LAK 1

Absolute linear encoder with signal control
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1. **Overview**

Position encoders in drive systems have to meet high and controversial demands, especially in linear drive systems. The demands opposing each other are high accuracy and resolution on the one hand and low mass, small dimensions and high measuring speed on the other hand.

The LAK encoders from NUMERIK JENA are equipped with features that fulfill these high requirements in an ideal manner. The special combination of incremental and absolute encoder does not only guarantee stable operation but also enables high speed measuring with high resolution while still maintaining very small dimensions. Furthermore NUMERIK JENA set great value to customization possibilities during the development. Therefore the LAK measuring system offers a large number of customization options as well as various interfaces:

- Possibility of an electronic adjustment after mounting to reduce static mounting errors
- Kit version for customer-specific housings/frames (available on request)
- Scales are available in steel and various types of glass
- Individual measuring lengths of the scales available (up to 1.24 m)
- Special vacuum version available
- Several interfaces usable: USB 2.0, 1Vpp, SSI and HFACE
- Wide range of supply voltages to compensate conduction losses
- Extensive diagnostic and monitoring functions (e.g. read head temperature)
- High control dynamics due to low calculation time
- Two absolute tracks and two incremental sensors ensure high contamination immunity

2. **Applications**

LAK - absolute linear encoder:

- Production and inspection machines for the semiconductor industry
- Linear units and linear drives
- Coordinate tables
- Measuring machines and measuring microscopes
- Robotics
- Precision devices in reprography
- Precise machining
- Positioning and measuring devices in medical technology
3. Technical data

| Resolution       | • 5.0 µm  
|                 | • 2.5 µm  
|                 | • 1.25 µm  
|                 | • 625.0 nm  
|                 | • 312.5 nm  
|                 | • 156.25 nm  
|                 | • 78.125 nm  
| Max. speed       | 10 m/s  
| Max. measuring length | 1.24 m (following versions up to 3.8 m)  
| Accuracy         | up to ±1 µm  
| Interpolation error | 80 nm_{rms}  
| Interfaces       | serial:  
|                 | • SSI  
|                 | • HFACE  
|                 | usable simultaneously:  
|                 | • USB 2.0 (diagnostics and user interface)  
|                 | • 1 V_{pp} (SIN+, COS+, SIN-, COS-)  
| Working distance (air gap) | 0.85 mm  
| Mounting tolerances | Δ Y = ±0.3 mm  
|                 | Δ Z = ±0.1 mm  
|                 | Δ φX = ±0.5°  
|                 | Δ φY = ±0.5°  
|                 | Δ φZ = ±0.25°  
| Weight - read head | 7 g  
| Protection type  | IP64  

![Image of technical data](image-url)
4. **General Specifications**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply voltage</td>
<td>3.5 V</td>
<td>5.0 V</td>
<td>5.5 V</td>
</tr>
<tr>
<td>Current consumption(^1)</td>
<td>-</td>
<td>100 mA</td>
<td>125 mA</td>
</tr>
<tr>
<td>Power Consumption(^1)</td>
<td>-</td>
<td>500 mW</td>
<td>687.5 mW</td>
</tr>
<tr>
<td>Calculation time</td>
<td>ca. 1 µs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boot time at power-on</td>
<td>300 ms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating temperature</td>
<td>0°C to 55°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage temperature</td>
<td>-20°C to 70°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>93% (non-condensating)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration (50 Hz ... 2,000 Hz)</td>
<td>≤200 m/s(^2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shock (11 ms)</td>
<td>≤400 m/s(^2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) Current and power consumption are dependent on used interfaces due to load variation on internal driver modules.

5. **Dimensions and mounting conditions**

- **F**: Machine guideway
- **U**: Ground surface that supports SINGLEFLEX, DOUBLEFLEX scale tape or QUICK GUIDE
- **M1/2/3**: Mounting surface of the machine for chosen mounting surface 1, 2 or 3
6. Encoder interfaces

6.1. Connector and PIN-assignment (15-pin D-Sub)

<table>
<thead>
<tr>
<th>PIN</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>Housing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal</td>
<td>$U_{in}$</td>
<td>GND</td>
<td>$U_{in}$</td>
<td>5 V</td>
<td>DAT+</td>
<td>-</td>
<td>USBD-</td>
<td>CLK+</td>
<td>$U_{in}$</td>
<td>-</td>
<td>$U_{in}$</td>
<td>-</td>
<td>DAT-</td>
<td>USBD+</td>
<td>CLK-</td>
<td>Shield</td>
</tr>
<tr>
<td>Cable Ø 3.7 mm</td>
<td>green</td>
<td>blue</td>
<td>white</td>
<td>brown</td>
<td>grey</td>
<td>-</td>
<td>black</td>
<td>violet</td>
<td>brown</td>
<td>-</td>
<td>white</td>
<td>-</td>
<td>pink</td>
<td>red</td>
<td>yellow</td>
<td>-</td>
</tr>
</tbody>
</table>
6.2. RS-485

The internal protocol setup is displayed in the following figure. The differential transmission lines have to be terminated on the customer’s side.

![Diagram of RS-485 setup]

6.3. Analogue 1 V\text{pp} interface

### Signal pattern

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal $U_1 = U_{1+} - U_{1-}$ (0°)</td>
<td>0.6 V\text{pp}</td>
<td>1.0 V\text{pp}</td>
<td>1.2 V\text{pp}</td>
</tr>
<tr>
<td>Signal $U_2 = U_{2+} - U_{2-}$ (90°)</td>
<td>0.6 V\text{pp}</td>
<td>1.0 V\text{pp}</td>
<td>1.2 V\text{pp}</td>
</tr>
<tr>
<td>Signal period</td>
<td>20 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase shift</td>
<td>tbd</td>
<td>90°</td>
<td>tbd</td>
</tr>
<tr>
<td>Max. scanning frequency</td>
<td></td>
<td></td>
<td>500 kHz</td>
</tr>
<tr>
<td>Cut-off frequency 3 dB</td>
<td></td>
<td></td>
<td>500 kHz</td>
</tr>
</tbody>
</table>
6.4. SSI interface

The SSI interface is a serial, synchronous protocol which supports position and error transmission exclusively. Due to its simple structure, integration on the customer's side is easy.

For verification purposes of the received position value, multi-cycle readout is supported.

6.4.1. Protocol description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position word</td>
<td>25 (Position bits = 24 + leading „0“, starts with MSB)</td>
</tr>
<tr>
<td>Mono flop time</td>
<td>5 µs, 10 µs or 20 µs</td>
</tr>
<tr>
<td>Max. clock frequency</td>
<td>2.0 MHz</td>
</tr>
<tr>
<td>Number format (gray/binary)</td>
<td>binary</td>
</tr>
<tr>
<td>Parity bits</td>
<td>none</td>
</tr>
<tr>
<td>Multi-cycle readout</td>
<td>yes</td>
</tr>
<tr>
<td>Error signaling</td>
<td>DAT = High, if critical errors occur, High remains until reset</td>
</tr>
</tbody>
</table>

6.4.2. Readout cycle

When the first falling edge is detected, the position value is loaded into the output register. Every rising edge provides a single bit at the output which can be taken over with the following falling edge.

When the last bit is taken over the data line level is "low". Once the mono flop time passes, the protocol goes back into Idle-mode and waits for a new cycle.

6.4.3. Multi-cycle readout

To verify that the data transmission works properly it is possible to read the same position information multiple times without changing it. In order to do that new clock cycles have to be applied during the mono flop time. The position information will be provided repeatedly by the feedback shift register.
6.5. **HFACE**

6.5.1. **Protocol description**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position word</td>
<td>4 x 8 Bit starting with LSB, 24 Bit position value + leading zeroes</td>
</tr>
<tr>
<td>Timeout time</td>
<td>11 / baud rate and 44 / baud rate</td>
</tr>
<tr>
<td>Max. clock frequency</td>
<td>921600 kHz, smaller baud rates adjustable</td>
</tr>
<tr>
<td>Number format (gray/binary)</td>
<td>binary</td>
</tr>
<tr>
<td>Parity bits</td>
<td>none, even, odd</td>
</tr>
<tr>
<td>Check sum</td>
<td>yes, EXOR operation on transmitted Bytes</td>
</tr>
<tr>
<td>User access memory</td>
<td>approx. 2 kByte</td>
</tr>
<tr>
<td></td>
<td>dividable in arrays of 16 to 128 Bytes</td>
</tr>
</tbody>
</table>

6.5.2. **Readout cycle**

The figure above shows a response of the measuring system to a position request. When the falling edge of the start bit is detected the position value is loaded into the output register. The communication on a Hiperface compatible bus always begins with the device address, followed by a command, data to be transmitted and a check sum.

It is possible to add a parity bit to every byte transmitted. Each of those is followed by a stop bit. The time between two bytes in a transmission cycle has to be smaller than the set timeout. Once the timeout passes the device expects a new command.
6.6. **USB 2.0 interface**

USB 2.0 is integrated in the LAK read head, which allows to have access to the read head via diagnostic software or a user interface (API).

An adapter cable can be used to connect the encoder to a PC for configuration purposes. It is also possible to pick off data by an adapter between the LAK connector and the controller.

Once the connection is established the user has several options:

- Diagnostics of internal read head signal via system margins (0% … 100%)
- Automatic adjustment of the signals to reduce the effects of static mounting errors
- Retrieval of position information
- Programming the counting direction
- Programming of zero position
6.6.1. Diagnostic software

NUMERIK JENA provides diagnostic software and a driver package for LAK encoders.

Supported operating systems:

- Windows XP, 7, 8 (32 and 64 bit)
- .NET Framework 4.0

6.6.2. Evaluation of the signal quality

The three blue bars in the middle of the figure show the current system margins. The white line represents a system margin of 12.5%. Below this threshold the system is in a pre-warning state. As long as the system margins are above 0% the system is error-free. Even at 0% the system works unless an error bit is set. Although at this point there is a high probability that an error bit is set momentarily.

The two columns on the right display the worst system margin and the corresponding absolute position for each category since the last reset. They do not correlate with the bars on the left unless the current absolute position matches one that appears in the rightmost column.
6.6.3. Evaluation of the mounting quality and automatic adjustment

This interface provides a tool to optimize the code connection in regard to the specific installation to reduce the effects of static displacement between read head and scale.