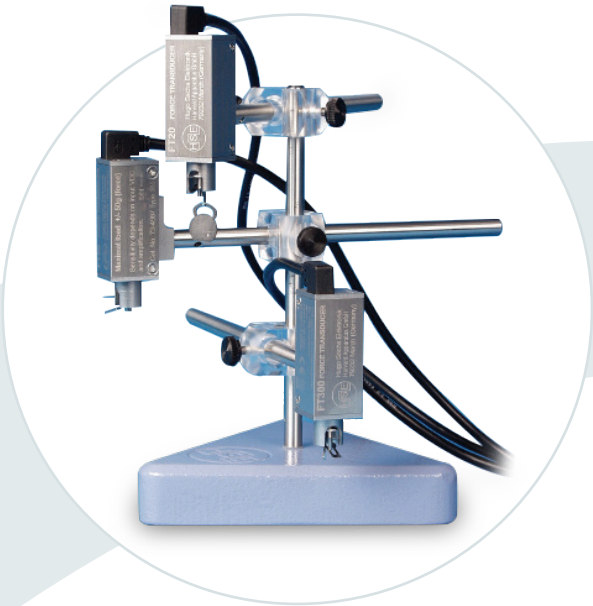
Isometric Force Transducer FT20 and FT50

USER'S MANUAL



FT20 Type 385: 73-4986, 73-5035
FT50 Type 385: 73-4987, 73-5036

HUGO SACHS ELEKTRONIK
a division of Harvard Bioscience, Inc.

5424-005 Rev 1.0

Table of Contents

Warranty

Research Use Only

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Phone: +49(0)7665/9200-0
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Hugo Sachs Elektronik (HSE) warranties the FT20 and FT50 Isometric Force Transducers for a period of two years from the date of purchase. At its option, HSE will repair or replace the unit if it is found to be defective as to workmanship or materials. This warranty does not extend to any instrumentation which has been (a) subjected to misuse, neglect, accident or abuse, (b) repaired or altered by anyone other than HSE without HSE express and prior approval, (c) used in violation of instructions furnished by HSE. This warranty extends only to the original customer purchaser. IN NO EVENT SHALL HSE ELEKTRONIK BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Some states and regions do not allow exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR USE, OR OF ANY OTHER NATURE. Some states or regions do not allow this limitation on an implied warranty, so the above limitation may not apply to you. Without limiting the generality of the foregoing, HSE shall not be liable for any claims of any kind whatsoever, as to the equipment delivered or for non-delivery of equipment, and whether or not based on negligence. Warranty is void if the device is changed in any way from its original factory design or if repairs are attempted without written authorization by HSE. Warranty is void if parts or connections not manufactured by HSE are used with the force transducer. If a defect arises within the warranty period, promptly contact Hugo Sachs Elektronik, Gruenstrasse 1, D-79232 March-Hugstetten Germany by phone at +49(0)7665/9200-0 or email sales@hugo-sachs.de. In the USA, call 800-272-2775 or 508-893-8999 or email: support@hbiosci.com).

Goods will not be accepted for return unless an RMA (Returned Materials Authorization) number has been issued by our customer service department. The customer is responsible for shipping charges. Please allow a reasonable period of time for completion of repairs, replacement and return. If the unit is replaced, the replacement unit is covered only for the remainder of the original warranty period dating from the purchase of the original device. This warranty gives you specific rights, and you may also have other rights, which vary from state to state.

Out of Warranty Service

Proceed exactly as for Warranty Service on previous page. If our service department can assist you by phone or other correspondence, we will be glad to help at no charge. Repair service will be billed on the basis of labor and materials. A complete statement of time spent and materials used will be supplied. Shipment should be prepaid. Your bill will include return shipment freight charges. Disassembly by the user is prohibited. Service should only be carried out by experienced HSE technicians.

Repair Facilities and Parts

HSE stocks replacement and repair parts. When ordering, please describe parts as completely as possible, preferably using our part numbers. If practical, enclose a sample photo or drawing.

Safety Information

Please read the following safety precautions to ensure proper use of your force transducer. If the equipment is used in a manner not specified, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury

The operating voltage range is 5 to 10 VDC.

Ground the Product

The metal housing and mounting rod of the transducer is grounded through the connecting cable to the shield connection of the bridge amplifier. Ensure that this device is properly grounded and electrically safe.

Make Proper Connections

Attach the connector of the force transducer always correctly to the input socket of the amplifier. The union nut or any other connector lock has to be fixed, to ensure that the shielding ground is connected. Never increase the connection cable length longer than 3 meters.

Observe All Terminal Ratings

Review the operating manual to learn the ratings on all connections.

Avoid Exposed Circuitry

Do not touch any electronic circuitry inside of the product.

Do Not Operate with Suspected Failures

If damage is suspected on or to the product do not operate the product.
Contact qualified service personnel to perform inspection.

Orient the Equipment Properly

Do not orient the equipment so that is is difficult to manage the connection and disconnection of devices.

Place Product in Proper Environment

Review the operating manual for guidelines for proper operating environments.

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

Prevent the Load Cell from Damage

The internal parallelogram spring system is very sensitive and therefore the transducer has to be handled very carefully. Never mechanically overload more than fivefold full scale or apply torsional loads to the actuator cap. The small hexagonal screw head in the

middle of the actuator cap is only for production use! Please never try to disassemble the actuator pin. Any mechanical damage due to overload, not intended use or disassembly will void warranty.

Please keep in mind, that every overload will alter the behavior of the transducer in a negative way.

Caution Notice

HSE products are intended for laboratory use only and can be used in research and development applications.

The unit itself does not generate waste, but may be used with samples that are hazardous. Please use appropriate PPE and ensure disposal in accordance with local regulations and practices. This product should not be used in the presence of a flammable atmosphere such as an anesthetic mixture with air, oxygen, or nitrous oxide.

Compliance

These systems have been designed to meet the standards for electromagnetic compatibility (EMC) intended for laboratory equipment applications as well as the applicable safety requirements for electrical equipment for measurement, control, and laboratory use.

Caution

Introduction

This User's Manual explains the installation, function and use of the FT20 and FT50 isometric force transducers. Carefully read the operating instructions as well as other materials in this manual, especially the section about connecting the bridge amplifier.

This manual is not a warranty of product performance. If you need help or have questions, please contact us and we will assist you. We want you to be completely satisfied with this product.

Product Overview

This force transducer series is designed for measurement applications in animal experimental research or other technical uses in general laboratory, light industrial or office environments. The installed sensor system is based on a resistance full bridge circuit, which can be directly connected to any HA-HSE bridge amplifier, e.g. the PLUGSYS TAM amplifier module or on a variety of AD Instruments bridge amplifiers. If using other DC bridge amplifiers, e.g. Grass or Gould, there are different connection cables available.

Key Features (All Versions)

- Isometric (low displacement of the measurement cell)
- Can be used in both directions, pull or push
- Two ranges available +/-20 g, and +/-50 g full scale (FS)
- Suitable for small muscle and tissue samples like papillary muscle, Purkinje fibers and vessel rings
- Resistance full bridge circuit (Wheatstone bridge) can be used with most commonly used DC bridge amplifiers
- Supply voltage range 5 to 10 VDC (max. 15 mA)

Product Overview

- Removable connection cable with 6-pin binder connector for HA-HSE bridge amps or 8-pin binder for ADI amps, special cables for products from other manufacturers, e.g. Grass or Gould, are available on request.
- Full metal housing made of aluminum and stainless steel
- Removable holder with two M5 fastening threads for horizontal or vertical rod mounting
- Compact design, two mechanical end stops as overload protection and additional front protection around the actuator cap.

Unpacking & Inspection

CAUTION: The transducer contains electrostatic sensitive components. Please observe precautions for handling the sensor device to prevent damage.

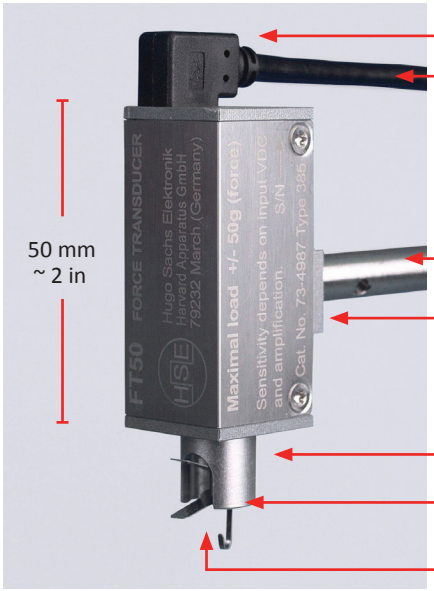
Please first check the contents of the shipment for completeness and note whether any damage has occurred during transport. If the contents are incomplete, or if there is damage to the transducer or its accessories, notify the supplier from whom you have ordered the device or Hugo Sachs Elektronik directly.

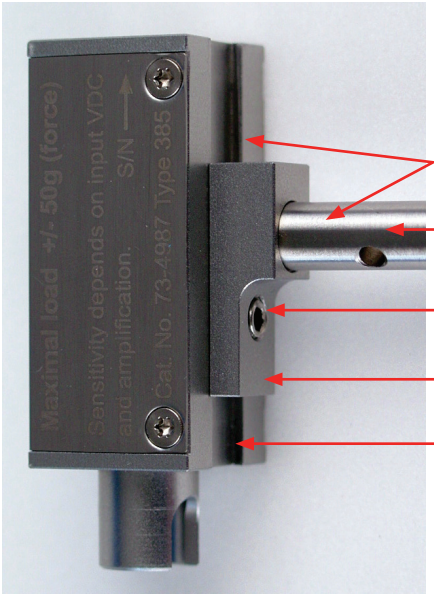
Check to ensure that all items ordered and listed are included in the shipment. The shipment includes the following items:

- Force transducer FT20 or FT50
- Removable holder with 8 mm mounting rod
- Standard connection cable
- Small spring attachment hook
- Test weight 1 cN (~1 g)
- Hexagon screwdriver 2.5 mm
- User's manual (operating instructions)
- Storage box

Detailed Description

Main Design Features

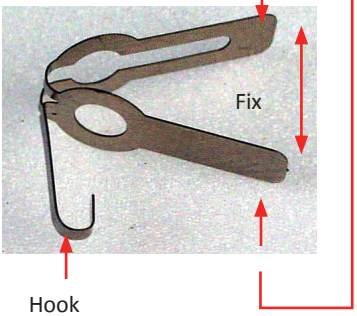


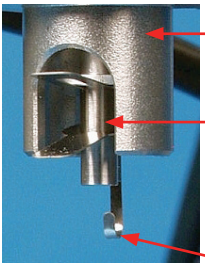


Detailed Description

Spring Hook & Handling in Operation

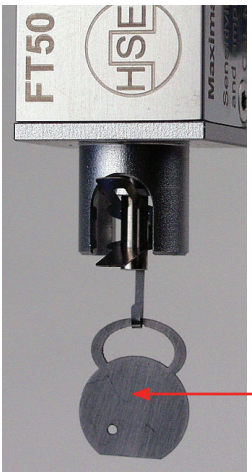
The spring hook is a specially designed flat spring used to affix a muscle preparation with a thread to the transducer for recording a dynamic force contraction signal. To remove the hook press both spring legs together and remove from stylus tip. In the event of an overload the spring hook will pull off from the stylus reducing the likelihood of damage.





Test Weight 1 cN

Part of the standard accessories is a small test weight 1 cN (~1 g). This test weight can be used to calibrate a Force Transducer FT20 or FT50 to the attached bridge amplifier. Such calibration sets the amplification of the amplifier to a self-defined measuring range, such as a 2 V output voltage per 1 cN load.



1 cN test weight
attached to an FT50

The calibration procedure is described in more detail in the Tips & Advice section.

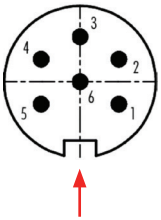
Electrical Connection

The transducers are connected to a suitable bridge amplifier via a removable and exchangeable cable. This allows connection of the transducer to different amplifier models by simply changing the connection cable.

Note that the connector on the transducer side is not a USB port; therefore do not use any extension cable between the transducer and amplifier. As an HSE standard, we offer a 2 m length connection cables with either 6-pin binder suitable for all HSE amplifiers, or 8-pin binder suitable for AD Instruments bridge amplifiers*. Special cables for amplifiers from other manufacturers e.g. Grass, Gould, etc. are available on request.

6-pin binder connector

Pin assignment

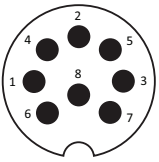


Pin assignment
(front view)

1. + Supply voltage
2. - Signal
3. Unused
4. + Signal
5. - Supply voltage
6. Unused

8-pin binder connector

Pin assignment



Pin assignment
(front view)

1. + Supply voltage
2. - Signal
3. + Signal
4. – Supply voltage
5. Excitation voltage programming resistor
6. Unused
7. Ground
8. Excitation voltage programming resistor

** Compatible with AD Instruments bridge amplifiers model ML110, ML112, ML221, ML224, ML228, FE221, FE228, FE224*

For more basic technical information about the resistance full bridge (Wheatstone bridge) circuit please see the Tips & Advice section.

Detailed Description

Mounting & Handling in Operation

The transducer can be mounted in any direction, but make sure that there is no risk that the transducer becomes contaminated directly by liquids or indirectly through condensation. The removable holder is attached to the housing with a dovetail joint and is fixed with an M5 hexagon socket set screw. The required retention force is very low; please use only a little force to fix it to prevent damage to the housing. An appropriate screwdriver is part of the standard accessories. The support rod can be screwed into one of the two M5 mount threads of the holder in a horizontal or vertical direction.

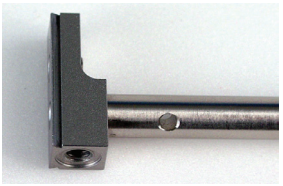
When measuring very small forces, especially when using an FT20, it is recommended that you place the setup on a vibration-free platform or equivalent vibration isolation equipment.

To minimize temperature drift, ensure that the transducer is not exposed directly to heat sources (lamps, heaters, direct sunlight, etc.).

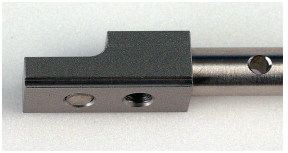
If the transducer is currently not in use, place it back into its storage box. Under normal conditions and with good handling practices, the force transducer will be a precise measuring tool for many years.

Removable Holder

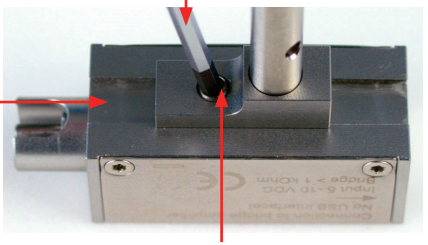
Transducer with holder and rod 90°



Rod mount 90°



Rod mount straight



Transducer with Vernier Control

For precise adjustment of a given preload, e.g. for certain isolated muscle preparations, a Vernier control is important. The transducer position can be finely set using the Vernier control to obtain the required preload force.

Specifications

	FT20	FT50
Maximal load:	± 20 cN (~20 g force)	± 50 cN (~50 g force)
Natural frequency	210 Hz	300 Hz
Bridge resistance	Signal = 1.6 kOhm Supply = 820 ohm	Signal = 1.6 kOhm Supply = 820 ohm
Supply Voltage	+5 to 10 VDC <20 mA	+5 to 10 VDC <20 mA
Displacement	8 µm / 1 cN	4 µm / 1 cN
Sensitivity	250 µV / 1V / 1 cN	58 µV / 1V / 1 cN
Shielding	Housing, holder and rod connected to shield	Housing, holder and rod connected to shield
Sensor moving mass	<1.1 cN (~1.12 g)	<1.1 cN (~1.12 g)
Operating temperature	10 to 50°C (50 to 122°F)	10 to 50°C (50 to 122°F)
Weight	120 g (Sensor and holder without cable)	120 g (Sensor and holder without cable)
Transducer dimensions (W x H x L)	21 x 21 x 64 mm 0.83 x 0.83 x 2.52 in	21 x 21 x 64 mm 0.83 x 0.83 x 2.52 in
Connecting socket	USB 2.0 A type socket / supply and signal (No USB interface)	USB 2.0 A type socket / supply and signal (No USB interface)
Connection cable	Standard cable either 6-pin or 8-pin binder connector 2 m / 78 in Other type available on request	Standard cable either 6-pin or 8-pin binder connector 2 m / 78 in Other type available on request
Rod length	8 x 160 mm 0.315 x 6.3 in	8 x 160 mm 0.315 x 6.3 in
Mounting holder for rod	Removable horizontal or vertical mount	Removable horizontal or vertical mount
Accessories	Standard connection cable, test weight and instruction	Standard connection cable, test weight and instruction

Servicing and Maintenance

The FT transducer series does not require any special maintenance. The inner sensing element is based on a contactless magneto-resistive system. The measurement anchor is part of a parallelogram spring guide, thus there is no friction and wear.

For routine maintenance, it is important to carefully clean the housing and sensor tip to remove dirt and residue. Light soiling can be removed with a damp cloth without detergent. For organic residues like oil, grease or an adhesive residue, use an alcoholic cleaning agent like isopropanol. In all cases be careful that no cleaning agent enters the housing, the input socket or sensing pin.

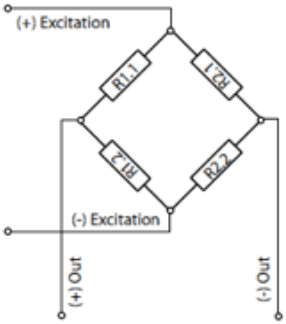
If your cleaning process is not successful, e.g. if the inside of the sensor is contaminated with saline solution, please do not open the housing. To disassemble the sensing element you need special tools and knowledge. In this case, it is necessary to send your transducer back to us for service and repair. Later damage due to corrosion is very expensive to repair.

Return Shipment

To send back the transducer it is essential to have very good packaging. It is best to use the supplied storage box together with an additional packaging around the plastic box. Please ensure that there is no direct pressure to the sensor tip.

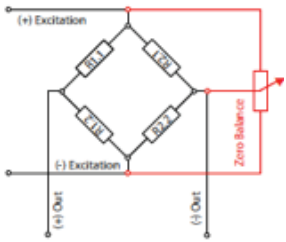
Tips & Advice

This section describes some basics about how a Wheatstone bridge transducer works, how to calibrate the transducer and set up the connected amplifier. All information hereinafter describes additional technical details which are important to understand your measuring setup in more detail.



Wheatstone Bridge Circuit

The installed full bridge magneto-resistive sensor chip consists of four equal magnetic field-dependent resistors. Through the movement of a magnetic anchor plate along the sensitive sensor area, the ohmic bridge resistance is changed by the displaced magnetic field. The sensitivity of the sensor is very high; thus the displacement of the anchor is very low.



The diagram to the left illustrates the basic circuit of the bridge sensor. There are two separate half-bridges: R1.1 and R1.2; and R2.1 and R2.2. All four resistors are magnetic sensitive and all have the same value. Thus if there is no difference in the magnetic excitation. The measured output voltage between the (+) Out and (-) Out is zero. A displacement of the magnetic anchor plate of the transducer shifts the magnetic excitation between the half-bridges; thus we can measure a positive or negative voltage on output (+) Out and (-) Out. This output voltage is very low, in the microvolt range. The size of the measured signal is directly proportional to the applied bridge excitation voltage. A fixed 5 VDC supply, as quasi standard, is mainly used by many manufacturers. The 5-volt supply offers a sufficient output signal and the self-heating of the sensor element is still very small, so the temperature drift within the switch-on phase is not critical.

An outstanding feature of a bridge circuit design is the ability to add an electrical zero balance. The correction is made directly into one of the two half-bridge sides. Derived from the bridge excitation voltage through a potentiometer or a digital to analog converter (auto zero circuit), a very small current is fed into the bridge circuit. Thus it is possible to compensate for the gravity error and user preload setting. The zero balance circuit is part of the connected bridge amplifier and not the transducer. The ability to compensate for any kind of transducer offset (non-zero output) before amplification allows distribution of any transducer sub-range, e.g. from 20% to 100% full scale amplifier output. However, for a relatively accurate measurement, the sub-range should be not less than 10% full scale. For a FT50 transducer with ±50 cN the maximal range spread is ±5 cN full scale amplifier output. This means that a FT50 can be adapted to a given amplifier only by gain adjustment in the range ±5 cN to ±50 cN. Values higher than 50 cN are limited by the deflection of the sensor mechanic and values lower than 5 cN are electrically limited by amplifier noise, temperature drift, max. gain, etc.

Bridge Excitation Voltage

Bridge excitation voltage is the supply voltage for the transducer. In our case we are using a DC supply in the range 5 to 10 V. The maximal current is below 20 mA. The special design feature of an additional installed preamplifier from an FT20 needs an extra current but is below 50 mA.

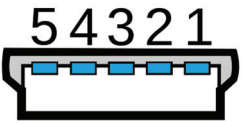
Never apply the excitation supply with reversed polarity. This will damage the electronic sensor.

Connection Cable and Pin Assignment

The standard connection cable is based on a modified mini USB cable 2 m long. On the transducer side there is a 90° angled mini USB plug and on the amplifier side a 6-pin binder plug according the HSE standard for bridge amplifiers. The optional available cables for other DC bridge amplifiers, e.g. Grass or Gould, are equipped with their appropriate plug.

The use of a mini USB connector has several benefits such as small size and high reliability even at a high number of mating cycles. Additionally, the cable offers a very good electrical shielding and is still handy and flexible. In case of accidental connection of a FT transducer to a real USB port, there is no risk of damage. Both systems have a DC supply voltage, a positive and negative signal line, and the same pin assignment.

Mini USB Connector



PIN	NAME	COLOR	DESCRIPTION
1	V(+)	red	(+) Excitation
2	Signal(-)	white	Signal(-)
3	Signal(+)	green	Signal(+)
4	NC	-	Not Connected
5	V(-) GND	black	(-) Excitation
-	Cable Sheild	-	Shielding

Tips & Advice

6-pin Binder connector HSE cable type

PIN	NAME	COLOR	DESCRIPTION
1	V(+)	red	(+) Excitation
2	Signal(-)	white	Signal(-)
3	NC	-	Not Connected
4	Signal(+)	green	Signal(+)
5	V(-) GND	black	(-) Excitation
6	NC	-	Not Connected
-	Cable Sheild	-	Shielding

6-pin Binder connector HSE cable type

PIN	NAME	DESCRIPTION
1	V(+)	(+) Excitation
2	Signal(-)	Signal(-)
3	Signal(+)	Signal(+)
4	V(-)	(-) Excitation
5 and 8		Excitation voltage programming resistor*
6	NC	Not connected
7	GND	Ground

** Excitation voltage programming resistor should be 470 kOhm to get 5V excitation voltage*

Calibration

The FT20 and FT50 transducers are supplied with a calibration test weight of 1 cN (~ 1 g). We recommend that there be one suitable set of Newton calibration weights available in your laboratory. The number of weights and their gradation depends on the measuring range of your application. In all cases, for maximum accuracy it is important to have a calibration weight in the same range as your measuring range or no less than 80% of the maximum force you want to measure.

Through the calibration procedure, all components of the setup are to be adjusted according the desired measuring range. The following is an example procedure for a HA-HSE TAM-A bridge amplifier.

Example Calibration Procedure for Transducer and Amplifier

1. Install all devices in their permanent location in your laboratory. The force transducer must be placed precisely in a vertical position because we are using the weight force as a calibration reference.
2. Power on the complete measuring system and allow it to warm up for 5 to 10 minutes to get stable conditions.
3. Set the variable GAIN setting to 100%, the mode switch to measure, and the filter to maximum frequency (300 Hz). Perform a zero adjustment without any calibration load. Place the selected calibration load (80 to 100%) on the transducer's tip. The amplifier output voltage now should be higher than 8 to 10 volts based on the load of 80 to 100% of the measuring range. If not, change the internal jumper settings for gain and auto zero range (low, medium or high). Please consult the instructions for the TAM-A bridge amplifier. For good measuring accuracy it is important to set the amplifier gain large enough so that the amplifier range is used full scale.
4. Once the correct gain range is selected, start the calibration procedure. A good additional tool is a small handheld voltmeter connected to the front panel BNC output. In this example we are using an FT50 and the desired measuring range should be ±6 cN. To get an evident relationship between the measured force and the amplifier output voltage we will set 1 cN to 1.5 V. Our calibration weight is a combination of a 5 and 1 cN item which we have attached. The resulting output voltage is 13.6 V which is more than the regular full-scale range of ±10 volts. Based on this, we reduce the gain with the variable gain trimmer to get an amplifier output of exactly 9.0 V. Because of the large amplification change there is also a small shift of the zero line. We remove the calibration weight and perform an additional zero adjust and then retry the calibration procedure and set the amplifier output to exactly 9.0 V such that 1 cN = 1.5 V amplifier output.
5. Next adjust the CAL simulation value.

Tips & Advice

CAL Simulation Value Adjustment

The following adjustment is a specific feature of the TAM-A (D) amplifier. Through the mode switch CAL - OFF - MEASURE it is possible to emulate the CAL-values for a 2-point calibration procedure of a connected data acquisition, scope or recording device. Thus there is no need to attach a calibration weight to the transducer tip.

The first calibration point ZERO is generated by setting the mode switch into the OFF position. The amplifier output is then 0 volts. The second calibration point (Mode switch = CAL) we will now adjust the output with the front panel trimmer CAL (for example to 2 cN = 3 V amplifier output). This adjustment can be done very easily if you have a voltmeter connected to the amplifier output. Our amplifier TAM-D has an integrated voltmeter (DVM) on the front panel and if the ADJ. trimmer of the DVM is on the clockwise right end, the reading is 10.00 V.

If there is no voltmeter available, it is also possible to attach a calibration weight to the transducer and adjust the simulation CAL value equal to the amplifier output voltage. For the adjustment of the CAL value the mode switch must be in the CAL position and for the output reference switch to the MEASURE position. This approach requires several mode switches CAL <> MEASURE for an exact adjustment.

Once the simulation CAL value is set, please make a note with a pencil in the designated field. If all settings are accurately done, it is now very easy to output the references for a two-point calibration, or you can add a calibration reference mark e.g. +2 cN to the currently running data acquisition.

IMPORTANT:

We cannot give general advice on how often a real calibration procedure must be done. This depends on your laboratory Standard Operation Procedures. It is a good practice to make a full calibration check at least every month or if there was an appreciable overload of the transducer to check if there is a damage to the sensor mechanics.

Once per day, before and at the end of each measurement, please check zero and the simulated CAL value to be sure that the measuring setup works well.

Manual Zero Adjust and Auto Zero Function on TAM-A (D)

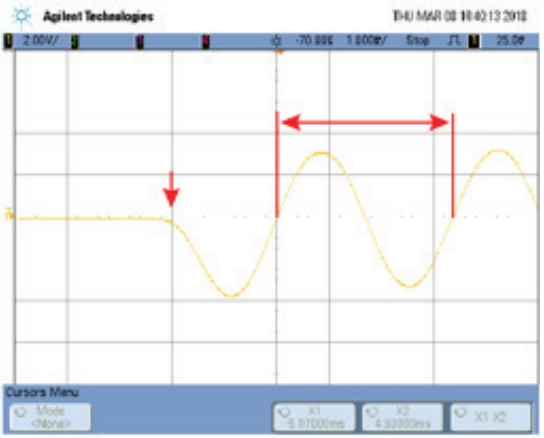
Like every modern electronic design, the TAM-A (D) amplifier has an auto zero function installed. The auto zero makes it easier to establish a zero offset exactly. But it must interact together with the manual zero trimmer settings.

First set the adjustment range of the auto-zero circuit into its middle position, making it possible to compensate positive and negative offsets in the same way later. This can be done by disconnecting the transducer and then starting the auto zero function. In case there is no transducer connected, zero cannot be adjusted and after an error signal the controller sets the auto-zero into the middle. Now reconnect the transducer and make first the zero adjustment with the FINE and COARSE trimmer of the TAM and then press the auto-zero key for an accurate zero baseline.

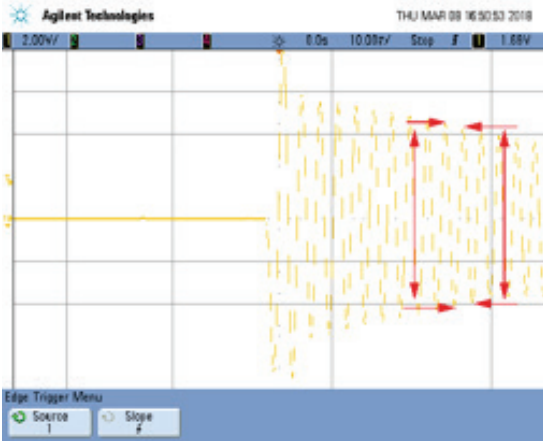
Natural Frequency and Damping

The term "natural frequency" describes the oscillation behavior of the sensor after a mechanical excitation. Like a tuning fork, the sensor parallelogram spring system has a specific individual natural frequency. This value depends on the spring constant and is therefore different according to the type of transducer (FT20 or FT50). The next three screenshots illustrate the behavior for a FT50 transducer, free swinging without any additional load.

Initial mechanical excitation and the resulting free swinging of the moving sensor shaft. The measured natural frequency of the FT50 is 300 Hz.

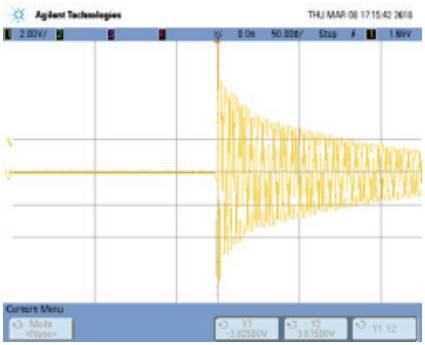


The damping factor specifies the amplitude reduction of the freely oscillating sensor. It is calculated from swing to swing. The damping factor DF = 1.045 and is calculated [Amplitude 1] divided by [Amplitude 2].



Tips & Advice

For the force measurement it is important that the natural frequency of the transducer be significantly higher than the force curve to be measured so that there is no risk that the mechanical parts come into resonance. The frequency parts of a derived muscle contraction is in all cases below 100 Hz, so there is no falsification of the measurement through resonance side effects.



Ordering Information

Item #	Description
73-4986	FT20 Isometric Force Transducer ± 20 g, includes 6 Pin DIN cable for HSE amplifiers
73-4987	FT50 Isometric Force Transducer ± 50 g, includes 6 Pin DIN cable for HSE amplifiers
73-5035	FT20 Isometric Force Transducer ± 20 g, includes 8 Pin DIN cable for ADI amplifiers*
73-5036	FT50 Isometric Force Transducer ± 50 g, includes 8 Pin DIN cable for ADI amplifiers*

* Compatible with AD Instruments bridge amplifiers model ML110, ML112, ML221, ML224, ML228, FE221, FE228, FE224.

Notes

Notes

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