Particular attention must be paid to **transmission of the signals** between the Digital-Tacho or the Sinus-Tacho and the controller. In the case of square-wave signals, the frequency spectrum of the signals transmitted stretches into the MHz region. For this reason a number of rules from the field of telecommunication engineering need to be observed:

- **Twisted pair signal cables** with an overall screen, e.g. Öflex-Servo®-720 (manufactured by Lapp) $4 \times 2 \times 0.25 + 2 \times 1$ CY should be used.
- The **cable screen** should be connected to the housing and the earth protection of the line receiver using a large area connection (➲ Figure 7, 8 on page 10 and Figure 10 on page 11). In some cases a cable screen terminated at only one end can lead to better results because balancing currents on the cable screen are prevented from flowing.

  For especially severe transmission conditions a **double screened cable** is recommended: the screens of the twisted pair leads are connected to the ground of the electronics and the common screen to the earth protecton.
- **Earth connection:** the Digital-Tacho and Sinus-Tacho should be connected via the flange and the drive motor, or the special **earth connection** on the device (➲ picture on page 22/23). Special attention must be paid to earthing the housing of Digital-Tachos when using insulated bearings due to the Safety Regulations.
- **Star point layout:** all earth connections should be connected to a common earthing point to avoid earth loops with potential differences between the equipment.

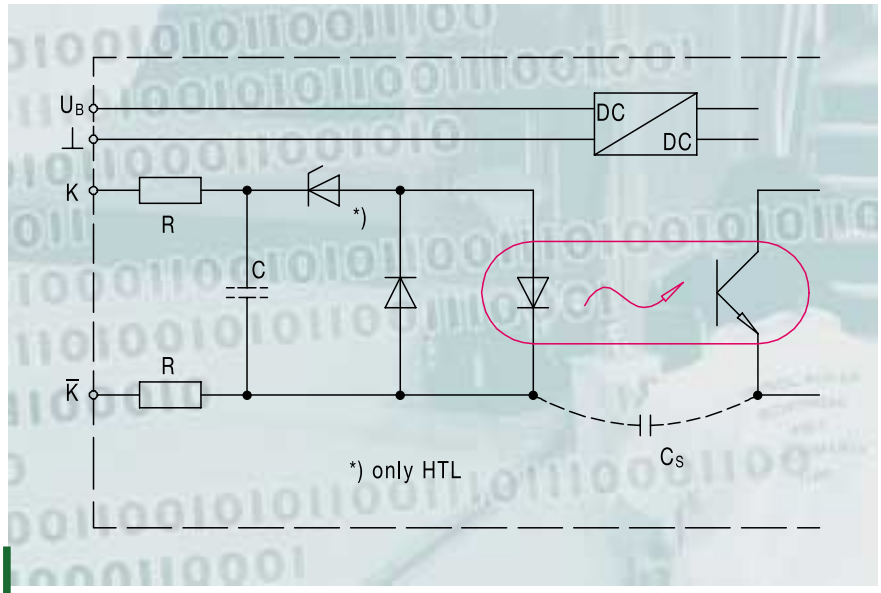

Figure 30: Opto-coupler inputs are distinguished by a very high common mode interference rejection and high electrical insulation.

- The **separation of signal cable** and cables carrying switched high currents must be kept as large as possible.
- The **cable terminating resistance** on both **TTL** and **sinewave technology** meeting RS-422 standard interface should be the same as the characteristic **impedance of the cable Z_0** to avoid reflections at the end of the cable:

$$Z_0 = \sqrt{L / C} \approx 100 - 150\ \Omega$$

- Z_0 : Characteristic impedance
- L : Cable inductance
- C : Cable capacitance

A 10 nF capacitor is often connected in series with the terminating resistor $R \approx Z_0$ to reduce the power loss in the line driver IC (➲ Figure 10 on page 11).

On the **HTL version** a matching cable terminating resistor is not used due to the high power loss (➲ Figure 7 on page 10). The mismatch causes signal reflections which are largely suppressed by the low impedance line driver outputs.

Line receivers

Line receivers with differential inputs and high **common mode rejection ratio** are decisive for reliable signal transmission of signals in high interference (➲ Figure 3 on page 8):

- On the **HTL version without inverted signals**, one input is set to the centre of the signal span using half the supply voltage (➲ Figure 7 on page 10).
- On the **HTL version with inverted signals**, a transmission technique similar to that of the RS-422 standard interface is used (➲ Figure 8 on page 10).
- On the **TTL version** and **sinewave technology**, signal transmission is generally performed using inverted signals due to the low signal levels (➲ Figure 10 on page 11 and Figure 16 on page 15)

The line receivers with differential inputs 26LS 33A (**HTL** ➲ Figure 7 on page 10) and 26LS 32A (**TTL** ➲ Figure 10 on page 11) output a *high* signal in the event of a cable break.

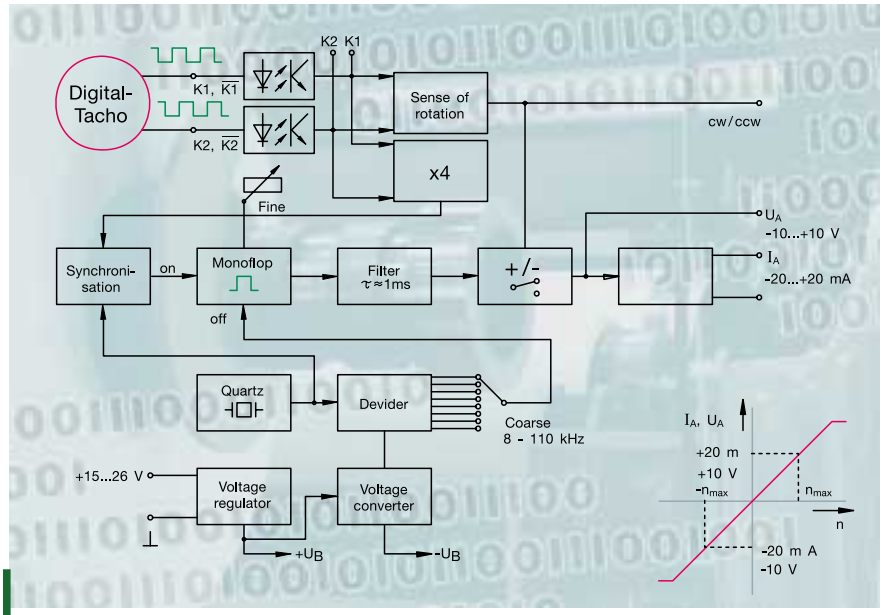

Figure 31: The bipolar f/A converter HEAG 121 P with opto-coupler input generates an analogue voltage relative to the incremental signal frequency.

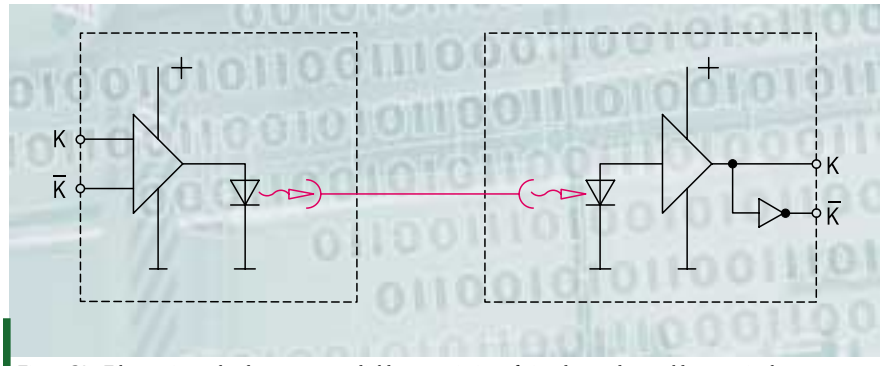

Figure 32: Fibre optics technology ensures reliable transmission of signals over long cables even in the presence of severe interference.

Opto-coupler receivers

Opto-coupler inputs are recommended due to their very high common mode rejection ratio because the deviation limits imposed by the supply voltage to the differential amplifiers are removed (Figure 30). A further advantage is that the Digital-Tacho is electrically isolated from the line receiver. This technique requires a decoupled power supply for the Digital-Tacho and an opto-coupler with a coupling capacitance C_S that is as small as possible.

For optimum signal transmission and processing HÜBNER has **electronic accessories** in its programme:

- The **Bipolar f/A Converter HEAG 121 P** with opto-couper inputs for electrical isolation, converts squarewave signals with a frequency f into a bipolar (for direction indication) **analogue value $U_A(f)$** or **$I_A(f)$**. The inputs can be selected for the signal level TTL (+5 V) or HTL (+9 V ... 30 V) and for the number of channels K1, K2 or K1, $\overline{K1}$, K2, $\overline{K2}$. The ripple of the ouput voltage is ≤ 1 % for a signal frequency f ≥ 200 Hz. The linearity tolerance of the quartz-stabilized converter is ≤ 0.02 % (Figure 31).

- The **Digital Converters HEAG 151 → HEAG 154** with opto-coupler inputs are used for **shifting signal levels**

  HEAG 152 HTL → TTL
  HEAG 153 TTL → HTL,

  for the **electrical isolation** of several receivers connected to one Digital-Tacho causing a possible earth loop hazard

  HEAG 151 TTL → TTL
  HEAG 154 HTL → HTL,

  and for **signal regeneration** over long transmission distances.

- The **Sinus-Digital Converters HEAG 156, 157** generate a higher frequency sequence of TTL squarewave pulses with marker pulse meeting RS-422 standard interface from sinewave signals using 5 or 10 times interpolation (selectable). The zero transitions can be used in the usual manner for signal quadrature and direction sensing. The **HEAG 156** processes sinewave signals at 1 V_{pp} and the **HEAG 157** at HÜBNER's level of 5 V_{pp}.

- The **fibre optic modules HEAG 171 → 174** with fiber optic link are used for realible transmission of squarewave signals under extremely severe conditions (Figure 32).

The modules convert incremental signals into pulses of light

HEAG 171 TTL → light
HEAG 172 HTL → light

and convert them back into electrical signals after transmission over optical fibre

HEAG 173 light → TTL
HEAG 174 light → HTL.

Fibre optic technology offers the possibility of **changing signal levels** by choosing suitable fibre optic modules

TTL → HTL or HTL → TTL.