Incremental Encoder
GEL 260

Magnetic measuring system, high resolution,
also suiable for use explosion-harzardous areas

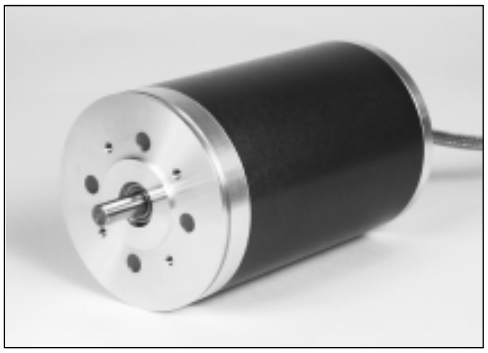
SENSORLINE

LENORD+BAUER

Technical information

version 12.08

GEL 260



GEL 260 EEx

Incremental encoders convert rotations into electric signals. The Lenord + Bauer encoders combine the advantages of a magnetic measuring system and a robust mechanical design. They have proven successful all over the world in many different applications and even under roughest industrial conditions. Their high reliability and a long service life go without saying.

Fields of application

- Heavy industry
- Paper-making and packaging machines
- Filling machines
- Transporting and storing systems
- Machines for processing steel, wood, stone, textiles and plastic, etc.

Main characteristics

- High resolution up to 273.408 pulses per revolution
- Interpolation up to 1024
- Additionally current output
  0 ... 20 mA, 4 ... 20 mA, -20 ... +20 mA (option)
- Reference signal
- Cable or plug outlet, axial or radial
- High electromagnetic compatibility (EMC)
- For use in explosion hazardous areas (option)

Measuring principle

The encoders work with differential sensors depending on magnetic fields and a precision toothed wheel as measure. The sensors scan the tooth structure of the toothed wheel and emit a sine or cosine voltage. The integrated evaluation electronics in ASIC and SMD technology converts the analogue sensor signals into incremental output signals.

Advantages of the magnetic system

- No adverse effect due to condensed water
- Absolute operational reliability even in case of high humidity (dewing) and frequent change of ambient temperature
- Extremely insensitive to dirt, oil and water
- Extremely shock- and vibration-resistant because the measure is not made of glass nor plastic
- Outstanding operational safety over a very long period of time as it does not suffer from ageing effects as optical systems do

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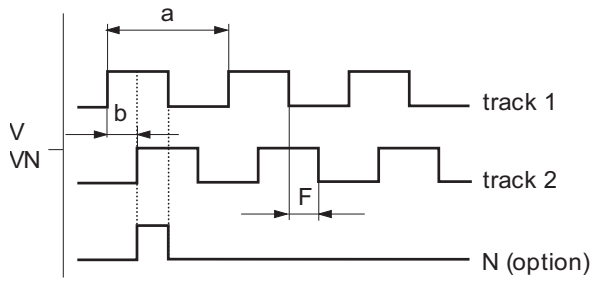
Output signals

Signal pattern V, VN

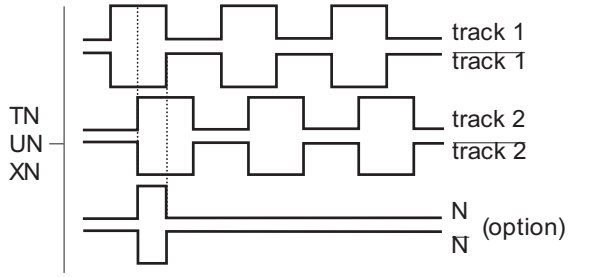
Signal pattern "V" stands for two tracks with square-wave signals, offset by 90° (push-pull output). With each revolution, a reference signal with defined length is put out on the third track N (optionally).
At an output frequency of 200 kHz the edge distance (F) is ≥ 0.6 µs.



	V_S	V_{Sig}
V, VN	10 ... 30 V DC	HTL

Signal pattern T, TN, U, UN, X, XN

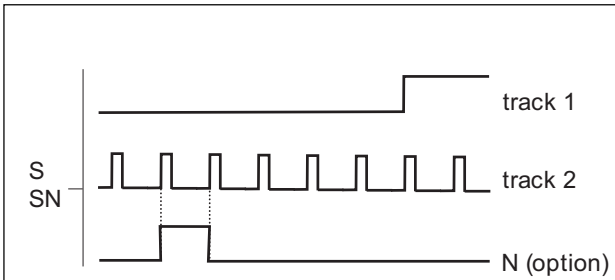
Both tracks and the reference signal (option) are additionally output as inverse signals.



	V_S	V_{Sig}
T, TN	+ 5 V DC ± 5 %	TTL
U, UN	10 ... 30 V DC	TTL
X, XN	10 ... 30 V DC	HTL

Signal pattern S, SN

Pulses which are independent of the rotational direction and the duration of which is constant are derived from the square-wave signals as per signal pattern V and put out on track 2. Furthermore, a signal depending on the rotational direction is obtained from the signal pattern which is put on track 1.
Once per each revolution a reference signal is output on the third track N (optional). The outputs have a final push-pull power stage. All outputs are sustained short-circuit-proof.
The pulses follow a possible change of rotation with a slight delay, in order that a subsequent counter setting can be adjusted to the counting direction prior to the pulse. The sense-dependent signal may be reversed via a which is accessible from outside (switch 1).



	V_S	V_{Sig}
S, SN	10 ... 30 V DC	HTL

Key

V_S = operating voltage
V_{Sig} = signal voltage
a = 360° electrical
b = 90° phase shift
F = edge distance (for an output frequency of 200 kHz the edge distance is F ≥ 0.6 µs)
Signal pattern = shown for clockwise rotation (view on top of the encoder shaft)
Reference signals with other lengths upon request.

Output level

The signal patterns S, SN, V, VN, X and XN have HTL level, the signal patterns T, TN, U and UN have TTL level (for the output voltage see electrical data).

All outputs have a push-pull power amplifier and are short-circuit-proof. The peak output current for recharging the cable capacity is 100 mA.

Various current outputs

A

Measuring current which is independent on the sense of rotation and which has a nominal range of -20 ... +20 mA. The polarity of the current can be reversed by switch 1 which is accessible from outside.

B

Measuring current which is independent of the sense of rotation and which has a nominal range of 0 ... +20 mA.

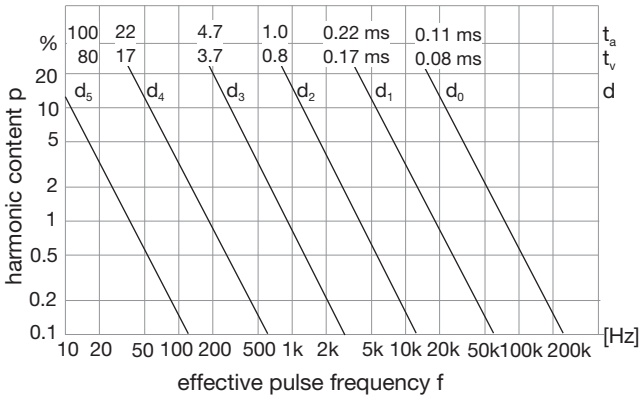
C

Measuring current which is independent of the sense of rotation and which has a nominal range of +4 ... +20 mA.

The switch position deviates from the one of the previous model, i. e. GEL 262. If the device is preset in the factory and in case of clockwise rotation the specified signals are valid.

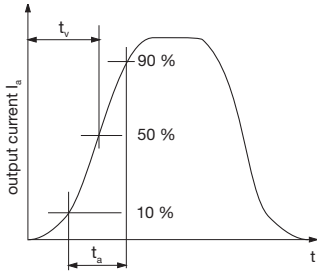
Current output

For the means of displaying and controlling, a measuring current of 0 to 20 mA, 4 to 20 mA or -20 to +20 mA can be obtained from the pulse frequency which depends on the speed and – if ordered – the sense of rotation. For this purpose the measuring pulses are integrated and converted into a rotation speed dependent output current. There is a strictly linear interrelation between the measuring current and the pulse frequency.
Because of the high resolution (up to 273,408 pulses per revolution) a DC output current is obtained which shows a low harmonic content even at a very low speed range (e.g. 0 to 0.5 min^{-1}). The harmonic content depends on the pulse frequency and the determined attenuation *d*, latter influencing the rising and trailing edge times as well as the delay time in case of erratic changes of the speed.
The preferred attenuation had been specified when ordering the encoder corresponding to the following diagram; d_3 is the default setting.



t_a = rise time
t_v = delay time
d = attenuation

t_a, t_v = f (d)
$p = I_{eff} / I_a$
$f = n \cdot i$ [Hz]



Data of the current outputs

max. apparent ohmic resistance	R_a		550	Ω
measuring device class	K		1	
rated current tolerance			< 1	%
linearity error			< 1	%
repeatability	r		100	%
temperature drift	ΔI_{aT}		< ±3	µA/1 °K
min. RPM	n_{min}	electrical (attenuation d_5)	1.5 x 10^3/i	RPM
max. RPM	n_{max}	electrical	6 x 10^6/i	RPM
			i = rated pulse number	

Technical data according DIN 32878

Description			GEL 260	GEL 260 EEx
measuring step from ... to [1]			36 ... 0.013°	
pulse number per revolution [1]			10 ... 273.408	
accuracy	error limit [2]		0.07°	
	incremental deviation [2]		0.01°	
	repeatability[2]		0.005°	
electrical data	power consumption	$R_L = \infty$, V_S = 10…30 V DC $R_L = \infty$, V_S = 5 V DC	≤ 1.3 W (with current output:≤ 1.65) ≤ 1.0 W(with current output: ≤ 1.40)	
	max. output frequency			
	output level for signal pattern T/TN (logic level TTL)		high signal: ≥ V_S - 1.00 V at I = 10 mA; ≥ V_S - 1.20 V at I = 30 mA low signal: ≤ 0.75 V at I = 10 mA; ≤ 1.00 V at I = 30 mA	
	output level for signal pattern U/UN (logic level TTL)		high signal: ≥ 4.00 V at I = 10 mA; ≥ 3.85 V at I = 30 mA low signal: ≤ 0.75 V at I = 10 mA; ≤ 1.00 V at I = 30 mA	
	output level for signal pattern S/SN, V/VN and X/XN (logic level HTL)		high signal: ≥ V_S- 1.80 V at I = 10 mA; ≥ V_S - 2.20 V at I = 30 mA low signal: ≤ 1.15 V at I = 10 mA; ≤ 1.55 V at I = 30 mA	
mechanical data	shaft diameter		6 mm, 8 mm, 10 mm, 12 mm	
	housing diameter		90 mm	115 mm
	weight		approx. 0.7 kg	approx. 5.1 kg
	max. operating		10,000 min^{-1}	3,000 min^{-1}
	moment of inertia of rotor		$7 \cdot 10^{-5}$ kgm²	
	max. angular acceleration		extremely high, as shaft and measuring wheel (steel) are pressed	
	operating torque		0.03 Nm (< 0.01 Nm with ball bearing cover (IP 50) Option)	
	starting torque		0.05 Nm (0.01 Nm with ball bearing cover (IP 50) Option)	
	max. shaft load (point of application 15 mm before the contact surface of the flange)		200 N axial 200 N radial	
	permissible shaft load		We recommend connection by a radial flexible coupling.	
	bearing life (at half shaft load)		$12.600 \cdot 10^6$ revolutions	
	bearing life (at max. shaft load)		$2.000 \cdot 10^6$ revolutions	
environmental conditions	operating temperature		0 ... + 70 °C (standard); - 20 ... +85 °C (option)	
	ambient temperature		- 20 ... + 85 °C	
	storage temperature		-40 ... +105 °C	
	protection class according to DIN EN 60529		IP 65	pressure-resistant IP 54
	vibration protection (option) according to DIN EN 60068-2-6		frequency 10 ... 2000 Hz; peak acceleration 100 m/s²; frequency cycles 10	
	shock protection (option) according to DIN EN 60068-2-27		peak acceleration 1000 m/s²; duration 11 ms	
	insulation strength according to VDE 0660 part 500 version 08/00 or DIN EN 60439-1		R_i > 1MΩ, at a testing voltage of 500 V AC	
	electromagnetic compatibility		EN 61000-6-1 to 4	

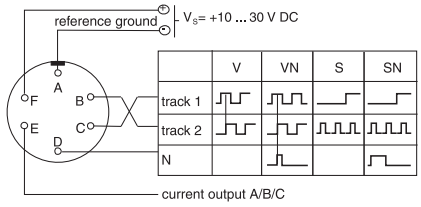
[1] max. value with external evaluation of the signal pattern. See page 7 for possible pulse numbers (resolutions).
[2] value fo highest resolutions. Values for low resolutions on request.

Pin layouts: plug, Cable assignment

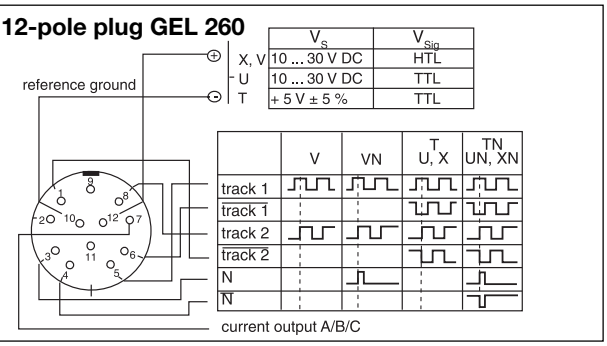
Pin layout: plug

(The counter plug is included in the scope of supply.)

6-pole plug GEL 260

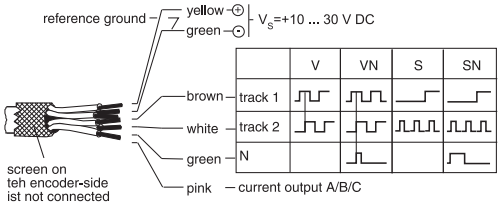


12-pole plug GEL 260

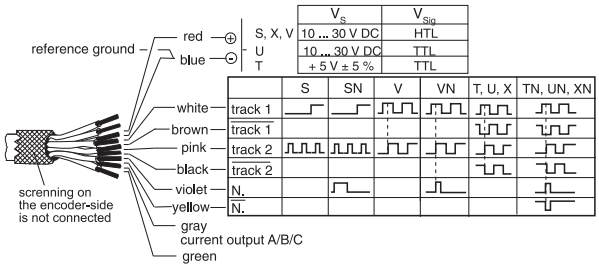


Cable assignment

6-core cable GEL 260

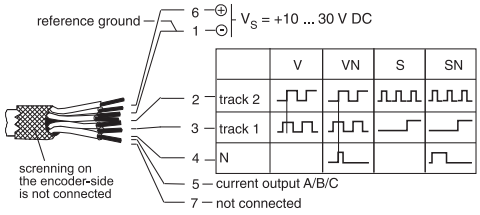


10-core cable GEL 260

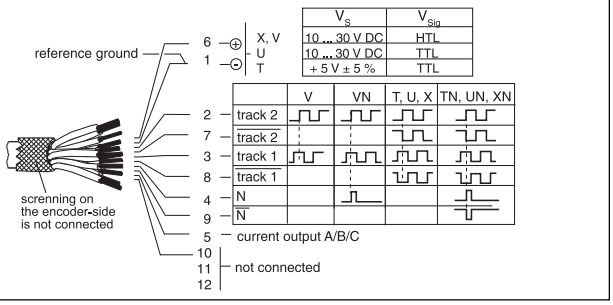


Cable assignment

7-core cable GEL 260 EEx



12-core cable GEL 260 EEx



Key

V_S = operating voltage
V_{Sig} = signal voltage
current output A = -20 mA ... +20 mA
current output B = 0 mA ... +20 mA
current output C = +4 mA ... +20 mA
Signal pattern shown for clockwise rotation (view on top of the encoder shaft). Reference signal with other length upon the request.

Maximum Cable Lengths

between encoder and secondary electronics.
The cable screening is to be earthed one-sided at the receiver. The stated data are standard values referring to cable type LiYCY 6 (10) x 0,25 mm^2 .

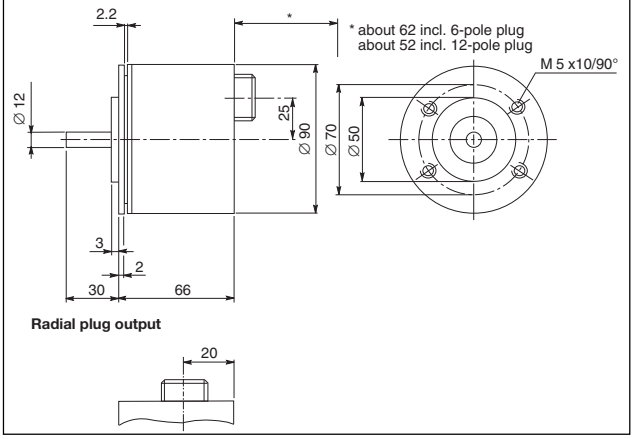
V_S= 5 V (TN, UN), sense connected						
f [kHz]	5	10	20	50	100	200
L_{max} [m]	200	200	200	200	145	72

V_S= 20 S, V (SN, VN)						
f [kHz]	5	10	20	50	100	200
L_{max} [m]	200	200	200	80	40	20

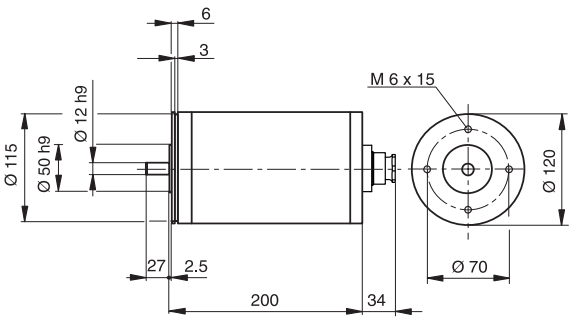
V_S= 20 V (XN)						
f [kHz]	5	10	20	50	100	200
L_{max} [m]	200	200	100	40	20	10

Dimensioned drawings, version EEx
Protection of the electronic (optional),

GEL 260



GEL 260 EEx (version Ex)



Protection of the electronics (optional)

Protection against humidity
The encoders' electronic unit is coated with a highly effective protection against humidity, salt-water atmosphere and corrosive vapours to ensure their proper functioning during years even under roughest conditions.

Condensed-water outlet
Water may accumulate in the encoder if it is exposed to multiple dewing. The water can drain off through the condensed-water outlet. When mounting the encoder the outlet must show downward. The protection class drops to IP 64.

Protection against vibration
The additional fixing of mechanical parts with special plastic prevents the electronics and the connections inside the encoder from vibrating. Thus the proper and continuous operation of the encoder - even if exposed to extreme vibration and shock – is guaranteed.

Version GEL 260 EEx

Through mounting of the GEL 260 in a flameproof housing Ex-protection to VDE 0171.

protection class : Ⓔx II 2G EEx de [ia/ib] IIC T5-T6
certificate : PTB03ATEX1051
(formerly PTB-Nr. Ex-87/1095)

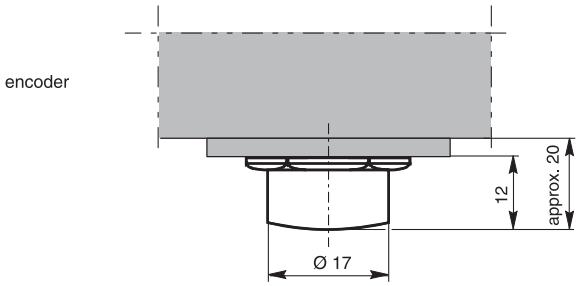
ordering details : in the type code
protection of the electronics
-protection class EEx select -
shaft diameter, length
- ø = 12 mm L = 27 mm select -
Cable outlet
- 7-core cable select -
or 12-core cable select -

GEL 260 EEx standard cable length: 1 metre. Please state in your order, if you wish other cable lengths.

Dimensioned drawing: counter plugs

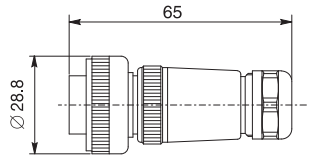
(GG 66 or GG 126 are included in the scope of supply, if you wish the optional GW 66 type please state in your order.)

Condensed-water outlet KS 200

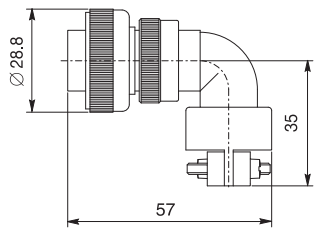


The position of the condensed-water outlet must be started upon placement of order.

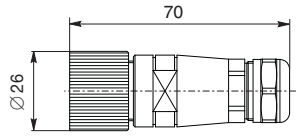
GG 66 (6-pole,straight)



GW 66 (6-pole, 90° offset)



GG 126 (12-pole, straight)



The pulse numbers printed in bold-face are standard pulse numbers.

Possible pulse numbers GEL 260

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
46	47	48	49	**50**	51	52	53	54	55	56	57	58	59	**60**	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
82	83	84	85	86	87	88	89	**90**	91	92	93	94	95	96	97	98	99
100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117
118	119	**120**	121	122	123	124	**125**	126	127	128	129	130	131	132	133	134	135
136	137	138	139	140	141	142	143	144	145	146	147	148	149	**150**	151	152	153
154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171
172	173	174	175	176	177	178	179	**180**	181	182	183	184	185	186	187	188	189
190	191	192	193	194	195	196	197	198	199	**200**	201	202	203	204	205	206	207
208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225
226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243
244	245	246	247	248	249	**250**	251	252	253	254	255	**256**	257	258	259	260	261
262	263	264	265	266	267	268	269	270	272	274	276	278	280	282	284	286	288
290	292	294	298	**300**	302	304	306	308	310	312	314	316	318	320	322	324	326
328	330	332	334	336	338	340	342	344	346	348	350	352	354	356	358	360	362
364	366	368	370	372	374	376	378	380	382	384	386	388	390	392	394	396	398
400	402	404	406	408	410	412	414	416	418	420	422	424	426	428	430	432	434
436	438	440	442	444	446	448	450	452	454	456	458	460	462	464	466	468	470
472	474	476	478	480	482	484	486	488	490	492	494	496	498	**500**	502	504	506
508	510	512	514	516	518	520	522	524	526	528	530	532	534	536	540	544	548
550	552	556	560	564	568	570	572	576	580	584	588	590	592	596	**600**	604	608
610	612	616	620	624	628	630	632	636	640	644	648	650	652	656	660	664	668
670	672	676	680	684	688	690	692	696	700	704	708	710	712	716	**720**	724	728
730	732	736	740	744	748	**750**	752	756	760	764	768	770	772	776	780	784	788
790	792	796	**800**	804	808	810	812	816	820	824	828	830	832	836	840	844	848
850	852	856	860	864	868	870	872	875	876	880	884	888	890	892	896	**900**	904
908	910	912	916	920	924	925	928	930	932	936	940	944	948	950	952	956	960
964	968	970	972	975	976	980	984	988	990	992	996	**1000**	1004	1008	1010	1012	1016
1020	**1024**	1025	1028	1030	1032	1036	1040	1044	1048	1050	1052	1056	1060	1064	1068	1070	1072
1075	1080	1088	1090	1096	1100	1104	1110	1112	1120	1125	1128	1130	1136	1140	1144	1150	1152
1160	1168	1170	1175	1176	1180	1184	1190	1192	**1200**	1208	1210	1216	1220	1224	1225	1230	1232
1240	1248	**1250**	1256	1260	1264	1270	1272	1280	1288	1290	1296	1300	1304	1310	1312	1320	1325
1328	1330	1336	1340	1344	1350	1352	1360	1368	1370	1375	1376	1380	1384	1390	1392	1400	1408
1410	1416	1420	1424	1425	1430	1432	1440	1448	1450	1456	1460	1464	1470	1472	1475	1480	1488
1490	1496	**1500**	1504	1510	1512	1520	1525	1528	1530	1536	1540	1544	1550	1552	1560	1568	1570
1575	1576	1580	1584	1590	1592	1600	1608	1610	1616	1620	1624	1625	1630	1632	1640	1648	1650
1656	1660	1664	1670	1672	1672	1675	1680	1688	1690	1696	1700	1704	1710	1712	1720	1725	1728
1730	1736	1740	1744	1750	1752	1760	1768	1770	1775	1776	1780	1784	1790	1792	**1800**	1808	1810
1816	1820	1824	1825	1830	1832	1840	1848	1850	1856	1860	1864	1870	1872	1875	1880	1888	1890
1896	1900	1904	1910	1912	1920	1925	1928	1930	1936	1940	1944	1950	1952	1960	1968	1970	1975
1976	1980	1984	1990	1992	**2000**	2008	2010	2016	2020	2024	2025	2030	2032	2040	**2048**	2050	2056
2060	2064	2070	2072	2075	2080	2088	2090	2096	2100	2104	2110	2104	2110	2112	2120	2125	2128
2130	2136	2140	2144	2150	2160	2170	2175	2176	2180	2190	2192	2200	2208	2210	2220	2224	2225
2230	2240	2250	2256	2260	2270	2272	2275	2280	2288	2290	2300	2304	2310	2320	2325	2330	2336
2340	2350	2352	2360	2368	2370	2375	2380	2384	2390	2400	2410	2416	2420	2425	2430	2432	2440
2448	2450	2460	2464	2470	2475	2480	2490	2496	**2500**	2510	2512	2520	2525	2528	2530	2540	2544
2550	2560	2570	2575	2576	2580	2590	2592	2600	2608	2610	2620	2624	2625	2630	2640	2650	2656
2660	2670	2672	2675	2680	2688	2700	2704	2720	2725	2736	2740	2750	2752	2760	2768	2775	2780
2784	2800	2816	2820	2825	2832	2840	2848	2850	2860	2864	2875	2880	2896	2900	2912	2920	2925
2928	2940	2944	2950	2960	2975	2976	2980	2992	**3000**	3008	3020	3024	3025	3040	3050	3056	3060
3072	3075	3080	3088	3100	3104	3120	3125	3136	3140	3150	3152	3160	3168	3175	3180	3184	3200
3216	3220	3225	3232	3240	3248	3250	3260	3264	3275	3280	3296	3300	3312	3320	3325	3328	3340
3344	3350	3360	3375	3376	3380	3392	3400	3408	3420	3424	3425	3440	3450	3456	3460	3472	3475
3480	3488	**3500**	3504	3520	3525	3536	3540	3550	3552	3560	3568	3575	3580	3584	**3600**	3616	3620
3625	3632	3640	3648	3650	3660	3664	3675	3680	3696	3700	3712	3720	3725	3728	3740	3744	3750
3760	3775	3776	3780	3792	3800	3808	3820	3824	3825	3840	3850	3856	3860	3872	3875	3880	3888
3900	3904	3920	3925	3936	3940	3950	3952	3960	3968	3975	3980	3984	**4000**	4016	4020	4025	4032
4040	4048	4050	4060	4064	4075	4080	**4096**	4100	4112	4120	4125	4128	4140	4144	4150	4160	4175
4176	4180	4192	4200	4208	4220	4224	4225	4240	4250	4256	4260	4272	4275	4280	4288	4300	4320
4325	4340	4350	4352	4360	4375	4380	4384	4400	4416	4420	4425	4440	4448	4450	4460	4475	4480
4500	4512	4520	4525	4540	4544	4550	4560	4575	4576	4580	4600	4608	4620	4625	4640	4650	4660
4672	4675	4680	4700	4704	4720	4725	4736	4740	4750	4760	4768	4775	4780	4800	4820	4825	4832
4840	4850	4860	4864	4875	4880	4896	4900	4920	4925	4928	4940	4950	4960	4975	4980	4992	**5000**
5020	5024	5025	5040	5050	5056	5060	5075	5080	5088	5100	5120	5125	5140	5150	5152	5160	5175
5180	5184	5200	5216	5220	5225	5240	5248	5250	5260	5275	5280	5300	5312	5320	5325	5340	5344
5350	5360	5375	5376	5400	5408	5425	5440	5450	5472	5475	5480	5500	5504	5520	5525	5536	5550
5560	5568	5575	5600	5625	5632	5640	5650	5664	5675	5680	5696	5700	5720	5725	5728	5750	5760
5775	5792	5800	5824	5825	5840	5850	5856	5875	5880	5888	5900	5920	5925	5950	5952	5960	5975
5984	**6000**	6016	6025	6040	6048	6050	6075	6080	6100	6112	6120	6125	6144	6150	6160	6175	6176
6200	6208	6225	6240	6250	6272	6275	6280	6300	6304	6320	6325	6336	6350	6360	6368	6375	6400
6425	6432	6440	6450	6464	6475	6480	6496	6500	6520	6525	6528	6550	6560	6575	6592	6600	6624
6625	6640	6650	6656	6675	6680	6688	6700	6720	6750	6752	6760	6784	6800	6816	6840	6848	6850
6875	6880	6900	6912	6920	6944	6950	6960	6976	**7000**	7008	7040	7050	7072	7080	7100	7104	7120
7125	7136	7150	7160	7168	**7200**	7232	7240	7250	7264	7280	7296	7300	7320	7328	7350	7360	7375
7392	7400	7424	7440	7450	7456	7480	7488	7500	7520	7550	7552	7560	7584	7600	7616	7625	7640
7648	7650	7680	7700	7712	7720	7744	7750	7760	7776	7800	7808	7840	7850	7872	7875	7880	7900
7904	7920	7936	7950	7960	7968	**8000**	8032	8040	8050	8064	8080	8096	8100	8120	8125	8128	8150
8160	8192	8200	8224	8240	8250	8252	8280	8288	8300	8320	8350	8352	8360	8375	8384	8400	8416
8440	8448	8480	8500	8512	8560	8576	8600	8625	8640	8700	8704	8720	8750	8800	8832	8875	8880
8900	8960	**9000**	9040	9088	9100	9120	9125	9200	9216	9250	9280	9300	9344	9360	9375	9400	9440
9472	9500	9520	9600	9625	9680	9700	9728	9750	9760	9800	9840	9856	9875	9900	9920	9984	**10000**

10080 ... 273408

Order details GEL 260

260	_	_	_	_ _ _ _ _	_	_	_	_	description
									temperature range
								1	0°C ... +70°C
								3	-20°C ... +85°C (option)
									protection of the electronics
								0	without any additional protection (standard)
								1	moisture-proof
								2	vibration-proof
								3	moisture- and vibration-proof
								4	moisture-proof of incl. condensed-water outlet
								5	moisture- and vibration-proof and condensed-water outlet
								6	protection class EEx with GEL 260 no additional protection
								7	protection class EEx with GEL 260 and moisture protected
								8	protection class EEx with GEL 260 and vibration protected
								9	protection class EEx with GEL 260 and protection agains moisture and vibration
									shaft diameter / length
								0	∅ = 12 mm L = 30 mm (standard), only by GEL 260 EEx (L= 27 mm)
								1	∅ = 6 mm L = 13 mm
								2	∅ = 8 mm L = 30 mm
								3	∅ = 8 mm L = 30 mm shaft additionally fitted with Woodruff key DIN 6888
								4	∅ = 10 mm L = 30 mm
								5	∅ = 10 mm L = 30 mm shaft additionally fitted with Woodruff key DIN 6888
								7	∅ = 12 mm L = 30 mm shaft additionally fitted with Woodruff key DIN 6888
									plug / cable outlet
						A			6-pole plug, axial
						B			6-pole plug, radial
						C			12-pole plug, axial
						D			12-pole plug, radial
						E			7-core cable (only by GEL 260 EEx)
						F			6-core cable, axial
						G			6-core cable radial
						H			10-core cable, axial
						I			10-core cable radial
						K			12-core cable (only by GEL 260 EEx)
				pulse number per revolution (see previous page)					
									reference signal
				-					without reference signal (standard)
				N					incl. reference signal (option)
									signal pattern (see page 2)
		-							without reference signal (standard)
		S							V_S = 10 ... 30 V DC, logic level HTL
		T							V_S = 5 V DC, logic level TTL
		U							V_S = 10 ... 30 V DC, logic level TTL
		V							V_S = 10 ... 30 V DC, logic level HTL
		X							V_S = 10 ... 30 V DC, logic level HTL
									current ouput
	-								without
	A								- 20 mA ... + 20 mA
	B								0 mA ... + 20 mA
	C								+ 4 mA ... + 20 mA

Order details

Standard cable length: 1metre. Please state in your order, if you wish other cable lengths. GG 66 or GG 126 are included in the scope of supply; if you wish GG 66 (option), please state in your order.

Order example

260 C V N 01000 A 0 3 3 or **260 - X N 01024 H 4 0 1 with 3 m cable.**

Subject to technical modifications and typographical errors.
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