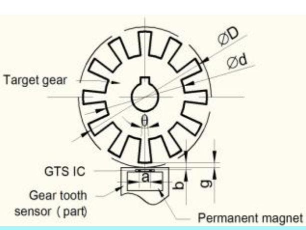
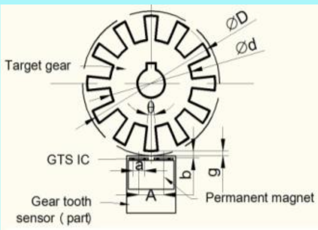
Parameter Optimization of Hall Effect Gear Tooth Speed Sensors

ChenYang Technologies GmbH & Co.KG

1. Hall Effect Gear Tooth Speed Sensors

Hall Effect gear tooth speed and direction sensors





Parameters

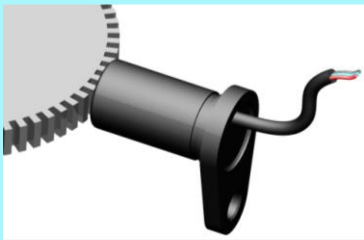
- D diameter of the addendum cycle
- d diameter of the dedendum cycle
- g sensing gap between the gear addendum and sensor's end
- b sensing distance between the gear addendum and sensing center of GTS IC
- a distance between the Hall Effect elements in each GTS IC
- θ arc angle
- A distance between the centerlines of the two GTS ICs

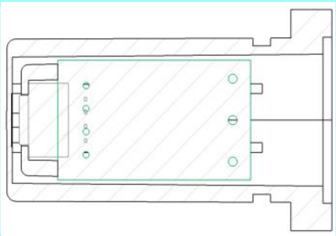
➢ Duty Cycle: $\eta = \frac{\delta L_1}{L} = \frac{\delta L_1 N}{\pi(D+2b)}$

➢ Phase Drift: $\Delta Ø = Ø_1(\text{output1}) - Ø_2(\text{output2}) = \frac{360°N}{\pi} \tan^{-1}\left(\frac{\underline{A}}{D+2b}\right)$

(Where $\underline{A}=A$ for counter clockwise rotation and $\underline{A}=-A$ for clockwise rotation)

CYGTS series Hall Effect gear tooth speed sensors appearance





2. Optimization of Sensing Gap/Distance

The sensing distance b or gap 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

Detection Method	Sensor	Sensing gap g (mm)
Peak magnetic field	1GT101DC	0.7
	CYGTS101DC	1.0
Differential magnetic field	CYGTS101DC-S	2.0

Testing with target gear 1 (D=28mm, d=18mm, N=22, θ=8.18°)

3. Optimization of Phase Drift

The Phase Drift Φ of the two output signals are dependent on:

- ➢ Distance between the two GTS ICs (distance A)
- ➢ Geometry of target gear

Distance A	Speed (rpm)	Calculated $\Delta\Phi$ (°)	Measured $\Delta\Phi$ (°)
5.4mm (CYGTS104U)	1500	54	45
	3000	54	46
1.2mm (CYGTS104X)	1500	108	107
	3000	108	106
1mm (SNDH-T4L-G01)	1500	90	83
	3000	90	94

Testing with target gear 2 (N=64, D=81.5mm, $L1$=L2)

4. Optimization of Duty Cycle

For most applications, the best duty cycle η is 50%. It depends on:

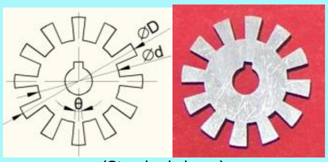
- ➢ Geometry of target gear wheel
  - ✓ Teeth number / Teeth shape
- ➢ Sensing distance etc.

Teeth Number of Target wheel

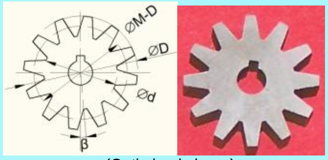
Sensing gap g(mm)		1.0	2.0	3.0	4.0	5.0
Tooth number of Target gear	6	59,31	57,91	53,59	48,62	46,18
	12	50,39	49,13	50,49	53,28	
	22	49,57	49,93	No signal		

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

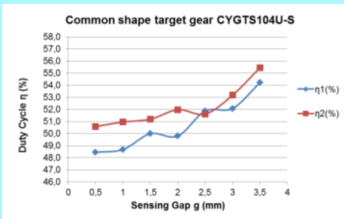
Tooth shape of Target Wheel

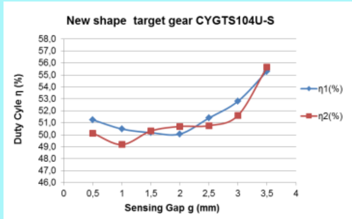


(Standard shape)



(Optimized shape)





Testing with CYGTS104U-S, standard shape target gear (D=28, d=18, N=12, θ=12°) and optimized shape target gear (D=28, d=18, N=12, β=5°)

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=0.2~1.35mm
- ➢ The speed of the rotor can be measured with CYGTS104X in sensing gap g=0.2~0.35mm.

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.

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