

LASER ROTARY ENCODER



Canon's Technology Has Changed the World of Rotary Encoders: 81,000 Pulses with 36mm Diameter

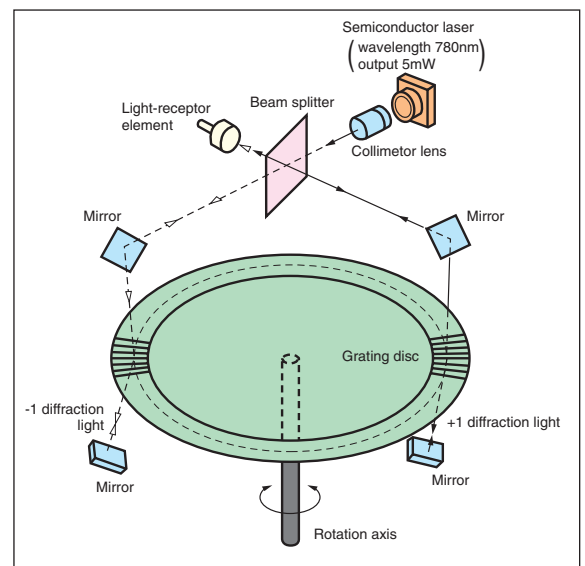
Canon laser rotary encoders use the light-diffraction interference method, with a semiconductor laser as the light-emitter element. The result is an ultra-compact size encoder that combined was impossible with traditional rotary encoders. This product is a compact, high-precision rotary-angle sensor that is certain to play a major role in the development of high-technology products that will lead the market in the 21st century in a wide variety of fields such as robotics, manufacturing machinery, and measuring equipment.

THEORY

As illustrated in the diagram, laser beams are applied to two points equidistant from the grating disc's center of revolution. One diffraction beam is positive first order (+1) and the other is negative first order (-1).

For each 1 pitch that the grating disc revolves, the ± 1 diffraction light will change each phase by $\pm 2\pi$. Reflecting the ± 1 diffraction light into respective mirrors and then reapplying it to the grating disc changes the phase by $\pm 4\pi$.

In this way, each time the grating disc revolves 1 pitch, the brightness interference signals for 4 cycles can be obtained, making highly accurate angle sensing possible.



FEATURES

- Using diffraction and interference with high precision grating disk, Canon laser rotary encoders minimize the product size and offer very high density pulse making features.
- Two laser beams are irradiated simultaneously onto two locations which are symmetrical with respect to the rotational center of the grating disk. This configuration compensates for the eccentricity of the disk, which often causes measurement error.
- The new reflection optical system eliminates measurement error caused by temperature change which affects the wavelength stability of a semiconductor laser.
- Based on the interference principle, light intensities at the end of optical paths are modulated sinusoidally with rotation of the grating disk changing them into electrical signal.

APPLICATION EXAMPLES

- Robotic engineering
- Sensor for NC machine
- Stage position control
- Direct motor control
- Angle sensor for measuring instruments

SPECIFICATIONS TABLE

	R-10	R-1L	K-1	R-1P20	M-1	KP-1Z	X-1M
Light source	Semiconductor Laser 780nm, 5mW max.						
Pulse/rev.	81,000			405,000	50,000	81,000	225,000
Angle/pulse	16 arc-sec.			3.2 arc-sec.	25.92 arc-sec.	16 arc-sec.	5.76 arc-sec.
Max. response	500kHz(360rpm)			1.62MHz(240rpm)	2MHz(2400rpm)	250kHz(185rpm)	675kHz(180rpm)
Output Signal							
A/B phase	2 phase rectangle wave incremental signal Open Collector	2 phase rectangle wave incremental signal Balanced Line driver	2 phase sine wave incremental signal	2 phase rectangle wave incremental signal Balanced Line driver		2 phase sine wave incremental signal	
Z phase*1	Rectangle wave signal Open Collector	Rectangle wave signal Balanced Line driver	Rectangle wave signal Open Collector	Rectangle wave signal Balanced Line driver		TTL	Rectangle wave signal Balanced Line driver
Permissible rotating speed	max 5,000rpm						
Starting torque	max 9g·cm				max 50g·cm		—
Rotor's inertial moment	8g·cm ²				40g·cm ²		—
Permissible load	Radial : 0.4Kg Thrust : 1.0Kg				Radial : 1.5Kg Thrust : 2.0Kg		—
Power supply							
Voltage	DC±5.00V ±5%						
Current *2	+5V 200mA max -5V 100mA max	+5V 250mA max -5V 100mA max	+5V 200mA max -5V 100mA max	+5V 250mA max -5V 50mA max	+5V 280mA max -5V 100mA max	+5V 200mA max -5V 100mA max	+5V 260mA max -5V 60mA max
Outer diameter	∅36mm				∅56mm		∅140mm
Weight *3	80g	95g	80g	95g	260g	160g(detection unit)	1.2kg(detection unit)
Working environment							
Operating temperature	0°C~50°C				0°C~70°C	0°C~50°C	10°C~40°C
Storage temperature	-30°C~80°C			-10°C~60°C	-30°C~80°C	-10°C~60°C	
Humidity	90%RH or less (No condensation)						80%RH or less (No condensation)
Vibration	10G, 500Hz or less			5G, 200Hz or less	10G, 500Hz or less	5G, 200Hz or less	5G, 250Hz or less
Impact	30G, 11msec or less				60G, 11msec or less	30G, 11msec or less	

*1 : Z phase signal is not synchronized with either A phase or B phase signal.

*2 : without output load.

*3 : without cable.

LASER ROTARY ENCODER

R-10

81,000 pulses per revolution in a compact housing,
Open collector output



- Compact and lightweight.
- High resolution : 81,000 pulses/rev, equal to 16 arc second for each pulse (without interpolator).
- Open collector output.
- Maximum frequency response of 500kHz.

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■ Resolution	81,000 pulse/revolution
■ Angle/Pulse	16 arc-sec (without interpolator)
■ Output Signal	2 phase rectangle wave incremental signal, Open Collector Z phase rectangle wave reference signal
● Signal width	A phase, B phase : $0.4 \leq (a+b)/p \leq 0.6$ $a = (1/4 \pm 1/36)p$ $c = (1/4 \pm 1/36)p$ Z phase : $100 \leq e \leq 250$ nsec
● Accumulate error	20arc-sec _{p-p} or less
■ Maximum response frequency	500kHz
■ Maximum response rotation speed	360rpm (6rps)
■ Light source	Semiconductor Laser 780nm, 5mw max.
■ Voltage	DC±5V ±5%
■ Current	+5V : 200mA maximum with no output load -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

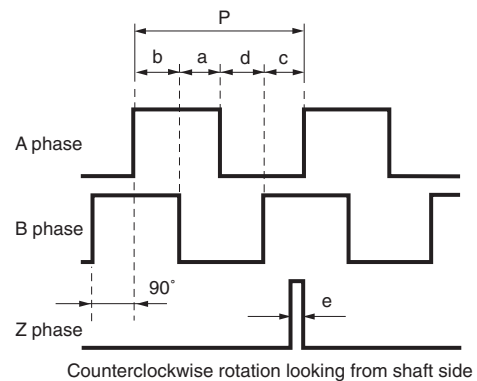
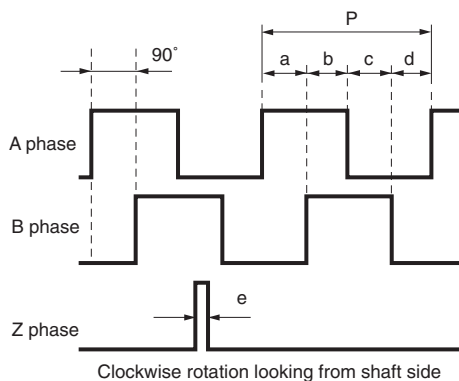
■ Maximum Rotation Rate	5,000rpm
■ Starting Torque	9g-cm or less
■ Inertial Moment of Rotor (GD ²)	8g-cm ²
■ Maximum Load on Shaft	Radial : 0.4kg Thrust : 1.0kg or less
■ Maximum Angular Acceleration	10°rad/sec ²
■ Weight	approx. 80g without cable
■ Diameter	36mm

ENVIRONMENTAL SPECIFICATIONS

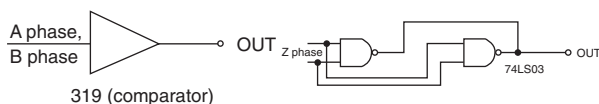
■ Operating Temperature	0 to 50°C
■ Storage Temperature	-30 to 80°C
■ Humidity	90%RH or less (no condensation)
■ Vibration	10G, 500Hz max.
■ Shock	30G, 11ms max.

OUTPUT SIGNAL

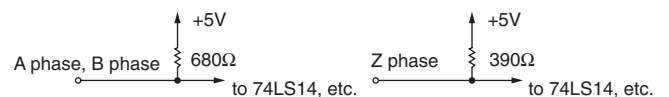
Z phase is not synchronized with either A phase or B phase



OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



R-1L



81,000 square wave pulses per revolution in a compact housing, Balanced line driver output

- Compact and lightweight.
- High resolution : 81,000 pulses/rev, equal to 16 arc second for each pulse (without interpolator).
- Balanced line driver output.
- Maximum frequency response of 500kHz.

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■ Resolution	81,000 pulse/revolution
■ Angle/Pulse	16 arc-sec (without interpolator)
■ Output Signal	2 phase rectangle wave incremental signal, Balanced Line Driver Z phase rectangle wave reference signal
● Signal width	A phase, B phase : $0.4 \leq (a+b)/p \leq 0.6$ $a = (1/4 \pm 1/36)p$ $c = (1/4 \pm 1/36)p$ Z phase : $100 \leq e \leq 250$ nsec
● Accumulate error	20arc-sec _{p-p} or less
■ Maximum response frequency	500kHz
■ Maximum response rotation speed	360rpm (6rps)
■ Light source	Semiconductor Laser 780nm, 5mw max.
■ Voltage	DC±5V ±5%
■ Current	+5V : 250mA maximum with no output load -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

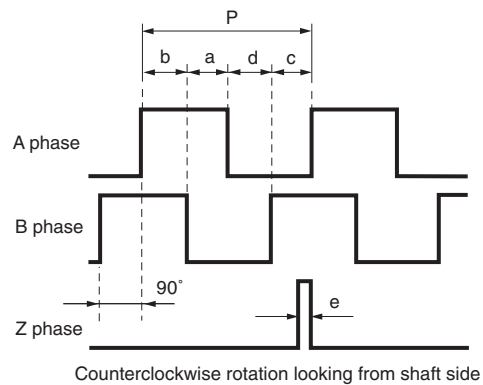
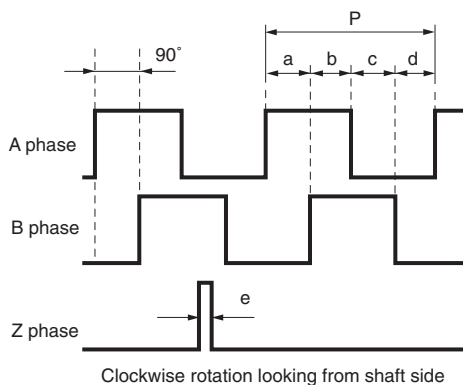
■ Maximum Rotation Rate	5,000rpm
■ Starting Torque	9g·cm or less
■ Inertial Moment of Rotor (GD ²)	8g·cm ²
■ Maximum Load on Shaft	Radial : 0.4kg Thrust : 1.0kg or less
■ Maximum Angular Acceleration	10°rad/sec ²
■ Weight	approx. 95g without cable
■ Diameter	36mm

ENVIRONMENTAL SPECIFICATIONS

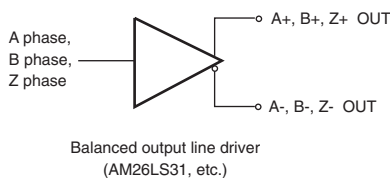
■ Operating Temperature	0 to 50°C
■ Storage Temperature	-30 to 80°C
■ Humidity	90%RH or less (no condensation)
■ Vibration	10G, 500Hz max.
■ Shock	30G, 11ms max.

OUTPUT SIGNAL

Z phase is not synchronized with either A phase or B phase



OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



LASER ROTARY ENCODER

K-1



81,000 sine wave pulses per revolution, 1 arc-sec with electric interpolator

- Compact and lightweight.
- High resolution : 81,000 pulses/rev, equal to 1 arc second with interpolator CI16-2.
(1,296,000 pulses per revolution)
- Maximum frequency response of 500kHz (360rpm).

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■ Resolution	81,000 sinusoidal wave/revolution
■ Angle/Pulse	16 arc-sec (without interpolator)
■ Output Signal	2 phase sin wave incremental signal, Z phase rectangle wave reference signal
■ Signal Amplitude	A phase, B phase : $1.0^{+0.2}_{-0.15} V_{P-P}$ (Open circuit output impedance is about 110Ω at a frequency of 100kHz)
● Phase Difference	between A phase and B phase $90^\circ \pm 10^\circ$
● Pulse width	Z phase : $100 \leq t \leq 250$ nsec
● Accumulate error	20arc-sec _{P-P} or less
■ Maximum response frequency	500kHz
■ Maximum response rotation speed	360rpm (6rps)
■ Light source	Semiconductor Laser 780nm, 5mw max.
■ Voltage	DC±5V ±5%
■ Current	+5V : 200mA maximum with no output load -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

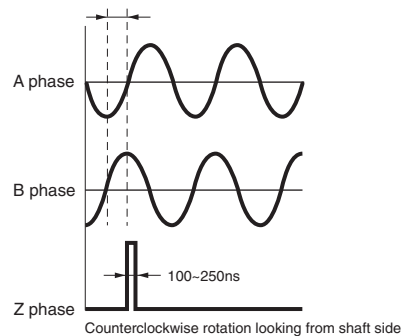
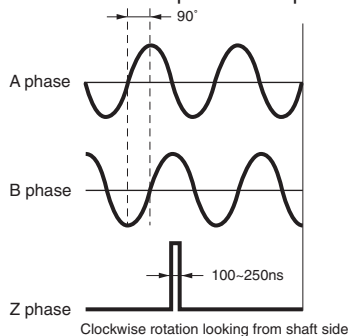
■ Maximum Rotation Rate	5,000rpm
■ Starting Torque	9g·cm or less
■ Inertial Moment of Rotor (GD ²)	8g·cm ²
■ Maximum Load on Shaft	Radial : 0.4kg Thrust : 1.0kg or less
■ Maximum Angular Acceleration	10°rad/sec ²
■ Weight	approx. 80g without cable
■ Diameter	36mm

ENVIRONMENTAL SPECIFICATIONS

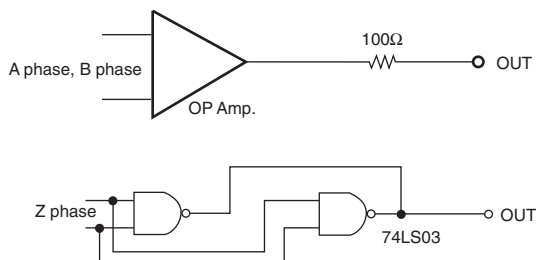
■ Operating Temperature	0 to 50°C
■ Storage Temperature	-30 to 80°C
■ Humidity	90%RH or less (no condensation)
■ Vibration	10G, 500Hz max.
■ Shock	30G, 11ms max.

OUTPUT SIGNAL

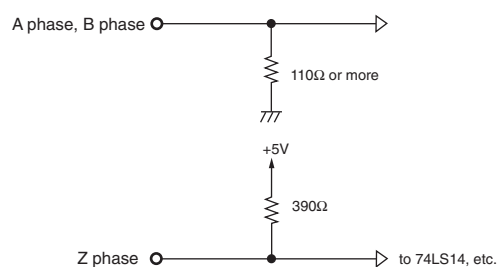
Z phase is not synchronized with either A phase or B phase



OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



R-1P20



405,000 pulses per rotation, 1,620,000 pulses can be read with ordinary divide-by-four circuit

- Compact and lightweight.
- 405,000 pulses per rotation with built-in interpolator.
- Maximum frequency response of 1.62MHz.
- 1,620,000 pulses per rotation can be read with ordinary divide-by-four circuit.

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■ Resolution	405,000 pulse/revolution (with built-in interpolator)
■ Angle/Pulse	3.2 arc-sec.
■ Output Signal	2 phase rectangle wave incremental signal, Balanced Line Driver Z phase rectangle wave reference signal, Balanced Line Driver Laser monitor signal, Open corrector (notice of time for LD exchange)
■ Z pulse width	185±75 nsec
■ Accumulate error	20arc-sec _{p-p} or less
■ Maximum response frequency	1.62MHz
■ Maximum response rotation speed	240rpm (4rps)
■ Light source	Semiconductor Laser 780nm, 5mw max.
■ Voltage	DC±5V ±5%
■ Current	+5V : 250mA maximum with no output load -5V : 50mA maximum

MECHANICAL SPECIFICATIONS

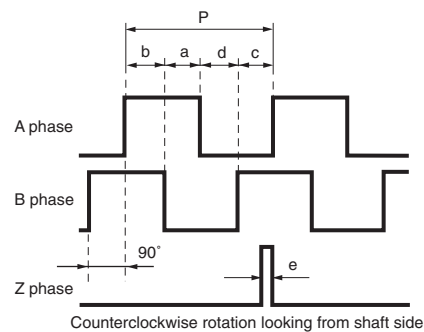
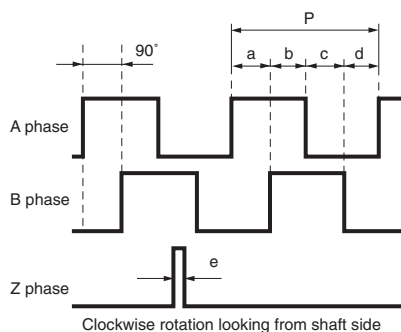
■ Maximum rotation rate	5,000rpm
■ Starting torque	9g·cm or less
■ Inertial moment of rotor (GD ²)	8g·cm ² or less
■ Maximum load on shaft	Radial : 0.4kg Thrust : 1.0kg or less
■ Maximum angular acceleration	105 rad/sec ²
■ Weight	approx. 95g without cable
■ Diameter	36mm

ENVIRONMENTAL SPECIFICATIONS

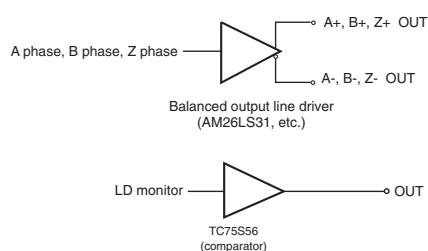
■ Operating temperature	0 to 50°C
■ Storage temperature	-10 to 60°C
■ Humidity	90%RH or less (no condensation)
■ Vibration	5G, 200Hz max.
■ Shock	30G, 11ms max.

OUTPUT SIGNAL

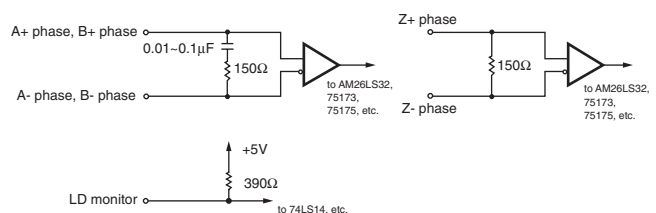
Z phase is not synchronized with either A phase or B phase



OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



LASER ROTARY ENCODER

M-1

2MHz (2,400rpm) high frequency response

- Heavy duty for factory environment.
- Maximum frequency response of 2MHz.
- Balanced line driver output circuit enables long distance signal transmission.



SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■Resolution	50,000 pulse/revolution
■Angle/Pulse	25.92 arc-sec (without interpolator)
■Output Signal	2 phase rectangle wave incremental signal, Balanced Line Driver Z phase rectangle wave reference signal
●Signal width	A phase, B phase : $0.4 \leq (a+b)/p \leq 0.6$ DC~500kHz : $a=(1/4 \pm 1/36)p$ $c=(1/4 \pm 1/36)p$ 500kHz~2MHz : $a=(1/4 \pm 1/18)p$ $c=(1/4 \pm 1/18)p$ Z phase : $100 \leq e \leq 250$ nsec
●Accumulate error	25arc-sec _{p-p} or less
■Maximum response frequency	2MHz
■Maximum response rotation speed	2,400rpm (40rps)
■Light source	Semiconductor Laser 780nm, 5mw max.
■Voltage	DC±5V ±5%
■Current	+5V : 280mA maximum with no output load -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

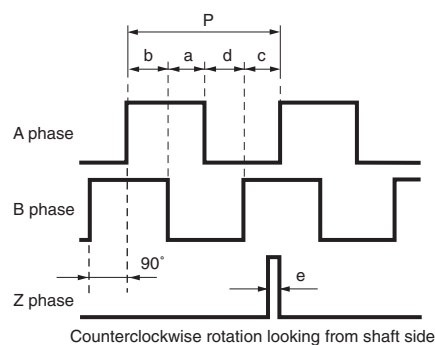
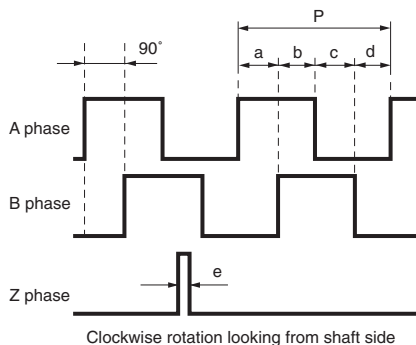
■Maximum Rotation Rate	5,000rpm
■Starting Torque	50g·cm or less
■Inertial Moment of Rotor (GD ²)	40g·cm ²
■Maximum Load on Shaft	Radial : 1.5kg Thrust : 2.0kg or less
■Maximum Angular Acceleration	2X10 ⁵ rad/sec ²
■Weight	approx. 260g without cable
■Diameter	56mm

ENVIRONMENTAL SPECIFICATIONS

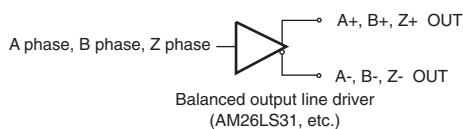
■Operating Temperature	0 to 70°C
■Storage Temperature	-30 to 80°C
■Humidity	90%RH or less (no condensation)
■Vibration	10G, 500Hz max.
■Shock	60G, 11ms max.

OUTPUT SIGNAL

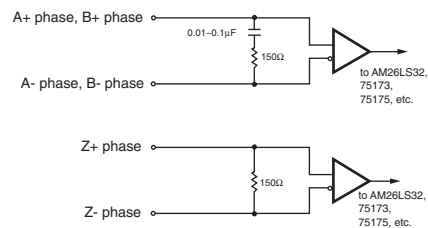
Z phase is not synchronized with either A phase or B phase



OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



KP-1Z

Module type rotary encoder, 81,000 sine wave per revolution

- Module type rotary encoder with canon original interference optics.
- Low influence from disk eccentricity.



SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■Resolution	81,000 sine wave/revolution
■Angle/Pulse	16 arc-sec (without interpolator)
■Output Signal	2 phase sin wave incremental signal, Balanced Line Driver Z phase 180°±1° High/Low reverse signal Laser monitor signal, Open corrector (notice of time for LD exchange)
■Signal Amplitude	A phase, B phase : 1.0V _{p-p} (typ.) Amplitude fluctuation due to revolution: ±0.15V
■Accumulate error	20arc-sec _{p-p} or less
■Maximum response frequency	500kHz
■Maximum response rotation speed	360rpm (6rps)
■Light source	Semiconductor Laser 780nm, 5mw max.
■Voltage	DC±5V ±5%
■Current	+5V : 200mA maximum -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

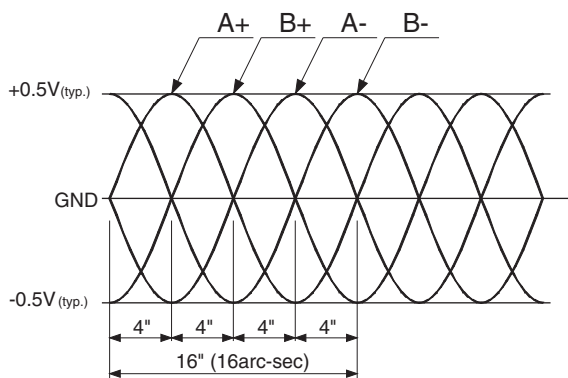
■Detection unit installation	Eccentricity : ±25µm Inclination : ±3 arc-sec toward disk surface runout due to revolution: less than 1arc-min. eccentricity of grating scale : less than 10µm
■Disk installation	
■Weight	approx. 160g without cable
■Diameter	Detection unit : 56mm, Disk : 48mm

ENVIRONMENTAL SPECIFICATIONS

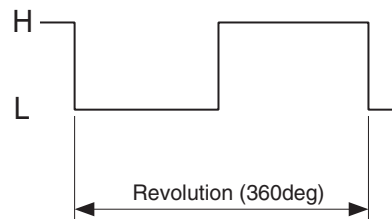
■Operating temperature	0 to 50°C
■Storage temperature	-10 to 60°C
■Humidity	90%RH or less (no condensation)
■Vibration	5G, 200Hz max.
■Shock	30G, 11ms max.

OUTPUT SIGNAL

A phase, B phase



Z phase



LASER ROTARY ENCODER

X-1M

Super High Resolution, 225,000 sine wave per revolution



- A sinusoidal wave output of 225,000 wave/rotation.
- High precision is assured by a common path optical system (accumulative accuracy ± 1 second or less).
- Installation in a machine is facilitated by the reflex configuration in which the detecting unit is separated from the disk.
- The encoder is designed to prevent transmission of light through the central section of the disk and sensor unit.

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

- Resolution 225,000 sinusoidal wave/revolution
- Angle/Pulse 5.76arc-sec (without interpolator)
- Output Signal 2 phase sine wave incremental signal, Balanced output
Z phase rectangle wave reference signal, Balanced Line Driver

- A, B phase signal
- Output voltage $1.1 \pm 0.2V_{p-p}$ (50kHz, no load, all of A+, A-, B+, B-)
 - Output impedance Each output approximately 110 Ω
 - Phase difference $90^\circ \pm 5^\circ$ (0~113kHz : 0~30rpm)
 $90^\circ \pm 10^\circ$ (~450kHz : ~120rpm)
 $90^\circ \pm 15^\circ$ (~675kHz : ~180rpm)
 - Phase relationship Looking from the disk or shaft side, A phase leads when the disk is rotating clockwise.

- Z phase signal
- Output format Differential Line driver output
 - Pulse width $1.0 \pm 0.2\mu\text{sec}$
 - Recommended load current $\pm 20\text{mA}$

- Maximum response frequency 675kHz
- Maximum response rotation speed 180rpm (3rpm)
- Light source Semiconductor Laser 780nm, 5mw max.
- Voltage DC $\pm 5V \pm 5\%$
- Current +5V : 260mA maximum with no output load
-5V : 60mA maximum

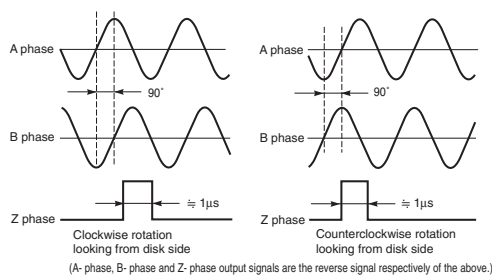
MECHANICAL SPECIFICATIONS

- Inertial Moment of Rotor $1.45 \times 10^{-6} \text{g}\cdot\text{cm}^2$
- Weight Detection unit : approx. 1.2kg without cable
Disk unit : approx. 0.26kg

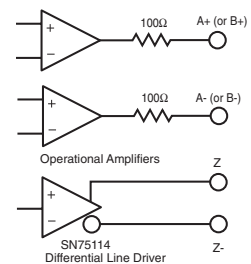
ENVIRONMENTAL SPECIFICATIONS

- Operating temperature 10 to 40 $^\circ\text{C}$
- Storage temperature -10 to 60 $^\circ\text{C}$
- Humidity 80%RH or less (no condensation)
- Vibration 5G, 250Hz max.
- Shock 30G, 11ms max.

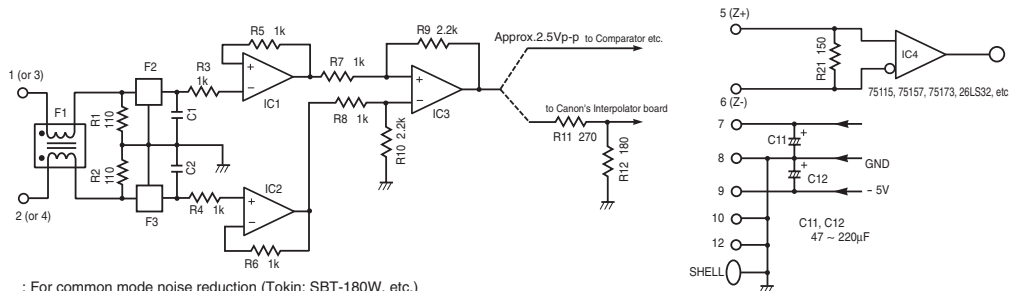
OUTPUT SIGNAL



OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



- F1 : For common mode noise reduction (Tokin: SBT-180W, etc.)
 F2, F3 : For normal mode noise reduction (Murata : DSS306-55B271M, etc.)
 C1, C2 : For frequency band restriction, When being used at low speed, add according to maximum frequency for use.
 IC1, IC2 : Unity Gain Frequency $\geq 3\text{MHz}$, Slew Rate $\geq 4\text{V}/\mu\text{s}$, Unity Gain Stable (NEC : μPC4572 , μPC812 , TI : TL072, NS : LF353, etc.)
 IC3 : Unity Gain Frequency $\geq 10\text{MHz}$, Slew Rate $\geq 18\text{V}/\mu\text{s}$ (LT1358, etc.)
 *For the power supply of IC1-3, it is recommended that a ripple filter be installed in each element.

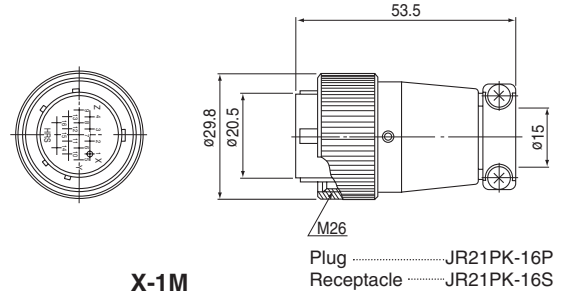
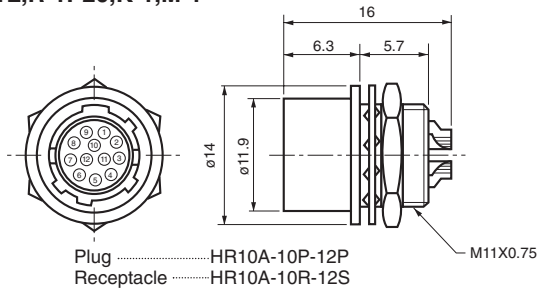
LASER ROTARY ENCODER

CONNECTORS PIN NUMBERS AND THE FUNCTIONS

R-10,R-1L,R-1P20,K-1,M-1

Unit: mm

X-1M



R-10,K-1

R-1L,R-1P20,M-1

X-1M

Pin No.	Function	Pin No.	Function
1	A phase	7	+5V
2	GND	8	GND
3	B phase	9	-5V
4	GND	10	GND
5	Z phase	11	NC
6	GND	12	CASE shielding
Shell	Shield (Frame Ground)		

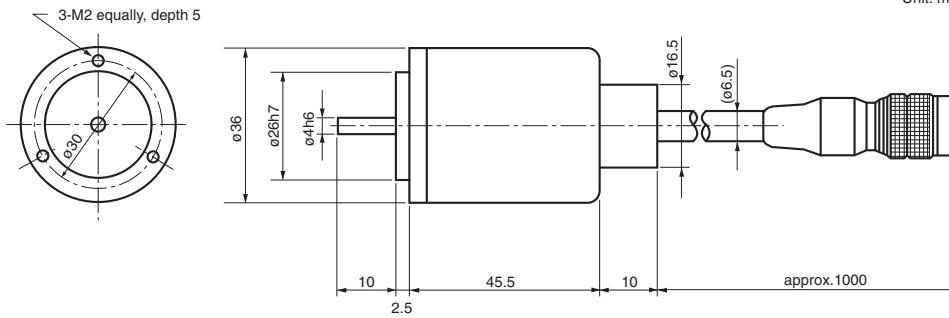
Pin No.	Function	Pin No.	Function
1	A+	7	+5V
2	A-	8	GND
3	B+	9	-5V
4	B-	10	GND
5	Z+	11	NC
6	Z-	12	CASE shielding
Shell	Shield (Frame Ground)		

Pin No.	Function	Pin No.	Function
1	A+	8	GND
2	A-	9	-5V
3	B+	10	GND
4	B-	11	NC
5	Z+	12	CASE shielding
6	Z-	13~16	NC
7	+5V	Shell	CASE shielding

EXTERNAL DIMENSIONS

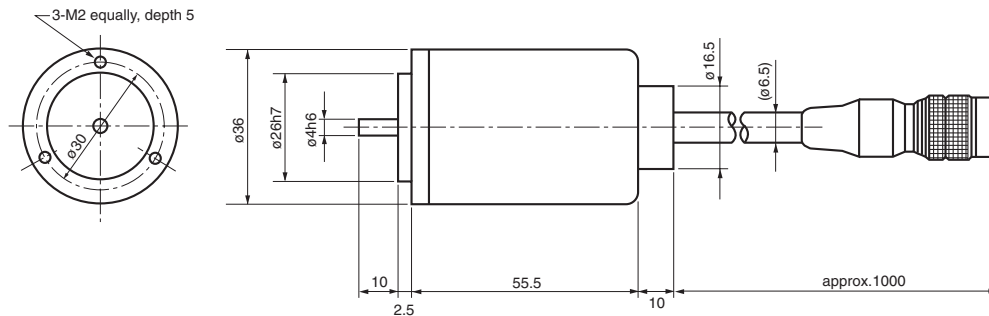
R-10,K-1

Unit: mm



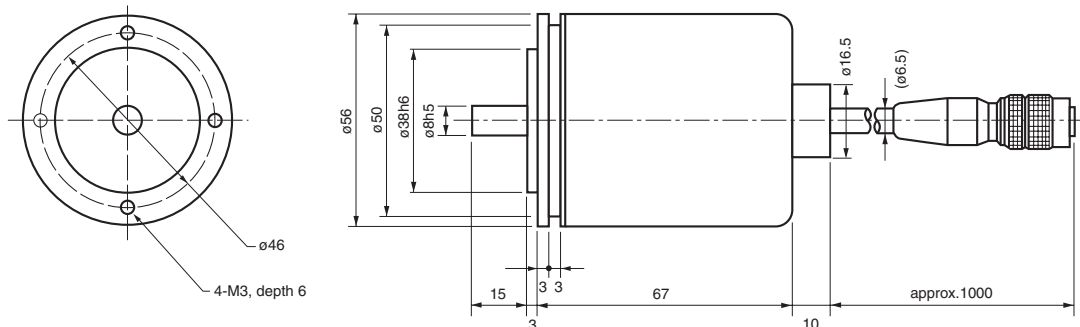
R-1L,R-1P20

Unit: mm



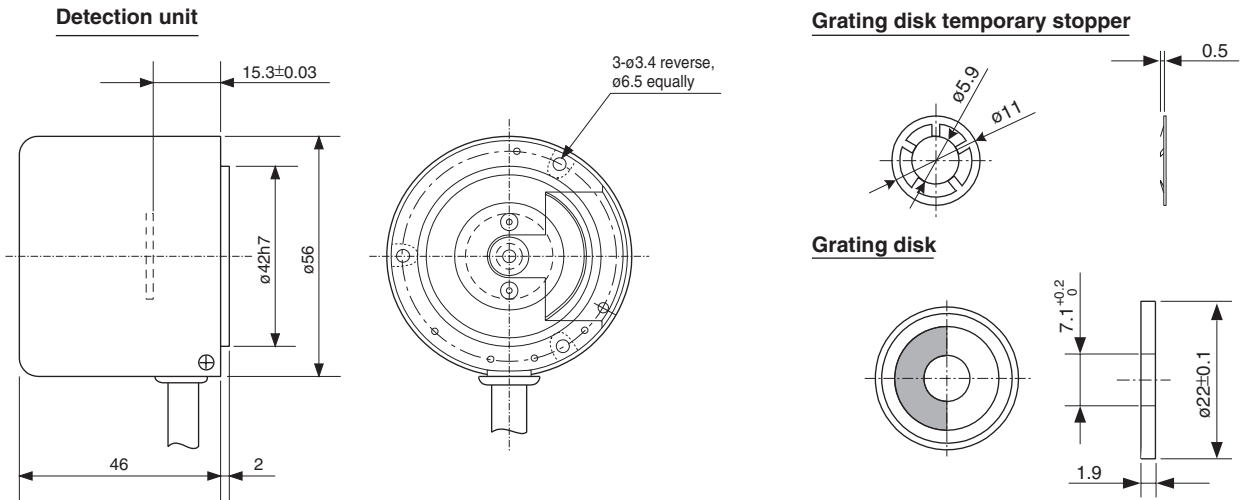
M-1

Unit: mm



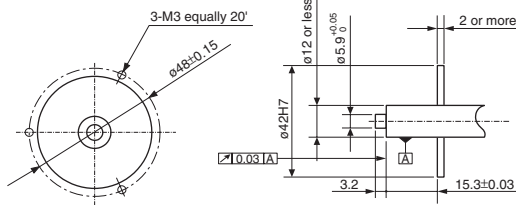
LASER ROTARY ENCODER

KP-1Z



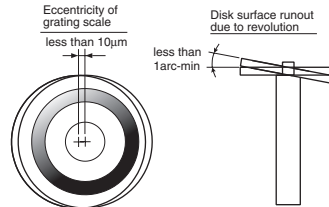
«Permissible level for installation of detection unit and disk»

Shape of fitting part



Scale fitting

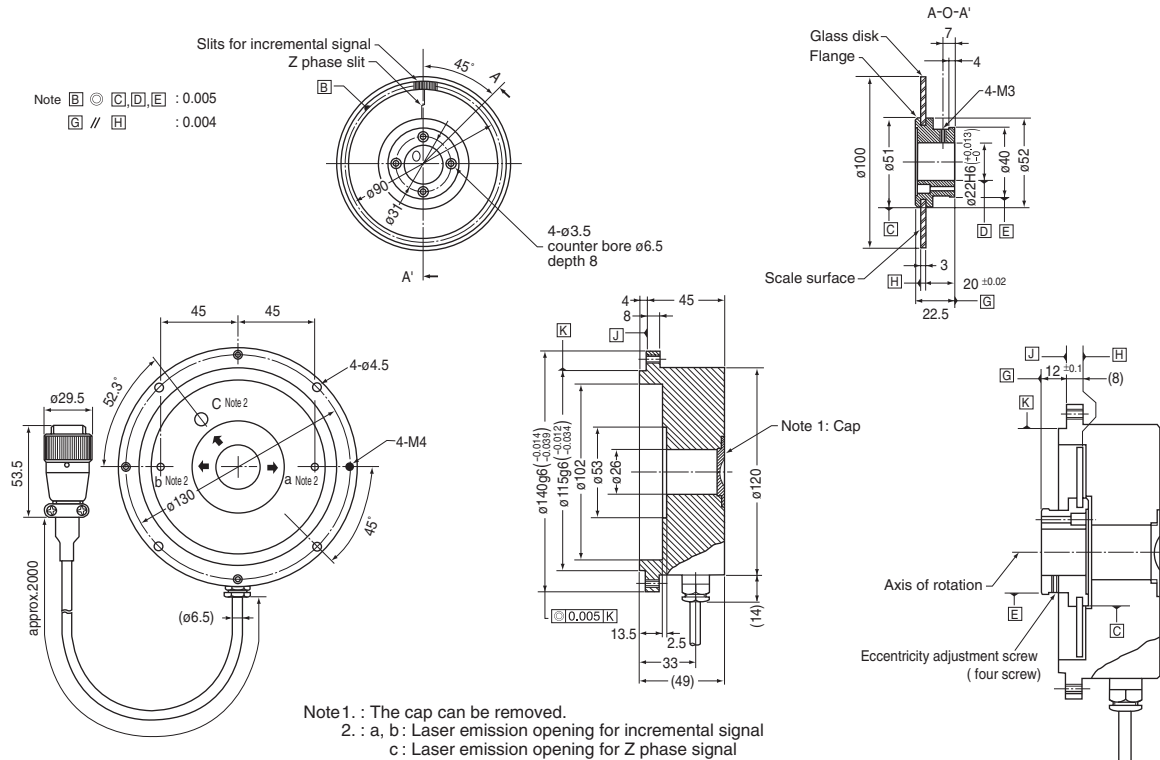
Disk surface runout due to revolution : less than 1arc-min.
Eccentricity of grating scale : less than 10µm



Detection unit fitting

Eccentricity : ±25µm
Inclination : ±3 arc-sec toward

X-1M



Note 1. : The cap can be removed.
2. : a, b: Laser emission opening for incremental signal
c: Laser emission opening for Z phase signal

«Permissible level for installation of detection unit and disk unit»

Inclination	less than ±3 arc-sec	The inclination of the G surface to the J surface is less than 3 arc minutes.
Interval	less than ±0.1mm	Interval between G surface and J surface is 12±0.1mm
Eccentricity	less than 10µm	The eccentricity of C surface or E surface is less than 10µm. (20µmp-p)
Eccentricity of detection unit	less than 50µm	The eccentricity of the K surface of the detection unit is 50µm or less to the rotation shaft.

Precautions When Installing

1. Maximum Load on the Shaft and Coupling

When a rotary encoder is connected to the drive shaft of another device, any sliding of the shaft core, vibration of the drive shaft, or a thrust change would affect the bearing that receives the force, resulting in a decreased level of precision, shorter life, and/or damage. Please use the unit within the maximum load.

If the unit is used with rigid connection, the centering offset and thrust change must not exceed 2mm and 1mm, respectively. If precise centering is difficult, use flexible coupling to absorb the centering offset, contact with the drive shaft, and thrust changes. Flexible coupling works well in a still state (at rest) even if the load due to eccentricity and/or tilting of the drive shaft exceeds the maximum limit; however, care must be taken during rotation as an unreasonable amount of force may cause damage.

2. Effects of Noise from Peripheral Devices

Pulse-type noises generated by motors, motor drivers, power supplies, relays, and other devices could cause adverse effects on the encoder, resulting in malfunctioning. In particular, common-mode (same phase) noise could affect the unit through the motor, encoder itself, power-supply line, and shield lines; therefore, measures must be taken with full understanding of the path of the electric current. Here is an example to reduce the effects of the noise.

Maximum Load

Model	Radial	Thrust
R-1 · K-1	0.4kg	1.0kg
M-1	1.5kg	2.0kg

Application Example (R-1)

To attain a transfer precision of 10 seconds with U-2 type coupling (manufactured by Daido Seimitsu Kogyo K.K.):

The mounting eccentricity shall be within 0.03mm.

