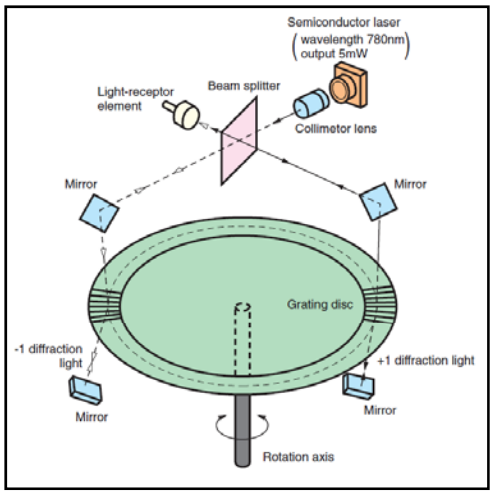
LASER
ROTARY ENCODER

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

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 ±2π. Reflecting the ±1 diffraction light into respective mirrors and then reapplying it to the grating disc changes the phase by ±4π.
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

SPECIFICATION TABLE

	R-1SO	R-1SL	K-1	R-1P32	M-1S	KP-1Z	X-1M
Light source	Semiconductor Laser 780nm, 5mW max.						
Pulse/rev. (wtihout external interpolation)	81,000			648,000 *2 (with internal interpolation unit)	50,000	81,000	225,000
Resolution*3	4 arc-sec.			0.5 arc-sec.	6.48arc-sec.	4 arc-sec.	1.44 arc-sec.
Max. response	500kHz(360rpm)			2.398MHz(222rpm)	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 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 Line driver		TTL	Rectangle wave signal Balanced Line driver
Permissible rotating speed	max 5,000rpm					–	–
Starting torque	max 9gf·cm				max 50gf·cm	–	–
Rotor intertial moment (GD^2)	8gf·cm^2				40gf·cm^2	–	–
Permissible load	Radial : 0.4Kgf Thrust : 1.0Kgf				Radial : 1.5Kgf Thrust : 2.0Kgf	–	–
Power supply							
Voltage	DC +/- 5.00V +/- 5%						
Current (without output load)	+5V 200mA max −5V 100mA max	+5V 250mA max −5V 100mA max	+5V 200mA max −5V 100mA max	+5V 250mA max −5V 100mA 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 (without cable)	80g	80g	80g	80g	260g	160g (detection unit)	1.2kg (detection unit)
Working environment							
Operating temperature	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: Resolution can be selected from 648,000/405,000/324,000/162,000 ppr by changing the setting of internal interpolation unit
*3: delta between A phase pulse and B phase pulse

LASER ROTARY ENCODER

R-1S0

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

- **Compact and lightweight.**
- **High resolution : 81,000 pulses/rev, equal to 4 arc second for each pulse (without interpolator).**
- **Open collector output.**
- **Maximum frequency response of 500kHz.**

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■ Pulse	81,000 pulse/revolution
■ Resolution	4 arc-sec (without interpolator)
■Output Signal	2 phase rectangle wave incremental signal, Open Collector Z phase rectangle wave reference signal ,Open Collector
●Signal width	A phase, B phase : 0.4<=(a+b)/p<=0.6 a=(1/4±1/36)p c=(1/4±1/36)p Z phase : 500<=e<=1250 nsec
● Accumulate error	20arc-secp-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 -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

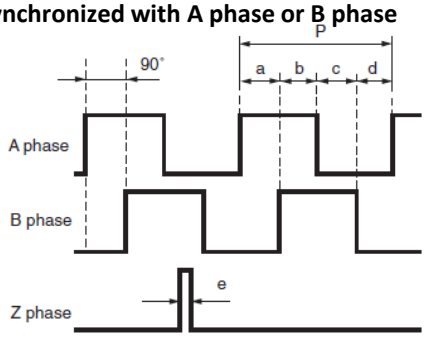
■Maximum Rotation Rate	5,000rpm
■Starting Torque	9gf·cm or less
■Inertial Moment of Rotor (GD2)	8gf·cm^2
■Maximum Load on Shaft Radial :	0.4kgf
■Thrust :	1.0kgf or less
■Maximum Angular Acceleration	10^5rad/sec^2
■Weight approx.	80g without cable
■Diameter	36mm

ENVIROMENTAL SPECIFICATIONS

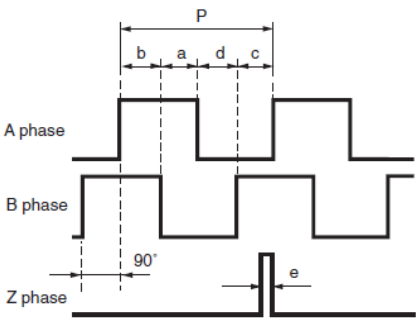
- ■Operating Temperature 0 to 50° C
- ■Storage Temperature -30 to 80° C
- ■Humidity 90%RH or less (no condensation)
- ■Vibration 10G, 500Hz max.
- ■Shock 30G, 11ms max.

OUTPUT SIGNAL

Z phase is not synchronized with A phase or B phase

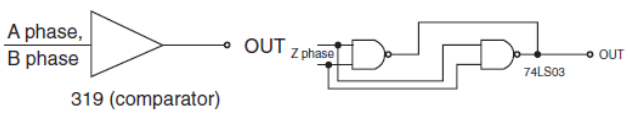


Clockwise rotation looking from shaft side

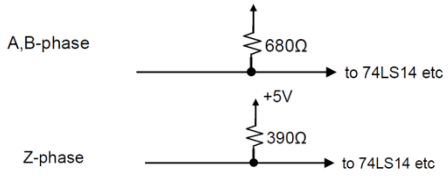


Counterclockwise rotation looking from shaft side

OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



LASER ROTARY ENCODER

R-1SL

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

- **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

■Pulse	81,000 pulse/revolution
■Resolution	4 arc-sec (without interpolator)
■Output Signal	2 phase rectangle wave incremental signal, Line Driver Z phase rectangle wave reference signal, Line Driver
●Signal width	A phase, B phase : 0.4<=(a+b)/p<=0.6 a=(1/4±1/36)p c=(1/4±1/36)p Z phase : 500<=e<=1250 nsec
● Accumulate error	20arc-secp-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 -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

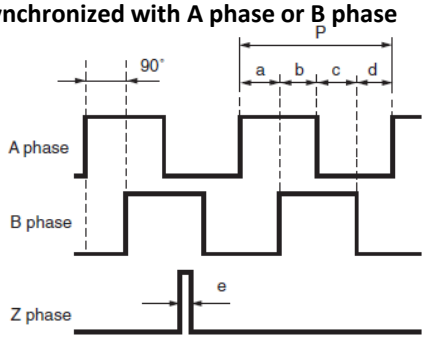
■Maximum Rotation Rate	5,000rpm
■Starting Torque	9gf·cm or less
■Inertial Moment of Rotor (GD2)	8gf·cm^2
■Maximum Load on Shaft Radial :	0.4kgf
■Thrust :	1.0kgf or less
■Maximum Angular Acceleration	10^5rad/sec^2
■Weight approx.	80g without cable
■Diameter	36mm

ENVIROMENTAL SPECIFICATIONS

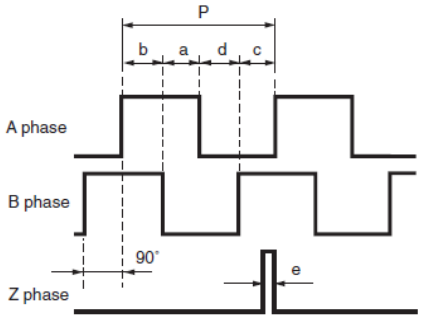
- ■Operating Temperature 0 to 50° C
- ■Storage Temperature -30 to 80° C
- ■Humidity 90%RH or less (no condensation)
- ■Vibration 10G, 500Hz max.
- ■Shock 30G, 11ms max.

OUTPUT SIGNAL

Z phase is not synchronized with A phase or B phase

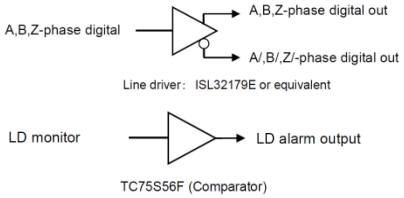


Clockwise rotation looking from shaft side

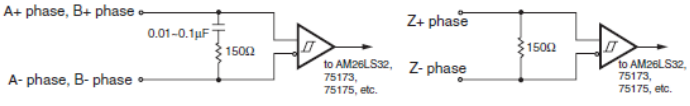


Counterclockwise rotation looking from shaft side

OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



LASER ROTARY ENCODER

K-1

81,000 sine wave pulses per revolution

- **Compact and lightweight.**
- **High resolution : 81,000 pulses/rev**
- **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 $^{+0.2}_{-0.15}$ $V_{p\text{-}p}$ (Open circuit output impedance is about 110Ω at a frequency of 100kHz)
●Phase Difference	between A phase and B phase 90˚±10˚
●Pulse width	Z phase : 100≦e≦250 nsec
●Accumulate error	20arc-sec$_{p\text{-}p}$ 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

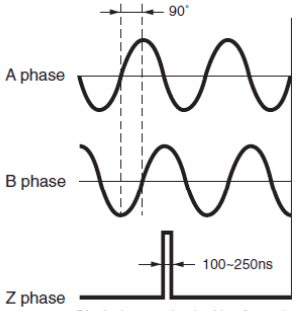
■Maximum Rotation Rate	5,000rpm
■Starting Torque	9g·cm or less
■Inertial Moment of Rotor (GD^2)	8g·cm^2
■Maximum Load on Shaft	Radial : 0.4kg Thrust : 1.0kg or less
■Maximum Angular Acceleration	10^5rad/sec^2
■Weight	approx. 80g without cable
■Diameter	36mm

ENVIRONMENTAL SPECIFICATIONS

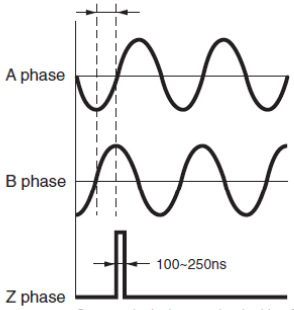
■Operating Temperature	0 to 50˚C
■Storage Temperature	-30 to 80˚C
■Humidity	90%RH or less (no condensation)
■Vibration	10G, 500Hz max.
■Shock	30G, 11ms max.

OUTPUT SIGNAL

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

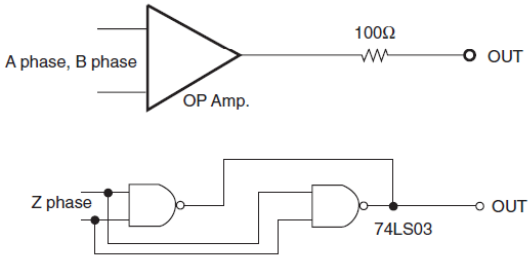


Clockwise rotation looking from shaft side

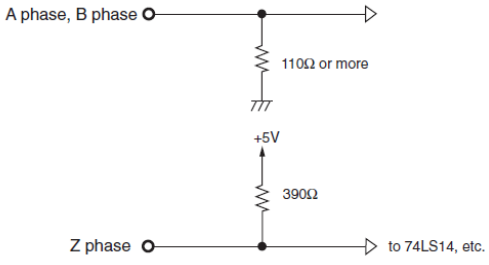


Counterclockwise rotation looking from shaft side

OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



LASER ROTARY ENCODER

M-1S

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

■ Pulse	5,000 pulse/revolution
■ Resolution	6.48 arc-sec (without interpolator)
■ Output Signal	2 phase rectangle wave incremental signal, Line Driver Z phase rectangle wave reference signal, Line Driver
● Signal width	A phase, B phase : 0.4<=(a+b)/p<=0.6 DC~500kHz : a=(1/4±1/36)p, c=(1/4±1/36)p 500kHz~2MHz : a=(1/4±1/18)p, c=(1/4±1/18)p Z phase : 100<=e<=250 nsec
● Accumulate error	25arc-secp-p or less
■ Maximum response frequency	2MHz
■ Maximum response rotation speed	2400rpm (40rps)
■ Light source	Semiconductor Laser 780nm, 5mw max.
■ Voltage	DC±5V ±5%
■ Current	+5V : 280mA maximum with no output -5V : 100mA maximum

MECHANICAL SPECIFICATIONS

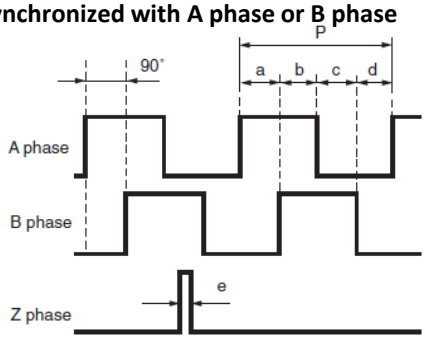
■ Maximum Rotation Rate	5,000rpm
■ Starting Torque	50gf·cm or less
■ Inertial Moment of Rotor (GD^2)	40gf·cm^2
■ Maximum Load on Shaft Radial :	1.5kgf
Thrust :	2.0kgf or less
■ Maximum Angular Acceleration	2x10^{5}rad/sec^2
■ Weight approx.	260g without cable
■ Diameter	56mm

ENVIROMENTAL SPECIFICATIONS

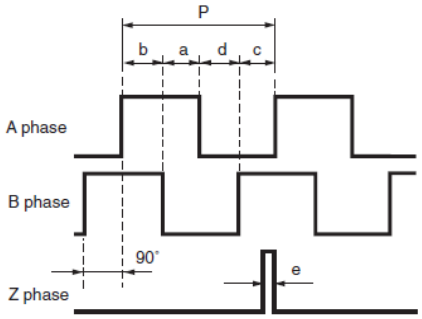
■ Operating Temperature	0 to 50° C
■ Storage Temperature	-30 to 80° C
■ Humidity	90%RH or less (no condensation)
■ Vibration	10G, 500Hz max.
■ Shock	60G, 11ms max.

OUTPUT SIGNAL

Z phase is not synchronized with A phase or B phase

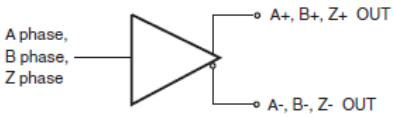


Clockwise rotation looking from shaft side



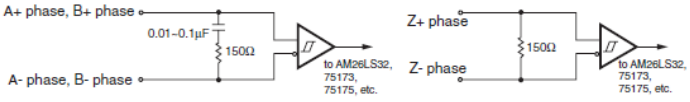
Counterclockwise rotation looking from shaft side

OUTPUT CIRCUIT



Balanced output line driver
(AM26LS31, etc.)

RECOMMENDED RECEIVING CIRCUIT



LASER ROTARY ENCODER

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 : 1.0$V_{p\text{-}p}$ (typ.) Amplitude fluctuation due to revolution: ±0.15V
■Accumulate error	20arc-sec$_{p\text{-}p}$ 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

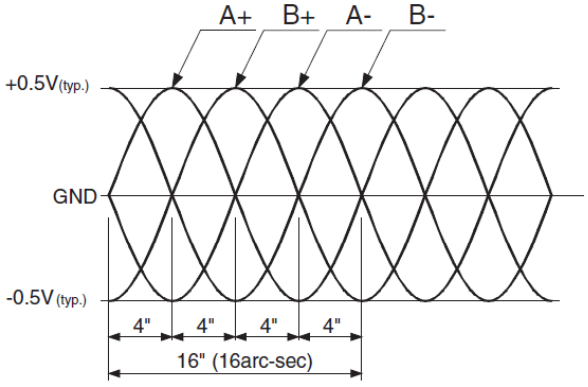
■Detection unit installation	Eccentricity : ±25μm Inclination : ±3 arc-sec toward
■Disk installation	disk surface runout due to revolution: less than 1arc-min. eccentricity of grating scale : less than 10μm
■Weight	approx. 160g without cable
■Diameter	Detection unit : 56mm, Disk : 48mm

ENVIRONMENTAL SPECIFICATIONS

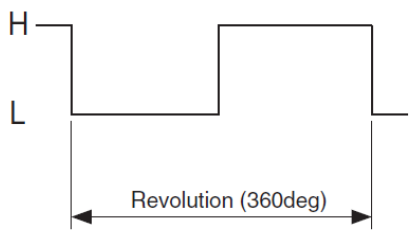
■Operating temperature	0 to 50˚C
■Storage temperature	-10 to 60˚C
■Humidity	90%RH or less (no condensation)
■Vibration	5G, 200Hz max.
■Shock	30G, 11ms max.

OUTPUT SIGNAL

A phase, B phase



Z phase



LASER ROTARY ENCODER

R-1P32

648,000 pulses per rotation 2,592,000 counts can be read with ordinary divide-by-four circuit

- **Compact and lightweight.**
- **648,000 pulses per rotation with built-in interpolator.**
- **Maximum frequency response of 2.398MHz.**
- **2,259,200 counts per rotation can be read with ordinary divide-by-four circuit.**

SPECIFICATIONS

ELECTRICAL SPECIFICATIONS

■Maximum Pulse	648,000 pulse/revolution (with built-in interpolator)
■ Resolution	0.5 arc-sec.
■Output Signal	2 phase rectangle wave incremental signal, Line Driver Z phase rectangle wave reference signal, Line Driver Laser monitor signal, Open corrector (notice of time for LD exchange)
■Z pulse width	500<=e<=1250 nsec
■ Accumulate error	20arc-secp-p or less
■ Maximum response frequency	2.398MHz
■ Maximum response rotation speed	222rpm (3.7rps)
■ Light source Semiconductor Laser	780nm, 5mw max.
■ Voltage	DC±5V ±5%
■ Current	+5V : 250mA maximum with no output load -5V : 50mA maximum

MECHANICAL SPECIFICATIONS

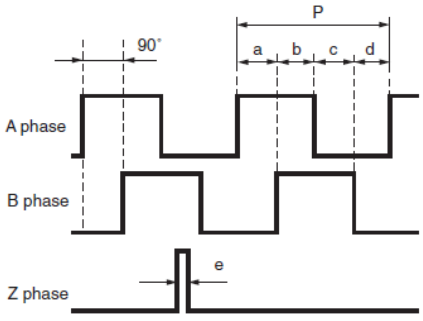
■ Maximum rotation rate	5,000rpm
■ Starting torque	9gf·cm or less
■ Inertial moment of rotor (GD^2)	8gf·cm^2 or less
■ Maximum load on shaft Radial :	0.4kgf
■ Thrust :	1.0kgf or less
■ Maximum angular acceleration	10^5 rad/sec^2
■ Weight approx.	80g without cable
■ Diameter	36mm

ENVIROMENTAL SPECIFICATIONS

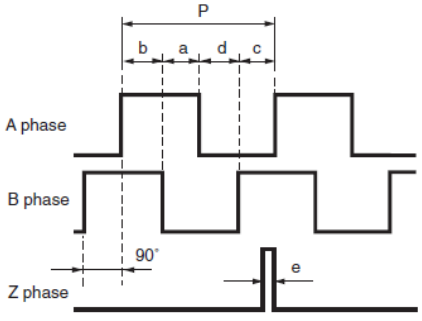
■Operating temperature	0 to 50° C
■ Storage temperature -	10 to 60° C
■ Humidity	90%RH or less (no condensation)
■ Vibration	5G, 200Hz max.
■ Shock	30G, 11ms max.

OUTPUT SIGNAL

Z phase is not synchronized with A phase or B phase

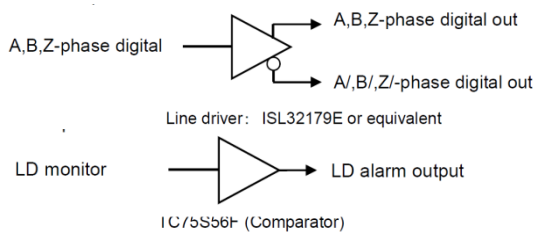


Clockwise rotation looking from shaft side

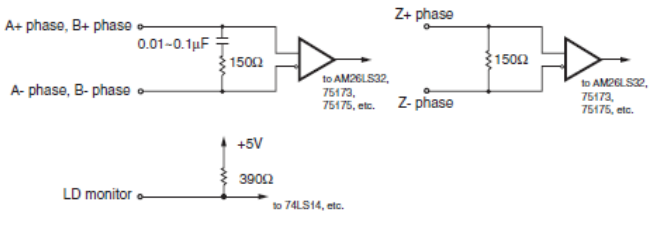


Counterclockwise rotation looking from shaft side

OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT



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 ±1second 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±0.2$V_{p\text{-}p}$ (50kHz, no load, all of A+, A-, B+, B-)
●Output impedance	Each output approximately 110Ω
●Phase difference	90˚±5˚ (0~113kHz : 0~30rpm) 90˚±10˚ (~450kHz : ~120rpm) 90˚±15˚ (~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±0.2μsec
●Recommended load current	±20mA
■Maximum response frequency	675kHz
■Maximum response rotation speed	180rpm (3rpm)
■Light source	Semiconductor Laser 780nm, 5mw max.
■Voltage	DC±5V ±5%
■Current	+5V : 260mA maximum with no output load -5V : 60mA maximum

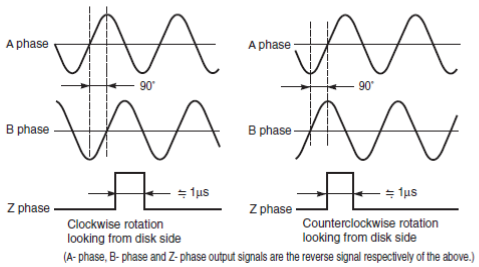
MECHANICAL SPECIFICATIONS

■Inertial Moment of Rotor	1.45X10³g·cm²
■Weight	Detection unit : approx. 1.2kg without cable Disk unit : approx. 0.26kg

ENVIRONMENTAL SPECIFICATIONS

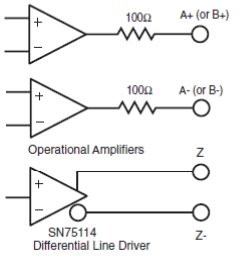
■Operating temperature	10 to 40˚C
■Storage temperature	-10 to 60˚C
■Humidity	80%RH or less (no condensation)
■Vibration	5G, 250Hz max.
■Shock	30G, 11ms max.

OUTPUT SIGNAL

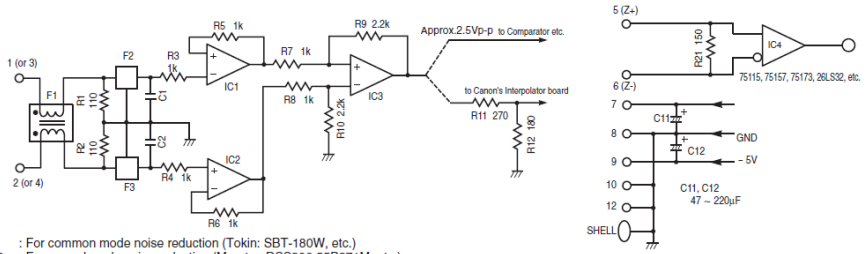


(A- phase, B- phase and Z- phase output signals are the reverse signal respectively of the above.)

OUTPUT CIRCUIT



RECOMMENDED RECEIVING CIRCUIT

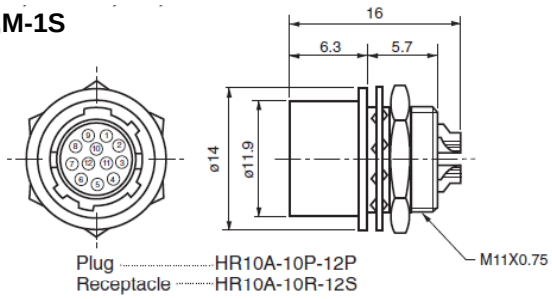


F1 : For common mode noise reduction (Tokin: SBT-180W, etc.)
F2, F3 : For normal mode noise reduction (Murata : DSS306-55B271M, etc.)
C1, C2 : For frequency band restriction, When being used at low speed, add according to maximum frequency for use.
IC1, IC2 : Unity Gain Frequency ≧3MHz, Slew Rate ≧4V/μs, Unity Gain Stable (NEC : μpc4572, μPC812, TI : TL072, NS : LF353, etc.)
IC3 : Unity Gain Frequency ≧10MHz, Slew Rate ≧18V/μs (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-1SO,R-1SL, K-1,M-1S



Receptacle: included

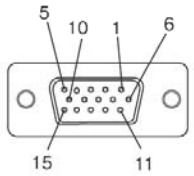
R-1SO, K-1

Pin No.	Function	Pin No.	Function
1	A phase *1	7	+5V
2	GND	8	GND
3	B phase *1	9	−5V
4	GND	10	GND
5	Z phase	11	R−1SO: LD alarm K−1: NC
6	GND	12	CASE / shield
Shell	Shield (Frame Ground)		

R-1SL, M-1S

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	R−1SL:LD alarm M−1S: NC
6	Z−	12	CASE / shield
Shell	Shield (Frame Ground)		

*1 K−1 : Analog output / R−SO: Rectangular Output



Plug ----D-sub 15pin
Cable Length: 300mm
Receptacle: not included

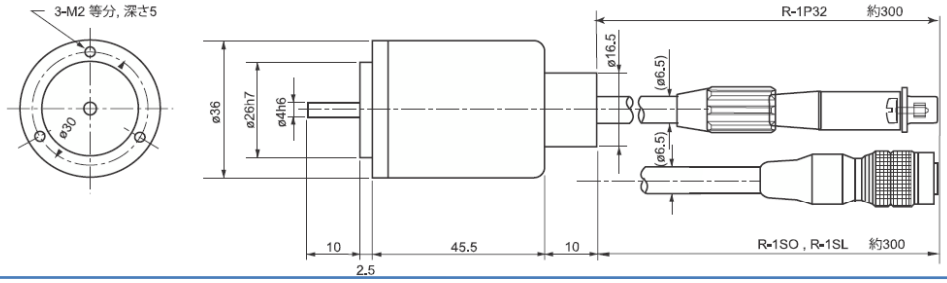
R-1P32

Pin No.	Function	Pin No.	Function
1	A+	8	−5V
2	A−	9	LD alarm
3	B+	10	Z+
4	B−	11	Z−
5	GND	12	NC
6	NC	13	NC
7	+5V	Shell	CASE / shield

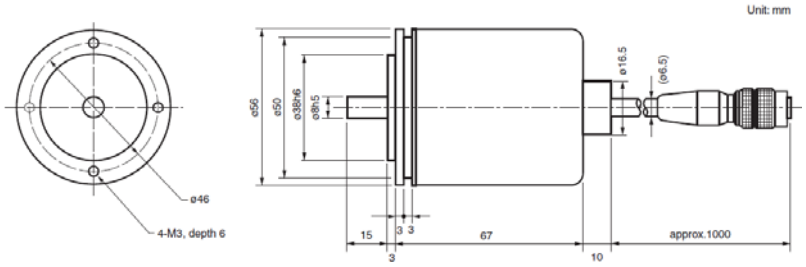
		Internal Interpolation Setting			
		x32	x 16	x 8	x 20
14	SEL 1	GND	OPEN	GND	OPEN
15	SEL 2	GND	GND	OPEN	OPEN

OUTER DIMENSIONS

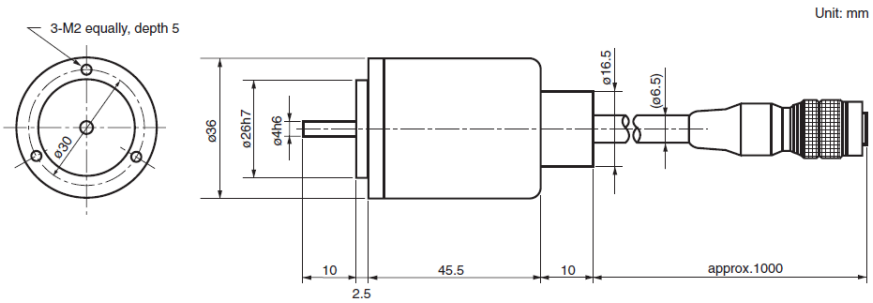
R-1SO, R-1SL, R-1P32



M-1S



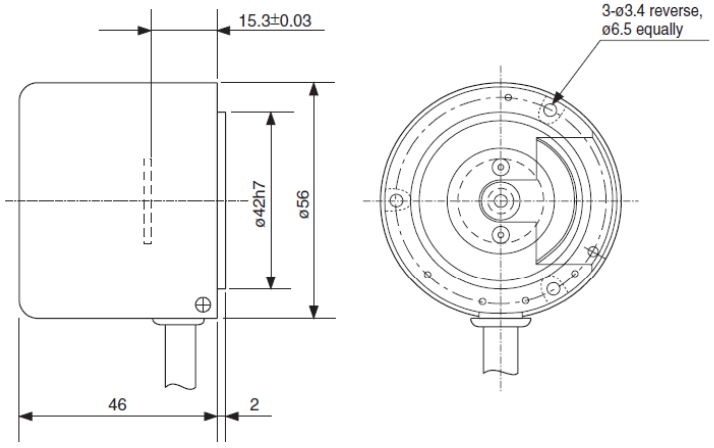
K-1



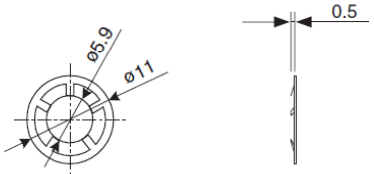
LASER ROTARY ENCODER

KP-1Z

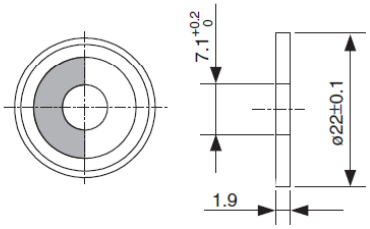
Detection unit



Grating disk temporary stopper

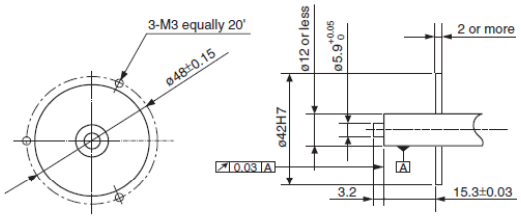


Grating disk



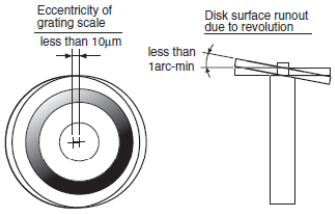
«Permissible level for installation of detection unit and disk»

Shape of fitting part



Scale fitting

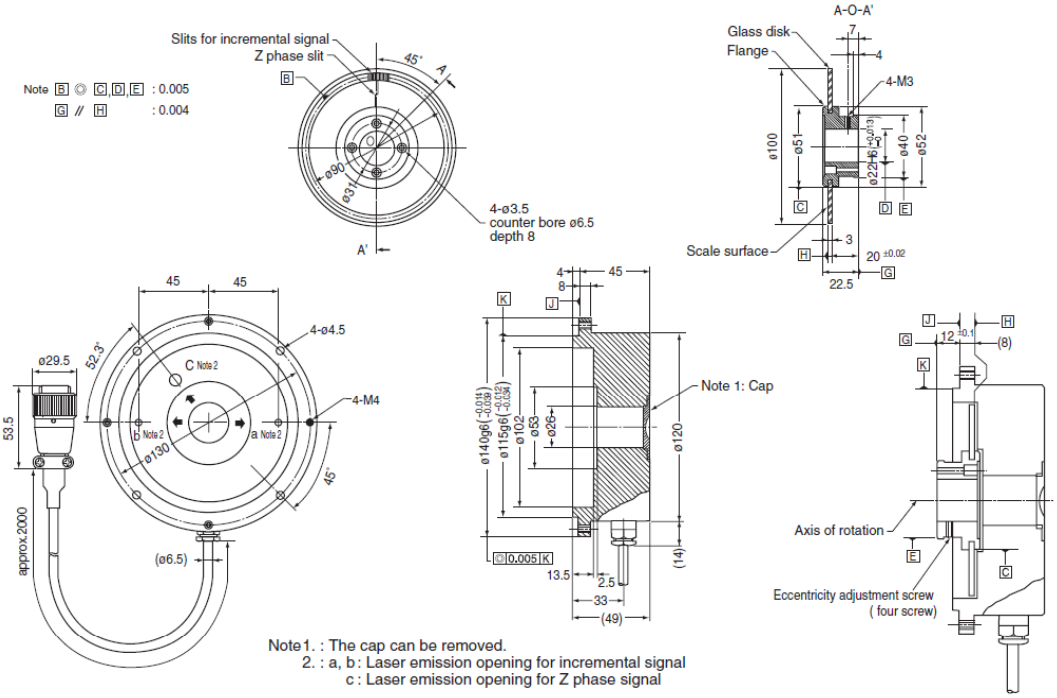
Disk surface runout due to revolution : less than 1arc-min.
Eccentricity of grating scale : less than 10µm



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.

LASER ROTARY ENCODER

Precautions When Installing

1.Maximum Load on the Shaft and Coupling

When a rotary encoder is connected to the drive shaft of anotherdevice, any sliding of the shaft core, vibration of the drive shaft,or a thrust change would affect the bearing that receives theforce, 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 andthrust change must not exceed 2mm and 1mm, respectively. Ifprecise centering is difficult, use flexible coupling to absorb thecentering offset, contact with the drive shaft, and thrust changes.Flexible coupling works well in a still state (at rest) even if theload due to eccentricity and/or tilting of the drive shaft exceedsthe maximum limit; however, care must be taken during rotationas an unreasonable amount of force may cause damage.

■.Maximum Load

Model	Radial	Thrust
R-1SL/SO/P32	0.4kgf	1.0kgf
M-1S	1.5kgf	2.0kgf

■Application Example (R-1)

To attain a transfer precision of 10 seconds with U-2type coupling (manufactured by Daido SeimitsuKogyo K.K.): The mounting eccentricity shall be within 0.03mm.

2. Effects of Noise from Peripheral Devices

Pulse-type noises generated by motors, motor drivers, powersupplies, relays, and other devices could cause adverse effectson the encoder, resulting in malfunctioning. In particular, com-mon-mode (same phase) noise could affect the unit through themotor, encoder itself, power-supply line, and shield lines; there-fore, measures must be taken with full understanding of the pathof the electric current. Here is an example to reduce the effectsof the noise.