1. Hall Effect Gear Tooth Speed Sensors

Hall Effect gear tooth speed and direction sensors

Parameters:
- \( D \): diameter of the addendum cycle
- \( d \): diameter of the dedendum cycle
- \( b \): sensing gap between the gear addendum and sensor’s end
- \( a \): distance between the Hall Effect elements in each GTS IC
- \( \theta \): arc angle
- \( A \): distance between the centerlines of the two GTS ICs

- Duty Cycle: \( \eta = \frac{\delta L_1}{L} = \frac{\delta L}{\pi (D+2b)} \)
- Phase Drift: \( \Delta \theta = \theta_1 - \theta_2 = \frac{360^\circ}{\pi} \left( \tan^{-1} \frac{\Delta A}{D+2b} \right) \)

(CYGTS series Hall Effect gear tooth speed sensors appearance)

2. Optimization of Sensing Gap/Distance

The sensing distance \( b \) or \( g \) can be optimized by:
- Hall Effect GTS IC by using
  - Differential magnetic field detection
  - Peak magnetic field detection
- Geometry / material of permanent magnet / sensor case etc.

The GTS IC using differential magnetic field has a better sensing distance.

<table>
<thead>
<tr>
<th>Detection Method</th>
<th>Sensor</th>
<th>Sensing gap g (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak magnetic field</td>
<td>CYGTS101DC</td>
<td>0.7</td>
</tr>
<tr>
<td>Differential magnetic field</td>
<td>CYGTS101DC-S</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Tested with target gear 1 \((D=28mm, d=18mm, N=22, \theta=8.18^\circ)\)

3. Optimization of Phase Drift

The Phase Drift \( \Phi \) of the two output signals are dependent on:
- Distance between the two GTS ICs (distance \( A \))
- Geometry of target gear

<table>
<thead>
<tr>
<th>Distance A (mm)</th>
<th>Speed (rpm)</th>
<th>Calculated ( \Delta \Phi )</th>
<th>Measured ( \Delta \Phi )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4mm (CYGTS104U)</td>
<td>1500</td>
<td>54</td>
<td>45</td>
</tr>
<tr>
<td>3000</td>
<td>54</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>1.2mm (CYGTS104X)</td>
<td>1500</td>
<td>108</td>
<td>106</td>
</tr>
<tr>
<td>3000</td>
<td>108</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>1mm (SN1DH-T4L-G01)</td>
<td>1500</td>
<td>90</td>
<td>83</td>
</tr>
<tr>
<td>3000</td>
<td>90</td>
<td>83</td>
<td>94</td>
</tr>
</tbody>
</table>

Tested with target gear 2 \((N=64, D=81.5mm, L1=L2)\)

4. Optimization of Duty Cycle

For most applications, the best duty cycle \( \eta \) is 50%. It depends on:
- Geometry of target gear wheel
- Teeth number / Teeth shape
- Sensing distance etc.

<table>
<thead>
<tr>
<th>Tooth number of Target gear</th>
<th>Sensing gap (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1.0</td>
</tr>
<tr>
<td>12</td>
<td>5.0</td>
</tr>
<tr>
<td>22</td>
<td>5.0</td>
</tr>
</tbody>
</table>

According to experimental results, target gear should have more than 10 teeth.

5. Application to Speed Measurement of Rotors

There is no output signal, when the rotor (see left picture) is measured with other sensors, except the optimized sensors: CYGTS101DC-S and CYGTS104X.
- The speed of the rotor can be measured with CYGTS101DC-S in sensing gap \( g=0.2\sim1.35mm \)
- The speed of the rotor can be measured with CYGTS104X in sensing gap \( g=0.2\sim0.35mm \).

6. Conclusions

- The sensing gap/distance of Hall Effect Gear Tooth sensors can be improved by using differential magnetic field detection.
- For dual output sensors, with smaller distance \( A \) the signals have better sensing gap.
- The duty cycle of Hall Effect gear tooth sensors depends on the geometric duty cycle and tooth shape of the target wheel.
- With differential magnetic field detection, smaller distance \( A \), the phase drift of dual output sensors can be determined by the mathematical model more accurately.