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			A	0290	Release	05/04/99	S. Ross
			B	0592	Change MUX to VM8016 and include test files	10/04/00	S. Ross
			C	0815	Revised Specification for various changes see ECO	04/26/01	S. Ross
			D	1200	Chg to sections Related Documents & Equipment Used	10/11/01	B. King
Purpose: The purpose of this document is to describe the calibration requirements and procedure for the VM3608/16 D/A converter. Scope: This document includes critical specifications for the required equipment, and a description of the algorithm used in the calibration program. This document covers the calibration of the VM3608A, and the VM3616A, all revisions through revision C. Related Documents: VM3616A Test and Calibration Cable Specification VXI Technology Inc. P/N 52-0222-000 Test.FRM Visual Basic Form Initialize.FRM Visual Basic Form VM3616 Consts_And_Vars.BAS Visual Basic Module FormMaintenance.BAS Visual Basic Module Visa32.BAS Visual Basic Module (National Instruments) SwitchConstants.BAS Visual Basic Module VM3616.BAS Visual Basic Module VTI.BAS Visual Basic Module Vtvm1548.BAS VXI Plug&Play Instrument Driver Vtvm2616.BAS VXI Plug&Play Instrument Driver Vtvm3616.BAS VXI Plug&Play Instrument Driver VtvmSmip.BAS VXI Plug&Play Instrument Driver Equipment used: Voltmeter Critical specifications: DAC Output Range 10.0V +/- 0.0035% of reading +/- 0.0005% of range 20.0V +/- 0.0045% of reading +/- 0.0006% of range Recommended Model Keithley Model 2002							
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2 PLCS ± 0.010	3 PLCS ± 0.005	ANGLES ± 1 DEG	Specification, Calibration, VM3608A/3616A				
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			ENGR: Herman Du		SCALE: NONE FILE: 80-0041-002-d.doc Page 1 of 5		
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Multiplexer

Critical Specifications:
Can switch any output to DMM

Recommended Model
SM3001 with 3xSM4004

External Trigger Source
Critical Specifications:
TTL Output

Recommended Model
VM1548

Method:

NOTE: For the remainder of this document, the term RangeCounter refers to the selected range as:

RangeCounter	Selected Range
0	10v
1	20v

The term ChannelCounter indicates the selected channel.

The variable CalibrationFactor is used to set the voltages to 80% of the selected range.

The VM3608/16 is calibrated by DAC modifiers. The voltage output is set on the device, and constants for offset and gain are loaded into Calibration DAC's, which modify the output value (multiplying by a gain factor, and adding an offset factor) to correct for Offset and Gain variances within the instrument.

1. Calibrate the Offset

NOTE: Offsets must be calibrated first.

The CalZeroConstant(RangeCounter, ChannelCounter) is adjusted using a Binary search pattern to establish the best offset value. This value is then loaded into the instrument using the CAL:ZERO command. The search is performed in the following manner.

- 1.1 Place the instrument in the appropriate range.
- 1.2 Set the variable CalZeroConstant(RangeCounter, ChannelCounter) to 0.
- 1.3 Set the VoltSetting variable to minus maximum range:

$\text{VoltSetting} = \text{ZeroCalibrationFactor} * -\text{Val}(\text{Left}(\text{Range}(\text{RangeCounter}), 2))$

(e.g. -10v for the 10v range, or -20v for the 20v range).

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- 1.4 Set the Multiplexer to route the selected channels output to the DMM.
- 1.5 Take a measurement on the DMM.
- 1.6 Compare the measurement to the volt setting if the measurement is below 0 (negative), the CalZeroConstant(RangeCounter, ChannelCounter) is adjusted to 64 (+50% of the available offset adjust range), making the output more positive.
- 1.7 Compare the measurement to the volt setting if the measurement is above 0, we adjust the CalZeroConstant(RangeCounter, ChannelCounter) to -64 (-50% of the available offset adjust range), making the output more negative.
- 1.8 Take another measurement on the DMM.
- 1.9 Steps 1.6 through 1.8 are repeated, adjusting the CalZeroConstant(RangeCounter, ChannelCounter) 50% of the previous value, (eg: +/-32, +/-16, +/-8, +/-4, +/-2, +/-1) until the correct setting is found. As the process continues, the closest measurement to Zero is saved as BestReading, and the setting at which this reading was made is saved as BestAdjustment.
- 1.10 After all possible values have been stepped through, the BestAdjustment value is loaded as CalZeroConstant(RangeCounter, ChannelCounter).
- 1.11 Repeat steps 1.1 through 1.10 for each channel.
- 1.12 Repeat steps 1.1 through 1.11 for each range.

2. Calibrate the Gain

NOTE: The CalGainConstant(RangeCounter, ChannelCounter) is calculated by measuring the minimum and maximum gain slopes, then adjusting the gain constant for a gain slope of 1.

2.1 Collect measurement data.

- 2.1.1 Set all channels of the DAC to the minimum (10v) range.
- 2.1.2 ZERO offsets have been set per the above procedure, and will not be affected by this part of the procedure.
- 2.1.3 Set the output of the DAC to negative 80% of the selected range.
- 2.1.4 Set the Multiplexer to route the selected channel to the DMM.
- 2.1.5 Set the GAIN constant for the selected channel to Maximum (127).
- 2.1.6 Take a reading on the DMM and save as MaxNegativeGainMeasurement(RangeCounter, ChannelCounter).
- 2.1.7 Set the output of the DAC to positive 80% of the selected range.
- 2.1.8 Take a reading on the DMM and save as MaxPositiveGainMeasurement(RangeCounter, ChannelCounter).
- 2.1.9 Set the output of the DAC to negative 80% of the selected range.

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- 2.1.10 Set the GAIN constant for the selected channel to Minimum (-128).
- 2.1.11 Take a reading on the DMM and save as MinNegativeGainMeasurement(RangeCounter, ChannelCounter).
- 2.1.12 Set the output of the DAC to positive 80% of the selected range.
- 2.1.13 Take a reading on the DMM and save as MaxPositiveGainMeasurement(RangeCounter, ChannelCounter).
- 2.1.14 Repeat steps 2.1.1 through 2.1.13 for each channel, and for each range.

2.2 Calculate the Gain Constants

The CalGainConstant is calculated in the following manner.

- 2.2.1 The MaxGainSlope and the MinGainSlope are calculated using the measurement data collected above.

$$\text{MaxGainSlope} = \frac{(\text{MaxPositiveGainMeasurement}(\text{RangeCounter}, \text{ChannelCounter}) - \text{MaxNegativeGainMeasurement}(\text{RangeCounter}, \text{ChannelCounter}))}{(2 * \text{VoltSetting})}$$

$$\text{MinGainSlope} = \frac{(\text{MinPositiveGainMeasurement}(\text{RangeCounter}, \text{ChannelCounter}) - \text{MinNegativeGainMeasurement}(\text{RangeCounter}, \text{ChannelCounter}))}{(2 * \text{VoltSetting})}$$

- 2.2.2 The CalGainConstantLSB is calculated by subtracting the MinGainSlope from the MaxGainSlope and dividing the result by the number of available settings. (In the case of the VM3608/16 there are 255 settings.)

$$\text{CalGainConstantLSB}(\text{RangeCounter}, \text{ChannelCounter}) = (\text{MaxGainSlope} - \text{MinGainSlope}) / 255$$

- 2.2.3 Since we want to adjust the GainSlope to 1, we subtract the MinGainSlope from 1 to determine how far from nominal the minimum CalGainConstant sets the GainSlope.

- 2.2.4 This value is then divided by the CalGainConstantLSB to determine how many CalGain steps are required from the minimum setting to adjust the GainSlope to the nominal value. This is the CalGainConstant setting.

$$\text{CalGainConstant}(\text{RangeCounter}, \text{ChannelCounter}) = \text{Int}(((1 - \text{MinGainSlope}) / \text{CalGainConstantLSB}(\text{RangeCounter}, \text{ChannelCounter})) - 127.5))$$

- 2.2.5 The calculated value CalGainConstant(RangeCounter, ChannelCounter) is then loaded to the instrument using the CAL:GAIN command.

- 2.2.6 Steps 2.2.1 through 2.2.5 are repeated for each channel, and for each range.

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3. Load Cal Constants

- 3.1 After completion of the calibration routine, Calibration Constants are stored into Non-Vol memory using the CAL:STORE command.
- 3.2 The Calibration security state is set to ON using the CAL:SEC:STATE command.

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