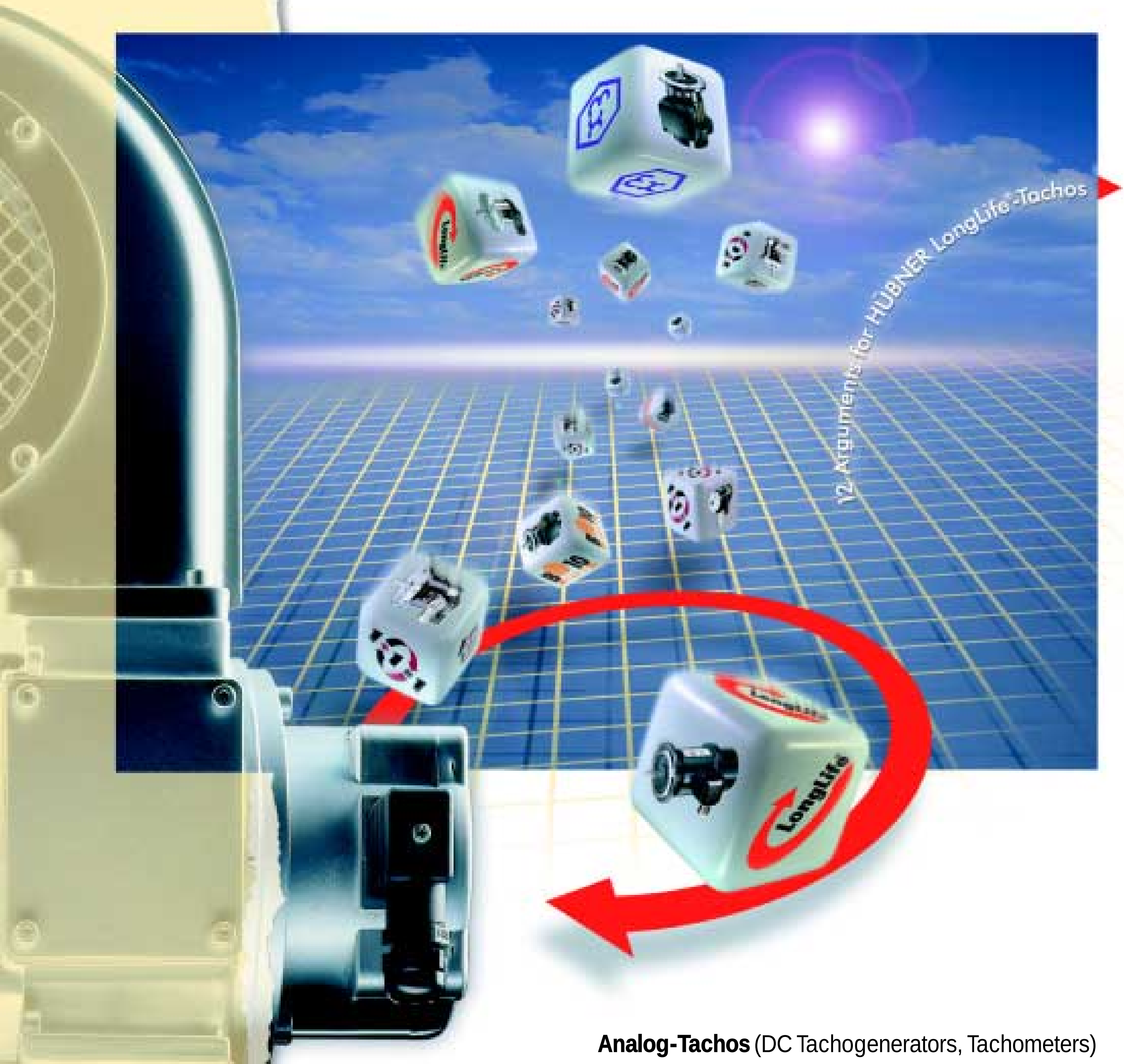
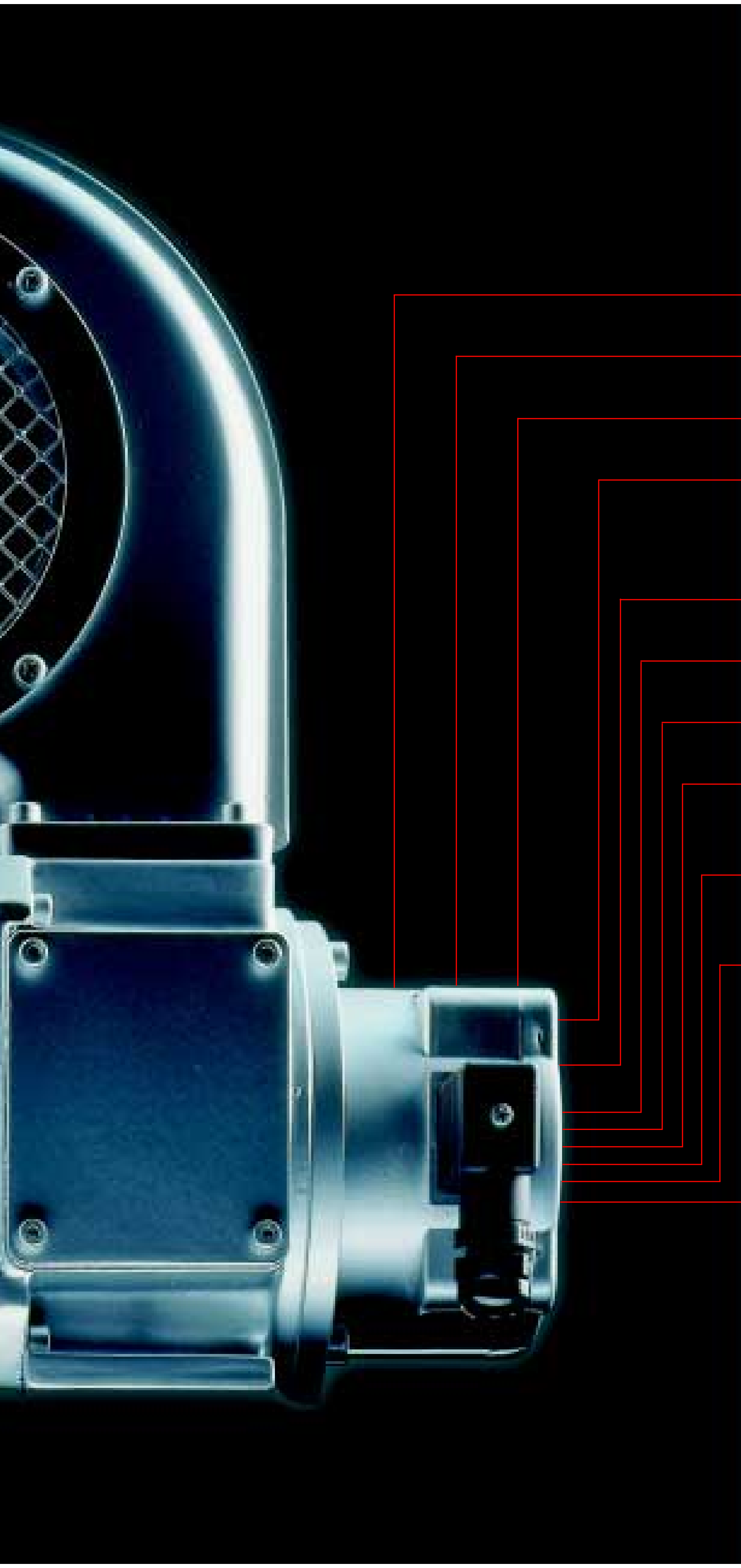
HÜBNER
ELEKTROMASCHINEN AG
BERLIN



Analog-Tachos (DC Tachogenerators, Tachometers)

Information for the User

- Criteria for Selection
- Combinations
- Optimum Signal Transmission
- Application Examples
- Technical Data



Analog-Tachos (DC tachogenerators, tachometers), usually called “tachos” for short (US: “tachs”), are devices for measuring **actual speed values**, which in drive engineering combine high control **dynamics** and **ruggedness**. HÜBNER LongLife® tachogenerators are characterized by the following features, some of which are offered by no other speed sensor:

- **Speed** and **direction of rotation** measured in **real-time**.
- **Speed range** exceeds 1:20,000 (>14 bit) distinctly.
- **Resistant** to mechanical and electrical influences.
- **Temperature range** –30 °C ... +130 °C as standard, lower temperature option. **Protection** against **maritime climates** and **tropicalization** as option.
- **Interference immunity** at signal transmission.
- **Two-core cable** for cost-effective signal transmission.
- **Auxiliary power** (power supply) unnecessary.
- **Bearingless** hollow-shaft types for direct mounting **without coupling** for high dynamics.
- **High signal quality** and **long lifetime** thanks to patented **HÜBNER LongLife® Technology**.
- **Cost-saving** package “Tachogenerator – cable – electronics”.
- **Combinations** with **common shaft**:
  - tachogenerator + tachogenerator (twin tachogenerator)
  - tachogenerator + Digital-Tacho (incremental encoder),
  - tachogenerator + overspeed switch.
- All HÜBNER devices are covered by a **two-year guarantee** subject to the conditions of the German Association of the German Electrical Engineering Industry (ZVEI).

HÜBNER, founded by Johannes Hübner in 1934 in Berlin as a factory for special electrical machines, has been setting standards for decades with innovative sensors for drive engineering applications:

1955 Rugged **Tachogenerator** with permanent magnets TDP 5,5 for rolling mill drives

1966 Tachogenerator TDP 0,2 with **EURO flange®** B10

1970 Europe's first **hollow-shaft tachogenerator** TDP 0,5

1971 **Centrifugal switch** FSL

1978 **HeavyDuty®** Digital-Tachos (incremental encoders) with EURO flange® B10 and high-volt signals (HTL)

1981 Tachogenerator **in explosion proof execution** EEx GP 0,2

1982 **Combination** of Analog- and Digital-Tacho TDP 0,2 + OG 9 with common shaft

1985 Hollow-shaft tachogenerator GTB 9 with protection class **IP 68**

1987 **LongLife®** Analog-Tachos with patented embedded silver track

1989 Digital-Tacho **in explosion proof execution** EEx OG 9,

Twin encoder (Twin Digital-Tacho) POG 9 G

1993 Overspeed switch with **three** switching speeds ES 93

1995 **LowHarmonics®** Sinus-Tachos (sinewave encoders) with high precision sinewave signals

1998 **ExtendedSpeed®** rotary acceleration sensors without speed limitation

1999 Digital-Tacho with large hollow-shaft in **explosion proof execution** EEx HOG 161.

Information for the User

This document is based on many years of experience with applications in various fields of industry (➲ *Typical Applications* on pages 30 to 35) and demonstrates the expertise of HÜBNER as a competent partner for tachogenerators and combinations across a wide range of electrical and mechanical variants tailored to suit specific applications and requirements.

- The following pages ...

... describe the most important features of the **LongLife® tachogenerators** to enable you to make the best possible use of the capabilities of this speed sensor, which has been tried and tested in numerous drive engineering applications.

- **AC tachogenerators**, **trapezoidal tachogenerators** and **f/A converters** round off the tachogenerator range.
- **Twin tachogenerators** and **Combinations** with their special possibilities for drive engineering applications will be dealt with in a specific chapter.
- Typical **Applications** show HÜBNER tachogenerators and combinations in practical use.
- Followed by a catalogue section with the most important **Technical Data**.
- A detailed **Index** makes working with this documentation easier.

You can find additional information on our website at:

http://www.huebner-berlin.de

or you may be advised individually by the **Hot Line +49 (0) 30 - 6 90 03 - 111**
or - 112.

We would be grateful for any information that will help us to develop this documentation further.

We reserve the right to modify technical data in the interest of technical advance.

HÜBNER Technology Survey

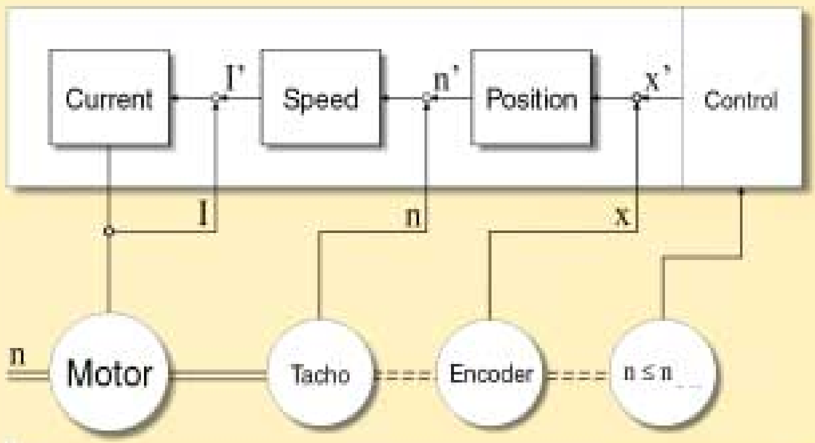


Figure 1: Principle of the cascade control: the control loops of motor current, speed and possibly position and speed monitoring are superposed.

Tachogenerators are used in measurement, control and automation engineering as sensors for converting the mechanical actual value "speed" into an electrical signal. Tachogenerators (Greek ταχοξ = speed, velocity) are **true** speed measuring devices, whose output signal $U_0(n)$ directly follows the speed n and the direction of rotation. This distinguishes them significantly from other speed sensors, such as resolvers, Digital-Tachos (incremental encoders) or sine-wave encoders, where the speed is derived by the signal rate per unit time, i.e. by differentiation.

The principle of the classic cascade control with tachogenerator is shown in Figure 1: The innermost and fastest control circuit detects the motor current I. The **speed control loop** is superimposed with the actual speed n delivered by the tachogenerator, which is compared with the set speed n'. Control of the position x takes place if necessary with a Digital-Tacho (incremental encoder).

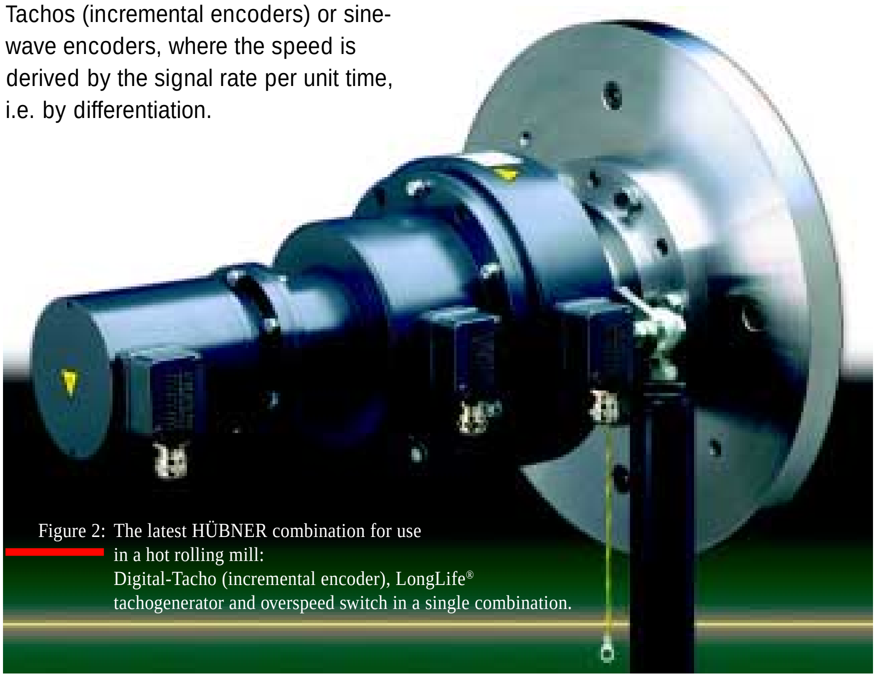


Figure 2: The latest HÜBNER combination for use in a hot rolling mill: Digital-Tacho (incremental encoder), LongLife® tachogenerator and overspeed switch in a single combination.

For monitoring a speed limit $n \leq n_{max}$, an overspeed switch can additionally be provided.
A HÜBNER combination for the variables "position", "speed" and "speed monitoring" is shown in Figure 2 (*Twin Tachogenerators and Combinations for special drive applications* on page 25).

Tachogenerator voltage

The tachogenerator armature (rotor) is connected as torsionally rigid as possible to the driving machine, whose speed is to be detected. As the armature rotates in the field of the permanent magnets, alternating voltages are induced in the armature winding. These voltages are tapped at the commutator with special brushes and in the process converted in correct phase relation (polarity dependent on direction of rotation) to a direct voltage. Available at the terminals is a no-load voltage $U_0(n)$, which is proportional to the speed (Figure 3). For obtaining this signal, auxiliary power (voltage supply) is unnecessary, unlike other speed sensors.

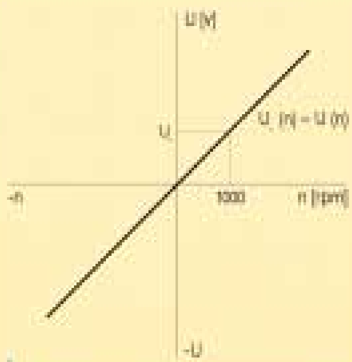


Figure 3: Tachogenerator speed-voltage characteristic.

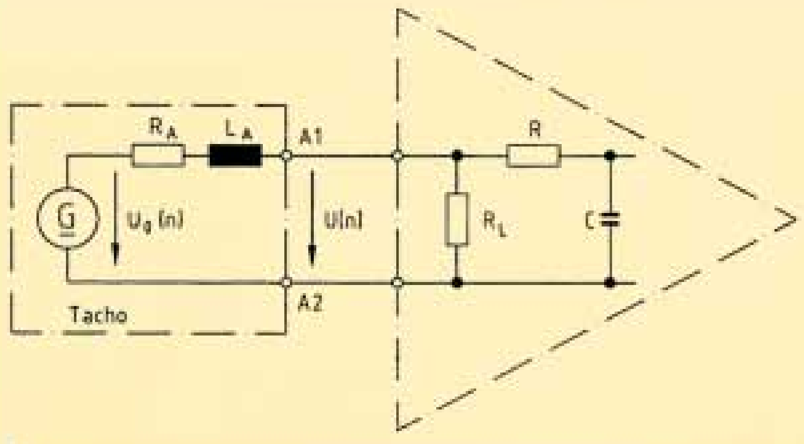


Figure 4: Equivalent circuit diagram of tachogenerator with subsequent control electronics.

From an electrical point of view, the tachogenerator represents a direct voltage source G with the no-load voltage U_0 (n), the armature (internal) resistance R_A and the armature inductivity L_A, which with the load resistance R_L is loaded, normally with the input resistance of the following control electronics (➲ Figure 4). For identification of the **speed-voltage characteristic** U_0 (n) (➲ Figure 3), the no-load voltage gradient [mV/rpm], i.e. the gradient of the straight line, or the no-load voltage U_0 normally delivered at rated speed n_n (typically n_n = 1,000 rpm), is specified. Both are standard reference values.

- Example:

The LongLife® tachogenerator TDP 0,2 LT-4 is characterized by the

– no-load voltage gradient	60 mV/rpm or the
– no-load voltage	60 V/1,000 rpm.

The **polarity** of the tachogenerator voltage (➲ Figure 3) depends on the direction of rotation and follows a reversal of direction without delay time. According to VDE specifications the polarity is defined with clockwise rotation of the drive, viewed from the drive end of the tachogenerator or drive (➲ Figure 5):

Terminal A1:+ Terminal A2:–

If the tachogenerator is loaded with the **load resistance** R_L or load current I_L (➲ Figure 4), applied to the terminals A1 and A2, the voltage is reduced by the voltage drop due to the armature resistance R_A

$$U(n) = U_0(n) - I_L \cdot R_A = U_0(n) \cdot \frac{R_L}{R_A + R_L}$$

As a rule, the load resistance R_L is very much higher than the armature resistance R_A, so that the following approximation applies

$$U(n) \approx U_0(n) \quad \text{for } R_L >> R_A$$

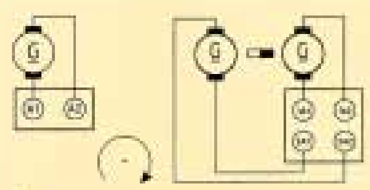


Figure 5: Terminals of the single and twin tachogenerator.

The voltage drop due to the armature resistance R_A in this case is so small that it does not appear in the speed-voltage characteristic (➲ Figure 3).

Minimum load resistance

The minimum load resistance is determined by the loading capacity of the tachogenerator. Shown in the HÜBNER data sheets is the **maximum power** P_{max}, with which the tachogenerator may be loaded. This depends on the size and is between 0.025 W (miniature hollow-shaft tachogenerator GT 3 for small servomotors) and 40 W (tachogenerator with own bearings TDP 13 for rolling mills).

The minimum load resistance to be derived from the maximum power

$$R_{L\,min} = \frac{U_0^2(n)}{P_{max}}$$

increases with the square voltage U_0 or speed n. For the purpose of simplification, HÜBNER specifies in the data sheets three speed ranges

$$0 \dots n_1 \quad \bullet \quad 0 \dots n_2 \quad \bullet \quad 0 \dots n_{max}$$

with the corresponding minimum load resistance R_{Lmin}.

- Example:

TDP 0,2 LT-4 (60 V/1,000 rpm, $R_A \approx 90\ \Omega$)		
0 ... n_1	0 ... n_2	0 ... n_{max}
0 – 3,000 rpm	0 – 6,000 rpm	0 – 10,000 rpm
R_{Lmin} = 2.7 kΩ	R_{Lmin} = 11 kΩ	R_{Lmin} = 30 kΩ

For practical application, this means that if the drive operates within a narrow speed range, the input resistance of the control amplifier can, if necessary, be much smaller than for a drive that uses the full speed range 0 ... n_{max}. The table also shows that the occasionally recommended rule of thumb R_{Lmin} = 100 x R_A results in a load resistance at higher speed which is too small.

In principle, a load resistance $R_L < R_{Lmin}$ is admissible, provided that at no speed on a time average the permissible temperature limit of +130 °C is exceeded defined in the regulation VDE 0530 according to the insulation class B.
The **thermal current limit** defines the maximum load: Above this limit, permanent damage to the tachogenerator can be expected due to internal heating.
A load resistance $R_L \le R_{Lmin}$ limits the accuracy of the tachogenerator voltage, particularly at high speeds, due to the armature reaction (*Linearity tolerance* in next but one chapter).

A **short-circuit** of the tachogenerator is briefly admissible, however, there is a risk of the permanent magnets losing part of their field, thus affecting the calibration tolerance of the tachogenerator.

Calibration tolerance

The permanent magnets of the tachogenerators are "aged" in a special process, i.e. their magnetic properties balanced and stabilized. As a result, the no-load voltage gradient [mV/rpm] or no-load voltage U_0/1,000 rpm (Figure 3) is set ("adjusted") to a tolerance range of ±1 % (TDP 0,2), ±3 % (tachogenerators with own bearings) or ±5 % (hollow-shaft tachogenerators).
The calibration tolerance has no influence on the tachogenerator voltage linearity.

Linearity tolerance

The tachogenerator voltage $U_0(n)$ is proportional to the speed within a very narrow tolerance range, i.e. linear (Figure 3).

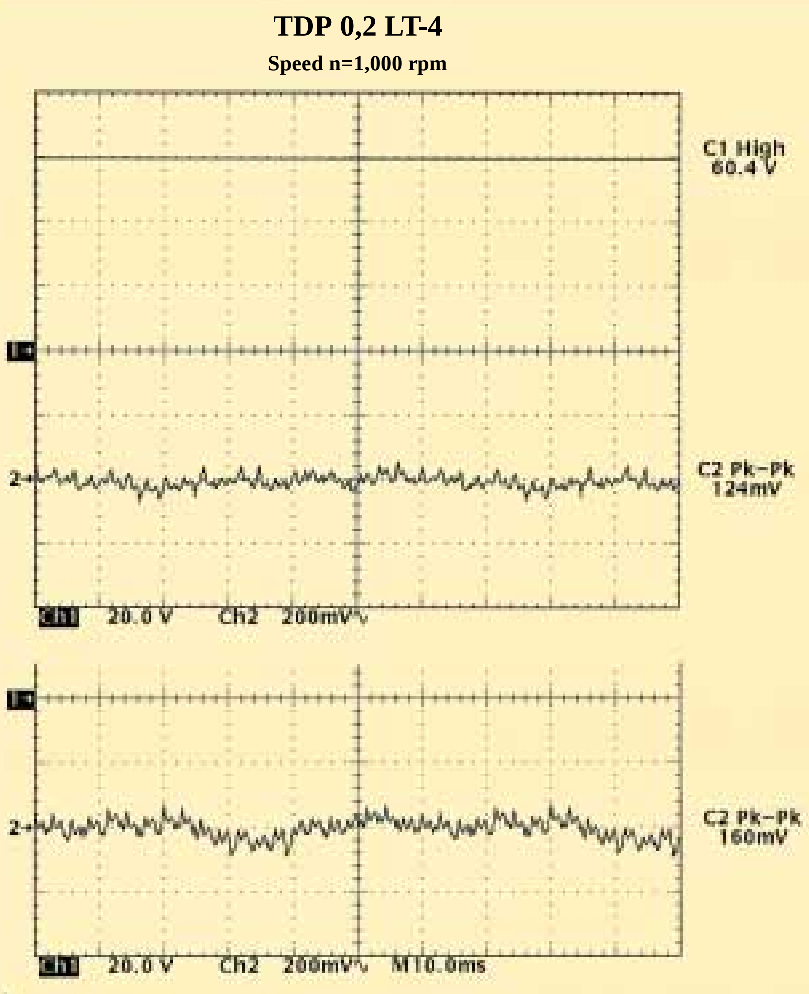


Figure 6: The tachogenerator voltages (above) are superposed by small ripple voltages (centre), incorrect mounting considerably increases the (low-frequency) ripple content (below).

The deviation

$$\frac{U_{\text{actual value}} - U_{\text{set value}}}{U_{\text{set value}}} \cdot 100\ \%$$

(normally ≤ 0.15%) occurs virtually only at high speeds. The causes are the armature reaction of the load current, the increase in the winding resistance due to the current displacement, the hysteresis loss in the core and the increased voltage drop due to the contact resistance between the commutator and brushes at the load current increasing with speed.

Reversing tolerance

With a reversal of direction, the position of the brushes on the commutator changes as a result of the brush clearance in the brush holders due to the design. This can result in a negligible difference in the tachogenerator voltage with clockwise and counter-clockwise rotation

$$\frac{U_{cw} - U_{ccw}}{U_{cw}} \cdot 100\ \%$$

The deviation is ≤ 0.1 %.

Ripple

The tachogenerator direct voltage is superposed with small ripple voltages u_{pp} (Figure 6), the frequency and amplitude of which depends on the speed, number of poles (number of magnetic poles), number of armature slots and number of commutator segments. Incorrect installation of the tachogenerator on the driving machine can increase ripple. For this reason, special attention must be paid to correct installation (Page 15 and 18). Two methods are used for ripple characterization:

Peak-to-peak value: With an oscilloscope set to "AC", the harmonic voltage u_{pp} is measured, whereby the low pass character of the control electronics (Figure 4) is simulated by an RC filter with the time constant

$$\tau_{RC} \approx R \cdot C \quad \text{for } R > R_L >> R_A$$

Depending on the type of tachogenerator and particular application $\tau_{RC} = 0{,}2 \ldots 1$ ms.

The ripple voltage u_{pp} is referenced to the associated direct voltage U

$$\frac{u_{pp}}{U} \cdot 100\ \%$$

Some manufacturers base calculation on only half the peak-to-peak value, which *"optically"* improves the result by the factor 2.

For highly dynamic drives, however, the peak-to-peak value is of significance and should be as small as possible.

- **Root-mean-square value:** The root-mean-square value is measured with an evaluating measuring instrument. Because the higher frequency components of the ripple voltage make only a small contribution to the root-mean-square value, this value is lower than the peak-to-peak value. Definition of the root-mean-square value is therefore only of significance for large, less dynamic drives.

- Example:

The tachogenerator voltage of the TDP 0,2 has a peak-to-peak value of ≤ 0.5 % and a root-mean-square value of ≤ 0.2 %.

Temperature coefficient

The energy content of the permanent magnets reduces with increasing temperature. This affects the tachogenerator voltage with a temperature coefficient of

$$T_C = -0{,}03\ \%/K$$

With special soft iron alloys, which have a positive temperature coefficient and short-circuit a portion of the permanent magnet field, the temperature coefficient can be reduced almost to the power of ten to

$$T_C = \pm 0{,}005\ \%/K$$

The temperature coefficient of the armature winding

$$R_A(t) = R_A(20\ °C)\,[1 + \alpha_{Cu}\,(t - 20\ °C)]$$

($\alpha_{Cu} = +0{,}0039$) can be disregarded, as usually $R_L >> R_A$.

Delay time (armature circuit time constant)

The equivalent circuit diagram of the tachogenerator (Figure 4) contains in addition to the armature resistance R_A also the armature inductivity L_A. When terminating the circuit with a load resistance R_L, the tachogenerator voltage $U(n)$ follows a change in the generated tachogenerator voltage $U_0(n)$ with the armature circuit time constant

$$\tau_A = \frac{L_A}{R_A + R_L} \approx \frac{L_A}{R_L} \quad \text{for } R_L >> R_A$$

The armature inductivity

$$L_A = A_L \cdot N^2$$

depends on the square of the number of windings N. The factor A_L combines the electrical and mechanical properties of the tachogenerator. For the load resistance the power loss has to remain constant, independent of the tachogenerator voltage. This means that for the load resistance a square-law relation is also given,

$$R_L \sim N^2$$

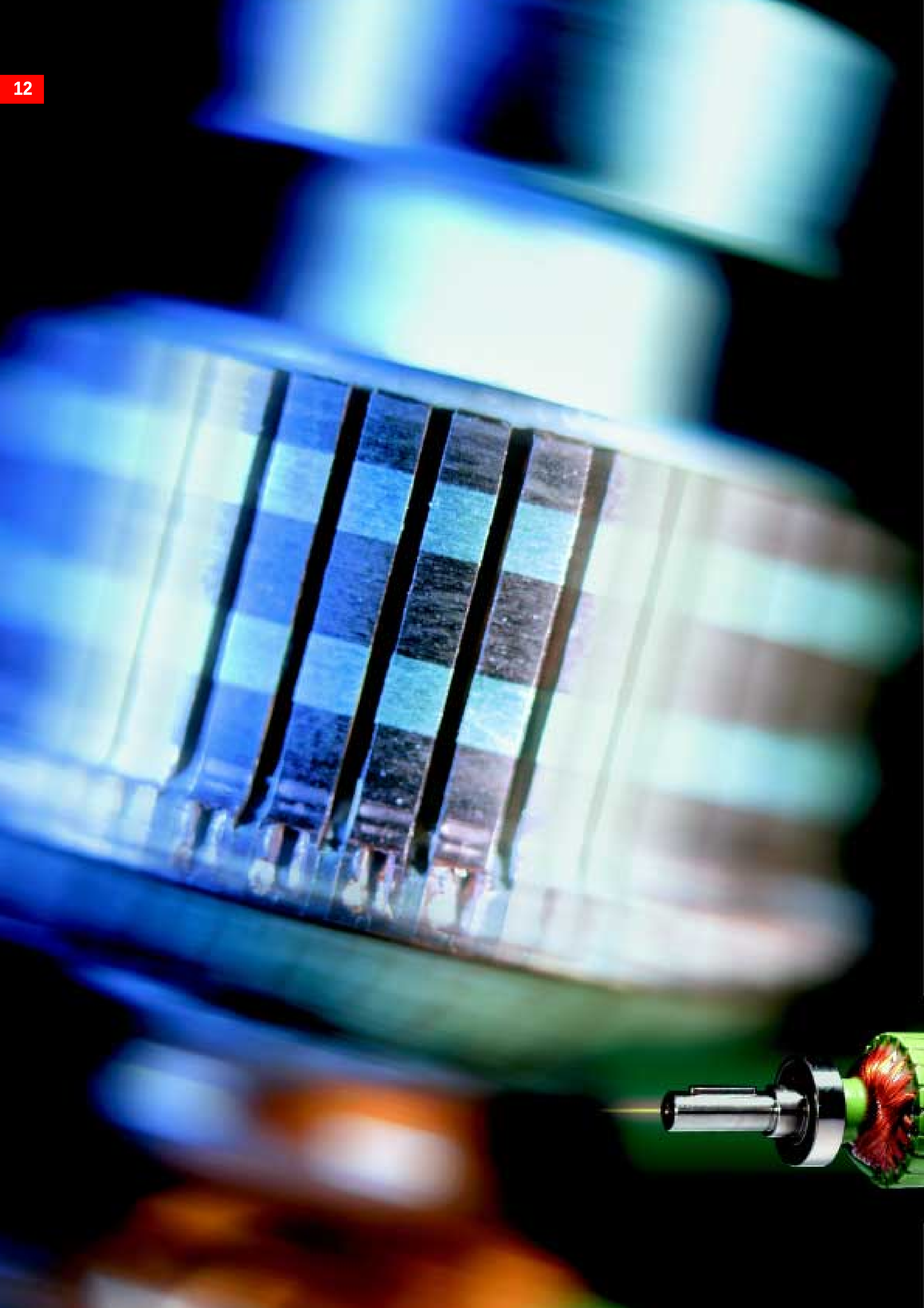
as explained on page 9, right column. The armature circuit delay time is thus

$$\tau_A \approx \text{const.}$$

This accordingly depends only on the tachogenerator type and not on the tachogenerator voltage.

The value specified in the HÜBNER data sheets for τ_A is based on the minimum load resistance R_{Lmin} and is in the µs range (tables on page 14 and 15).

For $R_L \to \infty$, i.e. no-load , $\tau_A \to 0$, i.e. with an unloaded tachogenerator, the tachogenerator voltage $U_0(n)$ follows the speed n virtually **without delay**.



LongLife® Technology

HÜBNER tachogenerators are characterized by high accuracy of the tachogenerator voltage $U_0(n)$ over the entire speed range n. An essential component is the standard-setting commutator – brush transfer system, which was further developed by HÜBNER:

Figure 7: Hollow-shaft armature (GTB 9) with embedded silver track.

Figure 8: Section through a LongLife® commutator (GT 5).

- **Copper commutator · Graphite brushes**

  This classic combination is technically overhauled. Low speeds cannot be detected precisely because the copper oxide layers on the commutator cause alternating contact resistances and in turn high tachogenerator voltage ripple. Advantageous by contrast is the long lifetime of the brushes, due to the good sliding properties of the graphite.

Figure 9: Armature of a two-pole tachogenerator with double silver track (TDP 0,2).

- **Copper commutator · Silver graphite brushes**

  The requirement for low speeds is met with noble-metal brushes which during operation apply a highly conductive layer to the commutator. However, the good transfer properties over the entire speed range can be lost in adverse atmospheres (oil, grease, sulphur and salt-laden air) if no layer develops. Because the metal-graphite brushes make direct contact with the copper, they are subject to wear.

- **LongLife® commutator · HÜBNER brushes**

  The LongLife® Technology, developed by HÜBNER and patented in 1987, combines the positive and eliminates the negative properties of both aforementioned techniques. In a special HÜBNER process, depending on the type of tachogenerator, one or two solid silver tracks are embedded in the commutator surface (➲ Figures 7 to 9). This ensures also in adverse ambient conditions a constant, small contact resistance. Because of the relatively small tachogenerator currents, the silver tracks can be narrow. The specially adapted HÜBNER brushes ensure together with the LongLife® commutator, freedom from maintenance that extends beyond the lifetime of ball-bearings (➲ *Ball bearings* on page 17).

The **LongLife® tachogenerators** are provided with **four** brushes for safe current transfer (redundancy), particularly under the influence of vibration and shock (➲ *Vibration and shock resistance* on page 19). (Exception: Miniature tachogenerator TDP 0,03 for use in measuring equipment):

- **Hollow-shaft tachogenerators** (Four-pole tachogenerators):
  The four brushes are accommodated in a brush holder each mechanically staggered by 90° (➲ Figure 10). Aposing brushes are electrically connected in parallel and all run on **one common** silver track (➲ Figure 7).

Figure 10: Four-pole tachogenerators are characterized by their four brushes staggered by 90° (GTB 9).

- **Tachogenerators with own bearings** (Two-pole tachogenerators):
  The brushes are mechanically staggered in pairs by 180° and accommodated in double brush holders.
  The two brushes each arranged side by side are electrically connected in parallel and run along **two parallel** silver tracks (➲ Figure 9).

Hollow-shaft tachogenerators
(Four-pole tachogenerators)

Distinctive characteristics are the **armature** with **hollow-shaft without own bearings**. The armature rotates in a magnet field, which in analogy to the arrangement of the brushes, contains four alternately magnetized magnetic poles, which are mechanically staggered by 90° in the stator.
These tachogenerators are therefore also known as "four-pole tachogenerators".
Following HÜBNER hollow-shaft tachogenerators have this design:

Type	P_{max} [W]	U_0 [mV/rpm]	τ_A [µs]
GT 3	0.025	5	≤ 2
GT 5	0.075	7 ... 10	≤ 4.5
GT 7	0.3 ... 0.6	10 ... 60	≤ 4
GT 9	0.3	10 ... 20	≤ 9
GTB 9[1)]	0.3	10 ... 20	≤ 9
GTR 9	0.9	10 ... 60	≤ 5
GT 16	1.8	60, 100	≤ 7

1) Mounting tachogenerator with IP 68, otherwise as GT 9

and further special types, e.g. TDP 0,5 (predecessor of GTR 9) (➲ *Technical Data).*

Hollow-shaft tachogenerators are designed for a lower load and lower tachogenerator voltage.
They are characterized by a very small delay time (armature circuit time constant) τ_A (➲ Page 11), small armature moment of inertia and direct mounting on the driving machine without further intermediate components (➲ Figures 11 and 12).

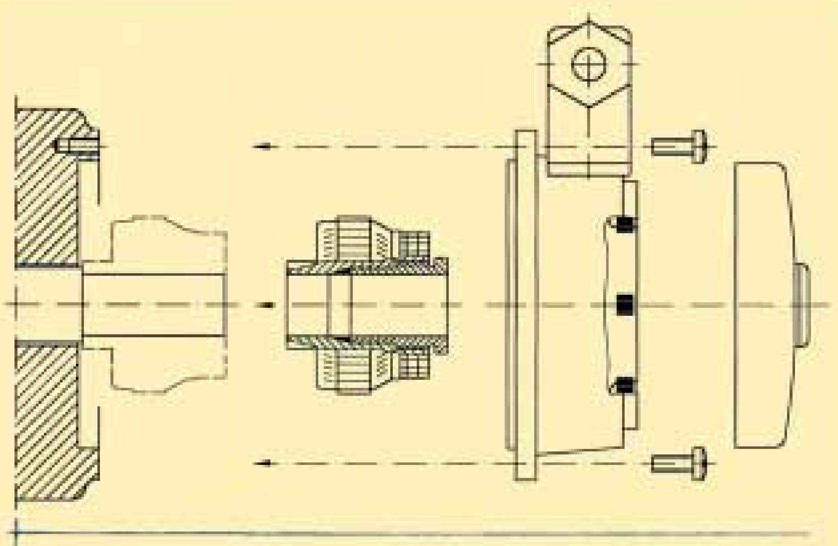


Figure 11: Hollow-shaft tachogenerators form together with the drive a torsionally stiff and particularly compact unit.

A body (stator) coupling is unnecessary, resulting in a **very high resonance frequency** of the closed control loop.
Because of their extremely short design, hollow-shaft tachogenerators are also called "Pan cake tachogenerators" in American speaking countries.

HÜBNER hollow shaft tachogenerators contain a **two circuit winding** with a parallel armature current path, which for perfect functioning, would require only two brushes mechanically staggered by 90°. The two additional brushes increase safe current transfer without influencing the armature resistance R_A and in turn the tachogenerator voltage or ripple rate.

Figure 12: Hollow-shaft tachogenerator (GTB 9 in IP 68) on a precision CNC machine.

Some tachogenerator manufacturers use the less sophisticated lap winding with several parallel armature current paths, which are connected in parallel through the brushes. Brief lifting of the brushes due to mechanical influences increases the armature resistance R_A, which causes small reduction of the tachogenerator voltage and consequently a strong increase in the ripple rate.

Typical applications of hollow-shaft tachogenerators are drives with high demands on **speed dynamics**.

Hollow-shaft tachogenerators are delivered in two parts: as the armature (rotor) with the associated stator (with fitted brush holder). They are initially ready to use once assembled with the drive unit. This must therefore have a centering shoulder and a free shaft end (➲ Figure 11). It is important that the dimensions and tolerances for the centering shoulder and shaft end specified in the data sheets are observed to maintain speed measurement accuracy.

- The **hollow-shaft armature** is fitted to the shaft without force and securely connected to the same by means of an integrated clamping element or a front screw fitting. The radial excentricity of the armature is limited to maximum ± 0.1 mm and the axial offset to maximum ± 0.5 mm. The radial excentricity should not exceed ± 0.05 mm.
- The **stator** of the hollow-shaft tachogenerator is slipped over the mounted armature onto the centering shoulder and screwed directly to the drive. To make the stator easier to slip over the armature without have to previously remove the brushes, HÜBNER has a mounting cone in its range of accessories.

Mounting of the armature and associated stator must be carried out with great care. Particularly the commutator and brushes have to be protected from damage and dirt. Care is required to avoid iron filings, which are attracted by the not yet mounted stator.

Assembly and **operating information** is available.

If necessary, hollow-shaft tachogenerators can be removed without a voltage loss occurring.

The protection class specified in the data sheets applies to correctly mounted hollow-shaft tachogenerators.

Tachogenerators with own bearings
(Two-pole tachogenerators)

Distinctive characteristics are the **armature** with **solid shaft** and **own bearings**. The armature rotates in a magnetic field, which, relative to the brush position, contains two alternatively magnetized poles, which are staggered by 180° in the stator. These tachogenerators are therefore also known as "two-pole tachogenerators". Following HÜBNER tachogenerators have this design:

Type	P_{max} [W]	U_0 [mV/rpm]	τ_A [µs]
TDP 0,03	0.14 ... 0.32	7 ... 20	≤ 20
TDP 0,09	1.2	10 ... 60	≤ 25
TDP 0,2	12	10 ... 150	≤ 160
EEx GP 0,2 TG 74[1)]	12	20 ... 150	≤ 150
GMP 1,0	30	40 ... 175	≤ 550
TDP 13	40	20 ... 200	≤ 400

[1)] for use in hazardous areas

and several special types, e.g. rolling mill tachogenerator TDP 5,5.

Tachogenerators with own bearings are characterized in comparison to hollow-shaft tachogenerators by an enclosed, rugged housing, higher loading capacity, higher tachogenerator voltages and longer delay time (armature circuit time constant) τ_A (Page 11).

A further characteristic is the tachogenerator drive via a coupling. Tachogenerators with flange, e.g. EURO® flange B10 (*EURO® flange B10* on page 21), are mounted on the driving machine via a support housing (Figures 13 and 14). Tachogenerators with foot ("B3 tachogenerators") are fixed to their own bracket. With this mounting variant, particular attention should be paid to mounting errors (*Coupling* on page 18). The tachogenerator shaft normally contains a key-way according to DIN 6885, page 1. The tachogenerator voltage can be transferred to the control electronics also over long distances, due to its amplitude and due to low tachogenerator internal resistance (*Optimum signal transmission* on page 29).

Typical applications are machines and plants with high demands on **ruggedness** and **reliability**.

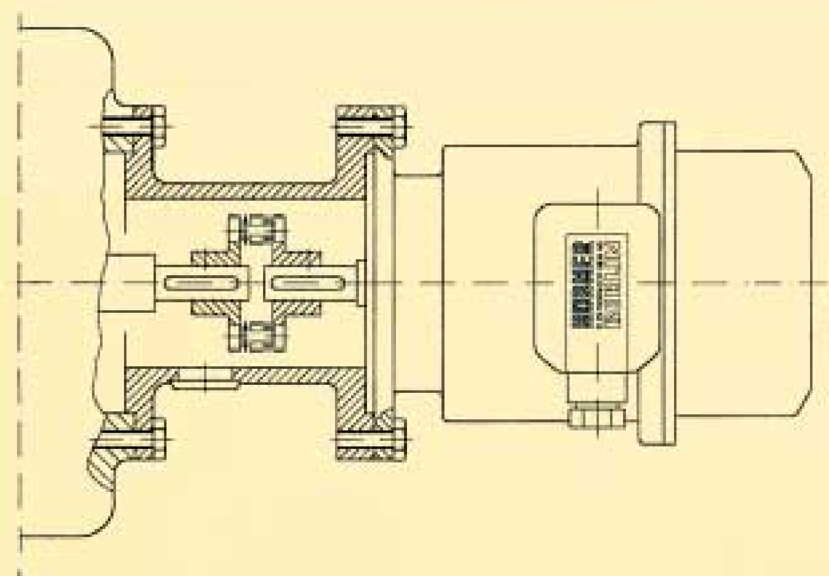


Figure 13: Tachogenerators with own bearings are connected to the drive via a support housing and coupling.

Figure 14: Tachogenerators with own bearings form a rugged unit with the driving machine (here a TDP 0,2 on one of the 500 kW drives of the Zugspitz cable-car).

If tachogenerators with own bearings should be dismantled for replacement of the ball bearings, the applicable **Assembly and Operating Information** must be observed, so that no voltage loss occurs after assembly. Only the TDP 0,2 can be dismantled without the otherwise required magnetic short-circuiting ring.

An exception to the classic division of “hollow-shaft tachogenerators”/“tachogenerators with own bearings” are **modified hollow-shaft tachogenerators**, which HÜBNER has in its range for special applications, e.g. the hollow shaft tachogenerator GTL 5 with own bearings and the solid shaft tachogenerator GTF 7 with EURO flange® B10, which were derived from the hollow-shaft tachogenerators GT 5 and GT 7. The designations indicate own bearings (“**L**ager”) or **f**lange.

Minimum – Maximum speed

- The minimum speed depends on the tachogenerator type, tachogenerator voltage level, transmission interference (➲ *Optimum signal transmission* on page 29) and sensitivity of the evaluating electronics. HÜBNER Long-Life® Technology is capable of resolving tachogenerator voltages below 5 mV. This value is on the level of sinewave encoders, whose analog sine/cosine voltages of $1V_{pp}$ with appropriate quality of the signals (➲ Data sheets of HÜBNER LowHarmonics® sinewave encoders and special publication *“The rest are just noise”*), are similarly interpolated in steps in the order of some millivolts. With this guide value, the following are minimum speeds for several typical HÜBNER tachogenerators:

GT 5	(10 mV/rpm)	➔ ≤ 0.5 rpm
TDP 0,2	(60 mV/rpm)	➔ ≤ 0.08 rpm
HTA 16	(1,000 mV/rpm)	➔ ≤ 0.005 rpm

The GT 5 is capable, as demonstrated at the Hannover Fair, to measure the “speed” of a seconds hand. The HTA 16 is a special tachogenerator for very slow (direct) drives.

- The **maximum** speed can have a mechanical or electrical limit:

– The **mechanical speed limit** is determined by the maximum permissible armature circumferential speed, or in the case of tachogenerators with own bearings, by the maximum ball bearing speed and is normally about n_{max} = 10,000 rpm (➲ *Ball bearings* on page 17).

– The **electrical speed limit** is determined by the maximum permissible voltage between adjacent commutator segments (segment voltage) and is about 30 V. From this it follows that tachogenerators with a lower voltage gradient have a higher maximum speed:

GT 5	(10 mV/rpm)	➔ 10,000 rpm (mechanical limit)
TDP 0,2	(60 mV/rpm)	➔ 10,000 rpm (mechanical = electrical limit)
HTA 16	(1,000 mV/rpm)	➔ 360 rpm (electrical limit)

The mechanical or electrical maximum speed is shown in the data sheets.

Thus, for the tachogenerators mentioned as an example result the following **speed range**:

GT 5	(10 mV/rpm)	➔ ≥ 1 : 20,000
TDP 0,2	(60 mV/rpm)	➔ ≥ 1 : 125,000
HTA 16	(1,000 mV/rpm)	➔ ≥ 1 : 72,000

Comparison: Modern 14-bit A/D converters have a dynamic range of 1:16,384.

Housings

For ruggedness, HÜBNER housings consist of a nickel-plated steel ring (preferably hollow-shaft tachogenerators) or die-cast, powder coated light-alloy in the colour anthracite RAL 7021 (tachogenerators with own bearings).

Some hollow-shaft tachogenerators are provided with a transparent cover (➲ Figure 10 and 12), to enable the direction of rotation of the drive to be easily checked.

The **tachogenerator size** and in turn the **housing size** should be adapted to suit to the application:

– Large driving machines require a tachogenerator of **adequate size** (➲ *Typical applications* on page 30).

– For use in maritime or particularly damp or humid climates, the tachogenerators can be provided with optional **protection against maritime climates and tropicalization**.

We will be pleased to give you **advice** on all design and planning matters.

Types

The types conform to the standard IEC 34-7. Modified types are distinguished by additional letters. The devices shown **horizontally** in the dimension drawings of the data sheets are also suitable for **vertical** operation. The dimensions in the dimensioned drawings are guide values and can change in line with technological advance or at the request of the customer. Technical drawings provided on request are binding.

Ball bearings

The permanently greased ball bearings are amply dimensioned for high vibration and shock resistance. The lifetime is decisively influenced by vibration, shock, temperature, angular acceleration and reversing. The **maximum speed** n_{max} specified in the data sheets must not be exceeded. The specified value is determined either by the bearings, the maximum circumferential speed of the armature, or the maximum permissible voltage between the commutator segments (segment voltage). (*Minimum – Maximum speed* on page 16).

The ball bearing manufacturers specify as a nominal **life expectancy** (number of revolutions) the following relation, which is reached or exceeded by 90 % of the bearings:

$$L = \left(\frac{C}{P}\right)^3$$

- L: Number of revolutions
- C: Dynamic load rating [N]
- P: Bearing load [N]

● Example:

For a HÜBNER tachogenerator with own bearing, e.g. TDP 0,2, the two ball bearings of which each equally support the armature with a weight of about 700 g, the following can be taken as basis

- C (typ. value) = 5,600 N
- P (typ. value) = 3.5 N

➔ L = $4.1 \cdot 10^9$ revolutions

This value coincides with normal practice: At 2,000 rpm, the ball bearings have a lifetime of over 40,000 hours, which corresponds to $4.8 \cdot 10^9$ revolutions.

The guide value of **10^9 revolutions** specified in the HÜBNER data sheets or 20,000 operating hours is greatly exceeded under normal conditions.

No-load drive torque

The brushes sliding on the commutator and, in the case of tachogenerators with own bearings, the ball bearings and shaft seals cause a no-load drive torque in the case of the unloaded tachogenerator, which is specified in the data sheets. With electrical load, this value increases according to the output power.

Bearings at both ends

Two-pole tachogenerators with bearings at both ends are characterized by a high radial and axial loading capacity of the shaft due to the armature being supported at both ends. This is of significance when the tachogenerator, for example, is driven with a toothed belt or friction wheel. The bearings at both ends also offer for the majority of tachogenerators the following **mounting variants** (*Twin Tachos and Combinations for special drive applications* on page 25):

- *Rear shaft end:*
  - Tachogenerators with rear shaft option can have *hollow-shaft* devices mounted and directly connected without coupling.
  - The rear shaft end of tachogenerator drives via a coupling devices with *own bearings*.
- *Twin tachogenerators and Combinations with common shaft:*
  - Tacho + Tacho (Twin tachogenerator) with two separate tachogenerator voltages
  - Tacho/Twin Tacho + Incremental encoder
  - Tacho/Twin Tacho + Overspeed switch.

Figure 15: HÜBNER spring disk couplings with insulated hub protect against shaft currents.

Coupling

The coupling between the drive and tachogenerator with own bearings is decisive for the accuracy of the tachogenerator voltage (➲ *Ripple* on page 11):

- The coupling is designed to connect the drive and tachogenerator as **backlash-free** and **torsionally rigid** as possible. HÜBNER has suitable spring disk couplings K 35, K 50 and K 60 in its product range (➲ Figure 15), offering high torsional stiffness and axial offset up to ± 0.7 mm to compensate thermal expansion of the drive.
  In the version with insulated output hub of high-strength plastic, they protect against **shaft currents** (➲ next chapter).
- The coupling must be mounted on the tachogenerator shaft **without exerting force** to avoid subjecting the precision ball bearings to uncontrolled axial pressure. The use of a hammer must be avoided in any event. The careful use of a rubber hammer is recommended for tight fits.
- **Parallel, angular and axial offset** (Shaft misalignment, mounting errors and coupling errors) must be kept to a minimum in the interest of high transmission accuracy. This applies in particular to tachogenerators with foot ("B3-tachogenerators") (➲ Figure 16).

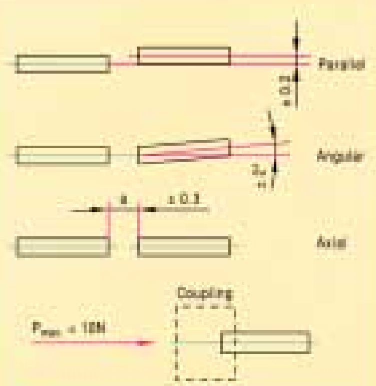


Figure 16: Parallel, angular and axial offset should be as small as possible.

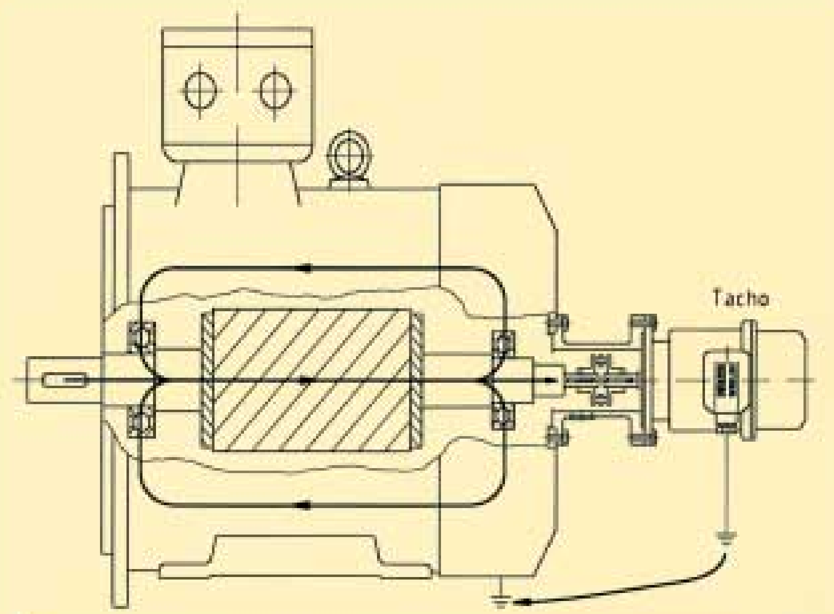


Figure 17: Voltage differences between each end of the rotor create shaft currents which can damage connected components if the rear bearing is insulated.

The **spring-mass system** of coupling and tachogenerator armature should have in the closed loop a **resonance frequency** $\mathbf{f_R}$ that should be as high as possible:

$$f_R = \frac{1}{2\pi}\sqrt{\frac{C_{T\,dyn}}{J}}$$

- f_R : Resonance frequency [Hz]
- $C_{T\,dyn}$: Torsional rigidity of coupling [Nm/rad]
- J : Moment of inertia of tachogenerator armature [kgm^2]

The values are given in the data sheets.

● Example:

- Coupling K 35:
  $C_{T\,dyn}$ = 900 Nm/rad
- Analog-Tacho TDP 0,09:
  J = 0.25 $Kgcm^2$

➔ f_R = 955 Hz

Protection against shaft currents

For motors above 100 kW or motors that are operated by high-speed frequency converters, voltage differences can be expected in the rotor, which may result in shaft currents (➲ Figure 17). From a current density of about 1 A/mm^2, the running surface of ball bearings can be damaged (➲ Figure 18).

The following causes are possible:

- Asymmetry in the magnetic circuit
- Capacitive coupling by high-speed frequency converter
- Interference voltages from driven machines
- Electrostatic charge through vee-belts or lubricants
- Unipolar voltages of sliding bearings.

For protection against **inductively** generated shaft currents, modern motors are provided with an insulated bearing at the rear end. In this way, the problem is shifted to the mounted devices (➲ Figure 17):

Figure 18: Ball bearings damaged by shaft currents are marked by a corrugated ball race surface.

- In the case of **tachogenerators with own bearings**, the tachogenerator housing is connected to the motor via the rear support housing and thus earthed. For safety reasons, the tachogenerators should additionally be earthed via their own **earth connection**. The shaft currents of the motor would accordingly find a way via the tachogenerator bearings to "earth". HÜBNER spring disk couplings K 35, K 50 or K 60 with insulated hub (➔ Figure 15) separate the path from the motor to the tachogenerator shaft and so suppress the shaft currents via the tachogenerator bearings.
- In the case of **hollow-shaft tachogenerators**, the tachogenerator armature is permanently connected both mechanically and thus electrically to the motor shaft. Protection against shaft currents is provided by the insulation between the armature core and tachogenerator winding.
  The **isolation voltage** according to VDE specifications is

  2 × max. tacho voltage + 1,000 V ≥ 1,500 V

  This isolating voltage generally applies to all HÜBNER tachogenerators, including the tachogenerators with own bearings.

For protection against **capacitive** coupled shaft currents, insulation of the ball bearings, coupling and winding is insufficient, as shaft currents flow from beyond these insulating clearances according to the capacitive voltage divider principle.
HÜBNER has therefore developed **earthing devices** with slipring contacts, for which a patent has been applied for, featuring HÜBNER LongLife® Technology. The shaft currents are accordingly able to by-pass the motor and tachogenerator bearings to "earth".

Further information on the subject of *shaft currents* is provided in the special publication **"Protecting Rotary Sensors by fitting Insulated Ball Bearings".**

Temperature range

The temperature range specified in the data sheets relates to the housing surface temperature and is the same for all analog tachogenerators

– 30 °C to +130 °C

The **characteristic temperature** of the tachogenerator (heating of the armature winding under load and of the ball bearings and their seals at high speeds) must be observed.

Vibration and shock resistance

The vibration and shock resistance depends on the design of the tachogenerator or the tachogenerator combination and is specified in the leaflets according to:

- **IEC 68-2-6** *"Vibrations, sinewave"*
- **IEC 68-2-27** *"Shocks"*
- **IEC 68-2-29** *"Repeated Shocks".*

Vibration tests, particularly relating to possible resonance frequencies of components, are carried out by HÜBNER on a special test bench (➔ Figure 19). The certificate of an accredited testing institute for successfully passed vibration and shock tests can be provided for the tachogenerator TDP 0,2.

Figure 19: Vibration test, particularly with regard to resonance frequencies; the electronics board of a HeavyDuty® Digital-Tacho (encoder) for the analog-digital combination TDP 0,2 + OG 9 in the frequency range 2 Hz to 4 kHz being tested on a test bench with air suspension.

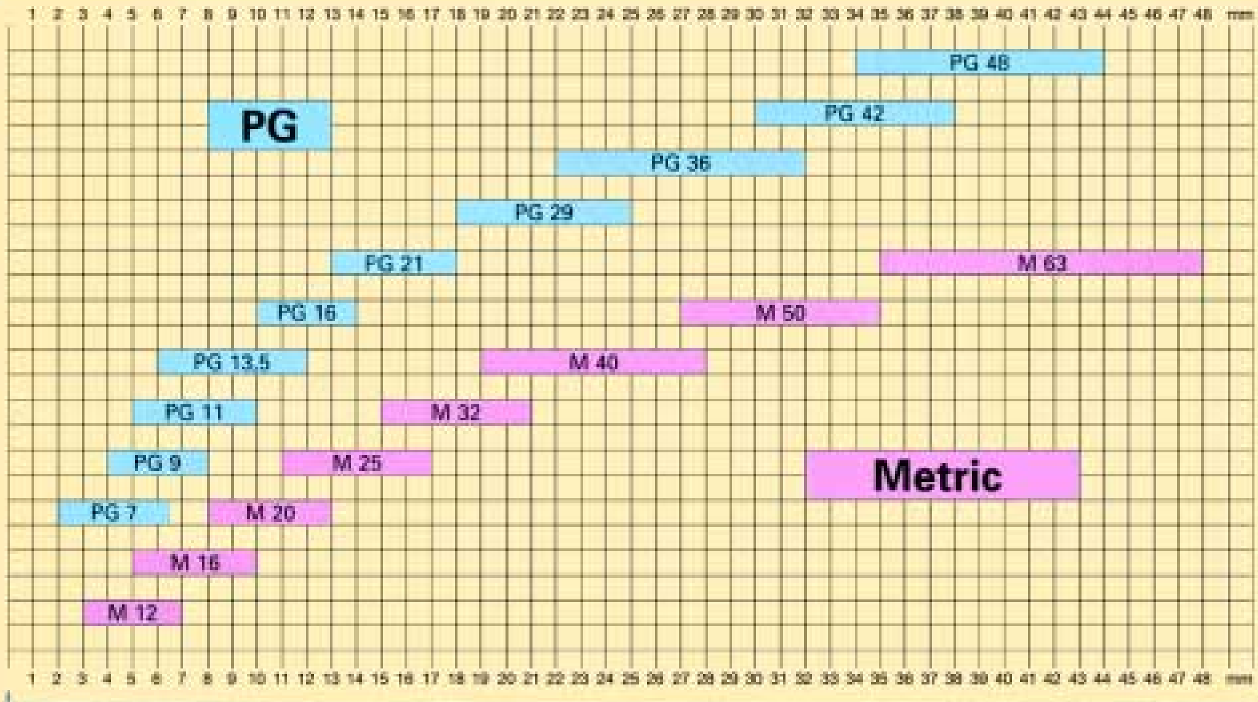


Figure 20: Clamping ranges of cable glands "metric"/"PG" (Jacob GmbH).

Protection class

The protection class IP (International Protection) according to **EN 60034-5** and **IEC 34-5** *(Classification of Protection Classes by Housings)* is of importance for the tachogenerator application and is specified in the data sheets as follows:

First digit: Protection against harmful contact and ingress of solid objects

- **5** = Protection against damaging dust deposit (dust protection)
- **6** = Protection against the ingress of dust (dust tight)

Second digit: Protection against the ingress of water

- **4** = Protection against splash-water
- **5** = Protection against jet-water
- **6** = Protection against flooding
- **7** = Protection against immersion
- **8** = Protection against submersion.

HÜBNER attaches particular importance to the degree of protection: Special sealing measures ensure that the hollow-shaft tachogenerator GTB 9, for example, has the protection class IP 68 after mounting on the driving machine.

Cable connection

The way in which the cable is connected depends on the device and application:

- Terminal box with Combicon® terminals and terminal cover reversable by 180° for cable outlet on the right or left of the tachogenerator
- Internal terminal strip
- Metal-bodied mating connector
- Flying connecting cable.

The connecting cable must have the diameter specified in the dimension drawings of the data sheets, so that the **cable entry** (cable gland) can ensure the protection class.

The new European standard

EN 50 262 – *Metric cable glands for electrical installations*

replaces the previous steel conduit thread PG by the **metric ISO fine-thread**. Instead of the PG 7 to PG 48 thread divided into ten categories, the M 12 to M 63 metric thread is divided into eight categories (➲ Figure 20).

The **cable shield** must be connected electrically with the cable gland, with special attention being given to the **earthing** of the tachogenerator. (➲ *Protection against shaft currents* on page 18 and *Optimum signal transmission* on page 29).

EURO flange® B10

With the internationally standardized EURO flange® B10 (➲ Figure 21 left), HÜBNER offers the widest range for diverse drive applications:

- **Analog-Tachos/Twin-Tachos**
- **Digital-Tachos (incremental encoders)**
- **Mechanical/electronic overspeed switches**
- **Combinations** of these devices **with common shaft** (➲ *Twin-Tachos and combinations for special drive applications* on page 25).

In the Section *"Technical Data"* on pages 36 to 45, reference is made to the EURO flange® B10 in the case of the respective devices. The standard tachogenerator TDP 0,2 is also available with **NEMA flange** (➲ Figure 21 right as TDP 0,2 US). Further devices with NEMA flange are available on request.

A complete summary of devices with EURO flange® and typical application examples can be found in the publication

"EURO flange® B10",

available on our website
www.huebner-berlin.de
or which we will be pleased to send to you.

Explosion proof

The German Federal Institute of Standards (PTB) has confirmed with the Declarations of Conformity that the tachogenerators **EEx GP 0,2** and **TG 74 d** according to

- **EN 50 014** *General Definition*
- **EN 50 018** *Explosion proof enclosure "d"*
- **EN 50 019** *Increased safety "e"*

are approved for operation with standard industrial cabling in hazardous areas, code **"EEx de IIC T6"** (➲ Figure 22).

ISO 9001

We will be pleased to make available to you the **ISO 9001 certificate** of the TÜV CERT as a recognized reprint for your quality management system.

EU Declaration of Conformity · CE

We will be pleased to send you the Manufacturer's Declaration that our products conform to the European Directive **89/336/EEC** *(Directive on Electromagnetic Compatibility).*

Figure 22: PTB certificate and tachogenerator on a motor both protected for use in hazardous locations.

AC tachogenerators

AC tachogenerators are brushless devices with a permanent magnet rotor which rotates in a three-phase stator winding system with neutral point (Y):

- They generate three linked **no-load alternating voltages $u_0(n)$**, each offset by 120°, the amplitude and frequency of which are proportional to the speed n (Version "D", ➲ Figure 23 above).
- The type with integrad three-phase bridge rectifier delivers from a minimum speed n_{min} (diode threshold voltage) a **no-load direct voltage $U_0(n)$**, the polarity of which is independent on the direction of rotation (Version "DG", ➲ Figure 23 below). The ripple rate content is 4.5 % rms.

AC tachogenerators with incorporated rectification are used for indicating speed measuring devices and simple controlled drives, where neither reversing nor speeds occur close to zero and where the relatively high ripple rate in comparison to dc tachogenerators does not play any noteworthy role (e.g. fan drives).

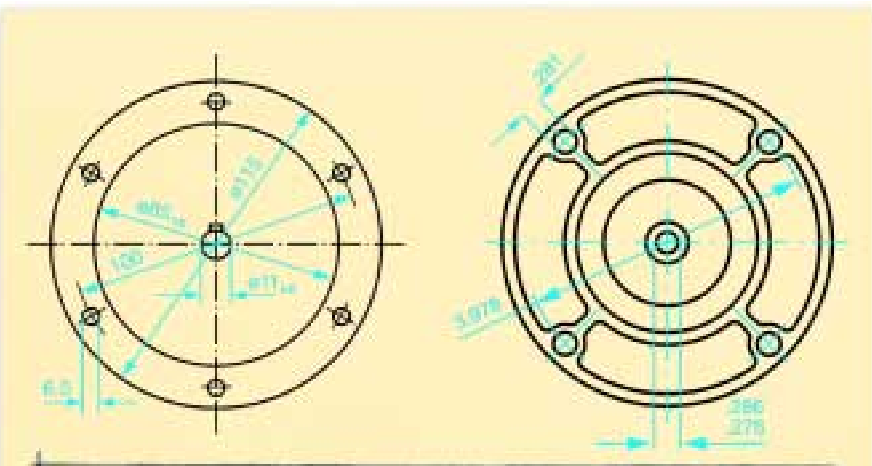


Figure 21: Left: The EURO flange® B10 is widely used as a standard flange for rugged devices, such as for diverse drive applications, see also Figure 14.
Right: The HÜBNER range also includes numerous devices with NEMA flange.

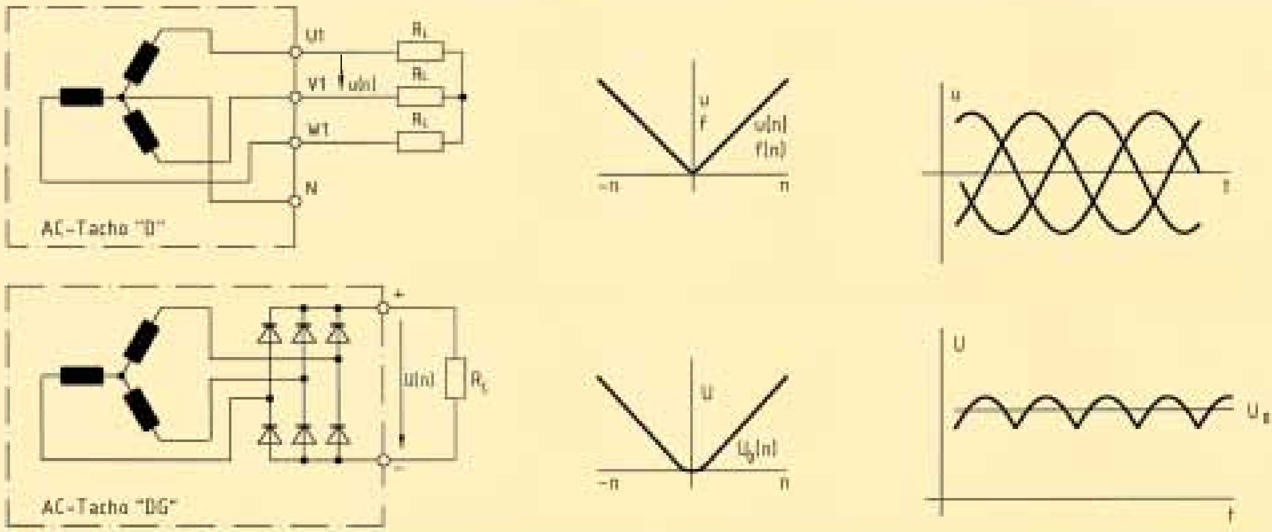


Figure 23: AC tachogenerators generate three-phase alternating voltages (above) proportional to the speed. The rectified alternating voltages are independent of the direction of rotation and have a rather high ripple rate (below).

Trapezoidal tachogenerators

Some applications require contactless signal acquisition, the quality of which is far higher than that of AC tachogenerators. In view of the work to electronically rectify each phase voltage, the number of windings, the voltages of which are to be rectified, must be minimized. The induced alternating voltages must therefore have a long linear characteristic to produce a continuous smooth direct voltage.

Figures 24 and 25 show the solution:

A six-pole, specially developed permanent magnet rotor induces in the appropriately dimensioned three winding systems, three time offset, overlapping **trapezoidal voltages**. The rotor also activates Hall-sensors in order to generate position-dependent commutation signals.

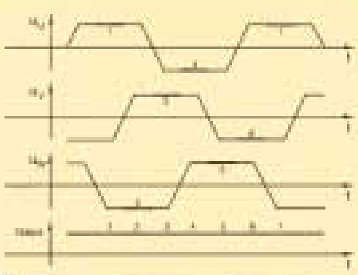


Figure 24: The six horizontal portions of the trapezoidal voltages are combined to a direct voltage.

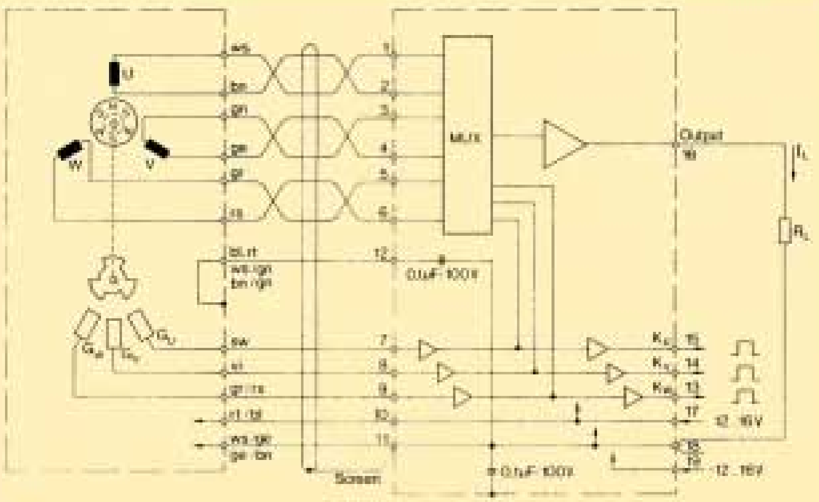


Figure 25: The trapezoidal tachogenerator also delivers the signals for the electronic rectification and block commutation of the brushless direct-current motor.

These signals switch the electronic rectifier (multiplexer MUX with operation amplifier), so that from the positive and negative trapezoidal voltages u_U, u_V and u_W, the segments 1 ... 6 are cut out and connected to the output signal. During a revolution of the rotor, $3 \times 6 = 18$ partial voltages are connected to the rectified voltage.

The commutation signals of the position sensor are also available at the driver outputs for control of the three-phase voltages of a six-pole, **block commutated brushless dc motor**. For this purpose, the winding systems in the trapezoidal tachogenerator and motor must be aligned. The trapezoidal tachogenerator housing is therefore provided with a servo-flange for adjustment purposes.

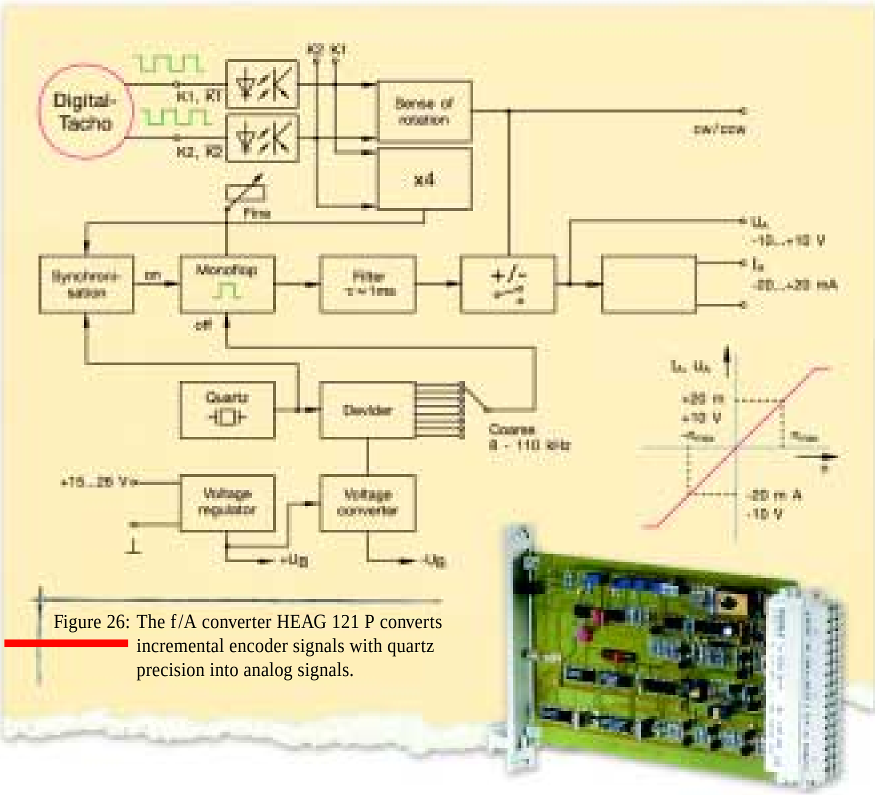


Figure 26: The f/A converter HEAG 121 P converts incremental encoder signals with quartz precision into analog signals.

f/A converter HEAG 121 P

Some drive engineering applications need to derive from a Digital-Tacho (incremental encoder) an additional analog or tachogenerator signal. The f/A converter HEAG 121 P developed and produced by HÜBNER converts the pulse frequency f delivered by the Digital-Tacho with quartz precision into speed and direction dependent **bipolar analog signals**: voltage U_A (f) or load-independent current I_A (f) (➔ Figure 26).

The "P" in the type designation HEAG 121 P indicates the **electrical isolation** of the outputs with opto-couplers.

The analog signal **ripple** is negligibly small above a pulse frequency $f_{Encoder} \geq 1$ kHz. Below this limiting frequency, the residual ripple increases, as only a limited number of incremental signals are available for evaluation. The limiting frequency can be shifted to lower values by providing the lowpass filter with an external capacitor.

However, the time constant τ increases as a result.

The maximum frequency f [Hz] of the Digital-Tacho depends on the resolution (counts z per turn) and the speed n [rpm]:

$$f = z \cdot \frac{n}{60}$$

The HEAG 121 P has eight adjustable input frequency ranges f = 8 ... 110 kHz and a fine adjustment to enable the customer to adapt the maximum frequency of the Digital-Tacho at the highest speed to the input frequency of the f/A converter.

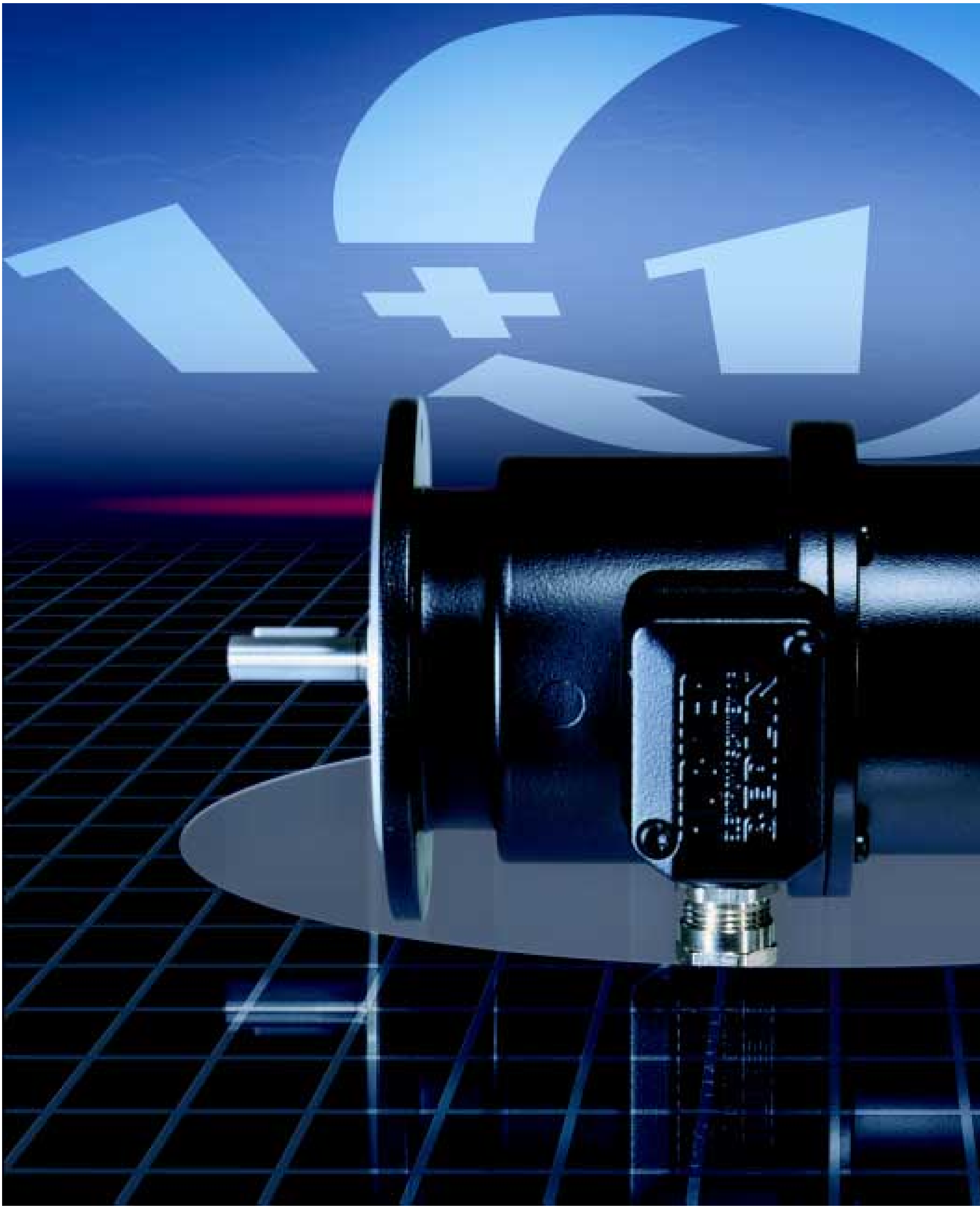
- Example:

Digital-Tacho with
z = 2,048 counts per turn

max. speed n_{max} = 3,000 rpm

➔ f_{max} = 102.4 kHz < 110 kHz.

Min. speed (negligible analog voltage ripple) n = 29 rpm.



The armature being supported at both ends, the majority of two-pole tachogenerators with own bearings offer the possibility to integrate further devices. The combinations are characterized by a common housing (logo 1+1=1®) and commonly feature a **common shaft** to avoid a spring-mass system with a low resonant frequency. This offers decisive advantages for driving engineering applications:

- Tacho + Tacho (Twin tachogenerator) with two separate tachogenerator voltages
- Tacho/Twin Tacho + Incremental encoder
- Tacho/Twin Tacho + Overspeed switch.

Twin-Tachos

Twin-Tachos (twin-tachogenerators) are produced with two electrically isolated tachogenerator voltages, whereby the windings are located in the slots of a common armature. The commutators are arranged on both sides of the armature (➔ Figure 27). The tachogenerator voltages are available in the terminal box at terminals 1A1 and 1A2 (1st system) and 2A1 and 2A2 (2nd system) (➔ Figure 5); they can be different or identical for **function monitoring** (redundancy): if they should deviate, i.e. cable break, a safety function is activated.

Figure 27: Twin tachogenerator with two winding system (TDPZ 0,2) – here on a drive of a cold forming press.

Tacho/Twin-Tacho + Digital-Tacho
(Incremental encoder)

Numerous drive applications require in addition to speed regulation also superimposed position control (Figure 1 on page 8). HÜBNER offers three variants of this combination, adapted to meet specific applications and requirements:

- The Tacho or Twin-tacho with bearings at both ends is the primary device with the Digital-Tacho (incremental encoder) attached:
- Example: **TDP 0,2 + OG 9** (Figure 28).

Figure 28: This combination of Analog-Tacho + Digital-Tacho (TDP 0,2 + OG 9) is a classic: Introduced to the market in 1978, it is widely used today employing modern technology.

- The Digital-Tacho (incremental encoder) with bearings at both ends is the primary device with the Analog-Tacho attached:
- Example: **FOG 9 + GT 7** (Figure 29).

Figure 29: The combination of Digital-Tacho + Analog-Tacho (FOG 9 + GT 7) harmonizes perfectly with the design of a hydraulic motor.

- The Tacho or Twin-Tacho has a non-drive end flange and a rear shaft on which the Digital-Tacho (or foreign encoder) with own bearings is mounted via a rear support housing and coupling:
- Example: **TDP 0,2 + OG 60** (Figure 30).

Figure 30: The rear shaft of the Analog-Tacho drives via a coupling within a rear support housing the Digital-Tacho with own bearings (TDP 0,2 + OG 60 or separate encoder).

HÜBNER develops and produces **Digital-Tachos** in a wide range of variants which, based on decades of experience with rugged dc tachogenerators, are similarly characterized by high mechanical and electrical ruggedness:

- Solid light metal housing with high vibration and shock resistance.
- Push-pull scanning with optical semiconductors, temperature and ageing compensation.
- Output signals with high-volt level HTL or 5 V level TTL according to RS-422.
- Output driver, depending on size, with short-circuit-proof power transistors or IC.

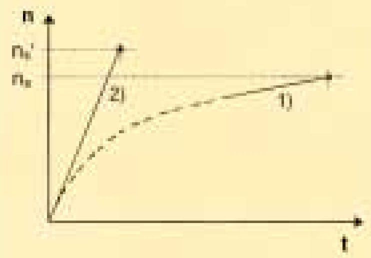
Detailed information with application examples are provided in our 48 pages publication
Information for the User
20 Years Competence in HeavyDuty:
Digital-Tachos (Incremental Encoders)
Sinus-Tachos (Sinewave Encoders),
which is available on our website
www.huebner-berlin.de
or can be sent to you on request.

Tacho/Twin-Tacho + Overspeed switch

The Tachos or Twin-Tachos (and several HÜBNER Digital-Tachos) are available as a combination with common shaft and integral mechanical or electronic overspeed switch, e.g.
TDP 0,2 + FSL (mechanical with *one* switching speed) or
TDP 0,2 + ESL ... (electronic with *one* or *three* switching speeds)
(*Technical Data*).

The overspeed switch is usually used for speed **safety monitoring**:

- **Mechanical overspeed switches (centrifugal switches)**
  They effect an *rapid* switching operation at a factory set switching speed without auxiliary electrical power. Centrifugal force actuate a switch with isolated make and break contacts. Reseting takes place automatically at an about 40 % lower speed (speed hysteresis). The **switching speed** n_s is defined for a **slow** speed change (Figure 31). At high acceleration, the switching speed shifts to a higher value n_s'. The hysteresis between clockwise and counter-clockwise rotation is about 3 %.



Test conditions for switching speed

1) Speed rise **Δ n = 2 rpm**

2) Speed rise **Δ n = 1500 rpm**

Figure 31: The switching speeds of the mechanical overspeed switches are defined for a crawling speed.

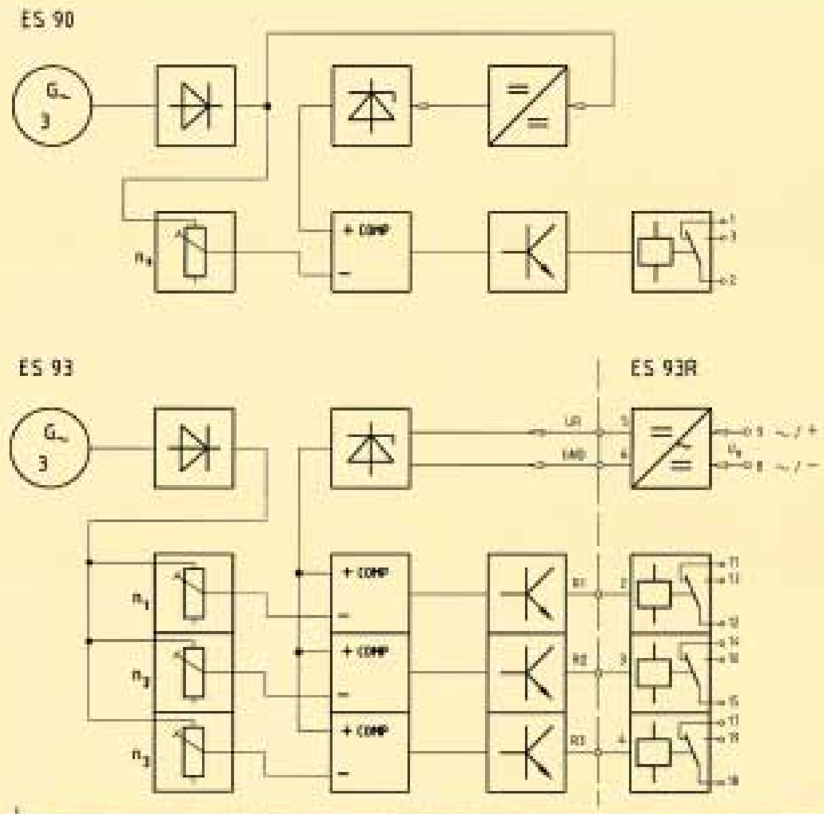


Figure 32: Block diagram of the electronic overspeed switch ES 90 with own supply and externally supplied electronic overspeed switch ES 93 with three switching speeds.

The **operating speed** should be below 90 % of the switching speed in the case of heavily vibrating drives. The **maximum speed** specified in the data sheet must not be exceeded for safety reasons. A switching operation from high to low speeds is not available on the mechanical overspeed switches.

Leaflet FS 90:
When combined with an Analog- or Digital-Tacho, the FS 90 has the designation **FSL**.

For lower switching speeds a **speed-up gear box** is available.

- **Electronic overspeed switches** with **one** or **three adjustable switching speeds**

The factory set switching speeds can be readjusted with potentiometers in the terminal box.
The switching operation is effected **abruptly** in both directions of rotation. Switching back takes place **automatically** (speed hysteresis).

Leaflet ES 90 · ES 93:
When combined with an Analog- or Digital-Tacho, the electronic overspeed switch with *one* switching speed has the designation **ESL 90** and with *three* switching speeds, the designation **ESL 93**.

The **ES 90** has one relay output with isolated changeover contact and is powered internally via an integral AC tachogenerator, so that an external voltage supply is unnecessary (Figure 32 above).

The **ES 93** has three independent transistor outputs and in conjunction with the relay module **ES 93 R**, three floating relay contacts with change-over contact. The three relays are changed over upon interruption of the supply or signal cables.
The relay module ES 93 R supplied with direct or alternating voltage also supplies the ES 93 (Figure 32 below).

As a supplement to the mentioned overspeed switches, HÜBNER has developed the electronic overspeed switch **ES 100** with particularly low switching speeds, provided with the EURO flange® B10 and shaft ∅ 11 mm and is connected to the drive via a coupling (Figure 2 on page 8).

The overspeed switches used in the combinations cover the following switching speed ranges:

FS 90 (FSL)	700 ... 4,900 rpm
ES 90 (ESL 90)	650 ... 6,000 rpm
ES 93 (ESL 93)	3 x 200 ... 5,000 rpm
ES 100	110 ... 500 rpm

For **safety-relevant** applications, combinations of mechanical and electronic overspeed switches are available.


60 mV / rpm

Rapid speed changes express themselves in a rapid change in real-time of the tachogenerator voltage due to the extremely short delay time of the tachogenerator voltage (*Delay time* on page 11). The "tachogenerator limiting frequency" therefore depends only on the **mechanical drive limiting frequency** which is negligible in comparison to the electrical limiting frequency of sinewave encoders and particularly Digital-Tachos (incremental encoders). However, attention should be paid to transmission of the tachogenerator voltage to the speed controller and several rules of telecommunication engineering practice should be observed:

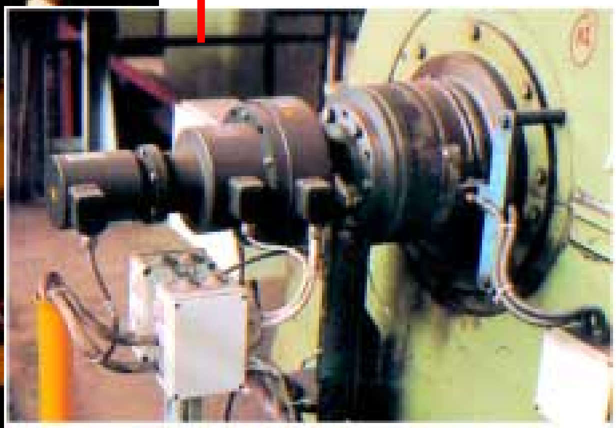
- **Twisted pair signal cables** with an overall screen, e.g. Ölflex-Servo®-720 (manufactured by LAPP) 4 × 2 × 0.25 + 2 × 1 CY, should be used.
- The **cable screen** should be connected to the housing and protective earth of the line receiver using a large area connection. In some cases, a single-ended cable screen connection can provide better results, since balancing currents (equipotential bonding) are suppressed flowing via the cable screen.
- **Earthing** of the tachogenerator or combination via the flange and driving machine or via the special **earth connection** of the device according to VDE specifications.
- **Star point layout** of all earth connections to a common earthing point (equipotential bonding) to avoid earth loops with voltage differences between the devices.
- The **distance of the signal cable** from motor cables with pulsed currents must be kept as large as possible.
- **Line Receivers** with differential input (Display in figure 33) are characterized by high **interference signal common mode rejection**: Interference signals that reach the cable cores despite screening and twisting, are reliably suppressed. This differential amplifier technology is to be given preference over the earlier used tachogenerator voltage transmission with a cable core connected to earth ("single-ended").
- **High tachogenerator voltage** should be used so that parasitic interference remains small in comparison to the tachogenerator voltage (high signal-to-noise ratio). The high tachogenerator voltage is an essential advantage compared with Digital-Tachos (incremental encoders) with TTL signals (+5 V) and sinewave encoders with 1 V_{pp}.

For the tachogenerator voltage, the following rule of thumb applies:

Tachogenerators with own bearings with 60 V/1,000 rpm (or more) are used for large machines and plants with long tachogenerator voltage transmission path subject to interference.

Hollow-shaft tachogenerators with 20 V/1,000 rpm (also slight more or less) are used for high dynamic drives with short tachogenerator voltage transmission path.

Figure 33: Uniform tracking of this radio telescope in Effelsberg in all weathers and for long-distance signal transmission – HÜBNER LongLife® tachogenerators mounted on the wheel drives ensure optimal results.



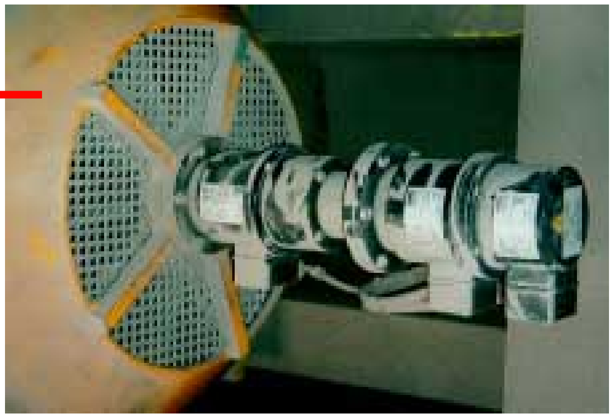
Hot, harsh atmospheres: This rolling mill needs rugged drives. The triple combination from HÜBNER – Digital-Tacho (encoder) + Analog-Tacho + overspeed switch (HOG 22 + HTA 11 + ES 100) – reliably and precisely delivers the signals needed for the electronic system.

Ice cold mobile: This automatic guided vehicle must operate reliably in the deep-freeze store at -30 °C. The tachogenerator mounted on the wheel drive is the GT 5 from HÜBNER.

Paper sheet cutting machines – here in China, the mother country of paper – must operate with maximum precision to cut sheets of large size accurately. The cross-cutter drive control receives speed signals from a direct-mounted GTB 9 hollow-shaft tachogenerator. An incremental encoder detects positions via a coupling in the rear support housing.

HÜBNER Tachogenerators and Combinations in Use

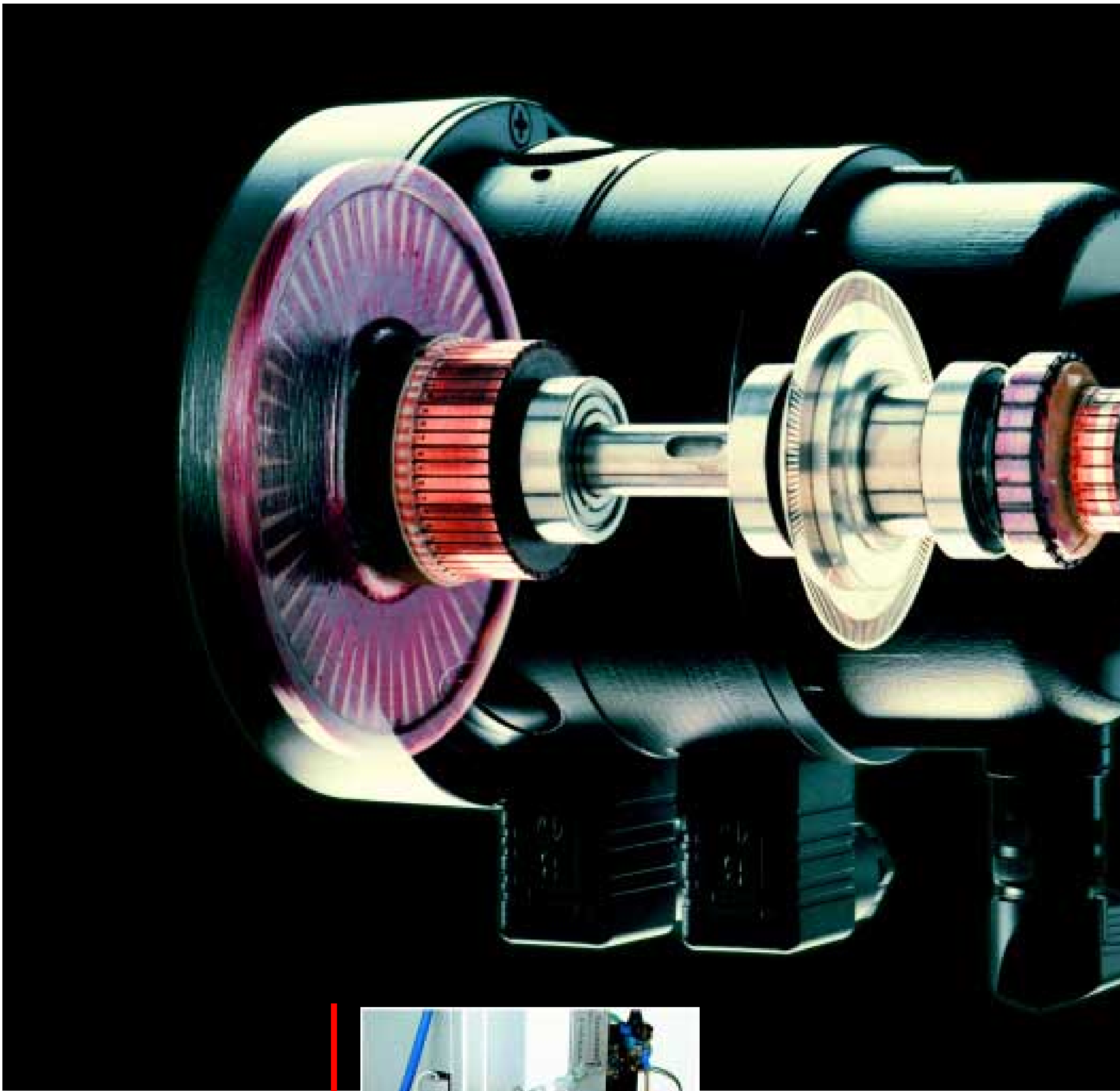
Soft start, smooth running, controlled speed:
The HÜBNER LongLife® tachogenerator GMP 1,0 reliably controls the speed of this ski-lift drive at all temperatures and in all weathers.



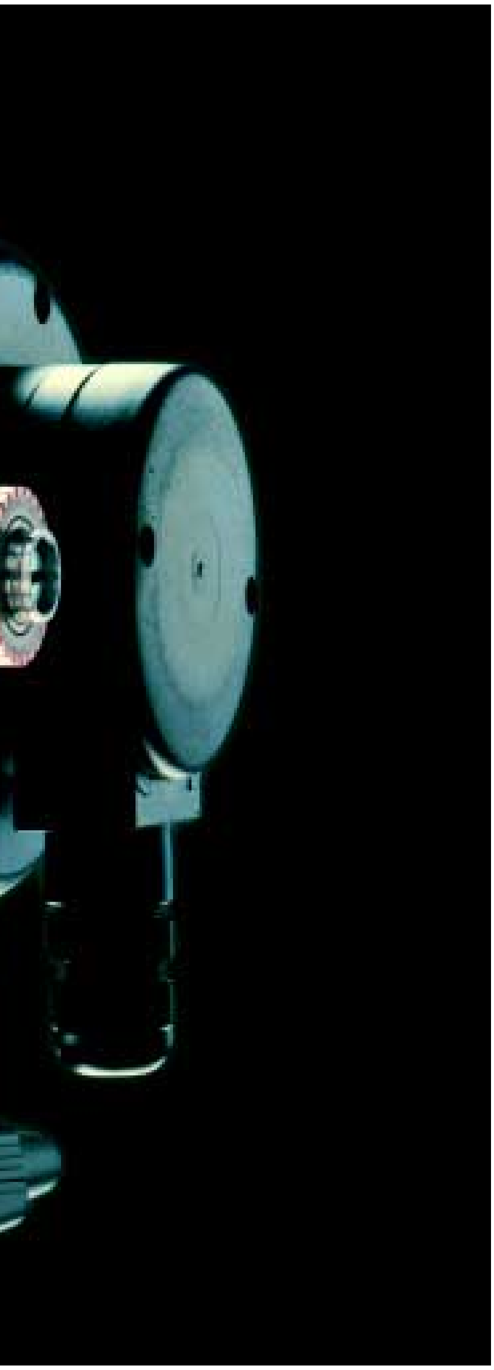
Dust-tight: Unaffected by dust and harsh atmosphere in the refuse incinerating plant, the triple combination of Analog-Tacho + Digital-Tacho + overspeed switch (TDP 0,2 + POG 9 + FSL) operates efficiently without interruption.

Moving heavy loads safely: Outdoor installations are constantly exposed to the effects of changes in weather – particular at the seaside.
HÜBNER LongLife® tachogenerators are designed for high precision and reliability – like the GMP 1,0 + POG 9 combination shown here on a container crane.

Rapid production: One of the largest European manufacturers of tin cans uses HÜBNER Analog-Tachos (GT 7) on the drives of their machines for extremely high output.

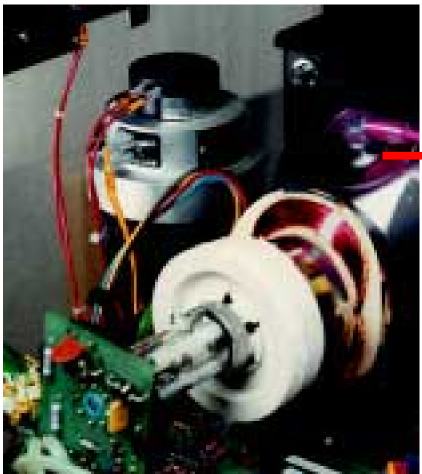


Highly dynamic disc-type motors can exploit their control capabilities with direct-mounted components: The Digital- and Analog-Tacho sit directly on the motor shaft – for example, as shown here on a special machine for embedding silver tracks in HÜBNER commutators.



In use around the clock across the world: TDP 0,2, shown here with NEMA flange on an American machine for coating base materials for nickel cadmium batteries.

Test passed: Only to be seen on the test-bench is the vehicle – the LongLife® tachogenerator TDP 0,09 is already proven on the drives.



The precision of digital exposure systems largely depends on the smooth operation of the drives – a typical application of small, highly dynamic hollow-shaft tachogenerators, for example, the GT 5.

Source of Photographs

ALSTOM
AMICON/SIEI AMERICA
B.A. Systèmes
ELIN
euroHÜBNER
EW HOF
HÜBNER
Max Planck Institut für Radioastronomie
Micromatik
PLM Dosenwerk
Schabmüller
Schenck Pegasus
Schuler-Pressen
SIEMENS
Winkelmann

HÜBNER Tachogenerators and Combinations and their Key Data

HÜBNER clearly identifies all its devices mechanically and electrically by the **serial number**. When reordering, please always state the serial number in addition to the type designation.

The following pages provide an **overview of the key data** of HÜBNER tachogenerators and combinations.

Detailed **leaflets** of the individual devices are available on request.

If you cannot find the solution best suited to your application – please ask us. The majority of the devices are of a modular design, enabling **specific customer requirements** to be met in most cases.

HÜBNER devices have a specific **type designation**.
The **mechanical** execution of the tachogenerators is distinguished as follows:

- **TDP**: **T**achogenerator with permanent magnets, own bearings of the shaft (Exception: TDP 0,5 – HÜBNER's and Europe's first hollow-shaft tachogenerator).
- **GT**: **T**achogenerator with hollow-shaft (standard range).
- **HTA**: **H**ollow-shaft **T**achogenerator for external mounting (special tachogenerators).
- **1st digit**: Series (for hollow-shaft tachogenerators, guide value for the housing diameter in cm).
- **2nd digit**: For hollow-shafts, guide value for the armature core width in mm.

The **electrical** execution of the tachogenerators is characterized as follows:

- **L**: **L**ongLife® technology.
- **LT-x**: **x** is the code number for the voltage gradient for (two-pole) tachogenerators with own bearings.
- **L/4xx**: **xx** indicates the voltage gradient for (four-pole) hollow-shaft tachogenerators.

- **Example**:

  TDP 0,2 LT-4 → LongLife® tachogenerator with own bearings, voltage gradient (digit 4 according to leaflet) 60 mV/rpm.

  GT 7.08 L/420 → Hollow-shaft tachogenerator with about 7 cm housing diameter, about 8 mm armature core width, LongLife® Technology, four-pole, voltage gradient 20 mV/rpm.

The designation of the **combinations** is made up of the primary device with own bearings and the mounted supplementary device:

- **Example**:

  TDP 0,2 + OG 9 → Abbreviated designation of a combination of Analog-Tacho TDP 0,2 and Digital-Tacho (incremental encoder) OG 9.
  The full ordering designation indicates for the Analog- and Digital-Tacho the electrical version, in this example **TDP 0,2 LT-4 + OG 9 DN 1024**, and accordingly indicates the tachogenerator voltage (**-4 →** 60 mV/rpm) and the type and number of squarewave pulses (1,024 pulses per turn, dual channel with signals displaced by 90°, marker pulse).

Further information is provided in our leaflets and publication
Information for the User – 20 Years Competence in HeavyDuty

Digital-Tachos (Incremental Encoders)
Sinus-Tachos (Sinewave Encoders)

which is available on our website *www.huebner-berlin.de* or can be sent to you on request.

HÜBNER Hollow-shaft Tachos and their Key Data

GT 3

Voltage:	5 mV/rpm
Temp. coefficient:	-0.035 %/K
Ripple:	≤ 1.2 % pp
Time constant:	2 µs
Power:	0.025 W
Option:	Flange ∅ 45 mm

Hollow-shaft:	∅ 6 mm
Max. Speed:	10,000 rpm
Moment of inertia:	9 gcm²
Weight rotor:	approx. 20 g
Housing:	∅ 34 mm
Protection:	IP 00; 54

GT 5

Voltage:	7; 9.5; 10 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.7 % pp
Time constant:	4.5 µs
Power:	0.075 W
GTL 5:	own bearings

Hollow-shaft:	∅ 8; 12 mm; ½”
Max. speed:	10,000 rpm
Moment of inertia:	50 gcm²
Weight rotor:	approx. 50 g
Housing:	∅ 52 mm
Protection:	IP 00; 54

GT 7

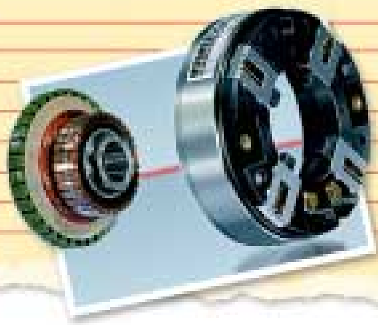
Voltage:	10 → 60 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.6 % pp
Time constant:	4 µs
Power:	0.3; 0.6 W
GTF 7:	EURO flange® B10

Hollow-shaft:	∅ 12; 14; 15; 16 mm
Max. speed:	9,000 → 6,100 rpm
Moment of inertia:	0.4; 0.6 kgcm²
Weight rotor:	approx. 110; 160 g
Housing:	∅ 70 mm
Protection:	IP 55

GT 9

Voltage:	10; 20 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.5 % pp
Time constant:	9 µs
Power:	0.3 W

Built-in tachogenerator



Hollow-shaft:	∅ 12; 16 mm; cone
Max. speed:	9,000 rpm
Moment of inertia:	0.95 kgcm²
Weight rotor:	approx. 155 g
Housing:	∅ 90 mm
Protection:	IP 00; 44

HÜBNER Hollow-shaft Tachos and their Key Data

GTB 9

Voltage:	10; 20 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.5 % pp
Time constant:	9 µs
Power:	0.3 W

External mounting

Hollow-shaft:	∅ 12; 16 mm; cone
Max. speed:	9,000 rpm
Moment of inertia:	0.95 $kgcm^2$
Weight rotor:	approx. 155 g
Housing:	∅ 90 mm
Protection:	IP 68

GTR 9

Voltage:	10 → 60 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.4 % pp
Time constant:	5 µs
Power:	0.9 W

Successor type for TDP 0,5

Hollow-shaft:	∅ 16 mm
Max. speed:	9,000 → 6,000 rpm
Moment of inertia:	1.95 $kgcm^2$
Weight rotor:	approx. 490 g
Housing:	∅ 95 mm
Protection:	IP 56

GT 16

Voltage:	60; 100 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.7 % pp
Time constant:	7 µs
Power:	1.8 W

Hollow-shaft:	∅ 40 → 70 mm
Max. speed:	3,000 rpm
Moment of inertia:	61 → 50 $kgcm^2$
Weight rotor:	approx. 3.6 → 2.3 kg
Housing:	∅ 158 mm
Protection:	IP 40

HÜBNER Tachos with own bearings and their Key Data

TDP 0,03

Voltage:	7; 20 mV/rpm	Flange:	∅ 44 mm ≙ 1 3/4”
Temp. coefficient:	-0.02 %/K	Shaft:	∅ 4.73 mm ≙ 3/16”
Ripple:	≤ 1.8 % pp	Max. speed:	12,000; 9,100 rpm
Time constant:	20 µs	Moment of inertia:	12; 21 gcm^2
Power:	0.14; 0.32 W	Weight:	approx. 0.15; 0.23 kg
		Protection:	IP 44

TDP 0,09

Voltage:	10 ➝ 60 mV/rpm	Flange:	∅ 85 mm
Temp. coefficient:	±0.005 %/K	Shaft:	∅ 6 mm
Ripple:	≤ 0.55 % pp	Max. speed:	10,000 ➝ 6,700 rpm
Time constant:	25 µs	Moment of inertia:	0.25 kgcm^2
Power:	1.2 W	Weight:	approx. 1.2 kg
Options:	Foot mounting	Protection:	IP 56
	Climate protection		
	Twin Tacho **TDPZ 0,09** page 43		

TDP 0,2 LT

Voltage:	10 ➝ 150 mV/rpm	EURO flange® B10	
Temp. coefficient:	±0.005 %/K	Shaft:	∅ 11 mm,
Ripple:	≤ 0.5 % pp		Option ∅ 7; 14 mm
Time constant:	160 µs	Max. speed:	10,000 ➝ 4,000 rpm
Power:	12 W	Moment of inertia:	1.1 kgcm^2
Options:	Rear shaft	Weight:	approx. 2.5 kg
	Climate protection	Protection:	IP 55
	Twin Tacho **TDPZ 0,2** page 43		

TDP 0,2 LT

Voltage:	10 ➝ 150 mV/rpm	Foot mounting B3	
Tk:	±0.005 %/K	Shaft:	∅ 11 mm
Ripple:	≤ 0.5 % pp	Max. speed:	10,000 ➝ 4,000 rpm
Time constant:	160 µs	Moment of inertia:	1.1 kgcm^2
Power:	12 W	Weight:	approx. 2.5 kg
Options:	Rear shaft	Protection:	IP 55
	Climate protection		
	Twin Tacho **TDPZ 0,2** page 43		

HÜBNER Tachos with own bearings and their Key Data

TDP 0,2 US

Voltage:	50; 100 mV/rpm	NEMA flange:	∅ 4.528”
Temp. coefficient:	±0.005 %/K	Shaft:	∅ 0.315”
Ripple:	≤ 0.5 % pp	Max. speed:	10,000 → 6,000 rpm
Time constant:	160 µs	Moment of inertia:	1.1 $kgcm^2$
Power:	12 W	Weight:	approx. 2.5 kg
Option:	Foot mounting	Protection:	IP 55

TDP 0,2 LS

Voltage:	60 mV/rpm	EURO flange® B10	
Temp. coefficient:	±0.005 %/K	Shaft:	∅ 11 mm
Ripple:	≤ 0.5 % pp	Max. speed:	10,000 rpm
Time constant:	160 µs	Moment of inertia:	1.1 $kgcm^2$
Power:	12 W	Weight:	approx. 2.4 kg
Cable connection		Protection:	IP 55

GMP 1,0

Voltage:	40 → 175 mV/rpm		
Temp. coefficient:	±0.005 %/K	Flange:	B5; B5n; B5s; B5k
Ripple:	≤ 1 % pp	Shaft:	∅ 12; 14 mm
Time constant:	550 µs	Max. speed:	6,000 → 3,000 rpm
Power:	30 W	Moment of inertia:	4.5 $kgcm^2$
Options:	Rear shaft	Weight:	approx. 4.5 kg
	Foot mounting B3	Protection:	IP 55
	Climate protection		
	Twin Tacho page 43		

TDP 13

Voltage:	20 → 200 mV/rpm	Flange:	B5; B5s; B5k;B10; B10w
Temp. coefficient:	±0.005 %/K	Shaft:	∅ 14; 20; 32 mm
Ripple:	≤ 0.5 % pp	Max. speed:	6,000 → 3,000 rpm
Time constant:	400 µs	Moment of inertia:	15 $kgcm^2$
Power:	40 W	Weight:	approx. 8.5 kg
Options:	Rear shaft	Protection:	IP 55
	Foot mounting B3; B5kd; B5km		
	Climate protection		
	Twin Tacho page 43		

EEx GP 0,2

"EEx de IIC T6"

		EURO flange® B10	
Voltage:	20 → 150 mV/rpm	Shaft:	∅ 11 mm
Temp. coefficient:	±0.005 %/K	Max. speed:	8,000 → 2,800 rpm
Ripple:	≤ 0.6 % pp	Moment of inertia:	1.15 $kgcm^2$
Time constant:	150 µs	Weight:	approx. 3.8 kg
Power:	12 W	Protection:	IP 54

TG 74 d

"EEx de IIC T6"

		EURO flange® B10	
Voltage:	20 → 150 mV/rpm	Shaft:	∅ 14 mm
Temp. coefficient:	±0.005 %/K	Max. speed:	8,000 → 2,800 rpm
Ripple:	≤ 0.6 % pp	Moment of inertia:	1.15 $kgcm^2$
Time constant:	150 µs	Weight:	approx. 3.8 kg
Power:	12 W	Protection:	IP 54
Option:	Rear shaft		

Special Tachogenerator with explosion proof housing

d3n GP 1,0

"Ex d3n G 5"

Voltage:	18 → 150 mV/rpm
Temp. coefficient:	-0.03 %/K
Max. speed:	4,000 → 2,600 rpm
Shaft:	∅ 14 mm
Housing:	∅ 140 mm

HÜBNER Special Tachogenerators and their Key Data

··· with own bearings

TDP 5,5

Voltage:	30 → 280 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	4,000 → 1,800 rpm
Shaft:	∅ 16; 32 mm
Housing:	∅ 72 mm

TDP 15

Voltage:	100 → 400 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	2,400 → 1,250 rpm
Shaft:	∅ 42; 55 mm; cone 1:20
Housing:	∅ 229 mm

TDP 60

Voltage:	200 → 4,000 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	1,200 → 125 rpm
Shaft:	∅ 55; 90 mm; cone 1:20
Housing:	∅ 380 mm

··· with hollow-shaft

HTA 9

Voltage:	10 → 60 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	9,000 → 5,000 rpm
Hollow-shaft:	∅ 12; 16 mm
Housing:	∅ 95 mm

HTA 10

Voltage:	20 → 60 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	9,000 → 6,000 rpm
Hollow-shaft:	∅ 19; 22; 25 mm
Housing:	∅ 95 mm

HTA 11

Voltage:	20; 60 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	6,000 rpm
Hollow-shaft:	∅ 28; 32; 35 mm
Housing:	∅ 110 mm

HTA 16

Voltage:	500; 1,000 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	720; 360 rpm
Hollow-shaft:	∅ 35 mm
Housing:	∅ 170 mm

TDP 0,5

Voltage:	20; 40 mV/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	9,000; 5,000 rpm
Hollow-shaft:	∅ 16 mm
Housing:	∅ 95 mm

Hollow-shaft with own bearings

TDPH 10 / TDPH 35 / TDPH 50

Voltage:	0.1 → 0.8; 0.1 → 1; 0.1 → 1.4 V/rpm
Temp. coefficient:	±0.005 %/K
Max. speed:	500 → 62; 750 → 75; 1,200 → 90 rpm
Hollow-shaft:	∅ 45 → 55; 65 → 85; 95 → 130 mm; cone 1:20
Housing:	∅ 210; 240; 290 mm

AC Tachogenerators

T 501 / T 701

Voltage AC:	3 × 11; 23 mV/rpm
Voltage DC:	15; 30 mV/rpm
Hollow-shaft:	∅ 6 → 16 mm
Housing:	∅ 51; 70 mm

Trapezoidal Tachogenerators

HWT 502 / HWT 801

	3 × 20 V_{pp}
Hollow-shaft:	∅ 8; 16 mm
Housing:	∅ 45; 80 mm

Series “Z”

TDPZ 0,09

Voltage:	2 × 10 → 40 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.55 % pp
Time constant:	10 µs
Power:	2 × 0,3 W

Flange:	∅ 85 mm
Shaft:	∅ 6 mm
Max. speed:	10,000 rpm
Moment of inertia:	0.3 kgcm²
Weight:	approx. 1.3 kg
Protection:	IP 56

TDPZ 0,2

Voltage:	2 × 20 → 100 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.5 % pp
Time constant:	40 µs
Power:	2 × 3 W
Options:	Rear shaft
	Foot mounting B3
	Climate protection

EURO flange® B10	
Shaft:	∅ 11 mm
Max. speed:	10,000 → 6,000 rpm
Moment of inertia:	1.2 kgcm²
Weight:	approx. 3 kg
Protection:	IP 55

GMPZ 1,0

Voltage:	2 × 40 → 175 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 1 % pp
Time constant:	270 µs
Power:	2 × 30 W
Options:	Rear shaft
	Foot mounting B3; B5kd; B5km
	Climate protection

Flange:	B5; B5n; B5s; B5k
Shaft:	∅ 12; 14 mm
Max. speed:	6,000 → 3,400 rpm
Moment of inertia:	8.5 kgcm²
Weight:	approx. 7 kg
Protection:	IP 55

TDPZ 13

Voltage:	2 × 20 → 200 mV/rpm
Temp. coefficient:	±0.005 %/K
Ripple:	≤ 0.5 % pp
Time constant:	200 µs
Power:	2 × 20 W
Options:	Rear shaft
	Foot mounting B3; B5kd
	Climate protection

Flange:	B5; B5s; B5k; B10; B10w
Shaft:	∅ 14; 20; 32 mm
Max. speed:	6,000 → 3,000 rpm
Moment of inertia:	17 kgcm²
Weight:	approx. 10 kg
Protection:	IP 55

Analog + Digital-Tachos

TDP 0,2 / TDPZ 0,2 + OG 9

Analog-Tacho TDP 0,2/
Twin Tacho TDPZ 0,2
with Digital-Tacho OG 9

OG 9:	1 → 1,250 counts per turn
	HTL, TTL, TTL (R)

EURO flange® B10, Option foot mounting B3
Common shaft

Shock resistance:	1,000 m/s² (6 ms)
Weight:	approx. 3 kg
Protection:	IP 55

TDP 0,2 + OG 60

Analog-Tacho TDP 0,2
with Digital-Tacho OG 60

OG 60:	200 → 10,000 counts per turn
	TTL, TTL (R), HTL (C),

EURO flange® B10
Internal coupling

Shock resistance:	1,000 m/s² (6 ms)
Weight:	approx. 3 kg
Protection:	IP 55

FOG 9 + GT 7

Digital-Tacho FOG 9
with Analog-Tacho GT 7

FOG 9:	1 → 1,250 counts per turn
	HTL, TTL, TTL (R)

EURO flange® B10
Common shaft

Shock resistance:	1,000 m/s² (6 ms)
Weight:	approx. 1.1 kg
Protection:	IP 55

OG 60 + GT 5

Digital-Tacho OG 60
with Analog-Tacho GT 5

OG 60:	200 → 10,000 counts per turn
	TTL, TTL (R), HTL (C),

Servo flange
Common shaft

Shock resistance:	1,000 m/s² (6 ms)
Weight:	approx. 450 g
Protection:	IP 54

Analog-Tachos + Overspeed switches

TDP 0,09 + FSL

Analog-Tacho TDP 0,09
with mechanical
overspeed switch FS(L) 90

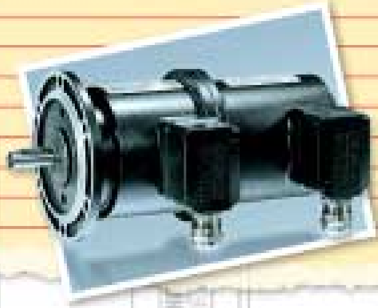
FS(L) 90:	700 → 4,900 rpm

Flange:	∅ 85 mm
Common shaft	
Shock resistance:	1,000 m/s^2 (6 ms)
Weight:	approx. 1.5 kg
Protection:	IP 55

TDP 0,2 + FSL

Analog-Tacho TDP 0,2
with mechanical
overspeed switch FS(L) 90

FS(L) 90:	700 → 4,900 rpm



EURO flange® B10	
Common shaft	
Shock resistance:	1,000 m/s^2 (6 ms)
Weight:	approx. 2.9 kg
Protection:	IP 55

TDP 0,2 + ESL

Analog-Tacho TDP 0,2
with electronic
overspeed switch ES(L) 90

ES(L) 90:	650 → 6.000 rpm
ES(L) 93:	3 × 200 → 5.000 rpm

EURO flange® B10	
Common shaft	
Shock resistance:	1,000 m/s^2 (6 ms)
Weight:	approx. 2.9 kg
Protection:	IP 55

TDPZ + FSL/ESL

Twin-Tacho TDPZ 0,2
with mechanical
overspeed switch FS(L) 90
or with electronic
overspeed switch ES(L) 90 or ES(L) 93

ES(L) 90:	650 → 6.000 rpm
ES(L) 93:	3 × 200 → 5.000 rpm

EURO flange® B10	
Common shaft	
Shock resistance:	1,000 m/s^2 (6 ms)
Weight:	approx. 3.4 kg
Protection:	IP 55

Index

R

S

T

V

W

Z

HÜBNER
ELEKTROMASCHINEN AG
BERLIN

HÜBNER ELEKTROMASCHINEN AG

P. O. Box 61 02 71, D-10924 Berlin
Planufer 92 b, D-10967 Berlin

Phone + 49-(0) 30-6 90 03-0
Telefax + 49-(0) 30-6 90 03-104

http://www.huebner-berlin.de
eMail: marketing@huebner-berlin.de

The height of precision in speed and position: HÜBNER Technology.

LongLife® DC Tachogenerators with the patented silver track embedded into the commutator. We support this with a two year guarantee.

Digital-Tachos (incremental encoders) in **HeavyDuty®** technology: rugged electrical and mechanical construction.

LowHarmonics® Sinus-Tachos: Sinewave signals with significantly low harmonics – a new level of precision.

Overspeed switches: mechanically by centrifugal actuator or electronically with own or external voltage supply.

ExtendedSpeed® angular and linear acceleration sensors with no speed limit.

Combinations: Digital-Tachos, dc tachogenerators or over-speed switches in one single housing with continuous shaft.

A.1