ChenYang
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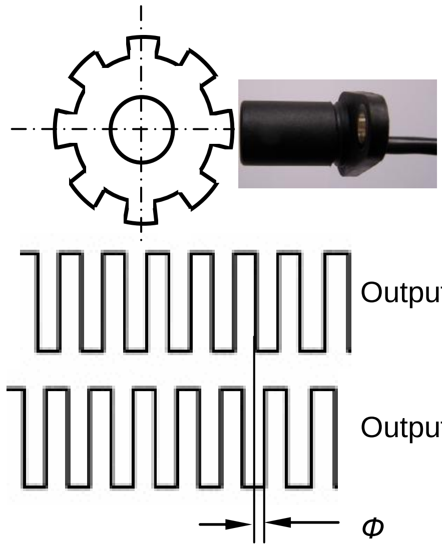
Hall Effect Gear Tooth Sensors CYGTS104

Hall Effect Gear Tooth Sensor CYGTS104 uses two magnetically biased Hall Effect integrated circuits (ICs) to accurately sense movement of ferrous metal target (measuring) wheel. These specially designed integrated circuits, with bias magnet and discrete capacitor, are sealed in plastic package for physical protection and cost effective installation.
This sensor functions under power supply from 4.5 to 24VDC. Two output signals are impulse, current sinking (open collector, NPN), which can be used for rotary speed measurement with direction detection. It has the advantage of reverse polarity protection. The sensor will not be damaged if power is inadvertently wired backwards.

Features

- Sensing ferrous metal target wheels
- Two impulse current sinking outputs NPN (OC) for speed measurement with direction detection
- Good signal-to-noise ratio
- Excellent low speed performance (1Hz)
- Output amplitude not dependent on RPM
- Fast operating speed, over 10kHz
- EMI resistant
- Reverse polarity protection and transient protection
- Wide operating temperature -40°~+150°C



Applications

Automotive and Heavy Duty Vehicles:

- Camshaft and crankshaft speed and position
- Transmission speed
- Tachometers
- Anti-skid/traction control

Industrial Areas:

- Sprocket speed
- Chain link conveyor speed/distance
- Stop motion detector
- High speed low cost proximity
- Tachometers, counters.

Recommended Operating Conditions

Parameter	Conditions	Min	Typ	Max	Unit
Operating Temperature		-40		+150	°C
Supply Voltage Vcc		4.5		24.0	V DC
Supply Current Icc		1	2.0	3.0	mA
Output Saturation Voltage Vsat	Low Output	≤0.50			V DC
High Output Voltage (Voh)		Voh ≥Vcc-0.5V			V
Frequency range		0.001		10	kHz
Output Current	Low Output			20	mA
Output Leakage Current	High Output			10	µA
Rise Time (at load resistanc 2kΩ)				≤10.0	µs
Fall Time (at load resistanc 2kΩ)				≤10.0	µs
Duty Cycle for L_1=L_2		0.4	0.5	0.6	

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Definition of Part Numbers:

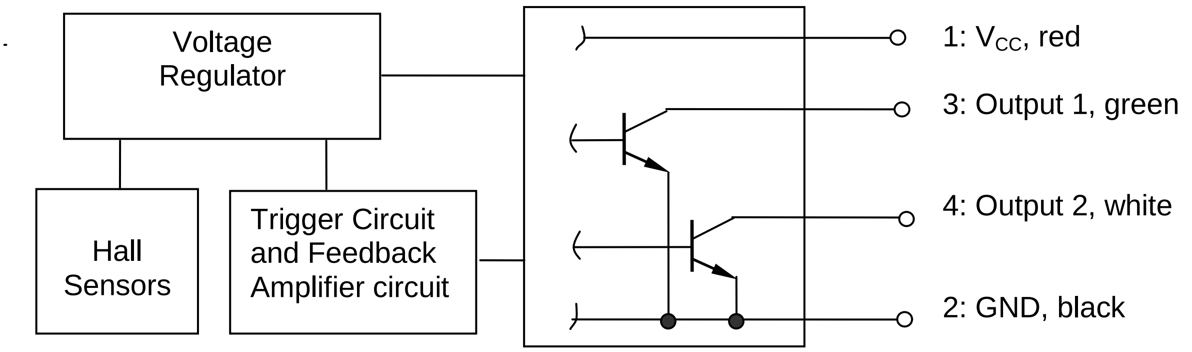
CYGTS 104	d
(1)	(2)

(1) Series Name	(2) Distance (*a*) between the sensing centers
CYGTS104	**d=U:** 5.4mm; **d=X:** 1.2mm

Absolute Maximum Ratings

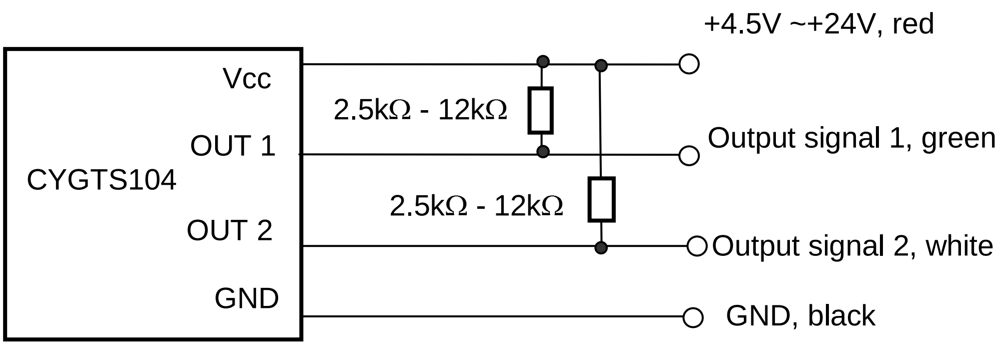
Supply Voltage	+28V
Voltage Externally Applied to Output	-0.3V～+28V (Output high)
Output Current	Sinking 30mA

Block Diagram

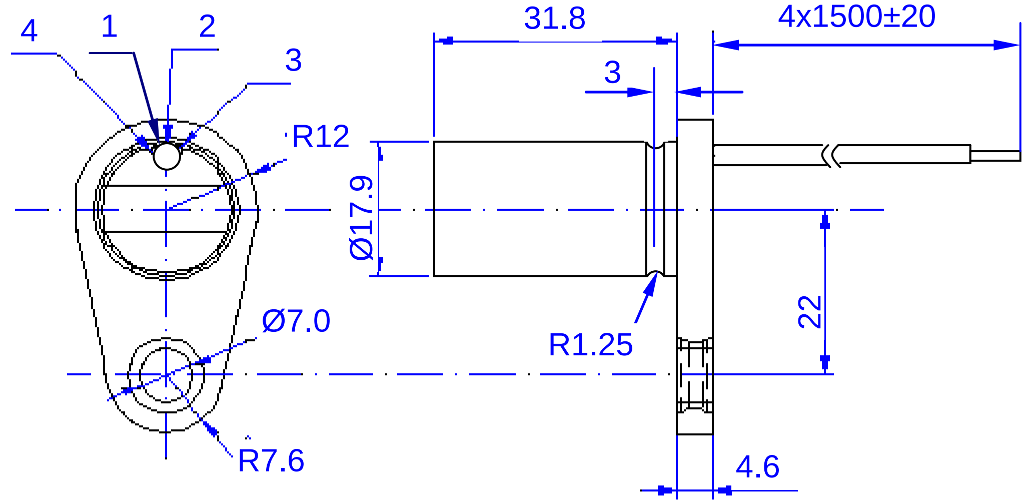


Connection

The output of the sensors is sinking current NPN (open collector). A pull-up resistor (2.5kΩ-12kΩ) should be connected to the sensor output circuit (between power supply Vcc and output).

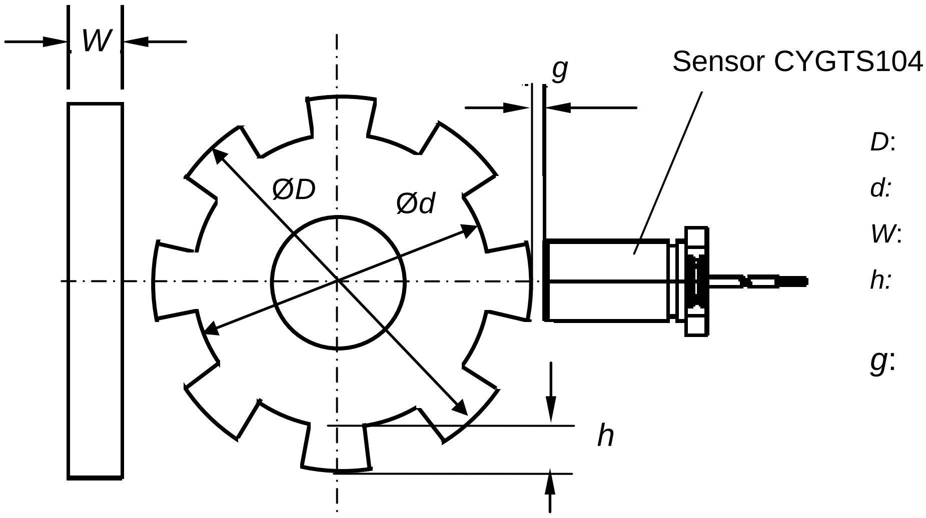


Mounting Dimensions (for reference only)



The standard length of the leads is 1.50m; diameter Ø4.0mm

Sensor Position to Target (Measuring) Wheel



D:	Outside Diameter
d:	Root Diameter
W:	Face width ≥5mm
h:	Addendum height ≥3mm
	h=(*D*-*d*)/2
g:	Sensing Gap ≥0.1mm

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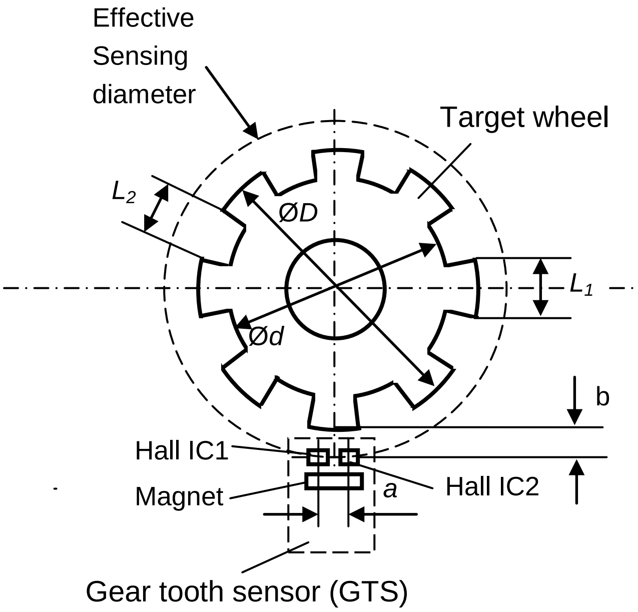
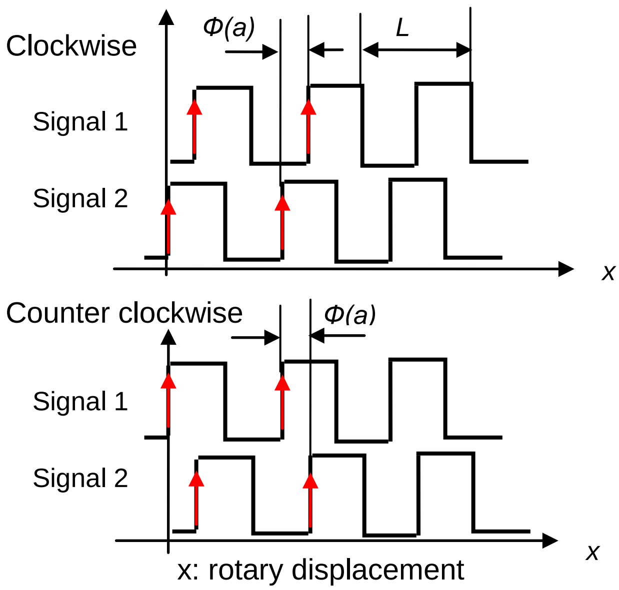
Measuring Principle

The Sensor CYGTS104 consists of two Hall Effect Switch ICs and one permanent magnet. The Hall ICs are faced to the target wheel. The distance (*a*) between the sensing centers of the Hall ICs is defined, for instance, 5.4mm for CYGTS104U and 1.2mm for CYGTS104X.





The magnetic fluxdensity change passed through the Hall ICs is higher than the releasing point of the Hall IC during the sensor moves from the tooth valley to the addendum of the target wheel. In this case, the sensor CYGTS104 has the HIGH voltage output. The magntic fluxdensity change through the sensor is lower than the operating point of the Hall ICs when the sensor comes from the addendum to tooth valley. The sensor gets then the LOW voltage level.

The phase drift *Φ* between the two output signals (signal 1 and signal 2) depends on the sensing distance (*a)* of the two Hall ICs and the effective tooth arc pitch (*L*) of the target wheel. It is calculated proximately as follows:

$$\phi = \phi_2(signal\ \ 2) - \phi_1(signal\ \ 1) = \frac{2\pi}{L}a \qquad (1)$$

The effective tooth arc pitch *L* is determined by

$$L = \frac{\pi}{N}\sqrt{(D+2b)^2 + a^2} \qquad (2a)$$

$$L = \frac{\pi(D+2b)}{N} \quad \text{for D+2b >>a} \qquad (2b)$$

with *b* as distance between the sensing centers and the addendum of target wheel and *N* as teeth number of the target wheel. Under the condition *a*=*L*/4 the phase difference is *Φ=π/2.*

For *D>>b* the effective tooth arc pitch *L* is simplified as:

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$$L = \frac{\pi D}{N} = L_1 + L_2 \qquad (3)$$

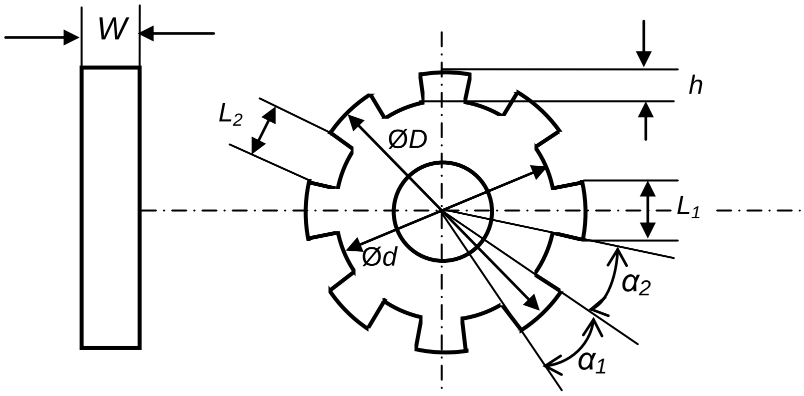
with L_1 as addendum arc width, L_2 as outside arc width of the tooth valley.

The Duty Cycle (factor) η of the output signals is determined by

$$\eta = \frac{\delta L_1}{L} \qquad (4)$$

with δ as Edge effect coefficient ($\delta \geq 1$).

Parameter Recommendation of Target (Measuring) Wheel



Here are the recommended paramters for the design of a target (measuring) wheel under the condition $D >> b$:

Parameter and materials	CYGTS104U	CYGTS104X
Material	Magnetic material with high permeability (Low-carbon steel)	Magnetic material with high permeability (Low-carbon steel)
Addendum Surface	Smooth surface	Smooth surface
Addendum height h	$h \geq 3$mm	$h \geq 3$mm
Sensing gap g	$g \geq 0.1$mm, $g_{max}=3.0$mm	$g \geq 0.1$mm, $g_{max}=3.0$mm
Addendum arc width L_1	$L_1 \geq 3$mm	$L_1 \geq 2$mm
Outside arc width of tooth valley L_2	$L_2 = L - L_1$, $L_2 > 3$mm	$L_2 = L - L_1$, $L_2 > 2$mm
EffectiveTooth arc pitch L	$L \approx L_1 + L_2 = 4a$ (4 times of the distance between sensing centers of Hall ICs)	$L \approx L_1 + L_2 = 4a$ (4 times of the distance between sensing centers of Hall ICs)
Number of teeth N	Dependent on the solution of speed measurement	Dependent on the solution of speed measurement
Outside Diameter D	$D = NL/\pi$	$D = NL/\pi$
Diameter d	$d = D - 2h$,	$d = D - 2h$,
Face width W	$W \geq 5$mm	$W \geq 5$mm
Tooth angle α_1, Valley angle α_2	$\alpha_1 = \alpha_2 = \pi/N$ or $\alpha_1 \geq \alpha_2$	$\alpha_1 = \alpha_2 = \pi/N$ or $\alpha_1 \geq \alpha_2$

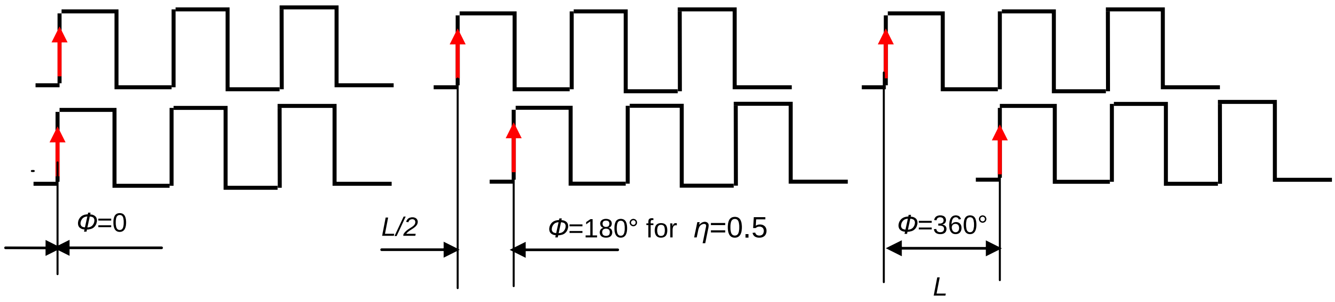
Application Notes

As mentioned above the effective tooth arc pitch L and the distance a between the sensing centers of Hall ICs play an important role for the phase difference Φ. According to equation (1) we can get the following table:

Phase difference between the output signals (counter clockwise)

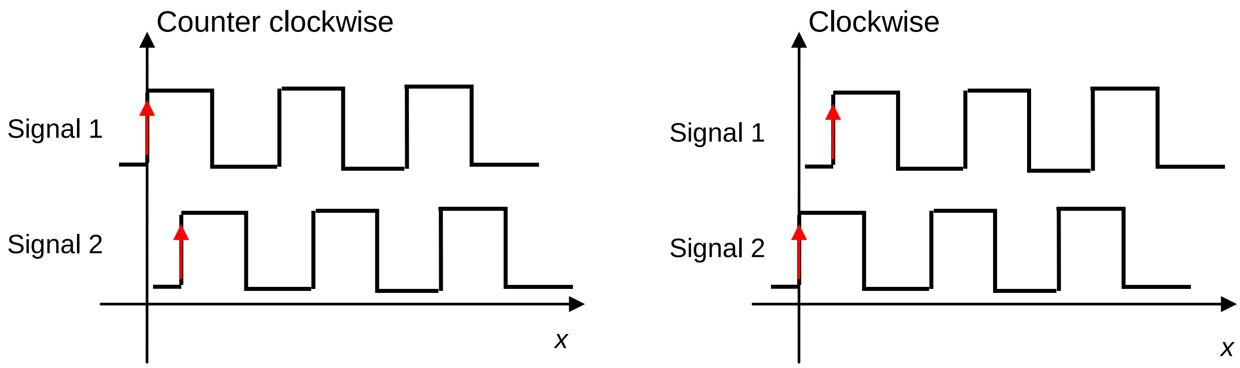
Ratio a /L	**0**	0.125	0.25	0.375	**0.5**	0.625	0.75	0.875	**1**
Phase difference Φ	**0**	45°	90°	135°	**180°**	225°	270°	315°	**360°**

For phase difference Φ=0, 180° and 360° the rotary direction of the target wheel is not detectable using asynchronous R-S flip-flops.



Therefore the detectable ranges are 0<Φ<180° or 180°<Φ<360° under the condition $\alpha_1 = \alpha_2=\pi/N$.

In the range 0<Φ<180°, i.e., $a < L/2$, the first impulses of both output signals are used for direction detection.



We can get the phase difference Φ >0 for counter clockwise rotation and Φ <0 for clockwise rotation of the target wheel. One can use the phase difference to detect the rotary direction of target wheel. It is suitable for speed measurement target wheel with big outer diameter or low tooth number. In this case the recommended effective tooth arc pitch of target wheel should be determined by

$$L = \frac{\pi(D+2b)}{N} = 4a \qquad (5)$$

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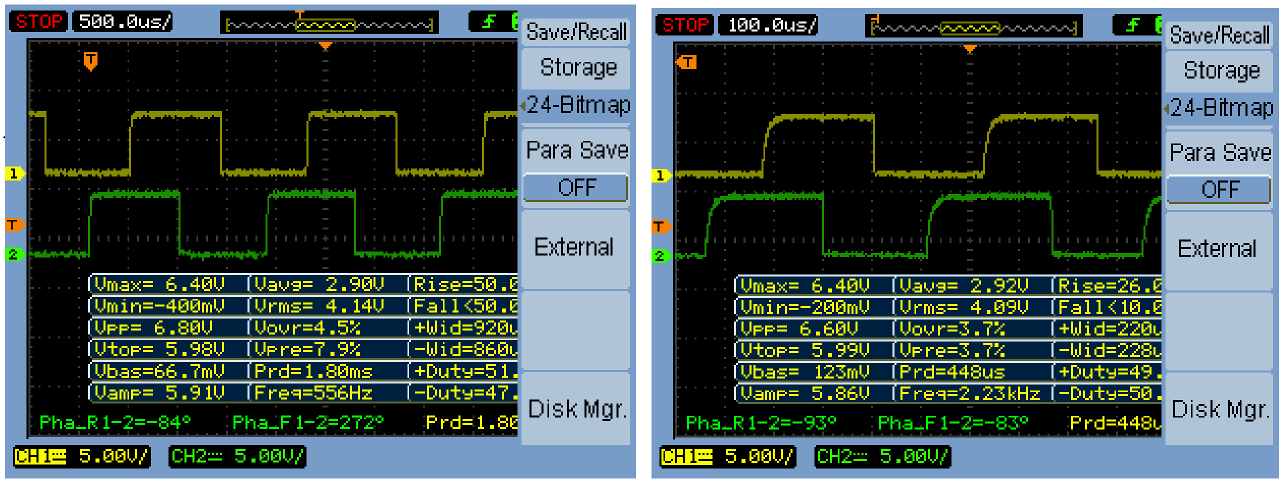
in order to get a phase difference Φ =90°.

Example 1: A target wheel has an outer diameter 28mm. The distance between the Hall elements and the addendum of target wheel is 3mm. The recommened tooth number N of the target wheel for sensor CYGTS104U and CYGTS104X is shown in the following table:

Recommened parameters of the target wheel at $a < L/2$

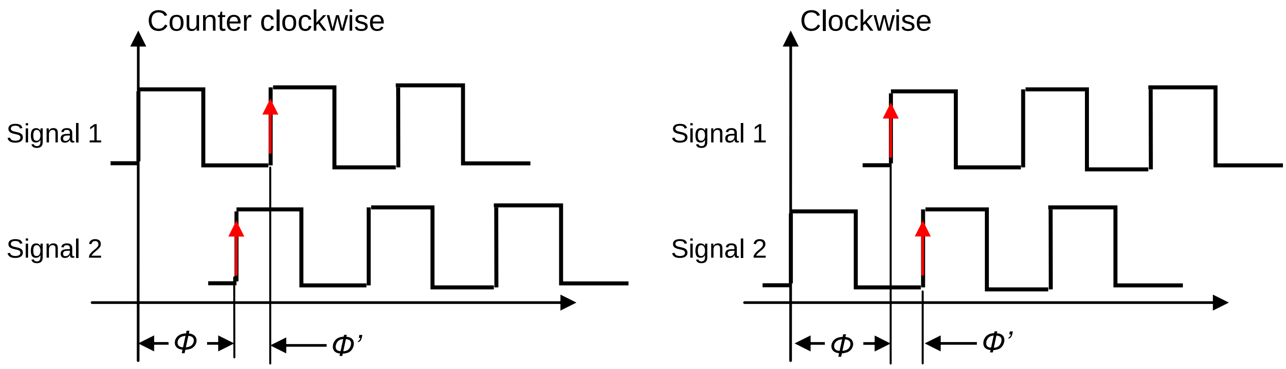
Sensor	Addendum arc width L_1	Outside arc width of tooth valley L_2	Tooth arc pitch L	Tooth number N
CYGTS104U	8.79mm	8.80mm	21.36mm	5
CYGTS104X	2.00mm	2.00 mm	4.86mm	22



a) Rotational speed 1500rpm b) Rotational speed 6000rpm

Measuring result using sensor CYGTS104X and Target wheel with the number of teeth N=22, outer diameter of 28mm and sensing distance b=3mm

In the range 180°<Φ<360° , i.e., $L/2 < a < L$, the first impulse of signal 2 and the second impulse of signal 1 are used for direction detection when the target wheel rotates in the counter clockwise direction, and the first impulse of signal 1 and the second impulse of signal 2 are used for direction detection when the target wheel rotates in the clockwise direction:



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We can get the phase difference $\Phi' = \Phi - 360°$ < 0 for counter clockwise rotation and $\Phi' = \Phi + 360°$ > 0 for clockwise rotation of the target wheel. One can also use the phase difference to detect the rotary direction of target wheel. However the phase difference has opposite value agaist that of the range $0<\Phi<180°$.

This range is suitable for speed measurement target wheel with small outer diameter or high tooth number. In this case the recommended tooth arc pitch of target wheel should be determined by

$$L = \frac{\pi(D+2b)}{N} = \frac{4}{3}a \qquad (6)$$

in order to get a phase difference Φ =90°.

Example 2: A target wheel has an outer diameter 28mm. The distance between the Hall elements and the addendum of target wheel is 3mm. The recommened tooth number N of the target wheel for sensor CYGTS104U is shown in the following table:

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Recommened parameters of the target wheel at $L/2 < a < L$

Sensor	Addendum arc width L_1	Outside arc width of tooth valley L_2	Tooth arc pitch L	Tooth number N if outer diameter about 28mm
CYGTS104U	3.14mm	3.14mm	7.63mm	14

According to the relation (6) the effective tooth arc pitch L should be 7.2mm. In this case the tooth number is determined by

$$N = \frac{\pi(D+2b)}{L} = \frac{3.14x(28+2x3)}{7.2} = 14.82$$

N can be 14 or 15. However, the addendum arc width L_1 and the outside arc width of tooth valley L_2 are about 2.93mm, i.e., smaller than 3mm, if N=15.

The sensor CYGTS104X cannot be used in the case of $180°<\Phi<360°$, i.e., $L/2 < a < L$, because the parameters L_1 and L_2 are smaller than 2mm (according to (6) the pitch L=1.6mm. The tooth number N should be 66 and $L_1 = L_2$ is 0.8mm)

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