

Data:			
Load	Qmax=	90	[N]
Stroke	Lmax=	50	[mm]
Stroke Speed	Vmax=	2	[mm/s]
Resolution	Δs=	1	[μm]

Pusher Rod diameter calculation:

L1=	10	[mm]	
L2=	30	[mm]	
L3=	55	[mm]	added safety length 5mm
Lb=	60	[mm]	
L3<Lb			
LT=	95	[mm]	total length of pusher
given:			
E=	210000	MPa	
b=	2		
k=	3		
Fmax=Fcr=	270	[N]	k*Qmax
dmin=	2.783488	[mm]	I chose M4 thread
dmin=	4	[mm]	

Material calculations:

qcr=	44.3706	MPa
qcr<=kcr		
kcr=0.5Re		
2kcr=Re=	88.7412	MPa
Re=	88.7412	MPa
Material:	10S20 (A11)	

Efficiency calculation:

n(nut)=	171.4286	[rot/min]	
i(red)	31.5		the whole reduction of the system
i(gear trans)	1.166667		gear ratio in our project
n(gear trans)	0.9		
n(red)	73.899		efficiency of gear system
y	0.062771		
p'	0.215971		
n(np)	0.21962		efficiency of pusher
n(LMM)	16.22971		efficiency of the whole LMM

Power requirement:

N(pusher)	0.18	[W]	Power to start the pusher movement
N(cal)	1.109077	[W]	
1.441800052	<P(dc)<	1.663615445	

initial assumptions for motor calculation:

n(motor)	5500	[rot/min]	motor speed
n(gearhead)	0.75		efficiency of gear head

Properties of chosen components

n(motor)	5500	[rot/min]	motor speed
i(gh)	27		gear head reduction
n(gh)	82.11		efficiency of gearhead
M(motor)	6.6	[mNm]	Max Continuous Torque
P(out)	5.2	[W]	Output Power

thread data:

thread	P[mm]	d2	dr	d1
M4	0.7	4	3	3

Torque requirement:

M(nut)	45.65502	[mNm]	required torque to rotate nut
M(red)	6.599419	[mNm]	required torque of dc motor

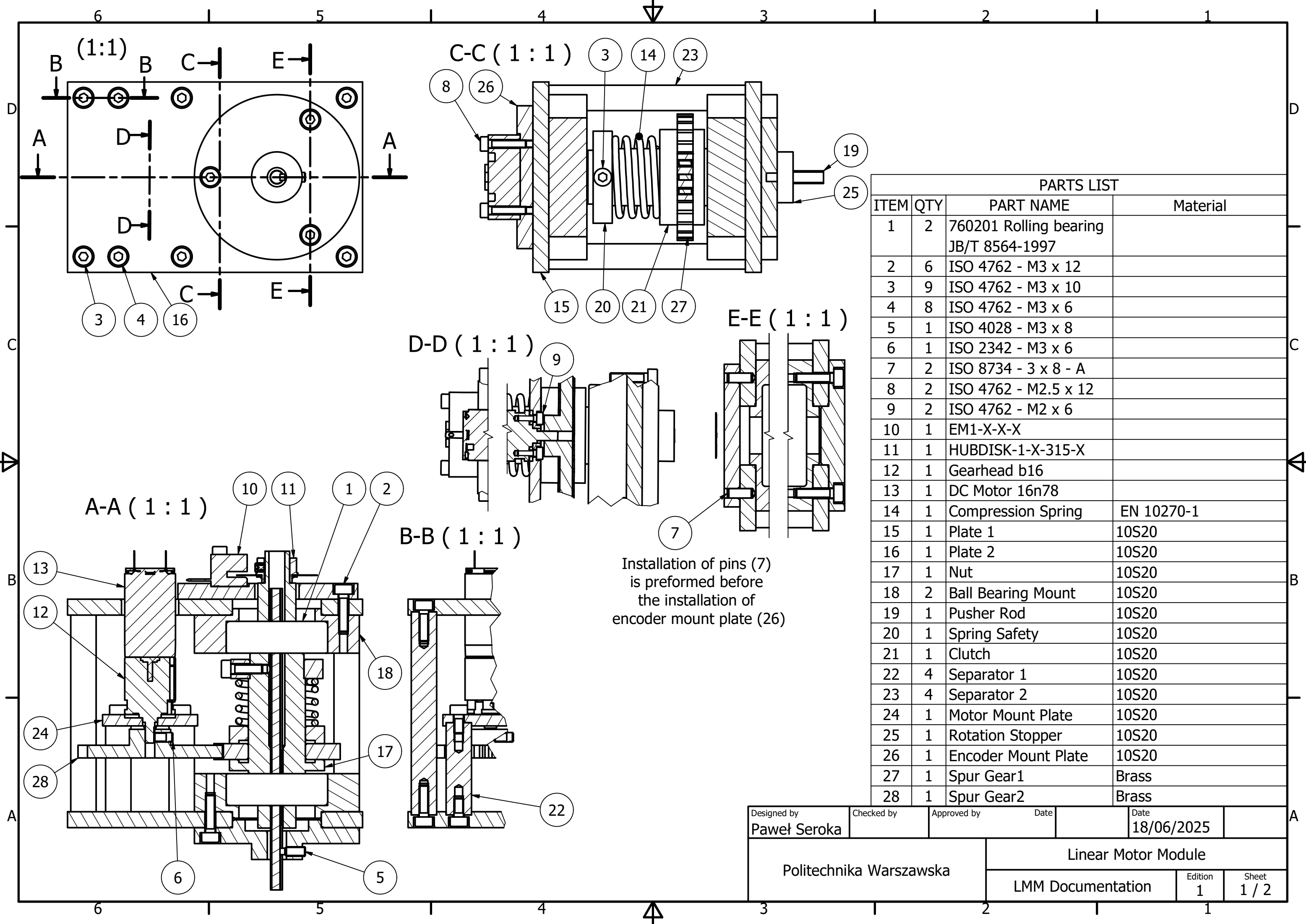
Encoder calculation:

encoder nuber of impulses =700

I chose:	B16-0-27	gear head
	16N78-212E	dc motor
	HEDS-6140#B13	encoder

For the design:

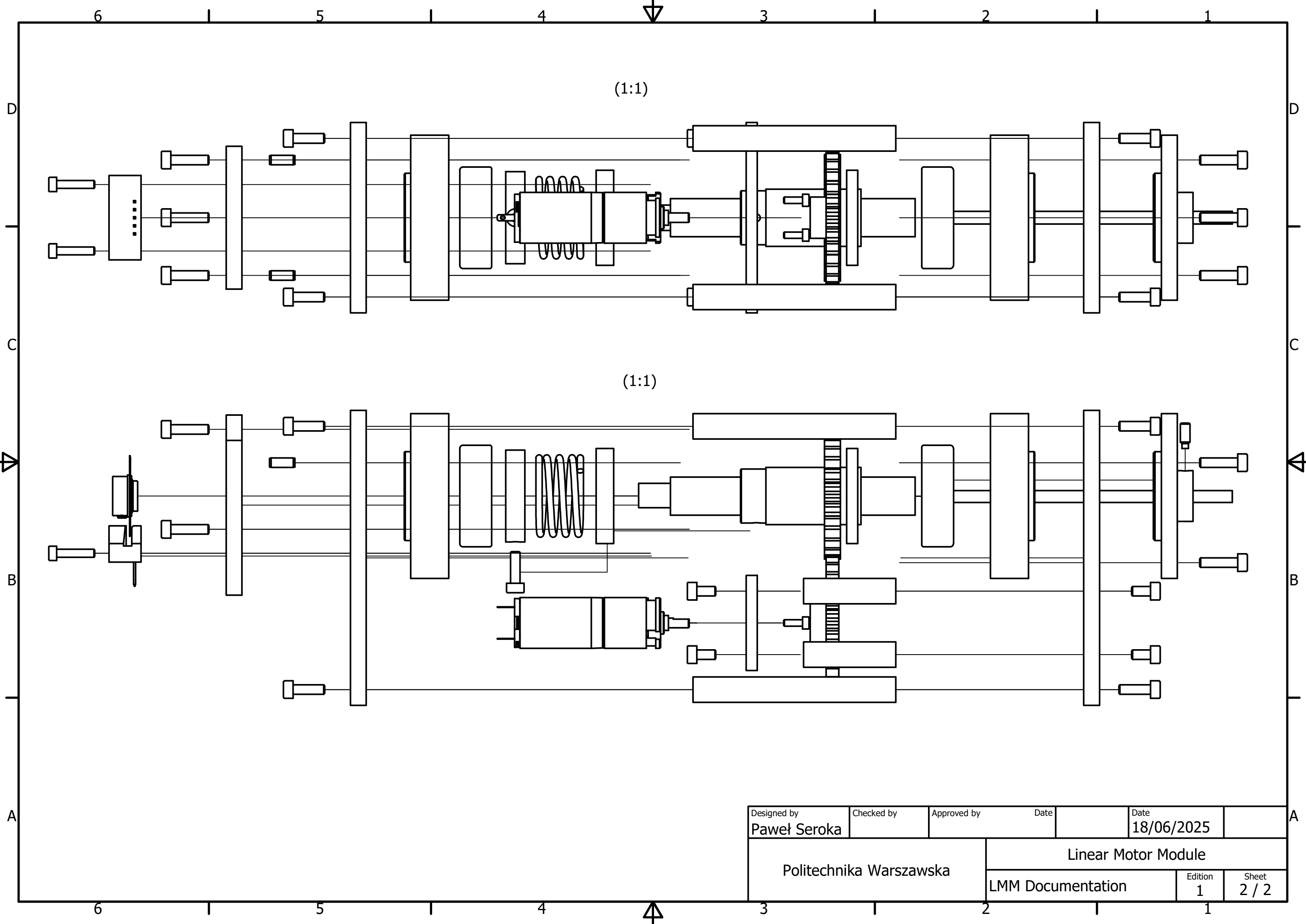
dmin=	2.783488	[mm]
i(gear trans)	1.166667	



PARTS LIST			
ITEM	QTY	PART NAME	Material
1	2	760201 Rolling bearing JB/T 8564-1997	
2	6	ISO 4762 - M3 x 12	
3	9	ISO 4762 - M3 x 10	
4	8	ISO 4762 - M3 x 6	
5	1	ISO 4028 - M3 x 8	
6	1	ISO 2342 - M3 x 6	
7	2	ISO 8734 - 3 x 8 - A	
8	2	ISO 4762 - M2.5 x 12	
9	2	ISO 4762 - M2 x 6	
10	1	EM1-X-X-X	
11	1	HUBDISK-1-X-315-X	
12	1	Gearhead b16	
13	1	DC Motor 16n78	
14	1	Compression Spring	EN 10270-1
15	1	Plate 1	10S20
16	1	Plate 2	10S20
17	1	Nut	10S20
18	2	Ball Bearing Mount	10S20
19	1	Pusher Rod	10S20
20	1	Spring Safety	10S20
21	1	Clutch	10S20
22	4	Separator 1	10S20
23	4	Separator 2	10S20
24	1	Motor Mount Plate	10S20
25	1	Rotation Stopper	10S20
26	1	Encoder Mount Plate	10S20
27	1	Spur Gear1	Brass
28	1	Spur Gear2	Brass

Installation of pins (7)
is preformed before
the installation of
encoder mount plate (26)

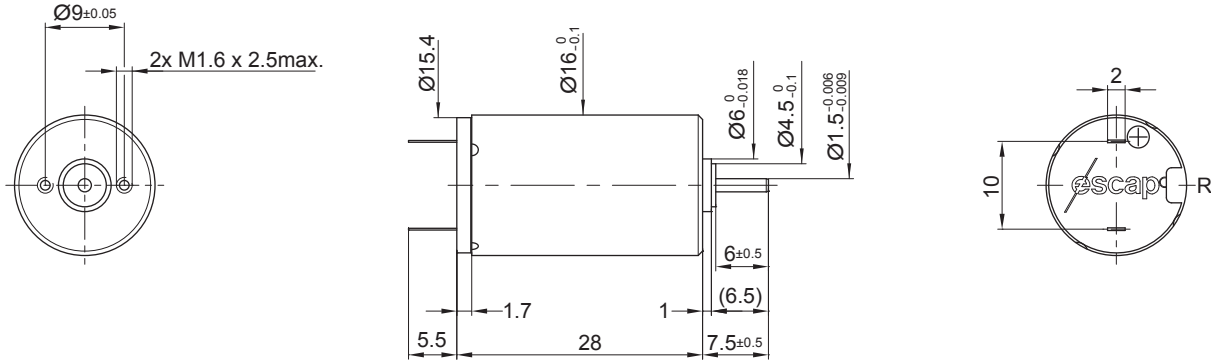
Designed by Paweł Seroka	Checked by	Approved by	Date 18/06/2025
Politechnika Warszawska		Linear Motor Module	
		LMM Documentation	Edition 1 Sheet 1 / 2



Designed by Paweł Seroka	Checked by	Approved by	Date	18/06/2025	
Politechnika Warszawska			Linear Motor Module		
			LMM Documentation	Edition 1	Sheet 2 / 2

16N78 Athlonix™

Ø 16 mm • Precious metal commutation • 6.9 mNm



Dimensions in inches [mm]

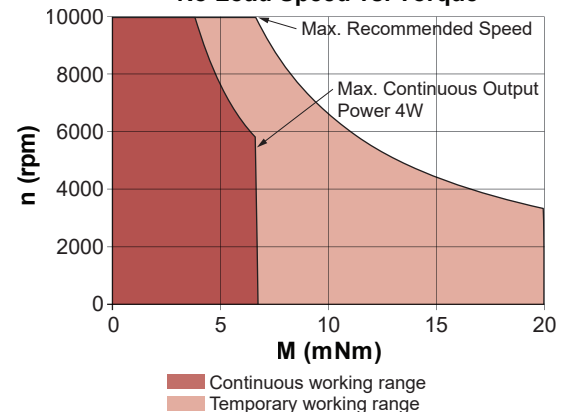
Electrical Data	Symbol	16N781001						Unit
		135	212P	214E	212E	210E	208E	
1 Nominal Voltage	V	1.5	6	9	12	18	24	Volt
2 No-Load Speed	n_0	7,894	8,350	8,275	8,380	8,530	8,200	rpm
3 No-Load Current	I_0	90.0	18.0	10.0	5.0	5.0	4.0	mA
4 Terminal Resistance	R	0.2	3.0	7.5	13.2	27.5	60.5	Ω
5 Output Power	$P_{2max.}$	4.7	5.4	5.2	5.2	4.9	4.9	W
6 Stall Torque	mNm	13.5 (1.91)	13.6 (1.93)	12.4 (1.76)	12.4 (1.76)	13.1 (1.86)	11 (1.56)	mNm (oz-in)
7 Efficiency	$\eta_{max.}$	83	82	83	86	83	81	%
8 Max Continuous Speed	$n_{e max.}$	10,000	10,000	10,000	10,000	10,000	10,000	rpm
9 Max Continuous Torque	$M_{e max.}$	6 (0.98)	6.9 (0.98)	6.6 (0.94)	6.6 (0.94)	6.2 (0.88)	6.3 (0.9)	mNm (oz-in)
10 Max Continuous Current	$I_{e max.}$	3.41	1.03	0.65	0.49	0.34	0.23	A
11 Back-EMF Constant	k_E	0.19	0.71	1.08	1.42	2.09	2.90	mV/rpm
12 Torque Constant	k_M	1.80	6.80	10.30	13.60	20.00	27.70	mNm/A
13 Motor Regulation	R/k^2	62.0	64.9	70.7	71.37	69.0	78.85	10 ³ /Nms
14 Friction Torque	T_F	0.09 (0.02)	0.12 (0.02)	0.1 (0.02)	0.07 (0.01)	0.09 (0.02)	0.08 (0.02)	mNm (oz-in)
15 Rotor Inductance	L	0.01	0.10	0.30	0.50	1.00	2.40	mH
16 Mechanical Time Constant	τ_m	6.8	6.8	8.8	8.6	8.3	9.3	ms
17 Rotor Inertia	J	1.10	1.05	1.25	1.20	1.20	1.18	g-cm ²

General Data

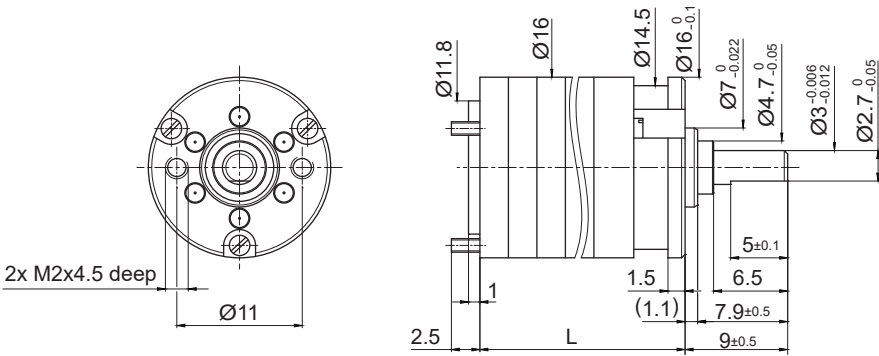
18 Thermal Resistance (rotor/body)	R_{th1}/R_{th2}	6/25						°C/W
19 Thermal Time Constant (rotor/stator)	t_{W1}/t_{W2}	12/250						S
20 Operating Temperature Range:	motor	-30°C to 85°C (-22°F to 185°F) 100°C (212°F)						°C (°F)
	rotor							°C (°F)
21 Shaft Load Max.: (5 mm from bearing)	-radial	With sleeve bearings						N (oz)
								N (oz)
	-axial	1.5 (5.4)						N (oz)
22 Shaft Play:	-radial	100 (359.6)						mm (inch)
	-axial	<0.03 (0.0012)						mm (inch)
	-axial	0.15 (0.0059)						mm (inch)
23 Weight	g	24 (0.85)						g (oz)
24 Commutation Segment	-	9						segment

Execution Table

Gearbox	Single Shaft	MR2
B16	1005	1008
BA16	1005	1008
R16	1001	1007

No Load Speed vs. Torque

► Motor shaft rotates CW when seen from motor front face when +ve and -ve supply is given to respective terminals.

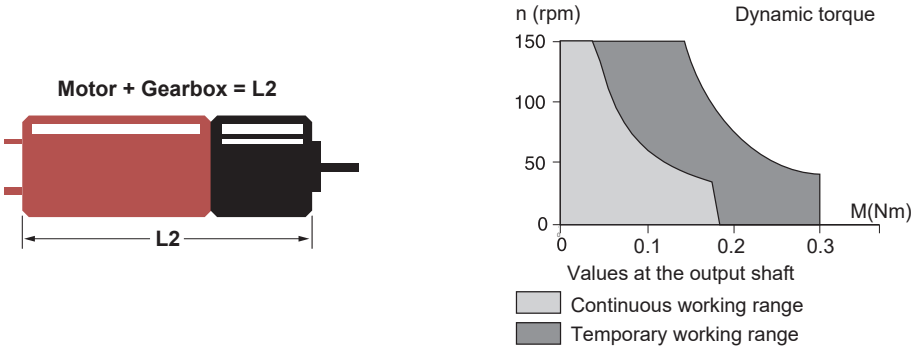


Dimensions in mm

Ratio	5	9	15	27	45	81	135	141	243	405	729	1215	2187
1 Number of Gear Stages	2	2	3	3	4	4	5	5	5	6	6	7	7
2 Direction of Rotation	=	=	≠	≠	=	=	≠	≠	≠	=	=	≠	≠
3 Efficiency	0.81	0.81	0.73	0.73	0.65	0.65	0.59	0.59	0.59	0.53	0.53	0.48	0.48
4 L (mm)	10.5	10.5	13	13	15.5	15.5	18	18	18	20.5	20.5	23	23
5 Weight	g (oz)	7 (0.246)	7 (0.246)	8 (0.282)	8 (0.282)	9 (0.317)	9 (0.317)	10 (0.352)	10 (0.352)	10 (0.352)	11 (0.388)	11 (0.388)	12 (0.423)

6 Available with Motor – L2 - Length with motor (mm)	5	9	15	27	45	81	135	141	243	405	729	1215	2187
16C18	29.2	29.2	31.7	31.7	34.2	34.2	36.7	36.7	36.7	39.2	39.2	41.7	41.7
16N78	41.5	41.5	44	44	46.5	46.5	49	49	49	51.5	51.5	54	54
16G88	41.5	41.5	44	44	46.5	46.5	49	49	49	51.5	51.5	54	54
17S78	32.2	32.2	34.7	34.7	37.2	37.2	39.7	39.7	39.7	42.2	42.2	44.7	44.7
17N78	39.4	39.4	41.9	41.9	44.4	44.4	47.9	47.9	47.9	49.4	49.4	51.9	51.9
P110	29.5	29.5	32	32	34.5	34.5	37	37	37	39.5	39.5	42	42
16DCP/16DCT/17DCT CB	39.5	39.5	42	42	44.5	44.5	47	47	47	49.5	49.5	52	52
16DCP/16DCT/17DCT PM	39	39	41.5	41.5	44	44	46.5	46.5	46.5	49	49	51.5	51.5

Characteristics	5	B16 • 0 •	B16 2R • 0 •
7 Shaft Bearings		Sleeve	Ball Bearing
8 Maximum Static Torque	Nm (oz-in)	0.3 (42)	0.3 (42)
9 Maximum Radial Force @ 8mm from mounting face	N (lb)	5 (1.1)	10 (2.2)
10 Maximum Axial Force	N (lb)	5 (1.1)	10 (2.2)
11 Maximum Press Fit Force	N (lb)	100 (23)	100 (23)
12 Average Backlash @ no-load		1.5°	1.5°
13 Average Backlash @ 0.3 Nm		3°	3°
Shaft Play:			
14 -radial	µm	≤ 20	≤ 10
15 -axial	µm	50-150	≤ 100
16 Maximum Recommended Input Speed	rpm	8000	8000
17 Operating Temperature Range:	°C (°F)	-30 to +65 (-22 to +150)	





HUBDISK-1 Features

- 1 in. disk with hub
- 32 to 5,000 CPR (128 to 20,000 PPR)



HUBDISK-1 Product Description

US Digital offers a wide variety of standard HubDisk assemblies (optical encoder disk attached to an aluminum hub) to aid mounting onto a shaft. Encoder disks may also be ordered as stand-alone items. The rotary encoder disks are made from 0.007 in. thick Mylar polyester film, and the material allows for a -40C to 100C temperature range. The disk on the HubDisk assembly comes attached with the emulsion side up when the disk text is right-reading.



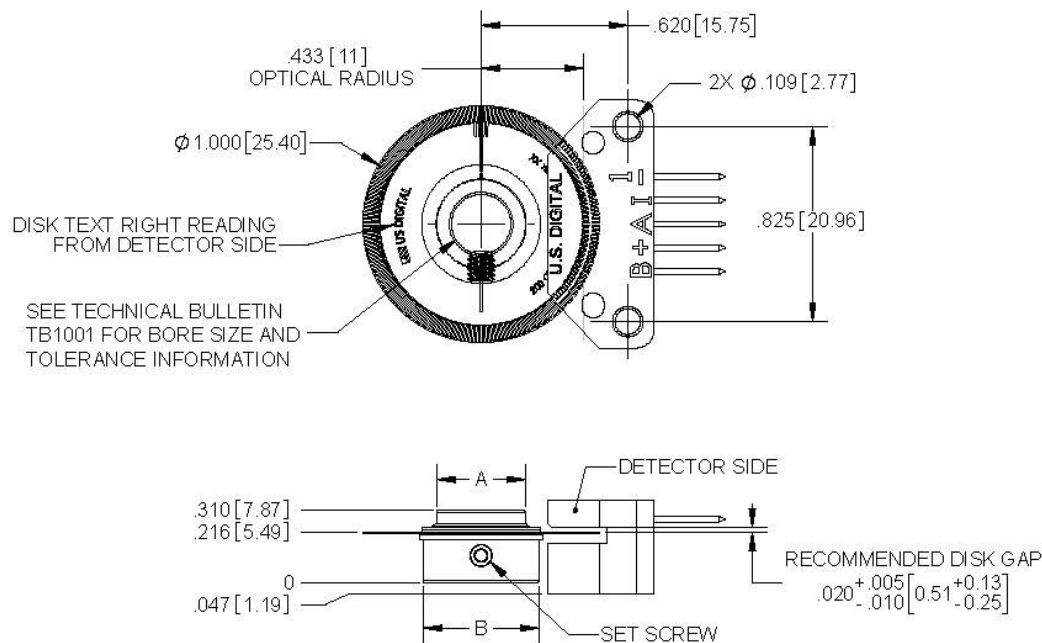
HUBDISK-1 consists of a precision machined aluminum hub fastened to a 1 in. diameter optical encoder disk (DISK-1 (<https://www.usdigital.com/disk-1>)). One .050 in. flat-to-flat set screw is used to fasten the hub to a shaft. The HubDisk assembly is available with bore sizes ranging from 2mm to 10mm. All HubDisk assembly bores are held to a very tight tolerance defined by US Digital Technical Bulletin, Shaft and Bore Tolerances TB1001

(<https://www.usdigital.com/support/resources/reference/technical-docs/technical-bulletins/shaft-and-bore-tolerances-tb1001/>).

Mechanical Drawings

HUBDISK-1 1" Transmissive Rotary Codewheel

RELEASE DATE: 10/23/2019



	SHAFT SIZES	
	2MM-8MM	.375 & 10MM
A	ϕ .375 [9.53]	ϕ .441 [11.20]
B	ϕ .487 [12.37]	ϕ .500 [12.70]



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Specifications

SPECIFICATIONS

Temperature Range	-40C to 100C
Hub Set Screw Torque	2-3 in-lbs
Bore Diameter Tolerance	See Technical Bulletin TB1001 (https://www.usdigital.com/support/resources/reference/technical-docs/technical-bulletins/shaft-and-bore-tolerances-tb1001/)
Outside Disk Diameter (OD)	1" \pm 0.010 in.
Disk Thickness	0.007"

TECHNICAL BULLETINS

TITLE	DOWNLOAD
Technical Bulletin TB1001 - Shaft and Bore Tolerances	Download (https://www.usdigital.com/support/resources/reference/technical-docs/technical-bulletins/shaft-and-bore-tolerances-tb1001/)

COMPATIBLE ENCODER MODULES

CPR	1" HUBDISK Non-Index	MODULE Non-Index	1" HUBDISK Index	MODULE Index
32	HUBDISK-1-32-*-NE	EM1-1-32-N		
50	HUBDISK-1-50-*-NE	EM1-1-50-N	HUBDISK-1-50-*-IE	EM1-1-50-I
96	HUBDISK-1-96-*-NE	EM1-1-100-N	HUBDISK-1-96-*-IE	EM1-1-100-I
100	HUBDISK-1-100-*-NE	EM1-1-100-N	HUBDISK-1-100-*-IE	EM1-1-100-I
120	HUBDISK-1-120-*-NE	EM1-1-100-N		
200	HUBDISK-1-200-*-NE	EM1-1-200-N	HUBDISK-1-200-*-IE	EM1-1-200-I
192	HUBDISK-1-192-*-NE	EM1-1-200-N	HUBDISK-1-192-*-IE	EM1-1-200-I
250	HUBDISK-1-250-*-NE	EM1-1-250-N	HUBDISK-1-250-*-IE	EM1-1-250-I
256	HUBDISK-1-256-*-NE	EM1-1-250-N	HUBDISK-1-256-*-IE	EM1-1-250-I
360	HUBDISK-1-360-*-NE	EM1-1-360-N	HUBDISK-1-360-*-IE	EM1-1-360-I
400	HUBDISK-1-400-*-NE	EM1-1-400-N	HUBDISK-1-400-*-IE	EM1-1-400-I
500	HUBDISK-1-500-*-NE	EM1-1-500-N	HUBDISK-1-500-*-IE	EM1-1-500-I
512	HUBDISK-1-512-*-NE	EM1-1-512-N	HUBDISK-1-512-*-IE	EM1-1-512-I
540	HUBDISK-1-540-*-NE	EM1-1-540-N	HUBDISK-1-540-*-IE	EM1-1-540-I
720	HUBDISK-1-720-*-NE	EM1-1-720-N	HUBDISK-1-720-*-IE	EM1-1-720-I
800	HUBDISK-1-800-*-NE	EM1-1-800-N	HUBDISK-1-800-*-IE	EM1-1-800-I



HUBDISK-1 1 in. Transmissive Rotary Disk

900	HUBDISK-1-900-*-NE	EM1-1-900-N	HUBDISK-1-900-*-IE	EM1-1-900-I
1000	HUBDISK-1-1000-*-NE	EM1-1-1000-N	HUBDISK-1-1000-*-IE	EM1-1-1000-I
1024	HUBDISK-1-1024-*-NE	EM1-1-1024-N	HUBDISK-1-1024-*-IE	EM1-1-1024-I
2000			HUBDISK-1-2000-*-IE	EM2-1-2000-I
2048			HUBDISK-1-2048-*-IE	EM2-1-2048-I
2500			HUBDISK-1-2500-*-IE	EM2-1-2500-I
4000			HUBDISK-1-4000-*-IE	EM2-1-4000-I
4096			HUBDISK-1-4096-*-IE	EM2-1-4096-I
5000			HUBDISK-1-5000-*-IE	EM2-1-5000-I

*Represents the bore size

Notes

- US Digital® warrants its products against defects in materials and workmanship for two years. See complete warranty (<https://www.usdigital.com/company/warranty>) for details.

Configuration Options

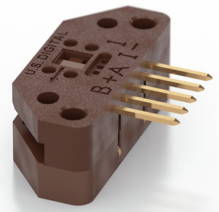
HUBDISK-1	CPR (Cycles Per Revolution)	Bore Size	Index
	32	079 (2.0mm)	IE (Index)
	50	118 (3.0mm)	I (Index)
	96	125 (1/8")	NE (Non-Index)
	100	156 (5/32")	
	120	157 (4.0mm)	
	192	188 (3/16")	
	200	197 (5.0mm)	
	250	236 (6.0mm)	
	256	250 (1/4")	
	360	276 (7.0mm)	
	400	313 (5/16")	
	500	315 (8.0mm)	
	512	375 (3/8")	
	540	394 (10.0mm)	
	720		
	800		
	900		
	1000		
	1024		
	1250		
	2000		
	2048		
	2500		
	4000		
	4096		
	5000		

PLEASE NOTE: This chart is for informational use only. Certain product configuration combinations are not available. Visit the HUBDISK-1 product page (<https://www.usdigital.com/products/HUBDISK-1>) for pricing and additional information.



EM1_WEB Features

- Two-channel quadrature with optional index
- Improved replacement for HEDS-9000 Series
- Single 5 VDC supply
- Resolutions from 32 to 2,500 CPR
- Internal decoupling capacitor
- Sink/source 8mA outputs



EM1 Product Description

The EM1 is a transmissive optical encoder module designed to detect rotary or linear position when paired together with an encoder disk or linear strip. The EM1 consists of a lensed LED source and a monolithic detector IC enclosed in a small polymer package. The EM1 uses phased array detector technology to provide superior performance and greater tolerances over traditional aperture mask-type encoders.



The EM1 provides digital A & B quadrature outputs with an optional third output index channel. Each EM1 module is resolution-specific and is matched to the resolution of an encoder disk or linear strip. The EM1 module now supports all standard resolutions offered by the HEDS-9000 series encoder module and additional resolutions. The EM1 operates with a single 5V supply and provides single-ended outputs capable of sinking and sourcing 8mA. An internal 0.1 μ F decoupling capacitor is designed into the EM1 to provide enhanced noise immunity over the HEDS-9000 series encoder modules.

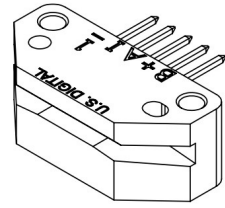
For open collector and higher voltage applications, add the PC3 (<https://www.usdigital.com/products/accessories/interfaces/cable-drivers/pc3/>) cable driver, or for differential cable driver outputs, add the PC4 (<https://www.usdigital.com/products/accessories/interfaces/cable-drivers/pc4/>) cable driver. Encoder disks, linear strips, quadrature decoder chips, counter chips, computer interface boards, mating connectors, and cables are also available.

Mechanical Drawings

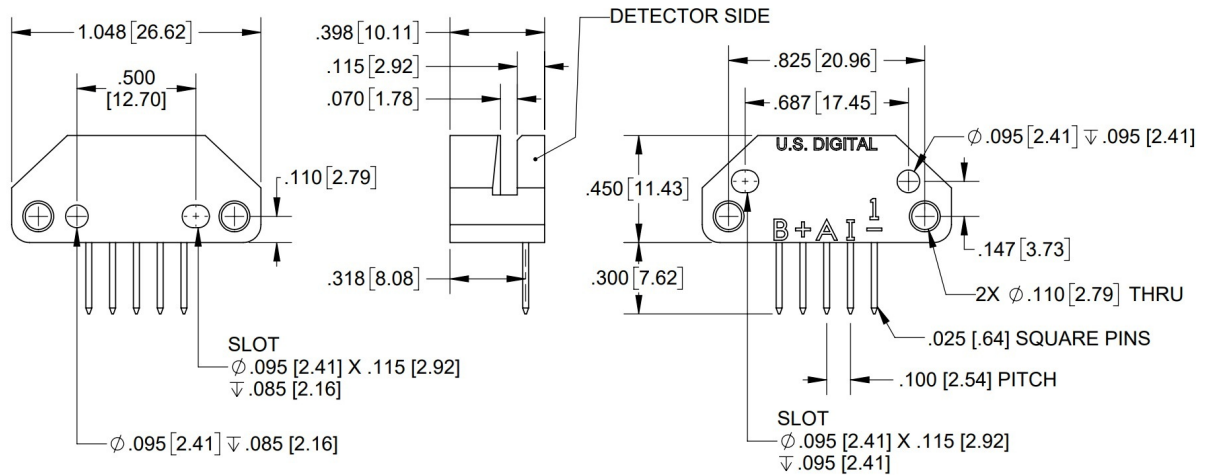


EM1 Transmissive Optical Encoder Module

EM1 Transmissive Optical Encoder Module



RELEASE DATE: 02/07/2022



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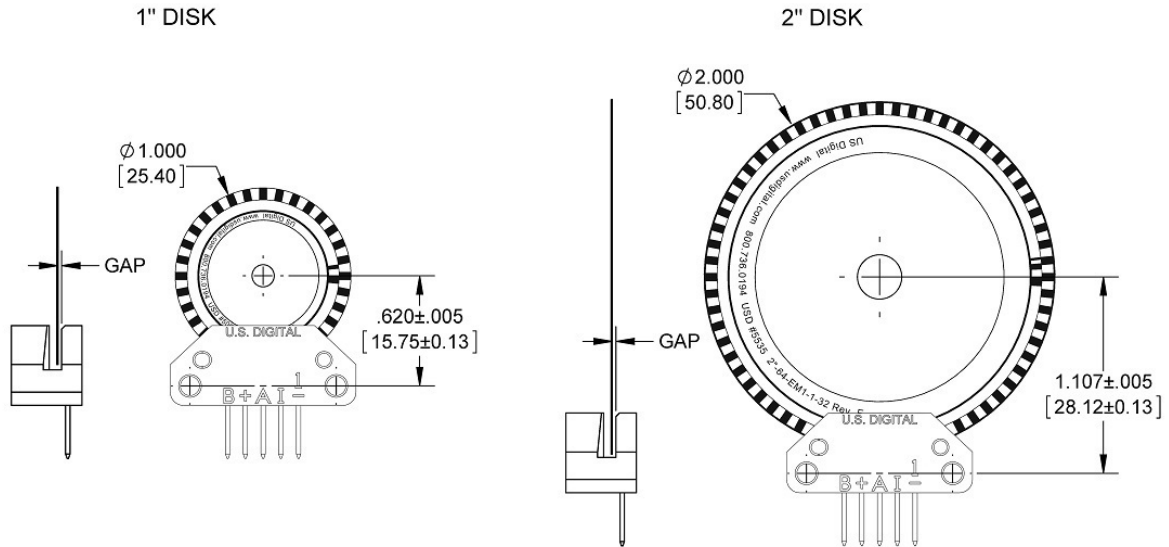
Page: 2 of 12
5/12/2025 59100
EM1



EM1 Transmissive Optical Encoder Module

EM1 Transmissive Optical Encoder Module Disk Alignment

RELEASE DATE: 04/09/2015



RECOMMENDED DISK GAP: $.020^{+.005}_{-.010}$ [0.51 \pm 0.25]
(.020 \pm .005 [0.51 \pm 0.13] FOR 32 CPR 1" DISKS OR 64 CPR 2" DISKS)



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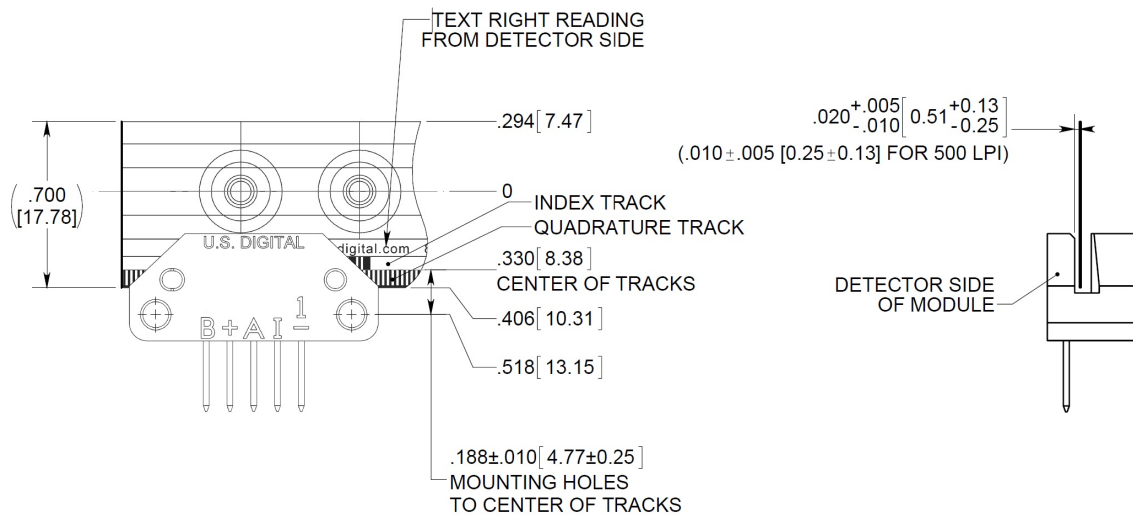
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EM1 Transmissive Optical Encoder Module

EM1 Transmissive Optical Encoder Module Linear Strip Alignment

RELEASE DATE: 04/07/2015



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Specifications

COMPATIBLE 1" & 2" DISKS

CPR	1" DISKS			
	MODULE Non-Index	1" DISK Non-Index	MODULE Index	1" DISK Index
32	EM1-1-32-N	DISK-1-32-*-NE		
50	EM1-1-50-N	DISK-1-50-*-NE	EM1-1-50-I	DISK-1-50-*-IE
96	EM1-1-100-N	DISK-1-96-*-NE	EM1-1-100-I	DISK-1-96-*-IE
100	EM1-1-100-N	DISK-1-100-*-NE	EM1-1-100-I	DISK-1-100-*-IE
120	EM1-1-100-N	DISK-1-120-*-NE		
192	EM1-1-200-N	DISK-1-192-*-NE	EM1-1-200-I	DISK-1-192-*-IE



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5/12/2025 59100
EM1



EM1 Transmissive Optical Encoder Module

200	EM1-1-200-N	DISK-1-200-*-NE	EM1-1-200-I	DISK-1-200-*-IE
250	EM1-1-250-N	DISK-1-250-*-NE	EM1-1-250-I	DISK-1-250-*-IE
256	EM1-1-250-N	DISK-1-256-*-NE	EM1-1-250-I	DISK-1-256-*-IE
360	EM1-1-360-N	DISK-1-360-*-NE	EM1-1-360-I	DISK-1-360-*-IE
400	EM1-1-400-N	DISK-1-400-*-NE	EM1-1-400-I	DISK-1-400-*-IE
500	EM1-1-500-N	DISK-1-500-*-NE	EM1-1-500-I	DISK-1-500-*-IE
512	EM1-1-512-N	DISK-1-512-*-NE	EM1-1-512-I	DISK-1-512-*-IE
540	EM1-1-540-N	DISK-1-540-*-NE	EM1-1-540-I	DISK-1-540-*-IE
720	EM1-1-720-N	DISK-1-720-*-NE	EM1-1-720-I	DISK-1-720-*-IE
800	EM1-1-800-N	DISK-1-800-*-NE	EM1-1-800-I	DISK-1-800-*-IE
900	EM1-1-900-N	DISK-1-900-*-NE	EM1-1-900-I	DISK-1-900-*-IE
1000	EM1-1-1000-N	DISK-1-1000-*-NE	EM1-1-1000-I	DISK-1-1000-*-IE
1024	EM1-1-1024-N	DISK-1-1024-*-NE	EM1-1-1024-I	DISK-1-1024-*-IE
1250	EM1-1-1250-N	DISK-1-1250-*-NE	EM1-1-1250-I	DISK-1-1250-*-IE
*Represents the bore size				

2" DISKS

CPR	MODULE Non-Index	2" DISK Non-Index	MODULE Index	2" DISK Index
64	EM1-1-32-N	DISK-2-64-*-NE		
100	EM1-1-50-N	DISK-2-100-*-NE	EM1-1-50-I	DISK-2-100-*-IE
200	EM1-1-100-N	DISK-2-200-*-NE	EM1-1-100-I	DISK-2-200-*-IE
400	EM1-1-200-N	DISK-2-400-*-NE	EM1-1-200-I	DISK-2-400-*-IE
500	EM1-2-500-N	DISK-2-500-*-NE	EM1-2-500-I	DISK-2-500-*-IE
512	EM1-2-500-N	DISK-2-512-*-NE	EM1-2-500-I	DISK-2-512-*-IE
800	EM1-1-400-N	DISK-2-800-*-NE	EM1-1-400-I	DISK-2-800-*-IE
1000	EM1-2-1000-N	DISK-2-1000-*-NE	EM1-2-1000-I	DISK-2-1000-*-IE
1024	EM1-2-1024-N	DISK-2-1024-*-NE	EM1-2-1024-I	DISK-2-1024-*-IE
1800	EM1-2-1800-N	DISK-2-1800-*-NE	EM1-2-1800-I	DISK-2-1800-*-IE
2000	EM1-2-2000-N	DISK-2-2000-*-NE	EM1-2-2000-I	DISK-2-2000-*-IE
2048	EM1-2-2048-N	DISK-2-2048-*-NE	EM1-2-2048-I	DISK-2-2048-*-IE
2500	EM1-2-2500-N	DISK-2-2500-*-NE	EM1-2-2500-I	DISK-2-2500-*-IE
*Represents the bore size				



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COMPATIBLE 1" & 2" HUBDISKS

1" HUBDISKS				
CPR	MODULE Non-Index	1" HUBDISK Non-Index	MODULE Index	1" HUBDISK Index
32	EM1-1-32-N	HUBDISK-1-32-*-NE		
50	EM1-1-50-N	HUBDISK-1-50-*-NE	EM1-1-50-I	HUBDISK-1-50-*-IE
96	EM1-1-100-N	HUBDISK-1-96-*-NE	EM1-1-100-I	HUBDISK-1-96-*-IE
100	EM1-1-100-N	HUBDISK-1-100-*-NE	EM1-1-100-I	HUBDISK-1-100-*-IE
120	EM1-1-100-N	HUBDISK-1-120-*-NE		
192	EM1-1-200-N	HUBDISK-1-192-*-NE	EM1-1-200-I	HUBDISK-1-192-*-IE
200	EM1-1-200-N	HUBDISK-1-200-*-NE	EM1-1-200-I	HUBDISK-1-200-*-IE
250	EM1-1-250-N	HUBDISK-1-250-*-NE	EM1-1-250-I	HUBDISK-1-250-*-IE
256	EM1-1-250-N	HUBDISK-1-256-*-NE	EM1-1-250-I	HUBDISK-1-256-*-IE
360	EM1-1-360-N	HUBDISK-1-360-*-NE	EM1-1-360-I	HUBDISK-1-360-*-IE
400	EM1-1-400-N	HUBDISK-1-400-*-NE	EM1-1-400-I	HUBDISK-1-400-*-IE
500	EM1-1-500-N	HUBDISK-1-500-*-NE	EM1-1-500-I	HUBDISK-1-500-*-IE
512	EM1-1-512-N	HUBDISK-1-512-*-NE	EM1-1-512-I	HUBDISK-1-512-*-IE
540	EM1-1-540-N	HUBDISK-1-540-*-NE	EM1-1-540-I	HUBDISK-1-540-*-IE
720	EM1-1-720-N	HUBDISK-1-720-*-NE	EM1-1-720-I	HUBDISK-1-720-*-IE
800	EM1-1-800-N	HUBDISK-1-800-*-NE	EM1-1-800-I	HUBDISK-1-800-*-IE
900	EM1-1-900-N	HUBDISK-1-900-*-NE	EM1-1-900-I	HUBDISK-1-900-*-IE
1000	EM1-1-1000-N	HUBDISK-1-1000-*-NE	EM1-1-1000-I	HUBDISK-1-1000-*-IE
1024	EM1-1-1024-N	HUBDISK-1-1024-*-NE	EM1-1-1024-I	HUBDISK-1-1024-*-IE
1250	EM1-1-1250-N	HUBDISK-1-1250-*-NE	EM1-1-1250-I	HUBDISK-1-1250-*-IE
*Represents the bore size				
2" HUBDISKS				
CPR	MODULE Non-Index	2" HUBDISK Non-Index	MODULE Index	2" HUBDISK Index
64	EM1-1-32-N	HUBDISK-2-64-*-NE		
100	EM1-1-50-N	HUBDISK-2-100-*-NE	EM1-1-50-I	HUBDISK-2-100-*-IE
200	EM1-1-100-N	HUBDISK-2-200-*-NE	EM1-1-100-I	HUBDISK-2-200-*-IE
400	EM1-1-200-N	HUBDISK-2-400-*-NE	EM1-1-200-I	HUBDISK-2-400-*-IE



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500	EM1-2-500-N	HUBDISK-2-500*-NE	EM1-2-500-I	HUBDISK-2-500*-IE
512	EM1-2-500-N	HUBDISK-2-512*-NE	EM1-2-500-I	HUBDISK-2-512*-IE
800	EM1-1-400-N	HUBDISK-2-800*-NE	EM1-1-400-I	HUBDISK-2-800*-IE
1000	EM1-2-1000-N	HUBDISK-2-1000*-NE	EM1-2-1000-I	HUBDISK-2-1000*-IE
1024	EM1-2-1024-N	HUBDISK-2-1024*-NE	EM1-2-1024-I	HUBDISK-2-1024*-IE
1800	EM1-2-1800-N	HUBDISK-2-1800*-NE	EM1-2-1800-I	HUBDISK-2-1800*-IE
2000	EM1-2-2000-N	HUBDISK-2-2000*-NE	EM1-2-2000-I	HUBDISK-2-2000*-IE
2048	EM1-2-2048-N	HUBDISK-2-2048*-NE	EM1-2-2048-I	HUBDISK-2-2048*-IE
2500	EM1-2-2500-N	HUBDISK-2-2500*-NE	EM1-2-2500-I	HUBDISK-2-2500*-IE
*Represents the bore size				

COMPATIBLE LINEAR STRIPS

LPI	MODULE Non-Index	Linear Strip Non-Index	MODULE Index	Linear Strip Index
120	EM1-0-120-N	LIN-120*-N	EM1-0-120-I	LIN-120*-#
127	EM1-0-127-N	LIN-127*-N	EM1-0-127-I	LIN-127*-#
150	EM1-0-150-N	LIN-150*-N	EM1-0-150-I	LIN-150*-#
180	EM1-0-180-N	LIN-180*-N	EM1-0-180-I	LIN-180*-#
200	EM1-0-200-N	LIN-200*-N	EM1-0-200-I	LIN-200*-#
250	EM1-0-250-N	LIN-250*-N	EM1-0-250-I	LIN-250*-#
300	EM1-0-300-N	LIN-300*-N	EM1-0-300-I	LIN-300*-#
360	EM1-0-360-N	LIN-360*-N	EM1-0-360-I	LIN-360*-#
500	EM1-0-500-N	LIN-500*-N	EM1-0-500-I	LIN-500*-#
* Represents length of Linear Strip			* Represents length of Linear Strip # Represents location of Index	

ENVIRONMENTAL

Parameter	Value	Units
Operating Temperature	-40 to 100	C
Electrostatic Discharge, IEC 61000-4-2	± 4	kV
Vibration (10Hz to 2kHz, sinusoidal)	20	G
Shock (6 milliseconds, half-sine)	75	G



OPERATING CONDITIONS

PARAMETER	MIN.	MAX.	UNITS
A/B Output Frequency	0	300	kHz
Disk RPM	0	$(18 \times 10^6) / \text{CPR}$	RPM
Linear Strip Speed	0	$(3 \times 10^5) / \text{LPI}$	inches/sec.
Disk/Linear Strip Radial Position Tolerance	$\pm .005$		inch

ELECTRICAL SPECIFICATIONS

- Specifications apply over the entire operating temperature range.
- Typical values are specified at $V_{CC} = 5.0V$ and $25^{\circ}C$.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
Supply Voltage	4.5	5.0	5.5	V	Ripple < 100 mVpp
Supply Current, EM1-0- (linear strip)		27	33	mA	LPI < 300, no load
		54	65	mA	LPI ≥ 300 , no load
Supply Current, EM1-1- (1" disk)		27	33	mA	CPR < 500, no load
		54	65	mA	CPR ≥ 500 , no load
Supply Current, EM1-2- (2" disk)		27	33	mA	CPR < 1000, no load
		54	65	mA	CPR ≥ 1000 , no load
Low-level Output			0.5	V	$I_{OL} = 8mA$ max.
		0.05		V	No load
High-level Output	2.0			V	$I_{OH} = -8mA$ max.
		4.8		V	No load
Output Current Per Channel	-8		8	mA	
Load Capacitance			100	pF	
Output Rise Time		110		nS	
Output Fall Time		100		nS	

TIMING CHARACTERISTICS

ENCODING CHARACTERISTICS:

- Specifications apply over the entire operating temperature range.
- Values are for the worst error over full rotation.

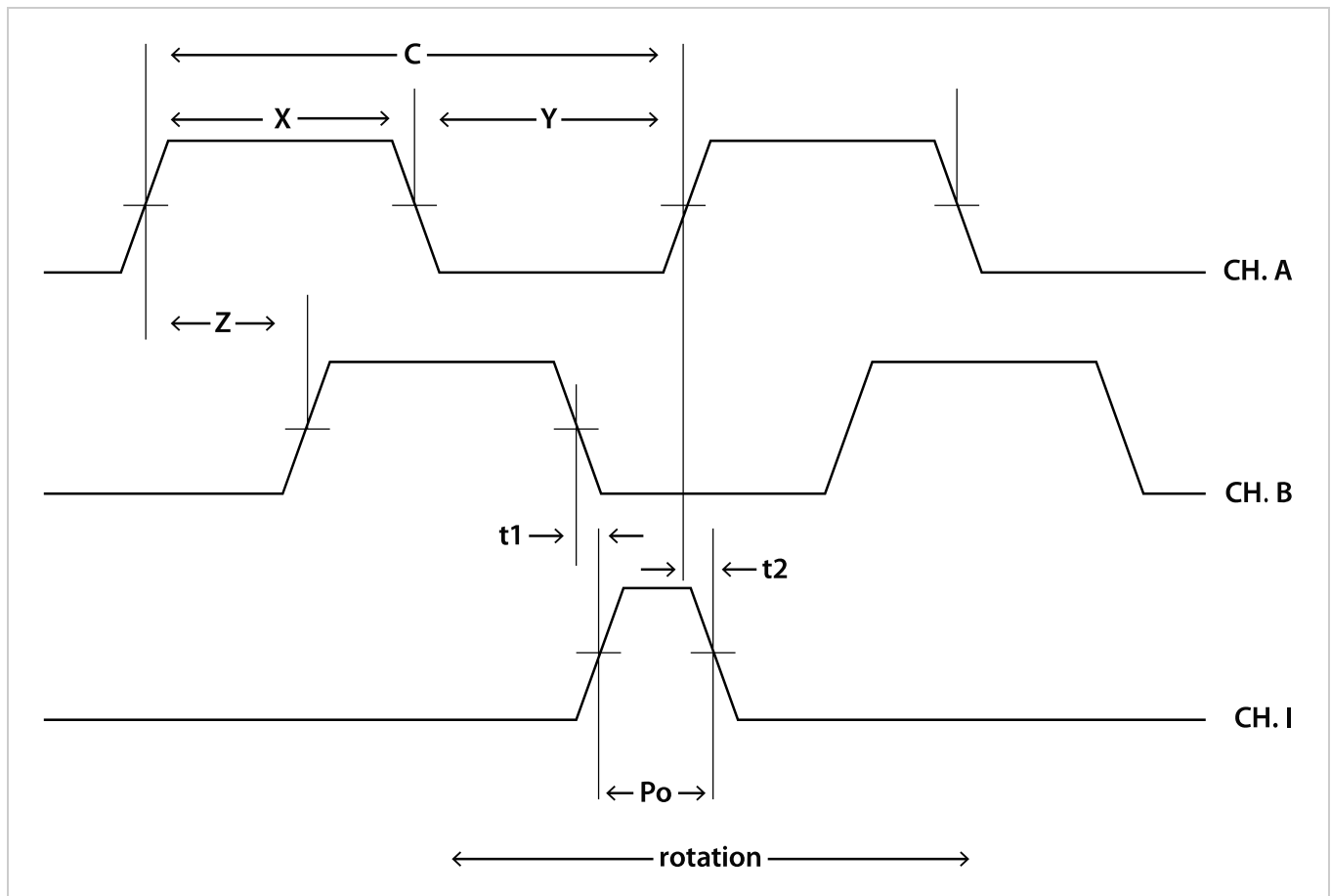


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- Refer to the timing diagram below.

PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS
Symmetry	X, Y	150	180	210	°e (https://www.usdigital.com/support/resources/glossary/#glossary_e)
Quadrature	Z	60	90	120	°e (https://www.usdigital.com/support/resources/glossary/#glossary_e)
Index Pulse Width	Po	40	90	120	°e (https://www.usdigital.com/support/resources/glossary/#glossary_e)
Ch. I Rise After Ch. B or Ch. A Fall	t1	50	100	200	ns
Ch. I Fall After Ch. B or Ch. A Rise	t2	-10	15	25	ns

TIMING DIAGRAM:



CPR: The number of Cycles (C) of the A or B outputs Per Revolution.

Cycle Error: An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/CPR of a revolution.

Index (I): The index output goes high once per revolution, coincident with the low states of channels A and B, nominally 1/4 of one cycle (90 °e).



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LPI: Lines Per Inch. The number of Cycles (C) of the A or B output per inch of linear strip movement.

One Shaft Rotation: 360 mechanical degrees.

One Electrical Degree (°e): 1/360th of one cycle.

One Cycle (C): 360 electrical degrees (°e). Each cycle can be decoded into 1 or 4 states, referred to as X1 or X4 resolution multiplication.

PPR: The number of resolvable Positions Per Revolution of the encoder disk with x4 quadrature decoding.

Quadrature (Z): The phase lag or lead between channels A and B in electrical degrees, nominally 90 °e.

Symmetry: A measure of the relationship between (X) and (Y) in electrical degrees, nominally 180°e.

INSTALLATION TORQUE

PARAMETER	TORQUE
Mounting Screws	3.5-4 in-lbs

EM1 / HEDS COMPARISON

US Digital is the designer and manufacturer of the **EM1** transmissive optical encoder module. The design of the **EM1** provides electrical and mechanical compatibility with **HEDS-9000**, **HEDS-9100**, **HEDS-9200**, **HEDS-9040**, and **HEDS-9140** series modules.

The process of switching from the **HEDS** to the **EM1** module should not require any mechanical or electrical changes. Simply use the **EM1** and matching codewheel in place of the **HEDS** module and codewheel. The **EM1** has a built-in index channel available on most resolutions, for both rotary disks and linear strips. The **EM1** uses a US Digital designed codewheel with 2 tracks rather than 3 tracks for index versions. The **EM1** offers improved output drive capability and will source and sink 8mA at TTL levels.

Physically, the **EM1** has no external wire loops which can interfere when mounting. The connector pins are 0.051" shorter than **HEDS** modules, while still providing .30" insertion depth. US Digital's **EM1** offers custom resolutions.

PIN-OUTS

Pin	Description
1	Ground
2	Index
3	A channel
4	+5VDC power
5	B channel

Notes

- US Digital® warrants its products against defects in materials and workmanship for two years. See complete warranty (<https://www.usdigital.com/company/warranty>) for details.



Configuration Options

EM1_WEB	Type	Resolution	Index
	0 (<i>Linear Strip</i>)	120 LPI	I (<i>Index</i>)
	1 (<i>1" Disk</i>)	127 LPI	N (<i>Non-Index</i>)
	2 (<i>2" Disk</i>)	150 LPI	
		180 LPI	
		200 LPI	
		250 LPI	
		300 LPI	
		360 LPI	
		500 LPI	
		32 CPR	
		50 CPR	
		64 CPR	
		100 CPR	
		100 CPR	
		200 CPR	
		200 CPR	
		250 CPR	
		360 CPR	
		400 CPR	
		400 CPR	
		500 CPR	
		500 CPR	
		512 CPR	
		540 CPR	
		720 CPR	
		800 CPR	
		800 CPR	
		900 CPR	
		1000 CPR	
		1024 CPR	
		1250 CPR	
		1000 CPR	
		1024 CPR	
		1800 CPR	
		2000 CPR	
		2048 CPR	
		2500 CPR	



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PLEASE NOTE: This chart is for informational use only. Certain product configuration combinations are not available. Visit the EM1_WEB product page (https://www.usdigital.com/products/EM1_WEB) for pricing and additional information.