Tektronix®

2445/2465
OPTION 01
DMM OPTION
OPERATORS

INSTRUCTION MANUAL

Tektronix®
COMMITTED TO EXCELLENCE

PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

2445/2465
OPTION 01
DMM OPTION
OPERATORS

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077

070-4183-00
Product Group 38

Serial Number _____

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply and do not appear in this summary.

Terms in This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

Terms as Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the markings, or a hazard to property, including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

Symbols As Marked on Equipment

DANGER — High voltage.

Protective ground (earth) terminal.

ATTENTION — Refer to manual.

Power Source

This product is intended to operate from a power source that does not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Power Cord

Use only the power cord and connector specified for your product.

Use only a power cord that is in good condition.

Use the Proper Fuse

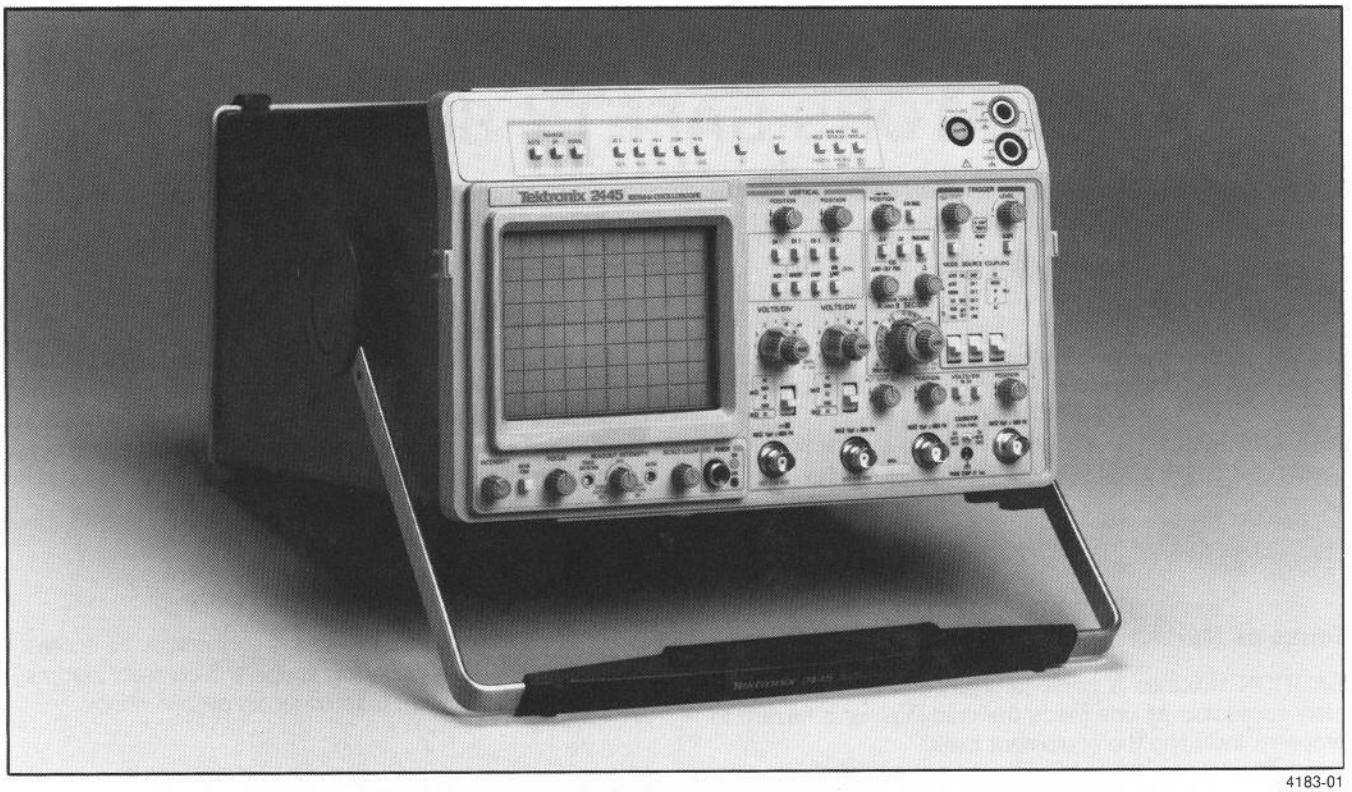
To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified in the parts list for your product.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

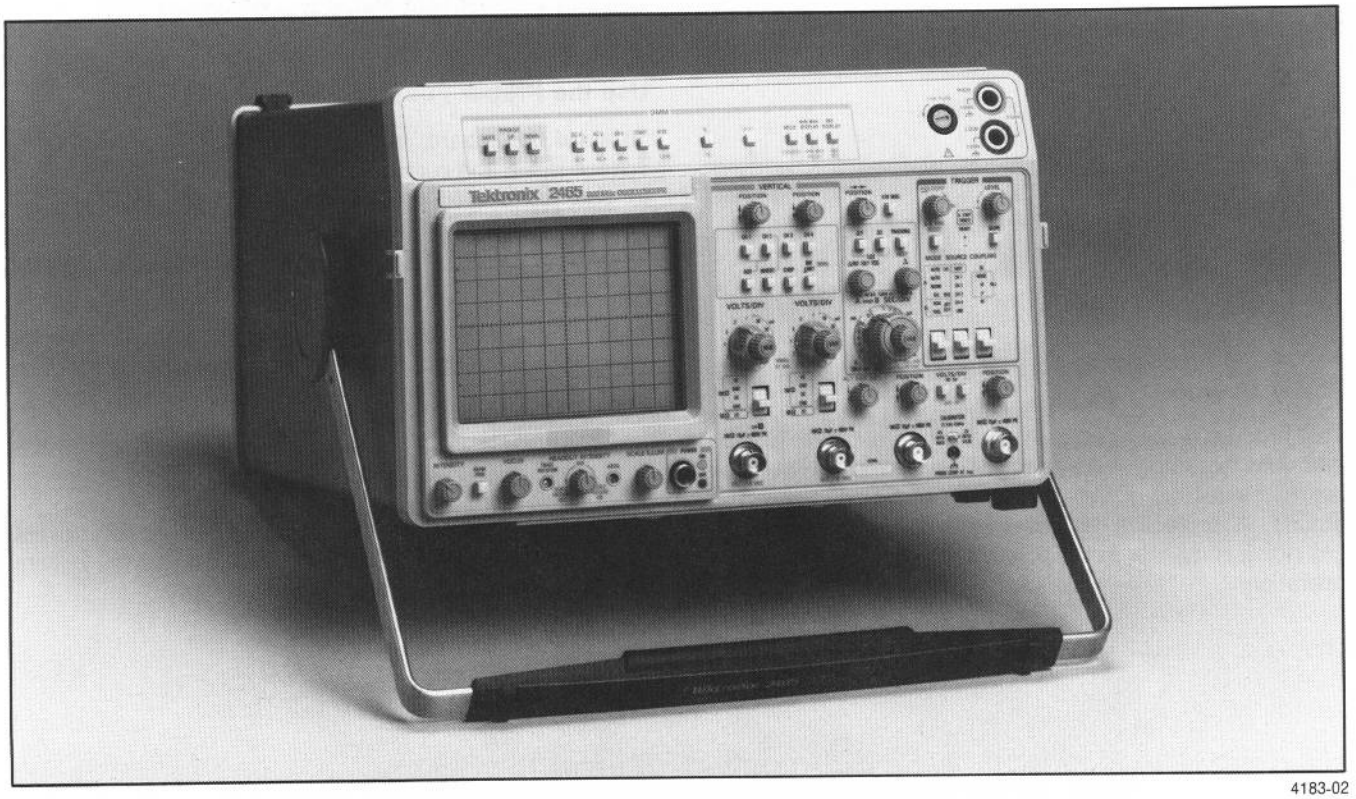
Do Not Remove Covers or Panels

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.



4183-01

The 2445 Option 01 (DMM) Oscilloscope.



4183-02

The 2465 Option 01 (DMM) Oscilloscope.

SPECIFICATION

INTRODUCTION

Option 01 (DMM) to the TEKTRONIX 2445 and 2465 Oscilloscopes is a 4-1/2 digit, fully autoranging digital multimeter which measures dc and ac voltage and current, resistance, dBV, dBm, continuity, and temperature. Option 1B is the same as Option 01 except that the temperature probe is not included. The DMM is controlled by "soft" front-panel switches which are used by the operator to determine the function or operation to be performed. All the controls are contained in the extended front panel.

Measurement results and DMM messages are displayed on the top line of the oscilloscope crt readout. The processor can turn off the DMM when a display conflict arises either between the DMM and the standard oscilloscope or between the DMM and an option.

When the GPIB (General Purpose Information Bus) Option (Option 10) is also installed in the oscilloscope, the DMM functions can be controlled and the measurement results read via the bus. All controls available from the DMM front panel are also available through the GPIB interface. GPIB control, which differs from front-panel control, explicitly turns functions on and off. The normal front-panel control switches work as toggles (when pressed, the function switches to the opposite state).

In addition to the standard accessories listed in the basic oscilloscope manuals, the following DMM Option standard accessories are provided:

2445/2465 Option 01 DMM Operators Manual
Probe Set
Accessories to Probe Set
P6602 Temperature Probe

For part numbers and further information, refer to "Options and Accessories" (Section 6) of this manual. The service manual and all other optional accessories are orderable from Tektronix, Inc. A local Tektronix Field Office, representative, or the Tektronix product catalog can provide ordering and product information.

PERFORMANCE CONDITIONS

Except as noted in Tables 1-1 and 1-2 of this manual, the electrical, mechanical, and environmental characteristics of Option 01 instruments are identical to those specified in the respective 2445 or 2465 Oscilloscope Operators Manual.

Table 1-1
Option 01 Electrical Characteristics

Characteristics	Performance Requirements
DC VOLTS	
Range Accuracies	
+18°C to +28°C	
200 mV to 200 V	±(0.03% of reading +0.01% of full scale).
500 V	±(0.03% of reading +0.04% of full scale).
−15°C to +18°C and +28°C to +55°C	
200 mV to 200 V	Add ±(0.003% of reading +0.001% of full scale)/°C below 18°C or above 28°C.
500 V	Add ±(0.003% of reading +0.004% of full scale)/°C below 18°C or above 28°C.

Table 1-1 (cont)

Characteristics	Performance Requirements
Common Mode Rejection Ratio	>100 dB at dc: >80 dB at 50 and 60 Hz, with 1 kΩ imbalance.
Normal Mode Rejection Ratio	>60 dB at 50 and 60 Hz.
Resolution	4-1/2 digits.
Step Response Time	
Manual	Less than 1 second.
Auto	Less than 2 seconds.
Input Resistance	
200 mV and 2 V Ranges	>1 GΩ or 10 MΩ.
20 V to 500 V Ranges	10 MΩ ±1%.
Maximum Input Voltage between Inputs or Ground	500 V rms; 700 V peak.
Input Bias Current at 23°C Ambient Temperature	Less than 10 pA.
Reading Rate	Approximately 3 per second.
AC VOLTS	
Range Accuracies	
+18°C to +28°C	
200 mV to 200 V	Input signal between 5% and 100% of full scale.
40 Hz to 10 kHz	±(0.6% of reading +0.1% of full scale).
20 Hz to 40 Hz and 10 kHz to 20 kHz	±(1% of reading +0.1% of full scale).
20 kHz to 100 kHz	±(5% of reading + 0.1% of full scale).
500 V	Input signal greater than 100 V and less than 500 V.
40 Hz to 10 kHz	±(0.6% of reading +0.2% of full scale).
20 Hz to 40 Hz and 10 kHz to 20 kHz	±(1% of reading +0.2% of full scale).
20 kHz to 100 kHz	±(5% of reading +0.2% of full scale).
−15°C to +18°C and +28°C to +55°C	
200 mV to 200 V	Input signal between 5% and 100% of full scale.
40 Hz to 10 kHz	±(0.8% of reading +0.1% of full scale).
20 Hz to 40 Hz and 10 kHz to 20 kHz	±(1.3% of reading +0.1% of full scale).
20 kHz to 10 kHz	±(6% of reading +0.1% of full scale).
500 V	Input signal greater than 100 V and less than 500 V.
40 Hz to 10 kHz	±(0.8% of reading +0.3% of full scale).
20 Hz to 40 Hz and 10kHz to 20 kHz	±(1.3% of reading +0.3% of full scale).
20 kHz to 100 kHz	±(6% of reading +0.3% of full scale).

Table 1-1 (cont)

Characteristics	Performance Requirements
Common Mode Rejection Ratio	>60 dB from dc to 60 Hz, with 1 kΩ imbalance.
Crest Factor	4 at full scale.
Resolution	4-1/2 digits.
Response Time	
Manual	Less than 2 seconds.
Auto	Less than 3 seconds.
Input Impedance	1 MΩ in parallel with less than 100 pF.
Maximum V*Hz Product	10^7 V*Hz.
Maximum Input Voltage between Inputs and Ground	500 V rms; 700 V peak.
dB Volts	
Accuracy	Same as AC VOLTS specification.
Resolution	0.01 dB.
OHMS HI	
Range Accuracies	
+18°C to +28°C	
2 kΩ to 2 MΩ	±(0.1% of reading +0.01% of full scale).
20 MΩ	±(0.5% of reading +0.01% of full scale).
−15°C to +18°C and +28°C to +55°C	
2 kΩ to 200 kΩ	Add ±(0.01% of reading +0.001% of full scale)/°C above 28°C or below 18°C.
2 MΩ	Add ±(0.01% of reading +0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity.
20 MΩ	Add ± (0.05% of reading +0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity.
Maximum Input Voltage	500 V rms; 700 V peak.
Voltage at Full Scale	Approximately 2 V.
Maximum Open Circuit Voltage	Less than 6 V.
Range Measuring Current	
2 kΩ	Approximately 1 mA.
20 kΩ	Approximately 0.1 mA.
200 kΩ	Approximately 10 μA.
2 MΩ	Approximately 1 μA.
20 MΩ	Approximately 0.1 μA.

Table 1-1 (cont)

Characteristics	Performance Requirements
Resolution	4-1/2 digits.
Range Response Time	
2 kΩ to 2 MΩ	
Manual	Less than 1 second.
Auto	Less than 2 seconds.
20 MΩ	Less than 5 seconds.
Range Reading Rate	
2 kΩ to 2 MΩ	Approximately 3 per second.
20 MΩ	Approximately 1.5 per second.
OHMS LO	
Range Accuracies	
+18°C to +28°C	
200 Ω	±(0.1% of reading +0.1% of full scale).
2 kΩ to 200 kΩ	±(0.1% of reading +0.01% of full scale).
2 MΩ	±(0.25% of reading +0.01% of full scale).
−15°C to +18°C and +28°C to +55°C	
200 Ω to 20 kΩ	Add ±(0.01% of reading +0.001% of full scale)/°C above 28°C or below 18°C.
200 kΩ	Add ±(0.01% of reading +0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity.
2 MΩ	Add ±(0.025% of reading +0.001% of full scale)/°C above 28°C or below 18°C ±2% of reading per 10% relative humidity above 70% relative humidity.
Maximum Input Voltage	500 V rms; 700 V peak.
Voltage at Full Scale	Approximately 0.2 V.
Maximum Open Circuit Voltage	Less than 6 V.
Range Measuring Current	
200 Ω	Approximately 1 mA.
2 kΩ	Approximately 0.1 mA.
20 kΩ	Approximately 10 μA.
200 kΩ	Approximately 1 μA.
2 MΩ	Approximately 0.1 μA.
Resolution	4-1/2 digits.

Table 1-1 (cont)

Characteristics	Performance Requirements
Response Time	
Manual	Less than 1 second.
Auto	Less than 2 seconds.
Reading Rate	Approximately 3 per second.
DC AMPS	
Range Accuracy	
+18°C to +28°C	±(0.1% of reading + 0.02% of full scale).
−15°C to +18°C and +28°C to +55°C	±(0.15% of reading +0.06% of full scale).
Response Time	
Manual	Less than 1 second.
Auto	Less than 2 seconds.
Input Resistance	
100 μA	Approximately 1 kΩ.
1 mA	Approximately 100 Ω.
10 mA	Approximately 10.5 Ω.
100 mA	Approximately 1.5 Ω.
1 A (1000 mA)	Approximately 0.5 Ω
Maximum Input Current	1 A.
Maximum Open Circuit Input Voltage (mA to LOW)	500 V rms; 700 V peak.
Maximum Floating Voltage (mA or LOW to Ground)	500 V rms; 700 V peak.
Resolution	4 digits.
AC AMPS	
Accuracy	20 Hz to 10 kHz sinusoidal waveform.
+18°C to +28°C	±0.6% of reading + 0.1% of full scale.
−15°C to +18°c and +28°C to +55°C	±0.7% of reading +0.15% of full scale.
Response Time	
Manual	Less than 2 seconds.
Auto	Less than 3 seconds.

Table 1-1 (cont)

Characteristics	Performance Requirements
Input Resistance	
100 μA	Approximately 1 kΩ.
1 mA	Approximately 100 Ω.
10 mA	Approximately 10.5 Ω.
100 mA	Approximately 1.5 Ω.
1 A (1000 mA)	Approximately 0.5 Ω.
Maximum Input Current	1 A.
Maximum Open Circuit Input Voltage (mA to LOW)	500 V rms; 700 V peak.
Maximum Floating Voltage (mA or LOW to Ground)	500 V rms; 700 V peak.
Resolution	4 digits.
CONTINUITY	
Response Time	Approximately 0.1 second.
Threshold Resistance	10 Ω ±1 Ω.
TEMPERATURE	
Range Accuracy	
+18°C to +28°C Ambient Temperature	±(2% of reading +1.5°C).
−15°C to +18°C and +28°C to +55°C Ambient Temperature	±(2% of reading +2.0°C).
Probe Tip Measurement Range	−62°C to +230°C in one range.
Resolution	0.1°C or 0.1°F.
ADDITIONAL CHARACTERISTICS	
Warmup Time to Meet Electrical Specification	45 minutes.
DMM Isolation	500 V rms; 700 V peak.
Maximum V*Hz Product	10^7 V*Hz.

Table 1-2
Option 01 Mechanical Characteristics

Characteristics	Description
Weight	
With Accessories and Accessories Pouch	13.1 kg (28.8 lb).
Without Accessories and Accessories Pouch	12.2 kg (26.9 lb).
Shipping Weight	
Domestic	19.2 kg (42.2 lb).
Height	
With Feet and Accessories Pouch	231 mm (9.1 in).
Without Accessories Pouch	201 mm (7.9 in).
Width	
With Handle	330 mm (13.0 in).
Depth	
With Front Cover	434 mm (17.1 in).
With Handle Extended	505 mm (19.9 in).

PREPARATION FOR USE

This section of the manual explains the power-up of the main instrument containing the DMM Option. The power-up sequence of the oscilloscope is described, along with explanations of option-related error messages that may occur if the instrument is not functioning properly.

POWER-UP SEQUENCE

Before turning on power to the instrument, read Section 2, "Preparation for Use," in the oscilloscope operators manual and follow the safety and precautionary information described there.

The power-up tests, automatically performed each time the oscilloscope is turned on, test both the standard oscilloscope circuitry and the DMM Option circuitry. Tests that apply to the DMM Option are integrated into the power-up tests for the host oscilloscope and include the DMM Kernel test.

Kernel Test

Operation of the DMM Option memory (ROM) is checked by the standard instrument Kernel test. Kernel test failures will result in an attempt to flash the front-panel A SWP TRIG'D indicator.

NOTE

On some instruments having other options installed, the A/B TRIG button may be labeled A/B/MENU.

Even with a Kernel failure, pressing in the A/B TRIG switch may still place the instrument in an operating mode. However, if the operating mode is successfully entered, instrument operation may be unpredictable. If the instrument then functions adequately for your particular measurement, it can be used; but refer it to a qualified service technician for repair as soon as possible.

Confidence Tests

Failure of a DMM Confidence test during power-up is indicated in the bottom line of the crt readout. The failure display has the following format:

DM TEST 7X FAIL YY

where 7X indicates the DMM Option and YY represents the code for the failed test segment.

A Confidence test failure may not render the DMM inoperable. Pressing the A/B TRIG button may still place the instrument into the normal operating mode; however, it may not meet all DMM specifications.

Successful Power-Up Sequencing

When the power-up routine is completed without a failure indication, the oscilloscope enters the normal operating state. The oscilloscope parameters are set to correspond with current front-panel switch positions and with switch functions that were established for at least 10 seconds before instrument power was last turned off. The instrument is now ready to make measurements.

If the DMM was on when the oscilloscope was turned off, the DMM will return to the same operating condition when power is restored to the main instrument, with the exception of dc amps, ac amps, continuity, and the hold operator. With any one of these functions, the DMM will initialize upon power-up to dc volts. For all DMM functions at power-up, the minimum and maximum values will be reset, but the reference in effect before the oscilloscope was turned off will be retained.

POWER-DOWN SEQUENCE

When the POWER switch is set to OFF, the instrument powers down and the instrument front-panel settings that were unchanged for at least 10 seconds before power-off will be stored for use the next time power is applied to the instrument.

DMM PARAMETER SELECTION

The following procedures are used to verify DMM push-button operation, to set the continuity function audible indicator frequency, and, if enabled, to set or determine the input impedance of the 0.2 V and 2 V DC DMM ranges.

Exercise procedure DM EXER 71, accessed via the oscilloscope Diagnostic Monitor, allows the operator to verify that the DMM front-panel push buttons are functioning properly.

Exercise procedure DM EXER 72, also accessed via the Monitor, lets the operator set the continuity function audible-indicator frequency. Also, if enabled during the calibration of the DMM Option, the input impedance of the 0.2 V and 2 V DC ranges may be selected.

Perform the following procedure to access the functional selections described above.

1. Hold in both the ΔV and Δt buttons and push in the TRIGGER SLOPE button to enter the Diagnositic Monitor.

2. Repeatedly push up and release the TRIGGER MODE switch until the message **DM EXER 71** appears at the bottom-left corner of the crt.

3. Push up and release the TRIGGER COUPLING switch once, and the top of the display will contain all 1's grouped on the crt to match the DMM push-button layout.

4. When a DMM button is pressed, the corresponding 1 in the crt readout should change to a 0. This will verify that the button is functioning. After checking each button, push down once on the COUPLING switch.

5. Push up and release the TRIGGER MODE switch. The message **DM EXER 72** will be displayed at the bottom-left corner of the crt.

6. Push up and release the COUPLING switch once, and the message **MOVE SOURCE FOR CONTINUITY TONE** will appear in the crt readout.

7. Touch the test lead tips together and a tone will be heard. Push up on the SOURCE switch to increase the frequency of the tone or push down on the SOURCE switch to decrease the frequency of the tone.

8. Push up on the COUPLING switch to get the message relating to the input impedance of the DMM in the 0.2 V and 2 V DC ranges. The message will be either:

INPUT Z ON 0.2VDC 2VDC = 10 MΩ or

INPUT Z ON 0.2VDC 2VDC > 100GΩ

9. If the desired input impedance is not displayed, push up once and release the COUPLING switch. The correct impedance should now be displayed.

10. Once the correct impedance is displayed, push down once on the COUPLING switch to store the impedance selection.

11. Push the A/B TRIG button to exit the Diagnostic Monitor and resume normal operation.

DMM FUSES

The DMM has two fuses, in series with the HI input connector, to protect the DMM circuitry from current overload. One of the fuses is on the DMM front panel and the other is inside the instrument cabinet. Only the front-panel fuse is operator replaceable; if the internal fuse opens, refer the instrument for fuse replacement or repair to a qualified service technician.

If the DMM does not make measurements after a potential current overload condition has occurred, turn off the instrument, remove the probes, and check the front-panel fuse. If it has opened, replace it with a fuse of the same type and rating. Otherwise replace the fuse in its holder and turn on the instrument. If the internal fuse has opened, the message **DM TEST 76 FAIL 01** will appear on the crt readout during instrument power-up. In this case, refer the instrument to a qualified service technician for repair.

CONTROLS, CONNECTORS, AND INDICATORS

This section of the manual describes the controls, connectors, and indicators used in the operation of the DMM Option. For details about the controls used to operate the basic oscilloscope, refer to the respective instrument operators manual.

FRONT PANEL CONTROLS AND CONNECTORS

All DMM front-panel controls are momentary push buttons. See Figure 3-1 for the location of the controls and connectors described in this section.

(56) **RANGE Switches**—These switches set the measurement mode and range to be used.

AUTO—Pressing this button sets the DMM to autorange. In this mode, the input attenuator settings are changed as necessary to maintain the proper measurement range. Autoranging is automatically selected each time a measurement function is changed. If the DMM is in the autorange mode, pressing this button stops autoranging, and the current range is held. When the button is pressed again, the DMM returns to the autoranging mode.

While the DMM is selecting the range which produces the greatest resolution, the display remains blanked. If the parameter value being measured is beyond the limits of the autoranging capability, an overrange indication, **OVER**, is displayed in the crt readout.

A measurement range is down-shifted only when a reading is more than 10% below the top of the next lower range. This amount of range overlapping prevents unnecessary range shifting near the range boundary limits. For example, if the reading is 1.799 kΩ and the present range is 20 kΩ, then the DMM will shift down to the 2 kΩ range. The range shifts down from 20 kΩ to 2 kΩ as the reading drops below 1.800 kΩ; it shifts up from 2 kΩ to 20 kΩ when the reading exceeds 2.0000 kΩ.

UP and DOWN—Pressing these buttons manually changes the measurement range to the next higher (UP button) or next lower (DOWN button) range, if available. If the DMM is in autorange and either button is pushed, autoranging will be disabled and the DMM will switch to the next range above or below the present range, if available. When the DMM is in the highest range and the UP button is pressed, or the lowest range and DOWN is pressed, the range will not change. The

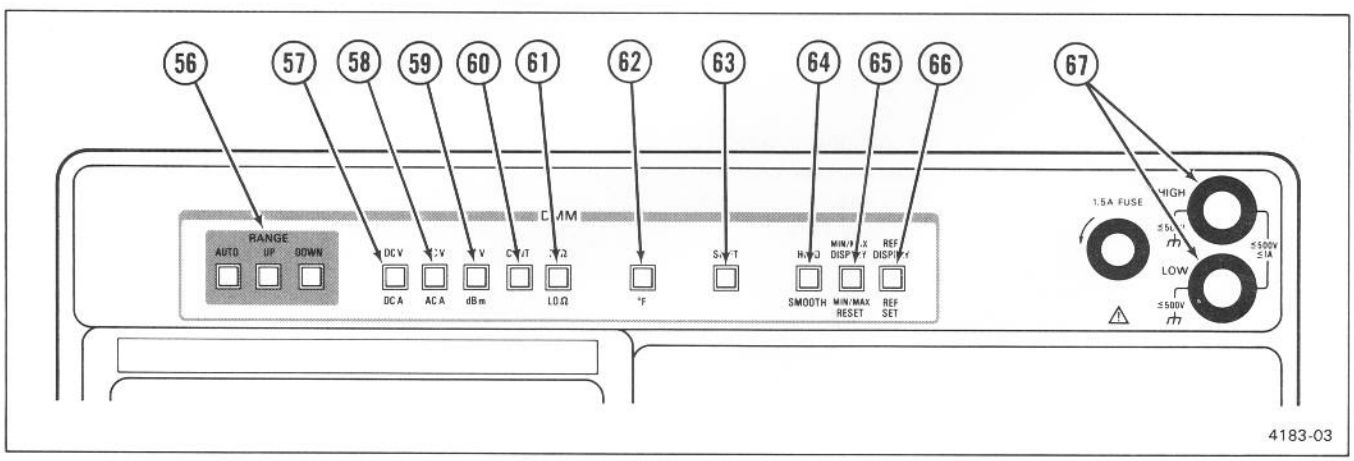


Figure 3-1. DMM Option front-panel controls and connectors.

DMM will go from autoranging to manual or manual to autoranging, depending on the previous mode selection.

The display will show **MNL** when the DMM is manually ranging. Autoranging is the default mode.

In the manual range mode, the DMM allows 10% overranging in every range except the top range. Above the range limit, the word **OVER** is displayed in the numerical field of the crt readout to indicate that the value being measured is over the limit of the presently selected range. Overranging is not allowed above 500 V, ac or dc, as damage to the instrument may result.

(57) **DC V-DC A Switch**—Selects either dc volts or dc amps for measurement.

DC V—Sets the DMM to measure dc volts. The following ranges are available: 200 mV, 2 V, 20 V, 200 V, and 500 V.

DC A—Sets the DMM to measure dc current. The following ranges are available: 100 μA, 1 mA, 10 mA, 100 mA, and 1 A.

(58) **AC V-AC A Switch**—Selects either ac volts or ac amps for measurement.

AC V—Sets the DMM to measure rms ac volts. The ranges available are the same as those for DC V.

AC A—Sets the DMM to measure ac current. The ranges available are the same as those for DC A.

(59) **dB V-dB m Switch**—Selects either dB V or dB m for measurement.

dB V—Sets the DMM to measure the voltage ratio of an unknown input voltage referenced to 1 V. The displayed result is equal to 20 log (V_{unk}/V_{ref}), where V_{unk} is the unknown voltage and V_{ref} is 1 V. The dB V function can only be used for ac voltage measurements. If V_{unk} is equal to zero, the readout will display **OVER**.

dB m—Sets the DMM to measure the voltage ratio of an unknown reference voltage referenced to 1 mW into 600 Ω. The displayed result is equal to 20 log (V_{unk}/V_{ref} where V_{unk} is the unknown voltage and V_{ref} is 0.7746 V. The dB m function can only be used for ac voltage measurements. If V_{unk} is equal to zero, the readout will display **OVER**.

(60) **CONT Switch**—Selects the continuity function. The DMM is set to LO Ω resistance mode in the 200 Ω range, and autoranging is disabled. If the resistance being measured is less than 10 Ω, an audible tone is produced. The right side of the crt display will read either **< 10 Ω** or **> 10 Ω**, as appropriate, to indicate that continuity is being measured, and the center of the display will read either **SHORT** or **OPEN**. Continuity measurements are taken at a rate of 50 per second.

When the continuity function is selected, the following buttons have no effect on DMM operation: AUTO, UP, DOWN, HOLD, SMOOTH, MIN/MAX DISPLAY, MIN/MAX RESET, REF DISPLAY, and REF SET.

(61) **HI Ω-LO Ω Switch**—Selects the resistance measurement function of the DMM.

HI Ω—Sets the DMM for resistance measurements. The following ranges apply: 2 k, 20 k, 200 k, 2 M, and 20 M. The maximum output voltage used to determine resistance is 2 V, which will bias on a semiconductor junction.

LO Ω—Sets the DMM for resistance measurements. The following ranges apply: 200, 2 k, 20 k, 200 k, and 2 M. The output test voltage used to determine resistance is 0.2 V, which will not bias on a semiconductor junction.

(62) **°C-°F Switch**—Selects the temperature measurement function of the DMM when using the P6601 temperature probe. When this function is selected, the DMM automatically switches to the 200 Ω range. If a temperature probe is not connected to the input jacks when the function is selected, the crt display will read **ATTACH TEMP PROBE**. The temperature is displayed on the crt readout.

°C—Sets the DMM to measure temperature in °C.

°F—Sets the DMM to measure temperature in °F.

(63) **SHIFT**—This button acts as a function-change button and works with the following buttons: DC V-DC A, AC V-AC A, dB V-dB m, HI Ω-LO Ω, °C-°F, HOLD-SMOOTH, MIN/MAX DISPLAY-MIN/MAX RESET, and REF DISPLAY-REF SET. Pressing this button causes a shift to the lower row function associated with the next button that is pressed. For example, pushing SHIFT, then DC V-DC A, causes dc amps to be the measurement mode selected. If SHIFT is not pushed before DC V-DC A, then dc voltage is the measurement mode selected. Pushing the SHIFT button again will cancel the shift function.

(64) **HOLD-SMOOTH Switch**—Selects either the hold or smooth operators.

HOLD—Pressing the button stops the updating of the value being displayed, and the present value is held in the display. The crt readout will display **HLD** when the measurement is being held. The next push of the HOLD button will cause the DMM to resume the operation being performed before the HOLD command was invoked. The HOLD function will be turned off by activating any other DMM function or operator.

SMOOTH—Pressing this button provides a smoothing or filtering effect on subsequent measurement values. A mean value is calculated from blocks of eight accumulated measurement values and is displayed on the crt. After 64 measurements are accumulated, the running average is updated (in blocks of eight) to reflect the most recent 64 measurements. Another push of the SMOOTH button will turn this operator off.

Smoothing will be indicated in the display by a field on the right that shows the number of values used in the current average: /**XX**/, where XX is 8, 16, 24, 32, 40, 48, 56, or 64. When dB V or dB m is selected, the ac voltage values will be smoothed, and the smoothed values will be used to calculate the dB value. Smoothing is not allowed when the continuity function is selected.

To reset the averaging process, smoothing must first be turned off, then back on.

(65) **MIN/MAX DISPLAY-MIN/MAX RESET Switch**—Selects the minimum/maximum accumulators for display or resets the accumulators.

MIN/MAX DISPLAY—Pressing this button causes a display of either the minimum or the maximum value that has occurred since the last minimum/maximum accumulator reset or function change. Each press of this button will step the display through the following sequence: MIN, MAX, then the display measurement. Minimum and maximum values are not shown on the crt at the same time.

The minimum and maximum registers are continually updated with each measurement, so the user will see the value for the selected limit (e.g., the minimum value will change as new minimums are taken).

MIN/MAX RESET—Resets the values in the minimum and maximum accumulators to the next valid value. A minimum/maximum reset occurs after each function change.

(66) **REF DISPLAY-REF SET Switch**—Displays or sets the reference value used by the DMM.

REF DISPLAY—Displays the current value set as a reference. If the REFSET operator is off, the reference value display will be 0.

REF SET—Sets the reference value to the displayed value, which then becomes the new "zero". All subsequent values will have this reference value subtracted from them before they are displayed. If there is no value displayed, or if the present value is overrange, the REF SET button is ignored. To turn the reference off, either measure 0.0 and push the REF SET button or select a new function. When a reference value is being used, the display will have a delta (Δ) symbol on the left side. The REF SET operator can be used with every function except continuity. If REF SET is selected when the DMM is measuring dB V or dB m, the measured voltage will be used as V_{ref}.

(67) **HIGH and LOW Connectors**—Two banana-like jacks provide positive (red) and negative (black) inputs for the DMM probes.

DMM DISPLAYS

Large-sized digits are used in the crt readout to display DMM measurement values. All parameter units and other text except **OVER** are displayed as smaller sized letters and digits. The following examples show various output displays of the different functions:

DC Voltage	15.693 V DC
SMOOTH	1.4356 A DC /64/
Using a reference value	Δ 0.9861 A DC
Reference display	1.3461 V DC=REF
Minimum display	0.5201 V AC=MIN
Maximum display (with reference)	Δ 0.8293 V DC=MAX
Continuity display	OPEN >10Ω SHORT <10Ω
Overrange display	OVER

NONCALIBRATED DMM DISPLAYS

If during DMM calibration one or more steps were skipped or incorrectly done, the DMM will "remember" that those ranges and functions were not calibrated. When a measurement is requested in a range or function that was not calibrated or has an out-of-limit calibration constant, the value will be displayed with dots (...), as in the following examples, instead of blank spaces.

..... 1569.3.V DC.....

..... 2.05.V DC=REF.....

OPERATING PROCEDURES

Consult the oscilloscope operators manual to acquire a thorough understanding of the operation of the standard oscilloscope before trying to use the features of the DMM Option. With the DMM Option installed, all standard oscilloscope functions (as explained in the respective oscilloscope technical manuals) remain unchanged.

DMM OPTION SELECTION

The DMM is enabled when any function (DC V, DC A, AC V, AC A, dB V, dB m, CONT, HI Ω, LO Ω, °C, or °F) on the the front panel is selected while the oscilloscope is operating. If an operator button (HOLD, SMOOTH, REF SET, REF DISPLAY, AUTO, UP, DOWN, MIN/MAX DISPLAY, MIN/MAX RESET, or SHIFT) is pressed, the DMM will remain off. The DMM can be turned off by pressing the button of the function currently selected.

If the DMM is turned off because of a crt display conflict, the DMM will remain off even if the display space becomes available. A DMM function button must then be pressed to turn the DMM on again. If the function selected is the same one that was active when the DMM was turned off because of a display conflict (and the oscilloscope power has not been turned off and back on again), only the reference value will remain as set before the DMM was turned off.

OPERATING CONSIDERATIONS

Each operator interacts with the others as shown in Table 4-1. At every function change, all operators are turned off. A measurement value will have operators applied in the following order: MIN or MAX, SMOOTH, then REF, after which the result is displayed.

GPIB CONTROLLABLE FUNCTIONS

If the GPIB Option is installed in the instrument, the DMM Option adds additional commands to control the DMM Option via the GPIB. The commands are listed in Table 4-2, and only the upper-case characters of a command are required for recognition. See the GPIB Operators Manual for additional information relating to the GPIB Option.

Table 4-1
Operator Interaction

New Operator Requested	Currently Selected Operator				
	REF SET	HOLD	SMOOTH	REF DISLAY	MIN/MAX DISPLAY
REF SET	N	O	X	O	O
HOLD	X	N	X	X	X
SMOOTH	X	O	N	O	O
REF DISPLAY	X	O	X	N	O
MIN/MAX DISPLAY	X	O	X	O	A

O = Turn this operator off and return to normal or requested display.
X = Doesn't change the state of this operator.
N = Negate the state of this operator (if on, turn off; it off, turn on).
A = See the descriptions of the MIN/MAX display.

Table 4-2
GPIB Command Set for the DMM Option

Header	Argument	Argument	Comments
DMM	OFF SUSp		The DMM is turned on with a function command, the same as during front panel operation. However, to prevent the DMM from turning itself off by receiving a SET command, the GPIB is only able to turn off the DMM with the command "DMM OFF;". "DMM ON;" causes an error message (SRQ) to be sent back to the GPIB. "DMM SUS;" causes the DMM to be put into the state caused by being forced off by other options. The only difference between DMM SUS and DMM OFF is that the next time a function is selected, if it is the same at the function previously selected, the DMM will not reinitialize (the reference value and the states of SMOOTH, AUTO, etc. remain as set before the DMM was turned off). If the DMM is suspended when SET? or LLSET? is issued, the string will have DMM SUSP appended at the end. Otherwise, all settings would be lost when the user chose a function.
DMM?			Query response is: "DMM ON;", "DMM SUS;", or "DMM OFF;".
DMMSend DMMSend?			DMMSend and DMMSend? are treated identically. This command returns the displayed measurement in the <nr3> format. The value will be adjusted to basic units such as volts, ohms, or amps. If there is no valid value displayed, the DMM will wait until a value is available. If the value being displayed is overranged, the value 1.0E+99 will be returned.
DISplay	MINImum MAXimum REF NORmal		The MINImum and MAXimum arguments cause the display to show the minimum and maximum values that have been accumulating. The REF argument shows the present value of the reference. The NORmal argument restores the normal measurement to the display. With no argument, NORmal is assumed.
DISplay?			Query response is: "DIS MINI;", "DIS MAX;", "DIS NOR;" or "DIS REF;". To receive the value currently stored as minimum over the GPIB, for example, send "DISplay MINImum;" followed by "DMMSend;".
MINMaxres			This command caused the values in the minimum and maximum accumulators to be reset to the next valid value.
RANge	<nrx>		This command sets the range of the present function. The absolute value of <nrx> is rounded up to the top of the nearest range, making the measurement specified by <nrx> to the highest degree of resolution. If the argument is omitted or zero, the DMM will autorange. If the argument is negative, the DMM will autorange after setting the range as requested, except for the dB V, and dB m functions. For these two functions a valid negative argument will set manual ranging and issue a possible Settings Conflict warning (SRQ 101/550). If the argument value is larger than the highest range, an argument error (SRQ) will be issued, and the command will be ignored.
RANge?			Query response is: "RANGE <nr3>;". The range value will be in basic units such as volts, amps, or ohms. A positive argument indicates manual ranging, a negative argument autoranging, except for the dB V and dB m functions where the sign is required to identify the range and does not convey auto/manual information.

Table 4-2 (cont)

Header	Argument	Argument	Comments
REFset	<nrx>		This command caused the argument to be used as the reference value. If the argument is equal to zero, the reference will be turned off. If the argument is a negative value and the present function is one that doesn't allow negative values, the reference will also be turned off. The argument is rounded up to the closest value represented by the DMM (1 part in 40,000). If the argument is larger than the highest value that can be represented, an SRQ will be issued, and the reference will not be changed. This follows the convention set by the Tektronix Codes and Formats standard. If no argument follows REFset, the reference value will be set to the displayed value. This command is illegal in Continuity.
REFset?			Query response is: "REF <nr3>;". The reference value will be sent in basic units such as volts, ohms, or amps. This query is illegal in Continuity.
SET?			The answers to the queries of FUNCtion, DISplay, REFset, SMOoth, and OVEr are sent, in that order. If the DMM is suspended (SUS) when this query is sent, the most recent settings will be sent, followed by "DMM SUS". This string can be read back to the DMM to reset a previous instrument state.
HOLd	ON OFF		This command controls the display hold feature. If no argument is sent, ON will be assumed.
HOLd?			Query response is: "HOL ON;" or "HOL OFF;".
SMOoth	ON OFF		This command turns smoothing on or off. Each time the command "SMOoth ON;" is issued, the number of averages taken is reset to zero. If no argument is sent, ON will be assumed.
SMOoth?			Query response is: "SMO ON;" or "SMO OFF;".
AVGs?			Query response is: "AVG <nr3>;" <nr3> reflects the number of averages associated with the current displayed value. If smoothing is off, the query returns an SRQ.
DCV ACV DCA ACA HIOhms LOOHms DBV DBM DEGC DEGF CONt	<nrx> <nrx> <nrx> <nrx> <nrx> <nrx> <nrx> <nrx>		These commands select the desired measurement function. An optionally included argument will set the DMM function range, as described in the RANge comments.
FUNCtion?			This query returns "(function name) <nr3>;", where <nr3> is the highest value in the present range. Nr3 will be omitted when a range value is unnecessary (e.g., DEGC). If the DMM is autoranging, the range value preceded by a negative sign will be returned (for example DCV −2.0E+1), except for the dB V and dB m functions.

Table 4-2 (cont)

Header	Argument	Argument	Comments
OVEr	ON OFF		The command "OVEr ON" turns on the warning SRQ if an overrange condition is detected. "OVEr OFF" disables transmission of the warning SRQ. With no argument, ON is assumed.
OVEr?			Query response is: "OVE ON;" or "OVE OFF;".
TONE	<nrx>		This command selects the tone to be used by the Continuity function. The values for nrx are 1, 2, 3, or 4, and the default value is 1.
TONE?			Query response is: "TON <nr3>;". The value returned in <nr3> is the current tone value.
HIZ	ON OFF		This command selects the input impedance to be used by the DCV function in the 200 mV and 2 V ranges. No argument or the "ON" argument selects an input impedance > 100 GΩ, while the "OFF" argument selects an input impedance of 10 MΩ. During the CAL 7:7 procedure, 'Settable Input Impedance' must have been selected or a 'Settings Conflict' SRQ will be returned.
HIZ?			Query response is: "HIZ ON;" or "HIZ OFF;".
BEEp	<nrx>	:<nrx>	Causes a tone whose pitch is specified by the first argument with a duration as specified by the second argument, or multiple tones and durations by separating the groups of arguments by commas. The DMM Option must be either off or suspended or a mode SRQ is sent. The range of valid values for the first argument is 0 to 13 and 1 to 255 for the second argument. If arguments are not specified, default values of 6 and 3 respectively are used. The first argument must be present if a second argument is specified. A value of 0 for the first argument produces no sound, and each unit of the second argument is a duration of approximately 0.1 second.
ID?			See the GPIB Option manual system commands for details. The string returned for the DMM Option is DMM:FVz where z is the version number.

BASIC APPLICATIONS

This section of the manual gives information and procedures to enhance the operator's understanding of the DMM Option. After becoming familiar with the controls, connectors, indicators, operating considerations, and capabilities of the instrument, perform the following procedures to become familiar with the instrument functions for making DMM measurements.

Before proceeding with these instructions, refer to "Preparation for Use" (Section 2).

Verify that the POWER switch is OFF (push button out); then plug the power cord into the power outlet and turn the instrument on (POWER switch in). Connect the DMM meter leads to the HIGH and LOW input connectors.

1. Low Impedance Measurements

This procedure demonstrates how to use the DMM to make low-impedance measurements using the reference operator to negate meter lead resistance.

a. Select the LO Ω function.

b. Remove any adaptors from the DMM meter leads and short the two tips together.

c. Push in the REF SET button to "zero" the DMM reading.

d. A low-impedance measurement can now be accurately made, since the resistance of the meter leads is compensated for in the display readout.

e. Remove the meter leads from the test circuit.

2. Circuit dB Loss or Gain Measurements

This procedure shows how to make circuit dB loss or gain measurements using the DMM dB V or dB m functions and the reference operator.

a. Set the DMM for the desired measurement function (dB V or dB m).

b. Connect the meter leads to the input of the circuit to be measured.

c. Push in the REF SET button to "zero" the DMM reading. The display should be **0.00 DB R.**

d. Connect the meter leads to the output of the circuit being measured.

e. The readout now shows the circuit dB gain or loss relative to the circuit input.

f. The original reference can be displayed by pushing the REF DISPLAY button.

g. Remove the meter leads from the test circuitry.

3. Minimum/Maximum Circuit Monitor

This procedure demonstrates how to use the minimum and maximum accumulators to show the deviations over time of a dc power supply.

a. Push in the DC V button.

b. Connect the meter leads to the dc power supply to be monitored.

c. Push in the MIN/MAX RESET button to reset the high and low accumulators. The DMM accumulators will now track the minimum and maximum voltages of the supply.

d. To display the accumulators, push the MIN/MAX DISPLAY button to see the minimum voltage. Push the MIN/MAX DISPLAY button again to see the maximum voltage, and then a third time to return to the normal display mode.

e. Remove the meter leads from the test circuitry.

4. Manual Overrange Measurements

This procedure can be used when the value of the function does not exceed 10% of the top of the measurement range being used (except for the highest range). The DMM is first in the autoranging mode and is then set to the manual mode.

a. Select the function for the measurement to be taken.

b. Connect the probes to the circuit to be measured.

c. If the reading is within 10% of the top of the range being used by the DMM for the measurement (except for the highest range), greater resolution can be obtained by manually downranging the DMM (push the DOWN button).

d. The display now contains the reading with the highest resolution possible.

e. Remove the meter leads from the test circuitry.

OPTIONS AND ACCESSORIES

INTRODUCTION

This section contains a general description of instrument options at the time of publication of this manual. Also included is a complete list (with Tektronix part numbers) of standard accessories included with each instrument. Additional information about instrument options, option availability, and other accessories can be obtained either by consulting the current Tektronix Product Catalog or by contacting your local Tektronix Field Office or representative.

OPTION 1B

Option 1B to the DMM Option deletes the temperature probe.

STANDARD ACCESSORIES

In addition to the standard accessories listed in the basic oscilloscope manuals, one each of the following DMM Option standard accessories are provided:

Description	Part Number
2445/2465 Option 01 DMM Operators Manual	070-4183-00
Probe Set	012-0941-01
Accessories to Probe Set	020-0087-00
P6602 Temperature Probe	010-6602-00
2445/2465 Option 01 DMM Reference Guide	070-5365-00

When Option 1B is ordered, the temperature probe is not included.

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.