REVISION HISTORY

REV	ECO	DESCRIPTION	DATE	APPROVED
A	1200	Release	10/11/01	B. King
B		Updated Linearization Calibration Section	01/23/06	D. Weeks

PURPOSE

The purpose of this document is to describe the calibration requirements and procedure for the VM2710A Multimeter.

SCOPE

This document includes critical specifications for required equipment and a description of the algorithm used in the calibration programs. This document covers the calibration of the VM2710A, utilizing the 1 year specifications for 1 PLC. Calibration is performed on all PLC settings in the same manner, but would implement the specifications for the selected PLC setting and the designated accuracy period.

REQUIRED RESOURCES

Equipment

Calibrator (critical specifications)

Parameter	Instrument Range	Calibrator Tolerance
Voltage (ac & dc)	100 mV	±0.00000225 V
	1 V	±0.0000195 V
	10 V	±0.000225 V
	100 V	±0.00225 V
	300 V	±0.006 V
Current (ac & dc)	10 mA	±0.000000275 A
	100 mA	±0.00000175 A
	1 A	±0.0000275 A
Resistance	20 Ω	±0.00065 Ω
	200 Ω	±0.0075 Ω
	2 kΩ	±0.06 Ω
	20 kΩ	±0.6 Ω
	200 kΩ	±6 Ω
	2 MΩ	±75 Ω
	20 MΩ	±1250 Ω

Recommended Model: Fluke Model 5700A

Multiplexer (Multi-system program only)

Recommended Model: VXI Technology Inc. VM8016

Documents

VM2710A User's Manual, VTI P/N 82-0032-000.
VM2710A Test and Calibration Cable Specification VTI P/N 52-0191-000 or 52-0191-001.
VM2710 Multi-module.exe (VTI P/N 72-0032-000) or VM2710 Single.exe (VTI P/N 72-0032-001).

NOTE The VM2710A firmware must be at least revision 1.4 in order to use the 72-0032-00X programs.

METHOD

1. Set Defaults (All calibration constants can be set to the default values using the CalDef command.)

1.1 Set the “CAL:SEC:STATE” to OFF.

1.2 Send the command “CAL:DEF”

1.3 Send the command “CAL:STOR”

1.4 Set the “CAL:SEC:STATE” to ON.

NOTE	This will clear all constants from non-volatile memory (non-vol). If the “CAL:STORE” command is not issued after the “CAL:DEF” command is issued, then the previous values will be reloaded upon the next power up, or the next time the “*RST” command is issued.

2. A/D Converter Self-Calibration

The A/D converter has the capability to perform a self-calibration. This is done using an internal reference voltage and calibrates the A/D converter after all input signal conditioning. A/D converter self-calibration is performed for each Aperture Setting.

2.1 Set the instrument to the Aperture Setting to calibrate.

2.2 Set the converter into a Self-Calibration state by issuing the command "MFGTEST 2 #H0120".

2.3 Read the converter offset setting by issuing the query “MFGTEST? 30”.

2.4 Read the converter scale setting by issuing the query “MFGTEST? 31”.

2.5 Set the converter offset setting to non-vol by issuing the command “MFGTEST 0 ADO” and “MFGTEST 8 ADO”, where ADO is the offset value read from the query in step 2.3.

2.6 Set the converter scale setting to non-vol by issuing the command “MFGTEST 1 ADS” and “MFGTEST 7 ADS”, where ADS is the scale value read from the query in step 2.4.

2.7 Disable the calibration secure state using the “CAL:SEC:STAT” command.

2.8 Store the values in non-vol by issuing the command “CAL:STORE”

NOTE	For optimal performance, steps 2.2 through 2.4 can be performed multiple times, and the average of the multiple readings can be used in place of a single reading.

3. Linearization Calibration

Linearization on the VM2710A is performed in 16 linearization segments. Each segment effectively has a scale and offset calibration performed in a similar manner to the complete range calibration. Each linearization segment has a scale and offset constant calculated and loaded to non-vol. This provides a means for greater linearity throughout the full measurement range. The linearization calibration is performed using raw data, and therefore will only need to be performed on one measurement function and range.

NOTE	Linearization segments are numbered 0 through 15, with 0 indicating the negative most measurement segment in the range, and 15 indicating the positive most measurement segment in the range. The 16 segments are equally distributed throughout the range of the A/D converter. For this section of the calibration procedure, there are 17 measurements, representing the min and max measurement location for each of the 16 linearization segments. Linerization is performed on the 1 V range by applying equally spaced voltages from -1.200 V to +1.200 V and making a series of measurements. The starting voltage for each segment is the least positive (or most negative) and is designated as “point A”. The second measurement for each segment is 150 mV more positive than point A and is designated as “point B”. The voltage at point B for segment 0, then, becomes the point A voltage for segment 1, etc.

3.1 Set the instrument to the Volts dc measurement function in the 1 V range by issuing the command “CONF:VOLT:DC 1”.

3.2 Set the desired Aperture Setting.

3.3 Set the instrument to report raw data by issuing the command “MFGTEST 22 1”.

3.4 Set the instrument to report uncalibrated data by issuing the command “MFGTEST 20 0”.

3.5 Set the instrument to report non-linearized data by issuing the command “MFGTEST 23 0”, and “MFGTEST 32 0”.

3.6 With an input voltage of -1.2 V dc, capture a measurement on the VM2710A and designate it as “CalLinReadingA”.

NOTE	For optimal performance, multiple measurements can be captured, and the average of these measurements can be used in place of the single measurement.

3.7 Calculate the deviation from the expected value using the following formula:

CalculatedDevA = CalLinReadingA - ExpectedVoltage
Where:
CalLinReading A is the data captured in step 3.6.
ExpectedVoltage is the raw data value of the input voltage calculated as:

$$ExpectedVoltage = \frac{VoltageSetting}{0.0000003} + \&H400000 = \frac{-1.20V}{0.0000003} + \&H400000$$

$$ExpectedVoltage = -4000000 + \&H40000$$

$$ExpectedVoltage = \&H2F700 = 194304$$

3.8 Increment the voltage to -1.05 V.

3.9 Capture a measurement with the VM2710A and designate it as “CalLinReading B”. Repeat 3.7, but with point B in place of point A.

3.10 For each segment, calculate the CalLinConstant using the following formula:

CalLinConstant = ((CalculatedDevA – CalculatedDevB) / (CalLinReadingA – CalLinReadingB)) * &H800000
Where:
CalculatedDevA is the value calculated in step 3.7 for the start of the segment in question.
CalculatedDevB is the value calculated in step 3.9 for the end of the segment in question.
CalLinReadingA is the data captured in step 3.6 for the segment in question.
CalLinReadingB is the data captured in step 3.9 for the end of the segment in question.

3.11 Write the linearization calibration data for each segment to RAM by issuing the following commands:

MFGTEST 10 [LinNum] CalLinReadingA
MFGTEST 11 [LinNum] CalLinConstant
MFGTEST 12 [LinNum] CalculatedDevA

Where:
LinNum is the number representing the linearization segment, starting with 0.
CalLinReading is the data captured in step 3.7 for the segment in question.
CalLinConstant is the value calculated in step 3.10 for the Linearization Segment in question.
CalculatedDevA is the value calculated in step 3.7 for the linearization segment in question.

3.12 Set CalLinReadingA = CalLinReadingB
Set CalculatedDevA = CalculatedDevB

3.13 Increment the input voltage again by +0.15 V, capture a measurement on the VM2710A and designate it as “CalLinReadingB”. Again, calculate the new Expected Voltage, calculate DevB, and write the results to RAM by repeating steps 3.9 through 3.11.

3.14 Repeat the previous steps until all 16 segments have been characterized and the results are stored in RAM.

3.15 Disable the calibration security state using the command “CAL:SEC:STAT”,#.

3.16 Store the data to non-vol using the “CAL:STOR” command.

3.17 Set the instrument back to its normal data reporting state by issuing a “*RST” command. (Re-enables reporting calibrated, linearized measurement data and reports calculated values rather than raw data.)

4. Gain and Offset Calibration

Gain and offset are calibrated for each measurement function, in each range, at each available aperture setting. 2-wire resistance is not calibrated. To calibrate the 2-wire resistance function, perform a calibration on the 4-wire function. The constants calculated for the 4-wire function are used for both the 2-wire and 4-wire measurements. All ac values are calibrated at 1000 Hz.

Special note for the Fluke 5700A - For resistance calibration, use the query response of the calibrator setting, rather than the value input to the calibrator when calibrator settings are required. This is due to the fact that the Fluke 5700A will not set the resistance to the value that is input, but will report the actual set value with a significant amount of accuracy.

4.1 Set the instrument to the desired function, range, and aperture setting.

4.2 Set the Gain constant to nominal by issuing the command "MFGTEST 5 8388608"

4.3 Set the Offset constant to nominal by issuing the command "MFGTEST 6 0"

4.4 **Gain Calibration**

4.4.1 Set the calibrator to the High value for the selected range and function. See Table 1 for recommended values

Function	Range	CalHigh	CalLow	Offset Reference
4-Wire Res	20 MΩ	19 MΩ	1.9 MΩ	0
	2 MΩ	1.9 MΩ	190 kΩ	0
	200 kΩ	190 kΩ	19 kΩ	0
	20 kΩ	19 kΩ	1.9 kΩ	0
	2 kΩ	1.9 kΩ	190 Ω	0
	200 Ω	190 Ω	19 Ω	0
	20 Ω	19 Ω	1.9 Ω	0
Volts ac	300 V	290 V	30 V	9% of range
	100 V	100 V	10 V	9% of range
	10 V	10 V	1 V	9% of range
	1 V	1 V	100mV	9% of range
	100 mV	100 mV	10 mV	9% of range
Volts dc	300 V	290 V	-290 V	0
	100 V	100V	-100V	0
	10 V	10V	-10V	0
	1 V	1V	-1V	0
	100 mV	100mV	-100mV	0
Amps ac	1 A	1 A	100 mA	9% of range
	100 mA	100 mA	10 mA	9% of range
	10 mA	10 mA	1 mA	9% of range
Amps dc	1 A	1 A	-1 A	0
	100 mA	100 mA	-100 mA	0
	10 mA	10 mA	-10 mA	0

Table 1: Recommended Values

4.4.2 Capture a measurement on the VM2710A.

4.4.3 Set the calibrator to the low value for the selected range and function. See table 1 for recommended values

4.4.4 Capture a measurement on the VM2710A.

4.4.5 Calculate the gain constants using the following formula:

GainSlope = SlopeAdjust / ((HighValue - LowValue) / (CalValHigh - CalValLow))
Where:

SlopeAdjust = The value loaded into non-vol when the measurement data was captured (8388608 from step 4.2).
HighValue = The measurement captured in step 4.4.2.
LowValue = The measurement captured in step 4.4.4.
CalValHigh = The Calibrator setting from step 4.4.1.
CalValLow = The Calibrator setting from step 4.4.3.

4.4.6 Load the calculated value to non-vol using the command "MFGTEST 5 GainSlope" where GainSlope is the value calculated in step 4.4.5.

4.5 Offset Calibration

4.5.1 Set the calibrator to the Offset Reference for the selected function and range. See Table 1.

4.5.2 Capture a measurement on the VM2710A.

4.5.3 Set the offset constant to 10000 by issuing the command "MFGTEST 6 10000".

4.5.4 Capture a measurement on the VM2710A.

4.5.5 Calculate the Zero Offset value using the following formula:

ZeroOffset = (Ref - FirstReference) / ((SecondReference - FirstReference) / OFFSET_DELTA) + OffsetAdjust
Where:

Ref = The value the calibrator was set to in step 4.5.1.
FirstReference = The measurement data captured in step 4.5.2.
SecondReference = The measurement data captured in step 4.5.4.
OFFSET_DELTA = the Zero Offset setting loaded in step 4.5.3.
OffsetAdjust = the Zero Offset setting loaded at the beginning of this process.

4.5.6 Load the ZeroOffset constant to non-vol using the command "MFGTEST 6 ZeroOffset" where ZeroOffset is the value calculated in step 4.5.5.

4.6 Store the data to non-vol using the "CAL:STOR" command.

NOTE For greater accuracy, steps 4.4 through 4.5.6 can be repeated using the values calculated in the first pass as the SlopeAdjust and OffsetAdjust values.

5. AC Frequency Response Calibration

AC frequency response calibration is valid on all ac voltage and current ranges.

5.1 Set the instrument to the desired measurement function, range, and aperture setting to calibrate.

5.2 Set the bandwidth detector to 600 using the command "BAND:DET 600".

5.3 Set the calibrator voltage or current equals to the selected range (eg: set Calibrator to 10 V at 10 V Range) and frequency to the reference at 1 kHz.

5.4 Set the calibrator voltage or current equals to the selected range (eg: Set Calibrator to 0.1 A at 0.1 A Range) and frequency to the peak frequency at 50 kHz for ac voltage range or the peak frequency at 10 kHz for AC Current Range.

5.5 Set the instrument to nominal peak reading by issuing the command " MFGTEST 4 128"

5.6 Compare the peak reading to the reference reading if the peak reading is above the reference reading, the frequency response DAC is adjusted to 128 + 64 (FreqRespDelta=64).

5.7 Compare the peak reading to the reference reading if the peak reading is below the reference reading, the frequency response DAC is adjusted to 128 – 64 (FreqRespDelta=64).

5.8 Repeat steps 5.6 through 5.7, adjusting the FreqRespDelta 50% of the previous value, (eg: ±32, ±16, ±8, ±4, ±2, ±1) until the correct setting is found.

5.9 Compare the peak reading to the reference reading again if the peak reading is above reference reading, the value of FrequencyResponse. Compare the peak reading to reference reading again if the peak reading is above reference reading, the value of FrequencyResponse DAC is increase by 1, if peak reading is below reference reading, the value of FrequencyResponseDAC is decreased by 1.

5.10 Repeat steps 5.1 through 5.9 for each range.

5.11 Repeat steps 5.1 through 5.10 for each measurement function.

5.12 After all possible values have been stepped through, the values of FrequencyResponseDAC is loaded to non-vol by using the "CAL:STOR" command.