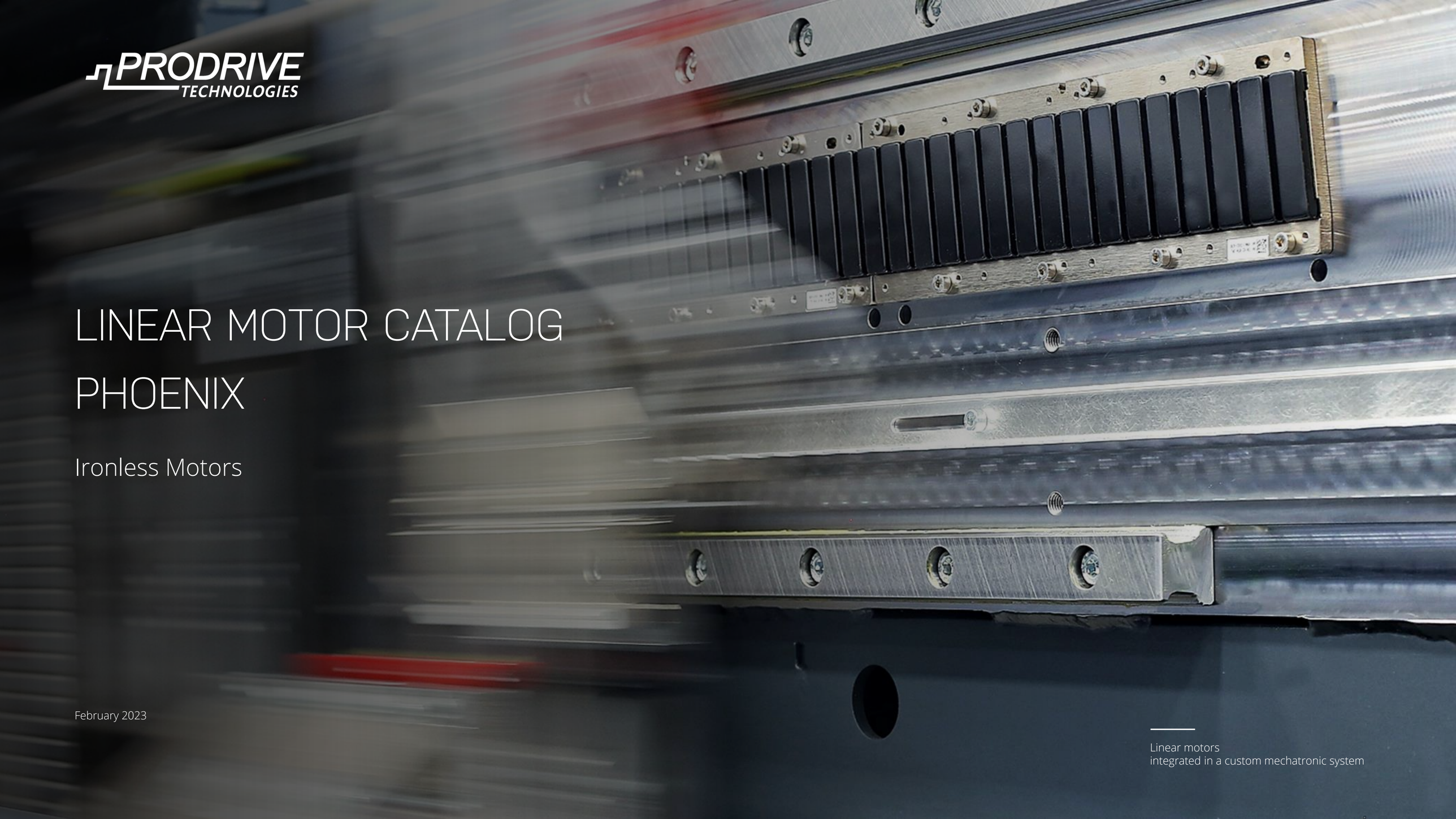
PRODRIVE TECHNOLOGIES

LINEAR MOTOR CATALOG PHOENIX

Ironless Motors

February 2023



Linear motors
integrated in a custom mechatronic system

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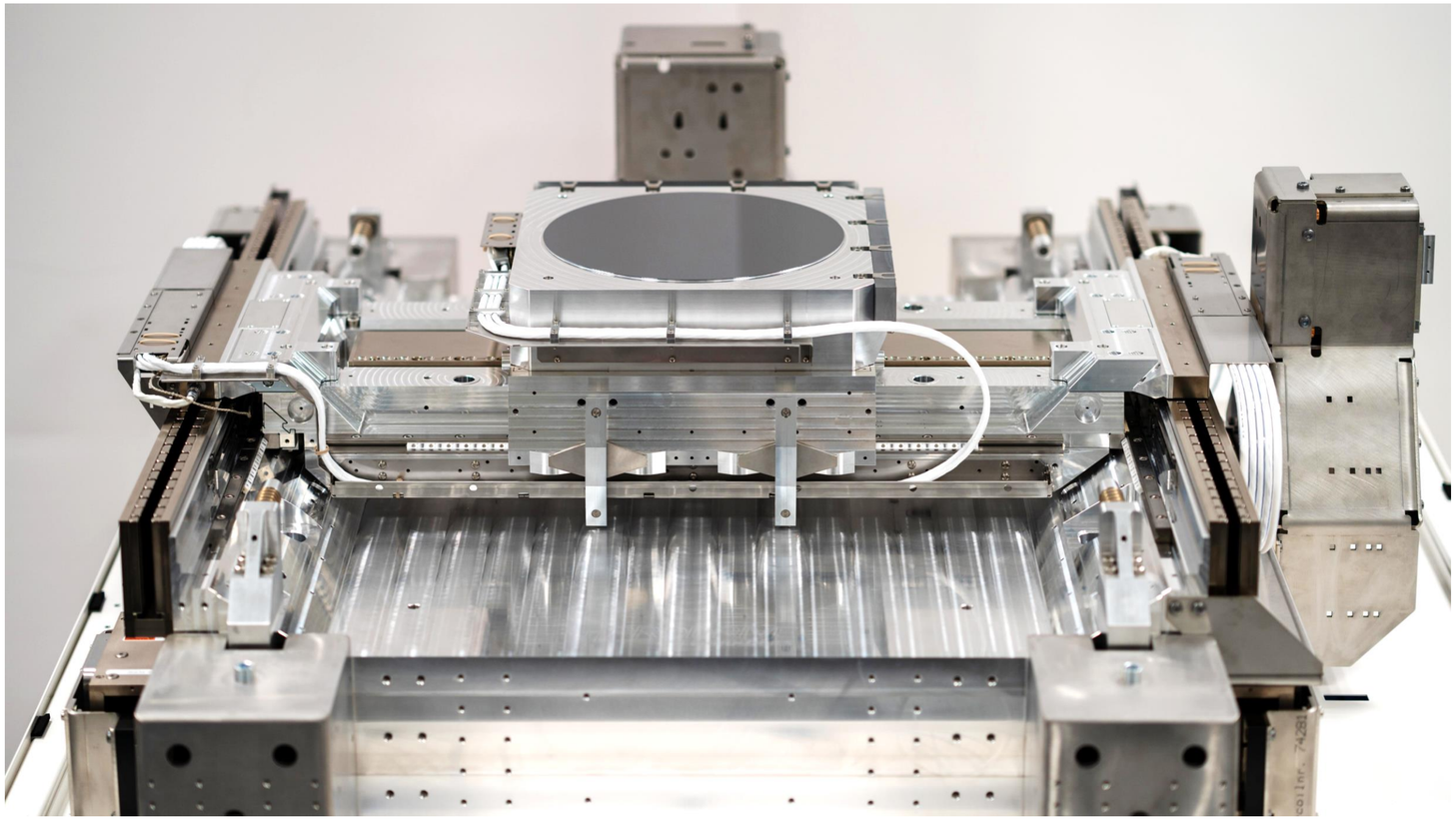


Linear motors integrated in a motion stage

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

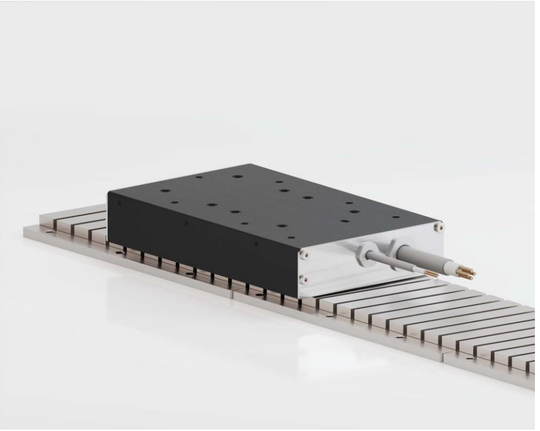
Design for manufacturing is key to reduce cost and guarantee quality. Winding, assembly, vacuum potting and magnet gluing are highly automated processes which guarantees a constant quality at minimum cost.

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.

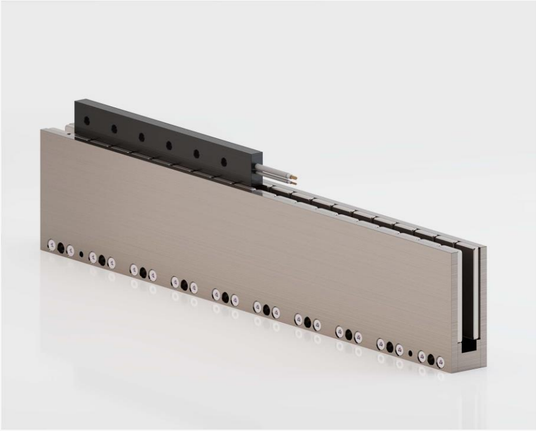
Prodrive Technologies HQ Campus, The Netherlands

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.

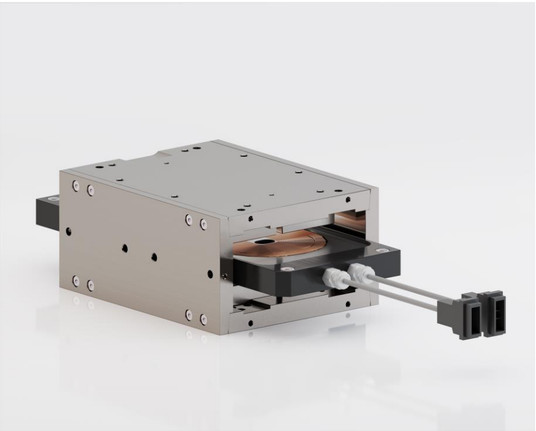


Phoenix

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

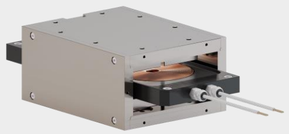
The Gryphon line offers a cost-effective solution for vacuum-compatible ironless linear motors. These motors also contain features providing magnetic shielding.

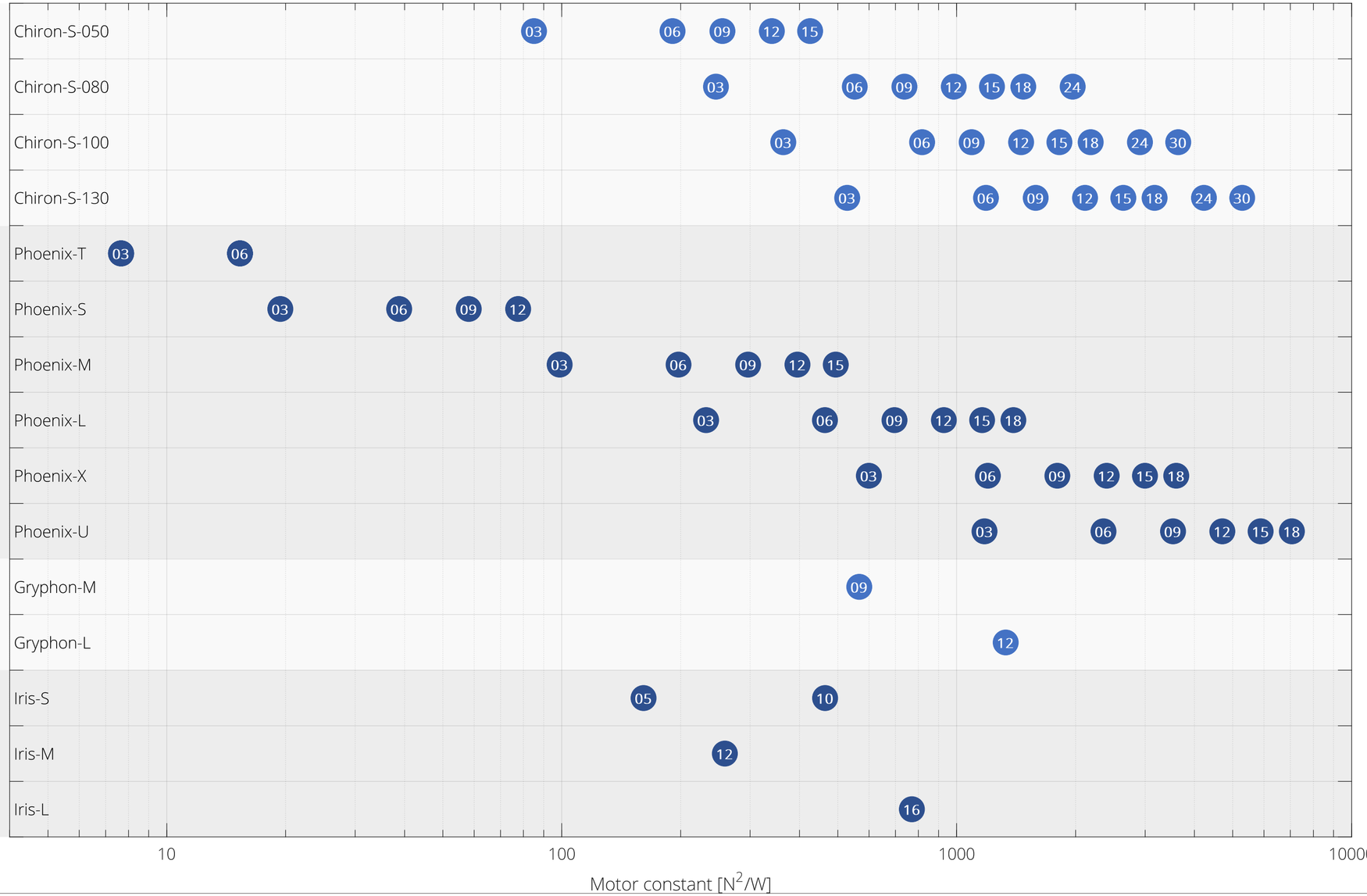


Iris

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
06
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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-T
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Phoenix-S
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Phoenix-M
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Phoenix-X
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Phoenix-U
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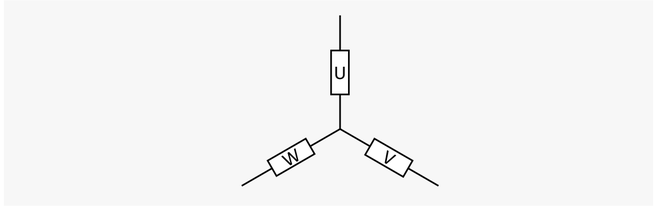
12
15
18
Gryphon-M
09
Gryphon-L
12
Iris-S
05
10
Iris-M
12
Iris-L
16
10
100
1000
10000
Motor constant [N2/W]

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

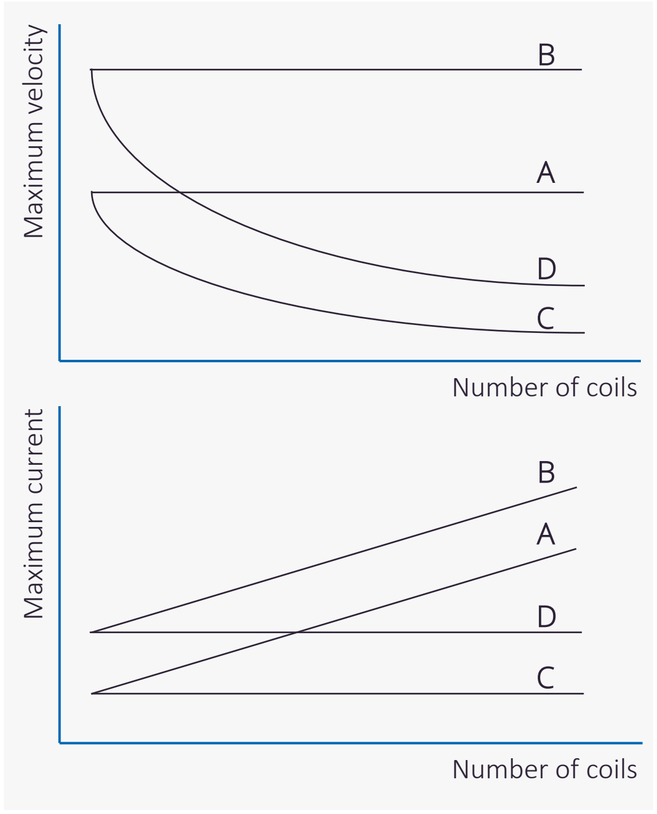
The windings are configured like winding configuration A, but this winding configuration can reach higher velocities at the expense of a lower force constant.

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

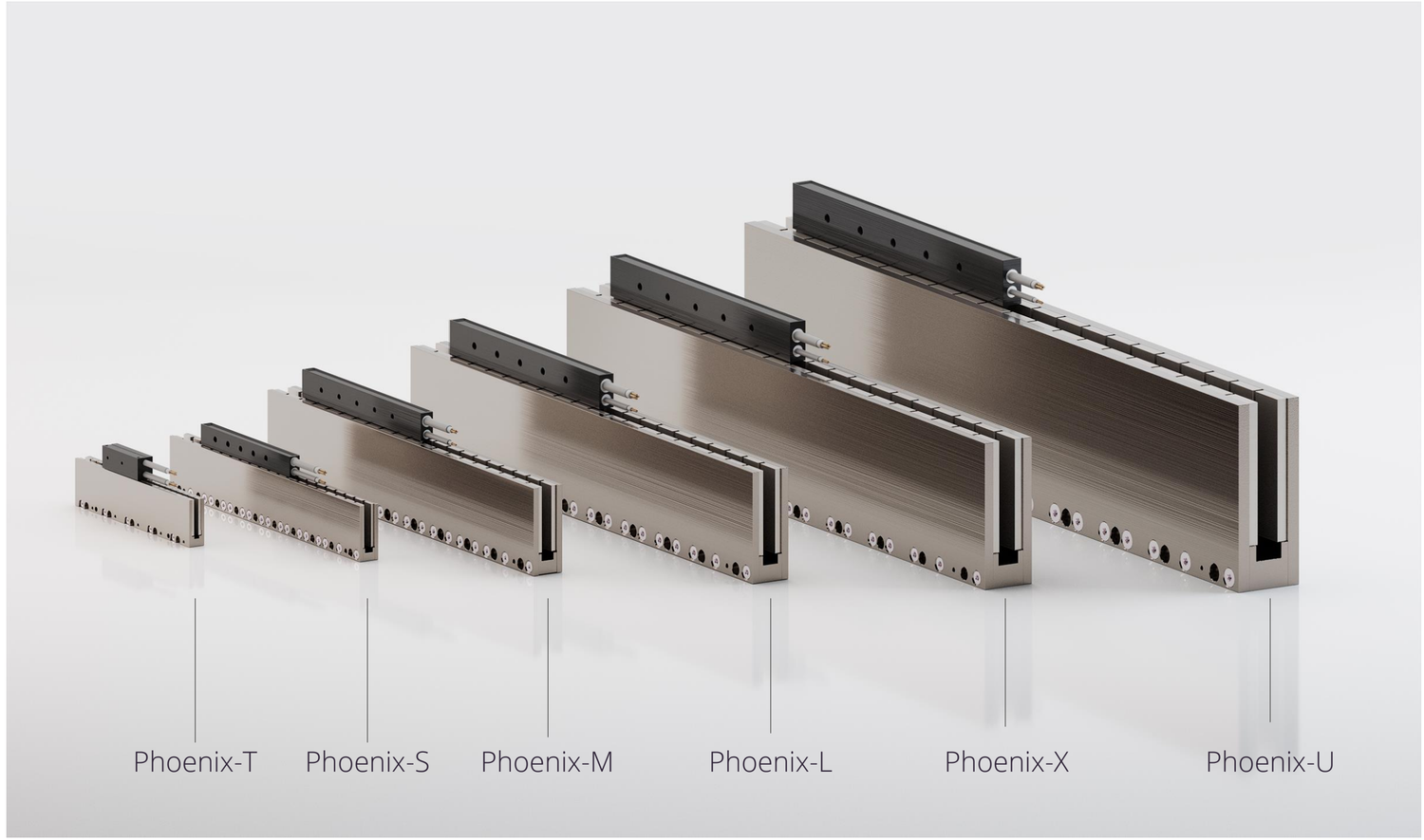
The windings are configured such that the current remains constant with increasing number of coils at the expense of reducing the maximum velocity. This configuration has a higher maximum velocity compared to winding configuration C. For the Phoenix line, this configuration allows moving magnet applications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



Phoenix line linear motors in different sizes

PHOENIX-T FEATURES

Phoenix-T magnet yoke (Phoenix-MY-T-20-G00) and coil unit (Phoenix-CU-T-03-C-S-P-CS)

Phoenix-CU-T-06-A-S-P-CS

- Commutation sensor (NS = without sensor / CS with sensor)
- Cable output direction (P = parallel / O = orthogonal)
- Thermal interface (S = PT1000)
- Winding configuration (A / C)
- # of coils
- Size (T)
- Coil unit

Phoenix-MY-T-20-G00

- Additional airgap x 0.1 mm on each side
- # of poles
- Size (T)
- Magnet yoke

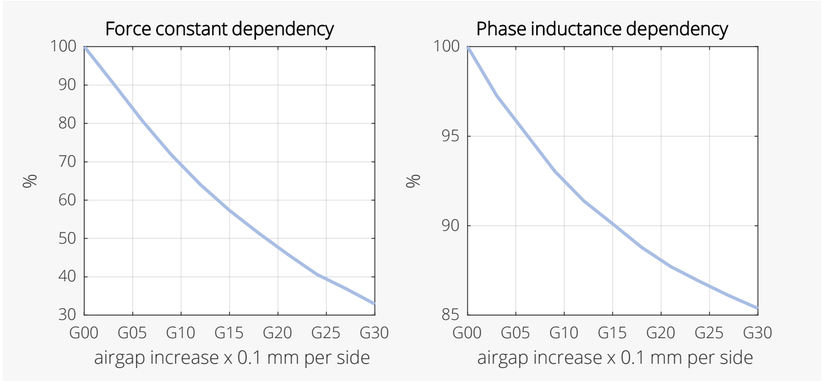
- Different cable output directions for optimal mechanical integration
- Coil units have a temperature sensor (PT1000)
- Motor phases and temperature sensor are integrated in a single cable
- Motor coils are made with PCB technology to improve quality and minimize cost
- Optional commutation sensor (CS), digital Hall, integrated in the coil unit
- Magnet yokes can be butted together
- Magnet yokes can be selected with larger airgaps to allow higher installation tolerances
- Extremely low force ripple due to ironless coil unit
- No attraction force
- Coil units are equipped with flex cables

PHOENIX-T PERFORMANCE SPECIFICATIONS

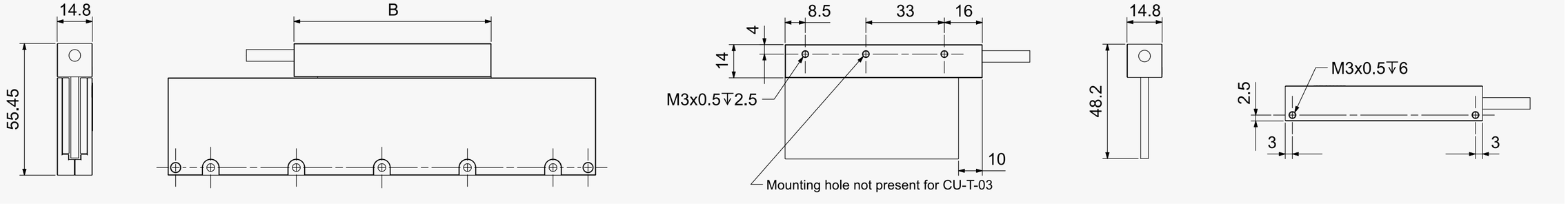
	Parameter	Symbol	Unit	T_{coil} (°C)	CU-T-03	CU-T-06
	Winding configuration	-	-	-	C	A
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	30	60
	Continuous force, interface at 20°C	F_c	N	100	10	20
	Attraction force (I = 0)	F_{att}	N	-	0	0
	Motor constant	S	N^2/W	20	8	15
	Force constant	K_f	N/A_{rms}	-	10.2	10.2
	Maximum velocity (F = 0)	v_m	m/s	-	7.2	7.2
	Maximum velocity (F = F_p)	v_i	m/s	20	3.4	3.4
Electrical	Maximum dc bus voltage	V_{dc}	V	-	60	60
	Phase resistance	$R_{ph,20}$	Ohm	20	4.5	2.3
	Phase inductance	L_{ph}	mH	20	0.50	0.25
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	8	8
	Maximum rms current	I_p	A_{rms}	20	2.9	5.8
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.0	1.9
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	16	33
	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	4.9	2.5
	Thermal resistance, coils to conv. surface	$R_{th,c}$	K/W	-	0.58	0.29
	Thermal time constant, interface at 20°C	τ_{th}	s	-	45	45

Notes

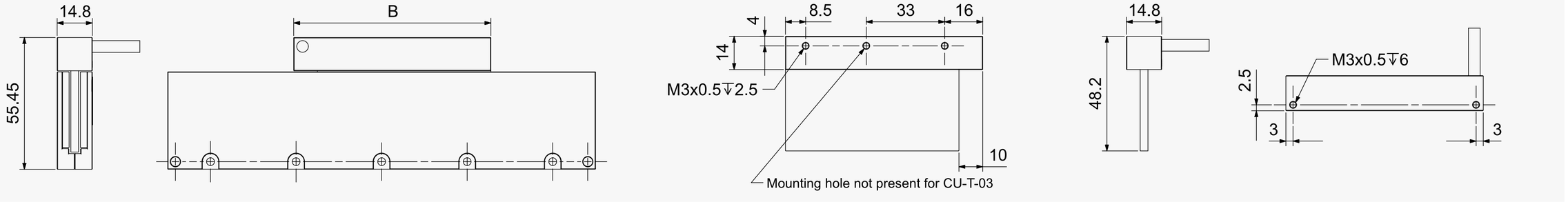
- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Specifications consider a magnet yoke with nominal airgap (G00)
- See ‘definitions’ section at the end of the catalog for more details



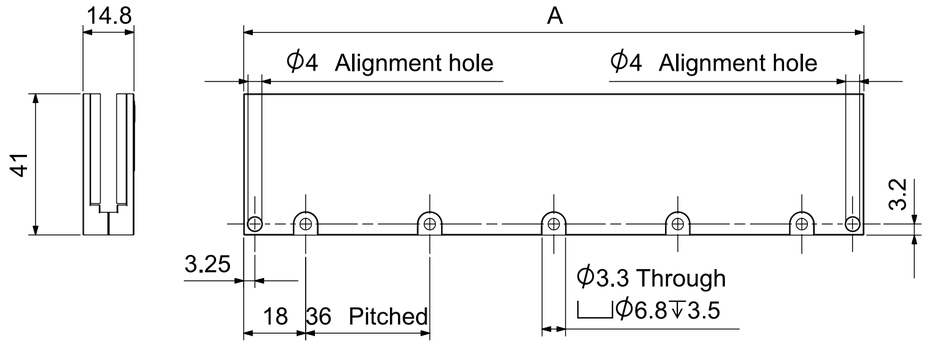
PHOENIX-T MECHANICAL SPECIFICATIONS WITHOUT CS



Parallel cable output



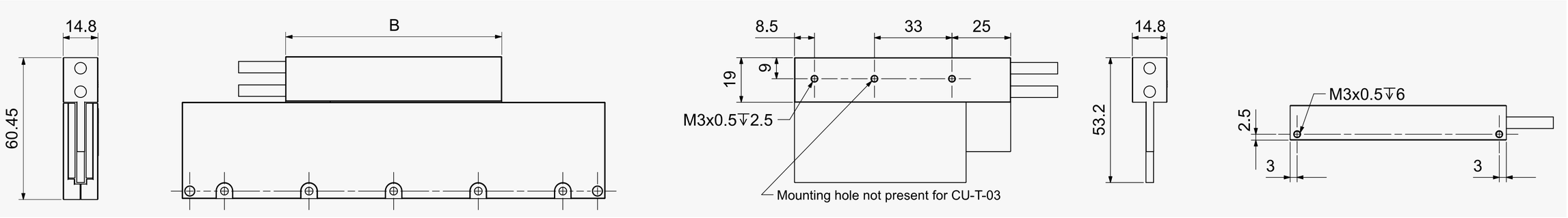
Orthogonal cable output



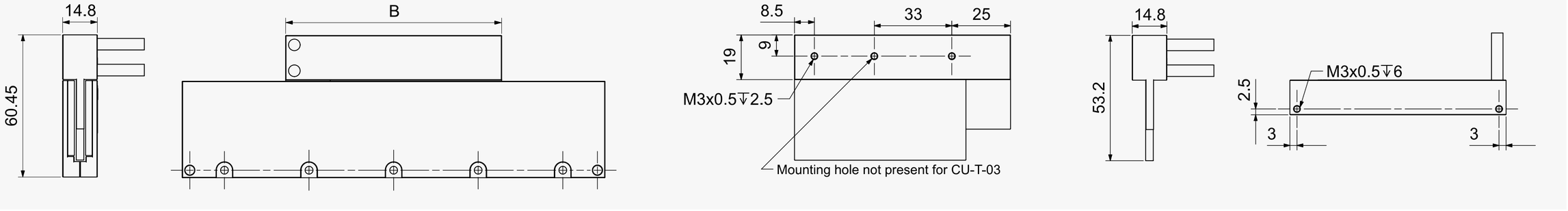
	Parameter	Symbol	Unit	MY-T-08	MY-T-12	MY-T-16	MY-T-20
Magnet Yokes	Number of poles	N_p	-	8	12	16	20
	Pole pitch (N-N)	$2\tau_p$	mm	18	18	18	18
	Width	A	mm	72	108	144	180
	Mass	M_{my}	kg	0.21	0.32	0.43	0.53

	Parameter	Symbol	Unit	CU-T-03	CU-T-06
Coil Units	Number of coils	N_{coil}	-	3	6
	Coil pitch	τ_{coil}	mm	12	12
	Width	B	mm	47	83
	Mass (ex. cable)	M_{cu}	kg	0.038	0.071
	Standard cable length	L_{cable}	m	1	1

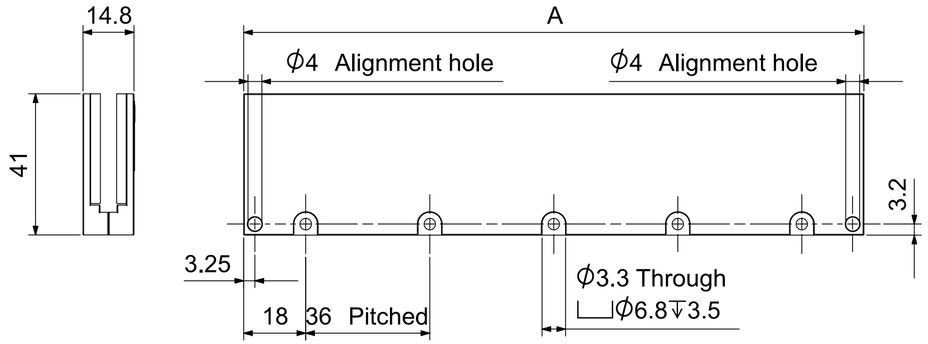
PHOENIX-T MECHANICAL SPECIFICATIONS WITH CS



Parallel cable output



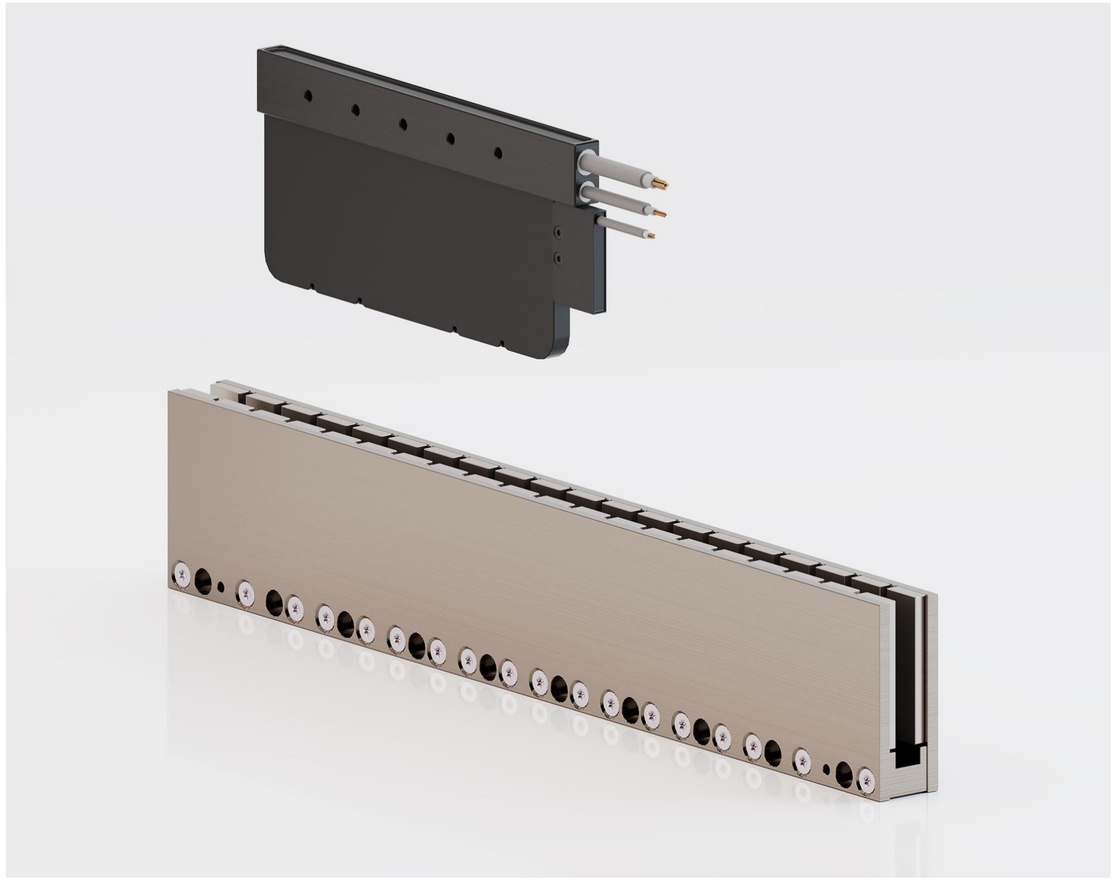
Orthogonal cable output



	Parameter	Symbol	Unit	MY-T-08	MY-T-12	MY-T-16	MY-T-20
Magnet Yokes	Number of poles	N_p	-	8	12	16	20
	Pole pitch (N-N)	$2\tau_p$	mm	18	18	18	18
	Width	A	mm	72	108	144	180
	Mass	M_{my}	kg	0.21	0.32	0.43	0.53

	Parameter	Symbol	Unit	CU-T-03	CU-T-06
Coil Units	Number of coils	N_{coil}	-	3	6
	Coil pitch	τ_{coil}	mm	12	12
	Width	B	mm	56	92
	Mass (ex. cable)	M_{cu}	kg	0.051	0.089
	Standard cable length	L_{cable}	m	1	1

PHOENIX-S/M/L/X/U FEATURES



Phoenix-S magnet yoke (Phoenix-MY-S-20-G00), coil unit (Phoenix-CU-S-06-A-B) and commutation sensor (Phoenix-CS-S)

Phoenix-CU-M-12-A-N

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

Phoenix-MY-M-20-G00

- Additional airgap x 0.1 mm on each side
- # of poles
- Size (S / M / L / X / U)
- Magnet yoke

Phoenix-CS-M

- Size (S / M / L / X / U)
- Commutation sensor

- 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
- Magnet yokes can be selected with larger airgaps to accommodate larger tolerances
- Extremely low force ripple due to ironless coil unit
- No attraction force
- IP rating of coil units is IP69K
- Optional commutation sensor (digital Hall A/B/C) can be connected to the coil unit

PHOENIX-S PERFORMANCE SPECIFICATIONS

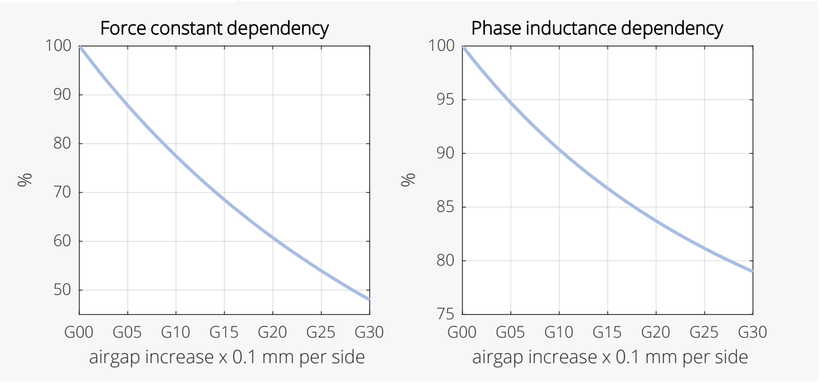
	Parameter	Symbol	Unit	T_{coil} (°C)	CU-S-03		CU-S-06			CU-S-09				CU-S-12		
	Winding configuration	-	-	-	C	D	A	B	C	A	B	C	D	A	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	80		160			230				310		
	Continuous force, interface at 20°C	F_c	N	100	25		50			75				95		
	Attraction force (I = 0)	F_{att}	N	-	0		0			0				0		
	Motor constant	S	N^2/W	20	20		40			60				80		
	Force constant	K_f	N/A_{rms}	-	17	8.6	17	9	34	17	8.6	51	26	17	68	34
	Maximum velocity (F = 0)	v_m	m/s	-	29	57	29	57	14	29	57	9.5	19	29	7.2	14
	Maximum velocity (F = F_p)	v_i	m/s	20	24	52	24	52	10	24	52	5.4	15	24	3.1	10
Electrical	Maximum dc bus voltage	V_{dc}	V	-	400		400			400				400		
	Phase resistance	$R_{ph,20}$	Ohm	20	5.0	1.3	2.5	0.6	10	1.7	0.4	15	3.8	1.3	20	5.0
	Phase inductance	L_{ph}	mH	20	1.5	0.4	0.7	0.2	3.0	0.5	0.1	4.4	1.1	0.4	5.9	1.5
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	14	7.0	14	7.0	28	14	7.0	42	21	14	56	28
	Maximum rms current	I_p	A_{rms}	20	4.5	9.1	9.1	18.2	4.5	13.6	27	4.5	9.1	18.2	4.5	9.1
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.4	2.8	2.8	5.7	1.4	4.2	8.5	1.4	2.8	5.7	1.4	2.8
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	40		79			119				159		
	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	2.0		1.0			0.67				0.50		
	Thermal resistance, coils to conv. surface	$R_{th,c}$	K/W	-	0.19		0.093			0.062				0.047		
	Thermal time constant, interface at 20°C	τ_{th}	s	-	65		65			65				65		

Notes

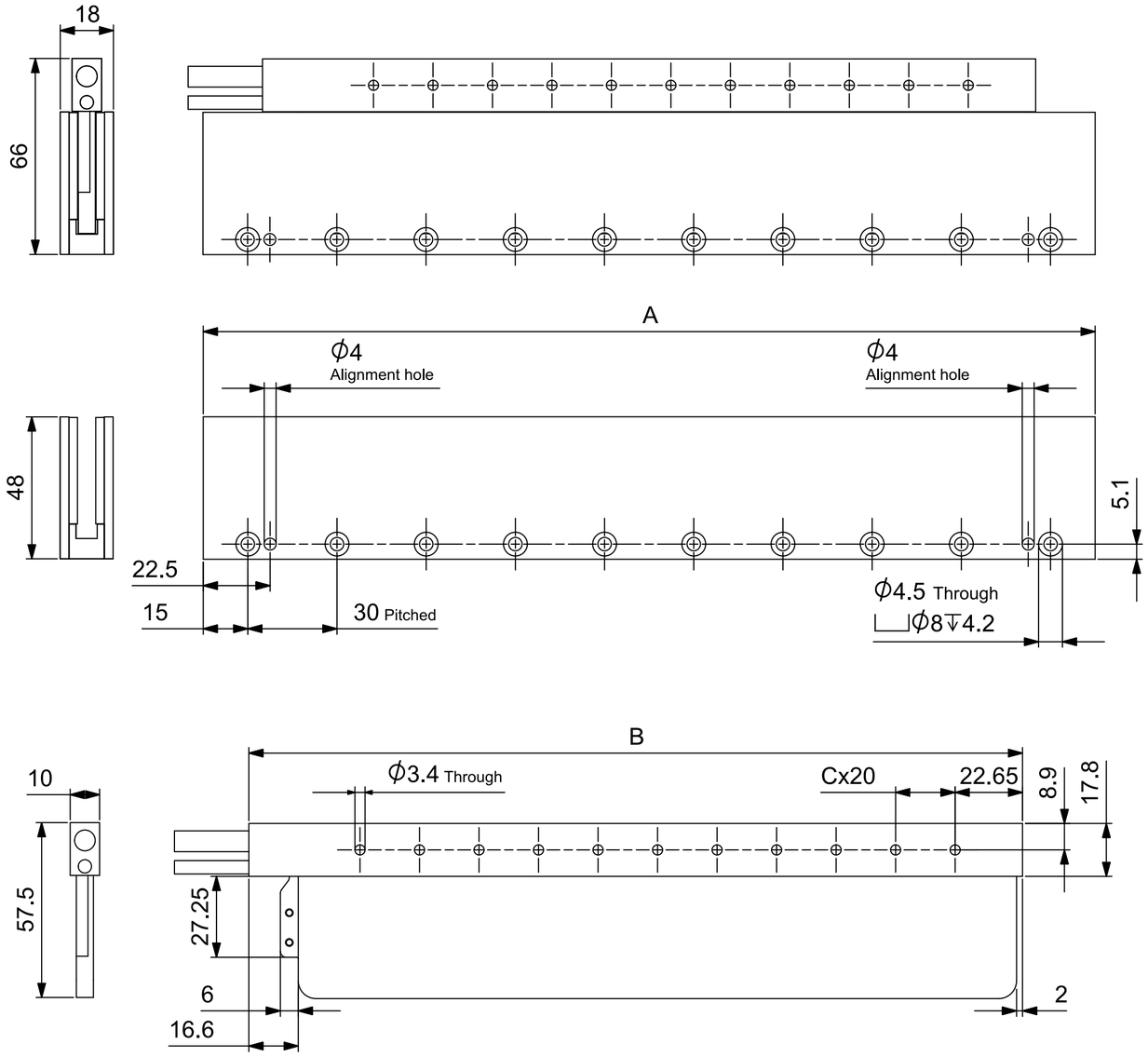
- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Specifications consider a magnet yoke with nominal airgap (G00)
- See ‘definitions’ section at the end of the catalog for more details

Product marking / approvals

CE



PHOENIX-S MECHANICAL SPECIFICATIONS



	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

	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 (ex. cable)	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	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		650			950		750	950	1250		750	1250	1600		750	1550
	Continuous force, interface at 20°C	F_c	N	100	70		140			210				270				340			
	Attraction force (I = 0)	F_{att}	N	-	0		0			0				0				0			
	Motor constant	S	N^2/W	20	100		200			300				400				500			
	Force constant	K_f	N/A_{rms}	-	63	32	63	32	125	63	32	188	95	63	32	251	126	63	32	314	158
	Maximum velocity (F = 0)	v_m	m/s	-	7.8	16	7.8	16	3.9	7.8	16	2.6	5.2	7.8	16	2.0	3.9	7.8	16	1.6	3.1
	Maximum velocity (F = F_p)	v_i	m/s	20	4.5	12	4.5	12	0.7	4.5	12	0.0	2.0	4.5	12	0.0	0.7	4.5	12	0.0	0.0
Electrical	Maximum dc bus voltage	V_{dc}	V	-	400		400			400				400				400			
	Phase resistance	$R_{ph,20}$	Ohm	20	13	3.3	6.6	1.6	27	4.4	1.1	40	10	3.3	0.8	53	13	2.7	0.7	66	16
	Phase inductance	L_{ph}	mH	20	8.3	2.1	4.1	1.0	17	2.8	0.7	25	6.3	2.1	0.5	33	8.4	1.7	0.4	41	10
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	51	26	51	26	102	51	26	154	77	51	26	205	103	51	26	256	129
	Maximum rms current	I_p	A_{rms}	20	5.0	10	10	20	5.0	15	30	4.1	10	20	40	3.1	10	25	50	2.5	10
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.1	2.2	2.2	4.4	1.1	3.3	6.6	1.1	2.2	4.4	8.8	1.1	2.2	5.4	11	1.1	2.2
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	62		124			186				247				309			
	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	1.3		0.65			0.43				0.32				0.26			
	Thermal resistance, coils to conv. surface	$R_{th,c}$	K/W	-	0.098		0.049			0.033				0.024				0.020			
	Thermal time constant, interface at 20°C	τ_{th}	s	-	160		160			160				160				160			

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
- Specifications consider a magnet yoke with nominal airgap (G00)
- See ‘definitions’ section at the end of the catalog for more details

Product marking / approvals

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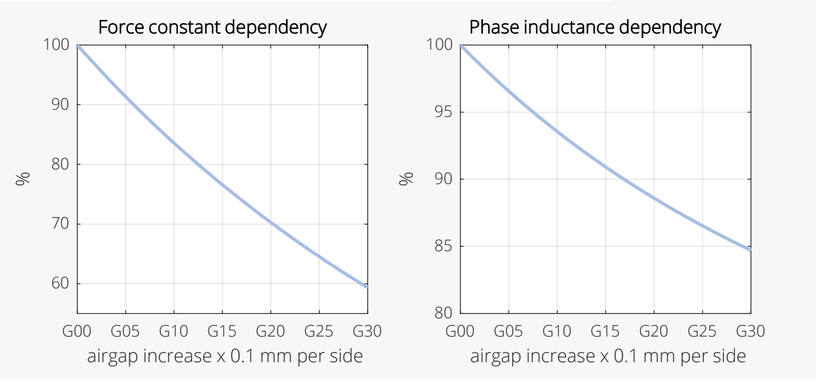
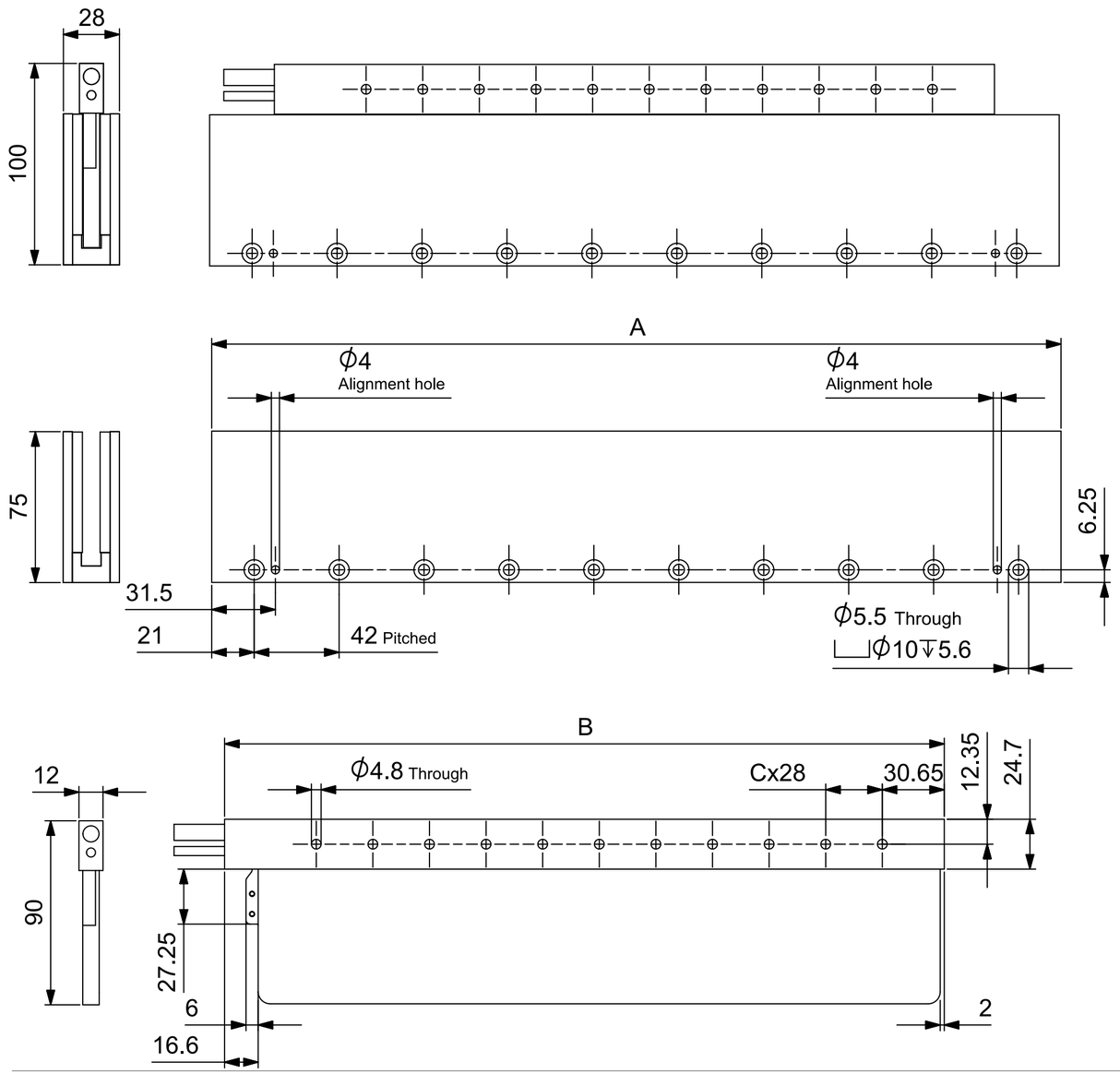


PHOENIX-M MECHANICAL SPECIFICATIONS



	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	9.1

	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 (ex. cable)	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

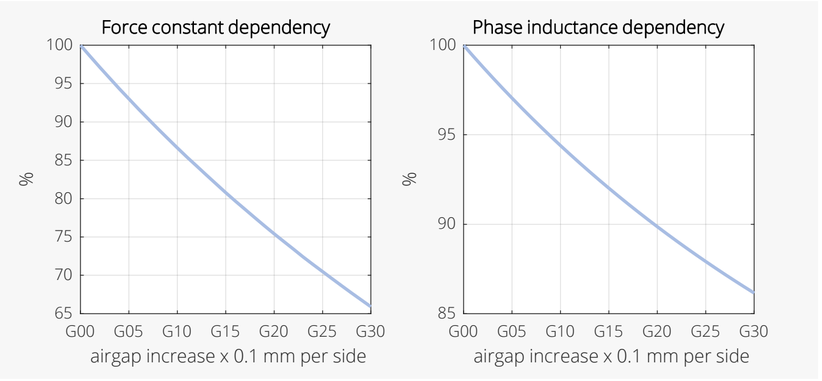
	Parameter	Symbol	Unit	T_{coil} (°C)	CU-L-03		CU-L-06			CU-L-09				CU-L-12				CU-L-15				CU-L-18			
	Winding configuration	-	-	-	C	D	A	B	C	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	700		1350			2050		1850	2050	2700		1850	2700	3400		1850	3400	4050		1850	4050
	Continuous force, interface at 20°C	F_c	N	100	125		245			370				490				615				735			
	Attraction force (I = 0)	F_{att}	N	-	0		0			0				0				0				0			
	Motor constant	S	N^2/W	20	230		460			700				930				1160				1400			
	Force constant	K_f	N/A_{rms}	-	107	48	107	48	214	107	48	321	145	107	48	428	193	107	48	535	241	107	48	641	289
	Maximum velocity (F = 0)	v_m	m/s	-	7.9	18	7.9	18	4.0	7.9	18	2.6	5.8	7.9	18	2.0	4.4	7.9	18	1.6	3.5	7.9	18	1.3	2.9
	Maximum velocity (F = F_p)	v_i	m/s	20	4.8	13.9	4.8	14	1.0	4.8	14	0.0	2.8	4.8	14	0.0	1.4	4.8	14	0.0	0.6	4.8	14	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	16	3.3	8.2	1.7	33	5.5	1.1	49	10	4.1	0.8	66	13	3.3	0.7	82	17	2.7	0.6	99	20
	Phase inductance	L_{ph}	mH	20	18	3.6	8.9	1.8	35	5.9	1.2	53	11	4.4	0.9	71	14	3.5	0.7	89	18	3.0	0.6	106	22
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	87	39	87	39	175	87	39	262	118	87	39	349	157	87	39	436	197	87	39	524	236
	Maximum rms current	I_p	A_{rms}	20	6.3	14	13	28	6.3	19	42	5.7	14	25	56	4.3	14	32	70	3.4	14	38	84	2.9	14
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.1	2.5	2.3	5.1	1.1	3.4	7.6	1.1	2.5	4.6	10	1.1	2.5	5.7	13	1.1	2.5	6.9	15	1.1	2.5
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	85		170			254				339				424				509			
	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	0.94		0.47			0.31				0.24				0.19				0.16			
	Thermal resistance, coils to conv. surface	$R_{th,c}$	K/W	-	0.067		0.033			0.022				0.017				0.013				0.011			
	Thermal time constant, interface at 20°C	τ_{th}	s	-	180		180			180				180				180				180			

Notes

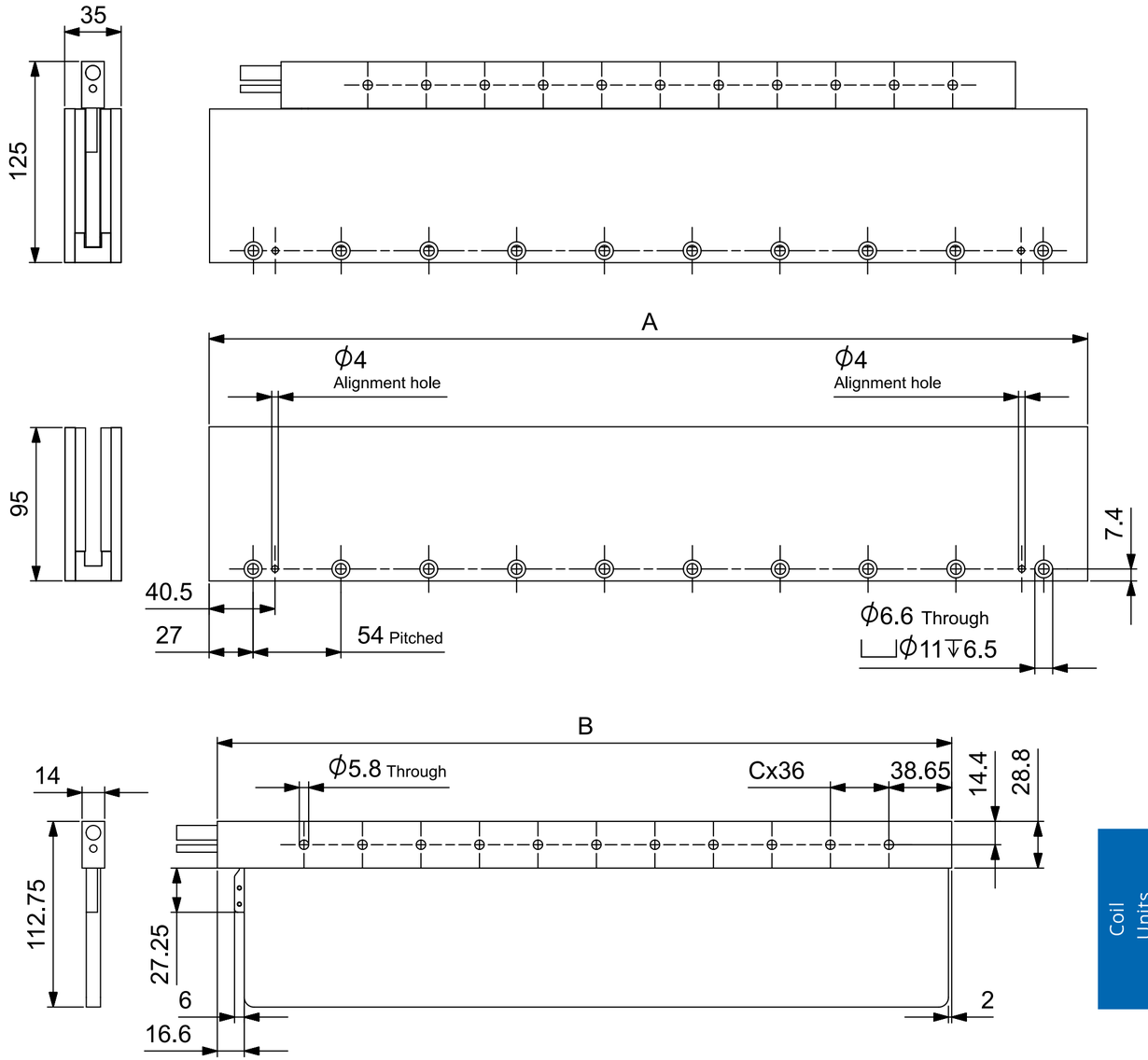
- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Specifications consider a magnet yoke with nominal airgap (G00)
- See 'definitions' section at the end of the catalog for more details

Product marking / approvals

CE



PHOENIX-L MECHANICAL SPECIFICATIONS



	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	14.3

	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 (ex. cable)	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

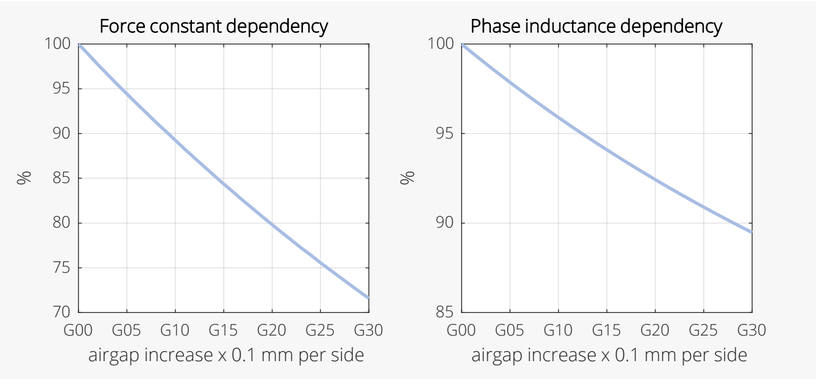
	Parameter	Symbol	Unit	T_{coil} (°C)	CU-X-03		CU-X-06			CU-X-09				CU-X-12				CU-X-15				CU-X-18		
	Winding configuration	-	-	-	C	D	A	B	C	A	B	C	D	A	B	C	D	A	B	C	D	A	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	1600		3250			4850		3500	4800	6450		3500	6400	8050		3500	7850	6600	5700	5600
	Continuous force, interface at 20°C	F_c	N	100	215		430			645				860				1075				1295		
	Attraction force (I = 0)	F_{att}	N	-	0		0			0				0				0				0		
	Motor constant	S	N^2/W	20	590		1190			1780				2370				2960				3570		
	Force constant	K_f	N/A_{rms}	-	144	63	144	63	288	144	63	433	189	144	63	577	252	144	63	721	315	144	865	378
	Maximum velocity (F = 0)	v_m	m/s	-	5.9	13	5.9	13	2.9	5.9	13	2.0	4.5	5.9	13	1.5	3.4	5.9	13	1.2	2.7	5.9	1.0	2.2
	Maximum velocity (F = F_p)	v_i	m/s	20	3.0	10	3.0	10	0.2	3.0	10	0.0	1.7	3.0	10	0.0	0.6	3.0	10	0.0	0.0	3.0	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	11.6	2.3	5.8	1.1	23	3.9	0.8	35	6.8	2.9	0.6	46	9.0	2.3	0.5	58	11	1.9	69	14
	Phase inductance	L_{ph}	mH	20	21	4.0	10.5	2.0	42	7.0	1.3	63	12	5.3	1.0	84	16	4.2	0.8	105	20	3.5	126	24
	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	118	51	118	51	235	118	51	353	154	118	51	471	206	118	51	589	257	118	706	309
	Maximum rms current	I_p	A_{rms}	20	11	25	22	51	11	34	76	8	25	45	102	6.1	25	56	127	4.9	25	67	4.1	21
	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	1.5	3.4	3.0	6.8	1.5	4.5	10	1.5	3.4	6.0	14	1.5	3.4	7.5	17	1.5	3.4	9	1.5	3.4
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	103		205			308				410				513				615		
	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	0.78		0.39			0.26				0.20				0.16				0.13		
	Thermal resistance, coils to conv. surface	$R_{th,c}$	K/W	-	0.046		0.023			0.015				0.012				0.0092				0.0077		
	Thermal time constant, interface at 20°C	τ_{th}	s	-	320		320			320				320				320				320		

Notes

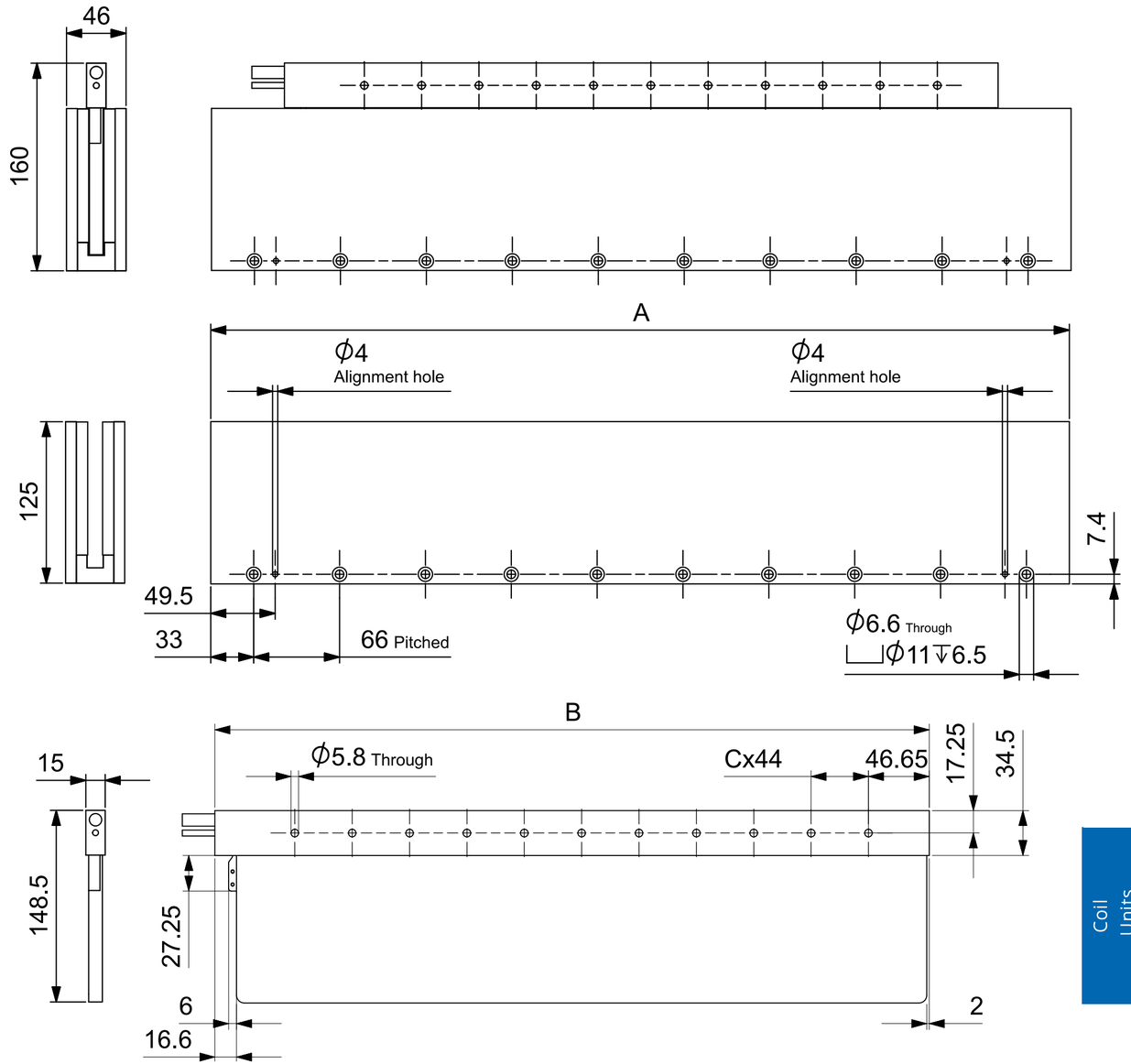
- Specifications are based upon a magnet temperature of 20°C
- Specifications consider complete overlap of the coil unit with a magnet yoke
- Specifications consider sinusoidal q-axis commutation
- Velocity specifications are based on the maximum bus voltage
- Specifications consider a magnet yoke with nominal airgap (G00)
- See 'definitions' section at the end of the catalog for more details

Product marking / approvals

CE



PHOENIX-X MECHANICAL SPECIFICATIONS



	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	17.9

	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 (ex. cable)	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	A	B	C	D	A	C	D	A	C	D	A	C	D
Electromechanical	Peak force (α_T = 20°C/s increase)	F_p	N	20	3350		6650		5800	10000		5800	9950	13450	5800	10650	16800	5800	10650	20150	5800	10650
Electromechanical	Continuous force, interface at 20°C	F_c	N	100	330		670			1000				1340			1670			2010		
Electromechanical	Attraction force (I = 0)	F_{att}	N	-	0		0			0				0			0			0		
Electromechanical	Motor constant	S	N^2/W	20	1150		2350			3500				4950			6400			6850		
Electromechanical	Force constant	K_f	N/A_{rms}	-	171	91	171	91	342	171	91	513	272	171	684	363	171	856	454	171	1027	544
Electromechanical	Maximum velocity (F = 0)	v_m	m/s	-	4.9	9.3	4.9	9.3	2.5	4.9	9.3	1.6	3.1	4.9	1.2	2.3	4.9	1.0	1.9	4.9	0.8	1.6
Electromechanical	Maximum velocity (F = F_p)	v_i	m/s	20	1.9	5.6	1.9	5.6	0.0	1.9	5.6	0.0	0.2	1.9	0.0	0.0	1.9	0.0	0.0	1.9	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	8.3	2.4	4.2	1.2	17	2.8	0.8	25	7.2	2.1	33	9.6	1.7	42	12	1.4	50	14
Electrical	Phase inductance	L_{ph}	mH	20	25	6.9	12	3.5	49	8.2	2.3	74	21	6.2	99	28	4.9	124	35	4.1	148	42
Electrical	Peak line emf constant	$K_{e,ll,p}$	Vs/m	-	140	74	140	74	279	140	74	419	222	140	559	296	140	699	370	140	838	444
Electrical	Maximum rms current	I_p	A_{rms}	20	20	36	39	73	17	59	109	11	36	78	8.5	29.3	98	6.8	23	118	5.7	20
Electrical	Continuous rms current, interface at 20°C	I_c	A_{rms}	100	2.0	3.7	3.9	7.3	2.0	5.9	11	2.0	3.7	7.9	2.0	3.7	10	2.0	3.7	12	2.0	3.7
Thermal	Continuous dissipation, interface at 20°C	$P_{d,c}$	W	100	126		253			379				537			695			758		
Thermal	Thermal resistance, coils to interface	$R_{th,i}$	K/W	-	0.63		0.32			0.21				0.15			0.12			0.11		
Thermal	Thermal resistance, coils to conv. surface	$R_{th,c}$	K/W	-	0.036		0.018			0.012				0.0086			0.0066			0.0060		
Thermal	Thermal time constant, interface at 20°C	τ_{th}	s	-	550		550			550				550			550			550		

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
- Specifications consider a magnet yoke with nominal airgap (G00)
- See ‘definitions’ section at the end of the catalog for more details

Product marking / approvals

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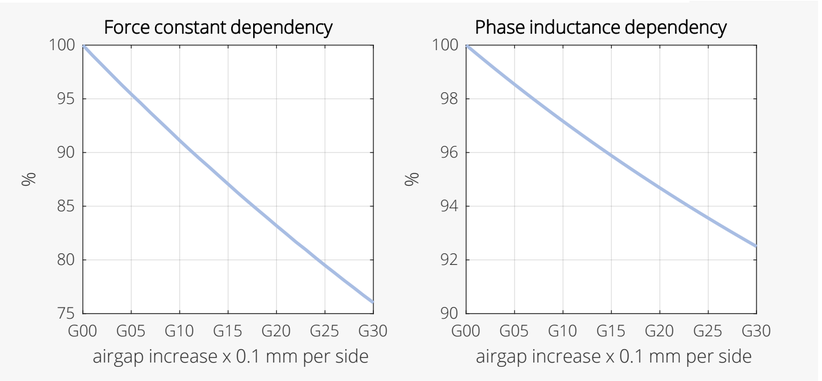
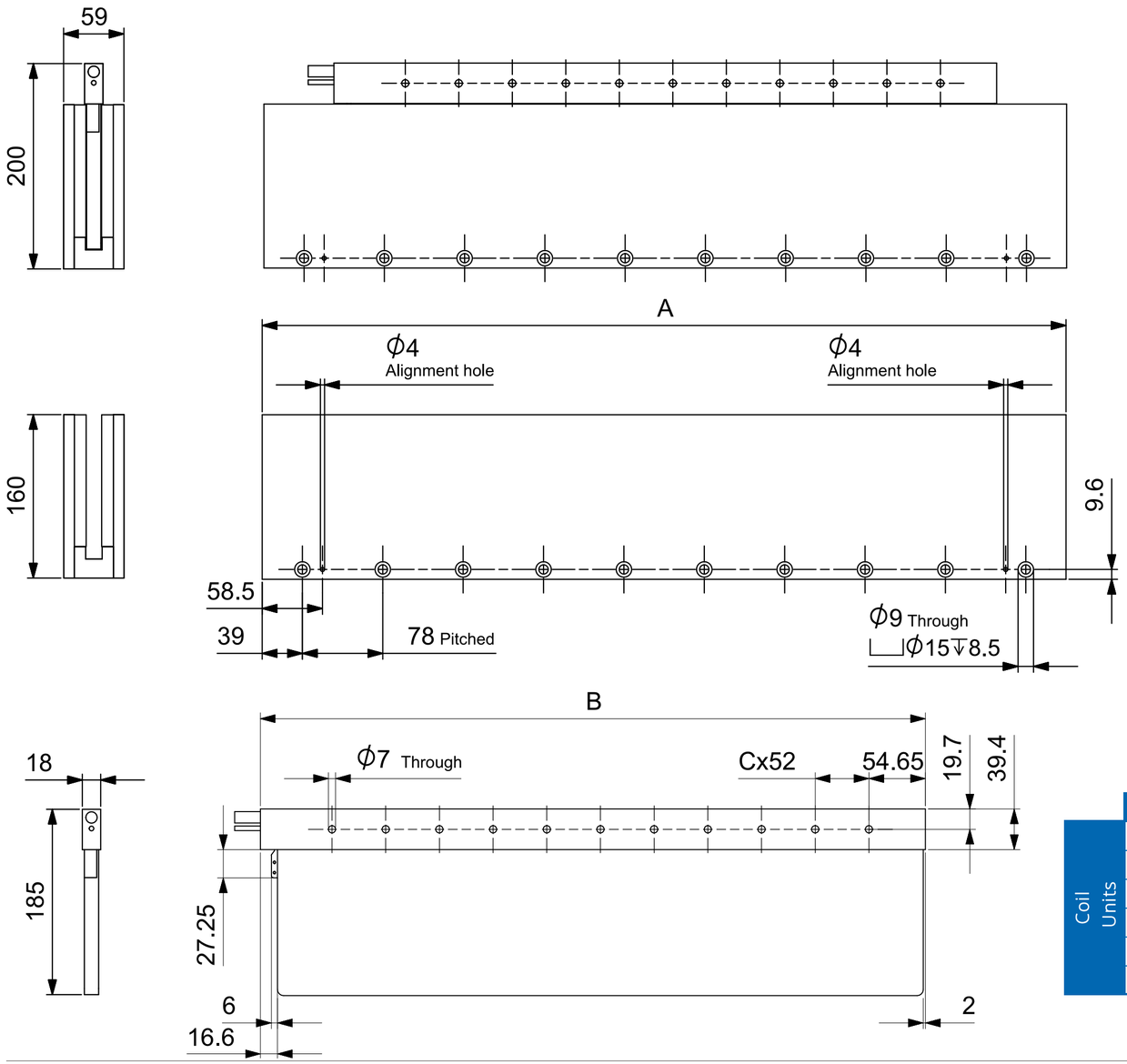


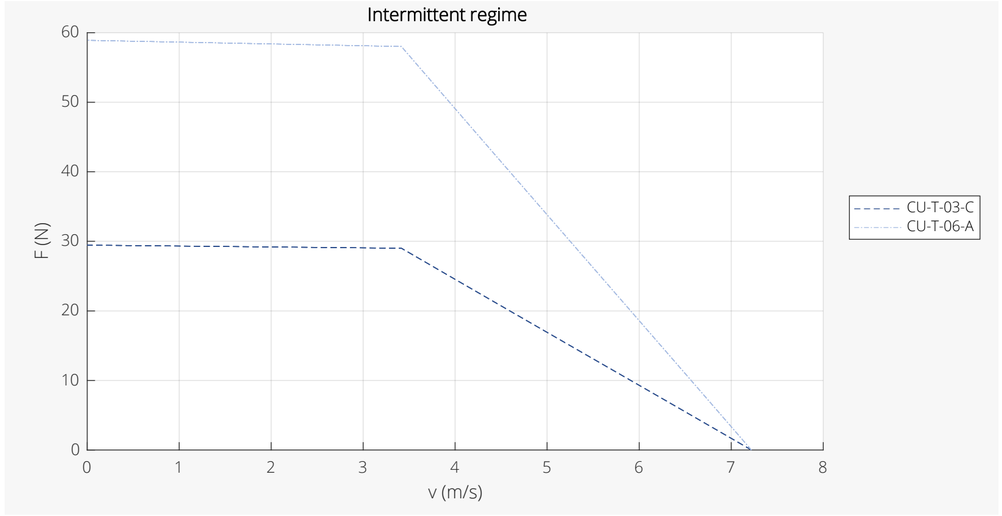
PHOENIX-U MECHANICAL SPECIFICATIONS



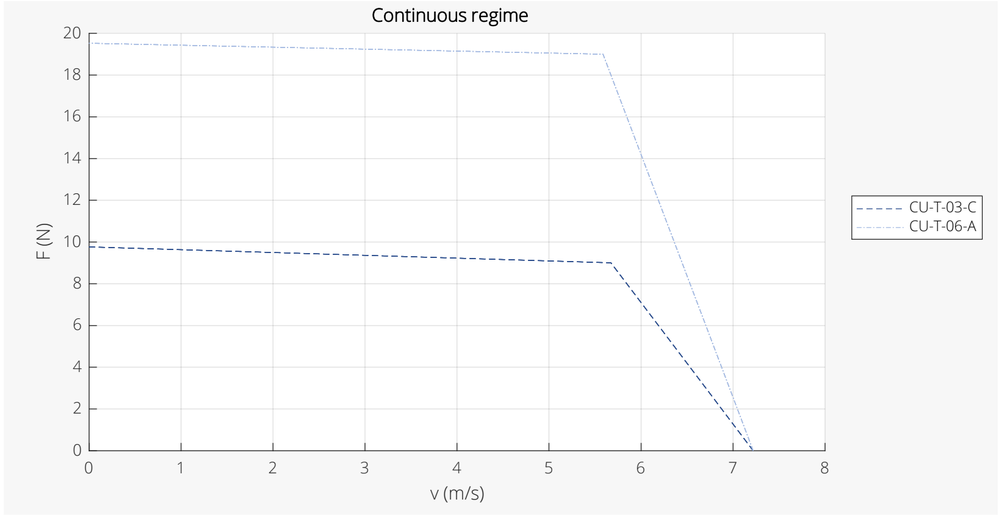
	Parameter	Symbol	Unit	MY-U-08	MY-U-10	MY-U-12	MY-U-18
Magnet Yokes	Number of poles	N_p	-	8	10	12	18
	Pole pitch (N-N)	$2\tau_p$	mm	78	78	78	78
	Width	A	mm	312	390	468	702
	Mass	M_{my}	kg	13.9	17.4	20.8	31.2

	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 (ex. cable)	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

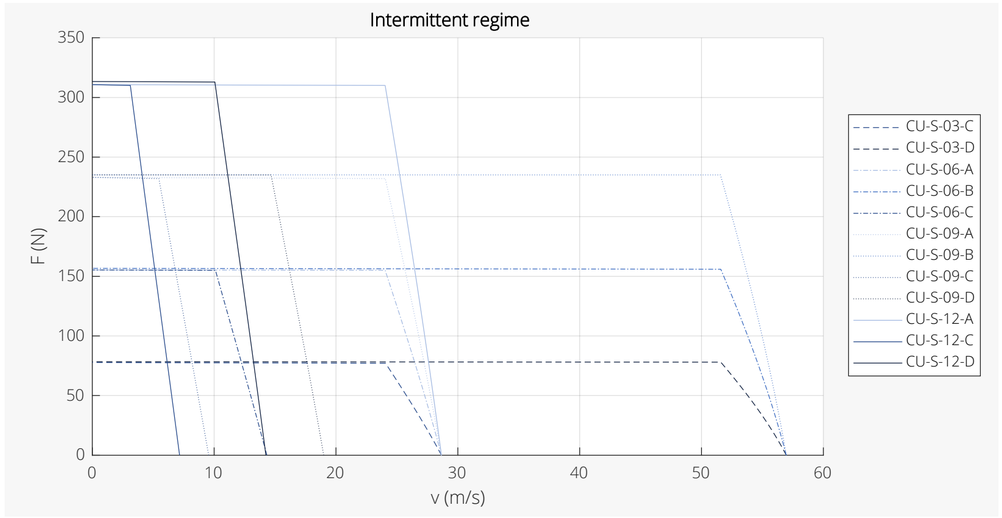
PHOENIX-T/S FORCE-VELOCITY DIAGRAMS



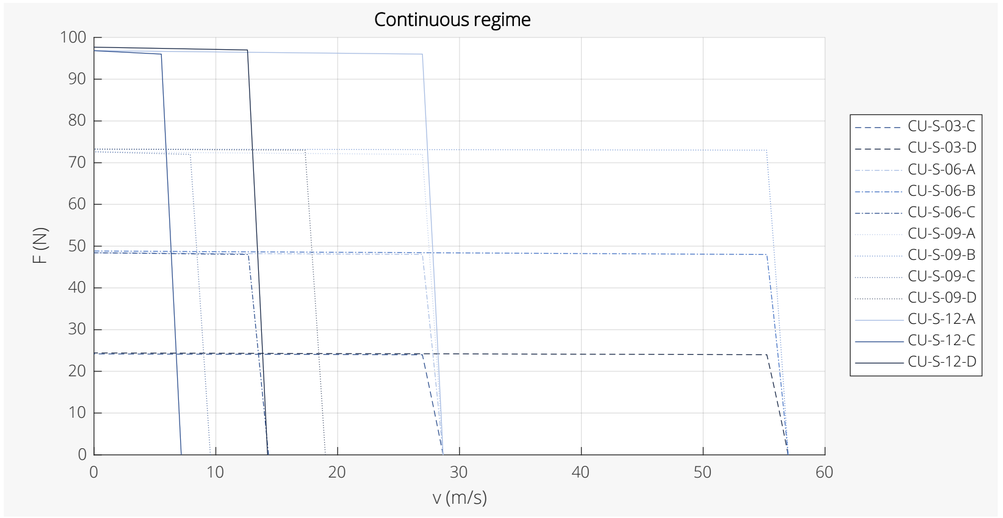
Force-Velocity Diagrams Size T Intermittent Regime



Force-Velocity Diagrams Size T Continuous Regime

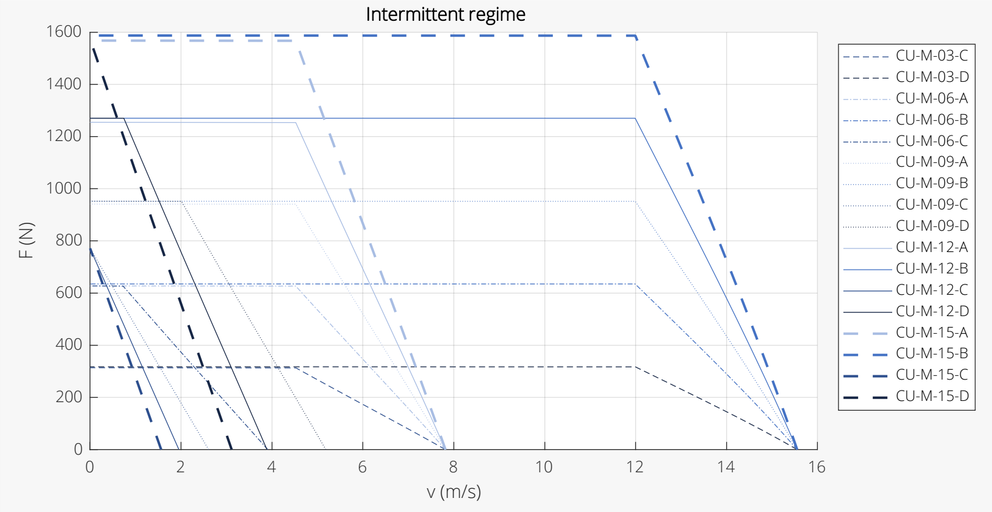


Force-Velocity Diagrams Size S Intermittent Regime

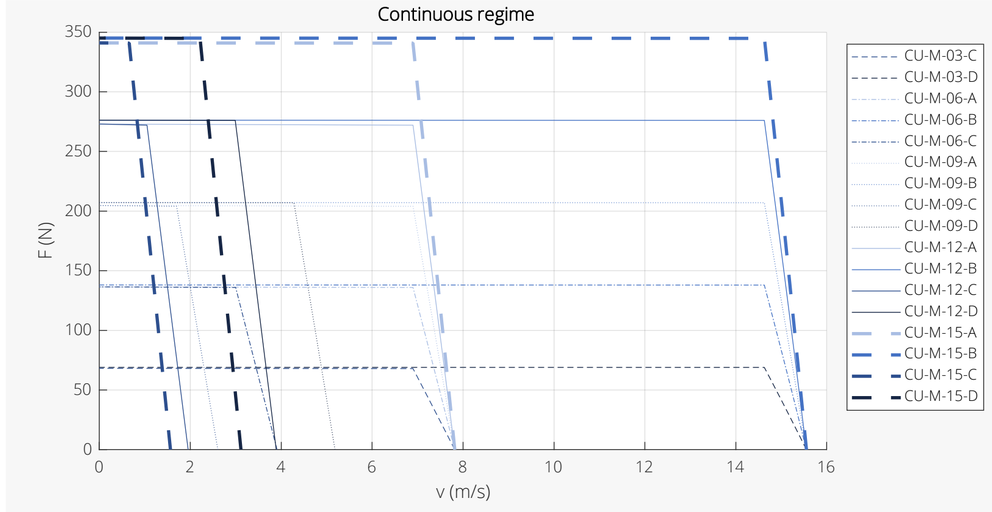


Force-Velocity Diagrams Size S Continuous Regime

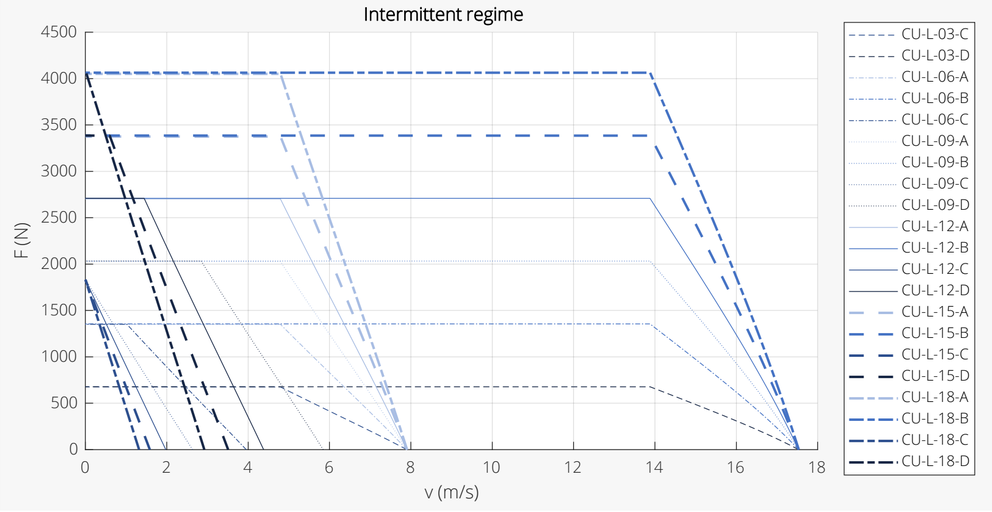
PHOENIX-M/L FORCE-VELOCITY DIAGRAMS



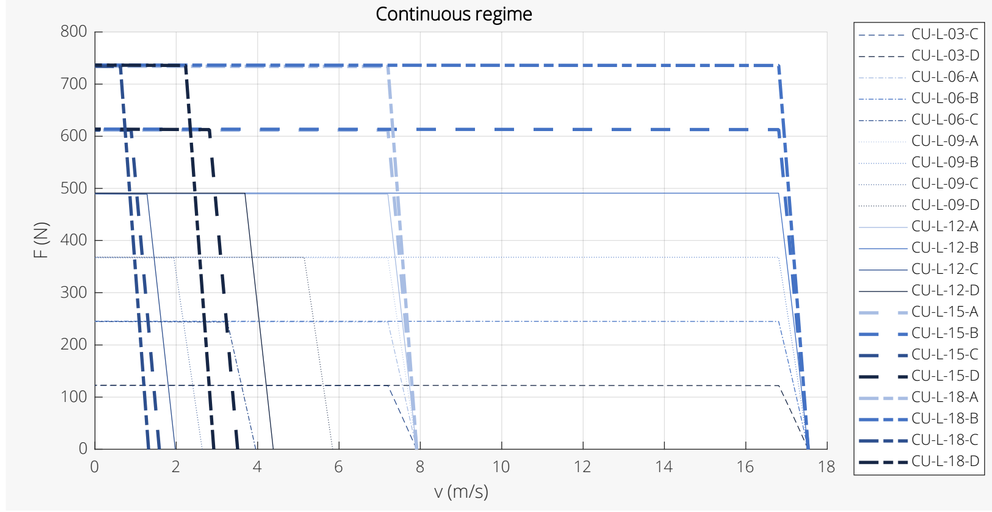
Force-Velocity Diagrams Size M Intermittent Regime



Force-Velocity Diagrams Size M Continuous Regime

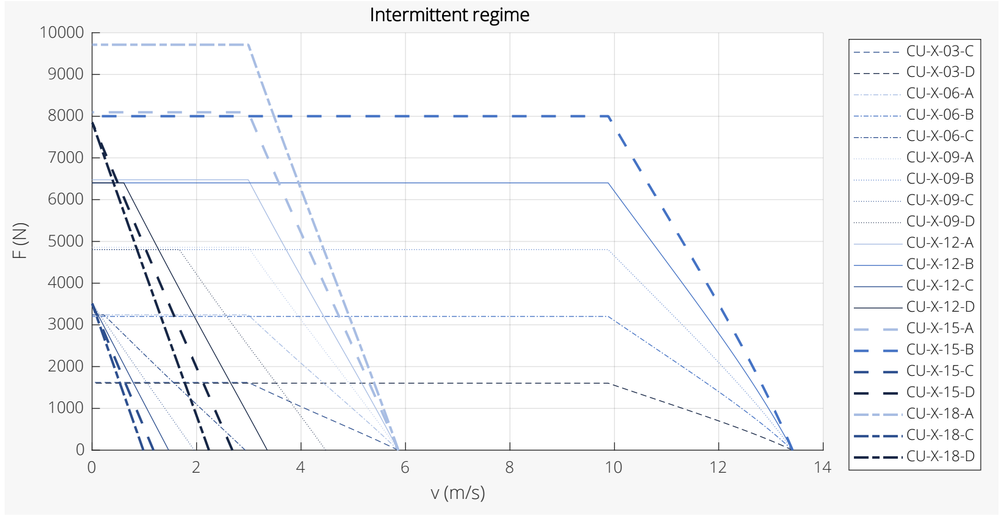


Force-Velocity Diagrams Size L Intermittent Regime

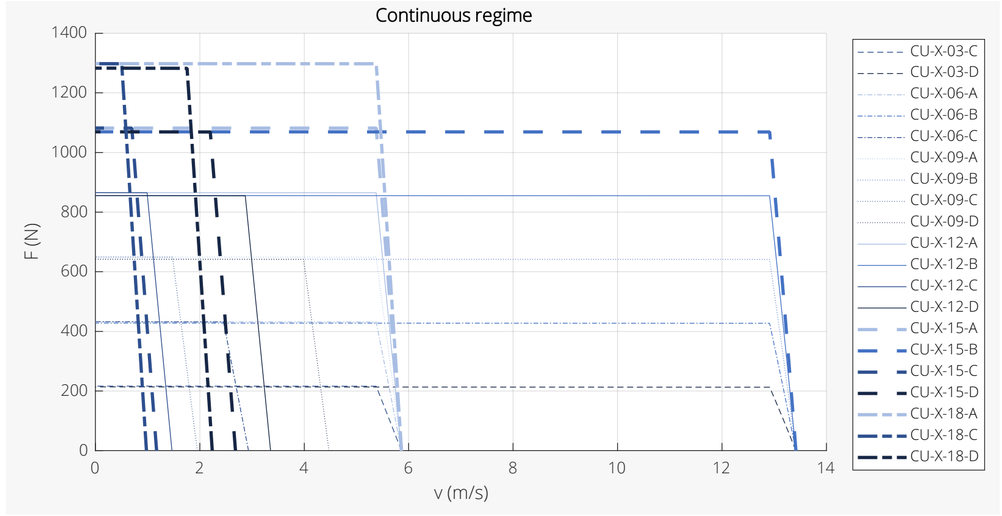


Force-Velocity Diagrams Size L Continuous Regime

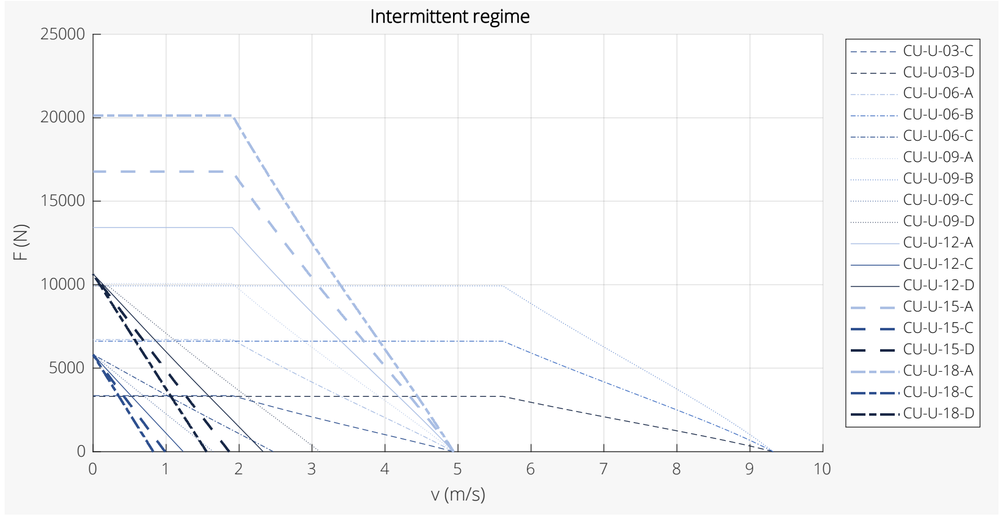
PHOENIX-X/U FORCE-VELOCITY DIAGRAMS



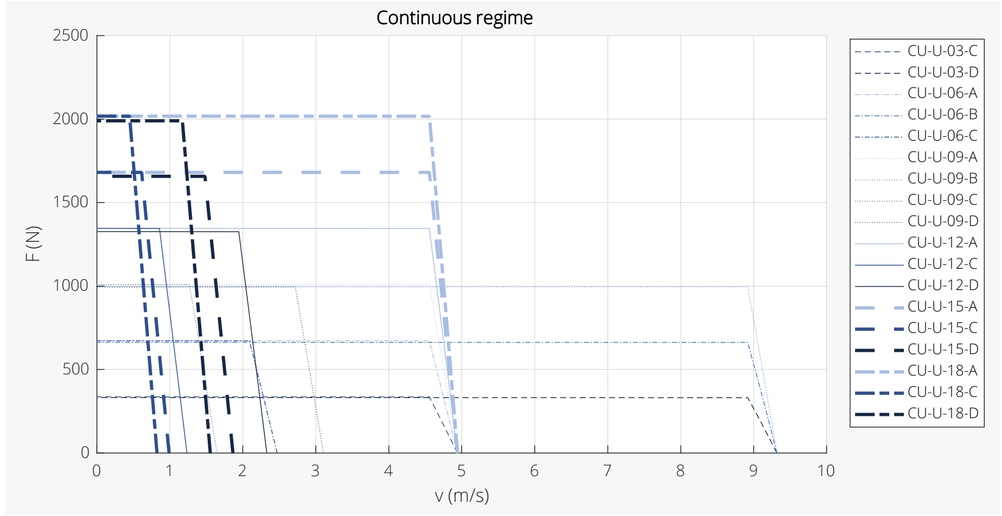
Force-Velocity Diagrams Size X Intermittent Regime



Force-Velocity Diagrams Size X Continuous Regime



Force-Velocity Diagrams Size U Intermittent Regime



Force-Velocity Diagrams Size U Continuous Regime

PHOENIX COMMUTATION SENSORS

Phoenix-S commutation sensor (Phoenix-CS-S)

- For correct operation of a linear motor, the commutation angle (the electrical angle between the coil unit and the magnet yoke) should be known. This commutation angle is needed to determine the phase angle of the three phase currents.

- The commutation angle can be derived from the relative displacement, for example using a position sensor. However, the Phoenix commutation sensor can directly measure the commutation angle without the need of a position sensor. The Phoenix commutation sensor can be directly attached to the coil unit which provides a cost-effective alternative to measure the commutation angle.

- The Phoenix commutation sensor contains three digital Hall sensors, each shifted by 120 electrical degrees, from which the commutation angle can be derived. Commutation sensors are available for each size of Phoenix (S/M/L/X/U).

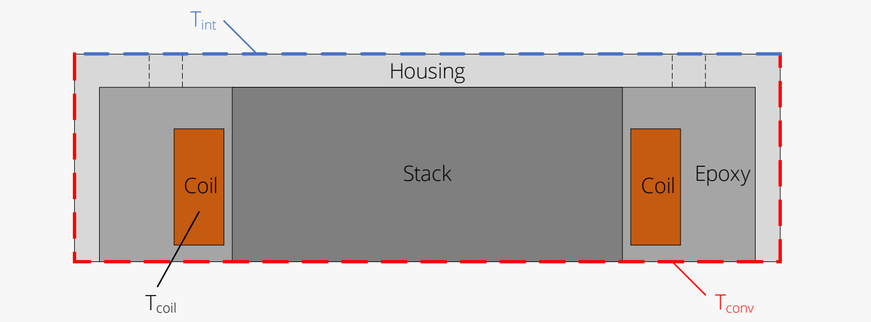
- The commutation sensor allows a supply voltage range between 4.5 Vdc and 28 Vdc.

DEFINITIONS

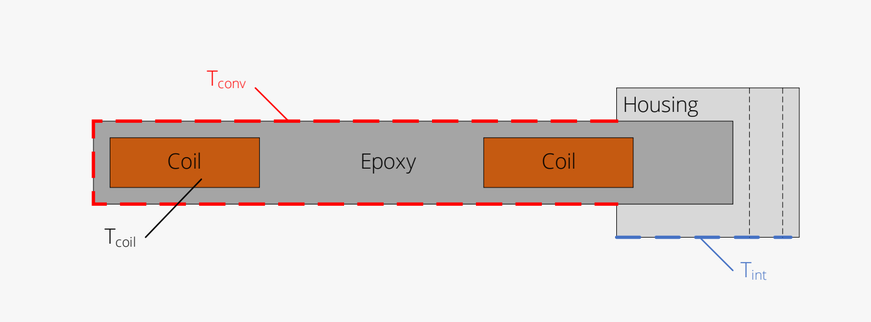
Parameter	Symbol / Equation	Unit	Remarks
Coil temperature	T_{coil}	°C	Average temperature over the complete coil volume
Interface temperature	T_{int}	°C	Average temperature over the complete interface surface
Convective surface temperature	T_{conv}	°C	Average temperature over the complete convective surface
Thermal resistance	$R_{th,i}$	K/W	From average coil temperature to average interface temperature
Thermal resistance	$R_{th,c}$	K/W	From average coil temperature to average convective surface temperature
Thermal time constant	τ_{th}	s	The time to reach 63.7% of the steady state temperature considering T_{int} = 20°C

The actual continuous force is strongly dependent on the cooling conditions available in the application. Depending on the situation (vacuum environment, natural convection, forced convection or other), the thermal resistances of the coil unit ($R_{th,i}$ and $R_{th,c}$) should be combined with the thermal resistances of the cooling interfaces to determine the overall thermal resistance (R_{th}). This overall thermal resistance provides the maximum dissipated power and continuous force.

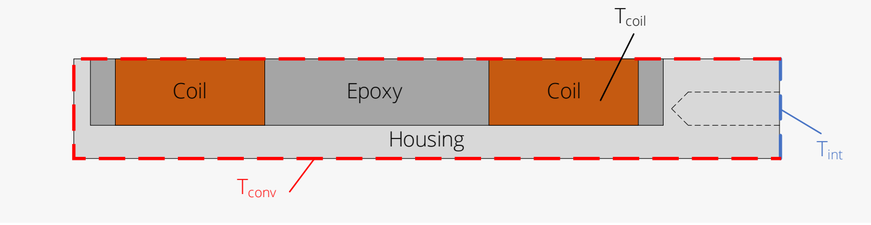
Please contact us for any support to calculate your specific application.



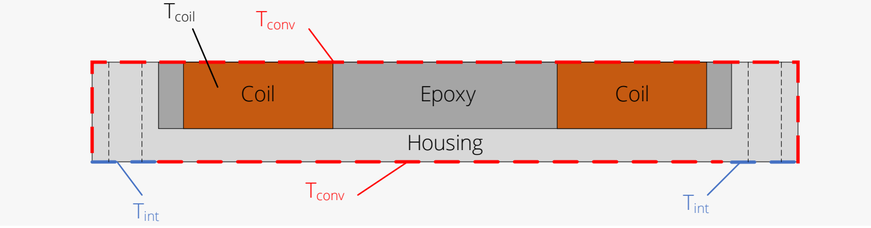
Chiron temperature definitions



Phoenix / Gryphon temperature definitions



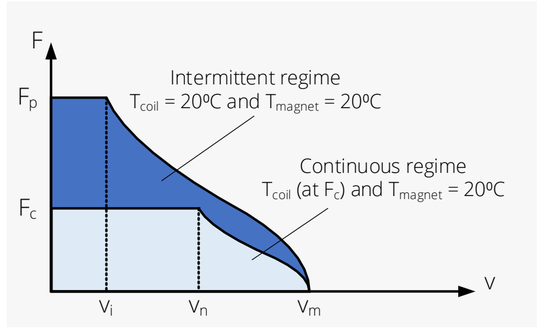
Iris-S temperature definitions



Iris-M/L temperature definitions

DEFINITIONS

Description	Equation	Unit	Remarks
Phase resistance at T_{coil}	$R_{ph} = R_{ph,20}\left(1+0.0039(T_{coil}-20)\right)$	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	$P_{d,c} = (T_{coil}-T_{int})/R_{th,i}$	W	Only copper losses are considered. This catalog considers T_{int} = 20ºC and only heat dissipation towards the interface.
Peak dissipation	$P_{d,p} = C_{th}\alpha_T$	W	α_T is mentioned at the peak force specification. C_{th} is the heat capacitance of the coils only and not specified seperately in the catalog.
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).
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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