M - 520

Capacitance Decade

Operation manual

MEATEST

CONTENT

1. Use of the instrument

Capacitance decade M-520 is 5-decade capacitance box designed for calibration of capacitance ranges of multimeters and RCL meters. Because of its ability to be controlled via RS-232 interface it is especially suitable for automatic calibration and automatic testing of instruments in production lines. Main components of decade are created by foil capacitors with polypropylen dielectricum, which are switched via relays with high burden current.
Capacitance decade is supplied from internal battery. External power adapter is used as external power source and as battery charger.

2. Content of delivery

Capacitance decade M-520	1 pc
Power line adapter	1 pc
Cable RS 232	1 pc
Application SW (CD)	1 pc
Operation manual	1 pc
Calibration certificate	1 pc

3. Technical data

Capacitance range	:	100 pF – 12.2221 uF
Residual capacitance Co	:	typ. < 2 pF with floating terminal L and 00000 setting typ. < 10 pF with grounded terminal L and 00000 setting
Number of decades	:	5
Accuracy	:	2.5 % ± 1pF for decade x 100 pF 0.25 % for all others
Temperature coefficient	:	< 250 ppm/ °C (polypropylen dielectricum)
Maximal allowed voltage	:	50 V DC (Imax 1.5 A) , 35 V AC (Imax 1 Aeff)
Test voltage	:	500 V DC between GND and L/H terminals in floating connection
Frequency range	:	40 Hz to 1 kHz
Connection	:	two-terminal
Typ of terminals	:	instrument gold plated terminals, diameter 4mm
Remote control	:	interface RS-232, galvanically isolated
Power supply	:	internal battery 12 V type LONG B-WP 1.9-12 power line adapter 15 V/1A (100 – 240 V)
Operating period	:	typ. 4 hours from internal battery
	:	continuously from power line adapter
Reference temperatures	:	+23 °C ±2°C
Range of working temperatures	:	+5 °C to 40 °C
Range of storing temperatures	:	-10 °C to +50 °C
Dimensions	:	W 364 mm, H 111 mm, D 316 mm
Weight	:	4 kg

Notes:

- *Only data shown with tolerance or with band of limits are tested. All other values have informative character.*
- *During over-switching, resistance circuit may be opened for a period about 250 ms.*

3.1. Accuracy

Specified accuracy is valid after 10 minutes warm up in temperature range 23 ± 2 °C. Uncertainties include long-term stability, temperature coefficient, linearity, load and line regulation and traceability of factory to National calibration standards. Accuracies assigned in % are related to the set value. Specified accuracy is one year accuracy and it is valid for both grounded and floating connection when decade is supplied from internal battery.

Decade	Accuracy f = 1 kHz	Accuracy f = 40 Hz to 1 kHz	Loss coefficient f = 1 kHz	Temperature coefficient +5 °C to +40 °C	Maximal Voltage[*1]
	[%]	[%]	[-]	[± ppm / °C]	[V DC/ RMS]
100 pF – 1100 pF	2.5 ± 1pF	5 ± 1pF	< 0.05	< 250	50/35
1.2 nF – 12.1 nF	0.25	0.5	< 0.005	< 250	50/35
12.2 nF – 122.1 nF	0.25	0.5	< 0.005	< 250	50/35
122.2 nF – 1222.1 nF	0.25	0.5	< 0.005	< 250	50/35
1.2222 uF – 12.2221 uF	0.25	0.5	< 0.05	< 250	50/35

[*1] at max I < 1,5 ADC /1 Aeff

Note:
Parameter of accuracy is related to series equivalent scheme. Capacitance is defined relatively to residual capacitance Co in 00000 position.

In temperature range 21°C -25 °C is total accuracy given by basic accuracy of nominal value.
In temperature range without 21°C -25 °C is total accuracy given by basic accuracy of nominal value + influence of temperature coefficient.

For example: set value 100 nF, ambient temperature 38°C)
Total accuracy : 0,25% + (38°C -25°C)*250ppm/°C =0,575%

4. Preparation for use

M-520 Capacitance decade is supplied from internal battery or from external power line adapter. Range of power line voltage is from 100 V to 240 V 50/60 Hz. M-520 is laboratory device. Its accuracy is guaranteed in temperature range 23 ± 2 °C. Instrument is aimed for use in horizontal or slope position. Angle of the slope is determined by downcast holder.

Place the instrument on a flat desk after unpacking. If the instrument was stored out of range of reference temperatures, let it stabilize for one hour.

4.1. Switching on

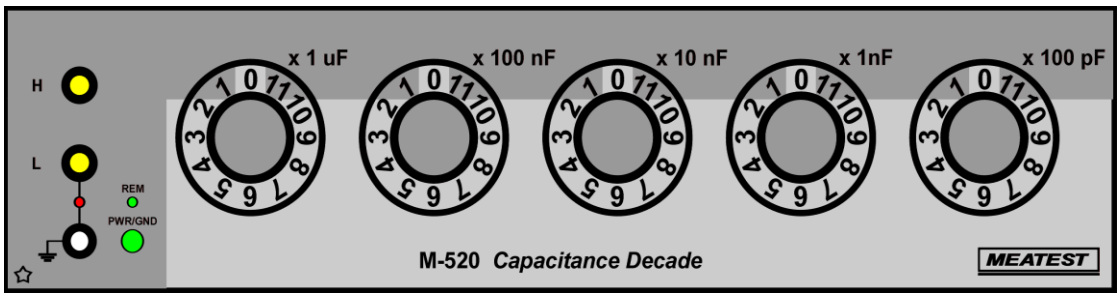
If the instrument is supplied from internal battery only, push the button POWER. If power line adapter is connected, capacitance decade is switched on automatically. After switching on internal tests are performed for approx.3s. After that value of output capacitance is set-up to the value indicated with front panel rotary buttons. Switching on status is indicated with green light PWR on the front panel.

4.2. Warm-up time

Capacitance decade can operate immediately after switching on. After 10 min. warm-up period it meets specified accuracy. During warm-up period it is not recommended to perform recalibration.

5. Description

5.1. Front panel



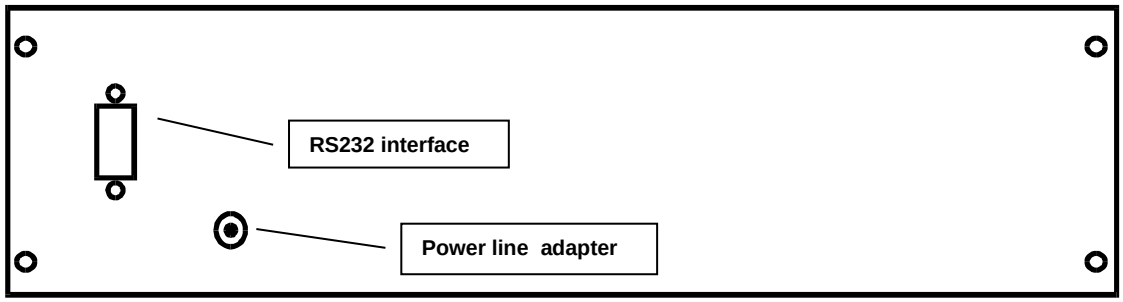
On the front panel there are located all main control keys, display and output terminals.

Rotary buttons
They enable to set-up requested capacitance in total range 100 pF to 12.2221 uF.

Buttons and indicators
Green LED diode with label REM indicates remote control mode. Red LED diode located between ground and L terminals indicates weather terminal L is galvanically connected to the ground terminal or if it is floating. Green button PWR indicates switching on or off.

Output terminals
Output capacitance is available between terminals L and H. The third terminal with ground symbol is galvanically connected with metal housing. This terminal can be connected to L terminal via internal relay, see chapter 6.2.1.

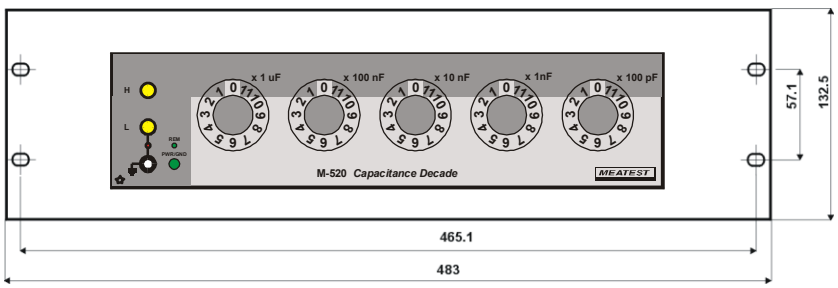
5.2. Rear panel



On the rear panel there are located power line adapter socket and connector with interface RS-232.

5.3. 19“ rack version (extra ordered)

Capacitance decade can be delivered in 3HE 19” rack module.



6. Operation

6.1. Switch on and off

6.1.1 Supplying from internal battery

Decade is equipped with internal maintenance less acid battery 12V. It can be used without any external power supply source. When no external power supply adapter is connected, decade can be switched on by long pushing (approx. 2 s) the button PWR. If with decade is not manipulated for a period longer than 9 minutes, i.e. no new rotary button setting is done, acoustic indication in parallel with LPWR button blinking is performed for period approx. 1 minute. After that decade is switched off. If battery comes to be discharged during operation, decade starts to beep in form long-short period and PWR button starts to blink fast. After approx. 1 minute, decade is switched off. Battery must be charged before next using. To charge battery external power supply adapter must be connected to decade and to power line.

6.1.2 Supplying from power line adapter

When power line adapter is connected to capacitance decade, it is always switched on automatically. Simultaneously internal battery is charged from the same adapter. Green LED diode is lighting all the time and indicated presence of power line adapter. Decade is automatically switched off, when power line adapter is disconnected from the rear panel socket or when its power supplying is interrupted, see chapter 6.1.1

6.2. Connection of terminals

On output terminals set-up capacitance plus residual Co capacitance is presented

The capacitance decade is equipped with two different way of connection of output terminals

- floating mode, L terminal is not connected to the front panel metal grounding post (GND)
- grounded mode, L terminal is connected to the front panel metal grounding post (GND)

Which method will be chosen depends on application. In both cases output capacitance is defined between H and L terminals.

Ways of connection can be switched over by short pushing the button PWR while decade is ON. Selected way is indicated on front panel by red LED diode located between GND and L terminals. After turning decade on, last selected way of connection is automatically set-up.

Note: To decrease high peak current pulses after connecting set capacitance to external circuit or changing set-up value, serial resistance is temporally inserted to set capacitance after changing button position.

Note: During changing set-up value short term about 250 ms disconnecting of H and L terminals is performed.

Note: When decade is switched off, H and L terminals are disconnected.

6.3. Calibration mode

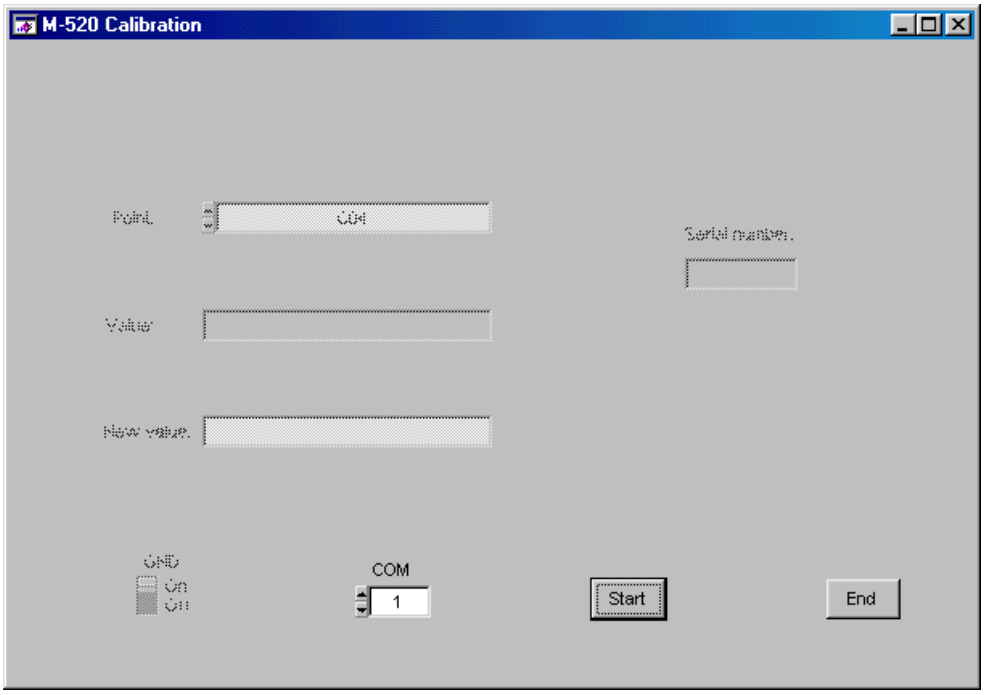
Capacitance decade is equipped with recalibration procedure, which allows also adjustment of partial capacitances. Recalibration is accessible only via RS-232 interface and delivered software. Recalibration is based on measurements of capacitance of partial capacitors and writing new data into internal memory. Nominal values of partial capacitors and request for accuracy of standard RCL meter is shown in following table.
Decade can be calibrated in either grounded or floating mode depending on means on measurement. Both possibilities are equivalent.

Standard	Nominal value in floating mode *	Nominal value in grounded mode L *	Requested accuracy at f = 1kHz
C04	30 pF	60 pF	0.5%
C05	35 pF	65 pF	0.5%
C06	45 pF	75 pF	0.5%
C07	48 pF	78 pF	0.5%
C08	70 pF	100 pF	0.5%
C09	120 pF	150 pF	0.5%
C10	135 pF	165 pF	0.5%
C11	245 pF	275 pF	0.5%
C12	465 pF	500 pF	0.5%
C13	520 pF	575 pF	0.5%
C14	1 nF	1 nF	0.05%
C15	2 nF	2 nF	0.05%
C16	2.35 nF	2.35 nF	0.05%
C17	4.7 nF	4.7 nF	0.05%
C18	9.4 nF	9.4 nF	0.05%
C19	11 nF	11 nF	0.05%
C20	22 nF	22 nF	0.05%
C21	44 nF	44 nF	0.05%
C22	50 nF	50 nF	0.05%
C23	100 nF	100 nF	0.05%
C24	200 nF	200 nF	0.05%
C25	235 nF	235 nF	0.05%
C26	470 nF	470 nF	0.05%
C27	940 nF	940 nF	0.05%
C28	1.1 uF	1.1 uF	0.05%
C29	2.2 uF	2.2 uF	0.05%
C30	4.4 uF	4.4 uF	0.05%
C31	4.4 uF	4.4 uF	0.05%

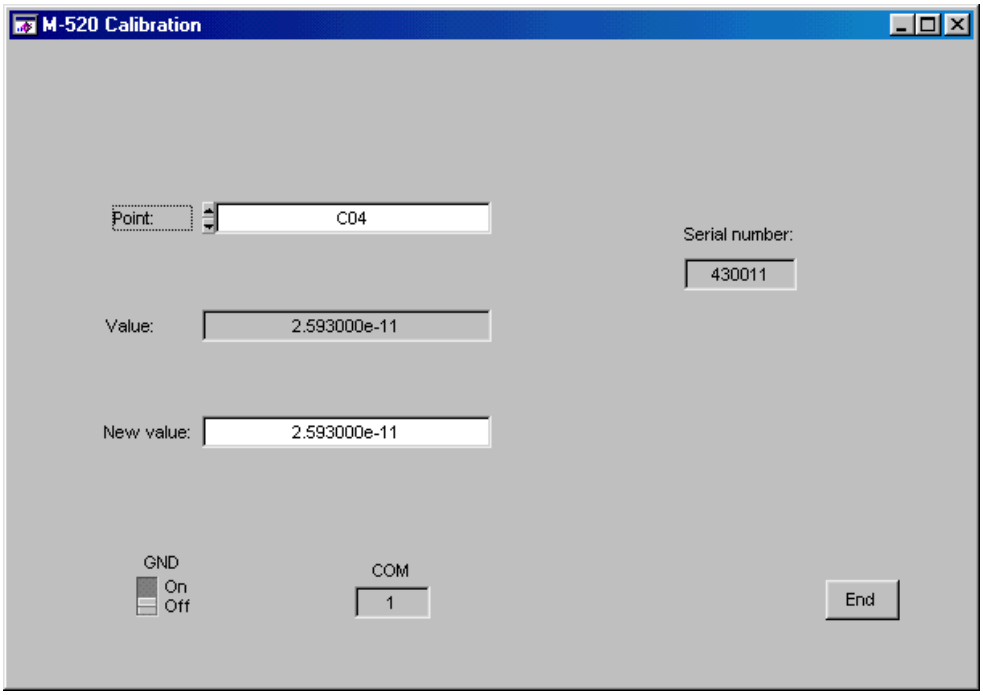
* Nominal values in the table are informative.

Calibration procedure:

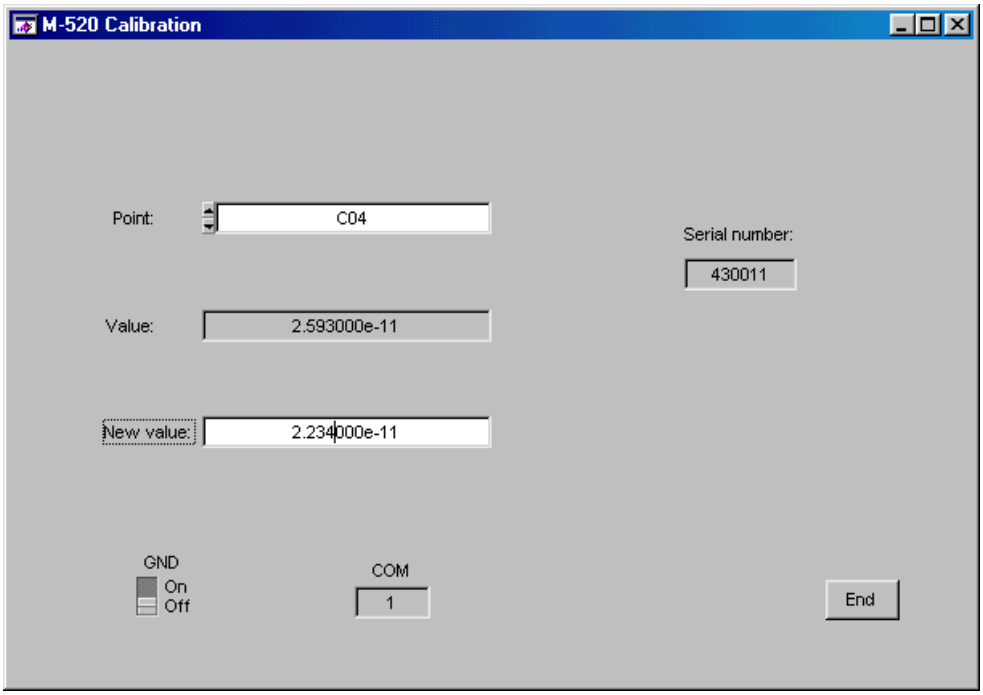
1. Calibration has to be performed with disconnected power supply adapter. The capacitance decade is supplied from internal battery.
2. Place decade to laboratory with ambient temperature 23°C ±1°C and let it stabilize for 2 hours in switch off status.
3. When calibrating in "Floating" mode front panel grounding post has to be connected to the ground potential. Use suitable banana-banana test lead. When calibrating in "Grounding" mode front panel grounding post must not be connected to any other potential.
4. Set configuration on standard RCL meter:
   frequency 1 kHz
   test voltage 1-2 V
   serial parameters
   four-pair-terminal or four-terminal connection
5. Make correction OPEN and SHORT on RCL meter to exclude residual parameters (with connected cables)
6. Connect RLC meter with capacitance decade and start calibration program. Software installation is described in chapter 9.



7. Set appropriate serial port (COM 1, 2) and push the button **Start**. Test of communication between PC and decade is performed. SN is displayed on screen.



8. Set requested mode of connection (recommended GND On).



9. Start measurement of partial capacitance, C04 is the first. Old calibration value is shown in the field “Value” Type new measured data to the field “New value” and push ENTER. Even it is not necessary it is recommended to recalibrate all partial capacitors C04 to C31.
10. After finishing close program with button “End”

7. Accuracy verification procedure

In the chapter accuarcy test procedure is decribed. Test is performed with measruing output capacitance with standard RCL meter in recommended test points.

Reqirements

- RCL meter with accuracy 0.05% with range 100 pF to 10 uF (HP 4284A, Wayne Kerr WK 6425, etc.)

Procedure

1. Charge internal battery from power supply adapter for 8 hours.
2. Place decade to laboratory with ambient temperature 23°C ±1°C and let it stabilize for 2 hours in switch off status.
3. When calibrating in "Floating" mode front panel grounding post has to be connected to the ground potential. Use suitable banana-banana test lead. When calibrating in "Grounding" mode front panel grounding post must not be connected to any other potential.
4. Disconnect power supply adapter and switch decade on.
5. Set configuration on standard RCL meter:
    - frequency 1 kHz
    - test voltage 1-2 V
    - serial parameters
    - four-pair-terminal or four-terminal connection
6. Make correction OPEN and SHORT on RCL meter to exclude residual parameters (with connected cables).
7. Set nominal value on decade according to test points shown in the table below. Measure capacitance with RCL meter. Deviations should not exceed shown limits.

Table of test points

Nom. value [nF]	Max.deviation [pF]	Nom. value [nF]	Max.deviation [pF]
0.1	3.5	10.2	25.5
0.2	6.0	13.0	32.5
0.3	8.5	26.0	65
0.4	11	47.1	118
0.5	13.5	60.0	150
0.6	16	120.0	300
0.7	18.5	217.2	543
0.8	21	280.0	700
0.9	23.5	550.0	1375
1.0	26	1019.0	2548
1.2	3	1300.0	3250
2.2	5.5	2600.0	6500
3.0	7.5	5100.0	12750
5.5	13.8	10200.0	25500

8. Remote control

8.1. Description

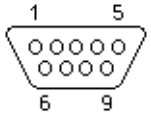
Capacitance decade is equipped with RS-232 interface with simple function. Signals in interface connector are galvanically isolated. RS-232 parameters are fix as follows:

Baud rate	1200 Bd
Data bits	8
Stop bit	1
Parity	none

Also neither hardware handshake (RTS/CTS) nor program handshake (XON/XOFF) is used.

Control computer must keep signal RTS in static level between –3 to –12 V and signal DTR in static level +3 to +12V

RS-232 connector



Pin	Name	Direction	Description
2	TXD	Output	Transmitter
3	RXD	Input	Receiver
4	DTR	Input	Power supply RS232 +
5	GND	-	Ground
7	RTS	Input	Power supply RS232 -

9-pin connector D-SUB MALE

Cable between decade and PC description (configuration 1:1)

PC	D-Sub 1	D-Sub 2	M-520
Receiver	2	2	Transmitter
Transmitter	3	3	Receiver
DTR (+3 … +12V) static level	4	4	Power supply RS232 +
Ground	5	5	Ground
RTS (-3 … -12V) static level	7	7	Power supply RS232 -

Demo program

As a standard simple communication software for systems WINDOWS 95/98/ME/NT/2000/XP/Vista is delivered with capacitance decade. Software is delivered on CD ROM.

8.2. Syntax

Communication between PC and decade is based of periodic alternating of command types command – query. Commands are presented by a letter. It must be followed with character <cr> or <lf>. Response is always ended with characters <cr> <lf>.

Abbreviation description

<DNPD> Decimal Numeric Program Data. It is used for setting of value in form with decimal point or as exponential number.

<CPD> Character Program Data. It represents mostly group of alternative sign parameters, for example {0 | 1}.

? Query character related to a parameter determined by command. Except question mark no other sign is allowed.

(?) Query character related to a parameter determined by command. It enables both query and setting.

<cr> Carriage return. It is ASCII character 13, used as executive character for command execution.

<lf> = Line feed. It is ASCII character 10, used as executive character for line with command execution.

8.3. List of commands

Setting / reading value

A (?) <DNPD>

Setting capacitance value.

<DNPD>

It represents capacitance value in F. Limit values are shown in chapter "Technical data". Set value on M-520 is confirmed with string „Ok <cr><lf>". In case of query M-520 returns set value in exponential format. E.g. value 150 nF is returned as 1.500000e-007.

Example :

„A1.1e-6 <cr>" set capacitance 1,1 uF.

After query „A?<cr>" M-520 returns response in form „1.100000e-006<cr><lf>".

I/D (device identification)

***IDN?**

Response to the query is name of manufacturer, model, SN and firmware version.

Format :

```
 1  2  3  4  5  6  7  8
 M  E  A  T  E  S  T  ,        - manufacturer
 9 10 11 12 13
 M  5  2  0  ,                 - model
14 15 16 17 18 19
 X  X  X  X  X  ,              - SN
20 21 22 23
 X  .  X                       - firmware version
```

Example :

After query „*IDN?<cr>" M-520 returns:

„MEATEST,M520,52000,1.0 <cr><lf>".

Output grounding

G <CPD> { 0 | 1 }

Grounding or floating L terminal.

Parameter:

1 L is grounded

0 L is not grounded

Example :

„G1<cr>" cause internal connection between GND and L terminals.

Set value reading
K?
M-520 returns setting of rotary buttons in hex code (signs 0, 1, … 9, A, B relates to setting 0 … 11).

Example :
After query „K?<cr>" M-520 returns for example:
„0000B <cr><lf>" 1100 pF value is set

Local control
L <CPD> { 0 | 1 }
Command switches decade to local/remote control.
Parameter:
1 decade is switched to remote control. Output capacitance value is determined by actual setting of rotary buttons.
0 decade is switched to manual control. Capacitance value equals the last set value via RS-232 line before switching to manual mode.

Example :
„L0<cr>" switches decade to remote control.

Switching OFF
P0
Command switches decade off. Command is executed only if decade is supplied from internal battery. If power supply adapter is connected, command is ignored. Execution is confirmed by sending of string „Ok <cr><lf>".

Example :
„P0<cr>" switches decade off.

Device status
V?
M-520 returns its status in form „GxLx <cr><lf>", where „x" are appropriate actually set parameters

Example :
After query „V?<cr>" M-520 returns for example:
„G1L0 <cr><lf>" L terminal is grounded, device in remote mode

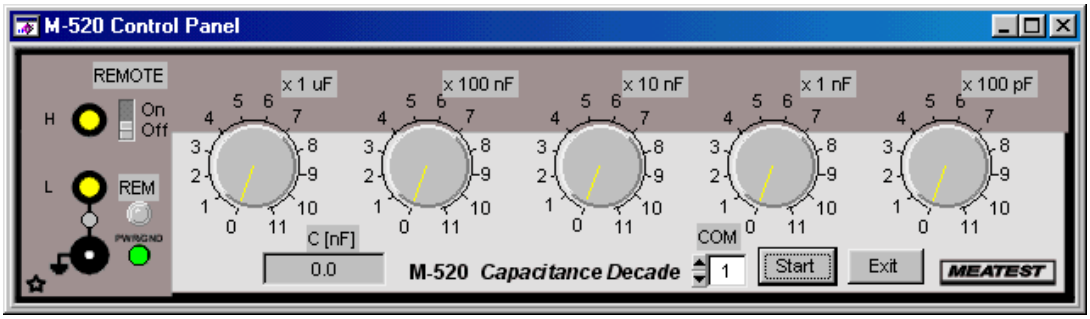
9. Application software

9.1. Installation

Insert the software CD into your CD ROM drive. Wait for autorun and select “Software installation” and “M520” or start direct „install\freeware\M520\en\setup.exe“. When you launch SETUP.EXE, the installation program asks for the destination directory and executes the actual installation. The UNINST.EXE program is also copied into the selected directory for alternative delete of the directory from the system.

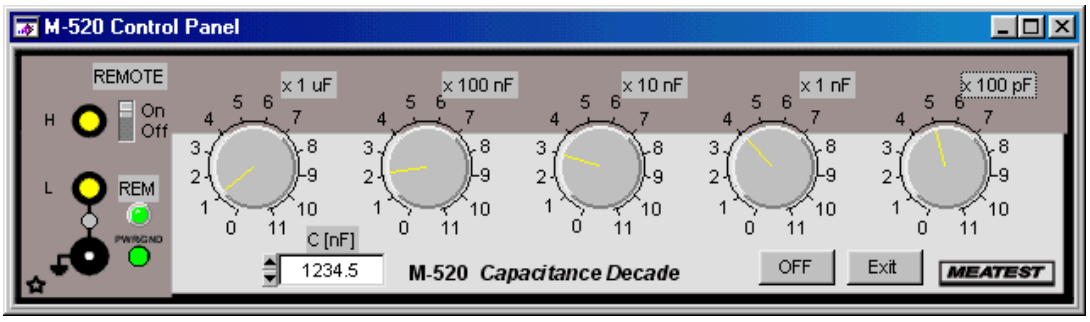
9.2. Features

After starting M520demo.exe M-520 front panel is displayed on the PC screen.



The first enter correct number of **COM** port, which is used. Confirm it by pressing the button **START**. If the device is found on RS-232 interface, actual setting of rotary buttons on decade is red and transferred to the front panel figure on the screen. Indication LEDs on left side correspond to the same LED indicators on the decade, including their active/passive status. .

After switching **REMOTE** slider to position ON decade over comes to the remote mode. REM LED diode is getting lit on the decade and front panel on the screen as well. Set output value is possible in following ways:



By mouse:

- After placing the mouse cursor on a rotary button and keeping pressed left mouse button, with button can be rotating and set value can be changed.
- After placing the mouse cursor on small black arrow left from the field C(nF) set value can be changed.

From keyboard:

- By entering numerical value to the field C(nF) in nF and confirming with ENTER.
- By activating C(nF) field, with cursor buttons UP and DOWN set value can be changed in step 100 pF
- By activating a rotary button, with cursor buttons UP and DOWN value can be changed in limits of selected decade.

Decade can be switched off after pushing the button "**Off".** Program can be closed by pushing the button **"End"** anytime.

Note: *When in remote mode, real decade value setting made via RS-232 line does not correspond to the physical position of rotary buttons on M-520.*

10. Electric circuit description

Partial capacitors are switched in parallel in binary code via reed relays. Board with relays, capacitors and rotary buttons forms separated mechanical part. Metal case is galvanically connected only with terminal GND on the front panel. Function of M-520 and communication on RS-232 is controlled by CPU board. Calibration data are saved in EEPROM memory.

In decade used capacitors are submitted aging during manufacturing and they are selected to dissipation factor criteria.

11. Mechanical construction

11.1. Description

Capacitance decade is build in standardized aluminum housing. Rotary buttons are mounted on front panel sheet together with terminals. End positions of buttons is blocked. Analogue board is located in the middle of the case, CPU is fixed on right side.

On the rear panel power supply and RS-232 connectors are located. Also internal battery is fixed to the rear panel.

11.2. Battery replacement

Internal battery needs about 40 hours to be fully charged. If M-520 is stored for more than 3 months without connected power supply adapter, it is recommended to charge it before using the decade.

To exchange internal battery top and bottom cover must be dismounted. Use standard screwdriver to remove 4 screws from the plastic foots. Both covers can be thrown back. Disconnect battery connectors and dismount battery holder. Insert new battery. Complete the procedure in opposite order.

Manufacturer

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CE Certificate of conformity

According to EN ISO/IEC 17050-1:2010 standard as well as 2014/30/EU and 2014/35/EU directives of European Parliament and European Council, MEATEST, spol. s r. o., manufacturer of M-520 Capacitance Decade based in Železná 3, 619 00 Brno, Czech Republic, declares that its product conforms to following specifications:

Safety requirements

- EN 61010-1:08 ed. 2:2011

Electromagnetic compatibility

- EN 61000 part 3-2 ed. 3:2016 + A1:2010+A2:2010
- EN 61000 part 3-3 ed. 2:2009
- EN 61000 part 4-2 ed. 2:2009
- EN 61000 part 4-3 ed. 3:2006 +A1:2008+A2:2011
- EN 61000 part 4-4 ed. 3:2013
- EN 61000 part 4-5 ed. 2:2007
- EN 61000 part 4-6 ed. 3:2009
- EN 61000 part 4-11 ed. 2:2005
- EN 61326-1 ed. 2:2013

Brno	April 16th, 2014	
Place	Date	Signature