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CALIBRATION PROCEDURE

Introduction

Use of this calibration procedure to restore DM2510G or DM2510 to the original performance requirements. This procedure needs not to be performed unless the Performance Check Procedure cannot be completed satisfactorily or the instrument fails to meet the Performance Requirements of the electrical characteristics listed in the Specification section in the DM2510G/2510 instruction manual (Part No. 070-8479-00).

Calibration Interval

Calibration should be performed if the performance check procedures show that the DM2510G/DM2510 is out of specification.

Calibration is also recommended following instrument repair or modification.

Environmental Conditions

Calibration Should be performed under laboratory conditions having an ambient temperature of 22 - 24°C and a relative humidity of less than 70%.

The DM2510G/2510 must be turned on and allowed to warm up for at least 30 minutes before beginning the performance checks. After exposure to or storage in high humidity (condensing) environment one hour warm-up time is required.

Recommended Test Equipment

The Test equipment listed in Table 1, or equivalent is suggested to perform the DM2510G/2510 calibration. Alternated equipment may be used as long as the accuracy is at least as good as the specifications listed in the table.

Table 1
TEST EQUIPMENT REQUIRED

Description	Performance Specifications	Required for These Adjustments	Recommended
DC Voltage Calibrator	Range, 0 to 1000V; accuracy, +/- 0.01%	DC Volts, DC Current	Fluke Model 343A or 341A
AC Voltage Calibrator + AC Power Amplifier	Range, 0 to 1000V; accuracy +/- 0.05%, 20Hz to 20KHz Adjustable +/- 0.2Hz at 50Hz and 60Hz.	TRMS AC Volts, TRMS AC Current	Fluke 5200A Fluke 5215A
Resistance Calibrator	Range, 0 - 20M Ω ; accuracy +/- 0.05%	Ohms	Electro Scientific Industries, Inc. Model DB62 Dekabox
Current Calibrator	0 to 2A AC, sine wave from 20Hz to 10KHz; accuracy, +/- 0.06%. Range 0 to 2A	AC Current, DC Current	Valhalla 2500E AC-DC Current Calibrator
Shorting plug			Tektronix PN 134-0012-00
Temperature	Temp. bath: 0°C +/- 0.1°C Temp. bath: 100°C +/- 0.1°C	Temperature probe check and adjustment	RTE 4 Neslab ZX3 Tamson
Extender Cable	TM500 and TM5000 mainframes	AC trimmer adjustment	Tektronix 067-0645-02
GPIO Extender Cable	TM5000 mainframes	AC trimmer adjustment, GPIO controlled	Tektronix 067-0996-00

Internal Adjustments

The entire calibration procedure may be performed without having to make any internal adjustments if AC compensation has been verified. Calibration can be performed by either of two methods:
(1) from the front panel or (2) over the IEEE-488 bus (GPIO).

To make internal adjustments, you must remove the top of the cabinet to access the component side of the main board.

All other calibrations need to be performed with the top of the cabinet closed.

Calibration - DM2510G/2510

Preparation for Calibration

1. Disconnect the power cord from DM2510 and remove the top of the cabinet.
A calibration enable jumper is positioned behind the front panel on the switch board assembly.
Place the jumper in the lower position (marked "CAL") and replace the cover.

2. Check that the line selector (on the rear panel cabinet) is set to the correct voltage.

3. Turn on the power.

4. Check to see if the calibration jumper is in the "CAL" position by noticing that the "AUTO" led is constantly blinking.

5. Check to see if the DMM is set at the proper line-frequency.

6. Allow the instrument to warm up for at least 30 minutes before continuing with the performance checks.

(See Environmental Conditions above.)

Calibration Procedures**NOTE**

In the following procedure, the DM2510G and DM2510 instruments are referred to as DMM.

The following steps are for calibrating the DM2510G or DM2510, for each of the six measuring functions: DC voltage, TRMS AC voltage, resistance, TRMS AC current, DC current and temperature. These procedures are intended for use by qualified personnel using accurate and reliable test equipment.

The dBm and dBV functions are recalculated AC

Voltage ranges.

Calibrating AC Voltage will suffice.

All following measurement procedures need to be performed with the following settings:

4.5 digit resolution	(Right hand digit ON)
NULL-mode OFF	(NULL-led OFF)
In RUN mode	(HOLD-led OFF)

WARNING

To prevent a shock hazard, do not exceed 1000V peak between input low and chassis ground. Some of the procedures in this section may expose the user to dangerous voltages. Use standard safety precautions when such dangerous voltages are encountered.

Introduction

The DM2510G and DM2510 are software calibrated by constants that are stored in EEPROM. Every range has its own calibration values: an offset and a gain.

In this way there is no interference between ranges; re-calibrating one range, will not change other ranges. All DC voltage and DC current ranges, have a positive and a negative offset value, and a positive and a negative gain.

When taking a measurement, the offset value is first subtracted from the measurement counts that are measured by the microcontroller. The result is multiplied by the gain to get the display value.

There is a GPIB query "CALFACTOR" that will output the calibration settings per range.

In AC ranges, calibration is done at 5% and 95% of full scale, because of reduced accuracy of true RMS converter at small signals. For microcontroller to be able to convert these two calibration measurements to the standard offset and gain, both measurements need to be known. For that reason, calibration of AC ranges needs to be done in a specific order.

Calibration - DM2510G/2510

The 5% of full scale calibration needs to be done first, immediately followed by the 95% calibration of that same range. Only after that, the new offset and gain values will be checked, and written to EEPROM. Obviously, for proper calibration of both gain and offset, it is needed to do the offset calibration of a range before the gain calibration.

In normal measurement, before the settings read from EEPROM are used, the firmware compares the offset and the gain with values in a table. When one of the EEPROM settings of a range is not within these boundaries, the DMM will consider that range to be uncalibrated.

In DC ranges this check is done on the calibration settings of the polarity that is used at that moment. In that way, the positive measurements of a range can be calibrated, while the negative measurements are uncalibrated.

The two least significant digits of the display will constantly blink, when a range is not fully calibrated. To be able to make measurements, the DMM microcontroller decides to use default offset and gain values from fixed firmware tables. Accuracy of the instrument is then reduced to about $\pm 2\%$!!! Uncalibrated ranges will only occur when the EEPROM is defective, or when the EEPROM (U209) has been done completely.

Calibration is done only in 4.5 digit mode. The 3.5 digit measurements are directly derived from the 4.5 digit calibration values.

Calibration can be done in either 50Hz or 60Hz. Changing the setting after calibration will not degrade performance. Obviously, setting the line frequency to the proper setting during calibration improves stability and accuracy.

Calibration - DM2510G/2510

Front Panel Calibration

Command Sequence

When the DM2510G is in the calibration mode, autoranging is no longer functioning. Simultaneously pressing of the UP and the DOWN of Autoranging key, is now the command for the DMM to calibrate !!!

The operator is warned for the DMM being in the CAL enabled mode, by the constantly blinking "AUTO"-led. When a calibration command is given to the DMM, the micro-controller will automatically determine if an offset or gain calibration is required. This is done, depending upon the input signal level. During calibration the operator is kept informed about the status, by messages on the display (Table 2).

The calibration command can also be given over the GPIB bus (DM2510G only).

GPIB error messages will then also indicate the status, enabling full automatic verification and calibration over the bus.

Table 2
Displayed Calibration Messages

Message	Problem and/or Suggested Action
doNE	The DM2510G/DM2510 has successfully executed a calibration step.
+0000	Positive offset calibration is busy; wait. (DC Voltage and DC Current only)
-0000	Negative offset calibration is busy; wait. (DC Voltage and DC Current only)

Table 2 (continue)
Displayed Calibration Messages

Message	Problem and/or Suggested Action
190.?	5% of full scale AC calibration command accepted, continue with 95% of full scale value.
500.?	100VAC calibration command accepted, continue with 500VAC value.
4.5 d	Select 4.5 digit; calibration command not accepted.
ACV	Select AC Voltage function; calibration cannot be done in dBm or dBV function.
????	Input reference is outside firmware boundary settings; calibration command is not accepted.
UnSt	Unstable input during calibration, calibration command is not accepted.
StoP	Calibration stopped, command not accepted: range or function setting changed during calibration.
1FrSt	Calibration command is not accepted, the lower calibration value should be applied first. (AC only)
EErr	EEPROM error; attempt to write new settings has failed. Hardware error??

Calibration - DM2510G/2510

1. Adjustment DC Voltage Accuracy

- a. Set the DMM in the DCV, 200mV range.
- b. Short circuit the LOW and V/ Ω /TEMP jacks with a shorting plug.
- c. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the positive and negative offset.
- d. After writing the new settings in EEPROM the readout will show: "doNE"
- e. A few seconds later, the readout returns to 0.00mV. The offset calibration of the 200mV range is now completed (see table 3).
- f. Repeat the steps a through e for the remaining DCV ranges.
- g. Remove the shorting plug and connect the DC Voltage calibrator to the LOW and V/ Ω /TEMP jacks.
- h. Set the DMM in the DCV, 200mV range.
- i. Set the calibrator to +190.00mV.
- j. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the positive gain.
- k. After completion of the calibration the readout will show: "doNE", and the positive gain is now successfully written in EEPROM.
- l. As a result, the DMM display should now read $+190.0\text{mV} \pm 1$ count.
- m. Apply -190.00mV to the DMM.
- n. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the negative gain.
- o. After completion of the calibration the readout will show: "doNE", meaning that also the negative gain is now successfully stored.
- p. As a result, the DMM display should now read $-190.0\text{mV} \pm 1$ count.
- q. Repeat steps h through p for the 2, 20, 200 and 1000 Volt DC ranges according to the settings in Table 3.

Calibration - DM2510G/2510

Table 3.
DC Voltage Calibration Settings

DM2510G/ DM2510 range	Input V/ Ω /TEMP to LOW	Display reading after Calibration (\pm LS digit)
200mV DC	Shorted	0.00 mV
2 V DC	Shorted	0.0000 V
20 V DC	Shorted	0.000 V
200 V DC	Shorted	0.00 V
1000 V DC	Shorted	0.0 V
200mV DC	+190.000mV	+190.00mV
2 V DC	+1.90000 V	+1.9000 V
20 V DC	+19.0000 V	+19.000 V
200 V DC	+190.000 V	+190.00 V
1000 V DC	+1000.00 V	+1000.0 V
200mV DC	- 190.000mV	- 190.00mV
2 V DC	- 1.90000 V	- 1.9000 V
20 V DC	- 19.0000 V	- 19.000 V
200 V DC	- 190.000 V	- 190.00 V
1000 V DC	- 1000.00 V	- 1000.0 V

2. Adjustment Resistance Accuracy

- Set the DMM in the Ohms, 200 Ω range.
- Short circuit the LOW and V/ Ω /TEMP jacks with a shorting plug.
- Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the offset of the 200 Ω range.
- After writing the new settings in EEPROM the readout will show: "doNE"
- A few seconds later, the readout returns to 0.00 Ω . The offset calibration of the 200 Ω range is now completed (see table 4).
- Repeat the steps a through e for the remaining Ohms ranges.
- Remove the shorting plug, and connect the Resistance Calibrator to the LOW and V/ Ω /TEMP jacks.

Calibration - DM2510G/2510

- h. Set the DMM in the Ohms, 200 Ω range.
- i. Set the Calibrator to +100.000 Ω .
- j. Press the DOWN and UP of Autoranging keys simultaneously.
- k. After completion of the calibration the readout will show: "doNE", and the gain of this range is now successfully written in EEPROM.
- l. As a result, the DMM display should now read 100.00 $\Omega \pm 1$ count.
- m. Repeat steps h through l for the 2k Ω , 20k Ω , 200k Ω , 2M Ω and 20M Ω ranges according to the settings in Table 4.

Table 4.
Resistance Calibration Settings

DM2510G/ DM2510 range	Input LOW to V/W/TEMP	Display reading after Calibration (± 1 LS digit)
200 Ω	Shorted	0.000 Ω
2 k Ω	Shorted	.00000 k Ω
20 k Ω	Shorted	0.0000 k Ω
200 k Ω	Shorted	0.000 k Ω
2 M Ω	Shorted	.0000 M Ω
20 M Ω	Shorted	0.000 M Ω
200 Ω	100.000 Ω	100.000 Ω
2 k Ω	1.00000 k Ω	1.00000 k Ω
20 k Ω	10.0000 k Ω	10.0000 k Ω
200 k Ω	100.000 k Ω	100.000 k Ω
2 M Ω	1.0000 M Ω	1.0000 M Ω
20 M Ω	10.000 M Ω	10.000 M Ω

3. Adjustment AC Voltage Accuracy

Before the calibration of the AC Voltage ranges can be done, the two resistance trimmers R113 and R121 need to be properly adjusted.

Adjustment of R113 (Frequency Compensation)

- a. Remove the top of the cabinet.

WARNING

To avoid electric shock hazard, do not touch exposed circuitry. Use an insulated alignment tool to make the following adjustments.

- b. Turn on the power.
- c. Select the 200V AC range and connect the AC Voltage calibrator to the LOW and V/ Ω /TEMP jacks.
- d. Set the calibrator to 180.000V AC.
- e. Switch the frequency of the calibrator signal between 300Hz and 10kHz, and adjust R113, until the reading is the same for both frequencies (within a tolerance of ± 3 counts).

Adjustment of R121 (AC stage DC offset voltage)

R121 gives the ability to reduce the DC offset voltage produced by the source follower circuitry of Q100 and Q101. When there is too much offset, switching between especially the 2V and the 20V ranges, will create temporary charge in the True RMS circuitry, that will disturb proper autoranging. Re-adjustment is needed when the readings 'jumps' more than 200 counts when switching between the 2VAC and the 20VAC range. If necessary, perform the following procedure:

- f. Disconnect the DC Voltage calibrator and connect the shorting plug to the LOW and V/ Ω /TEMP jacks.
- g. Select the 20 Volt AC range.
- h. Measure the voltage at U101 pt 7 (the AC amplifier output) with a DMM.
- i. Adjust R121 to reduce the DC voltage at that point to less than 20mV.
- j. Turn the power off, replace the top of the cabinet on the power and allow the instrument time to warm up.

Calibration - DM2510G/2510

Calibration of AC Voltage ranges.

k. Set the DMM in the AC, 200mV range.

l. Connect the AC Voltage calibrator to the LOW and V/ Ω /TEMP jacks.

m. Set the calibrator to 10.000mV AC @ 300Hz.

n. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then store this measurement in RAM memory and show "190.?" on the display.

o. Set the calibrator to 190.000mV AC @ 300Hz.

p. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calculate the offset and gain of the range.

q. After completion of the calibration the readout will show: "doNE", and the offset and gain are now successfully written in EEPROM.

r. As a result, the DMM display should now read +190.00mV AC \pm 1 count.

s. Repeat steps k through r for the 2, 20, 200 and 500 VAC ranges according to the settings in Table 5.

Table 5.

Ac Voltage Calibration Settings

DM2510G/ DM2510 range	Input LOW to V/ Ω /TEMP	Display reading after Calibration (\pm 1 LS digit)
200mV AC 200mV AC	10.000 mV, 300Hz 190.000mV, 300Hz	190.00mV AC
2 V AC 2 V AC	0.10000 V, 300Hz 1.90000 V, 300Hz	1.9000 V AC
20 V AC 20 V AC	1.0000 V, 300Hz 19.0000 V, 300Hz	19.000 V AC
200 V AC 200 V AC	10.000 V, 300Hz 190.000 v, 300Hz	190.00 V AC
500 V AC 500 V AC	100.00 V, 300Hz 500.00 V, 300Hz	500.0 V AC

Calibration - DM2510G/2510

4. Adjustment DC Current Accuracy

- a. Set the DMM in the DCA, 200 μ A range.
 - b. Use the DMM with open jacks.
 - c. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the positive and negative offset.
 - d. After writing the new settings in EEPROM the readout will show: "doNE"
 - e. A few seconds later, the readout returns to 0.00 μ A. The offset calibration of the 200 μ A range is now completed (see table 6).
 - f. Repeat the steps a through e for the remaining DCA ranges.
 - g. Connect the DC Current calibrator to the LOW and mA jacks.
 - h. Set the DMM in the DCA, 200 μ A range.
 - i. Set the calibrator to +190.000 μ A.
 - j. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the positive gain.
 - k. After completion of the calibration the readout will show: "doNE", and the positive gain is now successfully written in EEPROM.
 - l. As a result, the DMM display should now read +190.00 μ A \pm 1 count.
 - m. Apply -190.000 μ A to the DMM.
 - n. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the negative gain.
 - o. After completion of the calibration the readout will show: "doNE", meaning that also the negative gain is now successfully stored.
 - q. Repeat steps h through p for 2, 20, 200, 2000mA and 10A DC ranges according to the settings in Table 6.
- For 10A, make sure that the DC current calibrator is connected to the LOW and A input jacks and the DMM is set to A mode.

Calibration - DM2510G/2510

Table 6.
DC Current Calibration Settings

DM2510G/ DM2510 range	Input LOW to mA	Display reading after Calibration (± 1 LS digit)
200 μ A DC	Open	0.00 μ A
2 mA DC	Open	.0000 mA
20 mA DC	Open	0.000 mA
200 mA DC	Open	0.00 mA
2000 mA DC	Open	0.0 mA
10 A DC	Open	0.000 A
200 μ A DC	+190.000 μ A	+190.000 μ A
2 mA DC	+1.90000 mA	+1.90000 mA
20 mA DC	+19.0000 mA	+19.0000 mA
200 mA DC	+190.000 mA	+190.000 mA
2000 mA DC	+1900.00 mA	+1900.00 mA
10 A DC	+10.0000 A	+10.0000 A
200 μ A DC	- 190.000 μ A	- 190.000 μ A
2 mA DC	- 1.90000 mA	- 1.90000 mA
20 mA DC	- 19.0000 mA	- 19.0000 mA
200 mA DC	- 190.000 mA	- 190.000 mA
2000 mA DC	- 1900.00 mA	- 1900.00 mA
10 A DC	- 10.0000 A	- 10.0000 A

5. Adjustment AC Current Accuracy

Before calibrating AC current, R121 adjustment needs to be correct (see AC voltage calibration).

- Connect the AC current calibrator to the LOW and mA jacks.
- Set the DMM in the AC, 200 μ A range.
- Set the calibrator to 10.000 μ A AC @ 300Hz.
- Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then store this measurement in RAM memory and show "190.?" on the display.
- Set the calibrator to 190.000 μ A AC @ 300Hz.
- Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calculate the offset and gain of the range.

Calibration - DM2510G/2510

- g. After completion of the calibration the readout will show: "doNE", and the offset and gain are now successfully written in EEPROM.
- h. As a result, the DMM display should now read $190.00\mu\text{A AC} \pm 1$ count.
- i. Repeat steps b through h for the 2, 20, 200, 2000mA and 10A AC ranges according to the settings in Table 7.

Table 7.
AC Current Calibration Settings

DM2510G/ DM2510 range		Input LOW to mA	Display reading after Calibration (± 1 LS digit)
200 $\mu\text{A AC}$		10.000 μA , 300Hz	
200 $\mu\text{A AC}$		190.000 μA , 300Hz	190.00 μA , AC
2 mA AC		0.10000mA, 300Hz	
2 mA AC		1.90000mA, 300Hz	1.9000 mA, AC
20 mA AC		1.0000 mA, 300Hz	
20 mA AC		19.0000mA, 300Hz	19.000 mA, AC
200 mA AC		10.000 mA, 300Hz	
200 mA AC		190.000mA, 300Hz	190.00 mA, AC
2000 mA AC		100.00 mA, 300Hz	
2000 mA AC		1900.00mA, 300Hz	1900.0 mA, AC
10 A AC		1.0000 A, 300Hz	
10 A AC		10.0000 A, 300Hz	10.000 A, AC

Calibration - DM2510G/2510**6. Adjustment Temperature Accuracy**

As an option a P6602 PT100 temperature probe can be delivered with the DM2510G/DM2510. Then the instrument is calibrated to the probe at shipment. When re-calibration is needed, or when a different P6602 probe needs to be used, follow the next procedure:

- a. Set the DMM to Temperature measurement function by pressing the PROG and TEMP key.
- b. Connect the P6602 Probe to which the DMM is calibrated to the LOW and V/ Ω /TEMP jacks.
- c. Put the tip of the temperature probe about 1 inch into the temperature bath of 0°C ($\pm 0.1^\circ\text{C}$).
- d. Wait for the measurement to stabilize.
- e. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the offset.
- f. After writing the new settings in EEPROM the readout will show: "doNE"
- g. A few second later, the readout returns to 0.0°C. The offset calibration of the temperature function is now completed.
- h. Put the tip of the temperature probe about 1 inch into the temperature bath of 100°C ($\pm 0.1^\circ\text{C}$).
- i. Wait for the measurement to stabilize.
- j. Press the DOWN and UP of Autoranging keys simultaneously. The DMM will then calibrate the gain.
- k. After completion of the calibration the readout will show: "doNE", and the positive gain is now successfully written in EEPROM.
- l. As a result, the DMM display should now read $+100.0^\circ\text{C} \pm 1$ count.

When all previously mentioned calibration steps are successfully performed, re-calibration of the DM2510G/DM2510 is completed.