

TM1600/MA61

Breaker Analyzer System

Programma Products



User's Guide



GE Energy Services

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1 General safety regulations

- **Caution!** Before making any live connections to the TM 1600, make sure that it is connected to protective earth (ground), by the separate ground cable.
- When the TM1600 is connected to a wall socket, the socket must be a grounded power outlet.
- Follow local safety regulations for work on high-voltage circuit breakers.
- Before connecting the TM1600 to a high-voltage breaker, make sure the breaker is closed and earthed (grounded) on at least one side.
- Never do any work on a circuit breaker unless the control circuits of the breaker are disconnected from the TM1600 control outputs.
- Disconnect all the connected leads and the power plug and then turn off the power before dismounting any part of the TM1600.
- See the additional safety regulations presented in sections 4.1 and 5.1

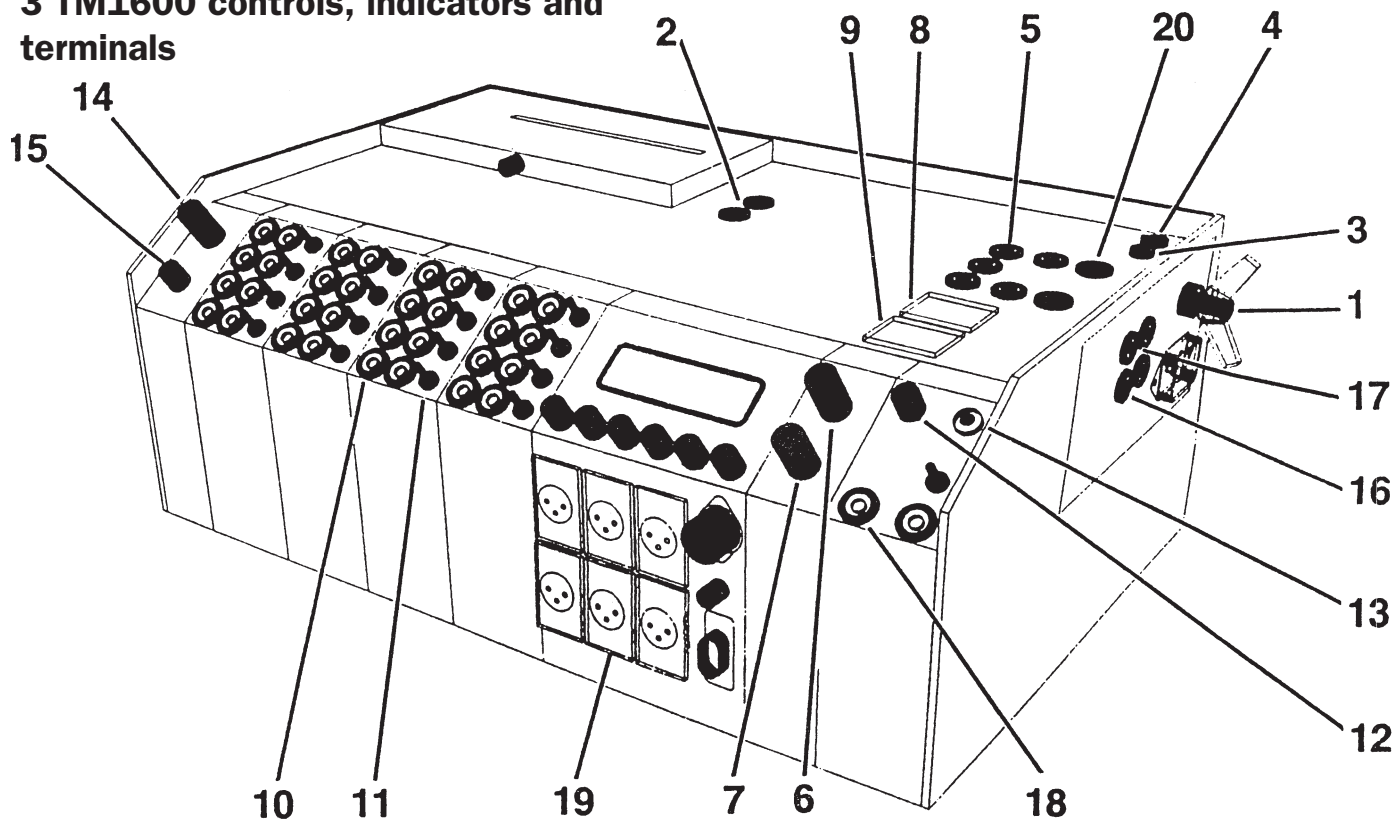
2 Power supply

The TM1600 can be powered from any AC or DC source, 100-250 V. Power can also be supplied from the built-in, auto-charged batteries.

For charging time refer to section 9.2.

Battery operation time is typically at least one hour at normal use.

3 TM1600 controls, indicators and terminals



- 1 Earth (ground) connection.**
- 2 BLIND TERMINALS.** Safety terminals for breaker control wires. Not connected to internal circuits.
- 3 Power ON/OFF.** ↑ ON, ↓ OFF.
- 4 POWER-ON lamp.** Flashing = Low battery.
- 5 Breaker control outputs.** Two separate contact functions. See section 4.7.
- 6 Breaker operation SEQUENCE selector switch.**
C = Close, O = Open, ‘-’ = Delay
- 7 START of breaker operation and recording switch.**
Recording starts only if the Ready lamp is on. See sections 4.7 and 6.1.
- 8 CLOSE DELAY. Closing pulse delay setting.** Pulse delay is measured from the start of the previous pulse. 10 ms resolution.
- 9 OPEN DELAY. Trip pulse delay setting.** Pulse delay is measured from the start of the previous pulse. 10 ms resolution.
- 10 Timing channel input terminals.**
- 11 Timing channel mode switch.** Contact mode: 0-250 ohms. Resistor contact mode: 0-3 kohms. Voltage mode: 12-250 V unpolarized. See section 5.10.1
- 12 READY for measuring button.** Enables the timing channels. 1st touch: Prepares for normal recording. Enables the timing channels throughout 90 s. 2nd touch: Provides long-term monitoring (optional). See section 6.3. 3rd touch: Disables recording.
- 13 READY lamp.** Steady light: Ready for normal recording. Slow flash: Ready for long term monitoring (optional). Fast flash: Measurement in progress.
- 14 PRINT MODE.** Report format selector switch. See section 7.
- 15 Printer START/STOP and PAPER FEED button.** Paper feed if pressed longer than 1 s.
- 16 REMOTE START input.** External short-circuit provides same result as turning the start switch (item 7).
- 17 TRIG OUT. Output for synchronous start of other equipment.** Short-circuits the terminals at instant of triggering. Used when several TM1600s are used together. See section 6.4.
- 18 TRIG. Input for external start of recording.** Recording starts if the READY lamp is on. See sections 6.2 and 6.4. Input data: 0-250 ohms polarized or 12-250 V unpolarized.
- 19 Motion Analyzer MAG1.** See sections 10 and 11
- 20 FUSES for breaker control outputs.** See section 9.3.

4 How to operate the breaker

4.1 Safety regulations

- Warning! Do not short-circuit or touch the auxiliary voltage. Use of “touch-protected” connectors is recommended.
- Never do any work on a circuit breaker unless the control circuits of the breaker are disconnected from the TM1600 control outputs.

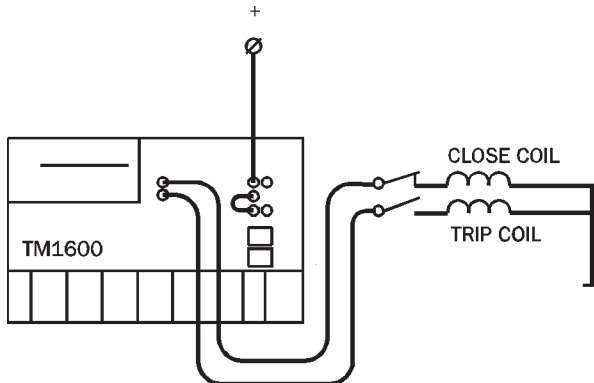


Figure 4.1. Safe disconnection of coil circuits.

4.2 Preventing unintentional breaker operation

To avoid unintentional breaker operation while working on the breaker, the breaker control circuits must be disconnected from the TM1600 outputs. The TM1600 BLIND TERMINALS are useful for this purpose. See Figure 4.1

4.3 Simple close or open operation

- Connect the breaker as shown in Figure 4.2 or 4.3.
- Select C (close) or O (open) on the SEQUENCEswitch.
- Start breaker operation with the START switch.

4.4 Close-open (trip-free)

- Connect the breaker as shown in Figure 4.2 or 4.3.
- Select C-O operation on the SEQUENCE switch.
- Set the OPEN DELAY to zero (0.00).
- Start breaker operation with the START switch.
- The trip circuit will be energized when the a-contact closes.

4.5 Open-delay-close-open

- Connect the breaker as shown in Figure 4.2 or 4.3.
- Select O-C-O on the SEQUENCE switch.
- Set the CLOSE DELAY to the desired value, 300 ms (0.30) for example.
- Set the OPEN DELAY to zero (0.00).
- Start breaker operation with the START switch.

4.6 Close-open-close

- Connect the breaker as shown in Figure 4.2 or 4.3 with one important difference: Interchange the wires that run from the TM1600 to the coils.
- Select O-C-O operation on the SEQUENCE switch.
- Set the CLOSE DELAY and OPEN DELAY to desired values.
- Start breaker operation with the START switch.

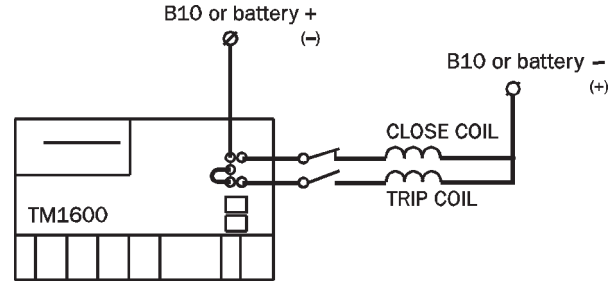


Figure 4.2. Positive or negative common supply.

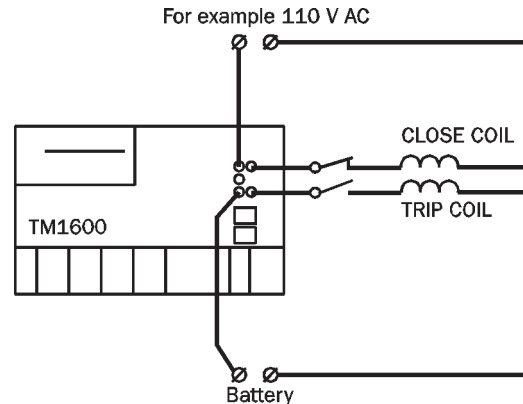


Figure 4.3. Separate supply voltages.

4.7 How the TM1600 breaker operation unit operates

4.7.1 Basic operation

The two contact functions are completely separate and isolated. The contacts are not polarized. Contact ratings: 25 A 250 V AC or DC. No bouncing.

The load of each contact function is monitored and affects the output pulse durations. Load indication threshold: 0.4 A.

Breaker operation can be started with the rotary START switch or by closing the REMOTE START input terminals.

If the TM1600 is in its READY state (READY lamp on), starting breaker operation will also start measurement. If the READY lamp is not on, the breaker is operated without measurement.

4.7.2 Control pulses

The first pulse in a sequence is synchronized with time measurement.

Pulse delay (as set on the corresponding thumbwheel) is measured from the start of the previous pulse.

A pulse lasts until the load is interrupted or until 320 ms has elapsed. If no load is connected, the pulse lasts for 320 ms. To avoid termination of pulses if current is interrupted briefly, the minimum pulse length after the load has been applied is 40 ms.

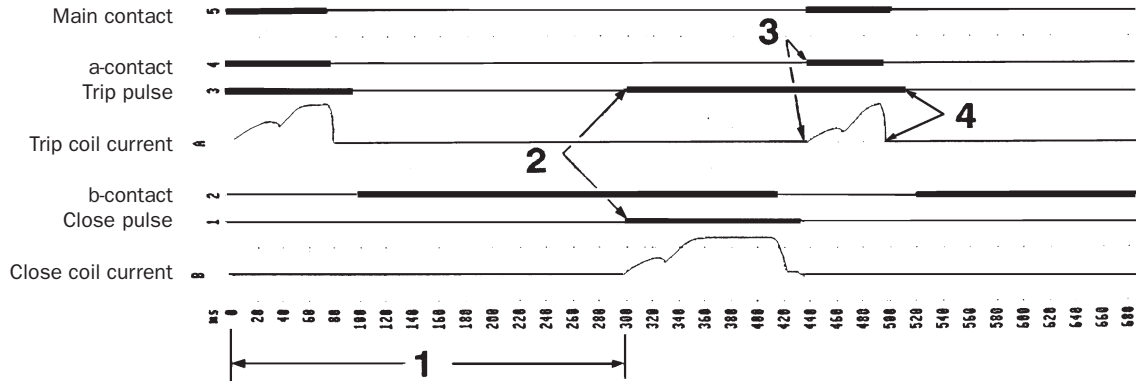


Figure 4.4 Example of sequence: Open - 300 ms delay - trip-free.

1. The 300 ms delay of the close pulse is based on the beginning of the first trip pulse.
2. The second trip pulse starts simultaneously with the close pulse, since the delay time for the trip pulse was set to zero.
3. The trip solenoid will be energized when the a-contact closes.
4. A pulse disappears approximately 15 ms after the coil current is interrupted.

5 How to connect the timing channels to the breaker

5.1 Safety regulations

- When only one side of the circuit breaker is connected to earth (ground), special precautions must be observed. To protect service personnel and the measuring equipment from surges, two important rules must be followed closely:
 1. The TM1600 case must be earthed (grounded) by the separate ground cable.
 2. All circuit breaker connections and disconnections must be made only while the breaker poles are closed and connected to earth (ground) on at least one side.
- The earth current, capacitively coupled from the surrounding high-voltage wires, through one timing input must not exceed 15 mA. See Figure 5.1. Two or more timing channels connected in parallel can handle higher currents.
- Do not exceed the input voltage limit of 250 V AC or 400 V DC. If two or more inputs are connected in series, change the polarity at every other input. (See Figure 5.3.)

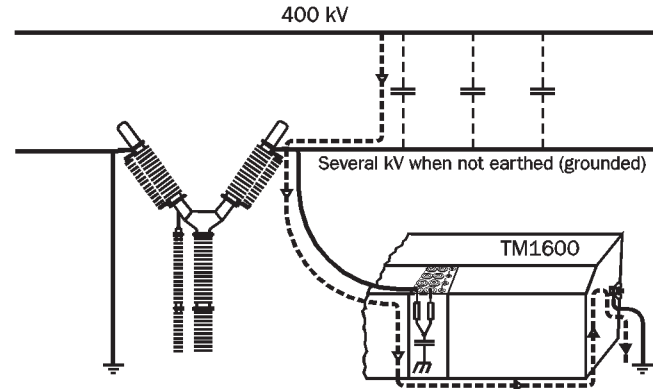


Figure 5.1.

5.2 Single breaking unit per phase

- See Figure 5.2.
- Use channels 1, 2 and 3 for example.
- Set the inputs to their Contact positions.

5.3 Two or more breaking units in series per phase

- See Figure 5.3.
- To limit the voltage between the end points, the polarity should be reversed at every other input.
- Set the inputs to their Contact positions.

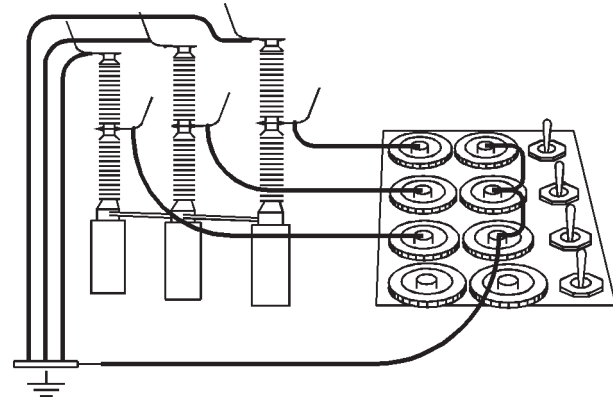


Figure 5.2.

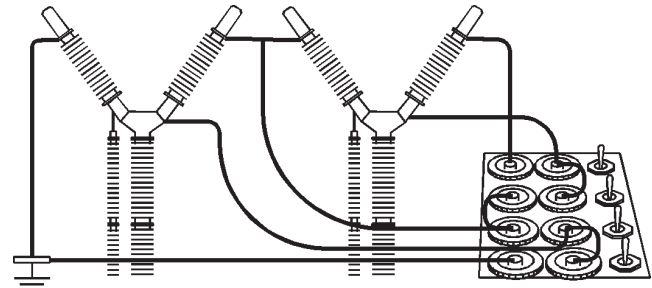


Figure 5.3.

5.4 Single breaking unit with preinsertion resistor

- See Figure 5.4.
- Set one mode switch to its Contact position and one to its Resistance position.
- Breaking units having resistors with values between 250 and 3000 ohms can be timed in this way.
- The polarities of the inputs must be the same. (Black to black and red to red.)

5.5 Two or more breaking units with preinsertion resistors

- See Figure 5.5
- For each breaking unit, set one channel to its Contact position and one channel to its Resistance position.
- The polarities of inputs connected in parallel must be the same. (Black to black and red to red.)

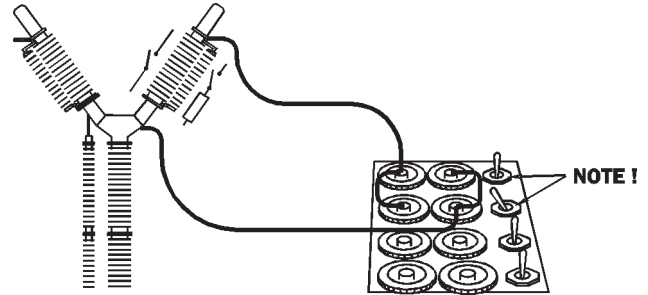


Figure 5.4.

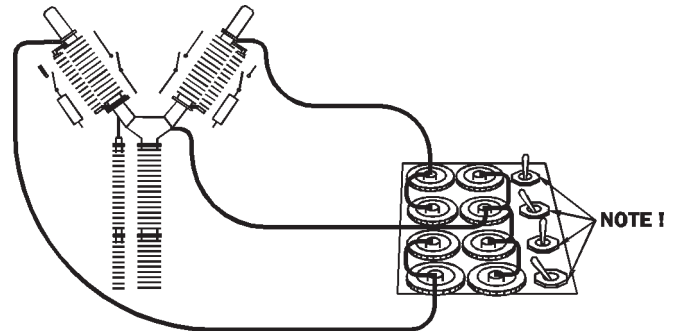


Figure 5.5.

5.6 Preinsertion resistance less than 250 ohms

- See Figure 5.6.
- One external resistor (Rx) must be connected to distinguish between the main contact and a parallel contact having a preinsertion resistor of less than 250 ohms.
- Note: The external resistor must be less than 250 ohms (see section 5.10).

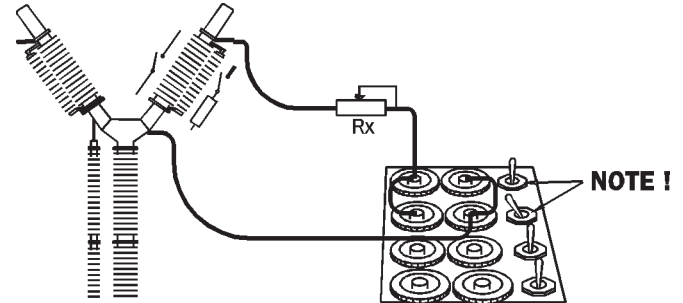


Figure 5.6.

5.7 Preinsertion resistance higher than 3000 ohms

- See Figure 5.7.
- For a resistance greater than 3 kohms, two or more inputs must be connected in series so that the voltage can drive enough current through the resistor.
- Do not connect more than six inputs in series in Resistance mode. If you do, the voltage will exceed 400 V DC.

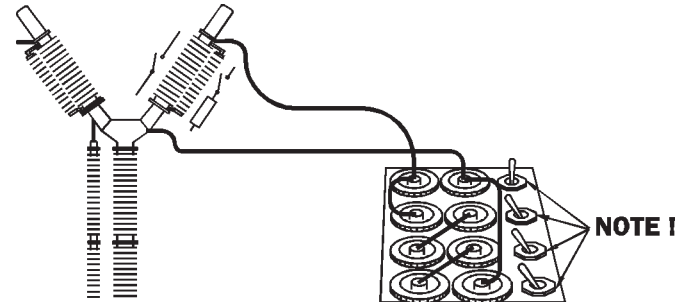


Figure 5.7.

5.8 Live auxiliary contacts

- See Figure 5.8.
- When timing live auxiliary contacts, connect the red socket to the side of the contact that is closest to the positive side of the auxiliary voltage supply.
- Set the channel in Contact mode.

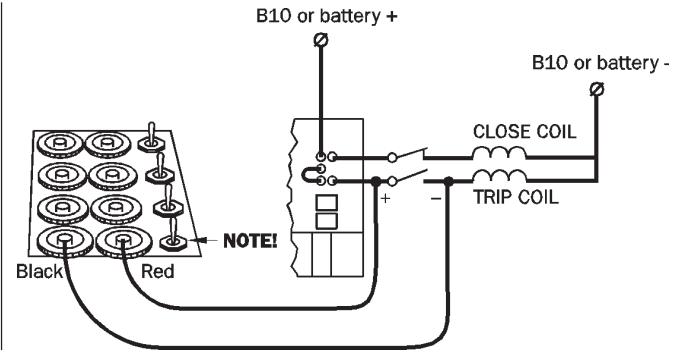


Figure 5.8.

5.9 Coil control pulse

- See Figure 5.9.
- Set the channel in Voltage mode.

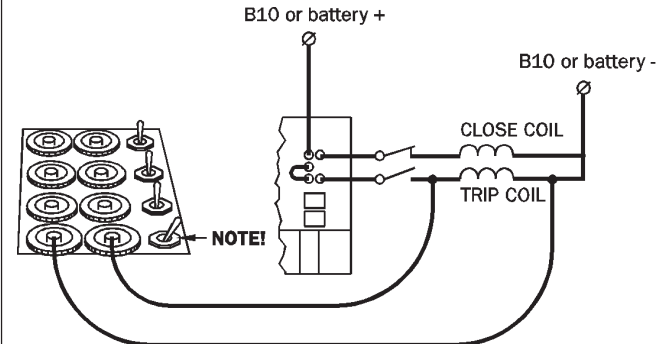


Figure 5.9.

5.10 How the timing channels operate

5.10.1 Measuring circuit

The measuring circuit can be set in three modes: Contact mode for timing main contacts, Resistance mode for timing resistor contacts and Voltage mode for detecting of a voltage.

Input mode	Resistance mode	Contact mode	Voltage mode
Short circuit current	25-30 mA	120-180 mA	120-180 mA
Open circuit voltage	50-60 V	25-30 V	—
Sense current	12-15 mA	80-100 mA	80-100 mA
Max external resistance	3 kohms	250 ohms	—

The timing channels are active when the READY lamp is on. In normal use, the Ready state lasts for 90 s.

In Resistance and Contact modes, an internal voltage source drives a current through a connected closed contact. The maximum current is limited to a preset level. A rectifying diode is connected in series with the voltage source. It permits one channel in Contact mode to be connected in parallel with any number of channels in Resistance mode.

In Voltage mode no internal voltage source is present. The load on an external source is about 4-10 Watts. The input is not polarity-dependent.

5.10.2 Protection circuits

Each channel is protected against surges by a protection circuit. See Figures 5.10 and 5.1

A 50 or 60 Hz interference current bypasses the measuring circuit and passes through the protection circuit to earth. Maximum earth current is 15 mA.

DC voltages up to 400 V are isolated from earth.

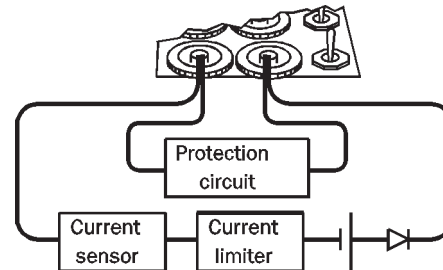


Figure 5.10. Schematic diagram of one TM1600 timing channel in Contact or Resistance mode.

6 How to measure

6.1 Normal recording

Enable a new recording by touching the READY button once. Start breaker operation with the START switch. Recording will start simultaneously. Printout takes place automatically after recording (but not for Report 6).

6.2 How to start timing from an arbitrary event

A recording can also be started in response to a contact closure (or a voltage) at the TRIG input (item 18 in Figure 3.1) If the Long-term monitoring feature (optional) is not implemented, the breaker must be operated from another control unit.

6.3 Long-term monitoring (optional)

Enable long-term monitoring by pressing the READY button twice. Recording starts in response to a change of state at any of the timing inputs. After the report is printed, the TM1600 automatically enters the Ready state.

6.4 Using two or more TM1600s together

Two or more TM1600s can be used together if more channels are needed. Here, one TM1600 is used to operate the breaker. For synchronus measurement the TRIG OUT output on this TM1600 has to be connected to the TRIG inputs on the other TM1600s. Note: The READY-lamp of all TM1600s must be on.

7 Printout

The desired report format can be selected with the PRINT MODE switch.

Report No.	Format
1	Table of events in channel-number order. Graph of events, compressed time scale.
2	Table of events in channel-number order.
3	Table of events in chronological order.
4	Graph of events, linear time scale. Overview with autoscale.
5	Optional
6	Static states of timing channel inputs.
7	MA61. Breaker summary + test diagram Built-in printer.
8	MA61. Breaker summary + test diagram External printer.

For Report 1 only: Bounces are suppressed in the table of events. For a contact closure, only the initial touch is printed. For a contact opening, only the final separation is printed. A contact opening must have a duration of at least 10 ms to be printed.

After a measurement, any number of reports can be printed from the same measurement data in any of the report formats. All timing info is based on the start of the recording. This means for example that if you want to obtain the opening operation time after a Close-Open operation, the starting time of the trip pulse will have to be subtracted from the reported opening time.

8 Paper reload

Paper feed is blocked when the paper runs out. Proceed as follows to reload.

- Release the printer locking mechanism with the button on the front of the printer cover. Pull the printer straight out and place it on the top panel.
- Lift the print head by pushing the lever on the left side towards the cover.
- Position the paper roll and insert the paper into the slot with the printing surface (the “outside” of the paper roll) downwards.
- Release the lever to its normal position.
- Put the printer back into its holder and make sure that it is securely locked.

9 Trouble shooting and performance check

9.1 The printer does not print

The printer can be out of paper even if there seems to be paper left. The printer stops just before the paper has left the print head. A red line at the edge of the paper indicates that there is only one metre (three feet) of paper left. Also check that the lever is released to its normal position.

9.2 Flashing power-on light

When the POWER-ON light is flashing, the battery needs to be recharged. The battery is automatically recharged whenever the TM1600 is connected to a power source regardless of whether the power is on or off. A full recharge cycle takes 10 hours (at 25°C (77°F)) but only 0.5 hours is enough to restore battery operation.

9.3 No pulses from the breaker operation unit

First check the output fuses. The fuses are rated 12 A, quick-acting, ceramic type, 6 x 32 mm, Programma ordering No.33-07147. Do not use fuses of any other type.

The breaker operation unit can be checked by connecting its outputs to a timing channel set in Contact mode. The pulse duration will be approx. 320 ms if the load is low or if the

load is not interrupted. The delay times can also be checked by means of a timing channel.

9.4 How to check the power supply unit

Connect mains power to the TM1600 and switch it on. Disconnect the power cable. If the POWER ON lamp goes out, it indicates that the supply unit is functioning properly.

9.5 How to check the TM1600 time base

This can be checked by making a comparison with the AC mains power frequency.

Warning! It is absolutely necessary to have the TM1600 cover connected to earth (ground) during this check. Use mains power that is galvanically isolated from earth (ground).

Set a timing channel in Resistance mode.

Set the PRINT MODE switch to position 2.

Apply mains power to the channel and start a measurement.

The time difference between breaks on the report corresponds to the mains frequency period. Note that this is a rough check having an accuracy of 0.1 - 0.2 ms.

If the word "OVERFLOW" is printed, press the printer START/STOP button once to obtain a report.

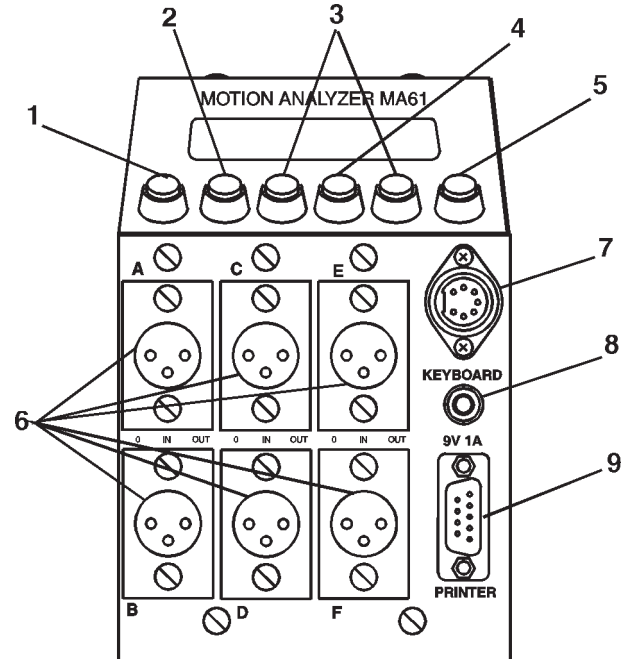
9.6 Wiring and input check

Wiring to the breaker contacts and transducer connections can be checked on the MA61 MON (5) display. The contact states can also be printed in Report 6.

10 MA61 controls, display and terminals

10.1 Control and front panel

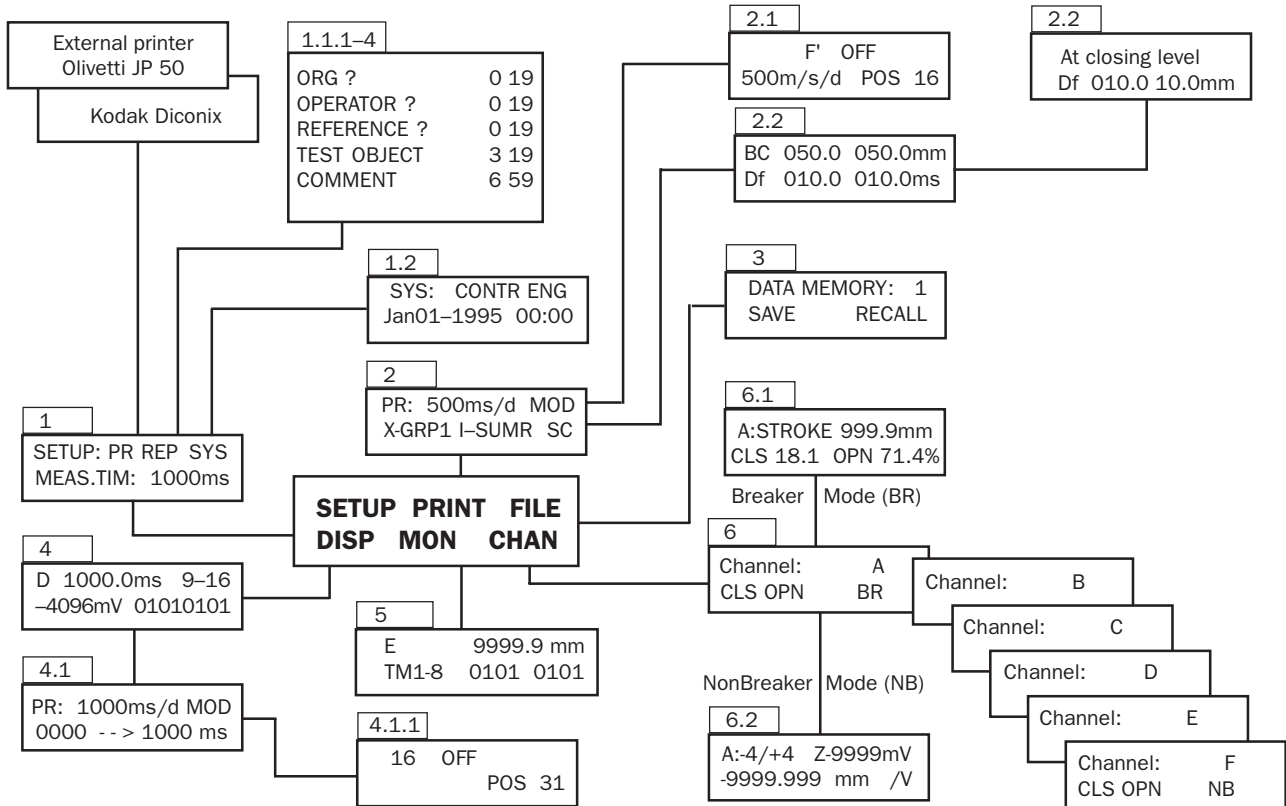
- 1 Shift of key function
- 2 Upwards in the menu tree
- 3 Movement inside a menu
- 4 Change a value/setting
- 5 Downwards in the menu tree. Also provides channel selection in menus 2.1 and 4.1.1.
- 6 Transducer connections
- 7 MA61 PC/XT-type keyboard connection
- 8 External printer power connection
- 9 External printer connection.



10.2 Abbreviations list

BC	Below closed	MOD	Modify printout settings
BR	Breaker mode	MON	Inputs monitor window
CHAN	Input chan. setup menu	NB	Non-breaker mode
CLS	Record closed position	OFF	Channel not plotted
Df	Diff. from points above	ON	Channel graph plotted
DISP	Display data menu	OPN	Record opened position
ENG	Language selection	POS	Curve position offset
FILE	Data storage menu	PR	Printout setup menu
GR21	Timing results in channel order (corresponding to TM1600 PRINT MODE No. 1.), motion caculation and graph. All in the same test report.	PRINT	Printout setup menu
GR22	As above, but PRINT MODE No. 2.	REP	Report form editor
GR23	As above, but PRINT MODE No. 3.	SC	Set speed calc. points
I-SUMR	Summary on int. printer. Defines action on Report 7	SETUP	System setup menu
MEAS.TIM	Measurement time	SYS	System setup
		X-GRP1	Graph 1 on ext. printer. Defines action on Report 8
		Z	Zero level input offset

10.3 The control menu



11 How to use the MA61

11.1 How to connect the channels

- Attach transducers to breaker and connect to MA61. (Pole A to MA61 Channel A, Pole B to MA61 Channel B etc).
- Connect TM1600 inputs to breaker poles. (Pole A to TM1600 Channel 1, Pole B to TM1600 Channel 2 etc.). If so desired, connect printer and keyboard.

For contact speed and penetration purposes, analogue channel A refers to timing channel 1, B to 2 etc. This is very important when connecting TM1600/MA61 to the breaker since correct calculation of these parameters will depend on the right connections being made.

11.2 Preparing for measurement

11.2.1 Setting up the system

- While in the main menu, select the SETUP menu.
- Select the desired measurement time giving due regard to the operation sequence and the breaker operation time.
- Select PR to choose printer. Select the REP form to enter header texts. Select the SYS menu to set date and time.

1
SETUP: PR REP SYS
MEAS.TIME 200 ms

11.2.2 Setting up the inputs

- Select the CHAN menu, where the inputs are set.
- **Set channels not connected to position transducers in NB (Non Breaker) mode.** Record closed (CLS) position. Open breaker. Record open (OPN) position.
- Select the next menu for input scaling.
- Set stroke for BR (BReaker) mode channels. Check transducer usage limits. At least 15% overtravel margin. CLS-OPN-difference reasonable?
- For channels in NB mode: Set input range, zero offset, input scale factor and input quantity.

6
CHANNEL: A
CLS OPEN BR

6.1
A:STROKE 120.0 mm
CLS 77 OPN 17%

6.2
C: -4/4 Z-9999 mV
-9999.999 mm /V

11.2.3 Preparing for the first printout

It is a good idea to always begin with a fast (short) printout to check all connections and settings:

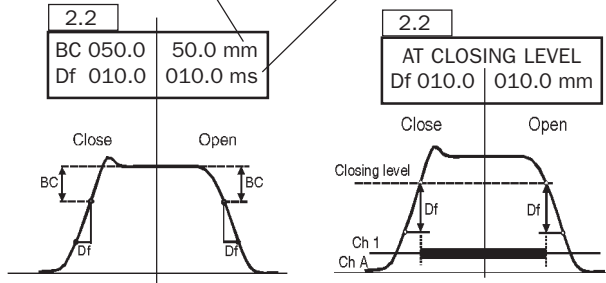
- Select the PRINT menu.
- Select number of ms per division. A value of half the measurement time provides a short graphical printout suitable for checking the settings.

2
PR: 100 ms/d MOD
X-GRP1 I-SUMR SC

- Enter the MOD(ify) menu.
- Set used channels to ON. Set scale factor and position.
- Enter the SC (Set speed Calculations) menu to set calculation points. Set the BC (Below Closed) levels. Select difference unit (mm or ms). Set the differences (for closing to the left and opening to the right).

2.1
A ON
500 mm/d POS 31

Select *Distance Below Closed* (BC), in mm or inch or *At Closing Level*. Select *Difference (Df)* to point above in time (ms or cycles) or distance (mm or inch).



- Set the TM1600 PRINT MODE selector switch to position 7 or 8 to enable automatic graphical printout after recording.

11.3 How to measure

Recording starts simultaneously with the TM1600. See section headed "6.1 Normal recording".

11.4 Additional printouts

Any number of printouts can be obtained after recording by pressing the printer START/STOP button.

11.5 A look at details

11.5.1 Breaker closing details

Printouts made from the DISP menu, have a different layout. The layout selected in menu 4.1.1 is used for this printout.

- When you enter the DISP menu, the time is set for the first event. (In this case the closing of channel 2).
- Pressing the printer START/STOP button provides a printout extending from 4 time divisions before the displayed time to 4 time divisions after the displayed time.
- The desired time can also be set in the time field. The next event can be selected in the lower right corner, for channels 1-8 or 9-16. In the lower left corner you can step between samples.

4
A 36.2 ms 1-8
85 mm 0100 0000

4
A 42.0 ms 1-8
132 mm 1110 0000

- Select the MA61 channel in the upper left corner. Select TM1600 channels in the upper right corner (toggle between 1-8 and 9-16).

11.5.2 Modification of layout for detailed printout

- Enter menu 4.1. Select start and stop-time for printout.
- Pressing the printer START/STOP button in this menu provides a print-out that covers the interval between the displayed time values.
- Move the cursor to the MOD field. Enter the MOD(ify) menu.
- Select a small print scale factor to magnify the curve. Set the open level to POS(ition) 2, so that you will be able to see the whole curve.

4.1
PR: 200 ms/d MOD
0000 -> 1000 ms

4.1.1
A ON
10 mm/d POS 2

12 Supplement

For software revision R04A (TM1600) + R06A (MA61) and onwards.

12.1 TM1600 system setup

- 1 Keep the READY button pressed two or more seconds. A menu will be printed by the built-in printer.
- 2 Enter selection by setting the PRINT MODE selector switch to the corresponding value.
- 3 Press the printer START/STOP button.
- 4 Depending on your choice, one of the menus will be presented on the printer.
- 5 Proceed as point 2 and 3 above.
- 6 After the selection, the TM1600 is ready for use.

12.2 MA61 Text editor

1.1.1-4
ORG ? 0 19
OPERATOR ? 1 19
REFERENCE ? 2 19
TEST OBJECT 5 19
COMMENT 9 59

Line No ———
Character No ———

On the external keyboard you can use four keys:

- | | |
|----------|-------------------------------------------------------------------------------|
| Insert | Inserts a space. |
| Delete | Deletes one character and moves the following characters to the left. |
| PageUp | Moves the cursor to the line above (or press BREAK and ENTER buttons on MA61) |
| PageDown | Moves the cursor to the next line (or press ENTER on MA61) |

12.3 MA61 System setup

The selections made here will be used in all of the MA61 menus and printouts as well as the TM1600 printouts.

12.3.1 Language selection, date and time set

1. Enter menu 1.2.

1.2
SYS: CONTR ENG
Mar05-1990 13:01

2. Select language.

3. Use the ESC button to leave the menu.

Please notice: If you have changed the date or time, use the ENTER button to leave the menu.

12.3.2 Timebase: ms or 60Hz cycles

1. Select the SETUP menu (No1).

1
SETUP: PR REP SYS
MEAS.TIME 400 ms

2. Select *ms* or *cy* (60 Hz cycles).

3. Use the ESC button to leave the menu.

12.3.3 Motion unit: mm or inches

1. Enter menu 6.1.

6.1
A:STROKE 254.0 mm
CLS 18.1 OPN 71.4%

2. Select *mm* or *in* (inches).

3. Use the ESC button to leave the menu.

12.4 Dynamic Resistance Measurement (DRM)

- Select the CHAN menu.
- Measure motion on channel A, voltage on channel B, and current on channel C. (To receive the resistance graph the voltage and the current channels have to be next to each other and in the mentioned order.)

- Set channel A to BR mode. Refer to section 11.2.2 for further motion parameters. Set channel B and C to NB mode.

B: 0/+1 Z+000mV
+1000.000 mV /V

C: 0/+1 Z+000mV
+1000.000 A /V

- For low injected currents, 10 - 50 A, use the 0/+1 input range for channel B. For higher currents, 100 - 1000 A, use the 0/+4 input range.

- For the current measuring channel, set the A/V value according to the used current shunt.

- When stepping through the graphs you will find the Resistance graph. Turn it ON and adjust the scale factor to 1 mΩ/d, as a beginning.

R ON
1 mΩ /d POS 2

For further guidance, please refer to the DRM USER'S MANUAL.

13 Printout example

Fasttest Inc.
0 P Rator

REPORT FORMAT 8
Jan 26, 1996 16:19.38

Session: 28
Reference: Powerfix

Page: 1 ()

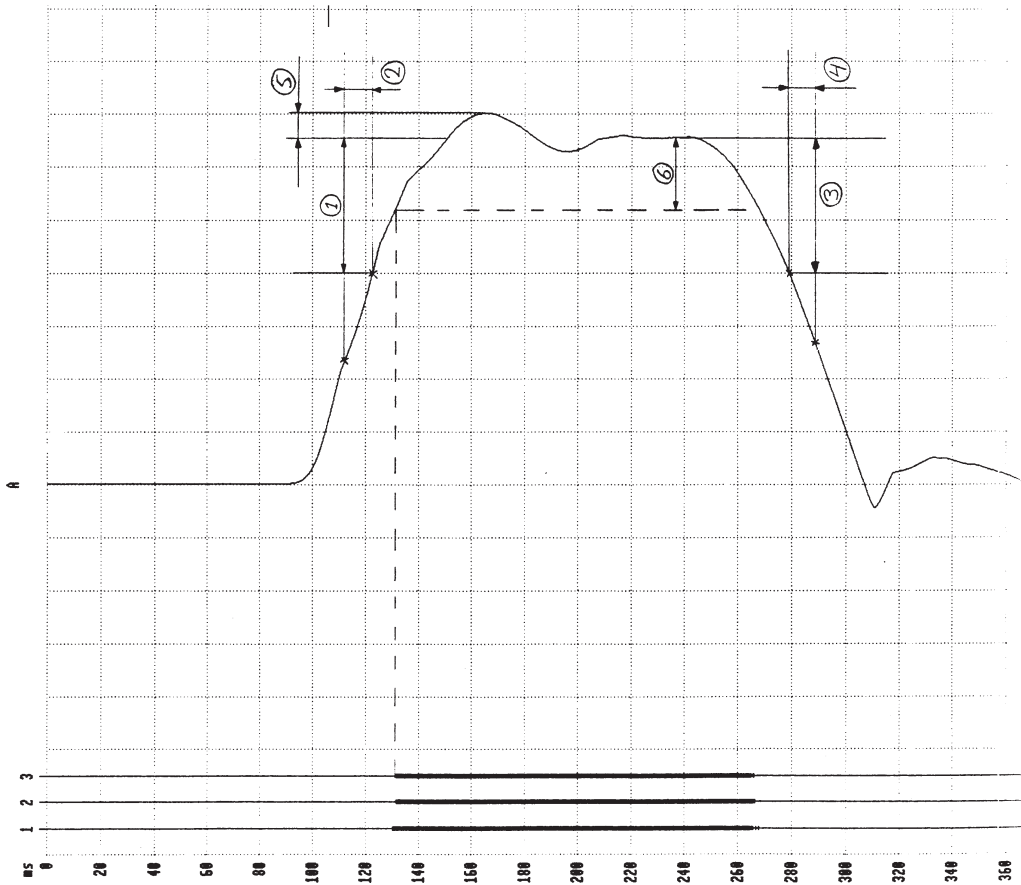
Channel	Closing speed	Opening speed	Cl's sp. calcpnts Blw cisd	Cl's diff	Opn sp. calcpnts Blw cisd	Opn diff	Over-travel	Pene-tration
A(1)	3.3 m/s	2.7 m/s	50.0 mm	10.0 ms	50.0 mm	10.0 ms	9.4 mm	29.5 mm
B(2)	---	---	---	---	---	---	---	---
C(3)	---	---	---	---	---	---	---	---
D(4)	---	---	---	---	---	---	---	---
E(5)	---	---	---	---	---	---	---	---
F(6)	---	---	---	---	---	---	---	---

Measurement time: 400 ms

Stroke: A : 131.0mm B : --NB C : --NB D : --NB E : --NB F : --NB

Units/div: A : 20mm B : OFF C : OFF D : OFF E : OFF F : OFF

A' : OFF





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