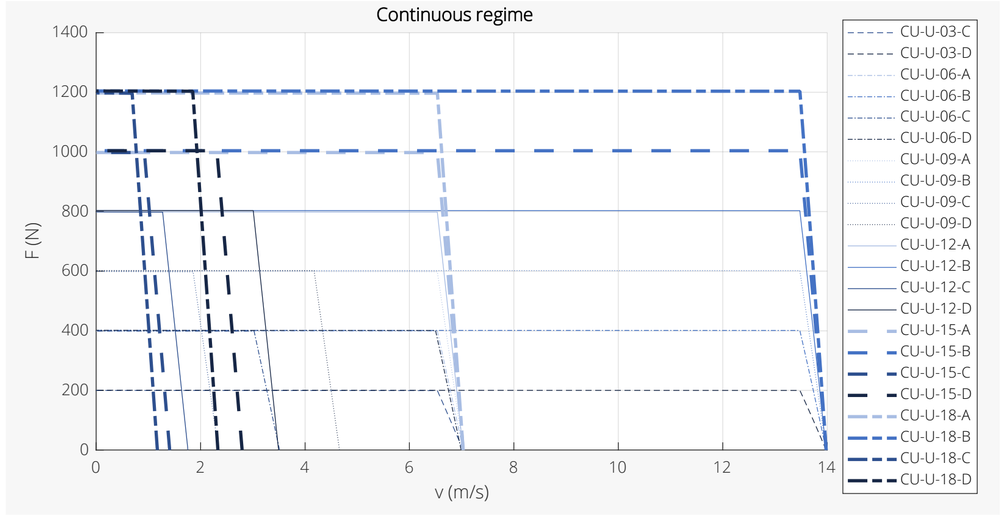


Force-Velocity Diagrams X Size Continuous Regime

PHOENIX-U FORCE-VELOCITY DIAGRAMS



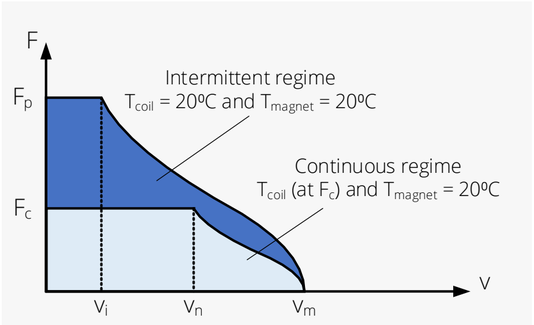
Force-Velocity Diagrams U Size Intermittent Regime



Force-Velocity Diagrams U Size Continuous Regime

DEFINITIONS

Description	Equation	Unit	Remarks
Phase resistance at T_{coil}	$R_{ph} = R_{ph,20}\left(1+0.0039\left(T_{coil}-20\right)\right)$	Ohm	
Force constant at no load	$K_{f,0} = \sqrt{3/2}\, K_{e,ll,p}$	N/A_{rms}	For Phoenix and Gryphon: $K_{f,0} = K_f$.
Continuous dissipation	$P_{d,c} = (T_{coil}-T_i)/R_{th}$	W	Only copper losses are considered. This catalogue considers T_i = 20ºC.
Peak dissipation	$P_{d,p} = C_{th}\alpha_T$	W	α_T is mentioned at the peak force specification.
Continuous rms current	$I_c = \min\left(\sqrt{\frac{P_{d,c}}{3R_{ph}}}, \frac{V_{dc}}{\sqrt{6}R_{ph}}\right)$	A_{rms}	Limited either by continuous dissipation or dc voltage and resistance or connector ratings (if applicable).
Peak rms current	$I_p = \min\left(\sqrt{\frac{P_{d,p}}{3R_{ph,20}}}, \frac{V_{dc}}{\sqrt{6}R_{ph,20}}\right)$	A_{rms}	Limited either by peak dissipation or dc voltage and resistance or connector ratings (if applicable).
Thermal time constant	$\tau_{th} = C_{th}R_{th}$	s	
Continuous force	$F_c = K_{f,c}I_c$	N	For Phoenix and Gryphon: $K_{f,c} = K_f$.
Peak force	$F_p = K_{f,p}I_p$	N	For Phoenix and Gryphon: $K_{f,p} = K_f$.
Steepness	$S = \frac{K_{f,0}^2}{3R_{ph,20}}$	N^2/W	For Phoenix and Gryphon: $K_{f,0} = K_f$.
Maximum velocity (F = 0)	$v_m = \frac{V_{dc}}{K_{e,ll,p}}$	m/s	Iron losses are not considered.
Maximum velocity ($F = F_p$)	$v_i = \left(\tau_p\sqrt{6\tau_p^2K_{f,p}^2V_{dc}^2+54\pi^2\left(L_{ph}^2I_p^2V_{dc}^2-6L_{ph}^2R_{ph,20}^2I_p^4\right)}-6\tau_p^2K_{f,p}R_{ph,20}I_p\right)\left(2\tau_p^2K_{f,p}^2+18\pi^2L_{ph}^2I_p^2\right)^{-1}$	m/s	For Phoenix and Gryphon: $K_{f,p} = K_f$. Iron losses are not considered.
Maximum velocity ($F = F_c$)	$v_n = \left(\tau_p\sqrt{6\tau_p^2K_{f,c}^2V_{dc}^2+54\pi^2\left(L_{ph}^2I_c^2V_{dc}^2-6L_{ph}^2R_{ph,100}^2I_p^4\right)}-6\tau_p^2K_{f,c}R_{ph,100}I_c\right)\left(2\tau_p^2K_{f,c}^2+18\pi^2L_{ph}^2I_c^2\right)^{-1}$	m/s	For Phoenix and Gryphon: $K_{f,c} = K_f$. Iron losses are not considered.



Force-velocity curves

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