LFM-A Compact 6-Component Force Transducer Instruction Manual

Thank you for purchasing LFM-A Compact 6-Component Force Transducer (hereinafter referred to as the LFM-A). Read carefully this Instruction Manual before using the LFM-A.
In addition, please keep this Instruction Manual near at hand to be used when necessary.

1. Symbols Used in The Instruction Manual

Important items that affect safety and instructions relating to LFM-A functions are indicated with symbols specified below. Be sure to read the instructions accompanied by these symbols.

WARNING — Improper operation of the LFM-A may result in death or severe injury of the operator or other person nearby. Be sure to read the instructions accompanied by this symbol.

CAUTION — Improper operation of the LFM-A may result in injury of the operator or other person nearby. Be sure to read the instructions accompanied by this symbol.

CAUTION — Improper handling may result in breakdown or damage to the LFM-A. To ensure correct operation, be sure to read the instructions accompanied by this symbol.

2. Safety Precautions

WARNING

- The LFM-A may break and fall if a load exceeding the rated load is applied. Install safety measures to prevent accidental fall due to overload.
- If the mounting screws are loosened, the LFM-A may fall and cause injury. Be sure to confirm that the mounting screws are securely tightened.

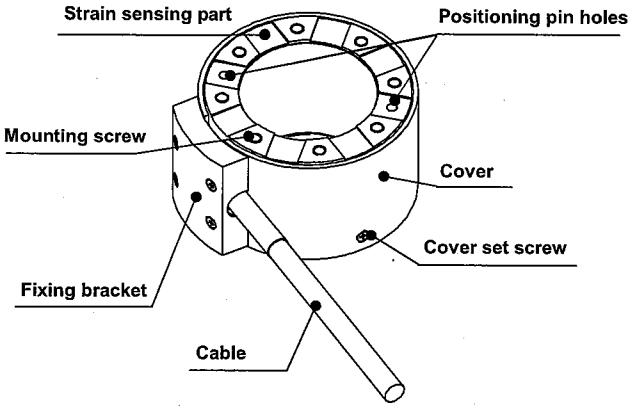
CAUTION

- Be careful not to overload the LFM-A when installing or taking measurement.

CAUTION

- Do not disassemble the LFM-A.
- Avoid dew condensation on the LFM-A.
  If condensation is formed on the LFM-A, promptly dry the LFM-A.
- Do not bend the cable near the cable outlet.
- If the LFM-A is used in an environment affected by vibration, fix the LFM-A cable near the fixing bracket to prevent vibration transfer to the LFM-A.
- The LFM-A is not in waterproof or dripproof structure. Do not allow the LFM-A come in contact with water or oil. Also, avoid using the LFM-A in a dusty environment.

3. Parts Names and Principal Functions



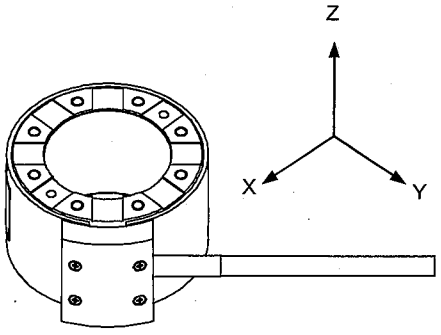
(1)Mounting screw holes
Install the LFM-A using the screw holes provided on the top and bottom (P.C.D. 52 mm, 8-M4, depth 5) of the LFM-A.

(2)Positioning pin holes
Two pin holes (ø3H7) are provided at the same P.C.D. 52-mm positions as screw holes. Use these pin holes to align the centers of the equipment and the LFM-A. Pin holes are provided on the top and bottom of the LFM-A.

Use the accessory parallel pins (ø3g6 $(^{-0.002}_{-0.008})$, length 8) or purchase commercially available parallel pins.

(Equivalent product)
SKFA-GG3-P3.00-L3-B4.5-E0.5-A45 (MISUMI made)

(3)Loading direction
Determine the force detecting direction of the LFM-A by using the positioning pin holes as reference. Connect the 2 pin holes on one side of the LFM-A to provide the X-axis, and specify the fixing bracket side as the positive direction. Consequently, the side where cover set screws are located becomes the negative direction.



4. Installation

4.1 Prior to Installation

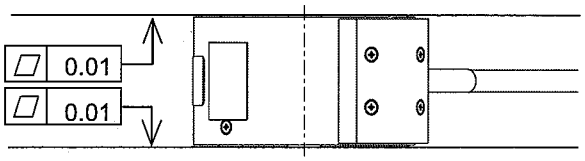
Before installing the LFM-A, take note of the following points.

a. Precautions on overload

Do not apply load exceeding the safe overload on the LFM-A. Applying such an excessive load may cause damage to the LFM-A. If impact load is applied, a force several times larger than the applied load acts upon the LFM-A. Pay due attention and handle the LFM-A with special care during work.

b. Flatness of the mounting surface of the measuring target

Since the LFM-A is installed on the measuring target by means of surface contact, uneven contact surface may affect the characteristics of the LFM-A. To prevent adverse effects on the LFM-A, it is recommended that the flatness of the mounting surface contacted with the LFM-A should be adjusted to 0.01 mm or less with ø64 mm in outer diameter and ø42 mm in inner diameter.



c. Mounting accuracy

The LFM-A is designed to detect 6-component force based on the coordinates of 3 reference axes (X, Y and Z-axes). If the LFM-A is not installed by perfectly aligning its coordinates with the coordinates of the measuring target, measured values may have a margin of error. For example, misalignment of 1 degree around the Z-axis generates an interference of approx. 1.7% in component forces FX and FY. Therefore, the LFM-A must be accurately installed in position to ensure accurate measurement.

d. Material of the measuring target

If the material of the measuring target on which the LFM-A is installed is different from the LFM-A, the difference between the linear expansion coefficient of the 2 may change the zero point. At this time, take care to keep the temperature at the time of installation as it is during the measurement.

<Linear expansion coefficient>

LFM-A-3KN: 10.6×10^{-6}/°C

LFM-A-1KN: 23.6×10^{-6}/°C

4.2 Installation Method

When installing the LFM-A on the measuring target, use the positioning pin holes to determine the force detecting direction. Check the positional relation between the LFM-A force detecting direction and pin holes.

⚠ CAUTION

- When machining the equipment, take special care for the strength of the equipment. If the machine processed equipment does not have sufficient strength, it may break and fall during use or cause unexpected accident.

4.3 Screw Tightening

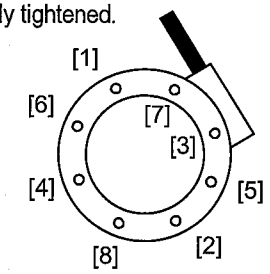
Install 2 parallel pins on each side of the LFM-A and tighten them with 8 hexagonal socket head bolts. If the operating environment is affected by vibration and bolts are likely to loosen, apply commercially available sealant to the bolts. If it is required to reduce the zero drift, apply commercially available adhesive (Recommended: LOCTITE 242) on the mounting surface. Do not allow the adhesive to contact the screw holes.

CAUTION

- If location of the mounting holes are misaligned or the bolts are not inserted vertically, the screw holes of the LFM-A may be damaged.

Tighten the bolts using a torque wrench, etc. The recommended tightening torque is 4.6 N·m for the LFM-A-3KN and 3.0 N·m for the LFM-A-1KN. Do not tighten the bolts with the specified torque in one go, but tighten them in diagonal pairs. Tighten one bolt, then tighten the bolt on the diagonally opposite side, and repeat this 3 times or so until both bolts are securely tightened.

Tighten the bolts in diagonal pairs.



	First tightening	Second tightening	Tightening torque
LFM-A-1KN	1.0 N·m	2.5 N·m	3.0 N·m
LFM-A-3KN	2.0 N·m	4.0 N·m	4.6 N·m

CAUTION

- Be sure to observe the specified tightening torque.
  If the tightening torque is smaller than the specified torque, the measurement accuracy of the LFM-A may be decreased or the mounting screws may become loose during use. On the other hand, applying excessive tightening torque may damage the threads of the LFM-A and render it unusable.

5. Cable Connection

Connect the LFM-A cable to the measuring device.

CH	Wire color	Symbol		Circuit
F1	Orange	-	Red	Input (+)
	Gray	-	Black	Output (-)
	Orange	-	Black	Input (-)
	Gray	-	Red	Output (+)
M1	White	-	Red	Input (+)
	Yellow	-	Black	Output (-)
	White	-	Black	Input (-)
	Yellow	-	Red	Output (+)
F2	Pink	-	Red	Input (+)
	Orange	--	Black	Output (-)
	Pink	-	Black	Input (-)
	Orange	--	Red	Output (+)
M2	Gray	--	Red	Input (+)
	White	--	Black	Output (-)
	Gray	--	Black	Input (-)
	White	--	Red	Output (+)
F3	Yellow	--	Red	Input (+)
	Pink	--	Black	Output (-)
	Yellow	--	Black	Input (-)
	Pink	--	Red	Output (+)
M3	Orange	---	Red	Input (+)
	Gray	---	Black	Output (-)
	Orange	---	Black	Input (-)
	Gray	---	Red	Output (+)
F4	White	---	Red	Input (+)
	Yellow	---	Black	Output (-)
	White	---	Black	Input (-)
	Yellow	---	Red	Output (+)
M4	Pink	---	Red	Input (+)
	Orange	----	Black	Output (-)
	Pink	---	Black	Input (-)
	Orange	----	Red	Output (+)

6. Output/Conversion

The LFM-A outputs 8 strain components F1 to F4 and M1 to M4.

- Measuring ranges are set as follows:

F1 to F4: 5000 μm/m (or more)
M1 to M4: 10000 μm/m (or more)

Take measurement using a constant voltage measuring instrument within the recommended excitation voltage range. To obtain accurate and safe measurement, change the measuring ranges to appropriate levels while conducting the measurement.

The measured outputs are converted into outputs of 6-component forces by the following equations:

$$\varepsilon fx = -(F1 - F3)$$
$$\varepsilon fy = -(F2 - F4)$$
$$\varepsilon fz = -(M1 + M2 + M3 + M4)$$
$$\varepsilon mx = M1 - M3$$
$$\varepsilon my = M2 - M4$$
$$\varepsilon mz = -(F1 + F2 + F3 + F4)$$

Next, interference correction is made. The calculated outputs of the 6-component forces are processed with a calibration constant matrix to obtain physical values of 6-component forces (loads FX, FY and FZ and moments MX, MY and MZ).

$$\begin{pmatrix} FX \\ FY \\ FZ \\ MX \\ MY \\ MZ \end{pmatrix} = \begin{pmatrix} \text{Calibration constant matrix} \\ 6 \times 6 \text{ matrix} \end{pmatrix} \begin{pmatrix} \varepsilon fx \\ \varepsilon fy \\ \varepsilon fz \\ \varepsilon mx \\ \varepsilon my \\ \varepsilon mz \end{pmatrix}$$

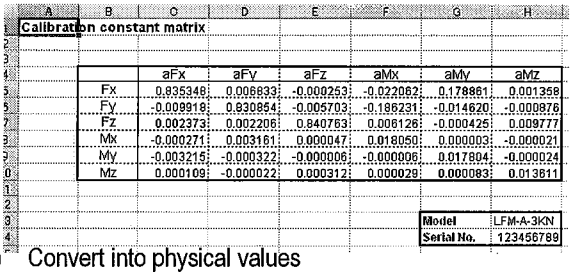
The accessory CD-ROM contains calibration constant matrix data as well as an Excel file for simplified output conversion designed to convert outputs from the LFM－A into loads/moments (This file is created using Microsoft Corporation's Microsoft Excel).

7. Excel File for Simplified Output Conversion

This Excel file is used to calculate physical values from strain outputs of the LFM-A. By entering strain outputs of 8 components, physical values of 6-component forces can be obtained through calculations. See the following steps to use this file.

(1)Input a calibration constant matrix.

Input a calibration constant matrix in the "Calibration Constant Matrix" sheet. The calibration constant matrix of the LFM-A is written in the accessory CD-ROM in advance.



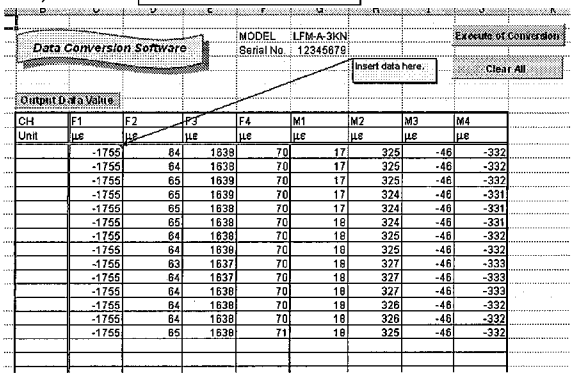
Calibration constant matrix

	aFx	aFy	aFz	aMx	aMy	aMz
Fx	0.835348	0.006833	-0.000253	-0.022062	0.178861	0.001358
Fy	-0.009919	0.830854	-0.005703	-0.186231	-0.014620	-0.000876
Fz	0.002373	0.002206	0.840763	0.006126	-0.000425	0.009777
Mx	-0.000271	0.003161	0.000047	0.018050	0.000003	-0.000021
My	-0.003215	-0.000322	-0.000006	-0.000006	0.017804	-0.000024
Mz	0.000109	-0.000022	0.000312	0.000029	0.000083	0.013811

Model	LFM-A-3KN
Serial No.	123456789

(2) Convert into physical values

Enter the desired data (Unit: μm/m) of the LFM-A outputs you want to convert in the "Data Conversion Software" sheet and then, click the Execute of Conversion button.



Data Conversion Software

MODEL LFM-A-3KN
Serial No. 12345678

Execute of Conversion
Insert data here.
Clear All

Output Data Value

CH	F1	F2	F3	F4	M1	M2	M3	M4
Unit	με	με	με	με	με	με	με	με
	-1755	64	1639	70	17	325	-46	-332
	-1755	64	1638	70	17	325	-46	-332
	-1755	65	1639	70	17	325	-46	-332
	-1755	65	1639	70	17	324	-46	-331
	-1755	65	1638	70	17	324	-46	-331
	-1755	65	1638	70	18	324	-46	-331
	-1755	64	1638	70	18	325	-46	-332
	-1755	64	1638	70	18	325	-46	-332
	-1755	63	1637	70	18	327	-46	-333
	-1755	64	1637	70	18	327	-46	-333
	-1755	64	1638	70	18	327	-46	-333
	-1755	64	1638	70	18	326	-46	-332
	-1755	64	1638	70	18	326	-46	-332
	-1755	65	1638	71	18	325	-46	-332

The converted physical values are displayed.

8. Precautions for Storage and Inspection

If the indicated value is unstable or abnormal, check the LFM-A is correctly and securely connected to the measuring device, and also check the LFM-A is used according to the specified instructions. If no abnormality was found, check the following items on the LFM-A.

(1)Check bridge resistance with a tester, etc.

The input resistance and output resistance should be in a range of 350 Ω ± 3%.

(2)Check insulation resistance between the LFM-A mainbody and any cable conductor wires except the shield wire with a tester, etc. Do not use a Megger for the measurement.

The insulation resistance should be 100 MΩ or more (Measurement voltage: 50 V or less).

If any of the above measured value is abnormal, contact KYOWA or our representative.

9. Specifications

(1)Weight: LFM-A-1KN Approx.160 g (LFM-A body only)
LFM-A-3KN Approx.360 g (LFM-A body only)
(2)Rated capacity: (See the next page.)
(3)Safe overload: 150%
(4)Nonlinearity: Within ±0.5% RO *1
(5)Hysteresis: Within ±0.5% RO *1
(6)Interference: 1.5% RO or less *1
(7)Recommended excitation voltage: 1 to 5 VAC or VDC
(8)Safe excitation voltage: 12 VAC or VDC
(9)Input/output resistance: 350 Ω ± 3%
(10)Temperature compensation range:
0 to +60°C (Non-condensing)
(11)Safe temperature range: -10 to +70°C (Non-condensing)
(12)Temperature effect on zero balance: Within ±0.05% RO/°C
(13)Temperature effect on output: Within ±0.05%/°C
(14)Protection code: IP40 (Not to be wetted)
(15)Cable:0.11mm², 16-paired twisted shield cable, Cable length: Approx. 55 cm, Outer diameter: 6.6 mm, Bare at the end (32 conductors)

*1: Items (4) to (6) indicate characteristic values after interference correction.

* The above characteristic values are measured and obtained using KYOWA's calibrator under KYOWA's standard conditions.

●Accessories Included in the Package

Calibration Sheet	1
Warranty	1
Instruction Manual	1
CD-ROM	1
Parallel pins	4 (ø3 g6, length 8)
Loading direction label	2

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(Reference)

If the Excel file for simplified output conversion does not function properly, change the security setting in Excel as follows:

Tools → Options → Security → Macro Security → Low

(Excel data display)

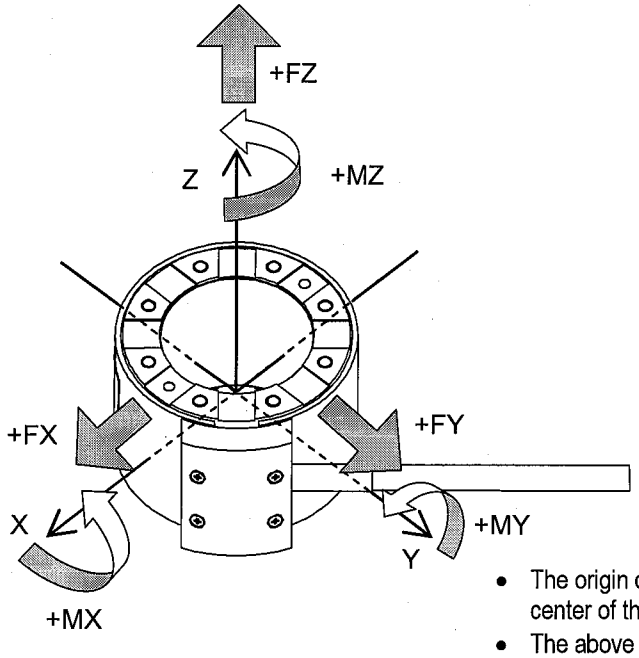
If your PC is not provided with Japanese font function, Excel data is garbled. Considering the users not to become troubled, Excel data in the Instruction Manual is translated purposely into English.

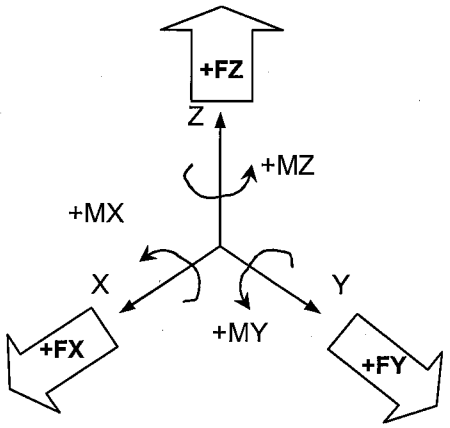
- Rated Capacity, Rated Output, Natural Frequency

Model	Top: Rated capacity / Bottom: Rated output				Natural frequency
	FX, FY	FZ	MX, MY	MZ	
LFM-A-1KN	1kN	1kN	50N・m	25N・m	Approx. 5kHz
	1.5 mV/V or more	1.8 mV/V or more	4.0 mV/V or more	2.4 mV/V or more	
LFM-A-3KN	3kN	3kN	100N・m	50N・m	Approx. 5kHz
	1.6 mV/V or more	1.6 mV/V or more	2.4 mV/V or more	1.6 mV/V or more	

Note) The above values are 6-component force outputs converted from 8-component outputs.

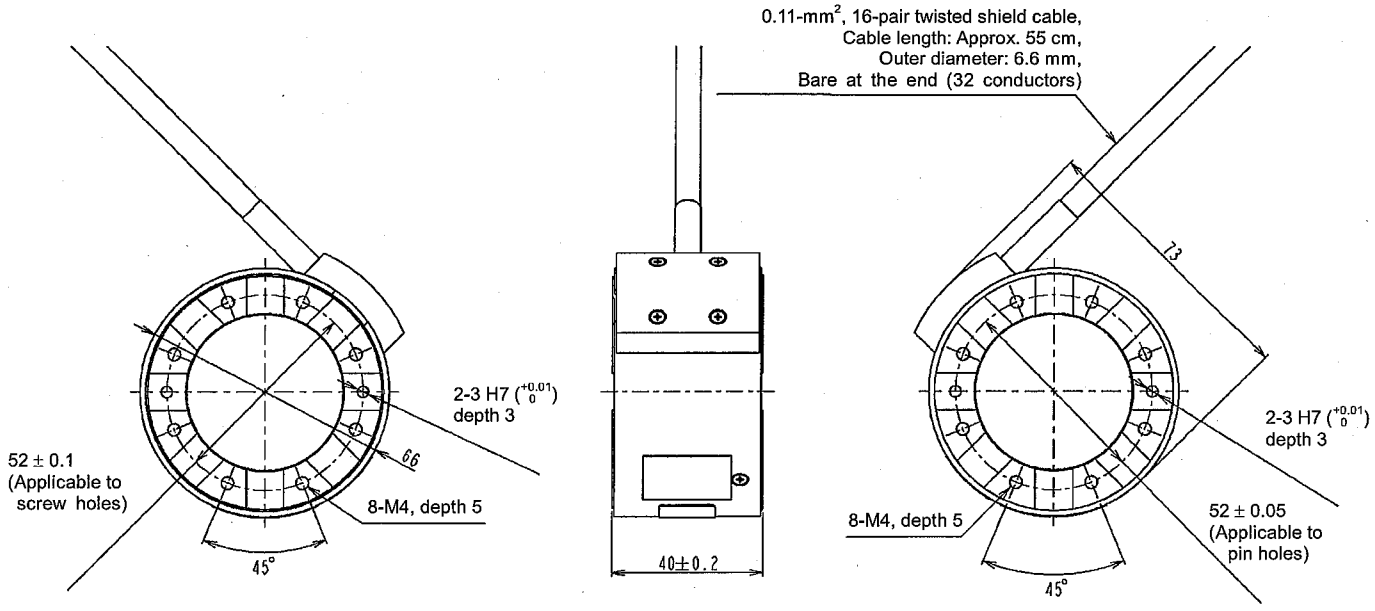
10. Load Directions and Outputs





- The origin of 3 reference axes, (X, Y, Z) = (0, 0, 0), corresponds to the center of the LFM-A.
- The above are load directions applied when the bottom side of the LFM-A (where cover set screws are located) is fixed.

11. Outside View



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