Assembly and Operating Manual

FMS

Force measuring system

Superior Clamping and Gripping

SCHUNK®

Imprint

Technical changes:

We reserve the right to make alterations for the purpose of technical improvement.

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Dear Customer,

thank you for trusting our products and our family-owned company, the leading technology supplier of robots and production machines.

Our team is always available to answer any questions on this product and other solutions. Ask us questions and challenge us. We will find a solution!

Best regards,

Your SCHUNK team

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1 General

1.1 About this manual

This manual contains important information for a safe and appropriate use of the product.

This manual is an integral part of the product and must be kept accessible for the personnel at all times.

Before starting work, the personnel must have read and understood this operating manual. Prerequisite for safe working is the observance of all safety instructions in this manual.

1.1.1 Presentation of Warning Labels

To make risks clear, the following signal words and symbols are used for safety notes.

⚠ DANGER

Danger for persons!

Non-observance will inevitably cause irreversible injury or death.

⚠ WARNING

Dangers for persons!

Non-observance can lead to irreversible injury and even death.

⚠ CAUTION

Dangers for persons!

Non-observance can cause minor injuries.

NOTICE

Material damage!

Information about avoiding material damage.

1.1.2 Applicable documents

- General terms of business*
- Catalog data sheet of the purchased product *
- Assembly- and Operating Manual of the SCHUNK-module, on which the sensor is mounted *

The documents marked with an asterisk (*) can be downloaded on our homepage **schunk.com**

1.2 Warranty

If the product is used as intended, the warranty is valid for 24 months from the ex-works delivery date under the following conditions:

- Observe the applicable documents, Applicable documents [▶ 4]
- Observe the ambient conditions and operating conditions, Environmental and operating conditions [▶ 6]

1.3 Scope of delivery

The scope of delivery includes

- Force measuring system FMS in the ordered model:
- Electronic processor FMS-A1
- Active force-measuring jaw FMS-ZBA
- Passive intermediate jaw FMS-ZBP
- Cable from the electronic processor to the force/torque sensor system controller

Depending on the force measuring adapter used, the appropriate electronic processor must be connected.

FMS Adapter type	Electronic processor
50	FMS-A1 301 810
64	FMS-A1 301 810
80	FMS-A1 301 810
100	FMS-A1 301 810
125	FMS-A1 301 810
160	FMS-A2 301 811
200	FMS-A2 301 811
300	FMS-A2 301 811

2 Basic safety notes

2.1 Intended use

The product is used exclusively to measure gripping forces or to determine workpiece weights or dimensional deviations.

- The product is intended for installation in a machine/system. The applicable guidelines must be observed and complied with.
- The product may only be used within the scope of its technical data, Technical data [▶ 8].

2.2 Inappropriate use

The product is not a safety component in accordance with the EC Machine Directive 2006/42/EC and must not be used in safety-relevant parts of machine control units.

2.3 Constructional changes

Implementation of structural changes

By conversions, changes, and reworking, e.g. additional threads, holes, or safety devices can impair the functioning or safety of the product or damage it.

- Structural changes should only be made with the written approval of SCHUNK.

2.4 Spare parts

Use of unauthorized spare parts

Using unauthorized spare parts can endanger personnel and damage the product or cause it to malfunction.

- Use only original spare parts or spares authorized by SCHUNK.

2.5 Environmental and operating conditions

Required ambient conditions and operating conditions

Incorrect ambient and operating conditions can make the product unsafe, leading to the risk of serious injuries, considerable material damage and/or a significant reduction to the product's life span.

- Make sure that the product is used only in the context of its defined application parameters, Technical data [▶ 8].
- Make sure that the environment is free from splash water and vapors as well as from abrasion or processing dust. Exceptions are products that are designed especially for contaminated environments.

2.6 Personnel qualification

Inadequate qualifications of the personnel

If the personnel working with the product is not sufficiently qualified, the result may be serious injuries and significant property damage.

- All work may only be performed by qualified personnel.
- Before working with the product, the personnel must have read and understood the complete assembly and operating manual.
- Observe the national safety regulations and rules and general safety instructions.

The following personal qualifications are necessary for the various activities related to the product:

Trained electrician Due to their technical training, knowledge and experience, trained electricians are able to work on electrical systems, recognize and avoid possible dangers and know the relevant standards and regulations.

Qualified personnel Due to its technical training, knowledge and experience, qualified personnel is able to perform the delegated tasks, recognize and avoid possible dangers and knows the relevant standards and regulations.

Instructed person Instructed persons were instructed by the operator about the delegated tasks and possible dangers due to improper behaviour.

Service personnel of the manufacturer Due to its technical training, knowledge and experience, service personnel of the manufacturer is able to perform the delegated tasks and to recognize and avoid possible dangers.

2.7 Notes on particular risks

⚠ DANGER

Danger from electric voltage!

Touching live parts may result in death.

- Switch off the power supply before any assembly, adjustment or maintenance work and secure against being switched on again.
- Only qualified electricians may perform electrical installations.
- Check if de-energized, ground it and hot-wire.
- Cover live parts.

3 Technical data

Electronic processor

Designation	FMS-A 1/2
Size	50 ... 125 ; 160 ... 380
Operating voltage [V] Nominal voltage [VDC] [Rated range]	18 - 30 24 [Reverse polarity protection]
Output signal * [V]	-5 ... +5
Current input [mA]	< 45
Ambient temperature [°C] Min. Max.	 -10 +65
Accuracy **	±3% for ID 301 810 ±5% for ID 301 811
Weight [kg]	0.38
IP rating	67 with inserted plug connector and closed cover

* The output voltage is linear to the forces occurring at the gripper fingers. The bandwidth of the output signal is not fully used by each active intermediate jaw.

** Before measuring, a zero adjustment must be carried out.

More technical data is included in the catalog data sheet. Whichever is the latest version.

The force measuring jaw and the passive intermediate jaw are always adapted to the gripper:

Behavior active (with sensor systems)	Height H [mm]	Measurement range up to [N]	Overload range up to [N]	Behavior passive (intermediate jaw)	Height H [mm]
FMS-ZBA → PGN-plus 50	20	145	290	FMS-ZBP → PGN-plus 50	20
FMS-ZBA → PGN-plus 64 / PZN-plus 64	22	260	520	FMS-ZBP → PGN-plus 64 / PZN-plus 64	22
FMS-ZBA → PGN-plus 80 / PZN-plus 80	24	430	860	FMS-ZBP → PGN-plus 80 / PZN-plus 80	24
FMS-ZBA → PGN-plus 100 / PZN-plus 100	28	685	1370	FMS-ZBP → PGN-plus 100 / PZN-plus 100	28
FMS-ZBA → PGN-plus 125 / PZN-plus 125	30	1120	2240	FMS-ZBP → PGN-plus 125 / PZN-plus 125	30
FMS-ZBA → PGN-plus 160 / PZN-plus 160	36	1600	3200	FMS-ZBP → PGN-plus 160 / PZN-plus 160	36
FMS-ZBA → PGN-plus 200 / PZN-plus 200	40	2325	4650	FMS-ZBP → PGN-plus 200 / PZN-plus 200	40
FMS-ZBA → PGN-plus 240 / PZN-plus 240	46	on request	on request	FMS-ZBP → PGN-plus 240 / PZN-plus 240	46
FMS-ZBA → PGN-plus 300 / PZN-plus 300	53	5150	10300	FMS-ZBP → PGN-plus 300 / PZN-plus 300	53
FMS-ZBA → PGN-plus 380	64	on request	on request	FMS-ZBP → PGN-plus 380	64

Range of measurement: range within which the total system has an accuracy of ±3% / ±5%.

Overload range: range within which the total system has an accuracy of > ±3% / ±5%. At the end of the overload range, there is the danger of the mechanical destruction of the intermediate jaw.

Range of measurement and overload range apply to **each** intermediate jaw.

4 Function description and application examples

4.1 Functional description

The FMS force measuring system allows you to measure forces that act on the base jaw in the direction of the jaw movement. The force must act centrally on the force measuring adapter.

Depending on the application, one to three active (equipped with sensor systems) FMS-ZBA intermediate jaws are needed. The remaining base jaws contain the passive FMS-ZBP intermediate jaws (without sensor systems). Alternatively, the fingers can be manufactured accordingly.

For each active intermediate jaw FMS-ZBA, an electronic processor FMS-A1 is required for the evaluation, as well as a connection cable FMS-AK for connecting the electronic processor with a power supply unit and a force/torque sensor system controller (e.g. a PLC).

The active intermediate jaw is made to be deformed specifically in the micron range. This deformation is detected by an integrated DMS. Furthermore, the intermediate jaw is made in such a way that a moment or force from a different direction only slightly changes the measured value. It is therefore generally only the gripping forces which are measured.

By means of the force/torque sensor system controller, the DMS small signal is amplified and output to a voltage level proportional to the gripping force.

When this is done, a positive value indicates a force acting from the center of the gripper on the finger (e.g., a workpiece between the gripper fingers), while a negative value indicates an external force on the gripper fingers (e.g. reaching into a bore hole).

The output voltage level has a linear relationship to the occurring force. However, only a change in force will be detected and not an absolute force.

This means that when measuring, the force/torque sensor system controller has to be reset to zero before gripping (button on the force/torque sensor system controller or digital signal). After that, gripping ought to be started immediately and the output measured value ought to be evaluated.

To convert the measured value into a force, the factor included in the data sheet and the value of the base gradient is required.

Since the pitch **m** is a function of the finger length, the distance from which the gripping takes place is inserted into the formula which has been provided by the factory. The distance is the length between the base jaws of the gripper and the gripping point. The result of this calculation is the gradient factor for the corresponding finger length.

Example

The gripping force is to be determined at a distance to the base jaw of 75 mm using an FMS 100.

Formula from the data sheet:

m [75 mm] = Factor * distance [mm] + basic pitch

$$m\,[75\ mm] = (-0.00307 * 75 + 2.49)\ \frac{mV}{N}$$

$$m\,[75\ mm] = 2.26\ \frac{mV}{N}$$

The measured value of the output voltage is:

Ua = 1100 mV

The gripping force is then calculated:

$$F = \frac{Ua}{m[75]} = \frac{1100\,mV}{2.26\,\frac{mV}{N}} = 487\ N$$

At a distance of 75 mm and the measured output voltage, the gripping force is: **487 N**.

4.2 Application example

Gripping force control

The PLC can output the automatically measured gripping force by control signals to the proportional valve supplying the gripper.

In this way, fragile parts can be approached with a weak force until the fingers rest against the part. Thereafter, the force is slowly increased until it is sufficient for a secure grip.

Teaching of robots

The teaching of robots to grip firmly fixed workpieces can be done easily and precisely.

Only when the left and right gripper jaws apply the same force does the gripper grip symmetrically. Grippers and robots are protected.

Static gripping force control

- Monitoring the gripping force as the jaws close prevents the workpiece from being dropped when movement initiates.
- Overload protection by monitoring the maximum permissible force which can, for instance, be triggered by an unintended increase in pressure, off-center gripping or incorrect positioning of the workpiece.
- Preventive servicing by changing grippers in good time when there is a decline in the gripping force. Unexpected manufacturing down-times are avoided.

Dynamic gripping force control

- The effect of acceleration forces on the gripper jaws can be recorded and the motion sequence modified if necessary.
- Component monitoring during highly dynamic movements.

Measuring and teaching processes

- Dimensional checking of the gripped component on the basis of an inserted reference component.
- Comparing the component weight:
  by measuring the weight force of the component acting on the gripper fingers.

5 Assembly

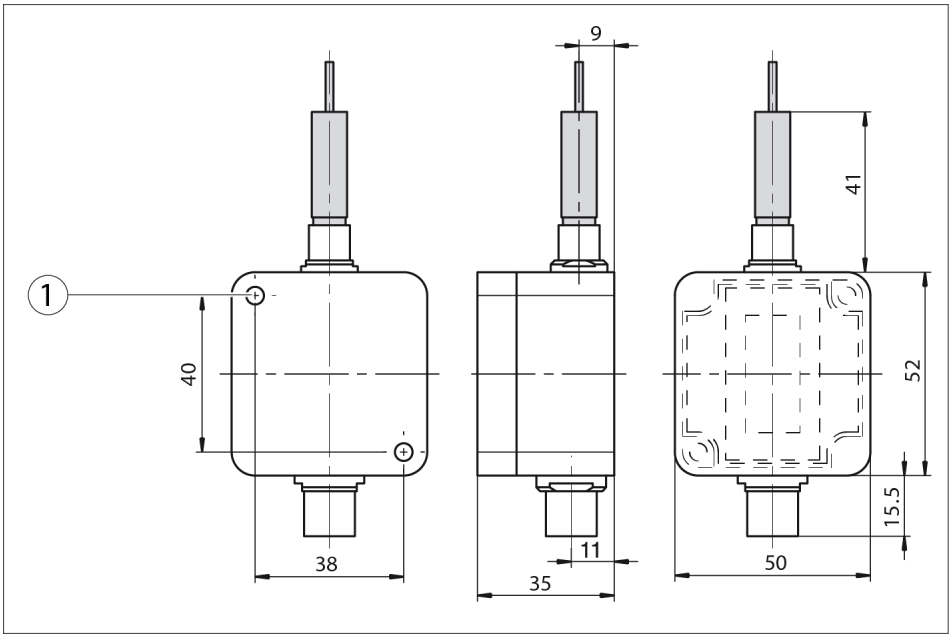
5.1 Mechanical installation of the measuring system

NOTICE

Property damage due to incorrect bending radius!

The product may get damaged if the cable's bending radius is less than the minimum.

- **Static:** 10 times the cable diameter.
- **Dynamic:** 15 times the cable diameter.



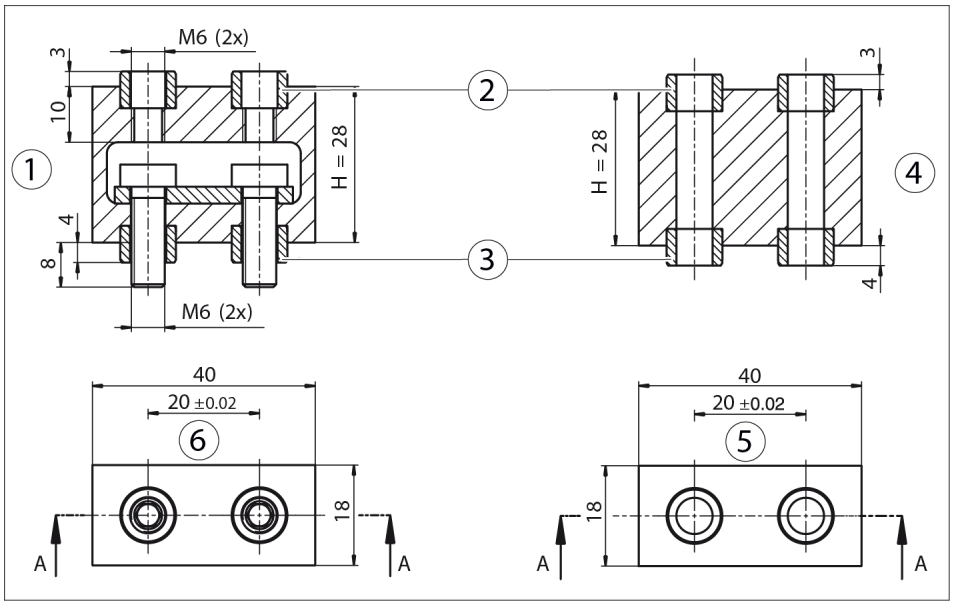
Dimensions of the force/torque sensor system controller FMS-A1/ A2

1	Ø4.5 (2x) for mounting screw M4

- Mounting the intermediate jaws on the base jaws of the gripper.
- Fasten the gripper fingers to the intermediate jaws.
  The drilling pattern of the intermediate jaws corresponds to that of the base jaws. This way, the gripper fingers can be mounted on the intermediate jaw as well as on the base jaw.
- Fasten the electronic processor using two M4 screws.
  The distance from the electronic processor to the force measuring jaws must not exceed the length of the cable supplied.

NOTE

When screwing the force measuring adapter onto the gripper, and the gripper finger to the force measuring adapter, the nominal torque of the screws is to be observed.



Dimensions of the FMS-ZBA/P intermediate jaws for PGN-plus 100 and PZN-plus 100

1	Active intermediate jaws	4	Passive intermediate jaws
2	Sleeve Ø 10_{f7} (2x each) for finger connection	5	for bore hole Ø10 ^{H7}
3	Sleeve Ø 10_{f7} (2x each) for gripper connection	6	for bore hole Ø10 ^{H7}

5.2 Electrical installation of the measuring system

Connecting the force measuring jaw to the electronic processor

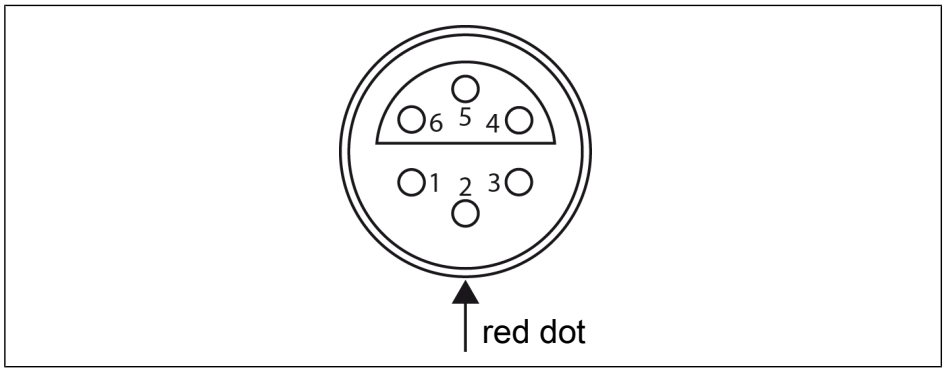
Since the cable is a direct part of the measuring body and has a strong influence on the measuring signal, it is firmly attached to the measuring body. Replacing or extending the cable will change the measuring accuracy.

There must be no alternating torsion. The specified bending radii must be observed.

With correct installation, the cable has a lifetime of > 9 million cycles.

Connecting the electronic processor to a controller

The extension cable type FMS-AKx should be used for this purpose.



Electrical interface for higher-level control unit

Wire colors in the cable	Pin in connection plug at the FMS-A1	Meaning of the signal
yellow	5	+24 V DC
gray	6	GND
green	4	Reset (zero adjustment of the output signal) 24 volt for 100 ms
brown	1	+ UA (shielded) (–5 to +5 V DC)
white	2	– UA (shielded)
Shield	3	Shield

6 Operation

6.1 Preparing for commissioning

- All points from the Installation chapter must have been carried out carefully.
- ➢ Apply a power supply to the electronic processor.
- ➢ Check if the display shows a value between -5V and +5 V.
- ➢ Check the function by manually exerting a force on the gripper finger with the force measuring adapter. If the measured value on the display changes visibly, the measuring system is operational.
- ➢ Subsequently, carry out a zero adjustment of the electronic processor and verify that the displayed value jumps to "zero".
- ✓ The measuring system is now ready for operation.

6.2 Determining the conversion factor

The "voltage to power" conversion factor was determined by SCHUNK and supplied with the measuring system on a data sheet.

During installation, this value may change again slightly (for instance depending on the tightening torque with which the screws of the intermediate jaws and fingers were tightened).

For very precise measuring values, the measuring system must be recalibrated. For the calibration of the measuring system, two measured values are needed. Since the ratio of the output voltage to the gripping force is linear, a pitch can be determined on the basis of these two measured values which very accurately correspond to the specific system design.

Determining the measured values:

- ➢ Open gripper (force-measuring jaws unloaded).
- ➢ Carrying out a zero adjustment Functional description [▶ 10].
- ➢ Mount a load cell (e.g. Kistler) between the gripper fingers.
- ➢ Close the gripper.
- ➢ Read off the gripping force at the force/torque sensor system controller of the load cell.
- ➢ Read the output voltage on the display of the FMS measuring system.
- ➢ Determine the pitch
  Gripper open: 0 N = 0 V
  Gripper closed: x N = y V

If no load cell is available, two different weights can also be used to determine the conversion factor. These are attached to the gripper finger with the measuring jaw hanging freely.

The conversion factor can be derived from the output voltage that appears on the display.

However, the supplied conversion factor is sufficient for most applications.

6.3 Operating the force measuring system

The output voltage must be correctly read by the control. The conversion factor must be programmed into the application.

The gripper can be operated as usual.

Gripping force control:

Always set the system to zero with a zero adjustment before gripping. The gripper is closed and the proportional valve is adjusted in accordance with the measured value until the desired value for the gripping force has been set.

Teaching of robots:

Method 1: If the gripper is open, movement will continue until the measuring finger touches the workpiece. Following this, the exact center position is calculated by the robot. It is easier to equip both gripper fingers with force measuring jaws and to approach the workpiece from both sides.

Method 2: The gripper is equipped with two force measuring jaws. A zero adjustment is performed with both FMS-A1/A2 units. The clamped workpiece is gripped. Now the gripper is moved by the robot (using the smallest possible steps) until the values of both force measuring jaws are identical. This position is the best gripping position.

Static gripping force control

In the system, the zero adjustment and the gripping are carried out and the value is compared to a set value or with previous measured values.

If the gripping force deviates substantially from the set value in spite of the same pressure, this indicates the aging of the gripper. If no gripping force is present, this indicates the loss of a workpiece.

If a measuring system has been installed on both base jaws and the measured values of the two systems differ, the gripping was carried out off-center (as a result, the gripper or the robot is frequently overloaded).

Dynamic gripping force control

The change in gripping force is monitored, thereby enabling the detection of overload or impending loss of parts before any damage occurs.

Measuring and teaching processes

Dimension check in the µm range:

A reference part is inserted as a gauge between the active jaw near the gripper and the passive intermediate jaw. The gripper is closed. Perform a zero adjustment with the system. The gripper opens. The part to be measured is inserted between the fingers in addition to the reference part. The gripper is closed with the same force (pressure or voltage). If the dimensions of the gripped workpiece are greater than planned, a gripping force greater than zero will be displayed.

If the gripped workpiece is too small, a gripping force of less than zero will be displayed. The reference part must be selected so that while the gripper is being closed with an inserted reference part, a dimensionally accurate workpiece is touched by the gripper fingers with exactly 0 N.

Weight checking:

The gripper grips the workpiece and the gripper is rotated so that the measuring jaw is on top.

Perform a zero adjustment with the system. Swing the gripper 180° and read the measured value.

This value only changes depending on the weight of the workpiece. The linearity of the output voltage to the workpiece weight is, however, only about 15%.

Within a small range, however, a change in weight can be determined very accurately.

If accurate measurements are to be made, it is worth determining the conversion factor within the range of the handling weights.

If, for example, the measuring is done in the range between 10 kg and 12 kg, the above measuring method is carried out once with 10.0 kg and once with 12.0 kg. From the two measured voltage levels, a highly accurate conversion value can be determined for this range.

7 Troubleshooting

Malfunctions	Possible cause	Corrective action
Replace display.	Voltage is missing or its polarity is incorrect or it is out of the permitted range.	Connecting the voltage correctly: 18 – 30 V (yellow = + 24 VDC; gray = 0 VDC)
The value in the display does not change when the measuring jaws are loaded	Measuring jaws not connected to force/ torque sensor system controller.	Insert the connection plug of the measuring jaw in the force/torque sensor system controller.
	The measuring jaws are not loaded in the direction of the jaw movement.	The system measures only forces in the direction of the jaw movement. Only the gripping forces are to be measured; for this purpose, the other forces are largely hidden.
The measured value fluctuates slightly	The air supply is not uniform.	Ensure constant pressure.
	Vibrations or external forces are occurring.	Hold the gripper steady.
The measured value »flows«	Determined by the system	When forces are constantly present, there is a slight flow of the material particularly in the upper part of the measurement range. This effect can be seen in the output voltage and is normal.
The measured value shown on the display differs from the analog signal	Resolution of the display	To optimize costs, a simple display unit is installed. The exact value is the voltage at the output.
	The shield has not been applied.	The shield must be connected for error-free transmission of the measured value to the analog input. Only in this way are the EMC rules observed.
	The analog input card is not set correctly.	The analog input card should have an input of –5 V to +5 V. Set the card correctly.
Other errors		Please inform SCHUNK.

8 Maintenance and care

The force measuring system is maintenance-free.

Unless otherwise specified, secure all screws and nuts with Loctite no. 243 and tighten with the appropriate tightening torque.

Any contact of drilling fluids with the measuring intermediate jaw ought to be avoided.