Appendix

Technical definitions of A to Z

Absolute single-turn encoder	Encoder which outputs a unique, coded item of information for each measuring step within a revolution. The information is retained even after a power failure.
Baud rate	Transmission frequency of serial interface in bits per second.
BCD (binary coded decimal) code	To avoid converting a decimal number into a binary number, instead of using natural binary code, often only the individual digits of the decimal number are encoded in binary.
Binary code	This code type is constructed similarly to the decimal system, but has only the digit values „0" and „1".
Clock+, clock-	Control lines of the SSI interface for synchronous data transmission. Clock+ and clock- together form a current loop, for potential-free reception of the clock frequency in SSI encoders.
Clock frequency (SSI)	For absolute encoders with synchronous serial interface (SSI), the clock frequency is the frequency of the clock signal during data transmission. The clock frequency is specified by the sequence electronics, and must be within the corresponding limits.
Code switching speed	Number of measuring steps per second for absolute multiturn encoders. For encoders with 13 bit resolution and 400 kHz code switching frequency, the maximum rotational speed is 3'000 rpm.
Connection cables	For shaft encoders, equipped with a connector base, the appropriate connector can be ordered as an accessory. For encoders with cable connection, the standard length of cable provided is 2 m respectively 1 m. The sheathing material for the incremental encoder is PUR. The wire size is 0,14 mm^2. The cable screen is connected to the housing respectively to the flange. The operating temperature range is -20 °C to +85 °C. Permissible bending radius at 20 °C: cable with a PUR sheath 12x cable ø
Couplings	The most suitable flexible coupling can be chosen from the data of a servo drive system. Resolution, acceleration and the desired positional precision must be considered. The lag angle can be judged from the torque stiffness. This torque might be considerable, if high dynamic drive systems are used. The inertia moment is specified on the product data pages.
Data valid	Diagnostic output for checking validity of output data.
Direction of rotation (F/$\overline{R}$)	Forward/reverse counting direction input. The input is HIGH when disconnected. F/$\overline{R}$ HIGH means increasing output data when the shaft is rotating to the right (cw). F/$\overline{R}$ LOW means increasing output data when the shaft is rotating to the left (ccw), looking at the shaft in each case.

Drive operating modes

A definition of drive operating modes is necessary to guarantee, that drive temperature limits are not exceeded. The following operating modes exist according to EN 60034-1:

Continuous operation S1
An operation with constant load, whose duration is sufficient to reach the thermal steady conditions. This corresponds to the nominal operation. The abbreviation is S1.

Short time operation S2
An operation with constant load, whose duration is not sufficient to reach the thermal steady condition, with a following pause with a duration, where the lowered machine temperature deviates less than 2°C from ambient temperature. The abbreviation is S2, supplemented with data about operation time, e.g. S2 60 min.

Intermittent operation S3
An operation made up of a series of periodic duties, each of which consisting of a time with constant load and a pause. The starting current does not noticeably effect the temperature rise. The abbreviation is S3, supplemented with data about relative operation time, e.g. S3 25%.

Duty factor f_B

The duty factor $\mathbf{f_B}$ is used for drive dimensioning to optimum lifetime. It is important to note, that the useable torque $\mathbf{T_{use}}$ can be reduced with respect to the maximum torque $\mathbf{T_{max}}$. This reduction depends on the operating mode and load type in the application and is calculated according to:

$$T_{use} = f_B * T_{max}$$

The duty factor $\mathbf{f_B}$ is based on experience data. Example: For operating mode „reversal", load type „even" operating time of 8 h/day and more than 10 reversals/h, the duty factor is $\mathbf{f_B}$ = 0,63.

operating mode	load type			operating time in h/day					
	even	pulsating	impulsive	3h	8h	24h	3h	8h	24h
				up to 10 cycles/h			more than 10 cycles/h		
one turn direction	■			1	1	0.83	1	0.83	0.66
direction change	■			1	0.77	0.63	0.83	0.63	0.52
one turn direction		■		0.9	0.77	0.63	0.77	0.66	0.55
direction change		■		0.71	0.58	0.5	0.63	0.53	0.43
one turn direction			■	0.83	0.66	0.55	0.66	0.55	0.45
direction change			■	0.63	0.5	0.43	0.5	0.43	0.35

Enable

Control input via which the data outputs of absolute encoders can be switched active.

Technical definitions of A to Z

Gear

A gear is necessary to
– reduce the speed to be used
– to increase the available torque.

Based on gear transmission ratio i and motor speed **n[motor],** the gear speed **n[gear]** can be calculated according to:

$$\mathbf{n\,[gear]} = \frac{\mathbf{n\,[motor]}}{\mathbf{i}}$$

n [gear] = output shaft of gear
n [motor] = motor speed
i = gear ratio

Based on motor torque **M [motor]** und **gear efficiency η**, the gear torque **M [gear]** can be calculated according to:

$$\mathbf{M\,[gear]} = \mathbf{M\,[motor]} \times \mathbf{i} \times \boldsymbol{\eta}$$

M [gear] = output shaft of gear
M [motor] = motor torque
i = gear ratio
η = gear coefficient

In order to calculate power from torque and speed, the following approximation can be used:

$$\mathbf{P\,[W]} = \frac{\mathbf{M}_{\,[Ncm]} \times \mathbf{n}_{\,[min^{-1}]}}{\mathbf{955}}$$

Gear types

Planetary gears offer triple meshing and the highest torque at any given volume. Furthermore, they are characterized by a centrical output shaft and a high efficiency.

Spur gears have a high efficiency even with large transmission ratios and offer an excellent price-performance ratio.

Worm gears offer a continuous power transmission, 90° power deviation, self-locking, and an optional second shaft. The poor efficiency at high transmission ratios should be kept in mind.

Gray code

Gray code fulfils the conditions for a single-step code. This code is used in most absolute encoders. Symmetrically capped Gray code is a particular section of a full Gray code. In this way, any evenly divided step division is always obtained.

Hall sensor

Hall sensors employ a magnetically biased semiconductor Hall element to sense moving ferromagnetic objects.

Incremental encoder

Rotary encoder which outputs an electrical signal (HIGH/LOW) for every measuring step. Two signals phase-shifted by 90° and the zero signal are outputs. For zero point determination, it must first be referenced.

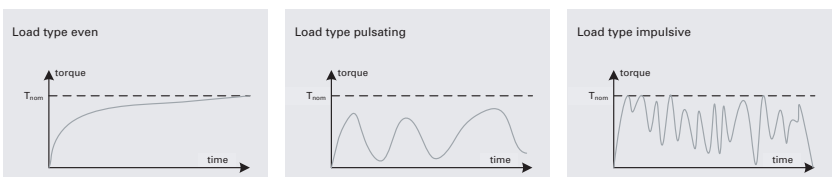
Interpolation

Using electronics and the laws of trigonometry, the basic period is subdivided into smaller units. 10 times the basic resolution is possible.

Load type

To determine duty factor $\mathbf{f_B}$ and useable gear torque $\mathbf{T_{use}}$, the following load types exist:
– even
– pulsating
– impulsive

These load types are illustrated in Figure 1 to 3. „Running against stop" is generally not permissible because very strong forces may occur which can destroy the gear.



Magnetic sensor

Magnetic sensors are magnetically controlled by a small rotor closely positioned in front of the active sensing face.

Maximum error limit

The maximum error limit is the maximum difference between measured and reference position over one 360-degree-rotation over the full operating temperature (range).

Measuring step

In the case of incremental encoders, the time between the positive edges of CHA and CHB is evaluated as measuring step. In this way, it is possible to achieve measuring step resolutions four times greater than the pulse rate used. This signal multiplication must be implemented by means of external sequence electronics.

Multi-turn encoder

Encoder which, as well as the singleturn signal, can uniquely sense and output revolutions. Here too, the information is retained even after a power failure, and continues to be sensed even during it.

Profibus-DP

Master-slave bus system with two-wire line. Linear bus with EIA RS 485 hardware interface. Standard Profibus DP protocol specified for encoders.

Protection class

Protection class is defined according to DIN VDE 0470 (EN 60529, IEC 529) standards. The protection class specified is valid for the installed encoder. There is a separate protection class for the housing and for the shaft. The protection class of the housing depends on the connector base and the type of connector used.

Pulse rate

A number of light and dark segments are put onto a glass pulse disk. In the encoder, these segments are scanned by the light beam and thus determine the possible resolution.

Pulse tolerances

The tolerance of the pulse/period ratio is ±10%. Values outside this range are specially marked on the product data pages. This tight tolerance is also valid between the two channels CHA and CHB, which are 90 degrees out of phase. Therefore the sense of rotation can be clearly defined and a quadrature of the signal can be attained.

Technical definitions of A to Z

Repeatability

The repeatability (according to DIN 32878) is defined as the maximum variance of measurement data of at least five deviation diagrams, taken sequentially with an identical rotational direction and at a fixed temperature.

Rpm

The maximum mechanical rpm is dependent on the bearing; an rpm of 12'000 should not be exceeded. The max. electrical rpm is defined by the max. frequency of the internal electronics and the user interface.

Resolution

For singleturn encoders, the resolution indicates the number of measuring steps per revolution. For multiturn encoders, it indicates the number of measuring steps per revolution and the number of revolutions.

Safety concept

The described products conform to EU rules and carry the CE mark. The safety concept defines the technical, training and legal actions which guarantee the user great safety in handling our sensors.

Scaling

Customer setting of the encoder resolution. The sensor calculates the desired customer resolution from the basic resolution and the scaling factor.

Set zero point

Control input to set a zero point at any point of the resolution range of an absolute encoder, without mechanical adjustment. In the case of programmable absolute encoders, an offset value can also be set using "set zero point".

Shaft loading

During operation encoders are exposed to various influences. Even if load and number of revolutions are known, other influences like temperature, humidity, vibration and greasing must be considered. The expected lifetime can only be predicted. Due to many influences and depending on the operational environment, the lifetime may fluctuate from less than 10^6 revolutions under heavy load conditions to over 10^9 revolutions under optimal conditions.

Shock and vibration

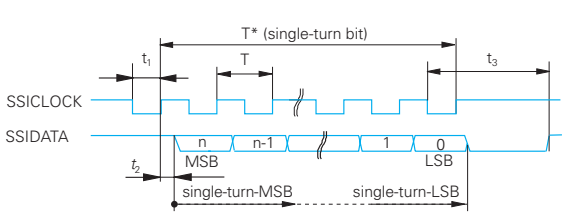
All encoders are tested according to the following standards.

shock test **IEC 60068-2-27**

vibration test **IEC 60068-2-6**

SSI

The SSI (Synchronous Serial Interface) transfer the position value serially, i. e. bit by bit from the encoder to the controller. The transfer is carried out as follows:



pulse time	T
monoflop time	Tm
delay time	Tv
pulse pause	Tp
data bit Dn Dn	MSB
data bit	LSB

In the idle state the data and pulse lines are at High level. The transfer beings with the first trailing edge. With each following rising edge, the data bits are output consecutively to the data line. The transfer begins with the MSB. If the number of pulses is higher than the number of data bits, only zeros are sent after the data bits.

After the end of the pulse sequence, the data lines are kept at Low during the monoflop time Tm. Twisted-pair data and pulse lines should be used for wiring. With line lengths exceeding 100 m, the data and pulse lines should have a minimum cross section of 0,25 mm^2 and the power supply line should be at least 0,5 mm^2 .

The range for the pulse rate is a maximum of 1,5 MHz.

The maximum line length is dependent on the SSI pulse frequency and should be adapted as follows:

Line length	**SSI pulse frequency**
12,5 m	810 kHz
25 m	750 kHz
50 m	570 kHz
100 m	360 kHz
200 m	220 kHz
400 m	120 kHz
500 m	100 kHz

Store

Control input by which the data outputs of absolute encoders are stored for safe reading. It is recommended that the store input should be used above all for multistep data codes.

Switching frequency

With the following formula the maximum rpm is calculated as a function of the number of pulses or steps P. The maximum rpm however must be lower than the allowable mechanical value.

$$f_{max.} = \frac{rpm \times P}{60}$$

Temperature range

The temperature range indicated under ambient conditions corresponds to the operating temperature range.

Torque

Because the encoder should not affect the load of the machine shaft, the torque is small. The torque depends on the size and the type of the bearing, grease, temperature, number of revolutions per minute and various other influences. The diagram on page 4.08 shows a typical overview of various encoder torques as a function of revolutions per minute. The torque decreases with lower rev/min, smaller shaft diameter and lower protection class.

Safety concept
CE-Information
International marks of conformity

Safety concept

The safety concept defines the technical, instructive and legal measures that will ensure a high degree of safety for the end user (system manufacturer, operator and user) when handling our components. This safety concept also serves as a basis for the CE marking of products and is available in German, French and English.

General

The size of many products of Baumer electric is too small for placing the mark on the product itself. Therefore the following markings are generally affixed to attachment sheets, installation manuals and packing.

CE Mark

The CE mark is not a quality-mark. First, it refers to the safety rather than to the quality of a product. Second, most quality markings are voluntary opposite to the CE marking, which is mandatory for the products it applies to. Through the CE marking for the respective product, the manufacturer confirms conformity with all the European Union (EU) Directives relating to this product. The CE marking must therefore be seen as proof of conformity with the Directives and has an official status, directed at the supervisor authorities in charge. For the different products Baumer electric is manufacturing, he is taking account the following pertinent EC Directives:

- Machine Directive (98/37/EEC)
- Low-voltage Directive (73/23/EEC)
- EMC Directive (89/336/EEC)
- Radio & Telecom Terminal Equipment Directive (99/5/EEC)

The declaration of conformity for the products is kept available to the issuer.

C-UL US Listing Mark

UL (Underwriters Laboratory Inc.) introduced this new Listing Mark in early 1998. According to UL it indicates compliance with both Canadian and U.S. requirements. The UL Listing Mark on a product is the manufacturer's representation that samples of that complete product have been tested by UL to nationally recognized Safety Standards and found to be free from reasonably foreseeable risk of fire, electric shock and related hazards and that the product was manufactured under UL's Follow-Up Services program. Most of the products of Baumer electric are UL listed. The file with the listed products can be looked into **http://www.ul.com/database** .

Recognized Component Mark for Canada and the United States

This UL Recognized Component Mark, which became effective also in early 1998, may be used on components certified by UL to both Canadian and U.S. requirements. The UL Recognized Component Mark means that the component alone meets the requirements for a limited, specified use and that the product also was manufactured under UL's Follow-Up Services program. Earlier products of Baumer electric were only UL recognized and are now generally certified as UL listed.