Operating Instructions

Multichannel Charge Amplifier

Type 5019B…

Your Competent Distributor:

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Contents

1 Introduction

By choosing this KISTLER quality product you have opted for an instrument distinguished by precision, long life and technical innovation.Please read these operating instructions through carefully. You will then be able to make the best use of the versatile capabilities of your new multichannel charge amplifier.

KISTLER offers a wide selection of measuring instruments and all-embracing systems:

- quartz sensors for force, pressure, acceleration, shock and vibration
- associated charge amplifiers and charge calibrators
- electronic control, display and evaluation instruments
- piezoresistive pressure resistors and transmitters with associated measuring amplifiers.

KISTLER also conceives entire measuring installations for special duties, as in the automobile industry, plastics processing and biomechanics.

Our general catalog provides an overview of our products. For virtually all of them detailed data sheets are available.

The worldwide KISTLER customer service is at your disposal for any special questions still open after studying these instructions. It will also render competent advice on specific application problems.

2 Important guidelines

The guidelines that follow should be observed without fail. Your personal safety when working with the multichannel charge amplifier will then be assured, together with long, trouble-free operation of the instrument.

2.1 For your safety

- This device has been manufactured and tested in accordance with EN Publication 61010-1 : 1993 (Safety Rules for Electronic Measuring Equipment), and it left our works in perfect condition from the safety viewpoint. To maintain this state and ensure operation without danger, the user must note the directives and warnings given in these operating instructions or inscribed on the amplifier.
- The local safety regulations affecting the handling of mains-powered electrical and electronic equipment must be observed also.
- If it must be assumed that safe operation is no longer possible, the amplifier must be taken out of operation and secured against inadvertent starting.

It must be assumed that safe operation is no longer possible if . . .

- the equipment reveals visible damage
- it no longer functions
- it has been stored a long time under adverse conditions
- it has sustained severe stressing during transport

If safe operation is no longer assured for one of the foregoing reasons, the amplifier must be sent in for repair promptly to our works or the competent distributor.

- When opening covers or removing parts, except when this is possible by hand, live parts may be exposed as long as the instrument is connected.
- Before adjusting, maintenance, repairing or changing parts, the amplifier must be disconnected from all voltage sources.
- If possible no adjusting, maintenance or repair work should be performed on opened equipment under voltage. If such work is unavoidable, it may be done only by a qualified person who is familiar with the associated risks.

WARNING!

- Any break in the grounding conductor inside or outside the amplifier or disconnecting of this conductor may render the amplifier dangerous. Deliberate disconnecting is inadmissible!
- The mains power plug may be connected only into a socket with grounding contact. The protection must not be nullified by an extension line without grounding contact connection.
- When changing fuses, only the type stated with the specified amperage may be used. Use of "repaired" fuses or short-circuiting the fuse holder is inadmissible.

2.2 Fundamental precautions, mains power switchover

- Inspect all packaging of the instrument for damage during transport. Report any such damage to the transport firm and the competent KISTLER distributor.
- Verify whether the multichannel charge amplifier is set for the right mains voltage.

The supply adjusted 230 V AC (for rated voltage range 200 ... 240 V AC) or 115 V AC(for rated voltage range 100 ... 125 V AC) is visible on the voltage selector at the back, by the side of the power connection.

Changing the supply voltage and fusing:

Make sure that the amplifier is disconnected from the power supply by unplugging the power plug. Use a screwdriver to set voltage selector to the required supply voltage. The two fuses must also be changed according to the supply voltage supply:

- 200 ... 240 V AC: dia. 5x20 mm, 250 V AC, 315 mA, slow-blow Type FST
- 100 ... 125 V AC: dia. 5x20 mm, 250 V AC, 630 mA, slow-blow Type FST

The fuse holder is located between the power switch and the power plug.

Attention:

To avoid endangering the safety of the amplifier the fuse for 100 ... 125 V AC (630 mA) must not be used to replace a blown 315 mA fuse, nor may "mended" fuses be used.

- The amplifier is to be used only under the specified operating conditions. It must be protected from excessive dust and mechanical stressing (shocks, vibration).
- High air humidity which may lead to condensation at temperature changes is to be avoided.
- Protect the inputs and outputs of the amplifier from dirt, and do not touch the insulations with the fingers. Fit the covers supplied when a connection is not in use and a cover has been provided for it.

2.3 Electromagnetic Compatibility

The Multichannel charge amplifierType 5019B is CE-compliant. It meets the safety requirements according to EN 61010-1, as well as the requirements for electromagnetic compatibility according to EN 50081-1 (interference emission) and EN 50082-0 (interference immunity).

For the tests performed in this respect, the analog common return of the 5019B was connected to the amplifier grounding conductor by a screw M4 at the back of the amplifier.

This connection between common return and grounding conductor is provided as standard, but can be removed at any time by the user removing the screw if, for example, measuring problems occur as a result of multiple grounding (ground loops). Multiple grounding is often unavoidable because the signal input and output circuits of the 5019B are not electrically isolated from one another.

A flat connector tab (6,3 mm) connected to the grounding conductor is fitted at bottom right on the back of the amplifier. This provides the facility for connecting an equipotential bonding conductor in the event of ground potential difference problems.

It can be stated that, in general, in the event of measuring problems of the type indicated, experiments will be necessary to find the best solution, e.g. removal of the grounding screw M4, installation of equipotential bonding conductors, isolating sensor ground (if possible) etc.

2.4 Tips for using these instructions

These instructions describe the multichannel charge amplifier Type 5019B. A supplementary designation defines the variant and the number of measuring channels.

We recommend reading the entire operating instructions through. Nevertheless if you are in a hurry and already acquainted with KISTLER charge amplifiers, you may confine your reading to the information needed at the moment.

We have endeavoured to set out these instructions as clearly as possible, to facilitate your access straight to the information you want.

Please keep these operating instructions in a safe place, where they are available at all times.

If you lose the instructions, request replacement at once from your KISTLER customer service point.

All data and instructions given here may be altered at any time without prior notice in the light of technical progress.

Designations in pointed brackets (like <Menu> key) refer to controls and displays bearing these names on the amplifier or in the display. The associated parameters are shown in square brackets [ ].

Instrument modifications (conversions, retrofits etc.) necessitate changes in the operating instructions as a rule. In such cases consult your KISTLER customer service about the possibilities of updating your documentation.

3 General description of the amplifier

3.1 Different variants

The complete type designation of the multichannel charge amplifier consists of the basic code 5019B followed by four further digits: **5019Bvwx**. This supplementary designation defines the housing variant (v), the number of charge amplifier measuring channels provided (w), and the options:

v = 0 The instrument is provided for mounting into a 19-inch rack system according to DIN 41 494, width 63 TE and height 4 HE, with side fixing flanges.

v = 1 The instrument is available with a "Schroff CARDPAC" table housing having the same front plate dimensions as above, with setting-up / carrying handle.

w = 3 or 4 This indicates the number of independent charge amplifiers built-in. If the instrument is supplied fitted with less than four charge amplifiers, it is always possible to add charge amplifiers later. More is said about this procedure in the remarks below concerning options.

x = 0 Instrument **without** A/D converter board

x = 1 Instrument **with** A/D converter board for signal display, Type 5261

3.2 Options

3.2.1 Charge amplifier on Euro-Card Type 5059, additional

With this option, charge amplifier channels may be added any time if the maximum of four is not being utilized yet. Extension is effected from left to right, taking the next channel number in succession. The front plate is already prepared for this extension: the channels not originally in use are covered on the front plate with a self-adhesive label divided into several sections. By tearing off the appropriate sections the front plate inscription is exposed successively, according to the extension stage.

Switching-on the instrument after fitting additional charge amplifiers calls for reinitializing. This is done following the instruction in the LCD by pressing the <Operate> key, or via the parallel interface.

3.2.2 A/D converter board for signal display Type 5261

Subsequent with equipment of the A/D converter board for signal display.

Procedure:
Lift off front plate with manual control. To this purpose, loosen the four fixing screws and pull the front plate out of its plug-in connection. Insert ADC board into the left hand free slot. Make sure that the board is inserted with the terminal in forward direction and the components side to the right. Plug the board with slight pressure into the terminal. Then replace front plate with manual control and screw it down.

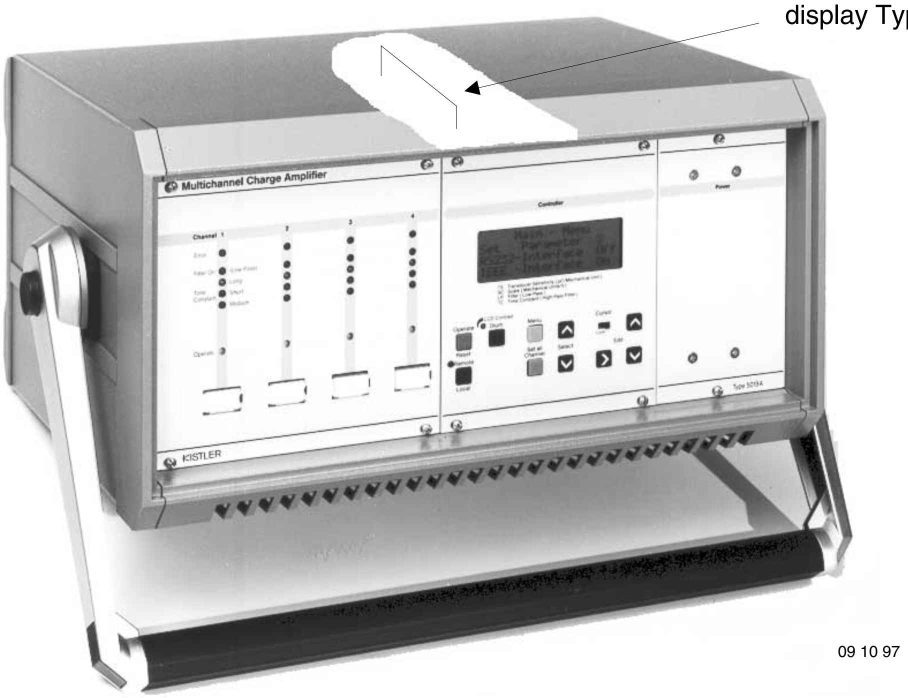


Fig. 2: Installing the option

- Re-insert manual control unit cautiously and screw down
- Connect instrument to mains
- The multichannel charge amplifier is operative again

The pin allocation of the output signals is listed in the section "Technical data / Voltage outputs".

Operation:

- Pin allocation and thus channel assignment is determined by the used dynamometer resp. summing amplifier type and the measuring task.

4 Technical data, Functional description

4.1 Introduction

The Type 5019B instrument is a multichannel calibrated multirange charge amplifier with microprocessor control. Typical applications for such multichannel charge amplifiers are to be found in combined force and moment measuring using piezoelectric multicomponent dynamometers. The desired parameters can be adjusted or read off conveniently by means of a keypad in conjunction with an alphanumeric LCD and various LEDs.

All functions can also be adjusted and queried via the IEEE-488 or RS-232C interfaces.

The instrument can be supplied in an all-metal table housing or as a 19-inch plug-in unit conforming to DIN 41 494 Part 5.

4.2 Function of the multichannel charge amplifier Type 5019B

4.2.1 Block diagram

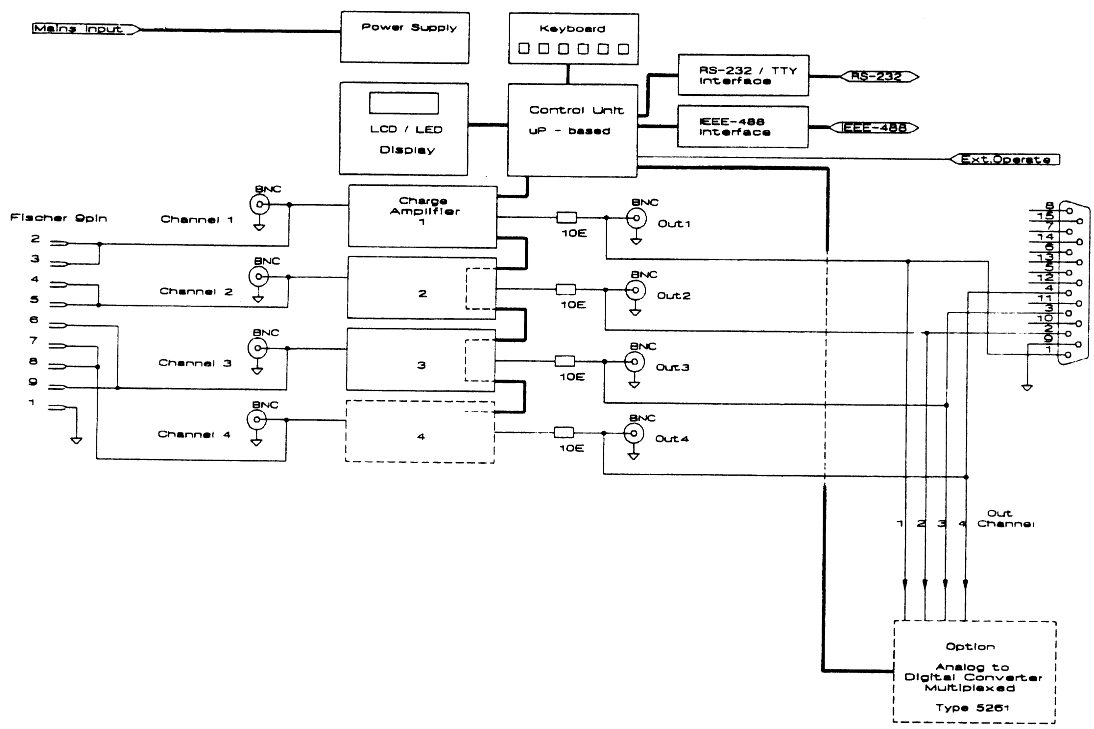


Fig. 3

The middle part of the block diagram shows the similar charge amplifiers Type 5059 numbered 1 to 4, executed as plug-in units. Depending on the application, partial fitting-out with less than 8 amplifiers is possible.

The 4 charge inputs (In Channels 1 ... 4) are duplicated, to 4 individual BNC sockets and collectively to a high-grade highly insulating Fischer socket.

The 4 charge amplifier outputs (Out 1 ... 4) are likewise connected to BNC sockets, and at the same time paralleled to a 15-pin D-Sub female multipoint connector.

To prepare a measurement the various charge amplifier parameters must be set. This is done serially via a data line looped from one charge amplifier to the next, with the control unit acting as sender. The data may be put in directly and manually (keypad) or through one of the interfaces (RS-232C or IEEE-488).In the reverse direction any error messages are transmitted from the charge amplifiers to the control unit likewise as serial data.

The alphanumeric LCD allows for convenient interactive data input via the keypad. Various LEDs on the controller and also on the different charge amplifiers (channels 1 ... 4) give information on the operating state and any filter functions switched in, moreover they signal possible error states. The parameters adjusted may differ without restriction on the various charge amplifier channels.

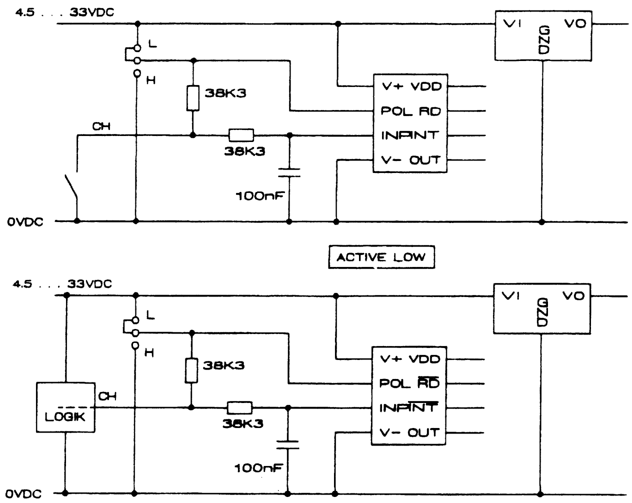
In the block diagram the power supply is the last unit shown. Here switched controllers are used to minimize the power loss of the installation.

With regard to the block diagram it should be noted that it has been simplified considerably. For example the charge amplifiers or the control unit consist of a whole number of function blocks. A comprehensive block diagram of a charge amplifier unit is described in subsection 4.3.1.

4.2.2 Digital input "Remote Operate"

Switching the charge amplifier over from the waiting state to readiness for measuring, i.e. from "Reset" to "Operate", can be performed in various ways:

- manually by pressing the <Operate> key on the front;
- with the appropriate command via the serial interface (RS-232C) or the parallel interface (IEEE-488).
- by leading a signal onto the 25-pin D-Sub socket on the rear, inscribed "Remote Operate". Each channel is controlled separately (see Technical data / Connections).
- Either a simple mechanical switch or a logic circuit can serve as signal transmitter.



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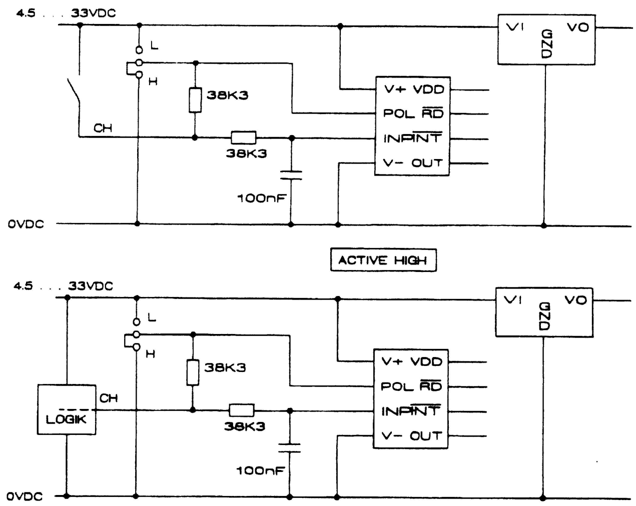

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4.2.3 Power supply

The power supply provides the various function units of the Type 5019B with +5 V and ±15 V DC voltages. The mains output on the left in the block diagram leads into a combined element comprising a connecting plug, power switch, mains filter, fuse holder and voltage selector. The mains filter serves to exclude high frequency interference superposed on the mains from the microprocessor part of the 5019B.

The mains transformer employed is a low-leak, low-loss toroidal core type. Since relatively high starting currents may occur with toroidal transformers, it is important when changing the fuse to fit exactly the type specified (subsection 2.2).

To minimize the power loss and with it the internal heating of the instrument, switched controllers are used for the three voltage controllers (+5 V, +15 V, -15 V).

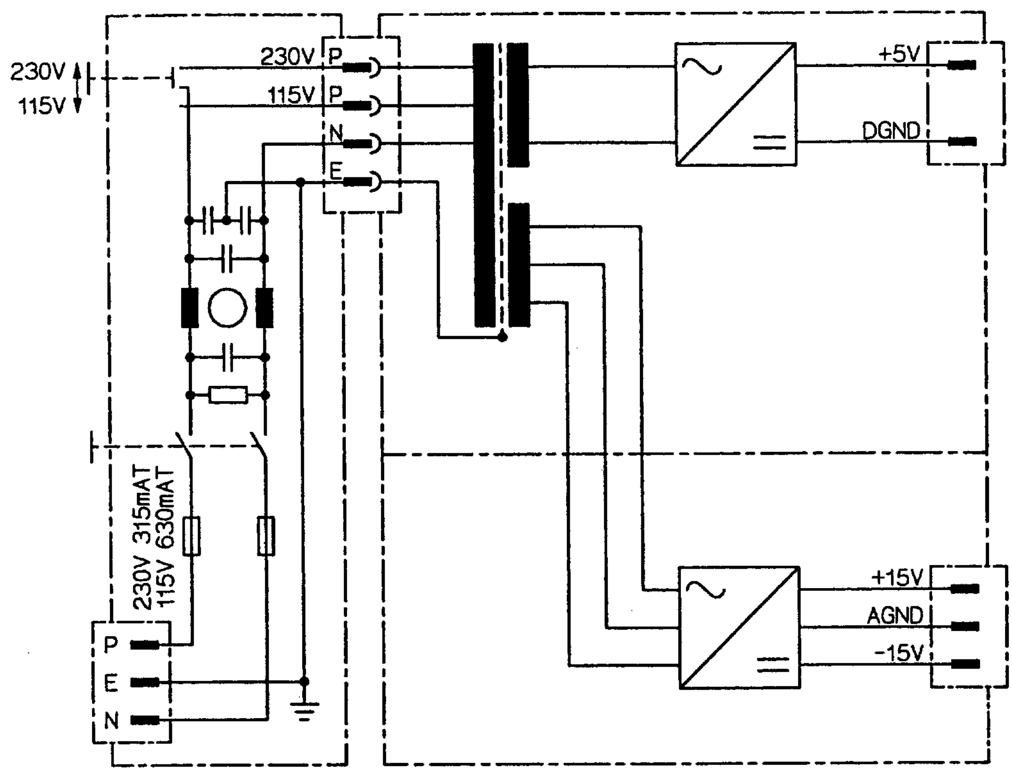


Fig. 6: Block diagram for power supply

4.3 Functional principle of the charge amplifier unit

4.3.1 Block diagram

The charge amplifier unit consists of the following function blocks:

- input stage with selection of measuring range and time constant
- amplifier stage with digital voltage divided DAC (**D**igital-to-**A**nalog **C**onverter) for adjusting the gain
- automatic zero compensation circuit
- low-pass filter, switchable
- signal output
- buffer storage for parameter adjustment and error processing, also series/parallel conversion
- various LEDs for status display

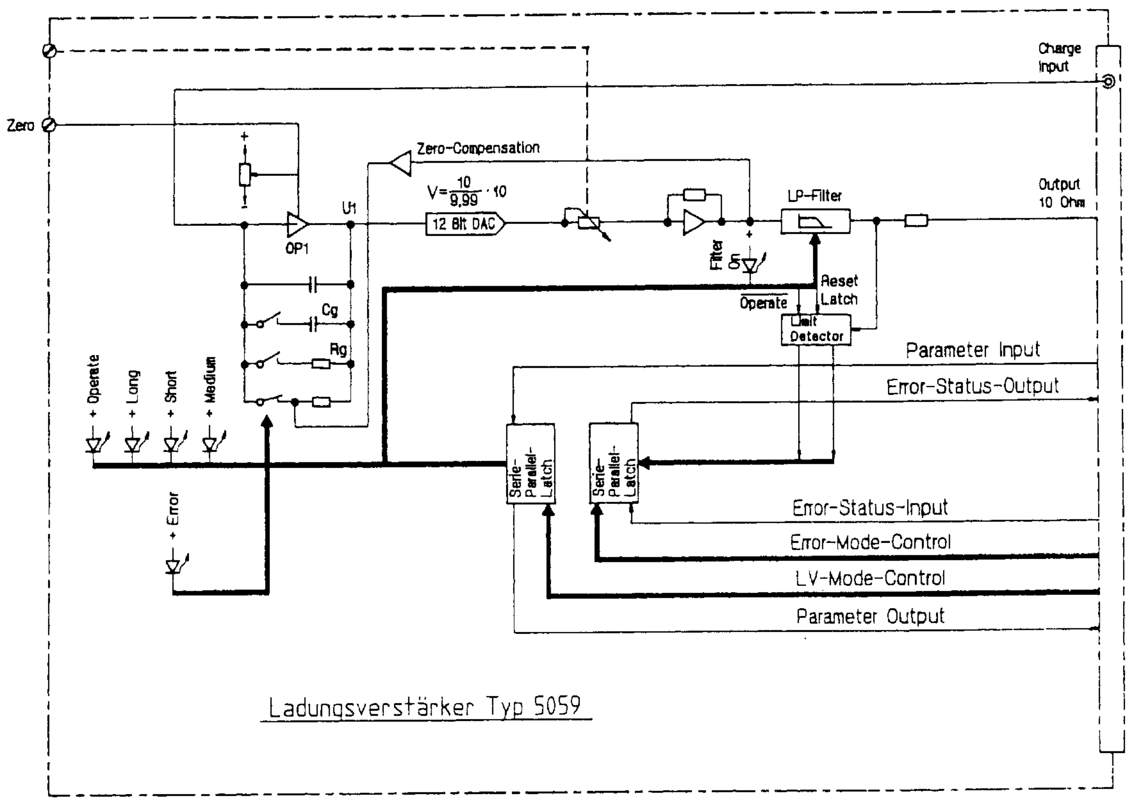


Fig. 7: Block diagram of charge amplifier unit

4.3.2 Input stage with range selection

The measuring range is selected by switching-in an appropriate range capacitor.

The input stage consists of a high-gain operational amplifier (OP1) with MOSFET input stage. It has negative feedback with one of the 5 highly insulating range capacitors C_g, thus acting as integrator for input currents flowing in via the [Charge Input]. These currents are generated by charge changes, i.e. load changes on the piezoelectric sensor.

At the amplifier output a voltage appears proportional to the integral of the charge change delivered by the sensor. The designation "charge amplifier" is therefore actually incorrect for this unit; it is rather a charge-to-voltage converter.

In the great majority of cases the following approximate formula is sufficient for determining U_1:

$$U_1 = \frac{Q}{C_g}$$

Q = charge at input
C_g = range capacitor

To obtain positive signal voltages for positive mechanical loads, KISTLER sensors deliver **negative** charge for **positive** mechanical loading. Owing to the inverting function of the charge amplifier a positive output signal is then assured under positive load (e.g. pressure).

The function of the charge-to-voltage conversion may also be described as follows:

The amplifier switched as integrator compensates the electrical charge from the sensor with an equal charge though of reverse sign, by building up a voltage U_1 via the range capacitor C_g.

An exact calculation, assuming a finite open-loop gain on OP1 and allowing for the input capacitance C_e (= cable capacitance and sensor capacitance), gives for U_1:

$$U_1 = \frac{Q}{C_g} \bullet \frac{1}{1 + \frac{1}{v} + \frac{C_e}{v \bullet C_g}}$$

v = frequency-dependent open-loop gain of OP1, approx. 150'000 for DC

C_e = total input capacitance

The right-hand term, the disturbance term, denotes the deviation from strict proportionality between input charge Q and output voltage U_1. In the great majority of cases, however, the simplified formula (1.1) is sufficient.

The particular range capacitor C_g may be paralleled with one of the two time constant resistors R_g (10^9 Ω and 10^{11} Ω respectively). This causes a slow discharge of C_g, which is beneficial for dynamic measurements.

A normally closed reed relay contact enabling the range capacitor to be bridged serves to reset the amplifier to its reset status. The output voltage is then zero, apart from possible zero deviations.

A [Zero] potentiometer serves to adjust the zero of the input stage. With it the offset voltage at the [Charge Input] can be adjusted to a minimum.

More detailed explanations concerning the piezoelectric measuring principle and charge amplifier theory may be found in the KISTLER reprint 20.116e: "Piezoelectric Measuring Instruments".

4.3.3 Digital voltage divider (12-bit DAC)

As described under 4.3.2 the range is selected in fixed stages by switching capacitors. A continuous fine adjustment is effected by the programmable digital voltage divider (DAC) connected. The scale and sensor sensitivity values adjusted via the keypad are processed by computer and the gain selected accordingly (v = 1 ...10).

4.3.4 Zero compensation

Between DAC and filter stage the amplifier zero offset is measured, processed in the zero compensation controlled stage, and fed back into the amplifier input stage. Adjustment follows automatically in the [Reset] position.

The zero adjustment of the input stage necessary after changing the input transistor (MOSFET) is performed from the front after removing the front plate, on the [Zero] potentiometer, again in the [Reset] position. The procedure is described more detailed in subsection 8.2.

4.3.5 Low-pass filter

After the DAC stage comes a low-pass filter switchable in 8 stages, with Butterworth characteristic. With the filter adjustment the upper limit frequency of the measuring system can be matched to the particular application. For employing additional external filters on the input or output side, data sheets 12.5321 and 12.5323 should be consulted.

4.3.6 Microprocessor control and monitoring

The charge amplifier units are controlled and monitored collectively by an 8-bit microprocessor.

Communication between the charge amplifier part and the processor part is serial via appropriate converters, with isolation by opto-couplers. Through this link the information of the limit detector, [Remote Control] connection and keypad is transmitted to the microprocessor. In the reverse direction the charge amplifiers are adjusted: ranges, time constant, DAC, filter, [Operate/Reset].

Directly linked with the microprocessor are the LCD display, memories and interfaces.

For storing the program a 64K EPROM is available. The adjusted parameters are filed in a nonvolatile 2K NOVRAM. These data are stored up to 10 years. The (plug-in) element must then be replaced.

4.4 Display, controls and connections

The controller on the front contains in its upper part the illuminable LCD for up to 4 x 20 characters. In the bottom part is a keypad for controlling the instrument "manually".

4.4.1 Display

Manual control of the instrument is interactive. To facilitate working the principal parameters and functions appear in the main menu. The flashing cursor shows which menu item is active at the moment or where an input is expected:

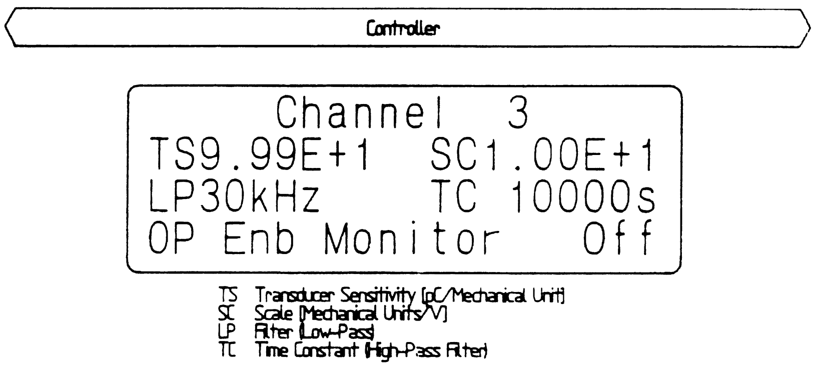


Fig. 8

[Channels 1 ... 4]:

It is indicated for which of the charge amplifier channels provided the values in the display apply or can be adjusted as the case may be.

[TSx.xxE+x]:

TS = Sensor sensitivity in pC per mechanical unit (pC/M.U.). The value is displayed in three significant digits and the power of ten.

[SCx.xxE+x]:

SC = scale in mechanical units per volt output signal (M.U. / V). This value is likewise displayed in three significant figures and the power of ten.

[LP] = low pass filter:

This shows whether the inbuilt filter has been either switched off or set to one of the 8 limit frequencies available.

[TC] = time constant
Three different statuses can be indicated:

TC = LONG: highest lower limit frequency possible, for investigating slow processes. This setting is used most.

TC = MEDIUM: instead of the word MEDIUM the display shows the value of the time constant in seconds, since this depends on the measuring range.

TC = SHORT: here again the time constant is displayed in seconds. MEDIUM and SHORT are selected for dynamic measurements such as vibration, or when special drift problems occur.

[Operate Enable/Disable]:

With this the Reset-Operate function may be activated or deactivated independently for each measuring channel. The status displayed applies to the measuring channel indicated in the top of the display.

[Monitor On/Off]:

If the instrument is fitted with an A/D converter board for the signal display, the measured value is shown in mechanical units (M.U.) depending on the scale factor.

Mechanical Units [M.U.] = Scale [SC] · U_{out}

4.4.2 Controls

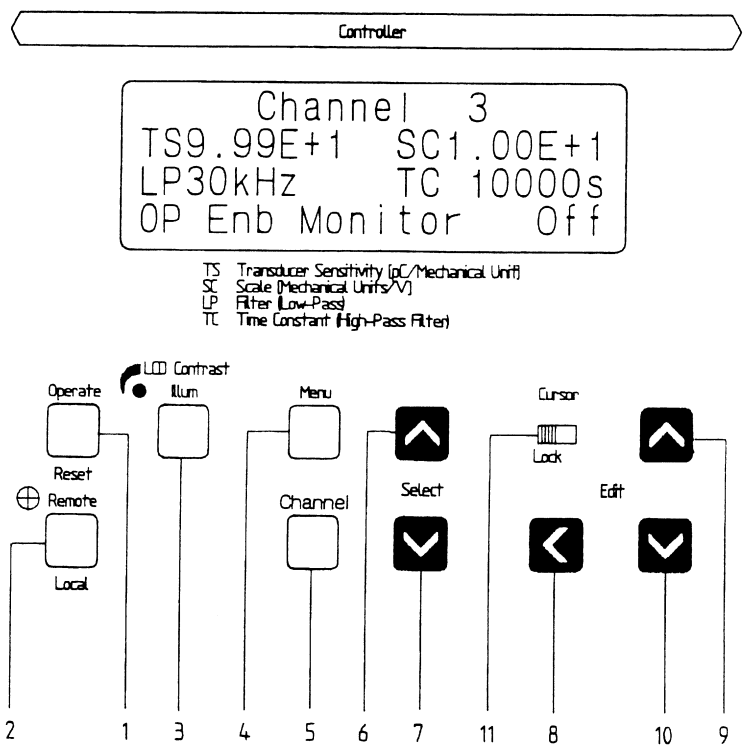


Fig. 9: Display and controls

The keys have the following functions:

Key 1: <Operate/Reset>

With this key the charge amplifiers are switched from the waiting state <Reset> to measuring readiness <Operate> and back again. The function of the key depends on the <Enable> or <Disable> status of the charge amplifier channel in question, which is shown in the LCD.

The <Operate> status is confirmed by the green LED of the charge amplifier.

Key 2: <Remote/Local>

This key activates the remote control for switching <Operate/Reset> from outside. The LED beside <Remote> confirms the switchover to remote control. Under certain conditions this LED lights during operation also, via one of the interfaces.

Key 3: <Illum>

By pressing this key the background lighting of the LCD can be switched on. It is switched off again automatically after about 30 seconds. However the illumination is activated again if any other key is pressed. In addition the display contrast can be adjusted optimally with the help of a small screwdriver on the trimmer potentiometer <LCD Contrast>.

If key 3 is pressed a second time, the lighting is switched off at once.

Key 4: <Menu>

This key switches another menu on the display, e.g. from the main menu into the "RS-232C interface" menu.

Key 5: <Set all Channels>

A submenu is called. All channels can then be adjusted to the same values as the parameters marked with the cursor.

Keys 6 and 7: <Select>

The parameter or function to be adjusted is selected with these keys.

Key 8: <Edit>

With key 8 the place to be edited within a parameter is selected (the place indicated by the flashing rectangle or cursor).

Keys 9 and 10: <Edit>

After selecting the right place within a parameter or display value, the desired value is put in with these keys. With key 9 ▲ the value is increased, with key 10 ▼ it is lowered.

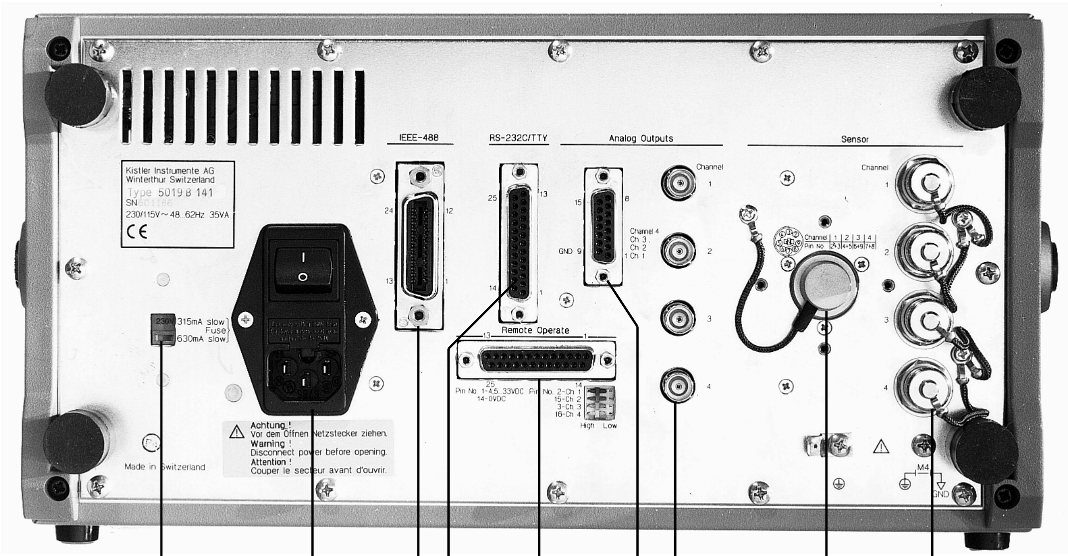
If the cursor is on a function to be adjusted, e.g. <LP> or <TC>, by pressing key 9 or 10 the available possibilities are displayed successively.

Slide switch 11: <Cursor/Lock>

By shifting the slide switch to the left (<Lock> position), operation of the keys (8, 9, 10) needed to change a parameter is blocked. Unintentional altering of the parameter values is prevented by this.

4.4.3 Connections, view of rear plate

Fig. 10: Connections, view of rear plate



09 70 12

Supply voltage selector

Supply connection with fuse holder

IEEE bus connection (Amphenol connector)

RS-232C connection (25-pin D-Sub connector)

Remote control of Reset-Operate function (25-pin D-Sub connector)

Outputs of the 4 measuring channels and their combinations (15-pin D-Sub connector)

Outputs of the 4 measuring channels on BNC sockets, paralleling D-Sub connector

Inputs of the 4 measuring channels led collectively to special Fischer socket

Inputs of the 4 measuring channels, on BNC sockets, connected in parallel with special Fischer socket. (Place protective caps over all channels not in use)

5 Assembly, installation and first commissioning

5.1 General information

The multichannel charge amplifier Type 5019B is designed in accordance with degree of protection IP-20 (according to DIN 40050), i.e. for use in enclosed, dry rooms. Excessive dust is to be avoided as is condensing moisture also. Because the proper functioning of a charge amplifier demands extremely high insulation values in some parts of the instrument, the prevailing air humidity must not be allowed to cause condensation in the event of a temperature drop at the installation site. If this should happen nonetheless, it is advisable to operate the instrument a few hours in the <Reset> mode so that it reaches its normal internal temperature rise.

If there is a possibility of persistent condensing moisture, the instrument is best left switched on at <Reset> as long as this danger is present.

The admisible ambient temperature range of -10°C to 60°C stipulated in the technical data must be observed. Permanent damage must be expected if 70°C or thereabouts is exceeded.

The siting of the instrument must be chosen so that it is not exposed to serious vibration or repeated shocks. Whether a vibrational acceleration is to be considered "serious" for the instrument cannot be defined numerically; the frequency or frequency range is very important here. Experience teaches that a vibrational acceleration of no more than 0.5 *g* is enough to cause damage if the frequency coincides with the resonant frequency of a part inside the instrument.

5.2 Connecting

Mains power connection:

This is effected via the three-wire power cable from a socket with grounding conductor connection. If it is necessary to use an extension cable, the protection must not be nullified by the absence of the grounding conductor connection. This has already been mentioned in subsection 2.1.

Above the mains combination element are two sockets, yellow/green (protective ground) and yellow (system ground or signal LOW). Normally both sockets are shorted by a jumper, joining the system ground to the protective ground.

Depending on local conditions, siting of the sensor and distance between sensor and instrument or the quality of the grounding of the machine on which the sensor is mounted, measuring problems may arise manifesting themselves in various ways, typically as mains frequency superposed on the useful signal or pulselike interference due to switching operations. Where such problems appear, the shorting jumper mentioned above may be opened to see if this helps.

If the improvement obtained is such that the jumper must be left opened in operation, make sure that the sensor mounted is connected to the protective ground according to regulations (e.g. via the machine to which it is screwed secure).

If the connection of the sensor housing with the protective ground is not assured, then a connection must be provided to the yellow/green socket on the 5019B. This line must have at least the same cross section as the conductors of the power cable. A potential equalization line of 1,5 to 2,5 mm^2 is advisable.

The voltage occurring between the two equipment sockets must under no circumstances exceed 50 V_{rms}!

IEEE-488 or RS-232C/TTY connection:

Connection of one of these interfaces is optional and not absolutely essential to the function of the instrument.

A commercial cable is used, subject to the following restrictions:

IEEE-488:

The distance between two instruments must not exceed 2 m and the overall length of the bus must not exceed 20 m.

RS-232C/TTY:

The distance between two instruments must not exceed 20 m, equivalent to a cable capacitance of 2500 pF. On the side of the Type 5019B a 25-pin D-Sub connector is used. The wiring of the cable depends on the handshake system adopted.

Analog signal outputs:

The signals may be taken either at the 15-pin D-Sub connector or at the 4 individual BNC sockets; both outputs are paralleled permanently. Depending on the cable type or capacitance, long connecting cables may lower the attainable upper limit frequency, but no serious errors are to be expected with lengths of 20 to 50 m or so.

„Transducer" signal inputs:

Here again there are two connection systems paralleled permanently: A 9-pin teflon-insulated Fischer socket and 4 individual BNC sockets.

Owing to the extremely high input resistance, these connections are very susceptible to interferences due to static. The parallel input not in use must therefore be shielded during operation. For the same reason the input sockets must be protected against any form of dirt.

When connecting sensors, even to the BNC sockets, we recommend the use of cables from the KISTLER range such as the Type 1631. These are tested especially for insulation resistance and triboelectricity.

When plugging-in the input cable the Type 5019B must be switched off, so that the reset reed contact is closed and damage to the input MOSFET is precluded. For the same reason the cables should be shorted with a short piece of wire before plugging-in, to discharge them.

When working with relatively high sensitivity, i.e. with small range capacitor, the following must be noted in addition:

The interference (noise) increases in proportion to the cable length or cable capacitance. This is specified more exactly in the technical data.

The input cables should not hang free over lengths longer than 30 to 50 cm if accelerations or vibrations must be expected during operation. Coaxial cables may generate spurious charges if moved, affecting the measurement.

Remote control Operate/Reset:

This is connected only if the switchover from waiting (Reset) to measuring readiness (Operate) is to be effected neither "manually" nor via one of the interfaces. The cables used are uncritical; they need not be either shielded or highly insulating.

As control element a mechanical switching contact or a logic may serve.

To enhance the immunity to interference the remote operating inputs may be operated with higher voltage. Above 5 V DC operating voltage the noise levels and hysteresis increase in proportion to the operating voltage. Depending on the function desired (active Low or active High), connection is made according to Fig. 4 or Fig. 5.

Active Low:
Set switch of appropriate channel to "Low". When controlling with logic, connect logic output to channel input (CH) and GND (0V DC) connection.

Note:
Active low means that the active state (measuring readiness, i.e. operation) is reached when the logic output is at "Low".

Active High:
Set switch of appropriate channel to "High". Negative pole of voltage source to GND connection. When controlling with logic, logic output at channel input (CH) and logic ground to GND.

5.3 First commissioning

When putting the instrument into operation the first time it would be advisable to connect a simple charge source such as a hand calibrator Z 13 734 or some other calibrator if one is available, instead of a sensor. At the signal output any DC multimeter able to indicate voltages in the ±10 V range is sufficient. Both instruments are connected first to channel 1.

```
   Checksum Error
RS/OP for Coldstart
      or send
 'CK' for Coldstart
```

This display may appear after switching the power on. It means that an initialization procedure must be started, for example by pressing the <Operate> key.

```
 Kistler Instr. AG
RAM Test EPROM Test
```

The display following confirms the start of internal test programs for verifying the internal RAM and ROM.

```
       Hello

     Test o.k.
RAM Test EPROM Test
```

Successful completion of the tests is now confirmed and at the same time the software version number is displayed.

```
     MAIN MENU
   Set Parameter
RS232C-Interface off
 IEEE-Interface on
```

If the instrument was already initialized when the power switch was turned on, as will be the case in normal operation, then after a brief display "RS/OP for Coldstart" you get into this **main menu.**

```
     Channel 1
TS9.99E+1   SC1.00E+1
LP   off     TC   long
OP Enb    Monitor off
```

By pressing the <Menu> key you get into the charge amplifier parameter menu.

The arrangement of the controls mentioned in the following text is shown in Fig. 9. The corresponding item number is bracketed ( ). If the LCD shows the values as in the above example, this means:

<Channel 1>: Measuring channel 1 is active and the Reset-Operate control is enabled: <Operate Enable>. If another measuring channel is to be enabled for display and editing, switchover is effected with keys <Select> (6) and (7) and <Edit> (9) and (10).

<TS9.99E+1> and <SC1.00E+1>:

With these the default values of the sensor sensitivity (pC/M.U.) and the scale factor (M.U./V) are displayed. It is best to do an example yourself, starting from the available charge source.

If the charge source is a charge calibrator for example, on which you can adjust the charge directly in pC (hand calibrator Z 13 734), then the M.U. cancels out when you multiply TS and SC, giving the sensitivity of the relevant measuring channel in pC/V.

In the following example the instrument is operated manually, i.e. not through one of the interfaces.

Example:
If a value of 10 pC/M.U. (TS1.00E+1) is put in for TS and value of 10 M.U./V (SC1.00E+1) for SC, the multiplication then yields 100 pC/V, i.e. 1 V output voltage for 100 pC input charge. The full output voltage range of ±10 V thus corresponds to a charge measuring range of ±1000 pC.

Be sure to bring the charge amplifier into the "Operate" state (key 1) **immediately before** switching-on the charge source. The status is confirmed by the green LED of the measuring channel in question. If the <Operate> key is ineffective, the selected measuring channel has been switched to <Operate Disable> or else <Operate Remote> is active.

To edit the values <TS> and <SC>, use the keys <Menu> (4) and then <Edit> (9), (10) and (8). With <Select> (6) and (7) you move within the menu from one parameter to the next, with key (8) within a parameter from one place to the next.

<LP OFF> This stands for "Low Pass = Off", i.e. the selectable low-passfilter is (still) switched off. If the word <OFF> is selected with keys <Select> (6) and (7), with the keys <Edit> (9) and (10) the low-pass filter can then be switched on and a particular limit frequency adjusted. In the above example with the (static) charge source the low-pass filter has no effect of course.

<TC LONG> With the measuring channel switched on, the longest possible time constant is effective, i.e., it is prepared for quasistatic measurements. As explained above, here too a certain value may be adjusted with the <Select> and <Edit> keys. It is defined in seconds and not as lower limit frequency in Hz, since we are in a very low frequency range here. Apart from the <LONG> adjustment two other values may be selected as well, though the application is confined to the domain of dynamic measurements (e.g. vibration).

If with the values of the above example and TC = 100 sec. the test with a static charge source is repeated, the slow drop of the output voltage starting from 10 V is easily observable. If the charge source is now switched off, still in the operate status, the output voltage then jumps first to minus before dropping back to zero again. The status of a time constant switched on is indicated on the corresponding charge amplifier by a red LED. In the above example the term <Medium> corresponds to 100 sec. and <Short> to 1 sec.

It is reiterated that the adjustments for TS, SC, LP, TC and the <Operate Enable/Disable> status may be selected differently at will for each charge amplifier channel. If you familiarize yourself with the adjustment possibilities of the Type 5019B by "playing" with it, as in the example given above, interactive manual operation should present no problems.

5.4 General operation

The basic procedure for adjusting the various parameters has been explained with the example in subsection 5.3. For general operation in practice there are a few further remarks to be observed:

After switching off the instrument or a power failure, the various adjustments remain stored in a battery-buffered module (NOVRAM). The battery integrated in this has a life of about 10 years.

When the instrument undergoes an initialization procedure, as after adding another measuring channel or changing the NOVRAM, the adjustments last put in are lost and the default values are activated again. These values are approximate means of the allowed adjustment ranges. When the instrument is switched off and on again after error messages [Range>] or [Range<], automatic reset of the TS and SC parameters to the default values ensues. The allowed adjustment ranges are:

TS = (1.00E-2 ... 9.99E+3) pC/M.U.	Default = 9.99E+1
SC = (1.000E-3 ... 9.99E+6) M.U./V	Default = 1.00E+1
LP (Tiefpassfilter) 10 Hz ... 30 kHz	Default = OFF
TC (Zeitkonstante) Long, Medium, Short	Default = LONG *)

*) **Note:**
The time constant for medium and short may be read off directly in seconds from the LCD. Its value depends on the parameters TS and SC. The adjustment ranges specified above for TS and SC cannot always be fully exploited, since both together determine the measuring range. If the product TS • SC lies outside certain limits, an error is signalled in the LCD and the red error LED of the measuring channel concerned flashes till the adjustment is corrected. The admissible adjustment range for TS and SC is graphed in Fig. 11.

The parameter adjusting keys can be locked with the <Cursor Lock> slide switch on the front in the <Lock> position. The functions of the other keys remain unaffected.

With the filter setting <LP> the upper limit frequency of the selected measuring channel is matched to the particular application. The following (–3 dB) limit frequencies may be selected:

10 Hz	30 Hz	100 Hz	300 Hz
1 kHz	3 kHz	10 kHz	30 kHz

If LP = OFF is set, the "natural" limit frequency of the measuring channel is effective. Depending on the range capacitor switched-in and the effective ground capacitance, up to 180 kHz is reached. It is possible in principle to work with external plug-in filters additionally, both on the input and output sides. For this the data sheets 12.5321 and 12.5323 may be consulted.

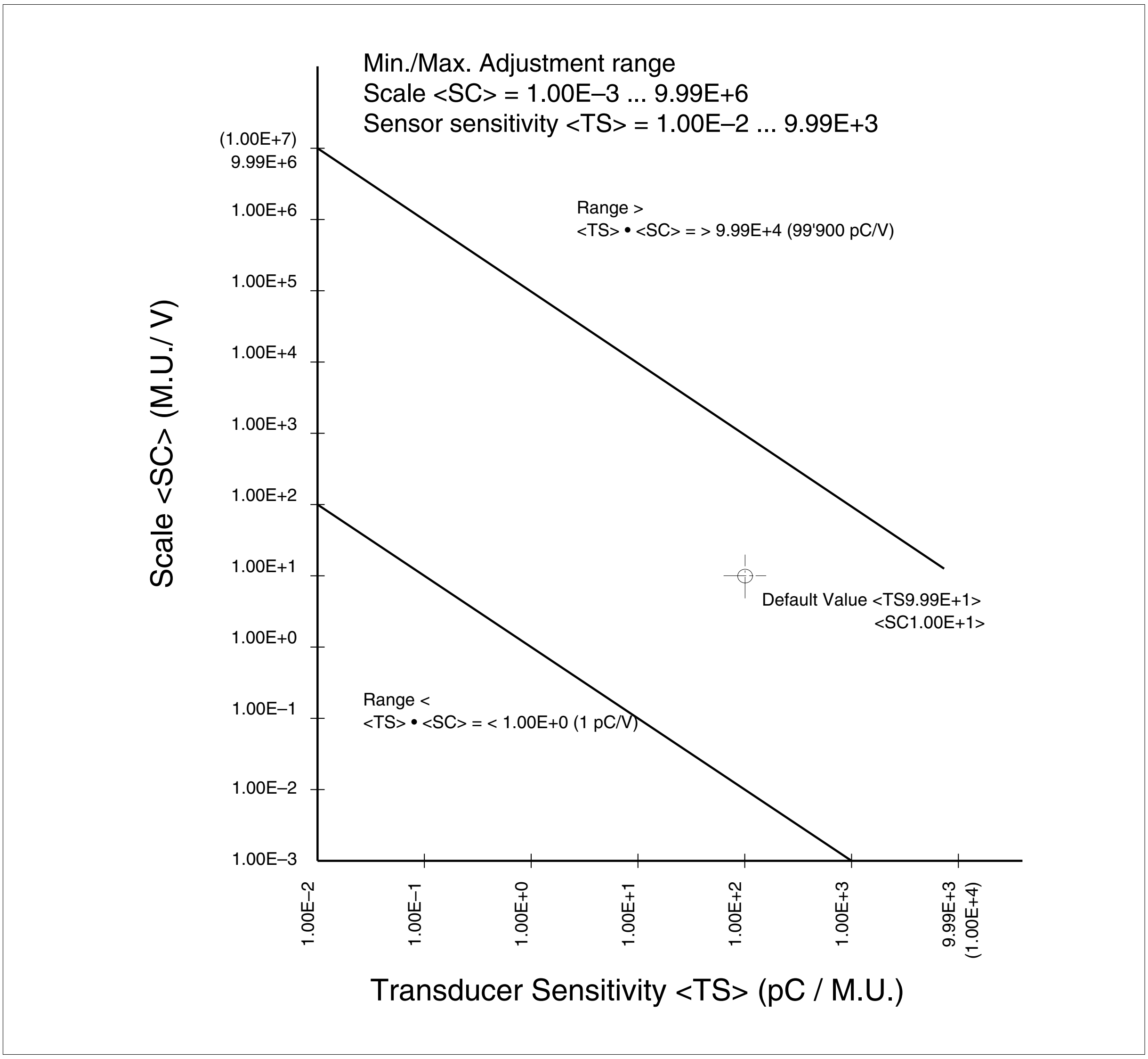


Fig. 11: Adjustment ranges for TS and SC

5.5 Operating philosophy

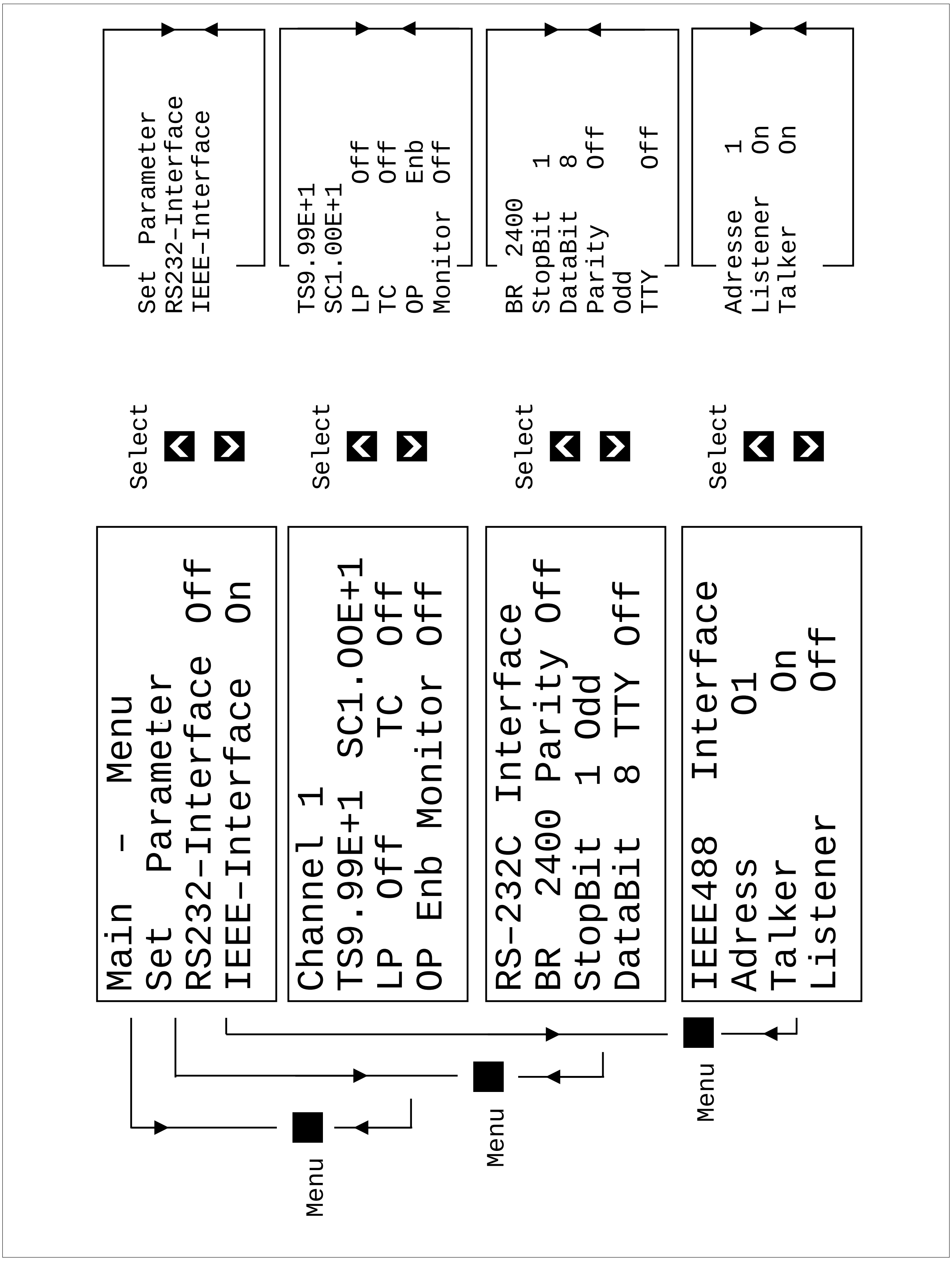


Fig. 12

5.6 Typical application

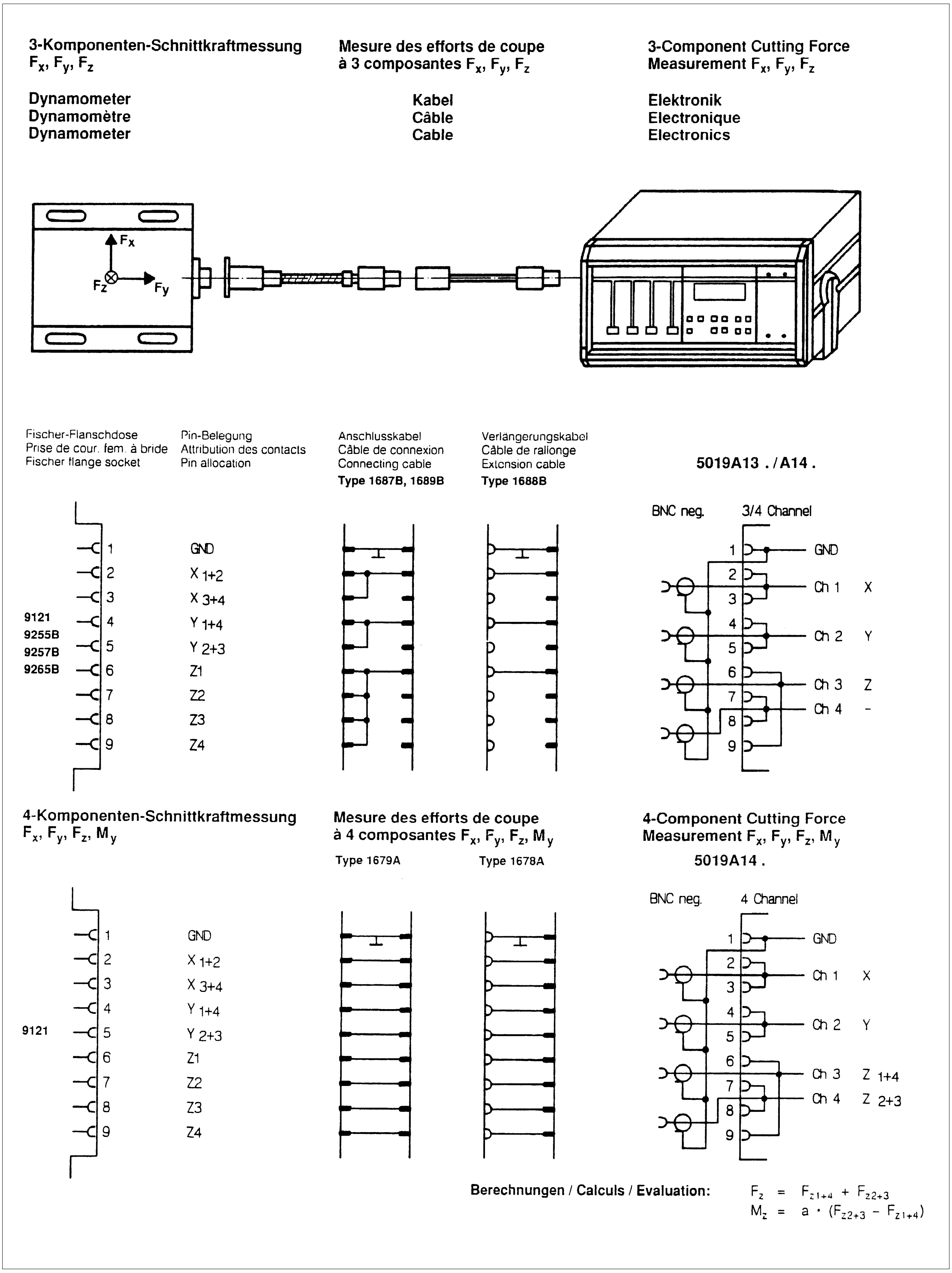


Fig. 13

5.7 How to work with piezoelectric measuring instruments

When working with piezoelectric measuring instruments it must be borne in mind that they differ from other instrumentation in that they process electrical **charges.** Such equipment is especially suited for dynamic and quasistatic measurements, but other criteria apply than those governing current or voltage measurements for example. Static measurements over long time are basically impossible.

When **unpacking** the sensors and special cables, make sure that their connectors remain clean and dry so that their high insulation resistance is retained.

The teflon insulator of all **socket connections in the input circuit** must be kept absolutely clean and must not be touched with the fingers. If the insulation is no longer assured, only extremely clean cleansing agents may be used, such as Type 1003 cleaning spray from KISTLER, Arklone 113 or rectified benzene, together with a paper cloth that does not shed fibres.

For **connecting** the sensors to the charge amplifier only low-noise special cables conforming to data sheet 15.011 may be used. Ordinary commercial coaxial cables would generate triboelectricity and falsify the measured result.

When **several sensors** are paralleled the charge amplifier measures the sum of all charges.

Application example:
A typical example is the paralleling of four force measuring elements and measuring the total force.

The **polarity** of the sensor signal is normally negative (pressure increase generates **negative** charge). In the charge amplifier the negative charge is converted into a positive voltage.

Cables must be short-circuited before connecting them to the charge amplifier, otherwise there is a danger of destroying the input MOSFET. The charging may be due to a highly loaded sensor for instance. To discharge, use a short piece of wire or a screwdriver, shorting the middle pin of the plug with the plug housing.

When working on the installation (connecting sensors and cables) the chargeamplifier must be at [Reset]. It is advisable to adjust the largest scale. The same precautions are advisable after longer out-of-operation times.

The **time constant** of the charge amplifier must normally be set to [Short] or [Medium] for measuring dynamic processes or during pauses, in order to avoid drift. Switchover to [Long] is needed only for quasistatic measurements or calibration.

Ground loops may cause interference. This may be remedied by mounting the sensor insulated from the measuring object, or using insulating couplings in conjunction with separate ground lines (insulating couplings Type 1737, 1739).

Overdriving by excessively strong charge signals will not harm the amplifier in principle, though with more than tenfold overdrive the charge may generate an inadmissibly high voltage. The voltage level depends on the charge, the total input capacitance (sensor and cable capacitance) and the range capacitor.

Example:
A load washer Type 9041 (–4,2 pC/N) loaded with 60 kN delivers a charge around 250'000 pC. Total capacitance, with short connecting cable and in the most sensitive range of the charge amplifier, is typically 250 pF. In this example the voltage reaches 1000 V and would destroy the input MOSFET.

To avoid **brief saturation** due to charge peaks (caused typically by impact or structure-borne noise with acceleration sensors) we advise using an input (RC) filter such as Type 5321A...

5.8 Error signals

Error signals are put out on the two bottom lines of the LCD or by the red LED arranged at the top for each measuring channel. The error display is intermittent.

5.8.1 Error signals while starting

"Checksum Error RS/OP for Coldstart or send CK for Coldstart"
This message appears for example when a charge amplifier board is fitted or removed. It is cleared by pressing <Operate>.

"SRAM - Error remove Nonvolatile SRAM":
The battery-buffered storage module or its battery is defective and the unit must be replaced.

"EPROM Error remove EPROM":
A defect on the EPROM memory module containing the operation software.

5.8.2 Error signals during operation

"Out of Range>>":
The admissible measuring range is too small. The error signal disappears as soon as the values of [TS] and [SC] give an admissible range.

"<<Out of Range":
The selected measuring range is too small; the error signal disappears as soon as the [TS] and [SC] values yield an admissible range.

"Overload":
The signal at the charge amplifier output has exceeded the maximum admissible value of ±10 V. This message and the flashing of the LED belonging to the charge amplifier appear even if the overloading was only brief, i.e. the affected measuring channel functions normally again as soon as the signal lies inside the admissible range once more, but the error signal remains till it is cleared by <Reset>.

"Out of Zero":
This signals excessive zero offset of the charge amplifier in the <Reset> state. The cause may be a defective MOSFET for example, or a wrongly adjusted trimmer potentiometer, or else a fault on the automatic zero correction (see 8.2: Replacing the input MOSFET).

"Range Change during Operate":
This means an attempt has been made to alter one of the parameters [TS] or [SC] during the <Operate> state.
Remedy: <Reset> and then correct the adjustment.

"Syntax Error"
This appears after an incorrect command input.

"I/O Buffer Overflow"
The input string is too long or an output has been requested which cannot be made ready completely in the output buffer.

"RS 232C Overrun Error"
Transmission error via the serial interface.

"Frame or Parity Error"
Transmission error of the serial interface.

5.9 Troubleshooting

The troubleshooting tips below are confined to localizing the defective part, and are not intended for carrying out repairs.

When troubles occur on the measuring installation the fault can be localized by proceeding methodically. With the specifically piezoelectric elements of the measuring chain proceed as follows:

- Connect the signal output in question with an oscilloscope (DC mode)
- Switch the charge amplifier to [Short] and for a brief moment to [Reset].
  Observe the reaction of the charge amplifier output voltage:

No output signal despite dynamic loading of the sensor:

- Make sure that the mains voltage is present and all instruments are switched on.
- Check the [TS] and [SC] adjustments. They may be too insensitive.
- Inspect all input cables. A plug may have come loose.
- Apply a known charge at the signal input (with charge calibrator 5357A or hand calibrator Z 13'734 for example). If there is still no output signal, the charge amplifier is defective. In an emergency a battery in series with a highly insulating capacitor will suffice as charge source.
- If an output signal appears, however, it must be assumed that one of the cables or sensors is defective, or disconnected. By systematically replacing the individual parts the one at fault is revealed.

Output signal approx. ± **12 ...** ± **15 V** (positive or negative saturation):

- Disconnect the input cable and switch to [Reset]. If the output voltage is still unchanged, the charge amplifier channel in question is defective.
- If the output voltage now returns to zero, this means a short-cicuit on one of the input cables or sensors. Uncouple one by one, afterwards switching briefly to [Reset] each time, till the defective part is found.

Drift (zero change at <Operate>):

- If the drift with the most sensitive (lowest) adjustment of the amplifier (equivalent to [TS] ·[SC] = 1 pC/V) is much more than 30 mV/s (= 0,03 pC/s), an attempt must be made to find the reason. It is usually poor insulation or a defective MOSFET.

6 Operating via parallel interface IEEE-488

6.1 Introduction

The parallel interface conforms to the standards IEEE-488-1978 and IEC 625-1, which are functionally identical.

To operate the interface, computer support is required in accordance with the standard.

6.2 Technical data

Standard	IEEE-488-1978
Distance between 2 instruments	2 m maximum
Maximum length of bus	20 m
Maximum number of instruments	15 on the bus
Address range	0 ... 30
Function	listener, talker
Input buffer	95 bytes
Output buffer	255 bytes
Interface functions	SH1, AH1, L3, LE0, T5, TE0, SR1, RL1, PP0, DT1,C0, E1
Multiline commands	LLO, GTL, UNL, UNT, SPE, SPD
Uniline commands	IFC, REN, EOI, SRQ, ATN

6.3 Function

The purpose of the standard interface is to decode the instructions sent by the computer via the standard bus cable and transmit them on to the processor system of the Type 5019B . In the case of the IEEE-488 computer interface a different address is allocated to each instrument connected, with address numbers 0 ... 30 allowed. In many computer configurations, however, not all addresses are still freely selectable.

An amplifier adjusted as receiver (listener) may receive data from the control computer. Data transmission is in ASCII format (**A**merican **S**tandard **C**ode of **I**nformation **I**nterchange). For data exchange from the Type 5019B to the computer the instrument must be adjusted as sender (talker).

The Type 5019B can be switched for both functions simultaneously (talker and listener).

In the present case all amplifier parameters can be remote-controlled via the interface. Not implemented is the transmission of measured data, because this would necessitate an additional A/D converter and appropriate software for the particular application.

6.4 Controls and connections

The arrangement of the connections is shown in Fig.10.

6.5 Operation

6.5.1 Instruction line (input buffer)

For each line several adjustment and query commands (instructions without parameter field) may be strung in any sequence. An instruction line must be concluded with a valid terminator.

Terminator:

<CR> <LF>	with / without EOI
<CR>	with / without EOI
<LF>	with / without EOI
only EOI	

Command structure:

header field --> parameter field --> separator

header field 2 characters

parameter field 1...7 characters

allowed separators , ; : /

blanks are ignored when putting-in

large or small letters allowed

separator may be omitted at last instruction in the line

instruction **without** parameter field:
query parameter adjusted momentarily

Processing an instruction line:

- After recognizing the terminator, the instruction line is worked off one command after another, carrying out every instruction at once except the adjustment commands TS and SC.
- The adjustment commands TS and/or SC are executed only after processing the instruction line.
- In the display the menu is shown according to the last command executed.

Buffer overflow:

Further characters are checked only for terminators. Error bit "Overflow" is set and service request (SRQ) triggered if necessary.

Syntax error:

Further command processing is interrupted. Error bit "Syntax" is set and service request (SRQ) triggered if necessary.

Query commands:

The momentarily adjusted parameter, together with the header field and separator, are taken from the input buffer into the output buffer ready for querying.

6.5.2 Dealing with errors

For each kind of error a bit is assigned in the error byte and serial poll register. The SRQ condition byte is built up similarly.

Values:

Bit 2^0	syntax error in input line
Bit 2^1	overflow on in- or output buffer
Bit 2^2	end of input line reached
Bit 2^3	parameter checksum error
Bit 2^4	charge amplifier error
Bit 2^5	RAM R/W error
Bit 2^6	(reserved for SRQ)
Bit 2^7	EPROM error

- Once an error occurs it stays in the error byte and serial poll register till it is rectified (charge amplifier error, EPROM error, RAM R/W error, parameter checksum error) or rendered invalid by a new instruction line (syntax, overflow, charge amplifier error, end of input line).
- After concluding the processing of the instruction line the error byte is updated (syntax, overflow, end of input line reached), filed in the serial poll register and service request (SRQ) triggered if necessary.

End of input line:

This bit is set if the instruction line has been worked off without syntax errors.

Local (manual operation):

Error byte and serial poll register are likewise updated (adjusting errors, overload, zero), service request (SRQ) triggered if necessary.

The following adjusting errors may occur:

[TS Sensor Sensitivity] outside the valid range

[SC Scale] outside the valid range

[TS · SC] adjustment range outside the valid range

Unallowed parameter change in [Operate] setting

The charge amplifier error byte is coded in detail in subsection 6.5.4 Instruction set.

- The SRQ conditions are set by the CS instruction.
- The error byte may be queried with the command CE (transfer in decimal form with two ASCII digits) or with serial poll (transfer in binary form).

6.5.3 Query line (output buffer)

At every query command the momentarily adjusted parameter together with the separator from the input buffer is made ready in the output buffer for querying.

Structure

Header field-->parameter field-->separator

Header field	2 characters (capital letters)
Parameter field	1 to 7 characters
Separator	taken from input line

Terminator:
The query line is concluded with the terminator agreed in accordance with command CT. The last byte is always sent with EOI.

Empty output buffer:
Only the terminator agreed according to the CT command is sent as reply. The last byte is always sent with EOI.

Buffer overflow:
Queries which would make the output buffer overflow are not filed. Further queries are ignored and the "Overflow" error bit is set.

Apart from monitoring, queries serve also for "learning" a valid adjustment.

6.5.4 Instruction set

Parameter commands:

LV*n* Charge amplifier (LV) selection

n=0	set all	LV	with same parameters
n=1	-->	LV 1	
n=2	-->	LV 2	
n=3	-->	LV 3	
n=4	-->	LV 4	

Important:

Charge amplifiers must be selected **before** every parameter command. If parameters are arrayed in a string, the selection must be made only once at the beginning of the string. If a control command is inserted in the string, the charge amplifier selection must be repeated.

OE*n* Operate Enable/Disable

n=0 --> Disable
n=1 --> Enable

TS*n.nn*E±e Sensor sensitivity
Adjustment range: 1.00E-2 ... 9.99E+3

Example: TS2.45E+0 for 2,45 pC/M.U.

SC*n.nn*E±e Scale
Adjustment range: 1.00E-3 ... 9.99E+6

Example: SC 5.00E-2 for 0,05 M.U./Volt

Any input format is admissible for TS and SC, for example TS2.45 or TS.245E+01.

TCn Time constant

n=0 --> switchover to [Long]
n=1 --> switchover to [Short]
n=2 --> switchover to [Medium]

LPn Low-pass filter

n=0 --> filter switched off [OFF]
n=1 --> 10 Hz
n=2 --> 30 Hz
n=3 --> 100 Hz
n=4 --> 300 Hz
n=5 --> 1 kHz
n=6 --> 3 kHz
n=7 --> 10 kHz
n=8 --> 30 kHz

ROn Reset / Operate

n=0 --> Reset
n=1 --> Operate

Option:

V = Measured value querying from any channel.The channel **must** be selected with the parameter selection LVn. Only **one channel** at a time may be queried. The channel selection LV0 for all channels is eliminated. The measured value is displayed exponentially,
e.g. 3.25E+0.2.

Control commands:

CH*n* Header for output line

n=0 --> without header
n=1 --> with header

CL*n* Switchover unlocked/locked

n=0 unlocked
n=1 locked

(in IEEE mode query command only)

CN Output of number of charge amplifiers mounted

CR*n* Switchover local/remote
(for RS-232C operation only)

n=0 --> local
n=1 --> remote

CS*nnn* SRQ condition --> instrument reports at corresponding error (not available with RS-232C)

nnn = sum of bit values (value to be adjusted)

Bit 2^0	syntax error in input line
Bit 2^1	overflow on in- or output buffer
Bit 2^2	end of input line reached
Bit 2^3	parameter checksum error
Bit 2^4	charge amplifier error
Bit 2^5	RAM R/W error
Bit 2^6	SRQ actuated
Bit 2^7	EPROM error

Example: SRQ for syntax, overflow and charge amplifier errors:

$2^0 + 2^1 + 2^4 = 1 + 2 + 16 = 19$
Command = CS019 (always 3 digits)

Bit 7 --> signals whether an SRQ condition has been set or not:

Bit 7 --> 1 : SRQ condition set
Bit 7 --> 0 : SRQ condition not set

After a fulfilled SRQ condition the error byte may be queried by serial poll.

CT*n* Terminator Type

n=0	-->	<CR> <LF>	with EOI
n=1	-->	<CR>	with EOI
n=2	-->	<LF>	with EOI

Note: EOI is not present in the instruction set of the serial interface RS-232C.

CU Instrument identification via interface

CV*n.nn* Software revision number query

CX*n* Remote (external) operate enable

n=0 --> Disable
n=1 --> Enable

OR*n* Clear overload error message
n=0 no action
n=1 clear error message

CO A/D converter board mounted
n=0 option not provided
n=1 option provided

(query command only !)

Error query:

CE*nnn* Query instrument-specific error byte

nnn=decimal sum of error byte

Weight	1:	syntax error in input line
Weight	2:	input or output buffer overflow
Weight	4:	end of input line reached
Weight	8:	parameter checksum error
Weight	16:	charge amplifier error
Weight	32:	RAM R/W error
Weight	64:	RS-232C transmission error or SRQ actuation
Weight	128:	EPROM error

Note:

When "Weight 16 (ch. ampl.) error" occurs, it must be with the next query "LV*n*;CCmm" which charge amplifier and which error are involved:

LV*n*;CC*mm*	Query ch. ampl. error byte
n = 0 -->	query all ch. ampl. error bytes
n = 1 -->	LV 1
n = 2 -->	LV 2
n = 3 -->	LV 3
n = 4 -->	LV 4

mm= decimal sum of error byte put out

Weight 1:	minimum measuring range understepped
Weight 2:	maximum measuring range exceeded
Weight 4:	range change during [Operate]
Weight 8:	overload
Weight 16:	zero error

6.5.5 Typical program for computers with IEEE-488 interface

System configuration:

Software:	Microsoft Quick Basic V4.5
Hardware:	IBM AT or compatible IBM AT with Keithley PC < > 488 interface board with driver software CEC 488 from version 2.05 for Quick Basic
Instrument address for 5017B/5019B	5
Sensor sensitivity	–4.3 pC/N
Measuring range	200 N
Scale	20 M.U./V
Filter	300 Hz

The example sets the parameters for the 1st charge amplifier (LV1) and queries the error byte constantly. If an error occurs, an error signal is displayed on the screen and the program is stopped.

```
CALL initialize (31.0)                              'Initialize system
CALL send (5, "LV1;RO0", status%)                   'Reset
CALL send (5, "LV1;TS4.3;SC20", status%)            'Sensor sensitivity '–4.3 pC/N
                                                    'Scale 20 M.U./V

CALL send (5, "LV1;LP4", status%)                   'Filter 300 Hz
CALL send (5, "LV1;RO1", status%)                   'Operate

r$ = "CE000"                                        'Initialize variable r$

WHILE r$ = "CE000" OR r$ = "CE004"
      CALL send (5, "CE", status%)                  'Query command for error byte

      IF status% < > 0 THEN PRINT status%: STOP     'Provide space for error byte
      r$ = SPACE$(30)

      CALL enter (r$, length%, 5, status%)          'Read-in error byte
      IF status% < > 0 THEN PRINT status%:STOP      'IEEE bus error
      r$ = LEFT$ (r$, length%)                      'Format data string
WEND
CLS                                                 'Clear computer screen

SELECT CASE r$                                      'Verify error
 CASE "CE001"
              PRINT "Syntax error in input line"
 CASE "CE002"
              PRINT "In- or output buffer overflow"
 CASE "CE008"
              PRINT "Parameter checksum error"
 CASE "CE016"
              PRINT "Charge Amplilfier error"
 CASE "CE032"
              PRINT "RAM R/W error"
 CASE "CE064"
              PRINT "Reserved for SRQ"
 CASE "CE128"
              PRINT "EPROM error"
END SELECT
END
```

7 Operating via serial interface RS-232C

7.1 Introduction

The standardized serial interface makes possible a point-to-point connection between a computer and the Type 5019B. Via this link all parameters can be adjusted and queried. A measured value query is possible with the optional A/D converter board for signal display, Type 5261.

7.2 Technical data

Standard	RS-232C or V24
Distance between 2 instruments	20m max. (max. cable capacitance 2500 pF)

Switch settings (read after power-up):

Baud rates	110, 300, 600, 1200, 2400, 4800, 9600
Data bits	7 or 8
Stop bits	1 or 2
Parity	without, even or odd
Input buffer	95 bytes
Output buffer	255 bytes

Software protocol XON/XOFF admissible

7.3 Function

The interface decodes the instructions sent from the computer and directs them on to the control system of the Type 5019B. The computer can also make the interface send various data requested.

Data transmission takes place in ASCII format. The number of data bits, stop bits and the transmission speed are adjusted with coding switches on the rear of the instrument.

7.4 Controls and connections

The arrangement of the connections is shown in Fig. 10 (view of rear plate).

7.5 Operation

7.5.1 Commissioning

Parameter reinitialization and self-test:

[Power]	switch on mains power
[Operate] [Reset]	press key

The instrument performs a self-test, during which the parameters are initialized anew.

Display:

```
KISTLER Instrumente AG
Result of RAM/ROM test
and software version number
```

With <Select> set the cursor to the IEEE interface in the main menu.

With <Edit> change the interface from IEEE-488 to RS-232C.

With <Menu> go to RS-232C interface.

Display:

BR = baud rate

Parity = [Off] = no parity
[Even] = even parity
[Odd] = odd parity

Stop bit = [1] or [2], number of stop bits

Data bit = [7] or [8], number of data bits

TTY = [Off] or [On], operating mode TTY

Note:
Depending on the serial number of the installation, the values displayed may be altered either on the back DIP switches or edited interactively with the LCD using the keys on the front.

After this the <Menu> key is used to return to the main menu.

The interface is initialized automatically after every parameter change.

7.5.2 Setting the TTY interface

The TTY interface is initialized via the control unit in the RS-232C interface menu. The addresses 0 to 3 are available. The active and passive switchover of the interface takes place on the controller board.

Procedure:

Disconnect the instrument from the mains power.

To make the adjustments the front plate must be removed with the manual control and the controller board behind it drawn out of its guides. For this purpose the four fixing screws must be unfastened and the front plate pulled out of its socket connection.

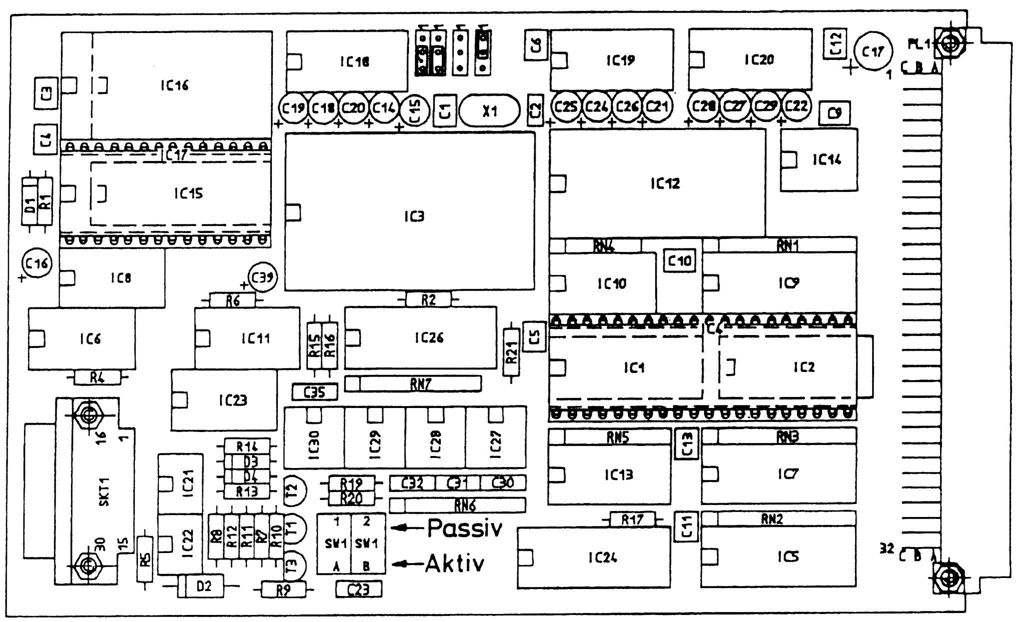


Fig. 14: Controller printer circuit board

Setting the TTY receiver

Fig. 14, below:--> active/passive with switch SW1A

Setting the TTY transmitter

Fig. 14, below:--> active/passive with switch SW1B

After making the adjustments the controller board is pushed into its guides again. A little pressure is necessary to reestablish the socket connection. The front plate is then fitted with the manual controls and screwed down.

Reconnect the instrument to the power supply.

Instruction set for current loop (TTY)

^A select 5019B with address 0
^B select 5019B with address 1
^C select 5019B with address 2
^D select 5019B with address 3

The instrument address is to be sent immediately before the command and without separator.
E.g. ^ALV0:TS:SC for outputting the sensor and scale adjustments of all channels.

Connecting Type 5019B in a current loop (TTY)

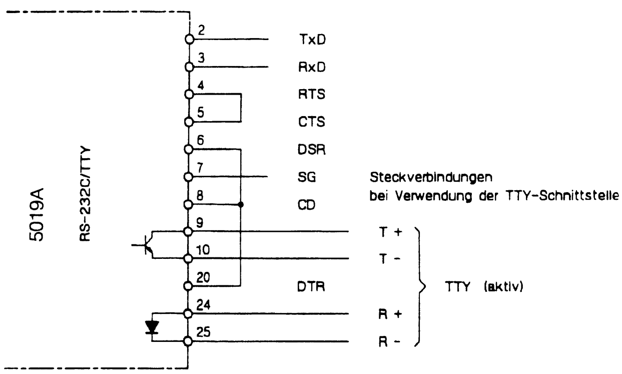


Fig. 15: TTY connection

Note:

- Use zero modem circuit
- Send instrument address even if only **one** instrument is connected

7.5.3 Instruction line (input buffer)

On each line several adjustment and query instructions (i.e. commands without parameter field) may be arrayed in any sequence. Each instruction line must be concluded with a valid terminator.

Terminator: <CR> <LF> or <CR> or <LF>

Command structure:

Header field --> parameter field --> separator

Header field	2 characters
Parameter field	1 ... 7 characters
Separators allowed	, ; : /

Blank characters are ignored when put in
Capital or small letters allowed
Separator may be omitted at the last command

Command **without** parameter field: query of the momentarily adjusted parameter

Processing an instruction line:

- After recognition of the terminator the instruction line is worked off one command after another, each command being executed at once, except the adjustment commands TS and SC.
- The adjustment commands TS and SC are executed only after the instruction line has been processed.
- The display shows the menu according to the last command executed.

Buffer overflow:
Further characters are verified only for terminators.The "overflow" error bit is set.

Syntax error:
The processing of further commands is discontinued.The "syntax" error bit is set. Transmission errors lead to a syntax error additionally.

Query commands:
The momentarily adjusted parameter is taken from the input buffer into the output buffer ready for querying, together with the header field and the separator.

7.5.4 Dealing with errors

For every kind of error a bit is assigned in the error byte.

Weight:

Bit 2^0 syntax error in input line
Bit 2^1 in- or output buffer overflow
Bit 2^2 end of input line reached
Bit 2^3 parameter checksum error
Bit 2^4 charge amplifier error
Bit 2^5 RAM R/W error
Bit 2^6 RS-232C transmission error
Bit 2^7 EPROM error

- Once an error occurs it remains in the error byte and serial poll register till the error ist corrected (charge amplifier error, EPROM error, RAM R/W error, parameter checksum error) or rendered invalid by a new command line (syntax, overflow, charge amplifier error, RS-232C transmission error, end of input line).
- After concluding the processing of the command line, the error byte is updated (syntax, overflow, transmission error, adjustment error).

The following adjustment errors may occur:

- [TS sensor sensitivity] outside its valid range.
- [SC Scale] outside its valid range.
- [TS · SC] adjustment range outside its admissible limits
- Unallowed parameter change in [Operate] setting

The charge amplifier error byte is explained in detail in subsection 6.5.4: Instruction Set.

- End of input line:
  This bit is set if the instruction line has been worked off without syntax errors.
- Local (manual) operation:
  The error byte is likewise updated (adjustment error, overload, zero).
- The error byte may be queried with the command CE (transmission in decimal form with two ASCII digits).

7.5.5 Query line (output buffer)

At every query command the momentarily adjusted parameter is taken from the input buffer into the output buffer ready for querying, together with the header field and separator.

Command structure:

Header field --> parameter field --> separator

Header field	2 characters (capitals)
Parameter fielf	1 ... 7 characters
Separator	taken from input lines

Note: For CH0 the header field is omitted

- Terminator:
  The query line is concluded with the terminator agreed according to the command CT.
- Empty output buffer:
  Only the terminator agreed according to the command CT is sent as answer.
- Buffer overflow:
  Queries which would cause an output buffer overflow are not filed. Further queries are ignored and the overflow error bit is set.
- Besides monitoring purposes, queries serve also for "learning" a valid adjustment.

7.5.6 Instruction set

This is summarized in subsection 6.5.4: Parallel interface, Instruction set, which applies also to the serial interface. Minor differences in the interface commands are pointed out in this subsection.

8 Maintenance

8.1 Safety rules

If it is to be assumed that safe operation is no longer possible, the instrument must be taken out of operation and secured against inadvertent starting. Refer to subsection 2.1.

8.2 Replacing the input MOSFET

- If LCD [Out of Zero] and [Error] lamp flashes.
- If drift > 30 mV/s with adjustment [TS] • [SC] = 1 pC/V;

Procedure:

- Disconnect instrument from mains power.
- Remove left-hand part of front plate after unfastening the fixing screws.
- Carefully pull out the charge amplifier board whose error lamp is lit, drawing it only by the two aluminium fixing angles at the top and bottom of the board.
- After unfastening the three fixing screws the two shielding plates can be removed. The MOSFET input transistor (KISTLER article No. 5.811.019) plugged into its teflon-insulated mounting can now be changed using tweezers or suitable pliers.

Note:

MOSFET components are destroyed by static charges. Consequently the person handling them must be grounded, preferably with a commercial grounding armband. Also avoid seizing the MOSFET by one of its connecting wires first; always touch its housing first.

- After changing, fit the shielding plates. Carefully push the amplifier unit into the basic instrument.
- If the new MOSFET input stage is to operate with the smallest possible drift, a zero adjustment must be made in the [Reset] state. Prior to this the installation should have been operating about 60 minutes. The adjustment is effected with the bottom trimmer potentiometer immediately above the (bottom) fixing angle. A commercial multimeter with a range of typically 200 mV and ≥ 1 MΩ input resistance will suffice as zero indicator. The multimeter is connected to the [Charge Input].

8.3 Calibrating the charge amplifier

The processor-controlled charge calibrator Type 5357A should be used preferably for calibrating. The procedure is explained in the operating instructions for that instrument.

If no special charge calibrator is available, as a stopgap a DC reference voltage source may be used in conjunction with a calibrating capacitor.

Example:
If a charge signal is to be generated, as a piezoelectric pressure sensor with a sensitivity of say –78.2 pC/bar would yield for a pressure rise of 50 bar, the necessary calibration charge is calculated first:

Q = –78.2 pC/bar · 50 bar = –3910 pC.

Since the calibration voltage may not exceed ±30 V and calibrating capacitors are available only in decadic grading, a calibration voltage of –3.91 V and a capacitor of 1000 pF (Type 5371A1000) are selected.

Q = U · C = -3.91 V · 1000 pF = –3910 pC.

The charge amplifier inverts the signal polarity (inverting amplifier); consequently a negative charge is needed to yield a positive output voltage.

Connection:
The calibrating capacitor is connected, either in place of a sensor or paralleling this, to one of the [Sensor] sockets. The other end of the cable must be terminated with low impedance by the voltage source, in the voltage-free state too.

Adjustment:

Menu	[TS]	7.82E+1	(-78.2 pC/M.U.)
	[SC]	5.00E+1	(50 M.U./V)
	[LP]	OFF	
	[TC]	[Long]	

Switch the instrument to [Operate].
Switch on the DC reference voltage source.

A voltage of 1 V DC appears at the [Analog Output].

If 5.00E+0 (5 M.U./V) is adjusted for [SC], the output voltage is 10 V.

Note:
The calibrating capacitor must be plugged directly into the Type 5019B and not in the (more remote) voltage source. This makes the connecting cable used uncritical with regard to insulation and triboelectricity. Another advantage is that the cable capacitance is not paralleled with the input capacitance, which would increase the noise signal unnecessarily.

If the calculated and indicated values differ, this can be corrected within certain limits with the second trimmer potentiometer (from the bottom).

8.4 Drift of the charge amplifier

Any drift ascertainable at the output of a charge amplifier (slow zero shift in the course of time in [Operate] state and with time constant TC = Long) cannot be avoided within the specified tolerance of 0,03 pC/s. If this value is largely exceeded however, this can be due to one of the following causes:

Cause 1
Drift due to insufficient insulation resistance in the feedback path of the charge amplifier (e.g. poorly insulating range capacitor). This drift is always in the direction of the zero output signal.

Cause 2
Drift due to damaged or defective MOSFET input stage (the direction may be positive or negative).

Cause 3
Drift due to insufficient insulation resistance at charge amplifier input (the direction may again be either positive or negative, depending on the polarity of the input offset voltage).

Remedy may be obtained by the following measures:

With cause 1

Symptom: Exponential signal decay after applying a static charge signal.

- Check whether [Long] time constant has been selected. [Medium] or [Short] produce the same effect as insufficient insulation resistance in the feedback path.
- If the trouble persists, poor insulation resistance on the particular range capacitor selected must be suspected. The competent distributor must be approached to get the instrument repaired.

With cause 2

Symptom: The polarity of the drift does not change with the polarity of the zero offset at the input.

- **Note:** A slight drift as specified in the technical data is normal for the charge amplifier.
  If it is excessive:

  Change the MOSFET, see subsection 8.2.

With cause 3

Symptom: The polarity of the drift depends on the polarity of the zero offset at the input.

- The most probable cause is insufficient insulation resistance in the input circuit. This can be verified with an insulation tester Type 5493.

Procedure:
Clean the sensor plug or change the sensor, and clean the sensor cable (cable connections) or change the cable.

If the trouble persists, as a stopgap adjust the zero of the input stage as accurately as possible (see subsection 8.2, zero adjustment). Then contact the competent distributor to have the instrument repaired.

Note:
Cause 3 can easily be diagnosed by removing the sensor and sensor cable from the charge amplifier input and connecting a charge calibrator. Cause 3 may also be due to insufficient insulation resistance of the MOSFET.

9 Technical data

9.1 Charge amplifier Type 5019B

Charge amplifier:

Number of channels			3 or 4	
Measuring range for ± 10 V FS (5 decades)		pC	± 10 ... 999'000	
Sensor-sensitivity [TS] (selectable with three significant digits)		pC/M.U.	0,01 ... 9990	
Scale [SC] (selectable with three significant digits)		M.U./V	0,001 ... 9'990'000	a)
Errors	up to ± 99.9 pC	%	≤ ± 3	
	from ± 100 pC	%	≤ ± 1	
Linearity errors		%FS	≤ ± 0,05	b)
Frequency range –3 dB (filter OFF)		kHz	≈0 ... 200	
Frequency response error	(filter OFF)			
	up to 50 kHz	%	–1 ... +2	
	up to 200 kHz	%	–30 ... +3	
Low-pass filter (Butterworth 2-pole) (adjustable in 8 stages: 10, 30, 100...30 000 Hz ± 10%)		–3dB	10Hz ... 30kHz	
Time constant resistance				
	Long (Cg<1 nF)	Ω	$>10^{14}$	
	Medium	Ω	approx. 10^{11}	
	Short	Ω	approx. 10^{9}	
Time constant ($T = R_g \cdot C_g$)				
	Long	s	>1000 ... 100'000	c)
	Medium	s	1 ... 10'000	
	Short	s	0,01 ... 100	

a) > M.U. = mechanical unit e.g. bar, N, *g*

b) > FS = full scale (end value of measuring range)

c) > The "Long" time constant cannot be used to define the behaviour of the charge amplifier with long measuring times (quasistatic measurements). The time behaviour of the signal is then influenced predominantly by the drift (input error current).

Zero transition at Reset -> Operate switchover		pC	< ± 0,2
Drift (25°C) MOSFET-input current		pC/s	< ± 0,03
Output	output voltage	V	± 10
	overload trigger threshold	V	approx. 10,5
	maximum output current	mA	± 5
	output impedance	Ω	10
	(output short-circuit-proof)		
Interference due to input cable capacitance		pC_{rms}/pF	$< 2 \cdot 10^{-5}$
Output interference (input shielded)			
	at 9,99 pC/V	mV_{rms}	< 0,8
		mV_{pp}	< 20
	at 1 pC/V	mV_{rms}	< 1,5
		mV_{pp}	< 20
Zero error at RESET (max. / typ.)		mV	< 2 / 0,4
(automatic zero correction)			
trigger threshold for zero out of limit		mV	approx. ± 10
Temperature coefficient of zero at RESET		µV/K	approx. 10
Input voltage, maximum admissible			
(pulse duration < 0,3 s)		V	± 125

Logic

Logic input level

(Remote Operate, electrically insulated)			
with operating voltage U_B = 5 V	U_H	V	> 2,4
	U_L	V	< 0,8
operating voltage range	U_B	V	4,5 ... 33

Note:

With an operating voltage of 4,5 ... 5,5 V the level values for U_H and U_L are TTL-compatible. From 5,5 to 33 V operating voltage the levels and the hysteresis increase in proportion to the operating voltage as follows:

	U_H	V	approx. $0{,}35 \cdot U_B$
	U_L	V	approx. $0{,}17 \cdot U_B$
Protected against overvoltage up to		V	± 75
with pulse duration ≤ 0,1 s up to		V	± 300
Operate delay			
External Operate (active Low)		ms	approx. 15
External Operate (active High)		ms	approx. 15
with IEEE command GET		ms	approx. 20
with IEEE command RO1		ms	approx. 120
Reset delay			
External Reset (active Low)		ms	approx. 15
External Reset (active High)		ms	approx. 15
with IEEE command RO0		ms	approx. 120

General data:

Temperature range	for specifications	°C	0 ... 50
	for function	°C	–10...60
Voltage supply (switchable)		V AC	230/115
		%	+15/–22
		Hz	48 ... 62
Power consumption		VA	approx. 20
Dimensions (Order designation Type 5019B1...)			
Housing with setting-up / carring handle)			
DIN 41494 Part 5	width	TE	63
	height	HE	4
	width	mm	396
	height	mm	187
	depth	mm	280
Weight		kg	approx. 8

Connections:

Mains 2P + E (measuring circuit off ground)	Type	IEC 320C14 (Degree of protection I)
Remote operate	Type	D-Sub connector 25-pin accord. to DIN 41652

Pin assignment

Pin	1:	4,5 ... 33 V DC
	14:	0 VDC
	2:	CHN 1

Note: A "Remote/External Operate" for only one channel is not possible.

Maximum voltage between power system ground and signal common V_{rms} ≤ 50

Measuring inputs, types (both parallel) Fischer 9-pole/BNC neg.

Pin assignment

Channel No. (BNC)	1	2	3	4	GND
Fischer pin No	2+3	4+5	6+9	7+8	1

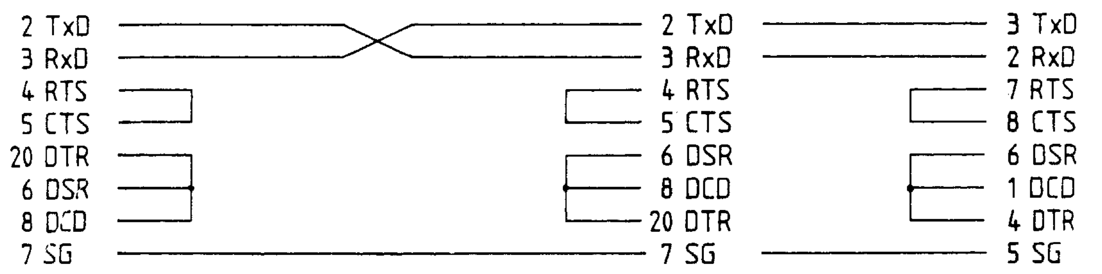
Voltage outputs, types (both parallel) D-Sub connector 15-pin/BNC neg.
Pin assignment

Channel No. (BNC)	1	2	3	4	GND
D-Sub pin No.	1	2	3	4	9

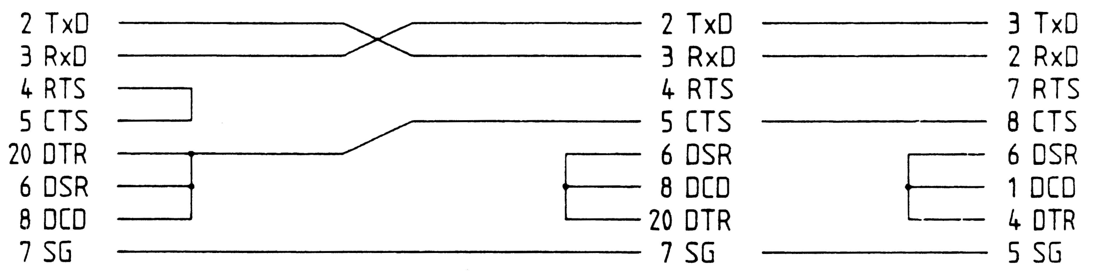
9.2 Connection assignment/cable wiring for RS-232C:

5019B (DB-25S, accord. to DIN 41652) — **PC** (DB-25P) or **PC** (DE-9P)

Without hardwired handshake, max. 1200 baud (for TTY applications):



With hardwired handshake, max. 9600 baud:



9.3 Explanations to the technical data

Below some terms from the table of technical data will be explained in more detail where this is deemed necessary for better understanding.

Note:
All designations inscribed on the actual instrument are given in square brackets in these operating instructions, e.g. [Scale].

9.3.1 Measuring range

This denotes the electrical charge generating a voltage of 10 V at the voltage output [Output 10 Ω] according to the menu adjustment [Sensor Sensitivity TS] and [Scale SC]. According to the sensor sensitivity the measuring range used in practice can be indicated in mechanical units.

The maximum charge range for 10 V output voltage is:

Range = 10 · SC · TS [pC]

On the LCD it is not the measuring range that is read off or adjusted but the scale [SC] in mechanical units per volt [mechanical units / V] for a given (adjusted) sensor sensitivity [TS] in pC/mechanical unit [Sensor Sensitivity (pC/mechanical unit)].

9.3.2 Sensor sensitivity

[TS = Sensor Sensivity (pC/mechanical unit)]

This contains the coefficient of measure for converting from mechanical units into an electrical charge. The values stated are sensor-specific and may be taken from the calibration sheet supplied with every sensor.

9.3.3 Frequency response error

These values represent the maximum deviation of the amplitude at the voltage output from the nominal value as it occurs in the medium frequency range, but not significantly above the lower limit frequency.

9.3.4 Time constant resistance, time constant

The time constant T with which the output signal from the measuring chain dies away with stationary measuring signal present is given by the product of the adjusted range capacitor C_g and the adjusted time constant resistance R_g paralleling it.

$T = R_g \cdot C_g$ (see block diagram Fig. 7). The longest time constants in the individual ranges exist when in the [Long] setting the resistance R_g is given only by the insulation resistance of the particular range capacitor. We then speak of so-called quasistatic measurements.

Through the finite insulation resistance of the sensor or its cable a drift current flows (caused for example by an offset voltage in the input circuit). Owing to this, in the extreme case the amplifier may drift to the limit after a certain time. To avoid this, a [Medium] or [Short] time constant may be selected, forgoing quasistatic measurements. The discharge of the particular range capacitor associated with this counteracts the charging by drift currents.

The [Medium] and [Short] operating modes are selected for dynamic measurements. For questions concerning zero and drift correction see 8.2 and 8.4 respectively. The time constant T determines the lowest detectable frequency of the measuring chain - the lower limit frequency:

$$f_g = \frac{1}{2\pi \cdot R_g \cdot C_g}$$

9.3.5 Noise signal due to input cable capacitance

Paralleling capacitances at the charge amplifier input, as ensues after connecting any sensor cable, amplifies the noise signals always present. The spurious charge generated by this is superposed on the signal charge delivered from the sensor.

Typical coaxial cables have 70...100 pF capacitance per meter length, then there is the capacitance of the sensor itself. Information on cables is given in data sheet 15.011.

9.3.6 Output interference

The output interference specified with shielded input (noise signals due to input cable capacitance negligible) is independent of the C_g (range capacitor) selected.

The total interference at the output is arrived at by adding the output interference and the transformed noise signal at the output as described in 9.3.5 (depending on the scale).

10 Program disk

With these operating instructions comes a diskette for IBM-compatible PCs with DOS operating system. It contains software to facilitate operating the multichannel charge amplifiers Type 5017B and Type 5019B via the interfaces IEEE-488 or RS-232C as the case may be.

In addition to the runnable program file 5017.EXE also contains the associated source programs (development environment: Quick-Basic Ver. 4.5 Engl.). This enables you to perform any program adaptations yourself.

In the text file also on the diskette (German: LIESMICH and English: README) you will find the necessary instructions

In addition these text files include:

- data on the diskette contents and version number
- data on the hardware required
- data on the connecting cables needed
- a general program description

The easiest way to obtain a printout on a printer connected to the parallel port is to put in the following on DOS level:

TYPE A:LIESMICH > PRN or TYPE B:README > PRN

Enclosure:

Program disk (No 7.642.012)
Auxiliary program for programming the interfaces.

11 Warranty

The equipment supplied by KISTLER INSTRUMENTE AG WINTERTHUR is covered by a warranty against faulty material and workmanship.

The warranty extends over one year from the date of delivery.

When submitting warranty claims, the items of equipment concerned must be delivered to the manufacturer's works or to the regional distributor free of all charges, stating full details as to the nature of the claims.

Settlement of warranty claims may be effected at the manufacturer's discretion either by reconditioning or replacing the faulty items, or by crediting their value. Items of equipment damaged as a result of improper use or handling are not covered by the warranty.

Our responsibility under the warranty is strictly restricted to the above provisions, and we specifically decline any liability for damages incurred consequent upon the use or operation of our equipment.

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KONFORMITÄTSERKLÄRUNG

DECLARATION OF CONFORMITY / DÉCLARATION DE CONFORMITÉ

Hersteller *Manufacturer* / Fabricant	Kistler Instrumente AG Winterthur CH-8408 Winterthur

erklärt, dass das Produkt
declare that the product / déclares que le produit

Name / *Name* / Nom	**Multichannel Charge Amlipfier**		
Typ / *Type* / Type	**5017B ....**	(3 ... 8 Channels)	
	5019B	(3 ... 4 Channels)	
Module / *Module* / Module	- Charge Amplifier	Type	5059
	- A/D Converter	Type	5261
	- Summing Amplifier	Art.No	7.615.088
	- Dividing Amplifier	Art.No	7.615.093
Optionen / *Options* / Options	alle / all / tous		

mit den folgenden Normen übereinstimmt
relates with the followings standards / est conforme aux normes

Sicherheit *Safety* / Sécurité	EN 61010-1:1993	
EMV Emission *EMC Emission* / EMC Emission	EN 50081-1:1992	(EN 55022 Class B)
EMV Immunität *EMC Immunity* / EMC Immunité	EN 50082-1:1992 pr EN 50082-1:1995	

Gemäss den Bestimmungen der Richtlinien
following the provisions of directives / conformément aux dispositions des directives

73/23/EWG	(Sicherheit / *Safety* / Securité)
89/336/EWG	(EMV / *EMC* / EMC)

Winterthur, 16. Dez. 96

ppa M. Dubs, Head of Electronics Development

Dr 747 9.96

ISO 9001 certified