Operator's Manual

Model SM2060   7½ Digit Digital PCI Multimeter
Model SMX2060   7½ Digit Digital PXI Multimeter
Model SM2064   7½ Digit High Work Load PCI Digital Multimeter
Model SMX2064   7½ Digit High Work Load PXI Digital Multimeter

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1.0 Introduction

Congratulations! You have purchased a Personal Computer (PC) Plug-in instrument with analog and systems performance that rivals the best, all-in-one box, instruments. The SM2060 and SMX2064 Digital Multimeters (DMM's) are easy to setup and use, have sophisticated analog and digital circuitry to provide very repeatable measurements, and are protected to handle any unexpected situations your measurement environment may encounter. To get years of reliable service from these DMM's, please take a few moments and review this manual before installing and using this precision instrument.

This manual describes the SM2060 and SM2064 DMM's. The SMX2060 is identical to the SM2060 and the SMX2064 is identical to the SM2064. The only difference is the bus type. The SM206X is a PCI module, while the SMX206X is a PXI/cPCI module.

Note: In this manual, all references made to the "SM2060" are applicable to the SMX2060, and references to the "SM2064" are applicable to the SMX2064. References to "DMM" apply to the SM2060, SMX2060, SM2064 and SMX2064. Features unique to the SM2064 will be identified as such.

1.1 Safety Considerations

Safety Considerations

The SM2060 series of DMM's is capable of measuring up to 300 VDC or 250 VAC across the Volt HI and LO terminals, and can also measure common mode signals that "float" the DMM above EARTH ground by up to 300 VDC or 250 VAC. When making common mode measurements, the majority of the circuits inside the DMM are at the common mode voltage. **These voltages can be lethal and can KILL! During and after installing your DMM, check to see that there are no wires or ribbon cables from your PC trapped inside the DMM.**

The DMM comes installed with four shields (bottom, top and two edge strips) that **must not be removed for performance as well as safety reasons.** Removal of these shields and/or improper assembly of the shields can result in lethal voltages occurring within your PC. Be sure to check your installation before closing the cover on your personal computer.

Warning

Check to see that no loose wires or ribbon cables infringe upon any of the internal circuits of the DMM, as this may apply measurement voltages to your computer, causing electrocution and/or damage to your computer!

To avoid shock hazard, install the DMM only into a computer that has its power connector connected to a power receptacle with an earth safety ground.

When making any measurements above 50 VDC or 40 VAC, only use Safety Test Leads. Examples of these are the Signametrics Basic Test Leads and Deluxe Test Leads, offered as an accessory with the Signametrics DMM's.

1.2 Minimum Requirements

The SM2060 series of system DMM's are precision plug-in modules that are compatible with IBM type personal computers (PCs), PXI and cPCI chassis. It requires as a minimum a Pentiums computer. They require a half-length expansion slot on the PCI bus or 3U PXI slot. A mouse must be installed when controlling the DMM from the Windows Control Panel. The SM2060 comes with a Windows' DLL, for operation with Windows' Version 95/98/Me/2000/XP and NT4.0.

1.3 Feature Set

The base unit, the SM2060, has traditional 7-1/2 digit features and it can be used as a general purpose DMM, where accuracy and speed are important. The High Workload Multi Function SM2064 adds timing, capacitance, inductance, sourcing and a lot more speed. With its specialized measurements, it can replace some costly instruments, shrinking the size and cost of a test system.

SM2060 and SM2064 7½ Digit DMM's feature table:

Function	SM/SMX2060 DMM	SM/SMX2064 High Workload DMM
DCV five ranges 240mV to 330V	√	√
ACV five ranges 240mV to 330V	√	√
2-Wire Ohms, six ranges 240 Ω to 24 MΩ	√	√
4-Wire Ohms, six ranges 240 Ω to 24 MΩ	√	√
DC current, four ranges 2.4 mA to 2.4 A	√	√
AC current, four ranges 2.4 mA to 2.4 A	√	√
Diode V/I characteristics at 100 ηA to 1mA	√	√ (plus 10mA)
Auto range, Relative	√	√
Min/Max, dB and percent deviation functions	√	√
On board measurement buffer	√	√
External and threshold trigger	√	√
Thermocouples type; B, E, J, K, N, R, S, T	√	√
High Dynamic range; ±24,000,000 counts	√	√
Frequency / Period measurement	√	√
Measurement rate: 0.2 to 1,400/sec	√	√
Measurement rate: to 20,000/sec		√
Capacitance, ramp type, eight ranges, 1 nF to 10 mF		√
Capacitance, In-Circuit method five ranges, 24nF to 2.4mF		√
Inductance, six ranges 33 µH to 3.3 H		√
Internal DMM temperature sensor		√
Offset Ohms		√
Temperature types pt385, 3911, 3916, 3926, Copper, variable Ro		√
Pulse width, pos./neg., & duty cycle		√
Totalizer/event counter		√
Variable threshold DAC; all timing measure.		√
Peak to Peak, Crest factor, Median		√
Six wire Ohms (with force/sense)		√
DCV source to ±10.0 V		√
ACV source 0 to 20 V pk-pk, 2 Hz to 75 KHz		√
DC current source, 1 nA to 12.5 mA		√
Leakage measurement to ±10.0V three ranges 240nA, 2.4uA, 25uA		√
Expanded ranges		√
2-Wire Ohms two additional ranges 24 Ω and 240 MΩ		√
4-Wire Ohms additional range 24 Ω		√
Resistance with V&I limits (to 10GΩ)		√
DC Current four additional ranges 240nA, 2.4µA, 24µA, 240µA		√

2.0 Specifications

The following specifications are based on both, verification of large number of units as well as mathematical evaluation. They should be considered under the environment specified.

It is important to note that a DMM specified range is expressed as a numeric value indicating the highest absolute voltage that can be measured. The lowest value that can be detected is expressed by the corresponding resolution for the range.

2.1 DC Voltage Measurement

Input Characteristics

- **Input Resistance 240 mV, 2.4 V Ranges:** >10 GΩ, with typical leakage of 50pA
- **Input Resistance 24 V, 240 V, 330V Ranges:** 10.00 MΩ

Accuracy ± (% of reading + Volts) [1]

Range	Full Scale 7-½ Digits	Resolution	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
240 mV	240.00000 mV	10 ηV	0.003 + 1 µV	0.004 + 1.5 µV	0.005 + 2 µV
2.4 V	2.4000000 V	100 ηV	0.002 + 3 µV	0.0025 + 5 µV	0.003 + 10 µV
24 V	24.000000 V	1 µV	0.003 + 150 µV	0.004 + 250 µV	0.005 + 300 µV
240 V	240.00000 V	10 µV	0.004 + 200 µV	0.005 + 300 µV	0.006 + 0.5 mV
330 V	330.00000 V	10 µV	0.005 + 250 µV	0.01+ 400 µV	0.015 + 0.7 mV

[1] With Aperture set to ≥ 0.5 Sec, and within one hour from Self Calibration (S-Cal).

For resolution at smaller Apertures, see the following table. Use this table for DC Volts, DC current and Resistance measurements.

Measurement Aperture SM2060, SM2064	Maximum reading rate	Resolution	
0.5 s ≤ Aperture	2 / second	7-1/2 digits	25 bits
10 ms ≤ Aperture	100 / second	6-1/2 digits	22 bits
625µs ≤ Aperture	1200 / second	5-1/2 digits	18 bits
2.5us ≤ Aperture [2]	20,000 / second [2]	4-1/2 digits	14 bits

[2] Available only with the SM2064.

DCV Noise Rejection Normal Mode Rejection, at 50, 60, or 400 Hz ± 0.5%, is better than 95 dB for apertures of 0.160s and higher. Common Mode Rejection (with 1 kΩ lead imbalance) is better than 120 dB for these conditions.

2.2 DC Current Measurement

Input Characteristics

- **Number of shunts** Five in SM2064, two in the SM2060
- **Protected** with 2.5A Fast blow fuse

Accuracy ± (% of reading + Amps) [1]

Range	Full Scale 6-½ Digits	Resolution	Max Burden Voltage	24 hours 23°C ± 5°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
240 ηA [2]	240.0000 ηA	0.1 pA	100 µV	0.07 + 40pA	0.1 + 45pA	0.17 + 60pA
2.4 µA [2]	2.400000 µA	1 pA	100 µV	0.05 + 70pA	0.08 + 90pA	0.21 + 150pA
24 µA [2]	24.00000 µA	10 pA	100 µV	0.05 + 400pA	0.08 + 600pA	0.13 + 0.8nA
240 µA [2]	240.000 µA	10 ηA	2.5mV	0.052 + 200 ηA	0.07 + 300 ηA	0.1 + 400 ηA
2.4 mA	2.40000 mA	10 ηA	25mV	0.05 + 300 ηA	0.06 + 400 ηA	0.07 + 550 ηA
24 mA	24.0000 mA	100 ηA	250mV	0.05 + 350 ηA	0.065 + 450 ηA	0.08 + 550 ηA
240 mA	240.000 mA	1 µA	55mV	0.05 + 50 µA	0.055 + 60 µA	0.065 + 80 µA
2.4 A	2.40000 A	10 µA	520mV	0.3 + 60 µA	0.4 + 70 µA	0.45 + 90 µA

[1] With Aperture set to ≥ 0.96 Sec, and within one hour from Zero (Relative control).
[2] Available only with the SM2064.

2.3 Resistance Measurements

2.3.1 2-wire

Accuracy ± (% of reading + Ω) [1]

Range [4]	Full Scale 7 ½ Digits	Resolution	Source current	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
24 Ω[3]	24.000000 Ω	1 μΩ	10 mA	0.0038 + 1.4 mΩ [2]	0.005 + 1.6 mΩ [2]	0.008 + 2 mΩ [2]
240 Ω	240.00000 Ω	10 μΩ	1 mA	0.0037 + 4.5 mΩ [2]	0.0046 + 5 mΩ [2]	0.007 + 6 mΩ [2]
2.4 kΩ	2.4000000 kΩ	100 μΩ	1 mA	0.0023 + 28 mΩ	0.004 + 32 mΩ	0.006 + 33 mΩ
24 kΩ	24.000000 kΩ	1 mΩ	100 μA	0.0025 + 300 mΩ	0.004 + 330 mΩ	0.006 + 350 mΩ
240 kΩ	240.00000 kΩ	10 mΩ	10 μA	0.0055 + 3.2 Ω	0.006 + 4 Ω	0.007 + 5 Ω
2.4 MΩ	2.4000000 MΩ	100 mΩ	1 μA	0.018 + 40 Ω	0.03 + 50 Ω	0.04 + 70 Ω
24 MΩ	24.0000 MΩ	100 Ω	100 nA	0.12 + 400 Ω	0.13 + 500 Ω	0.2 + 600 Ω
240 MΩ[3]	240.000 MΩ	1 kΩ	10 nA	0.8 + 20 kΩ	1.0 + 30 kΩ	1.3 + 50 kΩ

[1] With Aperture set to ≥ 0.5 Sec, and within one hour from Self Calibration (S-Cal).
[2] Use of S-Cal and Relative to improve measurement floor.
[3] Ranges are only available with the SM2064.
[4] Test voltages are 2.4V max with the exception of the 24 Ω and 240 Ω ranges 240 mV.

2.3.2 4-wire

Accuracy ± (% of reading + Ω) [1]

Range [4]	Full Scale 7 ½ Digits	Resolution	Source current	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
24 Ω [3]	24.000000 Ω	1 μΩ	10 mA	0.0038 + 0.7 mΩ [2]	0.005 + 0.8 mΩ [2]	0.008 + 1 mΩ [2]
240 Ω	240.00000 Ω	10 μΩ	1 mA	0.0037 + 3 mΩ [2]	0.0046 + 4 mΩ [2]	0.007 + 5 mΩ [2]
2.4 kΩ	2.4000000 kΩ	100 μΩ	1 mA	0.0023 + 28 mΩ	0.004 + 32 mΩ	0.006 + 33 mΩ
24 kΩ	24.000000 kΩ	1 mΩ	100 μA	0.0025 + 300 mΩ	0.004 + 330 mΩ	0.006 + 350 mΩ
240 kΩ	240.00000 kΩ	10 mΩ	10 μA	0.0055 + 3.2 Ω	0.007 + 4 Ω	0.007 + 5 Ω
2.4 MΩ	2.4000000 MΩ	100 mΩ	1 μA	0.018 + 40 Ω	0.03 + 50 Ω	0.04 + 70 Ω
24 MΩ	24.0000 MΩ	100 Ω	100 nA	0.12 + 400 Ω	0.13 + 500 Ω	0.2 + 600 Ω

[1] With Aperture set to ≥ 0.5 Sec, and within one hour from Self Calibration (S-Cal).
[2] Use of Relative to facilitate indicated floor (adder part of spec).
[3] 24 Ω range only available with SM2064.
[4] Test voltages are 2.4V max with the exception of the 24 Ω and 240 Ω ranges 240 mV.

2.3.3 6-wire Guarded Resistance Measurement (SM2064)

This is an in-circuit forced guard measurement method, as implemented in ICT testers. Add this typical additional error to the above specification.

Accuracy ± (% of reading + Ω)

Range	Guard forced current	One Year 23°C ± 5°C [1]
24 Ω [3]	10 mA	0.3 + 4 mΩ
240 Ω	1 mA	0.003 + 20 mΩ
2.4 kΩ	1 mA	0.005 + 100 mΩ
24 kΩ	100 μA	0.03 + 1 Ω
240 kΩ	10 μA	0.35 + 10 Ω
24 MΩ	1 μA	0.85 + 1000 Ω

[1] This table should be used in conjunction with the 2-wire and 4-wire table above.

2.3.4 Extended Resistance Measurements (SM2064)

Characteristics

- **Test Voltage** Adjustable between -10V and +10V in 5mV steps

Accuracy ± (% of reading + Amps) [1]

Range	Measurement range	Resolution	Current Limit [3]	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
400kΩ	1kΩ to 100MΩ	10Ω	25µA	0.2 + 50Ω	0.33 + 90Ω
4MΩ	10kΩ to 1GΩ	100Ω	2.5µA	0.3 + 350Ω	0.43 + 550Ω
40MΩ	100kΩ to 10GΩ	1kΩ	250nA	0.4 + 3kΩ	0.55 + 4.5kΩ

[1] With Aperture set to ≥ 0.5 Sec, and within one hour from Zero (Relative control).
[2] Multiply "% of reading" by 1/Voltage Source for applied voltages below 1V
[3] Limit is reached when the test current exceeds the Current Limit, or it is below 0.04% of this value.

2.4 AC Voltage Measurements

Input Characteristics

- **Input Resistance** 1 MΩ, shunted by < 300 pF, all ranges
- **Max. Crest Factor** 4 at Full Scale, increasing to 7 at Lowest Specified Voltage
- **AC coupled** Specified range: 10 Hz to 100 kHz
- **Typical Settling time** < 0.5 sec to within 0.1% of final value
- **Typical Settling time Fast RMS** < 0.05 sec to within 0.1% of final value

2.4.1 AC Voltage True RMS Measurement

Range	Full Scale 7-½ Digits	Lowest specified Voltage	Resolution
240 mV	240.0000 mV	5 mV [1]	100 ηV
2.4 V	2.400000 V	10 mV	1 µV
24 V	24.00000 V	100 mV	10 µV
240 V	240.0000 V	1 V	100 µV
330 V	330.0000 V	2 V	100 µV

[1] Between 5 mV and 10 mV, add 100 µV additional errors to the accuracy table below.
[2] Signal is limited to $8x10^6$ Volt Hz Product. For example, the largest frequency input at 250 V is 32 kHz, or $8x10^6$ Volt x Hz.

AC Volts Accuracy with Fast RMS disabled (default).

With Fast RMS disabled, settling time to rated accuracy is within 0.5 s.

Accuracy ± (% of reading + Volts) [1]

Range	Frequency	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
240 mV	10 Hz - 20 Hz	3.0 + 350 μV	3.1 + 380 μV	3.2 + 430 μV
	20 Hz - 47 Hz	0.92 + 150 μV	0.93 + 170 μV	0.95 + 200 μV
	47 Hz - 10 kHz	0.13 + 100 μV	0.14 + 110 μV	0.15 + 120 μV
	10 kHz - 50 kHz	0.55 + 160 μV	0.6 + 200 μV	0.63 + 230 μV
	50 kHz - 100 kHz	5.3 + 350 μV	5.4 + 370 μV	5.6 + 400 μV
2.4 V	10 Hz - 20 Hz	3.0 + 2 mV	3.1 + 2.2 mV	3.2 + 2.5 mV
	20 Hz - 47 Hz	0.93 + 1.3 mV	0.96 + 1.5 mV	1.0 + 1.7 mV
	47 Hz - 10 kHz	0.05 + 1 mV	0.055 + 1.1 mV	0.065 + 1.2 mV
	10 kHz - 50 kHz	0.62 + 1.2 mV	0.65 + 1.3 mV	0.70 + 1.5 mV
	50 kHz - 100 kHz	5.1 + 1.5 mV	5.2 + 1.7 mV	5.3 + 2 mV
24 V	10 Hz - 20 Hz	3.0 + 14 mV	3.1 + 16 mV	3.3 + 20 mV
	20 Hz - 47 Hz	0.93 + 12 mV	0.96 + 14 mV	1.0 + 16 mV
	47 Hz - 10 kHz	0.06 + 10 mV	0.065 + 11 mV	0.073 + 13 mV
	10 kHz - 50 kHz	0.31 + 18 mV	0.33 + 21 mV	0.35 + 25 mV
	50 kHz - 100 kHz	2.0 + 30 mV	2.2 + 35 mV	2.4 + 40 mV
240 V	10 Hz - 20 Hz	3.0 + 140 mV	3.1 + 160 mV	3.3 + 200 mV
	20 Hz - 47 Hz	0.93 + 120 mV	0.96 + 130 mV	1.0 + 150 mV
	47 Hz - 10 kHz	0.04 + 100 mV	0.045 + 110 mV	0.06 + 130 mV
	10 kHz - 50 kHz	0.32 + 150 mV	0.4 + 170 mV	0.45 + 200 mV
	50 kHz - 100 kHz	2.5 + 200 mV	2.8 + 240 mV	3.2 + 300 mV
330 V	10 Hz - 20 Hz	3.0 + 200 mV	3.1 + 160 mV	3.3 + 200 mV
	20 Hz - 47 Hz	1.0 + 180 mV	1.1 + 200 mV	1.1 + 250 mV
	47 Hz - 10 kHz	0.05 + 150 mV	0.07 + 200 mV	0.08 + 230 mV
	10 kHz - 50 kHz	0.34 + 200 mV	0.45 + 250 mV	0.5 + 300 mV
	50 kHz - 100 kHz	2.5 + 270 mV	2.8 + 350 mV	3.2 + 400 mV

ACV Noise Rejection Common Mode rejection, for 50 Hz or 60 Hz with 1 kΩ imbalance in either lead, is better than 60 dB.

AC Volts Accuracy with Fast RMS enabled.

Fast RMS settles to rated accuracy within 50ms.

Accuracy ± (% of reading + Volts) [1]

Range	Frequency	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
240 mV	350 Hz - 800 Hz	0.6 + 150 µV	0.65 + 170 µV	0.7 + 200 µV
	800 Hz - 10 kHz	0.13 + 100 µV	0.14 + 110 µV	0.15 + 120 µV
	10 kHz - 50 kHz	0.55 + 160 µV	0.6 + 200 µV	0.63 + 230 µV
	50 kHz - 100 kHz	5.3 + 350 µV	5.4 + 370 µV	5.6 + 400 µV
2.4 V	350 Hz - 800 Hz	0.93 + 1.3 mV	0.96 + 1.5 mV	1.0 + 1.7 mV
	800 Hz - 10 kHz	0.068 + 1 mV	0.075 + 1.1 mV	0.08 + 1.2 mV
	10 kHz - 50 kHz	0.62 + 1.2 mV	0.65 + 1.3 mV	0.70 + 1.5 mV
	50 kHz - 100 kHz	5.1 + 1.5 mV	5.2 + 1.7 mV	5.3 + 2 mV
24 V	350 Hz - 800 Hz	0.93 + 12 mV	0.96 + 14 mV	1.0 + 16 mV
	800 Hz - 10 kHz	0.065 + 10 mV	0.068 + 11 mV	0.073 + 13 mV
	10 kHz - 50 kHz	0.31 + 18 mV	0.33 + 21 mV	0.35 + 25 mV
	50 kHz - 100 kHz	2.0 + 30 mV	2.2 + 35 mV	2.4 + 40 mV
240 V	350 Hz - 800 Hz	0.93 + 120 mV	0.96 + 130 mV	1.0 + 150 mV
	800 Hz - 10 kHz	0.062 + 100 mV	0.065 + 110 mV	0.08 + 130 mV
	10 kHz - 50 kHz	0.32 + 150 mV	0.4 + 170 mV	0.45 + 200 mV
	50 kHz - 100 kHz	2.5 + 200 mV	2.8 + 240 mV	3.2 + 300 mV
330 V	350 Hz - 800 Hz	1.0 + 180 mV	1.1 + 200 mV	1.1 + 250 mV
	800 Hz - 10 kHz	0.065 + 150 mV	0.07 + 200 mV	0.08 + 230 mV
	10 kHz - 50 kHz	0.34 + 200 mV	0.45 + 250 mV	0.5 + 300 mV
	50 kHz - 100 kHz	2.5 + 270 mV	2.8 + 350 mV	3.2 + 400 mV

AC Volts Accuracy with Slow RMS (default).

Settles to rated accuracy within 1X to 10X signal period, settable by user.

Range	Frequency	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
240 mV	0.5 Hz - 10 Hz	0.25 + 100 µV	0.3 + 200 µV	0.35 + 300 µV
	10 Hz - 20 Hz	0.3 + 150 µV	0.35 + 170 µV	0.4 + 200 µV
	20 Hz - 60 Hz	0.13 + 100 µV	0.14 + 110 µV	0.15 + 120 µV
	60 kHz - 200 Hz	0.55 + 160 µV	0.6 + 200 µV	0.63 + 230 µV
2.4 V	0.5 Hz - 10 Hz	0.2 + 2 mV	0.25 + 2.2 mV	0.3 + 2.5 mV
	10 Hz - 20 Hz	0.3 + 1.3 mV	0.35 + 1.5 mV	1.0 + 1.7 mV
	20 Hz - 60 Hz	0.5 + 1 mV	0.55 + 1.1 mV	0.65 + 1.2 mV
	60 kHz - 200 Hz	0.62 + 1.2 mV	0.65 + 1.3 mV	0.70 + 1.5 mV
24 V	0.5 Hz - 10 Hz	3.0 + 14 mV	3.1 + 16 mV	3.3 + 20 mV
	10 Hz - 20 Hz	0.93 + 12 mV	0.96 + 14 mV	1.0 + 16 mV
	20 Hz - 60 Hz	0.06 + 10 mV	0.065 + 11 mV	0.073 + 13 mV
	60 kHz - 200 Hz	0.31 + 18 mV	0.33 + 21 mV	0.35 + 25 mV
240 V	0.5 Hz - 10 Hz	3.0 + 140 mV	3.1 + 160 mV	3.3 + 200 mV
	10 Hz - 20 Hz	0.93 + 120 mV	0.96 + 130 mV	1.0 + 150 mV
	20 Hz - 60 Hz	0.04 + 100 mV	0.045 + 110 mV	0.06 + 130 mV
	60 kHz - 200 Hz	0.32 + 150 mV	0.4 + 170 mV	0.45 + 200 mV
330 V	0.5 Hz - 10 Hz	3.0 + 200 mV	3.1 + 160 mV	3.3 + 200 mV
	10 Hz - 20 Hz	1.0 + 180 mV	1.1 + 200 mV	1.1 + 250 mV
	20 Hz - 60 Hz	0.05 + 150 mV	0.07 + 200 mV	0.08 + 230 mV
	60 kHz - 200 Hz	0.34 + 200 mV	0.45 + 250 mV	0.5 + 300 mV

2.4.2 AC Peak-to-Peak Measurement (SM2064)

- Measures the peak-to-peak value of a repetitive waveform.

ACV Range	Lowest specified input voltage (Vp-p)	Full Scale reading (Vp-p)	Resolution	Typical Accuracy 23°C ± 5°C One Year [1]
240 mV	0.1 V	1.9 V	1 mV	0.5 ± 3 mV
2.4 V	1.0 V	16 V	10 mV	0.5 ± 40 mV
24 V	10 V	190 V	100 mV	0.5 ± 700 mV
240 V	100 V	850 V	1 V	0.55 ± 6 V

[1] Signal frequency range 30 Hz to 60 kHz.

2.4.3 AC Crest Factor Measurement (SM2064)

- Measures the crest factor (CF) of a repetitive waveform

ACV Range	Lowest specified input voltage (Vp-p)	Highest specified input voltages (Vp-p)	Resolution	Typical Accuracy 23°C ± 5°C One Year [1]
240 mV	0.1 V	1.9 V	0.01	2.2 ±0.3
2.4 V	1.0 V	16 V	0.01	2.1 ±0.1
24 V	10 V	190 V	0.01	2.0 ±0.1
240 V	100 V	700 V	0.01	2.0 ±0.1
330 V	100 V	850 V	0.01	2.0 ±0.1

[1] Crest factor measurement requires signal frequency of 30 Hz to 60 kHz.

2.4.4 AC Median Value Measurement (SM2064)

- Measures the mid-point between the positive and negative peaks of a repetitive waveform
- Used to determine the Threshold DAC setting for optimal frequency and timing measurements

ACV Range	Lowest specified input voltage (Vp-p)	Full Scale reading	Resolution	Typical Accuracy 23°C ± 5°C One Year [1]
240 mV	0.08 V	±0.95 V	1 mV	2.0% ±17 mV
2.4 V	0.80 V	±9.5 V	10 mV	3% ±160 mV
24 V	8 V	±95.0 V	100 mV	3% ±1.4 V
240 V	80 V	±350.0 V	1 V	3% ±12 V
330 V	80 V	±350.0 V	1 V	3% ±12 V

[1] Median measurements require a repetitive signal with frequency range of 30 Hz to 30 KHz.

2.5 AC Current Measurement, True RMS

Input Characteristics

- **Crest Factor** 4 at Full Scale, increasing to 10 at Lowest Specified Current
- **Protected** with 2.5 A Fast Blow fuse

Range	Full Scale 6 1/2 Digits	Lowest Specified Current	Maximum Burden Voltage (RMS)	Resolution
2.4 mA	2.400000 mA	60 µA	25mV	1 nA
24 mA	24.00000 mA	300 µA	250mV	10 nA
240 mA	240.0000 mA	3 mA	55mV	100 nA
2.4 A	2.400000 A	30 mA	520mV	1 uA

Accuracy ± (% of reading + Amps)

Range	Frequency [1]	24 hours 23°C ± 1°C	90 Days 23°C ± 10°C	One Year 23°C ± 10°C
2.4 mA	10 Hz - 20 Hz	3.8 + 4 µA	2.7 + 4 µA	2.9 + 4 µA
	20 Hz - 47 Hz	0.9 + 4 µA	0.9 + 4 µA	1.0 + 4 µA
	47 Hz - 1 kHz	0.04 + 1.5 µA	0.08 + 3 µA	0.12 + 4 µA
	1 kHz - 10 kHz	0.12 + 4 µA	0.14 + 4 µA	0.22 + 4 µA
24 mA	10 Hz - 20 Hz	1.8 + 30 µA	2.6 + 30 µA	2.8 + 30 µA
	20 Hz - 47 Hz	0.6 + 30 µA	0.9 + 30 µA	1.0 + 30 µA
	47 Hz - 1 kHz	0.07 + 10 µA	0.15 + 20 µA	0.16 + 30 µA
	1 kHz - 10 kHz	0.21 + 30 µA	0.3 + 40 µA	0.4 + 40 µA
240 mA	10 Hz - 20 Hz	1.8 + 400 µA	2.7 + 400 µA	2.8 + 400 µA
	20 Hz - 47 Hz	0.6 + 400 µA	0.9 + 400 µA	1.0 + 400 µA
	47 Hz - 1 kHz	0.1 + 100 µA	0.17 + 180 µA	0.2 + 220 µA
	1 kHz - 10 kHz	0.3 + 300 µA	0.35 + 350 µA	0.4 + 400 µA
2.4 A	10 Hz - 20 Hz	1.8 + 4 mA	2.5 + 4.5 mA	2.7 + 5 mA
	20 Hz - 47 Hz	0.66 + 4 mA	0.8 + 6 mA	0.9 + 6 mA
	47 Hz - 1 kHz	0.3 + 3.8mA	0.33 + 3.8 mA	0.35 + 4 mA
	1 kHz - 10 kHz	0.4 + 4mA	0.45 + 4.5 mA	0.5 + 5 mA

[1] All AC Current ranges have typical measurement capability of at least 20 kHz.

2.6 Leakage Measurement (SM2064)

Characteristics

- **Burden Voltage:** < 100 µV
- **Test Voltage:** Adjustable between -10V to +10V in 5mV steps

Accuracy ± (% of reading + Amps) [1]

Range	Full Scale 6-½ Digits	Resolution	24 hours 23°C ± 5°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
240 ηA	240.0000 ηA	0.1 pA	0.15 + 50pA	0.2 + 65pA	0.17 + 100pA
2.4 µA	2.400000 µA	1 pA	0.1 + 350pA	0.15 + 500pA	0.2 + 600pA
24 µA	24.00000 µA	10 pA	0.08 + 3nA	0.12 + 4nA	0.18 + 2nA

[1] With Aperture set to ≥ 0.5 Sec, and within one hour from Zero (Relative control).

2.7 RTD Temperature Measurement (SM2064)

- **Ro:** Variable from 10 Ω to 10 kΩ
- **Measurement Method:** 4-Wire
- **Temperature units:** Selectable ^oC or ^oF

RTD Type	Ro (Ω)	Resolution	Temperature range	Temperature Accuracy 23°C ± 5°C [1] One Year
pt385, pt3911, pt3916, pt3926	100, 200 Ω	0.01°C	-150 to 650°C	±0.06°C
pt385, pt3911, pt3916, pt3926	500, 1 kΩ	0.01°C	-150 to 650°C	±0.03°C
Cu (Copper)	Less than 12 Ω	0.01°C	-100 to 200°C	±0.18°C for temperatures ≤ 20°C, ±0.05°C otherwise
Cu (Copper)	Higher than 90 Ω	0.01°C	-100 to 200°C	±0.10°C for temperatures ≤ 20°C, ±0.05°C otherwise

[1] With Aperture of 0.5s and higher, using a 4-wire RTD. Measurement accuracy does not include RTD probe error.

2.8 Thermocouple Temperature Measurement (SM2064)

- **Cold Junction Compensation:** By Sensor measurement or S/W setting.
- **Cold Junction Temperature range:** 0 ^oC to 50 ^oC
- **Cold Junction Sensor:** Use SMX40T or SM40T Isothermal unit, or define sensor equation
- **Isothermal Block compatibility:** SM4022, SM4042, SMX4032, SM40T, SMX40T
- **Temperature units:** Selectable ^oC or ^oF

TC Type	Resolution	Maximum Temperature [2]	Temperature Accuracy 23°C ± 5°C [1] One Year
B	0.01°C	2200°C	±0.38 °C
E	0.01°C	1200°C	±0.035 °C
J	0.01°C	2000°C	±0.06 °C
K	0.01°C	3000°C	±0.07 °C
N	0.01°C	3000°C	±0.10 °C
R	0.01°C	2700°C	±0.25 °C
S	0.01°C	3500°C	±0.35 °C
T	0.01°C	550°C	±0.06 °C

[1] With Aperture of 0.5s and higher. Measurement accuracy does not include Thermocouple error.
[2] DMM Linearization temperature range may be greater than that of the Thermocouple device.

2.9 Additional Component Measurement Capability

2.9.1 Diode Characterization

- **Available DC current values** 100 ηA, 1 µA, 10 µA, 100 µA and 1 mA.
- **SM2064 add variable current** of 10 ηA to 12.5 mA
- **Typical Current Value Uncertainty** 1%
- **Typical Voltage Value Uncertainty** 0.02%
- **Maximum diode voltage compliance** 4 V

2.9.2 Capacitance, Ramp Method (SM2064)

Accuracy ± (% of reading + Farads) [1]

Range	Full Scale Reading	Resolution	One Year 23°C ± 5°C
1,200 pF	1,199.9 pF	0.1 pF	1.5 ± 0.25 pF
12 ηF	11.999 ηF	1 pF	1.2 ± 5 pF
120 ηF	119.99 ηF	10 pF	1.0
1.2 μF	1.1999 μF	100 pF	1.0
12 μF	11.999 μF	1 ηF	1.0
120 μF	119.99 μF	10 ηF	1.0
1.2 mF	1.1999 mF	100 ηF	1.2
12 mF	50.000 mF	1 μF	2

[1] Within one hour of zero, using Relative control. Accuracy is specified for values higher than 5% of the selected range with the exception of the 1,200 pF range.

This Measurement is independent of set Aperture and Read Interval. If desired, the DMMSetCapsAveSamp() function may be used to control measurement parameters. It is provided means to fine tune the measurement timing for the application, trading off accuracy for speed.

Measurement time will vary as function of the set parameters, selected range and measured capacitance. The following are measurement times associated with the default parameters, as range is selected.

Range	Input	Measurement Time	Measurement Rate (rps)
1,200 pF	5% of Scale	19.5 ms	51.3
1,200 pF	Full Scale	52.3 ms	19.1
12 ηF	5% of Scale	70.0 ms	14.3
12 ηF	Full Scale	118ms	8.5
120 ηF	5% of Scale	8.9 ms	112.4
120 ηF	Full Scale	127 ms	7.9
1.2 μF	5% of Scale	15.6 ms	64.1
1.2 μF	Full Scale	175 ms	5.7
12 μF	5% of Scale	14.1 ms	70.9
12 μF	Full Scale	480 ms	2.1
120 μF	5% of Scale	17.3 ms	57.8
120 μF	Full Scale	50.3 ms	19.9
1.2 mF	5% of Scale	52.6 ms	19.0
1.2 mF	Full Scale	151.5 ms	6.6
12 mF	5% of Scale	52.8 ms	18.9
12 mF	Full Scale	170 ms	5.9

2.9.3 Capacitance, In-Circuit Method (SM2064)

- **Adjustable Peak Voltages Stimulus** 100mV to 1.3V
- **Minimum Parallel Load Resistance** 100Ω

Accuracy ± (% of reading + Farads) [1]

Range	Full Scale 3-½ Digits	Resolution	One Year 23°C ± 5°C [2]
24 ηF	23.99 ηF	10 pF	2.7 ± 100 pF
240 ηF	239.9 ηF	100 pF	2.5 ± 500 pF
2.4 μF	2.399 μF	1000 pF	2.5 ± 5 ηF
24 μF	23.99 μF	10 ηF	
240 μF	239.9 μF	100 ηF	
2.4 mF	2.399 mF	1 μF	
24 mF	23.99 mF	10 μF	

[1] Within one hour of zero, using Relative control, and Caps Open-Cal operation
[2] Accuracy is specified for values higher than 5% of the selected range with the exception of the 2.4 ηF range.

Capacitance Measurement time is independent of set Aperture and Read Interval. It depends on range, and capacitance.

2.9.4 Inductance Measurement (SM2064)

Range	Test frequency	Full Scale 4 ½ Digits	Resolution	Accuracy 23°C ± 5°C One Year [2]
24 μH	75 kHz	33.000 μH	1 ηH	3.0% + 500 ηH
240 μH	50 kHz	330.00 μH	10 ηH	2.0% + 3 μH
2.4 mH	4 kHz	3.3000 mH	100 ηH	1.5% + 25 μH
24 mH	1.5 kHz	33.000 mH	1 μH	1.5% + 200 μH
240 mH	1 kHz	330.00 mH	10 μH	2.5 + 3 mH
2.4 H	100 Hz	3.3000 H	100 μH	3 + 35 mH

[1] Within one hour of zero, and Open Terminal Calibration.
[2] Accuracy is specified for values greater than 5% of the selected range.

2.10 Time Measurements

2.10.1 Threshold DAC

- **The Threshold DAC is used for selecting a detection level, providing optimal frequency and timing measurements even at extreme duty cycle values.**

± (% of setting + volts)

Selected VAC range [1]	Threshold range (DC level)	Threshold DAC resolution	Highest allowed input Vp-p	Typical one year setting uncertainty
240 mV	-1.0 V to +1.0 V	0.5 mV	1.900 V	0.2% + 4 mV
2.4 V	-10.0 V to +10.0 V	5.0 mV	19.00 V	0.2% + 40 mV
24 V	-100.0 V to 100.0 V	50 mV	190.0 V	0.2% + 0.4 V
240 V	-400 V to 400 V	500 V	850.0 V	0.2% + 4 V

[1] This table should be used in conjunction with the AC volts section above.

2.10.2 Frequency and Period Measurement

ACV Mode

- **Input Impedance** 1 MΩ with < 300 pF

Frequency Range	2 Hz - 100 Hz	100 Hz-1 kHz	1 kHz-10 kHz	10 kHz-100 kHz	100 kHz-300 kHz
Resolution	1 mHz	10 mHz	100 mHz	1 Hz	1 Hz
Uncertainty is ±0.002% of reading ± adder shown	4 mHz	20 mHz	200 mHz	2 Hz	5 Hz
Input Signal Range [1]	10% - 200% of range	10% - 200% of range	10% -200% of range	10% - 200% of range	45% -200% of range

[1] Input RMS voltage required for a valid reading. Do not exceed 250 V RMS input. For example, 10% -200% of range indicates that in the 240 mVAC range, the input voltage should be 24 mV to 660 mV RMS.

ACI Mode

- **Input Impedance** 10 Ω in the 3 mA and 30 mA ranges, 0.1 Ω in the 330 mA and 2.5 A ranges.

Frequency Range	2 Hz - 100 Hz	100 Hz-1 kHz	1 kHz-10 kHz	10 kHz-500 kHz
Resolution	1 mHz	10 mHz	100 mHz	1 Hz
Uncertainty	0.01% ±4 mHz	0.01% ±20 mHz	0.01% ±200 mHz	0.01% ±2 Hz
Input Signal Range, 2.4 mA, 240mA Ranges [1]	10% -500% of range	10% - 500% of range	10% -500% of range	10% - 500% of range
Input Signal Range, 24 mA, 2.4 A ranges	50% -100% of range	50% - 100% of range	50% - 100% of range	50% - 100% of range

[1] Input current required to give a valid reading. For example, 10% -500% of range indicates that in the 3.3 mA range, the input current should be 0.33 mA to 16.5 mA.

2.10.3 Duty Cycle Measurement

Frequency Range	2 Hz to 100 Hz	100 Hz to 1 kHz	1 kHz to 10 kHz	10 kHz to 100 kHz
Resolution	0.02%	0.2%	2%	20%
Typical Uncertainty is ±0.03% of reading ± adder shown	0.03%	0.3%	3%	20%
Full scale reading	100.00 %	100.00 %	100.00 %	100.00 %

2.10.4 Pulse Width

± (% of reading + sec)

Polarity	Frequency range	Resolution	Width range	Typical Uncertainty
Positive or negative pulse widths	2 Hz to 100 kHz	1 µs	2 µs to 1 s	0.01 +/- 4 µs

2.10.5 Totalizer

- Active edge polarity: Positive or negative transition
- Maximum count: 10^9
- Allowed rate: 1 to 30,000 events per second
- Uses Threshold DAC

2.11 Trigger Functions

2.11.1 External Hardware Trigger (at DIN-7 connector)

Trigger Input voltage level range	+3 V to +15 V activates the trigger.
Trigger Pulse Width	Minimum = 1/Aperture + 50µS
Minimum trigger input current	1 mA
Internal Reading Buffer	Circular; 80 or 120 readings depending on resolution.
Isolation of trigger input	±50 V from analog DMM inputs, and from chassis earth ground.

2.11.2 Analog Threshold Trigger

- Trigger point: Selectable positive or negative transition of set threshold.
- Buffer type: Circular
- Captures up to 120 post-trigger readings for apertures $\leq$ 625uSec.
- Captures up to 80 post-trigger readings for apertures > 625uSec.
- Aperture range: 160ms to 625µS (to 2.5µS with SM2064)
- Read Interval range: 1/Aperture to 65ms
- User selects number of post-trigger readings.
- The number of pre-trigger readings: buffer size – post-trigger count.
- The number of cycles the circular filled, and the trigger point are retrievable.

2.11.3 Delayed Hardware Trigger

This function allows time for the signal to settle after a trigger has occurred.
It allows readings to be delayed up to 65mSec with 1µSec resolution.
It allows readings to be delayed up to 1s with 2µs resolutions.

2.12 Measurement Aperture and Read Interval

Both Aperture and The Read Interval may be set. The range of values depend on the DMM model and its mode of operation. For example, when using the internal buffer such as in External Trigger mode, the Read Interval can be set smaller than in Command/Response operation. The time involved in processing the measurement command and the post processing and transmission of the measurement results constitute an overhead, which limits the minimum Read Interval to a value that is greater than the Aperture. Setting it to zero (default) results in the fastest measurement rates at the selected Aperture. The faster SM2064 has lower overhead and therefore a shorter minimum Read Interval than the SM2060. For instance, with Aperture set to 625us and Read Interval set to zero, in command/response operation the SM2060 measurement rate is about 1,090/s while that of the SM2064 is 1,370/s. This indicates overhead of about 300µs for the SM2060 and 100µs for the SM2064.

The SM2064 has 31 A/D apertures available, ranging from 5 Seconds to 2.5µS. The following table contains all available measurement apertures and the corresponding minimum read intervals and measurement rates.

	Power Line Rejection	Command/Response mode min. Read	H/W Trigger mode min. Read Interval(s) / max meas. Rate

				Interval(s) / max meas. rate(Hz)	(Hz)
Aperture	60Hz	50Hz	400Hz		
5.1200s [1]	√	√	√	5.121s / 0.2	N/A
5.0666s [1]	√			5.0677s / 0.2	N/A
2.08s [1]		√	√	2.081s / 0.5	N/A
2.0s [1]	√	√	√	2.001s / 0.5	N/A
1.06666s [1]	√			1.067s / 1	N/A
960ms [1]		√	√	0.9605s / 1	N/A
533.33ms [1]	√			533.6ms / 2	N/A
480ms [1]		√	√	480.2ms / 2	N/A
266.666ms [1]	√			268ms / 4	N/A
160.0ms	√	√	√	166ms / 6	160.3 ms / 6
133.33ms	√			134ms / 8	133.5 ms / 8
80.00ms		√	√	80.4ms / 13	80.2 ms / 13
66.6667ms	√			67.2ms / 15	66.713 ms / 15
40.00ms		√	√	40.4ms / 25	40.32 ms / 24.8
33.333ms	√			33.643ms / 29.72	33.38 ms / 30
20.00ms		√	√	20.098ms / 49.76	20.33 ms / 50
16.6667ms	√			16.77ms / 59.6	16.89 ms / 59
10ms				10.094ms / 99	10.25 ms / 97
8.333ms				8.422ms / 119	8.503 ms / 115
5ms				5.109ms / 195	5.187 ms / 185
4.16667ms				4.265ms / 234	4.274 ms / 220
2.5ms				2.598ms / 385	2.614 ms / 350
2.0833ms				2.177ms / 458	2.216 ms / 410
1.25ms				1.344ms / 744	1.380 ms / 625
1.0417ms				1.133ms / 880	1.158 ms / 864
625µS				719µs / 1,390	728 µs / 1,370
520.83µS				617µs / 1,625	622 µs / 1,610
312.5µS				410µs / 2,445	414 µs / 2,445
260.42µS				355µs / 2,825	358 µs / 2,825
130.21µS				223µs / 4,475	217 µs / 4,660
2.5µS				47µs / 21,600	45 µs / 22,200

[1] Not available with any of the Triggered modes.

The SM2060 has are 26 A/D apertures available, ranging from 5 Seconds to 625uSec. The following table contains all available measurement apertures corresponding minimum read intervals and measurement rates.

	Power Line Rejection			Command/Response mode min. Read Interval(s) / max meas. rate(Hz)	H/W Trigger mode min. Read Interval(s) / max meas. Rate (Hz)
Aperture	60Hz	50Hz	400Hz		
5.1200s [1]	√	√	√	5.121s / 0.2	N/A
5.0666s [1]	√			5.0677s / 0.2	N/A
2.08s [1]		√	√	2.081s / 0.5	N/A
2.0s [1]	√	√	√	2.001s / 0.5	N/A
1.06666s [1]	√			1.067s / 1	N/A
960ms [1]		√	√	0.9605s / 1	N/A
533.33ms [1]	√			533.6ms / 2	N/A
480ms [1]		√	√	480.2ms / 2	N/A
266.666ms [1]	√			268ms / 4	N/A
160.0ms	√	√	√	166ms / 6	160.3 ms / 6
133.33ms	√			134ms / 8	133.5 ms / 8
80.00ms		√	√	80.4ms / 13	80.2 ms / 13
66.6667ms	√			67.2ms / 15	66.713 ms / 15
40.00ms		√	√	40.4ms / 25	40.32 ms / 24.8
33.333ms	√			33.7ms / 30	33.38 ms / 30
20.00ms		√	√	20.35ms / 50	20.33 ms / 50
16.6667ms	√			16.9ms / 59	16.89 ms / 59
10ms				10.36ms / 97	10.25 ms / 97
8.333ms				8.68ms / 115	8.503 ms / 115
5ms				5.36ms / 185	5.187 ms / 185
4.16667ms				4.52ms / 220	4.274 ms / 220
2.5ms				2.86ms / 350	2.614 ms / 350
2.0833ms				2.44ms / 410	2.216 ms / 410
1.25ms				1.6ms / 625	1.380 ms / 625
1.0417ms				1.39ms / 719	1.158 ms / 864
625µS				917µs / 1,090	728 µs / 1,370

[1] Not available with any of the Triggered modes.

Precise control of the measurement timing and line frequency rejection can be accomplished by controlling the Read Interval and Aperture. Line rejection is dictated by the Aperture, and the duration of measurement is controlled with Read Interval.

Read Interval can be programmed in µs increments for values up to 65ms, and in 20µs increments to 1 second.

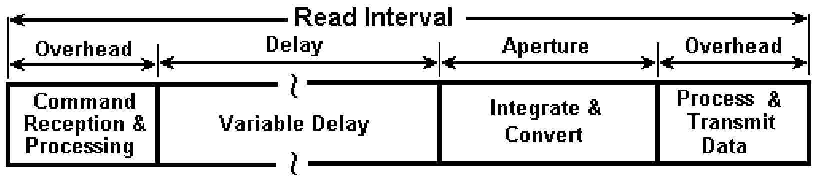


Figure 2-1: Time frame of a single measurement.

2.13 Source Functions (SMX2064)

- Isolated to 300 V DC from the Chassis
- Current can be paralleled with multiple SMX2064s
- Voltage can be put in series with multiple SMX2064s

2.13.1 DC Voltage Source

Parameter	Closed Loop [1]	Open Loop
Output Voltage range	-10.000 V to +10.000 V	
Typical Current source/sink at 5V output	5 mA	5 mA
DAC resolution	18 bits	12 bits
Accuracy 23°C ± 10°C One Year	0.015% ± 350 µV	1.0% ± 35 mV
Typical settling time	3 S (rate set to 2/s)	1 ms
Typical source resistance	250 Ω	

[1] An Aperture set to 133ms or higher is required for the closed loop mode.

2.13.2 AC Voltage Source

The AC Voltage source has two ranges. 900 mV range and 8V range. The lower range is capable of generating 50mV to 9.3V while the higher range can generate 300mV to 7.2V RMS.

Parameter	Specification
Ranges	900mV and 8V
Output Voltage, sine wave	30mV to 7.2 V RMS (0.14 to 20.0V peak-to-peak)
DAC resolution	12 bits
Typical Current Drive at 3.5V RMS	3 mA RMS
Accuracy 18°C to 28°C One Year	ACV spec + 0.8% ± 20 mV
Typical settling time (f-out > 40 Hz)	0.5 s
Typical source resistance	250 Ω
Frequency range / resolution	10 Hz to 100 kHz / 10 mHz
SFDR (spurious free dynamic range)	60dBc
THD (total harmonic distortion)	59dBc
Frequency stability	100 ppm ± 10 mHz

[1] 166ms or higher Aperture is required for proper closed loop mode.

2.13.3 DC Current Source

Range	Compliance Voltage	Resolution [1]	Minimum level	Accuracy 23°C ± 10°C One Year
1.25 µA	4.2 V	500 pA	1 ηA	1% + 10 ηA
12.5 µA	4.2 V	5 ηA	10 ηA	1% + 100 ηA
125 µA	4.2 V	50 ηA	100 ηA	1% + 500 ηA
1.25 mA	4.2 V	500 ηA	1 µA	1% + 5 µA
12.5 mA	1.5 V	5 µA	10 µA	1% + 50 µA

[1] Resolution without Trim DAC. The use of the Trim DAC can improve the resolution by a factor of 10, but it has to be set separately since it is not calibrated.

2.14 Accuracy Notes

Important: all accuracy specifications for DCV, Resistance, DCI, ACV, and ACI apply for the time periods shown in the respective specification tables. To meet these specifications, Self Calibration must be performed once a day or as indicated in the specification table. This is a simple software operation that takes a few seconds. It can be performed by calling Windows command DMMCal(), or selecting S-Cal in the control panel.

These products are capable of continuous measurement as well as data transfer rates of up to 20,000 readings per second (rps). In general, to achieve 7-1/2 Digits of resolution, the Aperture should be set to 0.5s or a higher value. 6-1/2 digit resolution requires at least 10ms Aperture. For 5-1/2 use at least 625us Aperture.

2.15 Other Specifications

Temperature Coefficient over 0°C to 50°C Range

- Less than 0.1 x accuracy specification per °C At 23C ± 5°C

Aperture (user selectable)

- 625 µs to 2s in 26 discrete values, SM2060 (approx. 0.5 to 1,400 readings per second)
- 2.5µs to 2s in 31 discrete values, SM2064 (approx. 0.5 to 20,000 readings per second)
- In Triggered modes Aperture is limited to 160ms or shorter.

Read Interval (user selectable)

- 47µs to 65ms, 1µs steps in Trigger modes, SM2064
- 730µs to 65ms, 1us steps in Trigger modes, SM2060
- 47µs to 1s, 1µs steps below 65ms, in command/response modes, SM2064
- 916µs to 1s, 1µs steps below 65ms, in command/response modes, SM2060

Hardware Interface	Single PCI slot
Overload Protection (voltage inputs)	330 VDC, 250 VAC
Isolation	330 VDC, 250 VAC from Earth Ground
Maximum Input (Volt x Hertz)	8x10^6 Volt x Hz normal mode input (across Voltage HI & LO). 1x10^6 Volt x Hz Common Mode input (from Voltage HI or LO relative to Earth Ground).
Safety	Designed to IEC 1010-1, Installation Category II.
Calibration	Calibrations are performed by ***Signametrics*** in a computer at 23°C internal temperature rise. All calibration constants are stored in a text file.
Temperature Range Operating	-10°C to 65°C
Temperature Range Storage	-40°C to 85°C
Size	SM2060, SM2064: 4.5” X 8.5” (PCI format) SMX2060, SMX2064: Single 3U PXI or CompactPCI slot
DMM Internal Temperature sensor accuracy	±1°C (SM2064)
Power	+5 volts, 300 mA maximum

Note: Signametrics reserves the right to make changes in materials, specifications, product functionality, or accessories without notice.

Accessories

Several accessories are available for the SM2060 series DMM's, which can be purchased directly from Signametrics, or one of its approved distributors or representatives. These are some of the accessories available:

- DMM probes SM-PRB ($15.70)
- DMM probe kit SM-PRK ($38.50)
- Deluxe probe kit SM-PRD ($95.00).
- Shielded SMT Tweezers Probes SM-PRSMT ($24.90).
- Multi Stacking Double Banana shielded cable 36" SM-CBL36 ($39.00).
- Multi Stacking Double Banana shielded cable 48" SM-CBL48 ($43.00).
- Mini DIN Trigger, 6-Wire Ohms connector SM2060-CON7 ($14.00).
- Lab View VI's library SM204x.llb (free).
- Extended 3 Year warrantee (does not include calibration) $150.00 for SM2060 and SMX2060, $240 for the SM2064 and SMX2064.

3.0 Getting Started

After unpacking the DMM, please inspect for any shipping damage that may have occurred, and report any claims to your transportation carrier.

The DMM is shipped with the Digital Multimeter module; Installation CD and a floppy disk that contain the calibration and verification files. Also included is the Certificate of Calibration.

3.1 Setting the DMM

The SM2060 series DMM's are PCI plug-and-play devices and do not require any switch settings, or other adjustments prior to installation.

The **SM60CAL.DAT** file supplied with your DMM has a unique calibration record for that DMM (See "**Calibration**" at the end of this manual.) When using multiple DMM's in the same chassis, the **SM60CAL.DAT** file must have a calibration record for each DMM. Append the unique calibration records of each DMM into one **SM60CAL.DAT** file using a text editor such as Notepad. The default location for the **SM60CAL.DAT** file is at the root directory C:\.

3.2 Installing the DMM Module

Warning

To avoid shock hazard, install the DMM only into a personal computer that has its power line connector connected to an AC receptacle with an Earth Safety ground.

After installation, check to see that no loose wires or ribbon cables infringe upon any of the internal circuits of the DMM, as this may apply measurement voltages to your computer, causing personal injury and/or damage to your computer!

Caution: Only install the DMM module with the power turned OFF to the PC!

Use extreme care when plugging the DMM module(s) into a PCI bus slot. If possible, choose an empty slot away from any high-speed boards (e.g. video cards) or the power supply. **Please be patient during the installation process!** The DMM comes with 4 safety-input jacks. Because of their necessary size, they are a tight fit in many PC chassis. Insert the bracket end of the DMM into your PC first, watching for any interference between the safety input jacks and your PC chassis. "Sliding" the bracket end of the DMM into the chassis may be helpful. **Be patient! You should only have to install it once!**

3.3 Installing the Software

It is recommended that you first plug in the DMM into the PC chassis, than turn on the computer power. The first time you power up your computer with the DMM installed, your computer will detect it as new hardware and prompt you for a driver. The driver your computer requires is located on the installation CD (SM2060.INF).

Following the above driver installation, run the **'SETUP'** program provided on the CD. This takes care of all installation and registration requirements of the software. If you are installing the DMM on a computer that had an SM2060 series install in it, you should first uninstall the old software. Also make sure you backup and remove the old calibration record (SM60CAL.DAT). For a clean reinstallation remove all INF files containing reference to the Signametrics DMM. Depending on operating system, these files will be located at Windows\inf, Windows\inf\other or WINNT\inf. The files will be named Oemx.INF where x is 0,1,2,… and/or SIGNAMETRICSSM2060.INF. If present, these files will prevent "Found New Hardware" wizard from detecting the new DMM.

3.4 DMM Input Connectors

Before using the DMM, please take a few moments and review this section to understand where the voltage, current, or resistance and other inputs and outputs should be applied. **This section contains important information concerning voltage and current limits. Do not exceed these limits, as personal injury or damage to the instrument, your computer or application may result.**

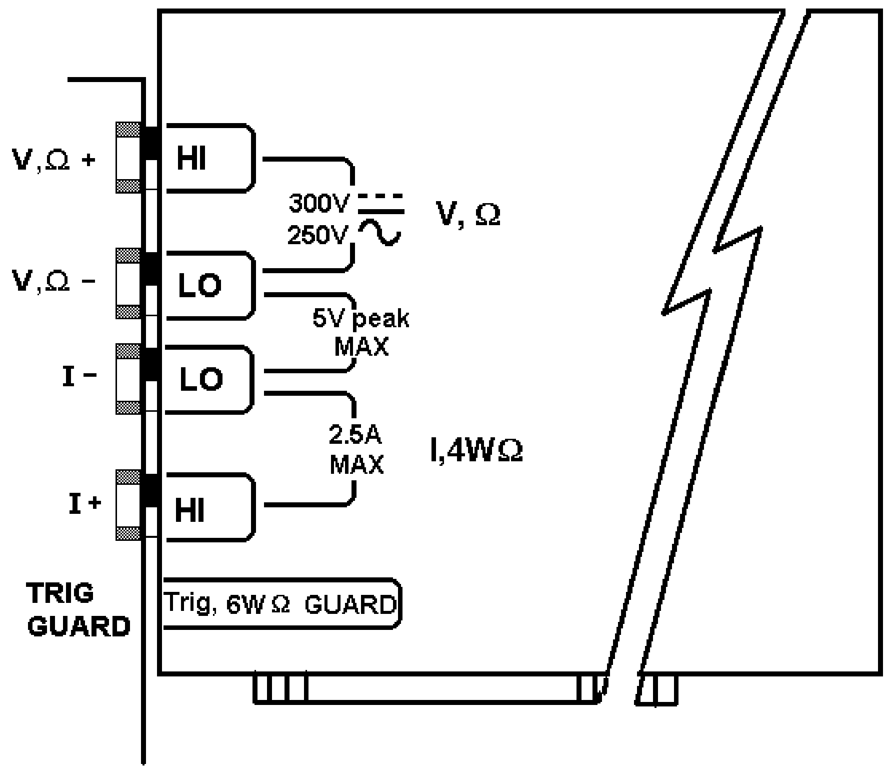


Figure 3-1. The DMM input connectors.

V, Ω + This is the positive terminal for all Volts, 2WΩ, capacitance, diode and inductance measurements, and for sourcing of VDC, VAC and IDC. It is also the Source HI for 4WΩ measurements. The maximum input across **V, Ω** + and **V, Ω** - is 300 VDC or 250 VAC when in the measuring mode**. When in the sourcing mode, the maximum input allowed before damage occurs is 100 volts.**

V, Ω - This is the negative terminal for all Volts, 2WΩ, capacitance diode and inductance measurements, and or sourcing of VDC, VAC and IDC. It is also the Source LO for 4WΩ. **Do not float this terminal or any other DMM terminal more than 300 VDC or 250 VAC above Earth Ground.** (Also, see **Trig, 6W Guard** below.)

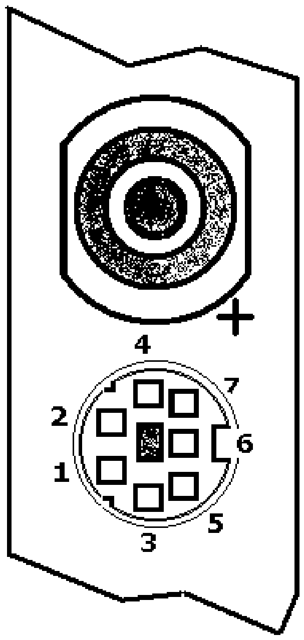
I + This is the positive terminal for all Current measurements. It is also the Sense HI for 4WΩ measurements and 6WΩ guarded measurements. The maximum input across **I, 4WΩ +** and **I, 4WΩ -** is **2.5 A**. Do not apply more than 5 V peak across these two terminals!

I – This is the negative terminal for all Current measurements. In the Current modes, it is protected with a **2.5 A, 250 V Fast Blow fuse** (5 x 20 mm). It is also the Sense LO for 4WΩ measurements and 6WΩ guarded measurements. **V, Ω -** and **I, 4WΩ -** should never have more than 5 V peak across them.

TRIG / GUARD Both the Trigger and Guard functions are at the DIN-7 connector. This group of pins includes the positive and negative hardware trigger input lines and the two SM2064 Guarded Measurement Force and Sense signals. The external trigger initiates reading(s) into the onboard buffer, and the 6W guard signals facilitate in-circuit resistor measurements by means of isolating a loading node. The DIN-7 plug can be ordered from Signametrics and is also available at many electronic hardware distributors. The connector is generically referred to as a mini DIN-7 male. The trigger signal should be in the range of 3 V to 12 V peak. The two 6W guard signals should never have more than 5 V peak across them.

Warning! The DIN connector pins are protected to a maximum of 35 V with respect to the PC chassis and any other DMM terminal. Do not apply any voltages greater than 35 V to the DIN connector pins. Violating this limit may result in personal injury and/or permanent damage to the DMM.

DIN-7, Pin number	Function
2	Sync output, referenced to pin 4
7	External Trigger input, Positive
4	Trigger and Sync Common
1	Guard Source (SM2064)
6	Guard Sense (SM2064)



DIN-7 Connector Pin Description, view from bracket side.

3.5 Starting the Control Panel

You can verify the installation and gain familiarity with the DMM by exercising its measurement functions using the Windows based Control Panel. To run the control panel, double click the "SM2064.EXE" icon. If you do not hear the relays click, it is most likely due to an installation error. Another possible source for an error is that the **SM60CAL.DAT** file does not correspond to the installed DMM.

When the DMM is started the first time, using the provided control panel (SM2064.EXE), it takes a few extra seconds to extract its calibration data from the on-board store, and write it to a file C:\SM60CAL.DAT

The Control Panel is operated with a mouse. All functions are accessed using the left mouse button. When the DMM is operated at very slow reading rates, you may have to hold down the left mouse button longer than usual for the program to acknowledge the mouse click.

Note: The SM2060 front panel powers up in DCV, 0.5s Aperture, 0 Read Interval and 240 V range. If the DMM is operated in Autorange, with an open input, it will switch between the 2.4V and 24V ranges every few seconds, as a range change occurs. This is perfectly normal with ultra high impedance DMM's such as the SM2060. This phenomenon is caused by the virtually infinite input impedance of the 2.4V DC range. On these ranges, an open input will read whatever charge is associated with the signal conditioning of the DMM. As this electrical charge changes, the SM2060 will change ranges, causing the range switching. This is normal.

3.6 Using the Control Panel

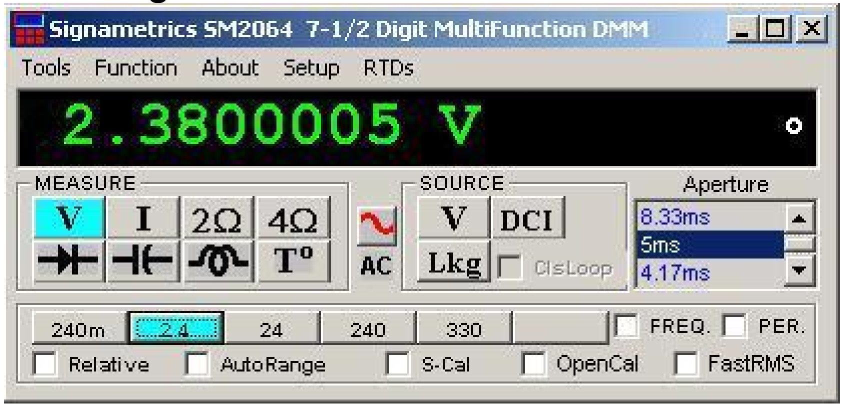
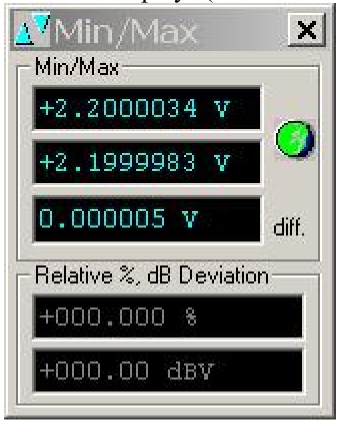

Signametrics SM2064 7-1/2 Digit MultiFunction DMM
Tools Function About Setup RTDs
2.3800005 V
MEASURE
V I 2Ω 4Ω
T°
AC
SOURCE
V DCI
Lkg ClsLoop
Aperture
8.33ms
5ms
4.17ms
240m 2.4 24 240 330
FREQ. PER.
Relative AutoRange S-Cal OpenCal FastRMS

Figure 3-2. The Control Panel for the SM2064. The three main groups include Measure, Source and Range buttons. The Range buttons are context sensitive such that only "240m, 2.4, 24, 240 and 330 appear when in AC Voltage Function is selected, and 2.4m, 24m, 240m and 2.4 appear when AC Current functions is selected, etc.

Note: All of the controls described below correspond to their respective software function, which can be invoked within your control software or as objects in a visual programming environment. The software command language of the SM2060 provides a powerful set of capabilities. Some of the functions are not included in the control panel, but are in the software.

DC/AC This function switches between DC and AC. This is applicable for the following DMM functions: Voltage, Current, and Voltage-Source. If Voltage-Source is the function presently in use, the Source control under the Tools menu can be used to set frequency and amplitude in ACV, and amplitude only in DCV and DCI.

Relative This is the Relative function. When activated, the last reading is stored and subtracted from all subsequent readings. This is a very important function when making low-level DCV measurements, or in 2WΩ. For example, when using 2WΩ, you can null out lead resistance by shorting the leads together and clicking on **Relative.** When making low level DC voltage measurements (e.g., in the μV region), first apply a copper short to the **V,Ω + & -** input terminals, allow the reading to stabilize for a few seconds, and click on **Relative**. This will correct for any offsets internal to the SM2060. The **Relative** button can also be used in the Percent and dB deviation displays (shown below), which are activated using the **Tools** in the top menu.



The Min/Max box can be used to analyze variations in terms of Min, Max, Percent and dBV. This display can be activated by selecting the Min/Max/Deviation from the Tools menue. For instance, testing a circuit bandwidth with an input of 1V RMS, activate the Relative function with the frequency set to 100Hz, than sweep gradually the frequency, and monitor the percent deviation as well as the dBV error and capture any response anomalies with the Min/Max display. The left display indicates peaking of 2.468% (0.21 dBV) and maximum peaking in the response of +56.24mV and a notch of –10.79mV from the reference at 100Hz.

Aperture Box: Controls the SM2060 reading aperture. As aperture decreases, the measurement noise increases. For best accuracy set to the longest aperture acceptable for the application. Also consider the line frequency (50/60 Hz) of operation when setting it, as certain apertures have better noise rejection at either 50 or 60 Hz. (See

"Specifications" for details.). When measuring RMS values, there is no point setting the Read Interval (1/rate) to a value shorter than 0.16s since the RMS circuitry has a settling time that is greater.

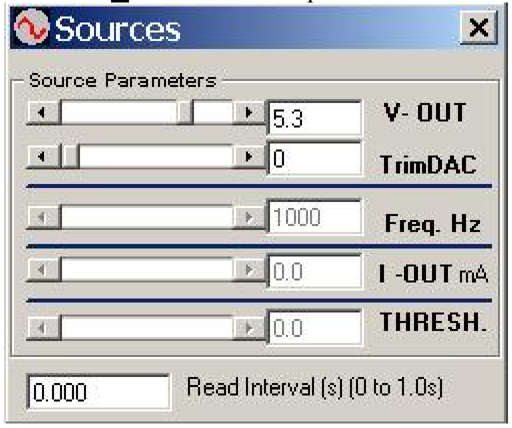
Range: Can be set to **Autorange** or manual by clicking on the appropriate range in the lower part of the Windows panel. Autoranging is best used for bench top application and is **not recommended** for an automated test application due to the uncertainty of the DMM range, as well as the extra time for range changes. Locking a range is highly recommended when operating in an automated test system, especially to speed up measurements. Another reason to lock a range is to control the input impedance in DCV. The 240 mV and 2.4 V ranges have virtually infinite input impedance, while the 24 V and 240 V and 330 V ranges have 10 MΩ input impedance.

S_Cal: This function is the System Calibration that corrects for internal gain, scale factor and zero errors. The DMM does this by alternatively selecting its local DC reference and a zero input. It is required at least once every day to meet the SM2060 accuracy specifications. It is recommended that you also perform this function whenever the external environment changes (e.g. the temperature in your work environment changes by more than 5°C, or the SM2064 on board temperature sensor indicates more than a 5°C change). This function takes less than a few seconds to perform. Disconnect all leads to the DMM before doing this operation. Keep in mind that this is not a substitute for periodic calibration, which must be performed with external standards.

ClosedLoop: This check box selection is used in conjunction with the AC and DC Voltage-Source functions of the SM2064. When checked, the DMM monitors the output level and continuously applies corrections to the output level. When not checked, the DMM is a 12-bit source vs. 16 bits in the ClosedLoop mode.

OpenCal: This check box selection is used in conjunction with inductance measurement. It is necessary to perform Open Terminal Calibration using this control, prior to measuring inductance. This function characterizes both the internal DMM circuitry as well as the probe cables. To perform OpenCal, attach the probe cables to the DMM, leaving the other end of the probe cables open circuited. Then, activate the OpenCal button.

Sources Panel: There are three function buttons in the Source group (SM2064 only). The **V, I, LEAK** buttons select one of three source functions, Voltage (DC and AC), IDC and Leakage. The **Sources Panel** is automatically enabled when one of the source functions is enabled. It can also be invoked using the **Sources Panel** selection under the **Tools** menu. This panel allows the entry of values for all of the source functions, including Leakage.



V- OUT: 5.3
TrimDAC: 0
Freq. Hz: 1000
I -OUT mA: 0.0
THRESH.: 0.0
Read Interval (s) (0 to 1.0s): 0.000

The **V-OUT** Scroll bar and Text box are used to set the Voltage for DC and AC Volts as well as for Leakage. When sourcing ACV, the voltage is in RMS and the **FREQ.** Scroll bar and Text box control the frequency of the source. It is also used to control inductance frequency. When sourcing DC current, use the **I-OUT** set of controls. When measuring timing or freqeuncy the **THRESH** set of controls is used for comperator threshold. All of the source controls are context sensitive and will be enabled when

4.0 DMM Operation and Measurement Tutorial

Most of the SM2060 measurement functions are accessible from the Windows Control Panel (Figure above). All of the functions are included in the Windows DLL driver library. To gain familiarity with the SM2060 series DMM's, run the Windows 'SETUP.EXE' to install the software, then run the DMM, as described in the previous section. This section describes in detail the DMM's operation and measurement practices for best performance.

4.1 Voltage Measurement

Measures from 0.1 µV to 330 VDC or 250 VAC. Use the **V, Ω +** and **V, Ω -** terminals, being certain to always leave the **I+, I-** and DIN-7 terminals disconnected. Use the AC/DC button on the Control Panel to switch between AC and DC.

Making Voltage Measurements is straightforward. The following tips will allow you to make the most accurate voltage measurements.

4.1.1 DC Voltage Measurements

When making very low-level DCV measurements (<1 mV), you should first place a copper wire shorting plug across the **V, Ω +** and **V, Ω -** terminals and perform **Relative** function to eliminate zero errors before making your measurements. A common source of error can come from your test leads, which can introduce several µVolts of error due to thermal voltages. To minimize thermal voltaic effects, after handling the test leads; you should wait a few seconds before making measurements. Signametrics offers several high quality probes that are optimal for low-level measurements.

Note: The SM2060 front panel powers up in DCV, 0.5s aperture, 240 *V range. If the DMM is operated in Autorange, with an open input, The DMM will keep changing ranges. This is perfectly normal with ultra high impedance DMM's such as the SM2060. The virtually infinite input impedance of the 240 mV and 2.4 V DCV ranges causes this phenomenon. On these ranges, an open input will read whatever charge is associated with the signal conditioning of the DMM. As this electrical charge accumulates, the SM2060 will change ranges.*

4.1.2 True RMS AC Voltage Measurements

ACV is specified for signals greater than 1mV, from 10 Hz to 100 kHz. The ACV function is AC coupled, and measures the true RMS value of the waveform. As with virtually all true-RMS measuring meters, the SM2060 may not read a perfect zero with a shorted input. This is normal.

ACV measurements, if possible, should have the NEUTRAL or GROUND attached to the SM2060 **V,Ω -** terminal. See Figure 4-1, below. This prevents any "Common Mode" problems from occurring (Common Mode refers to floating the SM2060 **V,Ω LO** above Earth Ground.) Common Mode problems can result in noisy readings, or even cause the PC to hang-up under high V X Hz input conditions. In many systems, grounding the source to be measured at Earth Ground (being certain to avoid any ground loops) can give better results.

The settling time and low end bandwidth of the RMS function are effected by the status of the Fast RMS control circuit. When fast RMS is selected, the RMS settling time is about 10 times faster, but the low end frequency is significantly increased.

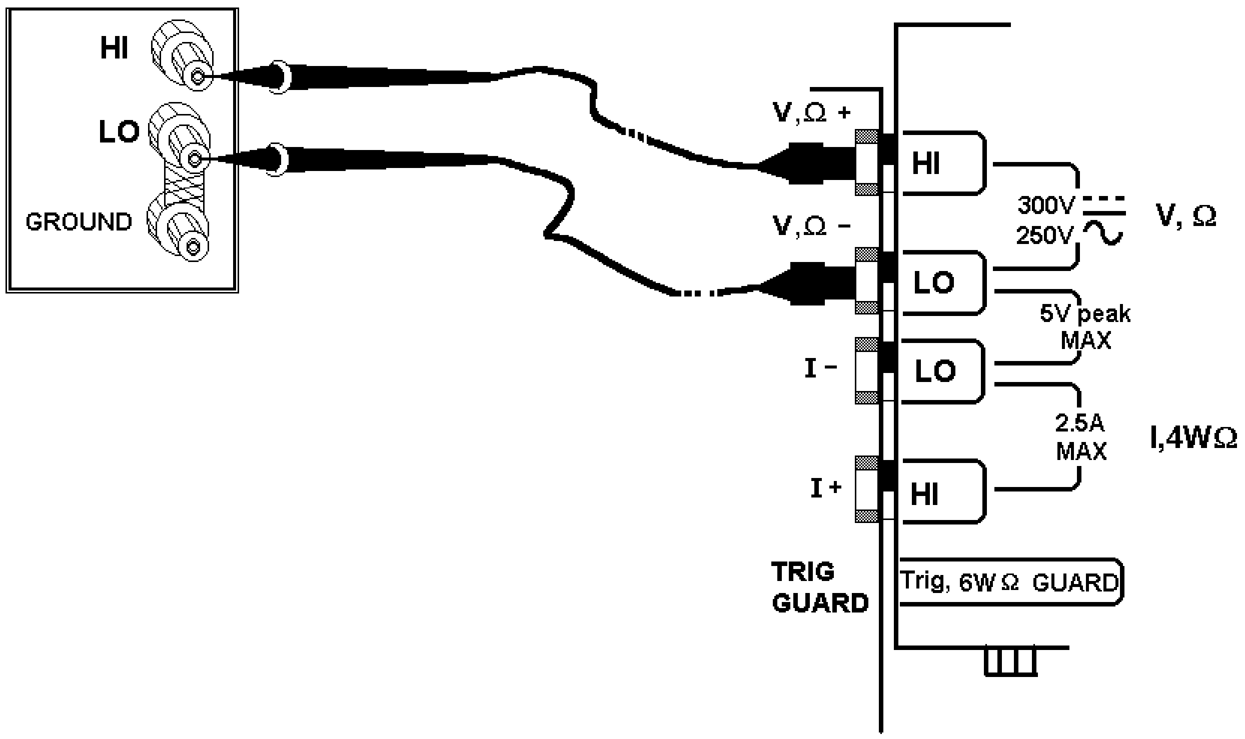


Figure 4-1. Make Voltage ACV measurements with the source ground attached to the SM2060 **V,Ω -** to minimize "Common Mode" measurement problems.

4.1.3 AC Peak-to-Peak and Crest Factor (SM2064)

Measurement of Peak-to-Peak, Crest Factor and AC Median values requires a repetitive waveform between 30 Hz and 100 kHz. The DMM must be in AC voltage measurement mode, with the appropriate range selected. Knowing the Peak-to-Peak value of the waveform is useful for setting the Threshold DAC (described below). This latter function is a composite function, and may take over 10 seconds to perform.

4.1.4 AC Median Value Measurement (SM2064)

To better understand the usage of this function, you should note that the DMM makes all AC voltage measurements through an internal DC blocking capacitor. The voltage is thus "AC coupled" to the DMM. The measurement of the Median value of the AC voltage is a DC measurement performed on the AC coupled input signal. This measurement returns the mid-point between the positive and negative peak of the waveform. The Median value is used for setting the comparator threshold level for best counter sensitivity and noise immunity. (It is difficult to measure the frequency of a low duty cycle, low amplitude AC signals since there is DC shift at the comparator input due to the internal AC coupling. The SM2064 overcome this problem by allowing you to set the comparator threshold level). For further information on the usage of AC Median value and Peak-to-Peak measurements, and the Threshold DAC, see the "Frequency and Timing Measurements" section below.

This function requires a repetitive signal. The DMM must be in AC voltage measurement mode, with the appropriate range selected.

4.2 Current Measurements

The SM2060 measures AC and DC currents between 100 ηA and 2.5 A. Use the **±I, 4WΩ** terminals, being certain to always leave the **V,Ω + & -** terminals disconnected. Use the AC/DC button to switch between AC and DC. The AC current is an AC coupled True RMS measurement function. See figure 4-2 for connection.

The Current functions are protected with a 2.5 A, 250 V fuse. The 2.4mA and 24mA ranges utilize a 10Ω shunt, while the 240mA and 2.4A ranges use a 0.1Ω shunt. In addition to the shunt resistors, there is some additional parasitic resistance in the current measurement path associated with the fuse and the internal wiring. The result is a burden voltage of up to about 250mV.

4.2.1 Extended DC Current Measurements (SM2064)

In addition to the 2.4mA, 24mA, 240mA and 2.4A, the SM2064 has also four DC current ranges; 240nA, 2.4uA, 24uA and 240uA ranges. The lower three ranges are implemented with a "Virtual Zero Shunt" technology, commonly associated with specialized Micro Amp meters. It has an ultra low noise low leakage that renders it useful for measuring down to few Pico-amperes. This means that super low currents from such circuits as Current output DACs of such devices as heart pace makers, or low semiconductor leakages can be measured with practically no voltage drop.

In order to measure down to Pico Amperes it may be necessary to guard the terminals as described in the guarding section of this manual (4.3.8 Guarding High Value Resistance Measurements (SM2064)).

Warning! Applying voltages greater than 35 V to the I+, I- terminals can cause personal injury and/or damage to your DMM and computer! Think before applying any inputs to these terminals!

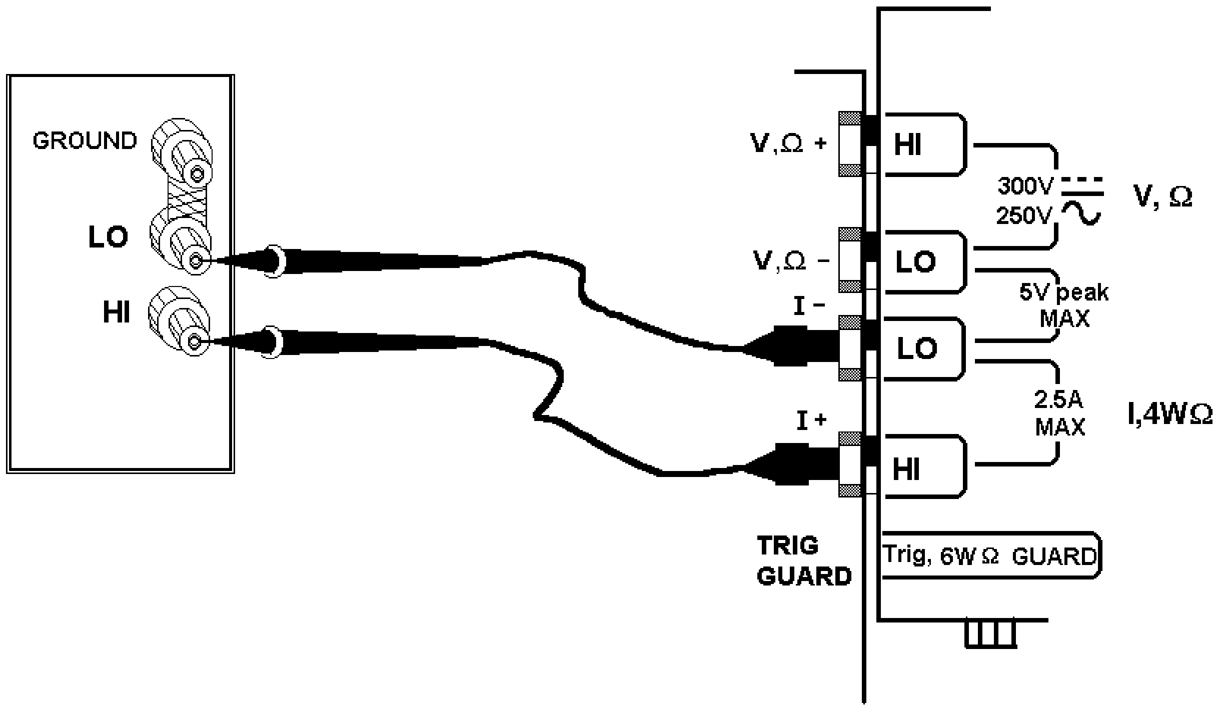


Figure 4-2. AC and DC Current measurement connection.

4.2.2 Improving DC Current Measurements

When making sensitive DC current measurements disconnect all terminals not associated with the measurement. User the **Relative** function while in the desired DC current range to zero out any residual error. Using the **S-Cal** (**DMMCalibrate ()**) prior to activating **Relative** will improve accuracy further. Although the SM2060 family is designed to withstand up-to 2.4A indefinitely, be aware that excessive heat may be generated when measuring higher AC or DC currents. If allowed to rise this heat may adversely effect subsequent measurements. In consideration with this effect, it is recommended that whenever practical, higher current measurements be limited to short time intervals. The lower two ranges of DC current may be effected by relay contamination. If the measurements seem unstable or high, while in IDC measurement, apply between 20mA and 50mA DC to the current terminals and clean the K2 relay using the **DMMCleanRelay(0, 2, 200)**. Repeat this until the measurements are stable.

4.2.3 DC Current Measurements at a specific voltage

The leakage measurement function can be used to measure low-level currents at a specific voltage. This function uses the top and bottom terminals of the SM2064. It measures low level DC currents with a specified DC voltage applied to the DUT.

4.3 Resistance Measurements

Resistance is measured using eight (six in the SM2060) precision current sources, with the DMM displaying the resistance value. Most measurements can be made in the 2-wire mode. The 4-wire ohms is used to make low value resistance measurements. All resistance measurement modes are susceptible to Thermo-Voltaic (Thermal EMF) errors. See section 4.3.5 for details.

4.3.1 2-Wire Ohm Measurements

The DMM measure using 240Ω to 24 MΩ ranges. The SM2064 adds 24 Ω and 240 MΩ ranges, as well as extended resistance to 100 GΩ. Use the **V,Ω+, V,Ω-** terminals for this function. Be certain to disconnect the **I+, I-** terminals in order to reduce leakage, noise and for better safety.

Most resistance measurements can be made using the simple 2-wire Ohms method. Simply connect **V,Ω+** to one end of the resistor, and the **V,Ω-** to the other end. If the resistor to be measured is less than 30 kΩ, you should null out any lead resistance errors by first touching the **V,Ω+** and **V,Ω-** test leads together and then performing a **Relative** function. If making measurements above 300 kΩ, you should use shielded or twisted leads to minimize noise pickup. This is especially true for measurements above 1 MΩ.

You may also want to control the Ohms current used in making resistance measurements. (See the Specifications section, "Resistance, 2-wire and 4-wire", for a table of resistance range vs. current level.) All of the Ohms ranges of the SM2060 have enough current and voltage compliance to turn on diode junctions. For characterizing semiconductor part types, use the Diode measurement function. To avoid turning on a semiconductor junction, you may need to select a higher range (lower current). When checking semiconductor junctions, the DMM displays a resistance value linearly related to the voltage across the junction.

For applications requiring voltage and current controlled resistance measurements, use the Extended Resistance Measurement function as well as active guarding is available with the SM2064.

4.3.2 4-Wire Ohm Measurements

4-wire Ohms measurements are advantageous for making measurements below 330 kΩ, eliminating lead resistance errors. The **Voltage** (**V,Ω**) Input terminals serve as a current source to stimulus the resistance, and the **I, 4WΩ** Input terminals are the sense inputs. The Source + and Sense + leads are connected to one side of the resistor, and the Source - and Sense - leads are connected to the other side. Both Sense leads should be closest to the body of the resistor. See Figure 4-3.

4-wire Ohm makes very repeatable low ohms measurements, from 100 μΩ (10 μΩ for SM2064) to 330 kΩ. It is not recommended to use **4WΩ** when making measurements above 100 kΩ, although 4-wire ohms measurements are facilitated up to 330 kΩ. 4-wire measurements are disabled above 330 kΩ since the extra set of leads can actually *degrade* the accuracy, due to additional leakage and noise paths.

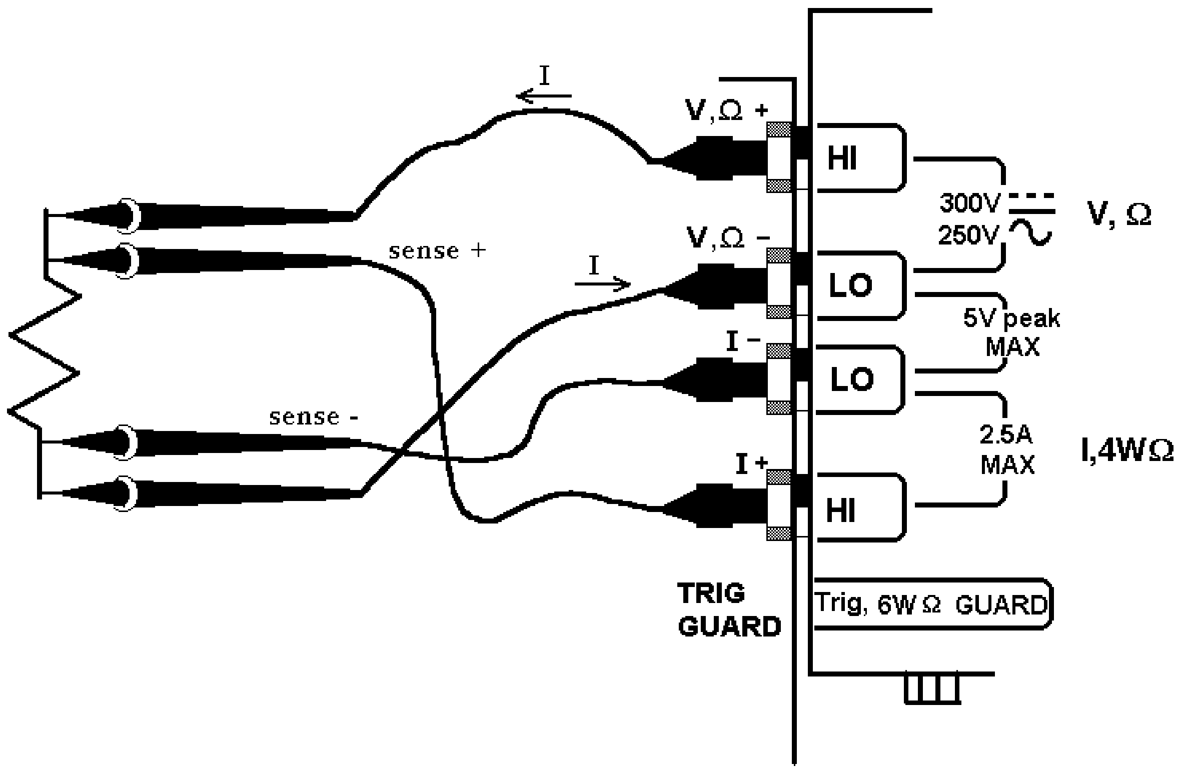


Figure 4-3. The **I- and I+** sense leads should be closest to the body of the resistor when making 4WΩ measurements.

4.3.3 Using Offset Ohms function (SM2064)

Inadvertent parasitic leakage currents, Thermo-voltaic voltages and other sources of voltage errors in a circuit can be the cause of inaccuracies in resistance measurements. This is common particularly when making measurements of active circuit. Many users, unaware of the above issues, select very poor switching systems prone to high Thermal Errors that introduces some very high offset voltages, be it in 2-Wire or 4-Wire measurements. Offset Ohms can alleviate some of this error. Enabling it can also be used to measure internal resistance of low value voltage sources such as various batteries, low voltage power supplies and sensors. Use the normal 2-Wire or 4-Awire Ohms connection, and set the Offset Ohms to the enabled or disabled state using the **DMMSetOffsetOhms()** function. When set TRUE, the read interval will be twice as set. Both negative and positive polarity voltages can be corrected as long as the total voltage including the resistance measurement voltage plus the parasitic voltage are less than 0.5V. To calculate this voltage consult the specification part of this manual for the specific current for each Ohms range. The default value of this function is FALSE. This function is implemented only with the SM2064.

4.3.4 6-wire Guarded Resistance Measurement (SM2064)

The SM2064 provides a guarded 6-wire resistance measurement method. It is used to make resistance measurements when the resistor-under-test has other shunting paths, which can cause inaccurate readings. This method isolates the resistor-under-test by maintaining a guard voltage at a user-defined node. The guard voltage prevents the shunting of the DMM Ohms source current from the resistor-under-test to other components. The Guard Source and Guard Sense terminals are provided at pins 1 and 6 of the DIN connector respectively.

Warning! The DIN connector pins are only protected to a maximum of 35 V with respect to the PC chassis or any other DMM terminal. Do not apply any voltages greater than 35 V to the DIN connector pins. Violating this limit may result in personal injury and/or permanent damage to the DMM.

Example: Assume a 30 kΩ resistor is in parallel with two resistors, a 510 Ω and a 220 Ω, which are connected in series with each other. In a normal resistance measurement, the 510 Ω and 220 Ω would "swamp" the measurement shunting most of the DMM Ohms source current. By sensing the voltage at the top of the 30 kΩ, and then applying this same voltage to the junction of the 510 Ω and 220 Ω, there is no current flow through the shunting path. With this "guarding", the SM2064 accurately measures the 30 kΩ resistor.

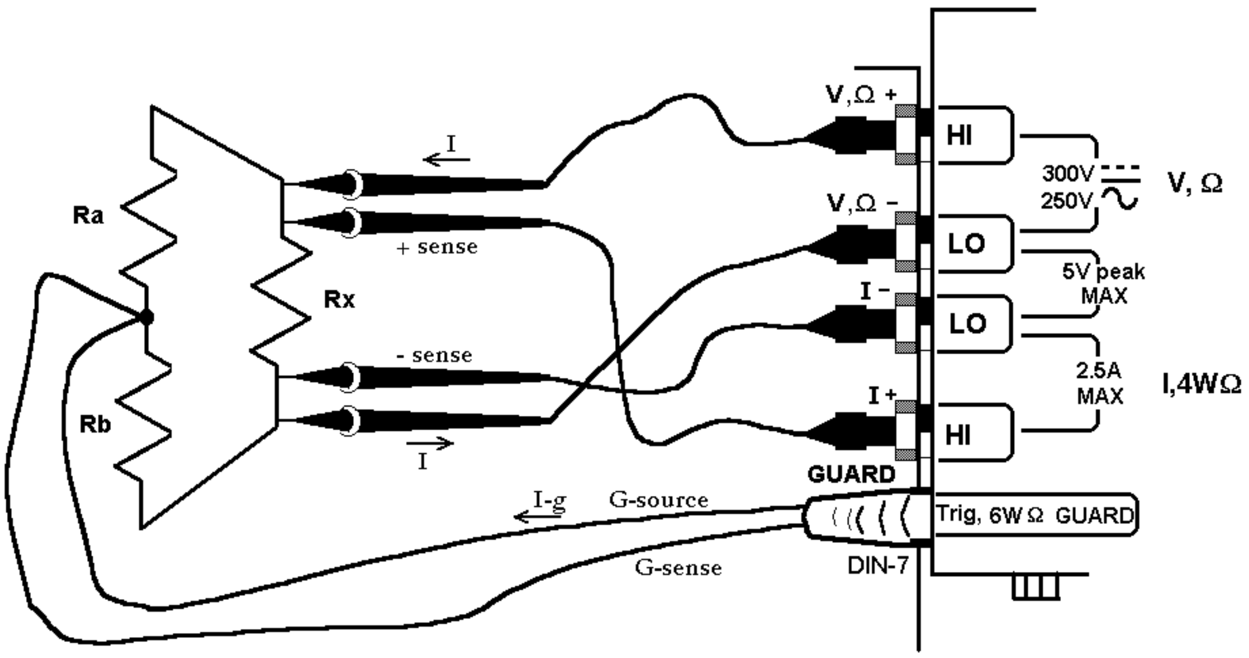


Figure 4-4. 6-wire guarded in-circuit ohms measurement configuration.

The current compliance of the Guard Force is limited to a maximum of 20 mA and is short circuit protected. The resistor connected between the low of the 4-wire terminals and the guard point is the burden resistor, or R_b. Due to the limited guard source current, this resistor can not be lower than R_{bmin}: $R_{bmin} = I_o * R_x / 0.02$, where I_o is the ohms source current for the selected range, and R_x is the resistance being measured. For example, selecting the 330 Ω range and measuring a 300 Ω resistor imposes a limit on R_b of at least 15 Ω or greater. Since the top burden resistor, R_a, does not have this limit imposed on it, selecting the measurement polarity, R_a can become R_b and vise versa. For cases where this limit is a problem, simply set the measurement polarity such that R_a is the higher of the two burden resistors.

To measure values greater than 330 kΩ using the 6-wire guarded method, it is necessary to select the 2-wire ohms function, and maintain the 6-wire connection as in Figure 4-4 above.

4.3.5 Extended Resistance Measurements (SM2064)

The Extended Resistance measurement function complements the standard resistance measurement. While the standard resistance measurement forces a constant current, this function forces a variable voltage. It is ratiometric in its operation, meaning it is using internal precision resistors to establish references for the various ranges. The maximum test current is defined by the selected range. Negative Over-Range is reached when the test current exceeds this limit. Positive Over-Range is declared when the current is lower than 0.04% of the current limit. The test current is equal to the set test voltage divided by the measured resistance value.

Ranges are defined in terms of their current limit rather than resistance. The lowest range's current limit is set at 24µA, therefore the lowest resistance it can measure with the test voltage programmed to 10V, is about 400k. With the test voltage set to 0.1V the minimum value is about 4k. The next range's limit is 2.4µA which corresponds with 4M at 10V and 40k with 0.1V. The highest range current is limited to 240nA, which implies that the lowest resistance it can measure with 10V source is 40M and the lowest resistance it can measure with 0.1V is 400k. The highest range practical measurement limit is as high as 10GΩ. The connection topology with optional active guarding is depicted in Figure 4-7.

Set the test voltage using the **DMMSetDCVSource()** function. Due to the availability of a higher test voltages than is available with the normal resistance function, as well as the ratiometric method, this measurement function is best for high value resistors such as measuring leaky cables. Further benefit in setting a specific test voltage is to prevent turning on of semiconductor junctions while testing high value resistors. The combined ability to limit both voltage and current is significant in test applications where the destruction of a delicate sensor is a concern. The built-in voltage source can be set between -10V and +10V. Also consider that with lower voltages, there is increase in measurement noise. For instance measuring 10Meg resistor with 0.1V is noisier than using 1V.

Additional applications include testing high value resistive elements such as cables, transformers, and other leaky objects such as printed circuit boards**,** connectors and semiconductors.

Range	Measurement range	Resolution	Voltage Range	Current Limit
400kΩ	1kΩ to 100MΩ	10Ω	±0.02V to ±10.0V	25µA
4MΩ	10kΩ to 1GΩ	100Ω	±0.02V to ±10.0V	2.5µA
40MΩ	100kΩ to 10GΩ	1kΩ	±0.02V to ±10.0V	250nA

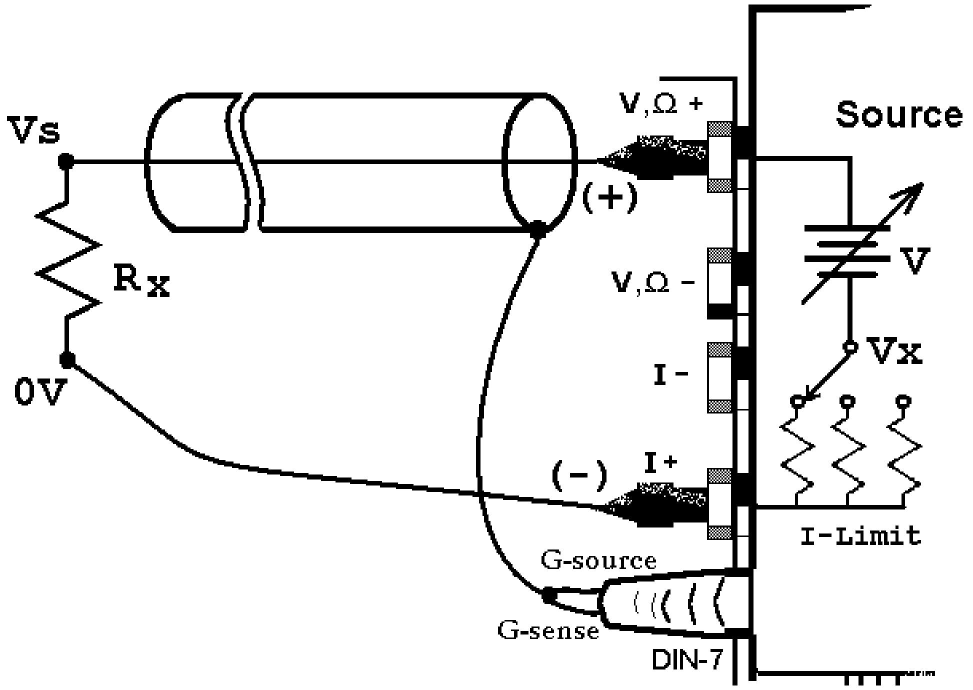


Figure 4-7. Guarding improves accuracy when measuring high value resistors using the Extended Resistance measurement method.

4.3.6 Effects of Thermo-Voltaic Offset

Resistance measurements are sensitive to Thermo-Voltaic (Thermal EMF) errors. These error voltages can be caused by poor test leads, relay contacts and other elements in the measurement path. They affect all measurement methods, including 2-Wire, 4-Wire, 6-Wire and 3-Wire (guarded 2-Wire ohms). To quantify this error, consider a system in which signals are routed to the DMM via a relay multiplexing system. Many vendors of switching products do not provide Thermal EMF specification, and it is not uncommon to find relays that have more than 50 µV. With several relay contacts in the path, the error can be significant. This error can be measured using the SM2060 240mV DC range. To do this, close a single relay that is not connected to any load, wait for a short time (about 2 minutes), than measure the voltage across the shorted relay contacts. Make sure to short the DMM leads and set 'relative' to clear the DMM offset prior to the measurement. To calculate worst-case error, count all relay contacts, which are in series with the measurement (**V, Ω+, V, Ω-** terminals in 2-Wire, and **I+, I-** terminals in 4-Wire mode). Multiply this count by the Thermal EMF voltage. Use Ohms law to convert this voltage to resistance error as in the following table.

Resistance Measurement Errors due to Thermo-Voltaic offsets.

SM2066 Range	Ohms Current	DMM Resolution	Error due to 10 µV EMF	Error due to 100 µV EMF	Error due to 1mV EMF
33 Ω	10 mA	10 µΩ	1 mΩ	10 mΩ	100 mΩ
330 Ω	1 mA	100 µΩ	10 mΩ	100 mΩ	1 Ω
3.3 kΩ	1 mA	1 mΩ	10 mΩ	100 mΩ	1 Ω
33 kΩ	100 uA	10 mΩ	100 mΩ	1 Ω	10 Ω
330 kΩ	10 uA	100 mΩ	1 Ω	10 Ω	100 Ω

3.3 MΩ	1 uA	1 Ω	10 Ω	100 Ω	10 Ω
33 MΩ	100 nA	100 Ω	100 Ω	1 kΩ	100 Ω
330 MΩ	10 nA	10 kΩ	1 kΩ	10 kΩ	100 kΩ

4.3.7 Guarding High Value Resistance Measurements (SM2064)

Measuring high value resistors using the 2-Wire function require special attention. Due to the high impedances involved during such measurements, noise pickup and leakage could be very significant. To improve this type of measurement it is important to use good quality shielded cables with a low leakage dielectric. Even with a good dielectric, if a significant length is involved, an error would result due to leakage. Figure 4.8 exemplifies this error source. It is important to emphasize that in addition to the finite leakage associated with the distributed resistance, R_L, there must also be a voltage present between the two conductors, the shield and the center lead, for leakage current to develop. Provided there was a way to eliminate this voltage, leakage would have been eliminated.

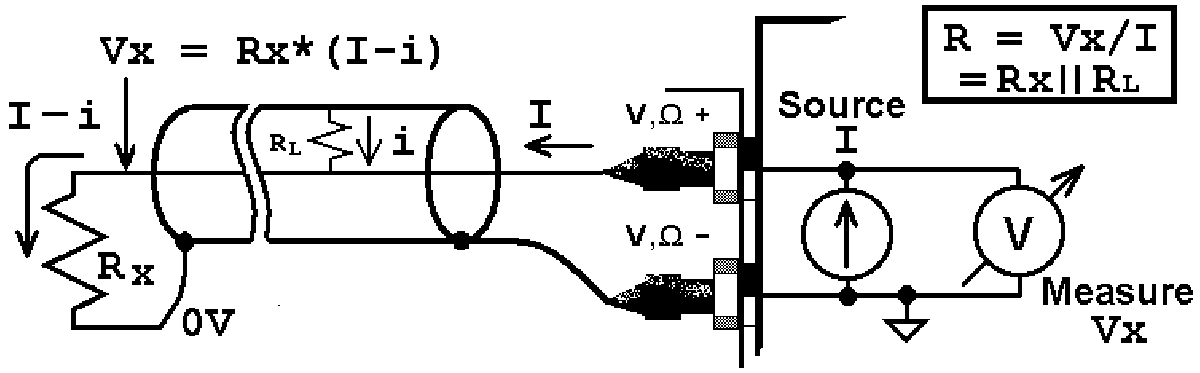


Figure 4-8. Depiction of the error caused the cable leakage, R_L.

The SM2064 provides an active guard signal that can be connected to the shield and prevent the leakage caused by the dielectric's finite resistance. With the shield voltage guarded with Vx, as indicated in Figure 4-9, there is 0V between the shield and the high sense wire, and therefore no current flows through R_L.

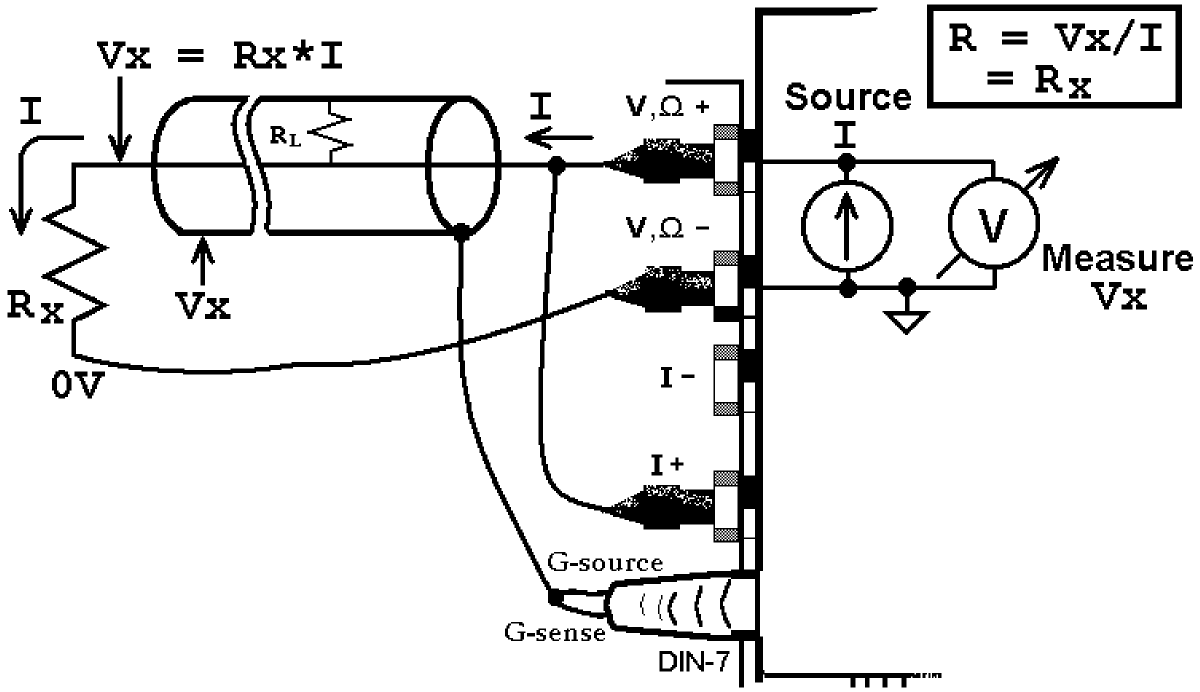


Figure 4-9. Guarding improves accuracy in 2-Wire measurement while testing high value resistors.

4.4 Leakage Measurements (SM2064)

The SM2064 measures leakage currents by applying a DC voltage across the device under test, and measuring the current through it. Three ranges are provided, 240nA, 2.4uA and 24uA. The voltage can be set between -10V and +10V. See Figures 4-10 for connection. The DC voltage at which leakage is measured is set using

DMMSetDCVSource(). Leakage current is read using **DMMRead(), DMMReadStr()** or **DMMReadNorm()** functions.

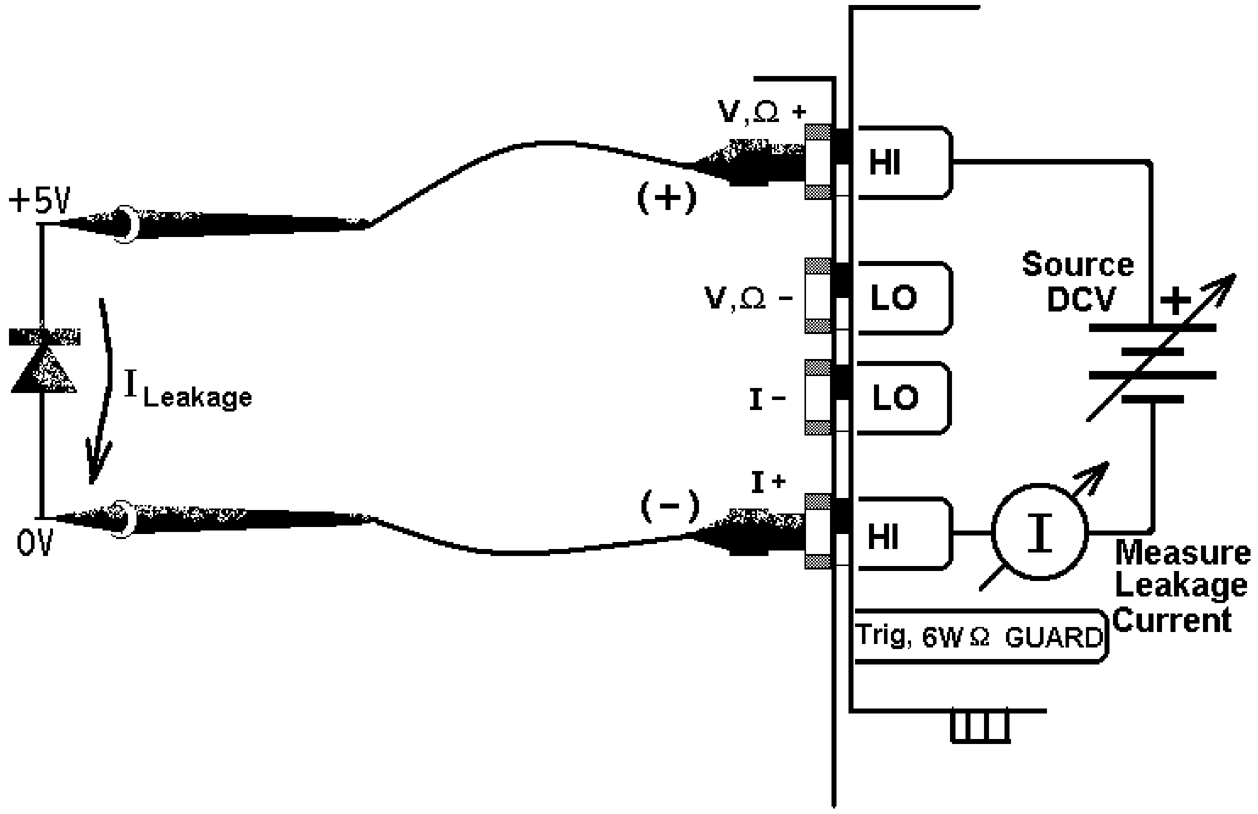


Figure 4-10. Leakage test configuration; reverse diode leakage at 5V.

4.5 Measurement Timing

4.5.1 Aperture

The SM2060 and SM2064 DMM's have several parameters governing measurement timing, including Aperture, Read Interval and Overhead time. To maintain low noise and high accuracy, the DMM shuts down all communications and other operations while converting. All other operations such as data transfers and command processing are performed while the A/D is not active. The A/D is an integrating type and has a time during which it integrates (a sort of averaging) the input. This time is the A/D Aperture. It is significant, particularly when it relates to noise rejections. For instance, in the presence of 60Hz power line environment, there is significant 60Hz and its harmonics which can contaminate a measurement. Setting the Aperture time to an integer multiple of this frequency dramatically reduces this interference. Apertures of 16.667ms, 33.33ms, 66.667ms, etc. provide this rejection.

Aperture values are made up of a set consisting of 31 discrete values. It is set using the DMMSetAperture() command, the SM2064 can set it between 2.5us and 5.066s, and the SM2060 can set it between 625us and 5.066s. While using the various Trigger modes, the Aperture time must be set to 160ms or a lower value.

4.5.2 Read Interval

The Read Interval parameter is the length of time the DMM makes a measurement, including the transfer of the measurement results. Both the Aperture and Read Interval can be set within their specified limits. Setting them allows control over measurement timing. Figure 4-11 depicts the various timing elements associated with each DMM reading cycle. The actual measurement rate is the reciprocal of the actual Read Interval (RI). The time intervals indicated "Command Reception and Processing" and the "Process & Transmit Data", are overhead times. This means that with the Read Interval set to 0, the DMM sets the Delay to 0, resulting in a minimal Read Interval consisting of the sum of the Aperture and the two overhead times indicated below. Set the Read Interval value using the DMMSetReadInterval() functions. Keep in mind that setting it to a value lower than the Minimum Read Interval indicated in the tables below will result in it being the table value.

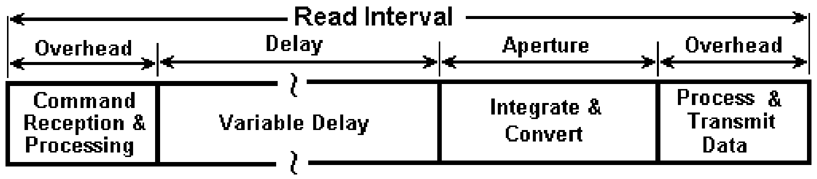


Figure 4-11. Anatomy of a measurement

	Power Line Rejection			Command/Response mode min. Read Interval(s) / max meas. rate(Hz)	H/W Trigger mode min. Read Interval(s) / max meas. Rate (Hz)
Aperture	60 Hz	50Hz	400Hz		
5.1200s [1]	√	√	√	5.121s / 0.2	N/A
5.0666s [1]	√			5.0677s / 0.2	N/A
2.08s [1]		√	√	2.081s / 0.5	N/A
2.0s [1]	√	√	√	2.001s / 0.5	N/A
1.06666s [1]	√			1.067s / 1	N/A
960ms [1]		√	√	0.9605s / 1	N/A
533.33ms [1]	√			533.6ms / 2	N/A
480ms [1]		√	√	480.2ms / 2	N/A
266.666ms [1]	√			268ms / 4	N/A
160.0ms	√	√	√	166ms / 6	160.3 ms / 6
133.33ms	√			134ms / 8	133.5 ms / 8
80.00ms		√	√	80.4ms / 13	80.2 ms / 13
66.6667ms	√			67.2ms / 15	66.713 ms / 15
40.00ms		√	√	40.4ms / 25	40.32 ms / 24.8
33.333ms	√			33.643ms / 29.72	33.38 ms / 30
20.00ms		√	√	20.098ms / 49.76	20.33 ms / 50
16.6667ms	√			16.77ms / 59.6	16.89 ms / 59
10ms				10.094ms / 99	10.25 ms / 97
8.333ms				8.422ms / 119	8.503 ms / 115
5ms				5.109ms / 195	5.187 ms / 185
4.16667ms				4.265ms / 234	4.274 ms / 220
2.5ms				2.598ms / 385	2.614 ms / 350
2.0833ms				2.177ms / 458	2.216 ms / 410
1.25ms				1.344ms / 744	1.380 ms / 625
1.0417ms				1.133ms / 880	1.158 ms / 864
625µS				719µs / 1,390	728 µs / 1,370
520.83µS				617µs / 1,625	622 µs / 1,610
312.5µS				410µs / 2,445	414 µs / 2,445
260.42µS				355µs / 2,825	358 µs / 2,825
130.21µS				215µs / 4,660	217 µs / 4,660
2.5µS				47µs / 21,600	45 µs / 22,200

[1] Not available with any of the Triggered modes.

Table 4.1: The SM2064 has 31 A/D apertures available, ranging from 5 Seconds to 2.5uSec. The table contains available measurement apertures and the corresponding minimum read intervals and measurement rates.

	Power Line Rejection			Command/Response mode min. Read Interval(s) / max meas. rate(Hz)	H/W Trigger mode min. Read Interval(s) / max meas. Rate (Hz)
Aperture	60 Hz	50Hz	400Hz		
5.1200s [1]	√	√	√	5.121s / 0.2	N/A
5.0666s [1]	√			5.0677s / 0.2	N/A
2.08s [1]		√	√	2.081s / 0.5	N/A
2.0s [1]	√	√	√	2.001s / 0.5	N/A
1.06666s [1]	√			1.067s / 1	N/A
960ms [1]		√	√	0.9605s / 1	N/A
533.33ms [1]	√			533.6ms / 2	N/A
480ms [1]		√	√	480.2ms / 2	N/A
266.666ms [1]	√			268ms / 4	N/A
160.0ms	√	√	√	166ms / 6	160.3 ms / 6
133.33ms	√			134ms / 8	133.5 ms / 8
80.00ms		√	√	80.4ms / 13	80.2 ms / 13
66.6667ms	√			67.2ms / 15	66.713 ms / 15
40.00ms		√	√	40.4ms / 25	40.32 ms / 24.8
33.333ms	√			33.7ms / 30	33.38 ms / 30
20.00ms		√	√	20.35ms / 50	20.33 ms / 50
16.6667ms	√			16.9ms / 59	16.89 ms / 59
10ms				10.36ms / 97	10.25 ms / 97
8.333ms				8.68ms / 115	8.503 ms / 115
5ms				5.36ms / 185	5.187 ms / 185
4.16667ms				4.52ms / 220	4.274 ms / 220
2.5ms				2.86ms / 350	2.614 ms / 350
2.0833ms				2.44ms / 410	2.216 ms / 410
1.25ms				1.6ms / 625	1.380 ms / 625
1.0417ms				1.39ms / 719	1.158 ms / 864
625µS				917µs / 1,090	728 µs / 1,370

[1] Not available with any of the Triggered modes.

Table 4.2: The SM2060 has 26 apertures available, ranging from 5 Seconds to 625uSec. The table contains all available measurement apertures and corresponding minimum read intervals and measurement rates.

4.6 RTD Temperature Measurement (SM2064)

For temperature measurements, the SM2064 measure and linearize RTDs. 4-wire RTD can be used by selecting the appropriate RTD type. Any ice temperature resistance between 25 Ω and 10 kΩ can be set for the platinum type RTDs. Copper RTDs can have ice temperature resistance values of 5 Ω to 200 Ω. The highest accuracy is obtained from 4-wire devices, since this method eliminates the error introduced by the resistance of the test leads. The connection configuration for RTDs is identical to 4-wire Ohms.

4.7 Internal Temperature (SM2064)

A special on board temperature sensor allows monitoring of the DMM's internal temperature. This provides the means to determine when to run the self-calibration function (S-Cal) for the DMM, as well as predicting the performance of the DMM under different operating conditions. When used properly, this measurement can enhance the accuracy and stability of the DMM. It also allows monitoring of the PC internal temperature, which is important for checking other instruments in a PC-based test system.

4.8 Diode Characterization

The Diode measurement function is used for characterizing semiconductor part types. This function is designed to display a semiconductor device's forward or reverse voltage. The DMM measures diode voltage at a selected current. The available source currents for diode I/V characterization include five DC current values, 100 ηA, 1 µA, 10 µA, 100 µA and 1 mA. The SM2064 have an additional 10 mA range. The SM2064 also has a variable current source that can be used concurrently with DCV measurement (see "Source Current / Measure Voltage"). This allows a variable current from 10 ηA to 12.5 mA. The maximum diode voltage compliance is approximately4 V.

Applications include I/V characteristics of Diodes, LEDs, Low voltage Zener diodes, Band Gap devices, as well as IC testing and polarity checking. Typical current level uncertainty for diode measurements is 1%, and typical voltage uncertainty is 0.02%.

4.9 Capacitance Measurement (SM2064)

The SM2064 measure capacitance using a differential charge balance (ramp) method, where variable currents are utilized to stimulate a dV/dt across the capacitor. Use short high quality shielded probe cables with no more than 200 pF. With the exception of the 10 ηF range, each of the ranges has a reading span from 5% of range to full scale. Capacitance values less than 5% of the selected range indicate zero. Since some large value electrolytic capacitors have significant inductance, as well as leakage and series resistance, the Auto ranging function may not be practical. Because Capacitance measurement is sensitive to noise, you should keep the measurement leads away from noise sources such as computer monitors. For best measurement accuracy at low capacitance values, zero the DMM using the 'Relative' while in the 10 ηF range. The effect of the cable quality and its total capacitance is profound particularly on low value capacitance. For testing surface mount parts, use the optional Signametrics SMT Tweeter probes. You may increase the measurement speed by using the **DMMSetCapsAveSamp()** function. See figure 4-12 for connection.

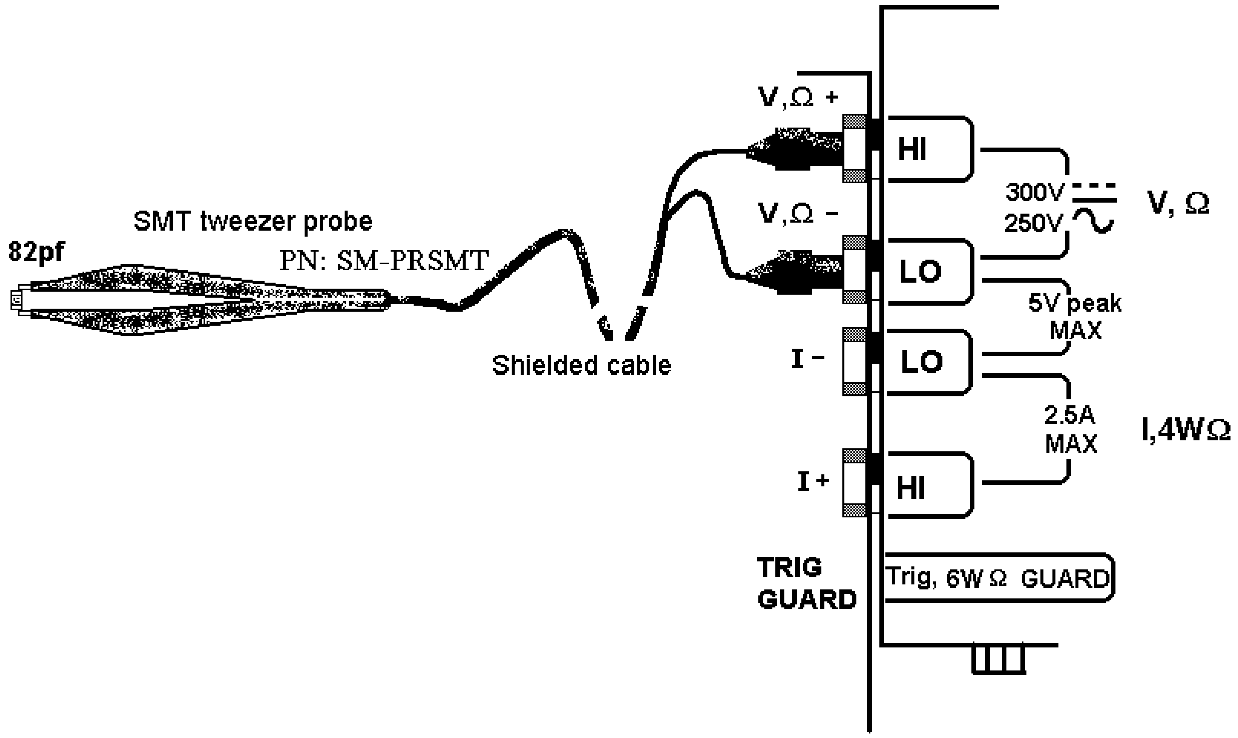


Figure 4-12. Measuring capacitors or inductors is best handled with coaxial or shielded probe wires.

4.10 In-Circuit Capacitance Measurement (SM2064)

A second method provided for measuring capacitors is the AC based method. Though not as accurate as the above function, the advantage of this method is that the default stimulus is set at 0.45V peak, which is lower than a semiconductor junction on voltage. It may also be set over a wide range of voltages. A further advantage is the ability of this function to measure capacitors that have a very low value parallel resistance, which is impossible to do using conventional methods. This test function operates by figuring the complex impedance and extracting from it both, the capacitance and resistance. The measurement is practical down to a few hundred Pico Farads, and up to several thousands micro Farads, with parallel resistances as low as 20Ω to 300Ω depending on range. Once set to this function, use **DMMRead()**, **DMMReadStr()** and **DMMReadNorm()** to measure the capacitance value. To get the resistance value use **DMMGetACCapsResist()** following a read. Each of the ranges must be calibrated with open terminals prior to making measurements. Each range must be calibrated. Do this by activating the AC-Caps function, selecting the range to be calibrated and issuing **DMMOpenCalACCaps()**. The last function normalizes the AC source signal. This open Calibration operation must be performed with the measurement cable or probes plugged into the DMM, with the other end open. See figure 4-12 above for connection. If not modified by the **DMMSetACCapsLevel()** function, when making a measurement the DMM uses a default voltage of 0.45Vpk, which means that a sine wave that has a peak-to-peak amplitude of 0.9V. This level is used during both, open calibration and measurements. Since the DMM is optimized for this value, and it is well below most semiconductors on voltage, it is recommended not to change the level from this default value. The stimulus voltage can be set from 0.1V peak to 5V peak using the **DMMSetACCapsLevel()** function. Any time the stimulus level is adjusted; open calibration must be carried out. The results of **DMMOpenCalACCaps()** are kept in memory until the DLL is unloaded. Repeating Open calibration periodically will result in improved accuracy. AC Capacitance measurement function must be used with a DMM Aperture of at least 80ms.

4.11 Inductance Measurement (SM2064)

The SM2064 measures inductance using a precision AC source with a frequency range of 20 Hz to 75 kHz. Since inductors can vary greatly with frequency, you should choose the appropriate generator frequency. In addition to inductance, the inductor's Q factor can be measured. A high quality coaxial or at least a shielded cable is highly recommended. For best accuracy, perform the Open Terminal Calibration function within an hour of inductance measurements. The Open Terminal Calibration function must be performed with the cable or probes plugged into the DMM, but with the other end open circuited. This process characterizes the internal signal path inside the DMM, the open application cable and the DMM circuitry. Set the Aperture to 40ms or to higher values for better accuracy.

For best measurement accuracy at low inductance values, zero the DMM often by using the '**Relative**' function with the leads shorted. This must be done after Open Terminal Calibration operation. This Relative action measures and removes the inductance of the DMM signal path and that of the application cable.

4.12 Characteristic Impedance Measurement (SM2064)

To measure transmission line's characteristic impedance, measure the cable's capacitance C (with the end of the cable open) and then its inductance L (with the end of the cable shorted). The cable's impedance equals the square root of L/C. Be certain the cable is long enough such that both the capacitance and inductance are within the specified measurement range of the SM2064.

4.13 Trigger Operation

Several trigger functions are provided; some are by means of an input signal to the trigger input, and others by means of input level. The Trigger functions provide for a stand-alone capture of measurements. The on-board controller supervises the operation, and when conditions are valid, it captures data into its circular buffer, or sends it back to the PC bus. The aperture must be set to a value equal or smaller to 160ms for all trigger operations.

4.13.1 External Hardware Trigger

The External Hardware Trigger inputs are isolated high and low input lines available at pins 7 (+) and 4 (-) of the DIN-7 connector. The External Trigger operation may be aborted using the DMMDisarmTrigger(). Read about these functions in the Windows Command Language section (5.6) for details.

Warning! The DIN connector pins are only protected to a maximum of 35 V with respect to the PC chassis or any other DMM terminal. Do not apply any voltages greater than 35 V to the DIN connector pins. Violating this limit may result in personal injury and/or permanent damage to the DMM.

4.13.1.1 Edge Triggered Operation

In this mode of operation, the DMM takes between 1 and 120 (or 1 and 80 if high resolution) measurements in response to the currently set edge. Once armed, the DMM waits for this Trigger event until it occurs, or the process is aborted (**DMMDisarmTrigr**(nDmm)). While waiting for the selected trigger edge, the DMM continuously makes measurements and stored them to the internal buffer, utilizing the whole buffer. Depending on the length of time prior to the trigger event, this circular buffer may or may not be filled / over-written. For additional information a counter is provided to counts the number of times the buffer fills up while waiting for the trigger event. On reception of the trigger, the DMM takes the number of readings specified in the **DMMArmTrigger**(nDmm, n) command and indicates it is ready (**DMMReady**() = TRUE). These post trigger readings are stored in subsequent locations of the circular buffer. At the end of the capture process the internal buffer pointer points to the beginning of the buffer. Following the completion of the process, subsequent readings from the buffer will return 120-n pre-trigger readings, followed by n post trigger readings. In the case where trigger occurred before the buffer is filled, there will be some NULL readings in the buffer, followed by pre-trigger and post-trigger readings. Following capture use the **DMMGetTriggerInfo**() function to retrieve information such as the number of NULL readings, Pre-Trigger samples and buffer fill cycles.

4.13.1.2 Delayed Triggered Operation

In this trigger mode of operation, following the reception of the selected trigger edge, the DMM waits for the specified delay, and then it takes from 1 to 120 (or 1 to 80 if high resolution) measurements. The delay can be set from 10us to 1s.

The specified number of measurements is stored in the buffer. At the end of this operation, the internal buffer pointer points to the beginning of the buffer, such that reading the buffer starts with the first sample taken. To read all samples resulting from this operation, use one of the buffer read functions. See **DMMDelayedTrigger**() function for details.

4.13.2 Analog Threshold Trigger

This mode of operation is entered by issuing the **DMMArmAnalogTrigger** command. In this mode, while waiting for a trigger event, the DMM makes repeated measurements and places them in the internal buffer, as to provide pre-trigger samples. All measurements are made using the currently set range, function, Aperture and Read Interval. Trigger event occurs when the input value transverses through the set Threshold (*dThresh*) value, in the currently set directions dictated by Edge (see **DMMSetTrigPolarity**). Following the trigger point, if enabled, the Sync output is activated (see **DMMSetSync**), and *iPostSamples* measurements are taken. At the end of this process the Sync output is deactivated. This mode may be aborted by issuing the Disarm command **(DMMDisArmTrigger)**. Use **DMMArmAnalogTrigger**(**int** *nDmm,* **int** *iPostSamples,* **double ****dThresh*). In addition to triggering on a value, this function may be used as a zero-crossing detector, where the Sync may be used as a flag.

The *dThresh* value is in base units, and must be within the selected measurement range. For example, while in the 240 mV range, *dThresh* must be within -0.24 and +0.24. In the 24kΩ, range it must be set between 0.0 and 24000.0.

Use the **DMMReady** to monitor completion of this operation. When ready, read up-to the above buffer size, using **DMMReadBuffer** or **DMMReadBufferStr** functions. Once DMMReady returns TRUE, it should not be used again prior to reading the buffer, since it initializes the buffer for reading when it detects a ready condition.

Read Interval must be set between 0 (default) and 65ms. Aperture must be set between 160ms and 2.5us. The value of *iPostSamples* must be set between 1 and the buffer size. The buffer size is 80 for Apertures of 160ms to 1.4ms, and 120 for Apertures in the range of 2.5µs to 625us. The highest Aperture allowed for this operation is 160ms. Aperture and Read Interval are set using the **DMMSetAperture** and **DMMSetReadInteval** functions, respectively.

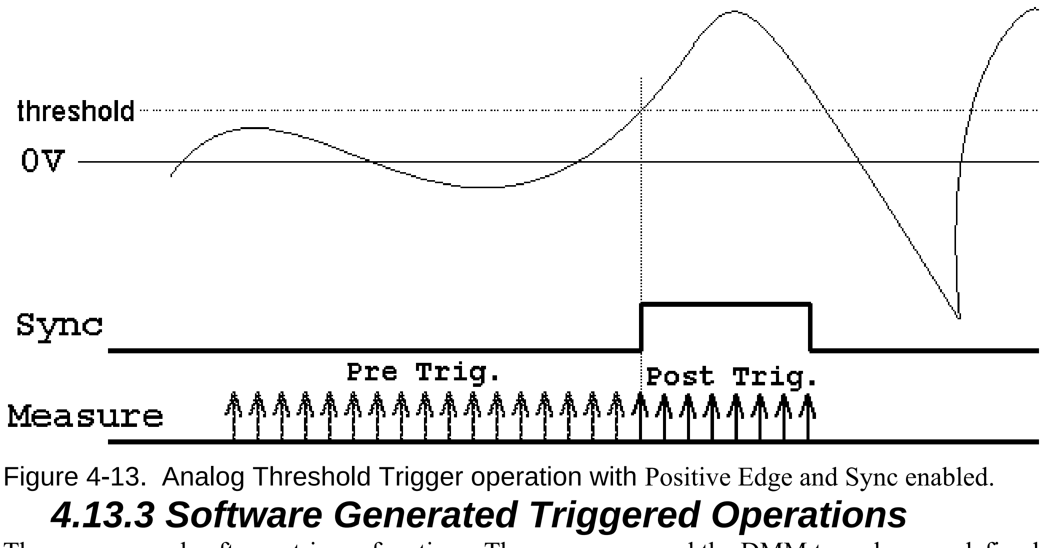


Figure 4-13. Analog Threshold Trigger operation with Positive Edge and Sync enabled.

4.13.3 Software Generated Triggered Operations

There are several software trigger functions. They can commend the DMM to make a predefined number of readings, with a specified number of settling readings. These include **DMMSetBuffTrigRead**, **DMMSetTrigRead**, **DMMTrigger**, **DMMBurstRead** and **DMMBurstBuffRead**. Read about these functions in the Windows Command Language section (5.6) for details.

4.13.3.1 Burst Read Operation

In response to the **DMMBurstRead(*nDmm, iSettle, iSamples*)** command, the DMM enters a tight measurement loop, where it samples the input and returns measurements to the calling S/W. For each measurement sent, it takes *iSettle* + 1 samples, sending only the last sample. A total of *iSamples* * (*iSettle* + 1) are taken by the DMM, and *iSamples* are sent back. With the Read Interval set to 0, the total time per measurement is (*iSettle* + 1) * Aperture time plus the time it takes to transmit the data back. The last is equal to 132µ for Aperture times greater than 625µs, and 88µs for other apertures. For instance, if *iSettle* is set to 3, and the Aperture is set to 10ms, the total time per sample will be 4 * 10ms + 132us = 40.132ms. *iSettle* may be set to a value between 0 to 250. The total number of measurements, *iSamples,* must be between 1 and 60,000. Setting the Read Interval can help with fine tuning of the sampling timing. Failing to read the measurements at the rate they become available, or not reading all of the readings will result in communicaiton overrun. Aperture must be set to 160ms or lower value. The Sync output line maybe turned on to synchronize external devices (**DMMSetSync(0, Yes, 1)**).

To retrieve the readings, following the issue of the **DMMBurstRead** command, use the **DMMReadMeasurement**. For proper operation, you must retrieve *iSamples* readings.

```
i = DMMBurstRead(0, 2, 1000)              ‘Take two setteling readings per sample, make 1000 measurements
For i = 0 To 1000 – 1                     'Tight read loop, need to get them as fast as they come. Read 1000
   While DMMReadMeasurement(0, rd(i)) = No    ‘ wait for readings to be ready, and pick them
   Wend
Next
```

4.13.3.2 Multiple Trigger Capture Operation

In response to the **DMMSetBuffTrigRead (*nDmm, iSettle, iSamples, iEdge*)** command, the DMM waites for hardware trigger edge of *iEdge* polarity to make measurements. For each trigger input it makes a measurement(s), storing the results in its on-board buffer. For each measurement is made up of *iSettle* + 1 samples, saving only the last sample. A total of *iSamples* trigger input pulses are required to complete the capture process, and *iSamples* are saved to the buffer. With the Read Interval set to 0, the total time per measurement is (*iSettle* + 1) * Aperture plus the time it takes to save the data to the buffer. The last is equal to 130µ for Aperture times greater than 625µs, and 117µs for other apertures. *iSettle* may be set to a value between 0 to 250. The total number of measurements, *iSamples,* must be between 1 and 80 for Apertur greater than 625µs, 120 otherwise. Setting the Read Interval can help with fine tuning of the sampling timing. Use the **DMMReady**() function to monitor completion. Aperture time must not exceed 160ms.

```
i = DMMSetBuffTrigRead(0, 2, 50, LEADING)    ‘two setteling readings, 50 samples and positive Edge.
While DMMReady (0) = No       ‘ wait for completion
Wend

For i = 0 To Samp - 1      'Read measuremets from buffer.
      DMMReadBuffer 0, rd(i)
Next
```

4.13.3.3 Burst Capture to Buffer

The **DMMBurstBuffRead** function is similar to the soft Trigger function, **DMMTrigger**. In response to the **DMMBurstBuffRead (***nDmm*, *iSettle*, *iSamples*) command, the DMM captures *iSamples* and stores them to the on-board buffer. For each measurement saved it takes *iSettle* + 1 samples, saving the last one. With the Read Interval set to 0, the total time per measurement is (*iSettle* + 1) * Aperture time plus the time it takes to save the data to the buffer. The last is equal to 130µ for Aperture times greater than 625µs, and 117µs for other apertures. *iSettle* may be set to a value between 0 to 250. The total number of measurements, *iSamples,* must be between 1 and 80 for Apertur greater than 625µs, 120 otherwise. Setting the Read Interval can help with fine tuning of the sampling timing. Use the **DMMReady**() function to monitor completion. Aperture time must not exceed 160ms.

```
i = DMMBurstBuffRead(0, 2, 50)            ‘two setteling readings, 50 samples and positive Edge.
While DMMReady (0) = No       ‘ wait for completion of capture process
Wend
For i = 0 To 50 - 1      'Read measuremets from on-board buffer.
      DMMReadBuffer 0, rd(i)
Next
```

4.13.3.4 Triggered Burst Capture

This function is similar to the Burst Read operation above. In response to the **DMMSetTrigRead (*nDmm, iSettle, iSamples, iEdge*)** command, the DMM enters a tight loop, where it responds to a trigger edge. On each of these edges triggers the DMM to capture and send back a measurement. The total of trigger edges and measurement being equal to *iSamples.* For each hardware trigger edge, the DMM takes *iSettle* + 1 measurements, sending the last one. The S/W must keep up and read those samples as they come. *iSettle* may be set to a value between 0 to 250. The total number of measurements, *iSamples,* must be between 1 and 30,000. Setting the Read Interval can help with defining the sampling timing. Use the **DMMReady**() function to monitor completion. Aperture time must not exceed 160ms. The amount of time it takes the DMM to transmit the data back depends on the selected Aperture. It is about 132µ for Aperture times greater than 625µs, and 88µs for other apertures.

```
i = DMMSetTrigRead(0, 2, 500, LEADING)        ‘Two setteling readings per sample, 500 measurements
For i = 0 To 500 – 1                          'Tight read loop, need to get them as fast as they come. Read 500
   While DMMReadMeasurement(0, rd(i)) = No    ‘ wait for readings to be ready, and pick them
   Wend
Next
```

4.14 Frequency and Time Measurements

While the maximum RMS reading is limited to the set range, you can use most of the timing functions even if the RMS voltage reading indicates over range. This is true as long as the input peak-to-peak value does not exceed 6 times the selected range.

4.14.1 Threshold DAC

All timing measurements utilize the AC Voltage path, which is AC coupled. You need to select the appropriate ACV range prior to using the various frequency and timing measurement functions. The SM2064 have a novel feature to accurately make these measurements for all waveforms. Unlike symmetrical waveforms such as a sine wave and square wave, non-symmetrical waves may produce a non-zero DC bias at the frequency counter’s comparator input. Other DMM’s have the comparator hard-wired to the zero crossing, and therefore cannot handle asymmetrical wave such as a very low duty cycle signal. The SM2064 have a bipolar, variable Threshold DAC that enables these DMM’s to performance of these measurements. Functions affected by the Threshold DAC include frequency, period, pulse-width, duty-cycle and the Totalizer/Event Counter.

The Threshold DAC has 12 bits of resolution. Depending on the selected ACV range, this bipolar DAC can be set from a few mV to several hundred volts, positive or negative. See the Specifications sections for the limits of AC Median Value measurements and Threshold DAC settings.

The best setting of the Threshold DAC is based on the AC Median Value and Peak-to-Peak measurement described earlier. For example 5 V logic level signal with 10% duty cycle. This input has a median value of 2 V. A 90% duty cycle signal will have a –2 V median value. Setting the Threshold DAC to the appropriate median value will result in reliable and accurate timing measurements in each case.

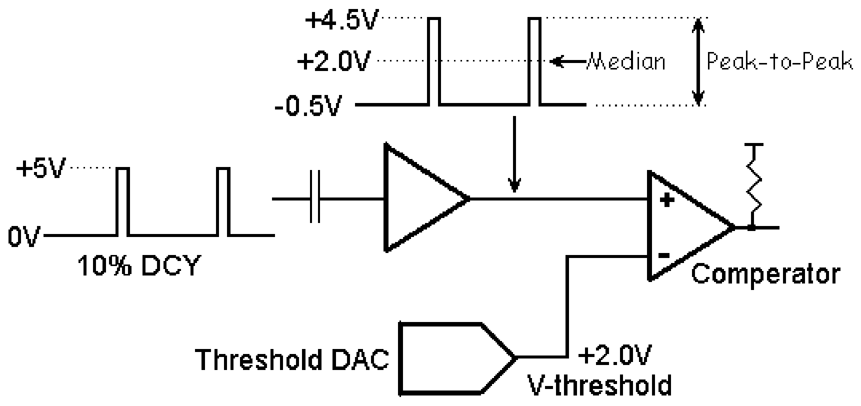


Figure 4-13.   AC coupled timing measurements with Threshold DAC.

In Figure 4-13, the DMM is set to 2.4 ACV range, while the input is a 10% duty-cycle wave with 5 V peak-to-peak. Due to AC coupling, the input at the comparator is –0.5 V to + 4.5 V. The Median Value is +2.0 V, which would be the optimal Threshold value.

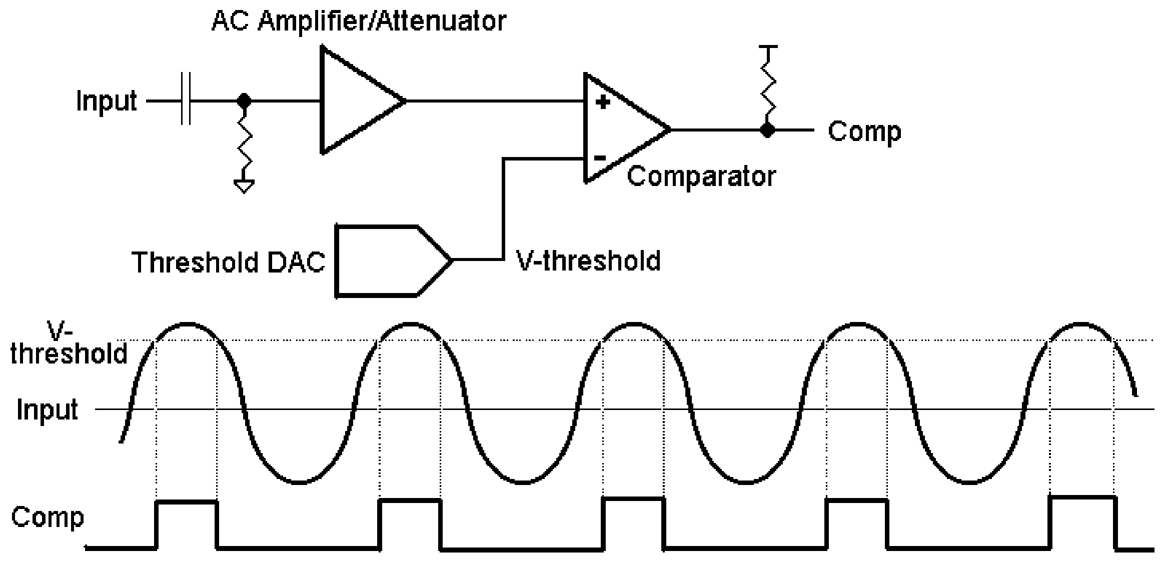


Figure 4-14. Comparator and Threshold DAC Settings

4.14.2 Frequency and Period Measurements

Both **Freq.** and **Per.** check boxes are only visible when ACV or ACI functions are selected. These check boxes are used to make frequency or period measurements. **Freq.** measures from 2 Hz to 300 kHz. When activated, the control panel alternately updates the amplitude reading followed by the frequency reading. The reading rate is slower than indicated when frequency is activated. In the Windows control panel, period (**Per**) is also selectable. Once the frequency range is acquired, Frequency and Period have a maximum measurement time of about 1 second. It could take up to five measurements before the correct frequency range is auto-selected. This process is automatic. Once within range, the next frequency measurement is made at the last selected range.

Both Frequency and Period measurement performance can be improved by properly setting the Threshold DAC, a novel feature of the SM2064. See “Threshold DAC”, “AC Median Value”, and “Peak-to-Peak” measurements for further details.

4.14.3 Duty Cycle Measurement

Duty Cycle of signals from 2 Hz to 100 kHz can be measured. The minimum positive or negative pulse width of the signal must be at least 19µs. When measuring duty cycle precisely, the voltage at which the measurement is made is important, due to finite slew rates of the signal. With the SM2064, the Threshold voltage can be set for precise control of the level at which duty cycle is measured. For best measurement results, set the Threshold DAC to the Median value. This is particularly important for signals with low duty-cycle and small amplitude relative to the selected scale.

4.14.4 Pulse Width

User selectable positive or negative pulse widths may be measured for signal frequencies of 2 Hz to 25 kHz and minimum pulse widths of 19 µs. The Threshold DAC feature allows measurements at a pre-defined signal level. See Threshold DAC above for more details.

To measure pulse width, the DMM must be in the AC volts range appropriate for the input voltage. Keeping the peak-to-peak amplitude of the measured signal below 5.75 times the set range will guarantee the signal is within the linear region of the AC circuitry and gives the best performance.

4.14.5 Totalizer Event Counter

The Totalizer can be selected while the DMM is in the ACV mode. It is capable of counting events such as over-voltage excursions, switch closures, decaying resonance count, etc. The active edge polarity can be set for a positive or negative transition. A count of up to 10^9 may be accumulated. The maximum rate of accumulation is 30,000 events per second.

The Threshold DAC can be set for a negative or positive voltage value. See Threshold DAC above for more details.

Example One: To monitor and capture the AC line for positive spikes which exceed 10% of the nominal 120 V RMS value, first select ACV 250 V range, than set the Threshold DAC to 186.7 V. This value is the peak value of 120 V RMS plus 10% (120V + 10%) X $\sqrt{2}$). Enable the Totalizer and read it periodically to get the number of times this value was exceeded.

Example Two: Defects in coils, inductors, or transformers can be manifested as an increased decay, or greatly attenuated resonance when stimulated with a charged capacitor. The Totalizer function can be utilized to count transitions above a preset Threshold voltage as in the Figure 4-15 below.

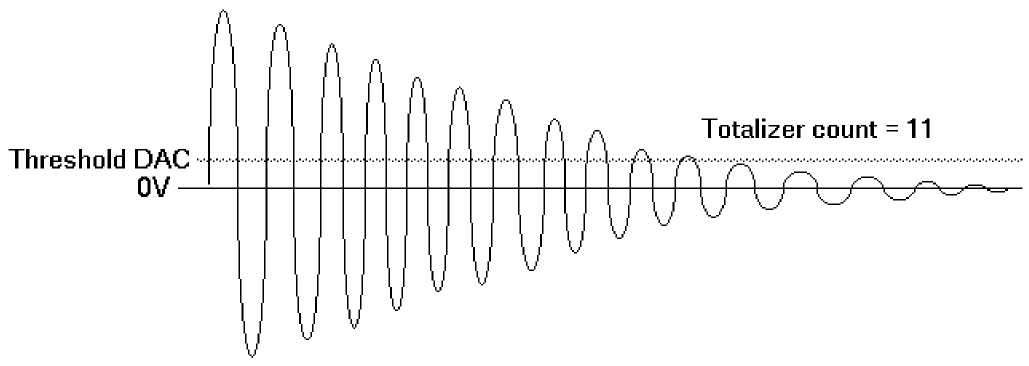


Figure 4-15. Testing inductor Q by counting the number of transitions of decaying resonance.

4.15 Sourcing Functions (SM2064)

The SM2064 adds a number of sourcing functions, giving greater versatility for a variety of applications. All of the available sources, VDC, VAC, IDC, are isolated (floating with respect to the PC chassis). This allows sourcing with a significant common mode voltage as well as the ability to connect several SM2064 units in parallel for increased DC current, or in series for increased DC voltage.

Two digital-to-analog converters (DACs) are used for the source functions, a 12-bit DAC, and a Trim DAC. The last augments the 12-bit DAC to form a 16 bit composite DAC and adds an additional 8 bits of resolution. For functions requiring high precision, use both DACs by selecting the ClosedLoop mode, otherwise only the 12-bit DAC is utilized. DCI source is limited to the 12-bit DAC only.

All three source functions use the **V,Ω+**, and the **V,Ω-** terminals of the SM2064.

4.15.1 DC Voltage Source

The SM2064 has a fully isolated bipolar DC voltage source. Two modes of operation are available: fast settling or closed loop. In the ClosedLoop mode the DMM monitors the voltage source output, and updates it using the composite 16 bit DAC, at a rate proportional to the set measurement rate. The ClosedLoop mode offers the best accuracy and resolution. An aperture of 160ms or higher recommended for the ClosedLoop mode. In the fast settling mode, no adjustments are made and the 12-bit DAC is used. Up to ±10.0 V can be sourced, with 10 mA maximum drive. The output source resistance of the DCV source is approximately 220 Ω. See Figure 4-15 for connection.

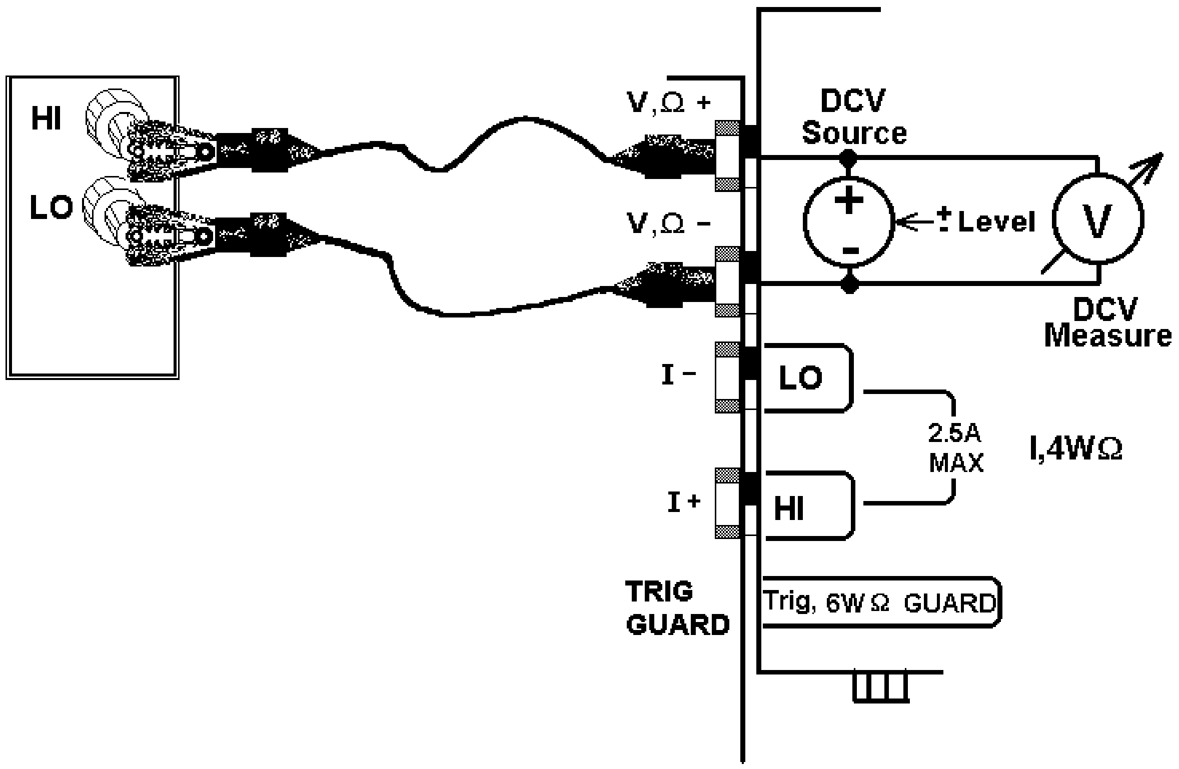


Figure 4-15. Sourcing DC voltage. Monitoring of the output in closed loop operation.

4.15.2 AC Voltage Source

The AC voltage source is fully isolated. It has two modes of operation: fast settling or closed loop. In the ClosedLoop mode, the source voltage is monitored, and corrections are made to the composite 16-bit DAC at a rate proportional to the set measurement rate. An aperture of 160ms or higher is recommended for the ClosedLoop mode. The ClosedLoop mode offers the best accuracy. In the fast settling mode, the source voltage is monitored and can be displayed, but no DAC adjustments are made. Both amplitude and frequency can be set. The frequency range is 2 Hz to 75 kHz, and the amplitude is up to 20 V peak-to-peak with 10 mA maximum peak current drive. The output impedance is approximately 250 Ω.

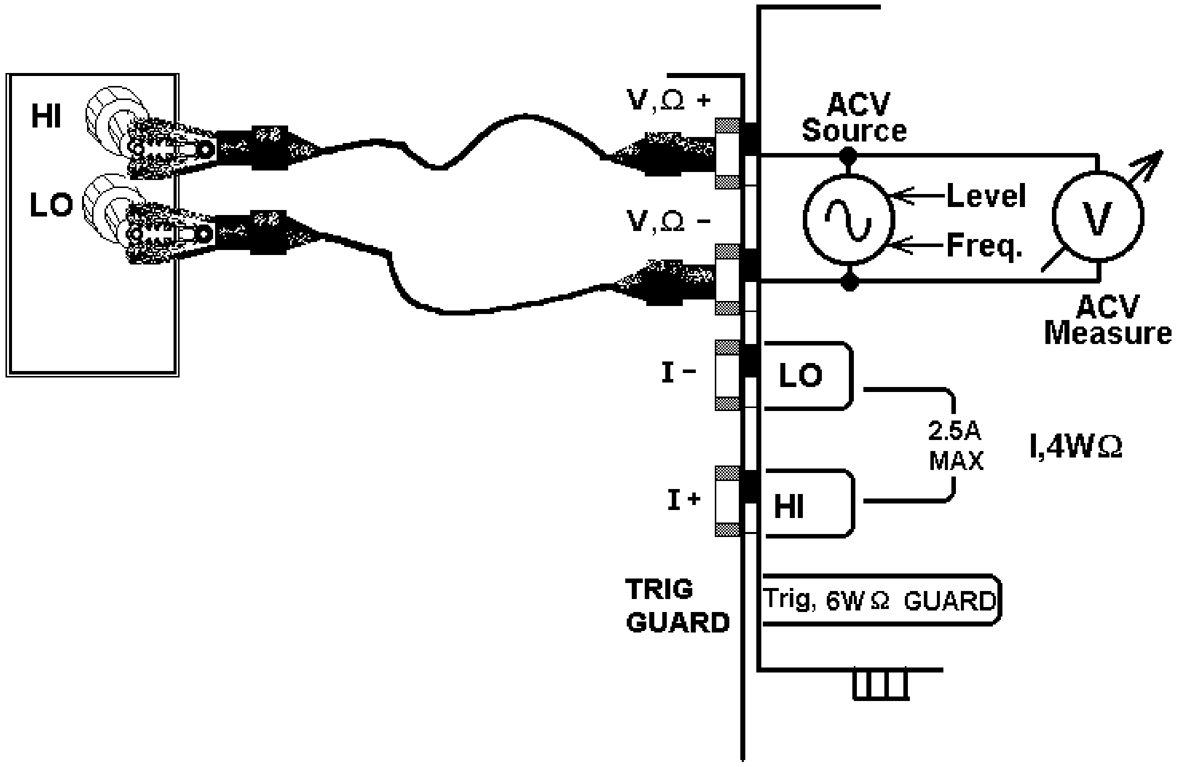


Figure 4-16. Generating AC voltage. Monitoring of the output in closed loop operation.

4.15.3 DC Current Source

The SM2064 has a fully isolated unipolar DC current source with five ranges. It uses the 12-bit DAC to control current level. This source function is useful for parametric component measurements as well as for system verification and calibration, where a precise DC current is necessary to calibrate current sensing components.

For improved resolution of the current source, use the Trim DAC. It has to be set separately, since it is not included in the calibration record, or the control software. Use DMMSetTrimDAC() command with a parameter of 0 to 100. Further details are in Chapter 6.

4.15.4 Source Current - Measure Voltage

When sourcing current and measuring voltage, there are two connection configurations: 1) Four wire connection, where the current sourcing terminals and the voltage sense terminals are connected to the load, as in 4-wire Ohms measurement function; and 2) Two wire connection, where the current source terminals also serve as voltage sense probes as in the 2-wire Ohms measurement configuration. The first method eliminates lead resistance errors. One application is in semiconductor diode characterization discussed in Component Testing above. See Current Source Output for range details. Voltage compliance is limited to 4 V in both configurations.

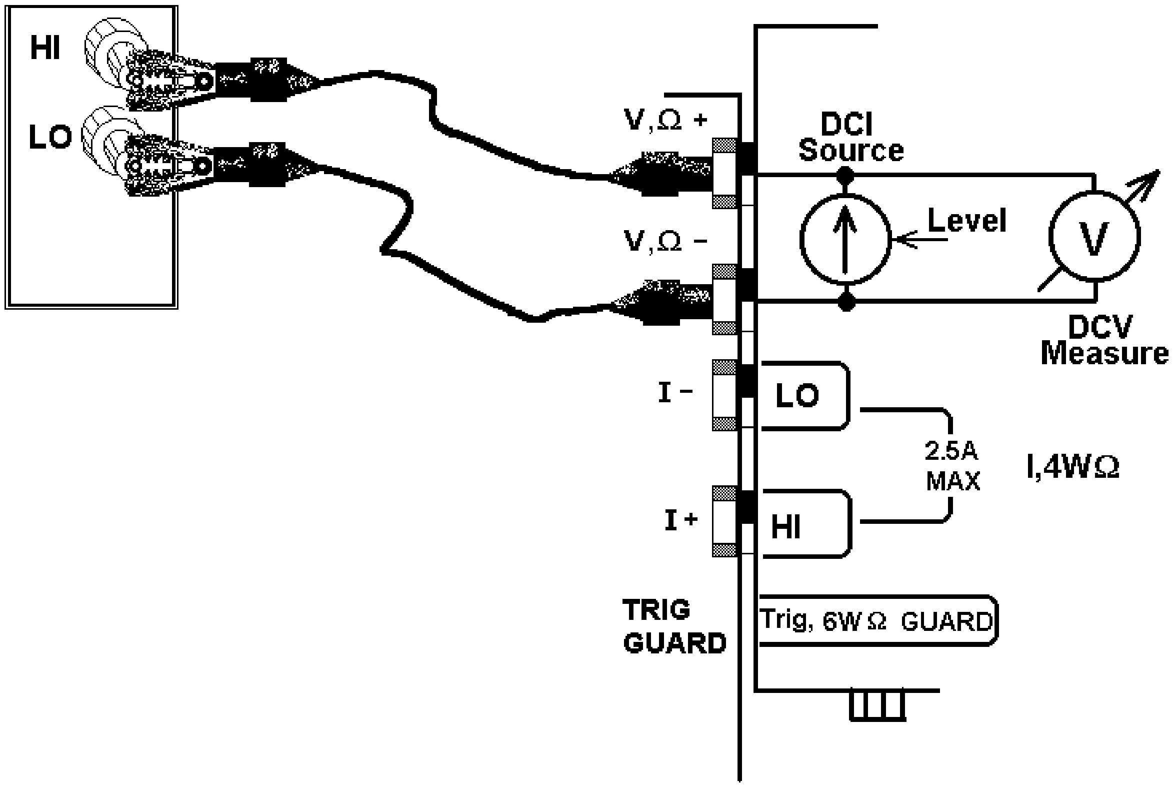


Figure 4-15. Sourcing DC current and measuring voltage in the two-wire configuration. This function can be used for semiconductor parametric tests.

4.16 Interfacing to the SM4040 series Relay Scanners

The SM2060 series of Digital Multimeters are designed to interface to the SM4000 series relay scanners. The following section describes both, the hardware interface and the software functions required to implement a synchronized operation.

4.16.1 Triggering the SM2060 DMM's

The SM2060 series can accept a hardware trigger from many sources, including the SM4000 scanners. The latter can be setup to trigger a measurement any time the scanner selects a new channel. The interface requires a single jumper between the SM4000 **Trig_com** and **Common** lines, and a connection between the SM4000 +5V and TRIG_out to the SM2060 Trigger inputs. The various SM4000 auto-scanning operations can run independently from the computer, whereby the Scanner selects channels from its Scan List table, and the DMM is triggered to take measurements following each channel selection.

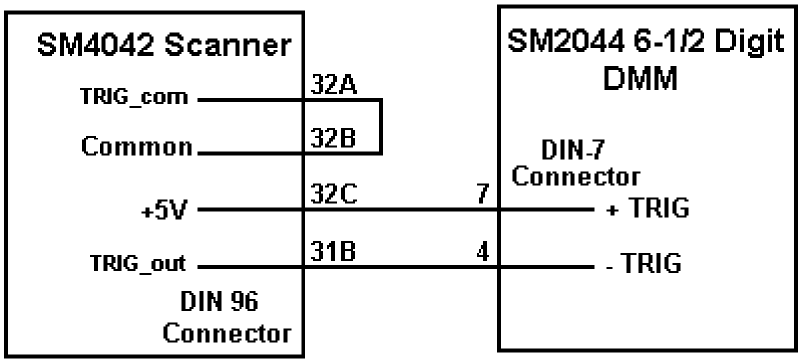


Figure 4-16. Trigger interfacing connection to an SM2060 class of DMM's.

4.16.2 Multiplexing with the SM2060 DMM's

For two wire measurements, the SM2060 DMM must be connected to the A-Bus or the scanner, or to both, the A-Bus and C-Bus for 4-Wire measurements (assuming an SM4040 or SM4042 scanner). It is important to consider system-settling time when making measurements. Time delays exist in any measurement system. These delays are contributed by various sources. These include the scanner's relay actuation times, the DMM input settling and wiring capacitance. The latter will varies with the type of measurement. For instance, when making high value Ohms measurements the DMM current source level could contribute significant delay due to the capacitance charge time. For example, with 1,000pf cable capacitance, the source current of the SM2064 DMM using the 33MΩ ranges is 0.1μA which translates to 33ms (dt = C*dV/I). It is also recommended to set the appropriate number of settling measurements for the DMM (a minimum of 4 is recommended regardless of measurement rate).

4.16.3 Interface Commands and Timing

The sequence requires the SM2060 DMM to make triggered measurements. The triggers are generated by the SM4040. Start by setting the SM4040 to the desired configuration, with Trigger Output enabled and positive polarity. Each channel selection will generate a positive pulse with duration equal to the actuation time. This could be generated by one of the scanning. The SM2060 must be set up for triggered readings by using the **DMMSetTrigRead()** command. In the following Visual Basic® example, the SM2060 sends readings during the scan. Since it's on board FIFO is limited to 5 readings, and the DMM must continue to send all readings during the scan, it is important to have a tight loop that reads the measurements fast enough so that no overrun error occurs. Refer to Figure 4-16 for proper trigger connection.

```
SCANTriggerOutState(nScan, Enabled, PosEdge)        // Set trigger output to Positive edge.
nReadings = 100                                     // Total number of measurements to take
DMMSetTrigRead(nDmm, 4, nReadings, NegEdge)         // Total of 100 readinigs and 4 settling readings
SCANAutoScan(nScan, nSteps)                         // Start auto scan
For I = 0 to nReadings -1                           // read values as they come
        while(DMMReadMeasurement(nDmm, reading) = NO      // wait for each reading and store it
Next
SCANOpenAllChannels(nScan)                          // Good idea to open all channels when done
```

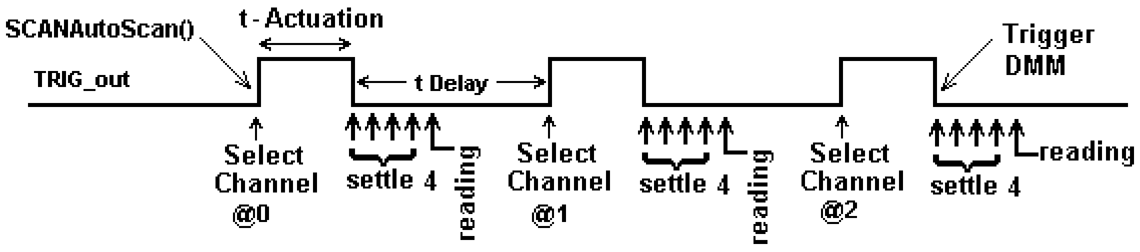


Figure 4-17. Triggered reading process and timing of SM4042 Scanner and an SM2064 DMM's.

Unlike the previous example, **DMMSetBuffTrigRead()** is not time critical since the DMM saves all measurements to it's on-board buffer, which is read after the scan is complete. However, this function is limited to a maximum of 64 readings per scan.

```
SCANTriggerOutState(nScan, Enabled, PosEdge)        ' Set trigger output to Positive edge.
nReadings = 50                                      ' Total number of measurements to take
DMMSetBuffTrigRead(nDmm, 4, nReadings, NegEdge)     ' Use 4 settling readings each
SCANAutoScan(nScan, nSteps)                         ' Set off AutoScan
```

```
While DMMReady(nDmm) = NO                        ‘ wait for the DMM to indicate completion
Wend
For I = 0 to nReadings -1                        ‘ read values stored in the buffer
        while(DMMReadBuffer(nDmm, reading(I))    ‘ Store each reading
Next
SCANOpenAllChannels(nScan)                       ‘ Good idea to open all channels when done
While SCANReady(nScan) = NO                      ‘ Since AutoScan is a polled operation,
DoEvents                                         ' Make sure Scanner is ready
Wend
```

There are several SM2060 family commands to be considered for this operation: **DMMSetTrigRead()**, **DMMSetBuffTrigRead()**, **DMMReadMeasurement()**, **DMMReady()**, **DMMReadBuffer()** and **DMMReadBufferStr()**.

Referring to figure 4.17, the total time it takes the DMM make a reading must be set to be shorter than t-Delay, for completion of the measurements prior to the selection of the next channel.

4.17 Measuring Temperature with Thermocouples

The SM2060 series of Digital Multimeters have built in linearization for eight thermocouple types including B, E, J, K, N, R, S and T. In addition the DMM has means for both, entering and measuring the reference (cold) junction temperature. The **DMMSetTemperatureUnits()** selects between ^oC and ^oF. Once selected, all subsequent temperature functions should consider the set temperature units. **DMMSetTCType()** selects the type of thermocouple being measured. It can be used as frequently as needed when measuring several types. Prior to measuring a Thermocouple it is important to set the reference, or cold junction temperature. This can be done as often as necessary as to keep track of variations in this temperature. Once set, all subsequent thermocouple measurements will use and compensate for this temperature. One way to set this temperature is to simply pass it to the DMM using the **DMMSetCJTemp()**. Make sure to set it to the currently set temperature units. The cold junction temperature range is 0^oC to 50^oC. If using the SM4042 or SM4040 to multiplex the thermocouples, and the SM40T screw terminal block is being utilized to connect the thermocouples, **DMMReadCJTemp()** should be used to measure the cold junction. Make sure to select and connect the “D” to the “A” bus of the SM4000 switching. The third method of measuring and entering the cold junction temperature is by measuring a user provided sensor. Provided this sensor have an output between –3.3V and +3.3V, and it can be characterize by the equation used by the **DMMReadCJTemp();** $t_{cj} = b + (V_{cjs} – a) / m$, the parameters can be set using **DMMSetSensorParams()**. V_{cjs} is the sensor generated voltage, a, b and m are the coefficients which are entered using **DMMSetSensorParams()** and t_{cj} the cold junction temperature. Once set, use **DMMReqadCJTemp()** to measure the sensor temperature.

4.18 Using the PXI bus Trigger Facilities (SMX2064)

The SMX2064 PXI Digital Multimeters is designed to interface to the PXI J2 Triggers. That includes the PXI_TRIG0 through PXI_TRIG6 and PXI_STAR trigger. The trigger to the DMM is a Wire-Ored function of the external trigger from the DIN-7 connector, and the PXI_TRIG input. The data ready signal from the SMX2064 can be selected to drive PXI_TRIG1 through PXI_TRIG6 or the PXI_STAR trigger. The **DMMSetPXITrigger()** function is used to select the input and output trigger.

4.18.1 Selecting PXI Trigger Outputs

The DMM issues a Data Ready pulse each time the A/D is done making a measurement, indicating data is ready to be read. A short (about 100μs) negative pulse is issued for each measurement, with the positive edge indicating data is ready. The Trigger output is selected by the third parameter (*iTrigOut*) of the **DMMsetPXITrigger()** function. The trigger pulse can be set to be output to any of the following lines.

iTrigOut	Trigger Output Routing
0 0 0	Disables trigger output
0 0 1	PXI_TRIG1
0 1 0	PXI_TRIG2
0 1 1	PXI_TRIG3
1 0 0	PXI_TRIG4
1 0 1	PXI_TRIG5
1 1 0	PXI_TRIG6
1 1 1	PXI_STAR

4.18.2 Selecting PXI Trigger Inputs

The trigger input to the DMM is the wired-ored signal of the trigger input from the DIN-7 connector and the selected PXI bus trigger. Make sure that no signal is connected to the DIN-7 trigger input while the PXI trigger bus is in use. When using the DIN-7 trigger input make sure the trigger input is Disabled (*iTrigInput* = 0). Read about the operation of the External Hardware trigger in the above sections, since that operation pertains to both, the external and the PXI trigger input operations. The Trigger input is selected by the second parameter (*iTrigIn*) of the **DMMsetPXITrigger()** function. The DMM trigger input may be selected from any of the following lines.

iTrigIn	Selected PXI Trigger input
0 0 0	Disables PXI trigger input
0 0 1	PXI_TRIG1
0 1 0	PXI_TRIG2
0 1 1	PXI_TRIG3
1 0 0	PXI_TRIG4
1 0 1	PXI_TRIG5
1 1 0	PXI_TRIG6
1 1 1	PXI_STAR

The default, when the DMM is initialized (started) is for both Trigger input and output to be deselected, or disabled.

5.0 Windows Interface

The Windows interface package provided with the SM2060 series DMM is a 32bit DLL based modules, which includes both, a DLL and a windows Kernel driver. This package is sufficient for most windows based software being used to control the DMM.

5.1 Distribution Files

The distribution diskette contains all the necessary components to install and run the DMM on computers running any of the Microsoft® Windows™ operating systems. It also provides means for various software packages to control the DMM. Before installing the DMM or software, read the "Readme.txt" file. To install this software "Run Program" menu select 'autorun.exe' from the provided CD by double-click. Most files on this CD are compressed, and are automatically installed by running 'autorun', which in turn executes the setup.exe file located on the CD in the respective product directory.

The SM2060 DLL is a protected-mode Microsoft® Windows™ DLL that is capable of handling up to ten Signametrics DMM's. Also provided are samples Visual Basic™ front-panel application and a C++ sample, to demonstrate the DMM and the interface to the DLL. Check the README.TXT file for more information about the files contained on the diskette. Some important files to note are:

File	Description
SM60CAL.DAT	Configuration file containing calibration information for each DMM. Do not write into this file unless you are performing an external calibration! This file is normally placed at the C:\ root directory by the setup program, and should be left there. It may contain calibration records for several DMM's.
SM206032.LIB	The Windows import library. Install in a directory pointed to by your **LIB** environment variable.
SM206032.DEF	SM2060 driver DLL module definition file.
SM206032.DLL	The 32-bit driver DLL. This should be installed either in your working directory, in the Windows system directory, or in a directory on your **PATH**. The installation program installs this file in your Windows system directory (usually **C:\WINDOWS\SYSTEM for Win98/95 or at C:\WINNT\SYSTEM32 for Windows NT**).
SM206032.H	Driver header file. Contains the definitions of all the DMM's function prototypes for the DLL, constant definitions, and error codes. Install in a directory pointed to by your **INCLUDE** environment variable.
DMMUser.H	Header file containing all of the necessary DMM's function, range, rate definitions to be used with the various measure and source functions.
Msvbvm50.dll	Visual Basic run-time interpreter. Usually already installed in your C**:\WINDOWS\SYSTEM** (or equivalent) directory. If it is not already installed, you will be prompted to install it by running Msvbvm50.exe for proper extraction and registration.
SM2064.vbw	Visual Basic project file
SM2064.frm	Visual Basic file with main form
SM2064.vbp	Visual Basic project file
2044glbl.bas	Visual Basic file with all global DMM declarations

File	**Description**
SM2064.exe	Visual Basic DMM control panel executable
Msvcrt.dll	System file. Installs in your **C:\WINDOWS\SYSTEM** directory.
Windrvr.vxd	Win98/95/Me Virtual Device Driver. Installs by 'setup' in your **C:\WINDOWS\SYSTEM\VMM32** directory.
Windrvr.sys	Win NT Virtual Device Driver. Installs by 'setup' in your **C:\WINNT\SYSTEM32\DRIVERS** directory.
Install.doc	Installation instructions in MS Word

Important Note about the SM60CAL.DAT file:

The file **SM60CAL.DAT** contains calibration information for each DMM, and determines the overall analog performance for that DMM. You must not alter this file unless you are performing an external calibration of the DMM. This file may contain multiple records for more than one DMM. Each record starts with a header line, followed by calibration data.

```
card_id  10123   type 2044 calibration_date 06/15/1999
ad       ; A/D compensation
72.0     20.0
vdc      ; VDC 330mV, 3.3V, 33V, 330V ranges. 1st entry is Offset the 2nd is gain parameters
-386.0 0.99961
-37.0 .999991
-83.0 0.999795
-8.8  1.00015
vac      ; VAC 1st line - DC offset. Subsequent lines: 1st entry is Offset the 2nd is gain, 3rd freq. comp
5.303    ; starting with the 330mV range, and last line is for the 250V range.
0.84          1.015461        23
0.0043        1.0256          23
0.0           1.02205         0
0.0           1.031386        0
idc      ; IDC 3.3mA to 2.5A ranges. 1st entry is offset, 2nd is gain parameter
-1450.0  1.00103
-176.0  1.00602
-1450.0  1.00482
-176.0  1.0
iac      ; IAC 3.3mA to 2.5A ranges, offset and gain
1.6  1.02402
0.0  1.03357
1.69  1.00513
0.0  1.0142
2w-ohm ; Ohms 33, 330, 3.3k,...,330Meg ranges, offset and gain
12700.0       1.002259        ;in the SM2060, the 1st and last lines are placeholders
1256.0        1.002307
110.0         1.002665
0.0           1.006304
0.0           1.003066
0.0           1.001848
0.0           0.995664
0.0           1.00030
…
```

The first line identifies the DMM and the calibration date. The "card-id" is stored in ROM on each DMM. During initialization the driver uses the information from the **DMM.CFG** file to identify where the DMM is located in I/O space, reads the "card-id" and "calibration_date", and then reads the corresponding calibration information from the **SM60CAL.DAT** file.

During initialization (**DMMInit()**), the driver reads various parameters such as DMM type (SM2060/44), and serial number, and then reads the corresponding calibration information from the **SM60CAL.DAT** file.

The **DMMInit()** function reads the information from these files to initialize the DMM. **DMMInit** accepts parameters that are the names of these files. A qualified technician may modify individual entries in the calibration file, then reload them using the **DMMLoadCalFile** command.

5.2 Using the SM2060 Driver With C++ or Similar Software

Install the **SM206032.H** and **DMMUser.H** header file in a directory that will be searched by your C/C++ compiler for header files. This header file is known to work with Microsoft Visual C++™. To compile using Borland, you will need to convert the **SM2060.DEF** and **SM2060.LIB** using **ImpDef.exe** and **ImpLib.exe**, provided with the compiler. Install **SM2060.LIB** in a directory that will be searched by the linker for import libraries. The SM2060 software must be installed prior to running any executable code. Install the **SM2060.DLL** in a location where either your program will do a **LoadLibrary** call to load it, or on the **PATH** so that Windows will load the DLL automatically.

In using the SM2060 driver, first call **DMMInit** to read the calibration information. Call **DMMSetFunction** to set the DMM function. The DMM function constants are defined in the **DMMUser.H** header file, and have names that clearly indicate the function they invoke. Use **DMMSetAperture and DMMSetReadInterval** to set the reading rate defined in the header file.

Two functions are provided to return DMM readings. **DMMRead** returns the next reading as a scaled double-precision (`double`) result, and **DMMReadStr** returns the next reading as a formatted string ready to be displayed.

All functions accept a DMM-number parameter, which must be set to the value **nDmm**, which was returned by **DMMInit()** function. For multiple DMM's, this value will be 0,1,2.. n. Most functions return an error code, which can be retrieved as a string using **DMMErrStr().**

5.2.1 Multiple Card Operations under Windows

<u>Single .EXE operation</u>

Accessing multiple DMM's from a single executable is the most common way for running up to 10 DMM's using the Windows DLL. A combination of several SM2060s and SM2064s can be controlled, as long as the single .EXE (Thread) is used to control all of the units. Make sure that prior to issuing commands to any DMM, it is initialized using **DMMInit()**. The *nDmm* parameter is passed with each DLL command to define the DMM to be accessed. Since this configuration utilizes the DLL to service all DMM's, it must handle a single reading or control command one at a time. For example, when one DMM reads DCV, and another reads Capacitance, the DLL must finish reading the DCV before it will proceed to take a Capacitance reading. Being a relatively slow measurement, Capacitance will dictate the measurement throughput. For improved performance, one can use the following:

<u>Multiple .EXE operation</u>

By having several copies of **SM206032.DLL**, and renaming them, you can run multiple DMM's with separate executables. For instance, having a copy named **SM206032A.DLL** in C:\windows\system (Win98/95), and having two executable files, **MultiExe0.exe** and **MultiExe1.exe**, each of the executables will run independently, making calls to the respective DLL. This can provide an execution throughput advantage over the method mentioned above. If using Visual Basic, the **MultiExe.exe** source code should define *nDmm* = 0, and **MultiExe1.exe** should define *nDmm* = 1. Also the first should declare the **SM2060.DLL** and the second should declare **SM2064.DLL**:

```
    MultiExe0.exe VB function declarations:
Declare Function DMMInit Lib "SM2060.dll" (ByVal calFile As String) As Long
Declare Function DMMRead Lib "SM2060.dll" (ByVal nDmm As Long, dResult As Double) As Long
NDmm = 0

    MultiExe1.exe VB function declarations:
Declare Function DMMInit Lib "sm20432A.dll" (ByVal calFile As String) As Long
Declare Function DMMRead Lib "sm20432A.dll" (ByVal nDmm As Long, dResult As Double) As Long
NDmm = 1
```

```
/************************************************************************
 * Exmp2040.C Exmp2040.EXE
 *
 * A simple Windows .EXE example for demonstrating the SM2060,64
 * DMM's using "C"
 * Sets Function to VDC, Range to 24V, Aperture set to 160ms.
 * Display five measurements using a Message box.
 ***********************************************************************
 * Make sure SM206032.lib is included in the libraries. For Microsoft
 * Version 4.0 C++ and above, place under 'Source Files' in the
 * Workspace, along side with Exmp2060.c
 *  PROJECT SETTINGS:
 *
 *   /nologo /ML /W3 /GX /O2 /D "WIN32" /D "NDEBUG" /D "_CONSOLE" /D "_MBCS"
 *   /FR"Release/" /Fp"Release/Exmp2060.pch" /YX /Fo"Release/" /Fd"Release/" /FD /c
 *
 *  Copy both SM206032.DLL and SM206032.LIB to the project directory.
 *
 ***********************************************************************/
// #define WINAPI __stdcall
#include <windows.h>
#include <string.h>
#ifdef _Windows
  #define _WINDOWS
#endif
#include "SMX2060.h"                    // functions declarations and error codes.
#include "DMMUser.h"                    // All functions, range and rate info and function declarations.
int main(void){
        int I, nDmm = 0;                // Address first DMM in the system
        char Read[16];
        char strMsg[256];
        i = DMMInit(nDmm,"C:\\SM60CAL.dat");        // initialize SM2064, and read calibration file
        if(i<0)
          MessageBox(0,"Initialization ERROR !", "Startup SM206032 DLL",MB_OK);            // Error
        DMMSetFunction(nDmm,VDC);                   // Set to DCV function
        DMMSetRange(nDmm,_24V);                     // and to 33V  range
        DMMSetAperture(nDmm, APR_p16s);             // 160ms Aperture
        strcpy(strMsg,"");                          // Clear string store
        for(i=1; i<= 5; i++){                       // take 5 readings
                DMMReadStr(nDmm, Read);             // read
                strcat(strMsg,Read);                // Append each reading
                strcat(strMsg,"  ");          // insert space between readings
        }
        MessageBox(0,strMsg, "SM206032.DLL Read Resistance & VDC",MB_OK);            // Show readings
        return 0L;
}
```

5.3 Visual Basic Front Panel Application

The Visual Basic front panel application, **SM2064.EXE,** is an interactive control panel for the SM2060 DMM. When it loads it will take a few seconds to initialize and self calibrate the hardware before the front panel is displayed.

The push buttons labeled **V, I**, etc. control the DMM function. As you push a function, the front panel application will switch the DMM to the selected range and function. Autorange mode is selected by pushing the **AutoRange** check box. The **S-Cal** box recalibrates the DMM, leaving the DMM in the same state prior to operation. (This is an internal calibration only, and is different from the external calibration, which writes to the **SM60CAL.DAT** file. **S-Cal** is used to correct for any internal offset and gain drifts due to changes in operating temperature).

The **freq** and **per** check boxes are context sensitive and appear in ACV and ACI. When **freq** is enabled, the frequency and amplitude are shown at the same time. In this mode, the reading rate is slower than indicated. When **per** is enabled, the period is shown. The SM2064 panel have additional capabilities, which are disabled if an SM2060 is detected.

The source code file **GLOBAL.BAS** (in the **V_BASIC** directory of the distribution diskette) contains the function declarations and the various ranges, rates and other parameters that are required. These definitions are the duplicates of the "C" header files required to write Visual Basic applications which interact with the driver DLL, along with some global variables required for this particular front-panel application.

5.3.1 Visual Basic Simple Application

The following is a simple panel application for Visual Basic, which includes two files, Global.Bas and SimplePanel.frm. It has a panel that contains two objects, a **Text Box** to display the DMM readings, and a **Command Button** that acts as a reading trigger.

Global.bas module file contents:

```
Option Explicit
' Declare all functions we are going to be using: From SM206032.H file.
Declare Function DMMInit Lib "SM2060.dll" (ByVal nDmm as long, ByVal calFile As String) As Long
Declare Function DMMSetAperture Lib "SM2060.dll" (ByVal nDmm As Long, ByVal nAperture As Long) _
As Long
Declare Function DMMSetFunction Lib "SM2060.dll" (ByVal nDmm As Long, ByVal nFunc As Long) As Long
Declare Function DMMSetRange Lib "SM2060.dll" (ByVal nDmm As Long, ByVal nRange As Long) As Long
Declare Function DMMRead Lib "SM2060.dll" (ByVal nDmm As Long, dResult As Double) As Long

' Definitions from DMMUser.H
' for DMMSetFunction()
Global Const VDCFunc = 0
Global Const VACFunc = 4
Global Const Ohm2Func = 21
Global nDmm as Long

' for DMMSetRange()
Global Const Range0 = 0
Global Const Range1 = 1
Global Const Range2 = 2
Global Const Range3 = 3

'Measurement Apertures for use with DMMSetAperture()
Global Const APR_1p0666s = 4      '1.07s
Global Const APR_p96s = 5         '960ms Aperture
Global Const APR_p5333s = 6       '533ms
Global Const APR_p48s = 7         '480ms
Global Const APR_p2666s = 8       '266ms
Global Const APR_p16s = 9         '160ms
Global nDmm As Long           ' Global store for the DMM number
```

SimplePanel.frm Form file contents:

```
Private Sub Form_Load()                          'Fomr_Load allways gets executed first.
   Dim i As Long
   nDmm = 0                         'Set to first DMM in the system
   i = DMMInit(nDmm,"C:\SM60CAL.dat")    'Initialize and load cal file
   i = DMMSetFunction(nDmm, VDCFunc)   'Set DMM to DCV function
   i = DMMSetRange(nDmm, Range2)      'Select the 24V range
   i = DMMSetAperture(nDmm, APR_p16s)      'Set measurement Aperture to 160ms
End Sub

Private Sub ReadBotton_Click()           'Read Botton Click action.
   Dim i As Long                         'Any time this botton is pressed
   Dim dReading As Double                'the DMM takes a reading and displays it.
   i = DMMRead(nDmm, dReading)                   'Take a reading
   TextReading.Text = dReading                   'display it in a Text box.
End Sub
```

5.4 Windows DLL Default Modes and Parameters

After initialization, the Windows DLL default modes and parameters on your DMM are set up as follows:

- Auto ranging: Off
- Function: DC Volts
- Range: 240V
- Relative: Off
- Measurement Aperture: 533.33ms
- Read Interval: 0ms
- Temperature units are set to °C
- Offset Ohms: Off
- In-Cirtuite Caps level: 0.45V Peak.
- Closed Loop mode: Off
- Trigger polarity: Positive Edge
- Sync output polarity: Positive
- Sync output: Disabled
- Fast RMS: off
- Thermocouple type: 'K'

5.5 Using the SM2060 DLL with LabWindows/CVI®

When using the SM2060 DLL with LabWindows/CVI, you should read the **LabWin.txt** file included with the software diskette.

An example application of SM2060 DLL calls from LabWindows/CVI ® is shown below. It contains functions **measure_ohms()** and **measure_vdc()**, with sample calls to the SM2060.

NOTE: Although these measurement functions use LabWindows/CVI® and the LabWindows/CVI(R) Test Executive, they are not necessarily coded to LabWindows® instrument driver standards.

```
/* function: measure_ohms, purpose: measure 2-wire ohms */
int measure_ohms(double OHMreading) {
        short ret, i;
        DMMSetFunctions (0, OHMS2W);
        DMMSetAutoRange (0, TRUE);
        /* to settle auto-range and function changes ignore three readings */
        for( i = 0 ; i < 4 ; i++ )  ret = DMMReadNorm (0, & OHMreading);
        return ret;
}
/* function: measure_vdc, purpose: measure DC Volts */
int measure_vdc(double Vreading) {
        short ret, i;
        DMMSetFunctions (0, VDC);
        DMMSetAutoRange (0, TRUE);
        /* to settle auto-range and function changes ignore three readings */
        for( i = 0 ; i < 4 ; i++ ) ret = DMMReadNorm (0, &Vreading);
        return ret; }
```

5.6 Windows Command Language

The following section contains detailed descriptions of each function of the Windows command language. Those commands that pertain to only the SM2060 are indicated. Most functions return an error code. The code can either be retrieved as a string using **DMMErrString** function, or looked up in the **SM2060.H** header file. The **DMMUser.H** file contains all the pertinent definitions for the DMM ranges functions etc. The following description for the various functions is based on "C" function declarations. Keep in mind that the Windows DLL containing these functions assumes all **int** values to be windows 32bit integers (corresponds to VisualBasic **long** type). TRUE is 1 and FALSE is 0 (which is also different from VisualBasic where True is –1 and False is 0).

Grayed out functions are either, untested or unimplemented.

DMMArmAnalogTrigger

SM2060 ☑ SM2064 ☑

Description Arm DMM for analog level trigger operation.

#include "SM206032.h"

int DMMArmAnalogTrigger(**int** *nDmm,* **int** *iPostSamples,* **double** ***dThresh*)

Remarks This function is usable for VDC, VAC, Ohms, IAC IDC and Leakage. It sets up the DMM for analog level trigger operation. In response to this command the DMM continuously makes measurements, storing them to a circular buffer. A trigger event occurs when a measured value crosses the threshold, dThresh, in the transition direction specified by the currently set Edge. The Edge polarity is set using the DMMSetTrigPolarity function. At the trigger point the DMM makes additional iPostSamples measurements and stores them to the circular buffer. Following completion of the capture process, use the DMMGetTriggerInfo function to get information related to the operation, such as the total number of pre trigger measurements.

The *dThresh* value is in base units, and must be within the selected measurement range. For example, in the 240 mV range, *dThresh* must be within -0.24 and +0.24. In the 24kΩ, range it must be set between 0.0 and 24000.0.

Prior to executing this operation set the measurement function, range, Aperture, Read Interval and Edge polarity. Between the time this function is issued and the time the buffer is read, no other command should be sent to the DMM. Two exceptions are the **DMMReady** and **DMMDisArmTrigger** commands.

Read Interval must be set between 0 (default) and 65ms. Aperture must be set between 160ms and 2.5us. The value of *iPostSamples* must be set between 1 and the buffer size. The buffer size is 80 for Apertures of 160ms to 1.4ms, and 120 for Apertures in the range of 2.5µs to 625us. The highest Aperture allowed for this operation is 160ms. Aperture and Read Interval are set using the **DMMSetAperture** and **DMMSetReadInteval** functions, respectively.

Use the **DMMReady** to monitor completion of this operation. When ready, read up-to the above buffer size, using **DMMReadBuffer** or **DMMReadBufferStr** functions. Once DMMReady returns TRUE, it should not be used again prior to reading the buffer, since it initializes the buffer for reading when it detects a ready condition.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iPostSamples	**int** The number of samples the DMM takes following a trigger pulse. This number must be between 1 to 80 or 1 to 120. See above details.
dThresh	**double** Analog level trigger threshold value

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully terminated
Negative value	Error code.

Example

```
double Buffer[80];
```

```
DMMArmAnalogTrigger(0,80,1.5);
while( ! DMMReady(0));
for(i=0; i < 80 ; i++)
      j = DMMReadBuffer(0, &Buffer[i]);
```

DMMArmTrigger

SM2060 ☑ SM2064 ☑

Description

Arm DMM for external trigger operation.

#include "SMX2060.h"

#include "SMX2060.h"

int DMMArmTrigger(**int** *nDmm,* **int** *iPostTrig*)

Remarks

Setup the DMM for external hardware trigger mode (input at DIN7 connector). Following reception of this command the DMM continuously makes measurements and places them in a circular buffer, while waiting for the for the selected trigger edge. All measurements are made at the currently set Aperture and Read Interval. On reception of the selected trigger edge the DMM makes ***iPostTrig*** samples at the currently function and range, storing them to the buffer. The result is a buffer containing both, pre-trigger and ***iPostTrig*** post-trigger samples. The total number of which is limited to the buffer size (120 or 80 depending on set Aperture. See **DMMArmAnalogTrigger** for details). With the exception of the **DMMReady** and **DMMDisarmTrigger** commands, following the issue of the **DMMArmTrigger** command**,** no other function should be sent to the DMM prior to reading the captured data. This function is usable for VDC, VAC, Ohms, IAC, RTD and IDC and Leakage. Following completion of the capture process, Use the **DMMGetTriggerInfo** function to get information related to the operation. The Trigger Edge polarity can be set with the **DMMSetTrigPolarity** function.

The width of the trigger input must be at least as wide as the selected Aperture and/or Read Interval, whichever is greater.

Following DMMArmTrigger, use the DMMReady to monitor completion of the capture process. When the DMM is ready read the buffer using DMMReadBuffer or DMMReadBufferStr functions. Make 120 or 80 read operations to read both, the pre-trigger and post-trigger (iPostTrig) samples. Following trigger operation, once DMMReady returns TRUE, it should not be called again since it prepares the buffer for reading when it detects a ready condition. Other related functions include, DMMReadBufferStr, DMMSetReadInterval, DMMSetSync, and DMMSetAperture.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iPostTrig	**int** The number of samples the DMM takes following a trigger. This value must be between 1 and 80 or 120 depending on set resolution.

Return Value

The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully terminated

Negative Value	Error code.

Example

```
double Buffer[70];
DMMArmTrigger(0,70);
while( ! DMMReady(0));
      for(i=0; i < 70 ; i++)
      j = DMMReadBuffer(0, &Buffer[i]);
```

DMMBurstBuffRead

SM2060 ☑ SM2064 ☑

Description

Setup the DMM for Triggered operation.

#include "SM206032.h"
#include "DMMUser.h"

int DMMBurstBuffRead(int *nDmm***, int** *iSettle***, int** *iSamples***)**

Remarks

Following reception of this command the DMM enters a burst read mode, taking a total of *iSamples* measurements at the currently set measurement function, range, Aperture and Read Interval. Those readings are saves to the on-board buffer. Each measurement I spreceeded by iSettle readings, which are discarded. Therfore for each sample saved iSettle + 1 readings are taken. The last reading is saved. This process repeats for *iSamples*. No other DMM command should be issued until the process is complete, and the contents of the buffer are read. One exception is the **DMMDisarmTrigger** command, which terminates the process. No autoranging is allowed in this mode. This function is usable for VDC, VAC, Ohms, IAC, IDC and RTD measurements. Measurement Aperture should be set to 160ms or lower. The total time it takes to complete this process is approximately *iSamples* * (*iSettle* + 1) * Aperture (or Read Interval, if set).

Use the **DMMReady** to monitor if the has completed the operation, and is ready. When ready, read up to *iSamples*, using **DMMReadBuffer** or **DMMReadBufferStr** functions. Once **DMMReady** returns TRUE, it should not be used again until the buffer is read, since it clears some flags in preparation for buffer reading when it detects a ready condition.

Parameter	Type/Description
iDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iSettle	**int** The number of setteling measurements, prior to read value. Must be set between 0 and 250.
iSamples	**int** The number of samples the DMM takes following the same number of trigger pulses. This number must be between 1 and 80 or 120 depending on set Aperture.

Return Value

The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
double Buffer[50];
```

```
DMMBurstBuffRead(0, 4, 50); // 4 settling readings for each
// measurement, and take 50 readings
while( ! DMMReady(0) );       // wait for completion
for(i=0; i < 50 ; i++)        // read 50 readings from DMM’s
// on-board buffer
      j = DMMReadBuffer(0, &Buffer[i]);
```

DMMBurstRead

SM2060 ☑ M2064 ☑

Description

Setup the DMM for multiple readings operation, sending back measurements as they come.

#include "SM206032.h"
#include "DMMUser.h"

int DMMBurstRead(int *nDmm***, int** *iSettle***, int** *iSamples***)**

Remarks

On execution of this command the DMM enters a tight loop, where it takes multiple measurements, sending them back as they come. This function is similar to the **DMMSetTrigRead** function, with the exception that it does not wait for a hardware trigger to start the process. For each reading returned the DMM takes *iSettle* + 1 samples, sending the last sample back. All samples are taken at the set Measurement function, Aperture and Read Interval currently set. This process repeats for *iSamples*. Following the issue of this command and until *iSampels* measurements are read back, it is necessary to keep up with the DMM and read all *iSample* measurements as fast as they come. Failing to do so will result in communication overrun. Use the **DMMReadMeasurement** command to read these measurements. The DMM communication channel has a limited size FIFO which helps a bit. No auto ranging is allowed in this mode. The advantage of this function is that it makes measurements with a consistant sampling rate. Use it carefuly and only in cases where this feature is necessary. It is usable for VDC, Ohms and IDC measurements. Measurement Aperture should be set to 160ms or lower. The total time it takes to complete this process is equal to (*iSamples* * (*iSettle* + 1) * Aperture or * Read Interval if it is not set to 0.

Use the **DMMReadMeasurement** to monitor when reading becomes available, and to read the data. Read as many samples as *iSamples* to guarantee proper conclusion of this capture process.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iSettle	**int** The number of settling measurements, prior to read value. Must be set between 0 and 250. Recommended value is 4.
iSamples	**int** The number of samples the DMM takes following the same number of trigger pulses. This number must be between 1 and 60,000, inclusive.

Return Value

The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
double Reading[250];
DMMBurstRead(0, 10, 250); // settle 10 reads., 250 samples
for(i=0; i < 250 ; i++) // read 250 meas. as they come
      while( ! DMMReadMeasurement(0 , Reading[i]) );
```

DMMCalibrate

SM2060 ☑ SM2064 ☑

Description Internally calibrate the DMM.

#include "SM206032.h"

int DMMCalibrate(**int** *nDmm*)

Remarks This function performs self calibration of the various components of the DMM, as well as an extensive self test. At the end of this operation it returns the DMM to the current operating mode. Using this function periodically, or when the DMM internal temperature varies, will enhance the accuracy of the DMM. Using this function does not remove the requirement to perform periodic external calibration.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM is OK.
Negative Value	Error

Example

```
status = DMMCalibrate(0); /* a quick internal cal.*/
```

Comments This performs an internal DMM calibration and is the same as the **S-Cal** command in the VB Control Panel. It is not related to the external calibration represented in the **SM60CAL.DAT** file.

DMMCleanRelay

SM2060 ☑ SM2064 ☑

Description Clean specified relay.

#include "SM206032.h"

int DMMCleanRelay(int *nDmm,* **int** *iRelay,* **int** *iCycles***)**

Remarks This function cleans *iRelay* by vibrating the contact *iCycles* times. This function is useful for removing oxides and other deposits from the relay contacts. DC Current measurements are particularly sensitive to K2 contact resistance and therefore should be cleaned periodically. It is also useful for making sound in computer without a speaker.

Parameter	Type/Description
iRelay	**int** The relay to clean. 1 for K2, 2 for K2 and 3 for K3.

iCycles	**int** The number of times the relay contact is shaken. 1 to 1000.
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code..

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
int status = DMMCleanRelay(0, 2, 100); // Shake K2 1000
```

DMMClearBuffer

SM2060 ☑ SM2064 ☑

Description Clears the contents of the internal buffer.

#include "SM206032.h"

int DMMClearBuffer(int *nDmm***)**

Remarks This function clears the internal buffer. It is useful when experimenting with the various trigger functions.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code..

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
int status = DMMClearBuffer(0);
```

DMMClearMinMax

SM2060 ☑ SM2064 ☑

Description Clears the Min/Max storage.

#include "SM206032.h"

int DMMClearMinMax(int *nDmm***)**

Remarks This function clears the Min/Max values, and initiates a new Min/Max detection. See **DMMGetMin** for more details.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
int status = DMMClearMinMax(0);
```

DMMClosePCI

SM2060 ☑ SM2064 ☑

Description Close the PCI bus for the specified DMM. Not for user applications.

#include "SM206032.h"

int DMMClosePCI(**int** *nDmm*)

Remarks This function is limited for servicing the DMM. It has no use in normal DMM operation. See also **DMMOpenPCI()** function.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
int status = DMMClosePCI(0);
```

DMMDelay

SM2060 ☑ SM2064 ☑

Description Wait for a given time.

#include "SM206032.h"

int DMMDelay(**double** *dTime*)

Remarks Delay of *dTime* seconds. *dTime* must be a positive double number between 0.0 and 100.0 seconds.

Parameter	Type/Description
dTime	**double** Delay time in seconds.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully terminated
Negative Value	Error code

Example

```
DMMDelay(1.2); /* wait for 1.2 Sec */
```

DMMDelayedTrigger

SM2060 ☑ SM2064 ☑

Description Arm DMM for delayed external trigger operation.

#include "SMX2060.h"

#include "SMX2060.h"

int DMMDelayedTrigger(int *nDmm,* **double** *dDelay,* **int** *iSamples*)

Remarks Setup for delayed external trigger capture mode (off the DIN7 connector). Following reception of this command the DMM enters a wait state, waiting for trigger edge currently selected (see DMMSetTrigPolarity()). At the detection of the selected polarity, the DMM waits for *dDelay* prior to making iSamples samples. The value of *dDelay* can be set between 0 and 1s. The samples are taken using the currently set function, range, Aperture (DMMSetAperture) and Read-Interval (DMMSetReadInterval). iSamples are stored in the DMM's internal buffer. With the exception of the DMMReady and DMMDisarmTrigger commands, following the issue of DMMDelayedTrigger command, no other function should be used prior to reading the captured data. This function is usable in VDC, VAC, Ohms, IAC, RTD and IDC.

Read Interval must be set between 0 (default) and 65ms. Aperture must be set between 160ms and 2.5us. The value of *iPostSamples* must be set between 1 and the buffer size. The buffer size is 80 for Apertures of 160ms to 1.4ms, and 120 for Apertures in the range of 2.5µs to 625us. The highest Aperture allowed for this operation is 160ms. Aperture and Read Interval are set using the **DMMSetAperture** and **DMMSetReadInteval** functions, respectively.

Following **DMMDelayedTrigger**, use the **DMMReady** to monitor completion of the capture process. When the DMM is ready read the buffer using **DMMReadBuffer** or **DMMReadBufferStr** functions. Read iSamples measurements from the buffer. Once **DMMReady** returns **TRUE**, it should not be called again since it prepares the buffer for reading when it detects a ready condition. Other related functions include; **DMMReady**, **DMMReadBuffer**, **DMMReadBufferStr**, **DMMSetReadInterval**, **DMMSetSync**, **DMMSetTrigPolarity**, **DMMDisarmTrigger**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dDelay	**double** This post-trigger delay value can be 0.0 to 1.0
iSamples	**int** The number of samples the DMM takes following a trigger. This value must be between 1 and 80 or 120 depending on set resolution.

Example

```
double Buffer[50]; //Delay 0.1s, take 50 samples
DMMDelayedTrigger(0, 0.1, 50);
while( ! DMMReady(0) ); // wait for completion
for(i=0;i<50;i++) DMMReadBuffer(nDmm, Buffer[i]); // read
```

DMMDisableTrimDAC

SM2060 ☐

Description Terminate the operation of the Trim DAC.

#include "SM206032.h"

int DMMDisableTrimDAC(int *nDmm***)**

Remarks This function disables the Trim DAC. Since usage of the Trim DAC consumes the on-board microcontroller's resources it must be turned off with this function when not in use. See **DMMSetTrimDAC**, **DMMSetDCVSource** and **DMMSetACVSource** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMDisableTrimDAC(0); // Remove Trim DAC from operation
```

DMMDisArmTrigger

SM2060 ☑ SM2064 ☑

Description Abort trigger operation.

int DMMDisArmTrigger(**int** *nDmm*)

Remarks This function sends the DMM a trigger termination command. If the DMM is waiting for a trigger, following one of the Triggered operations, it will terminate the operation and will be ready for a new operation. It can be used following an external hardware or analog level trigger arm command (**DMMArmAnalogTrigger, DMMArmTrigger,** or **DMMTrigger**).

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

DMMDutyCycleStr

SM2060 ☐ SM2064 ☑

Description Return percent duty cycle of an AC signal in string format.

#include "SM206032.h"

int DMMDutyCycleStr(int *nDmm,* **LPSTR** *lpszReading*)

Remarks This function is the string version of **DMMReadDutyCycle**. The measurement result is stored at the location pointed to by *lpszReading*. See **DMMReadDutyCycle** for more details.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the result.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
char cBuf[64]; int status = DMMDutyCycleStr(0, cBuf);
```

DMMErrString

SM2060 ☑ SM2064 ☑

Description Return the string describing the warning or error code.

#include "SM206032.h"

int DMMErrString(int *iErrorCode,* **LPSTR** *lpszError*, **int** *iBuffLength*)

Remarks This function returns a string containing the error or warning description which corresponds to the *iErrorCode.* The string is placed at *lpszError*. Error codes are negative numbers, while warning codes are positive numbers.

Parameter	**Type/Description**
iErrorCode	**int** Error code.
iBuffLength	**int** The maximum available length of the string buffer
lpszError	**LPSTR** Points to a buffer (at least 64 characters long) to hold the error/warning string.

Return Value The return value is the length of the error string or one of the following constants.

Value	**Meaning**
Negative Value	Error code

Example

```
char cBuf[64];
int length = DMMErrString( -3, cBuf, 48);
```

DMMFrequencyStr

SM2060 ☐ SM2064 ☑

Description Return the next DMM frequency reading, formatted for printing.

#include "SM206032.h"

int DMMFrequencyStr(**int** *nDmm,* **LPSTR** *lpszReading*)

Remarks This function makes frequency measurement and returns the result as a string formatted for printing. The print format is fixed to six digits plus units, e.g., 05.001 Hz. If the DMM is in Autorange, be certain to take an amplitude reading before using this command. It may take several calls to **DMMFrequencyStr()** to get the measured frequency, because the DMM frequency counter uses a frequency ranging scheme which gets activated only when a frequency or period reading function is received. If the previously measured frequency was 2 Hz and the frequency being measured is 300 kHz (or vise versa), it might take as many as six calls to **DMMFrequencyStr()** or any of the other frequency measurement functions, to read the correct frequency. To improve this use the **DMMSetCounterRng()** is function is a **Secondary** function which requires the DMM to be in either VAC or IAC function and at the appropriate range.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the converted result.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
DMM_CNT_RNG	Frequency counter is over or under range.

Negative Value	Error code

Example

```
char cBuf[64];
int status;
status = DMMFrequencyStr(0, cBuf);
```

DMMGetACCapsR

SM2060 ☐ SM2064 ☑

Description

Return the resistance component of the last AC Caps measurement.

#include "SM206032.h"

int DMMGetACCapsR(int *nDmm***, double ****lpdResult***)**

Remarks

This function retrieves the resistive component from last reading of the In Circuit (AC based) Capacitance measurement. It performs all scaling and conversion required, and returns the result as a 64-bit double-precision floating-point number in the location pointed to by *lpdResult*. Returned result is a value in ohms. Read about In-Circuit Capacitance Measurements section of this manual.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the resistance value.

Return Value

The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code
OVER_RNG	Over range occurred, implying a very high parallel resistance value.

Example

```
double d;
int status;
status = DMMGetACCapsR(0, &d);
```

DMMGetAperture

SM2060 ☑ SM2064 ☑

Description

Get DMM reading rate

#include "SM206032.h"

int DMMGetAperture(int *nDmm***, double ****lpdAperture***)**

Remarks

This function returns a double floating rate in readings per second.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

lpdAperture	**double *** Pointer where the aperture is saved to.

Return Value Integer value version code or an error code.

Value	Meaning
Negative Value	Error code

Example

```
int status; double  aperture;
status = DMMGetAperture(0, & aperture);
```

DMMGetBufferSize

SM2060 ☑ SM2064 ☑

Description Return the currently selected internal buffer size.

#include "SM206032.h"
#include "UseroDMM.h"

int DMMGetBufferSize(int *nDmm, int * lpiLength***)**

Remarks This function returns the currently set buffer size. This value can be 80 or 120. The value depends on the settings of the Aperture value.

Parameter	Type/Description
iDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpiLength	**Int *** Pointer at which the buffer length is stored.

Return Value The return value is one of the following constants.

Value	Meaning
Value	**int** Error or Warning code

Example

```
int length;
DMMGetBufferSize(0, & length); // read buffer size
```

DMMGetBusInfo

SM2060 ☑ SM2064 ☑

Description Returns the PCI Bus and Slot numbers for the selected DMM.

int DMMGetBusInfo(**int** *nDmm,* **int ****bus,* **int ****slot*)

Remarks This function reads the PCI *bus* and *slot* numbers for the selected DMM. . It provides means to relate the physical card location to the *nDmm* value by detecting the location of a DMM in the PCI system tree. This function actually scans the hardware rather then look up the information in the registry.

Parameter	Type/Description

nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
bus	**int *** a pointer to integer at which the bus number is stored (0 to 255)
slot	**int *** A pointer to an integer where the slot number is stored (0 to 15)

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation was successful.
Negative number	Error code

Example

```
int bus, slot; // Find on which bus, and slot the DMM is at
DMMGetBusInfo(3, &bus, &slot); // DMM#3
```

DMMGetCalDate

SM2060 ☑ SM2064 ☑

Description Return the calibration date string from the DMM.

int DMMGetCalDate(**int** *nDmm*, **LPSTR** *lpszCalDate*)

Remarks This function reads the calibration date string from the structure. This is the date the DMM was calibrated last.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszCalDate	**LPSTR** Points to a buffer (at least 64 characters long) to hold the cal date string.

Return Value The return value is one of the following constants.

Value	Meaning
any positive number	Length of the date string
Negative number	Error code

Example

```
char cBuf[64];
int status;
status = DMMGetCalDate(0, cBuf);
```

DMMGetdB

SM2060 ☑ SM2064 ☑

Description Get dB deviation from the reading at the time relative was activated.

#include "SM206032.h"

int DMMGetdB(int *nDmm***, double ****lpdDev***)**

Remarks This function returns a double floating value that is the dB deviation relative to the reading made just before the relative function was activated. This function is useful in determining measurement errors in dB. It can be used for bandwidth measurements or DC evaluation.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdDev	**double *** Pointer where the dB value is to be saved.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double dB; int status = DMMGetdB(0, &dB);
```

DMMGetdBStr

SM2060 ☑ SM2064 ☑

Description Get dB deviation from the reading at the time relative was activated.

#include "SM206032.h"

int DMMGetdBStr(int *nDmm***, LPCSTR** *lpszDB***)**

Remarks This function is the same as the **DMMGetdB()**, with the exception that it returns a string. See **DMMGetdB()** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszDB	**LPCSTR** Points to a buffer (at least 64 characters long) to hold the result. The return value will consist of a leading sign a floating-point, and a 'dB' units specifier

Return Value Integer string length if successful, or an error code..

Value	Meaning
Negative Value	Error code

Example

```
char cBuf[64]; int strLength = DMMGetdBStr(0, cBuf);
```

DMMGetCJTemp

SM2060 ☑ SM2064 ☑

Description Retrieve the currently set cold junction temperature.

#include "SM206032.h"

int DMMGetCJTemp(int *nDmm*, **double ***lp*dTemp***)**

Remarks Get the currently set cold junction temperature. For more details see **DMMSetCJTemp()** function.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdTemp	**double *** Points to the location to hold the temperature.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
DMMGetCJTemp(0, &temp);
```

DMMGetDeviation

SM2060 ☑ SM2064 ☑

Description Get percent deviation from the reading at the time relative was activated.

#include "SM206032.h"

int DMMGetDeviation(int *nDmm*, **double ****lpdDev***)**

Remarks This function returns a double floating value that is the percent deviation relative to the reading made just before the relative function was activated **(DMMSetRelative)**. This function is useful in quantifying measurement errors. It can be used for bandwidth measurements or DC evaluation, or percent variation of a device under test over temperature. The absolute value of *lpdDev* can be used as a pass/fail window for production. Another function effecting **DMMGetDeviation** is **DMMSetReference**. Unlike **DMMSetRelative**, which uses the current measurement as a reference, **DMMSetReference** provides the facility to set this reference.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdDev	**double *** Pointer where the deviation value is to be saved.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double  error;
int status = DMMGetDeviation(0, &error);
```

DMMGetDeviatStr

SM2060 ☑ SM2064 ☑

Description Get percent deviation from the reading at the time relative was activated.

#include "SM206032.h"

int DMMGetDeviatStr(int *nDmm*, **LPCSTR** *lpszDev***)**

Remarks This function is the same as the **DMMGetDeviation()**, with the exception that it returns a string. See **DMMGetDeviation()** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszDev	**LPCSTR** Points to a buffer (at least 64 characters long) to hold the result. The return value will consist of a leading sign a floating-point, and a % units specifier

Return Value Integer string length if successful, or an error code.

Value	Meaning
Negative Value	Error code

Example

```
char cBuf[64];
int strLength = DMMGetDeviatStr(0, cBuf);
```

DMMGetFuncRange

SM2060 ☑ SM2064 ☑

Description Get DMM range code.

#include "SM206032.h"
#include "DMMUser.h"

int DMMGetFuncRange(**int** *nDmm*)

Remarks This function returns the combined DMM function/range code. See **DMMUser.h** for the complete set of codes.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer value corresponding to the currently set DMM function/range, or an error code. The following are a few examples of the returned value.

Value	**Meaning**
Positive value	See DMMUser.h for function/range codes.
Negative Value	Error code

Example

```
if(DMMGetFuncRange == VDC_300mV) printf("Lowest VDC range
selected");
```

DMMGetFunction

SM2060 ☑ SM2064 ☑

Description Get DMM function code.

#include "SM206032.h"
#include "DMMUser.h"

int DMMGetFunction(**int** *nDmm*)

Remarks This function returns the DMM function code. The codes are defined in the DMMUser.h file.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer value corresponding to the current function, or an error code.

Value	**Meaning**
Positive value	See DMMUser.h for function/range codes.
Negative Value	Error code

Example

```
if(DMMGetFunction == VDC) printf("VDC Function selected");
```

DMMGetGrdVer

SM2060 ☑ SM2064 ☑

Description Get DMM firmware version.

#include "SM206032.h"

int DMMGetGrdVer(**int** *nDmm*)

Remarks This function returns the DMM firmware version of the on-board controller.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer value. The return value is the version value or an error code.

Value	**Meaning**
Positive Value	Version
Negative Value	Error code

Example

```
firmwarever = DMMGetGrdVer(0);
```

DMMGetHwVer

SM2060 ☑ SM2064 ☑

Description Get the hardware version of the DMM.

#include "SM206032.h"

int DMMGetHwVer(**int** *nDmm*)

Remarks This function returns the hardware version. A returned value of 0 corresponds to Rev_, 1 corresponds to Rev_A, 2 to Rev_B etc.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value DMM hardware code or an error code.

Value	**Meaning**
Positive value	Hardware version code
Negative Value	Error code

Example

```
int HWVer = DMMGetHwVer(0);
```

DMMGetID

SM2060 ☑ SM2064 ☑

Description Get DMM ID code.

#include "SM206032.h"

int DMMGetID(int *nDmm*)

Remarks This function returns the DMM identification code. Each DMM has a unique ID code that must match the calibration file **card_ID** field in **SM60CAL.DAT**. This code must reflect the last digits of the DMM serial number.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer value card ID code (serial number) or an error code.

Value	Meaning
DMM_E_DMM	Invalid DMM number.

Example
```
int id = DMMGetID(0);
```

DMMGetManDate

SM2060 ☑ SM2064 ☑

Description Get Manufacturing date stamp from the DMM hardware

#include "SM206032.h"

int DMMGetManDate(int *nDmm*, **int ***month*, **int ***day*, **int ***year*)

Remarks This function returns the DMM manufacturing date which is read from the hardware. The month, day and year are returned as integers. This is used to track the DMM to a specific manufacturing date.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
month	**int *** A pointer to an integer where the month is stored
day	**int *** A pointer to an integer where the day is stored
year	**int *** A pointer to an integer where the year is stored

Return Value Integer error code or.

Value	Meaning

DMM_OKAY	Operation was successful.
DMM_E_DMM	Invalid DMM number.

Example

```
int month, day, year, status
status = DMMGetManDate(0, &month, &day, &year);
```

DMMGetMax

SM2060 ☑ SM2064 ☑

Description Get Maximum reading history.

#include "SM206032.h"

int DMMGetMax(int *nDmm***, double ****lpdMax***)**

Remarks This function returns a double floating value that is the maximum (of the Min/Max function) value since either a function change, range change or call to the **DMMClearMinMax** function was made. This value is updated every time a measurement is performed using **DMMRead**, **DMMReadStr** or **DMMReadNorm**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdMax	**double *** Pointer where the Max value is to be saved.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double  Mx; int status = DMMGetMax(0, &Mx);
```

DMMGetMaxStr

SM2060 ☑ SM2064 ☑

Description Returns the maximum as a formatted string.

#include "SM206032.h"

int DMMGetMaxStr(int *nDmm*, **LPSTR** *lpszReading*)

Remarks This function is the string version of **DMMGetMax**. It returns the result as a string formatted for printing. The print format is determined by the range and function. See **DMMGetMax** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the result.

Return Value The return value is one of the following constants, or the string length is OK.

Value	Meaning
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
char cBuf[64];
int status = DMMGetMaxStr(0, cBuf);
```

DMMGetMin

SM2060 ☑ SM2064 ☑

Description Get Minimum reading history.

#include "SM206032.h"

int DMMGetMin(int *nDmm*, **double ****lpdMax***)**

Remarks This function returns a double floating value that is the minimum (of the Min/Max function) value since either a function change, range change or a call to the **DMMClearMinMax**() function was made. This value is updated every time a measurement is performed using **DMMRead**, **DMMReadStr** or **DMMReadNorm**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdMax	**double *** Pointer where the Min value is to be saved.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double  Min; int status = DMMGetMin(0, &Min);
```

DMMGetMinStr

SM2060 ☑ SM2064 ☑

Description Returns the minimum as a formatted string.

#include "SM206032.h"

int DMMGetMinStr(**int** *nDmm,* **LPSTR** *lpszReading*)

Remarks This function is the string version of **DMMGetMin**. It returns the result as a string formatted for printing. The print format is determined by the range and function. See **DMMGetMin** for more details.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the result.

Return Value The return value is one of the following constants, or the string length is OK.

Value	**Meaning**
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
char cBuf[64];
int status = DMMGetMinStr(0, cBuf);
```

DMMGetRange

SM2060 ☑ SM2064 ☑

Description Get DMM range code.

#include "SM206032.h"
#include "DMMUser.h"

int DMMGetRange(**int** *nDmm*)

Remarks This function returns the DMM range code. The range codes are in the sequence of 0, 1, 2, 3, … where 0 is the lowest range.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer value corresponding to the currently set DMM range, or an error code.

Value	**Meaning**
Zero or positive value	Range; zero being the lowest
Negative Value	Error code

Example

```
int id;
if(DMMGetRange == 0) printf("Lowest range selected");
```

DMMGetReadInterval

SM2060 ☑ SM2064 ☑

Description Get Read Interval value.

#include "SM206032.h"

int DMMGetReadInterval(int *nDmm*, **double ****lpdRI***)**

Remarks This function returns a double floating value that is the currently set A/D Read Interval.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdDev	**double *** Pointer where the Read Interval is saved.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double dRI; int status = DMMGetReadInterval(0, &dRI);
```

DMMGetSourceFreq

SM2060 ☐ SM2064 ☑

Description Get the currently set ACV Source frequency.

#include "SM206032.h"

int DMMGetSourceFreq(int *nDmm*, **double ****lpdFreq***)**

Remarks This function returns a double floating value that is the currently set ACV source frequency of the SM2064. It can be used to display or verify the default frequency of the stimulus for the various Inductance measurement ranges.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdFreq	**double *** Pointer where the frequency value is to be saved.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example `double  f; int status = DMMGetSourceFreq(0, &f);`

DMMGetTCType

SM2060 ☑ SM2064 ☑

Description Get the themocouple type currently selected.

#include "SM206032.h"
#include "DMMUser.h"

int DMMGetTCType(**int** *nDmm*)

Remarks This function returns the Themocouple type currently selected.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value DMM type Integer or an error code.

Value	Meaning
Btype to TType	Type of thermocuple as specified in DMMUser.h file
Negative Value	Error code

Example `int TCtype = DMMGetTCType(0);`

DMMGetTriggerInfo

SM2060 ☑ SM2064 ☑

Description Get Capture Infromation following Trigger operation.

#include "SMX2060.h"

int DMMGetTriggerInfo(**int** *nDmm int * iNullCount, int * iPreTrig, int *iBufCycles)*

Remarks This function returns various parameters associated with previous trigger operation. For instance, if the trigger event occurred soon after DMMArmTrigger command is issued, the buffer does have a chance to fill. That is the total number of pre trigger samples plus post trigger samples is less than the size of the buffer. The ***iNullCount*** is the number of these “empty” samples at the begining of the buffer. These empty samples should be ignored when reading the buffer by reading and discarding ***iNullCount*** samples. The ***iPreTrig*** value is the number of valid samples taken prior to the trigger event. If the circular buffer fills at least once, or “wraps”, the value of ***iBufCycles*** will be greater than 0. Than the sum of ***iPreTrig*** and ***iPostTrig*** samples is equat to the size of the buffer. The amount of time the trigger event occurred following the issue of the command may be calculated using the following relation:

tTriggDelay = ***iReadInterval*** * ((***iBufCycles*** * 120) + ***iPreTrig***)

Other related functions include; **DMMArmTrigger**, **DMMGetTriggerInfo**, **DMMReadBuffer**, **DMMReadBufferStr**, **DMMSetReadInterval**, **DMMSetSync**, **DMMSetTrigPolarity**, **DMMDisarmTrigger**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value DMM type Integer or an error code.

Value	Meaning
iNullCount	The number of empty buffer location can be 0 to 120 or 80 depending or set conversion resolution.
iPreTrig	The number of available pre-trigger samples. This value can be be 0 to 1 or 80 depending on set conversion resolution.
iBufCycles	The number of times the buffer filled prior to trigger. This value can be (0 to 65,280.
Negative Value	Error code

Example `int DMMtype = DMMGetType(0, &Empty, &Pre, &wraps);`

DMMGetType

SM2060 ☑ SM2064 ☑

Description Get the type of the DMM.

#include "SM206032.h"

int DMMGetType(**int** *nDmm*)

Remarks This function returns a value representing the DMM model.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value DMM type Integer or an error code.

Value	Meaning
2060	SM2060 is at nDmm slot
2064	SM2064 is at nDmm slot
Negative Value	Error code

Example `int DMMtype = DMMGetType(0);`

DMMGetVer

SM2060 ☑ SM2064 ☑

Description Get DMM software driver version.

#include "SM206032.h"

int DMMGetVer(**int** *nDmm***, double** ***lpfResult*)

Remarks This function returns the DMM software driver version, which is a double floating value.

Parameter	Type/Description

nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpfResult	**double *** Pointer to the location which holds the version.

Return Value Integer error code.

Value	Meaning
Negative Value	Error code

Example

```
int status; double ver;
status = DMMGetVer(0, &ver);
```

DMMInit

SM2060 ☑ SM2064 ☑

Description Initialize a DMM.

#include "SM206032.h"

int DMMInit(**int** *nDmm,* **LPCSTR** *lpszCal*)

Remarks This function or **DMMQuickInit()** must be the first function to be executed. It opens the driver for the specified DMM. The first DMM being 0, the second 1, etc.. It also initializes the DMM hardware and does extensive self test to the DMM hardware. It then initializes the software and reads the appropriate calibration record for the respective DMM from the file specified by *lpszCa,* followed by self calibration. If the calibration record is outdated, it opens a warning window. If an error is detected, an error code is returned.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszCal	**LPCSTR** Points to the name of the file containing the calibration constants for the DMM. Calibration information is normally read from the file named **SM60CAL.DAT** located in the current directory.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code

Example

```
/* initialize DMM */
int i = DMMInit(0,"C:\SM60CAL.dat");      // Initialize the first DMM
```

DMMIsAutoRange

SM2060 ☑ SM2064 ☑

Description Get the status of the autorange flag.

#include "SM206032.h"

int DMMIsAutoRange(**int** *nDmm*)

Remarks This function returns the DMM autorange flag state.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value TRUE, FALSE or an error code.

Value	**Meaning**
TRUE	Autoranging mode is selected.
FALSE	Autoranging mode is not selected.
DMM_E_DMM	Invalid DMM number.

Example

```
int autorange = DMMIsAutoRange(0);
```

DMMIsInitialized

SM2060 ☑ SM2064 ☑

Description Get the status of the DMM.

#include "SM206032.h"

int DMMIsInitialized(**int** *nDmm*)

Remarks This function returns the status of the DMM. If TRUE, the DMM has been initialized and is active. If FALSE the DMM is not initialized. To use the DMM, it must be initialized using **DMMInit** or **DMMQuickInit** functions. This function is used for maintenance and is not needed under normal operation.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value TRUE, FALSE or an error code.

Value	**Meaning**
TRUE	DMM is initialized and active.
FALSE	DMM is not initialized.
DMM_E_DMM	Invalid DMM number.

Example

```
int active = DMMIsInitialzied(0);
```

DMMIsRelative

SM2060 ☑ SM2064 ☑

Description Get the status of the Relative flag.

#include "SM206032.h"

int DMMIsRelative(int *nDmm*)

Remarks This function returns the DMM Relative flag state.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer TRUE, FALSE or an error code.

Value	Meaning
TRUE	Relative mode is selected.
FALSE	Relative mode is not selected.
Negative Value	Error code

Example
```
int rel = DMMIsRelative(0);
```

DMMOpenPCI

SM2060 ☑ SM2064 ☑

Description Open the PCI bus for the specified DMM. Not for user application.

#include "SM206032.h"

int DMMOpenPCI(int *nDmm*)

Remarks This function is limited for servicing the DMM. It has no use in normal DMM operation.. See also **DMMClosePCI()** function.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example
```
int status = DMMOpenPCI(0);
```

DMMOpenCalACCaps

SM2060 ☐ SM2064 ☑

Description Calibrate the AC based in circuit capacitance function.

#include "SM206032.h"

int DMMOpenCalACCapsl(int *nDmm*)

Remarks This function characterizes the selected range of the AC Capacitance measurement path and source, which is required prior to making measurements. For better accuracy it should be performed frequently. It should be performed without test leads. This function characterizes the stimulus source at the specific frequency associated with the selected range. It takes about fifteen seconds to complete the process. Make sure to perform this operation for each range you intend to use.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example
```
int status = DMMOpenCalACCaps(0);
```

DMMOpenTerminalCal

SM2060 ☐ SM2064 ☑

Description Calibrate the Inductance measurement function with open terminals.

#include "SM206032.h"

int DMMOpenTerminalCal(int *nDmm*)

Remarks This function characterizes the Inductance measurement path and source, which is required prior to making inductance measurements. It should be performed within one hour, before using the inductance measurements. For better accuracy it should be performed more frequently. The Open Terminal calibration should be performed with the test leads open. The **DMMOpenTerminalCal** sweeps the inductance stimulus source across the full bandwidth, and makes measurements at several points. It takes about twenty seconds to complete the process. For a complete characterization of the Inductance measurement system it is also necessary to perform the inductance zero operation with the inductance range and frequency selected, using the Relative function and with the probes shorted.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.

Negative Value	Error code

Example

```
int status = DMMOpenterminalCal(0);
```

DMMPeriodStr

SM2060 ☐ SM2064 ☑

Description

Return the next DMM period reading, formatted for printing.

#include "SM206032.h"

int DMMPeriodStr(**int** *nDmm*, **LPSTR** *lpszReading*)

Remarks

This function makes a period measurement and returns the result as a string formatted for printing. The print format is fixed to five digits plus units, e.g., 150.01 ms. See **DMMFrequencyStr()** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the converted result. The return value will consist of a leading sign, a floating-point value in exponential notation, and a units specifier.

Return Value

The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully terminated
Negative Value	Error code
DMM_CNT_RNG	Period measurement H/W is over or under range.

Example

```
char cBuf[64];
int status;
status = DMMPeriodStr(0, cBuf);
```

DMMPolledRead

SM2060 ☑ SM2060 ☑ SM2064 ☑

Description Tests the DMM for ready status, and returns the next floating-point reading.

#include "SM206032.h"

int DMMPolledRead(int *nDmm*, **double FAR ****lpdResult***)**

Remarks **DMMPolledRead** polls the DMM for readiness. If the DMM is not ready it will return **FALSE**. If the DMM is ready with a new reading it will return **TRUE**, and the reading will be placed at the location pointed to by *lpdResult*. See **DMMPolledReadCmd** for more details. Do not use **DMMReady** to check for readiness since it will cause communication failure.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double FAR *** Points to the location to hold the next reading.

Return Value The return value is one of the following constants.

Value	Meaning
FALSE	DMM is not ready
TRUE	DMM is ready, and reading is placed at *lpdResult*
Negative Value	Error code

Example

```
double read;
if(DMMPolledRead(0, &d)) fprintf(“%9.4f\n”,d);  // Show
```

DMMPolledReadCmd

SM2060 ☑ SM2064 ☑

Description Send DMM Polled Read command.

#include "SM206032.h"

int DMMPolledReadCmd(**int** *nDmm*)

Remarks If the DMM is not busy with a prior Polled read process, this function will trigger the DMM to execute a single read command. The DMM must be set to a specific range and one of the following functions to use the polled read command: VDC, VAC, IDC, IAC, 2-wire, 4-wire, 6-wire, or RTD function. Composite functions such as Capacitance, Inductance, Peak-to-Peak etc. are not capable of polled read operation. Measurement Aperture should be set to 160ms or lower. If FALSE is returned, the DMM is busy processing a prior polled read. A DMM_OKAY indicates the DMM accepted the read command and entered the busy state. The DMM remains busy until it is ready with the next reading. This function is useful where it is necessary to conserve CPU time and make the DMM a polled device. Use **DMMPolledRead** or **DMMPolledReadStr** to test for readiness and read measurement. Do not use **DMMReady** to check for readiness since it will cause communication failure.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value DMM_OKAY if command accepted, else FALSE or an error code.

Value	Meaning
FALSE	DMM is busy and can't execute a polled read command.
DMM_OKAY	Operation successful. DMM entered busy state
Negative Value	Error code

Example

```
int status = DMMPolledReadCmd(0);
```

DMMPolledReadStr

SM2060 ☑ SM2064 ☑

Description If DMM is ready, return the next reading from the DMM formatted for printing.

#include "SM206032.h"

int DMMPolledReadStr(**int** *nDmm*, **LPSTR** *lpszReading*)

Remarks This function is the string version of **DMMPolledRead**. See **DMMPolledRead** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the converted result. The return value will consist of a leading sign, a floating-point value in exponential notation, and a units specifier.

Return Value The return value is one of the following constants, or the string length is OK.

Value	Meaning
FALSE	DMM is not ready
TRUE	DMM is ready, and reading is placed at *lpszReading*
Negative Value	Error code

Example

```
char strMsg[64];
if(DMMPolledReadStr(0, strMsg)) MessageBox(0,strMsg,
"SM2064",MB_OK);  // display readings;
```

DMMQuickInit

SM2060 ☑ SM2064 ☑

Description Initialize a DMM without tests.

#include "SMX2060.h"

int DMMQuickInit(int *nDmm,* **LPCSTR** *lpszCal*)

Remarks This function or **DMMInit()** must be the first functions to be executed. It opens the driver for the specified DMM. The first DMM being 0, the second 1, etc... It also initializes the DMM hardware. This function is designed for speed and therefore does not perform the various self tests and calibration performed by the DMMInit functions. It initializes the software and reads the appropriate calibration record for the DMM from the file specified by *lpszCal*. Depending on the operating system, the execution of this function can be under 100ms.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszCal	**LPCSTR** Points to the name of the file containing the calibration constants for the DMM. Calibration information is normally read from the file named **SM60CAL.DAT** located in the current directory.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code

Example
```
/* initialize DMM */
int i = DMMQuickInit(0,"C:\SM60CAL.dat"); // Quickly initialize the first DMM
```

DMMRead

SM2060 ☑ SM2064 ☑

Description Return the next floating-point reading from the DMM.

#include "SM206032.h"

int DMMRead(int *nDmm***, double ****lpdResult***)**

Remarks Executing the **DMMRead** function causes the DMM to perform a single conversion and retrieve the result. The DMM, performs all scaling and conversion required, and returns the result as a 64-bit double-precision floating-point number in the location pointed to by *lpdResult*. It can read all the **Primary** functions (those that can be selected using **DMMSetFunction()** and **DMMSetRange()**). Returned result is a scaled value which is normilized to the selected range. That is . That is, it returns 200 for 200mV input in the 240 mV range, and 100 for 100 kΩ input in the 330k Ω range. Alternatively use the **DMMReadNorm()** function for base units read function, or **DMMReadStr()** to return the results as formated string of the **DMMRead()**.Very large values are indication of over range condition.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the next reading.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code
Positive Value	Warning code, including over range.

Example

```
double dResults[100];
int status;
For(i=0; I < 100; i++) DMMRead(0, &dResults[i]);// Read to a buffer
```

DMMReadBuffer

SM2060 ☑ SM2064 ☑

Description Return the next double floating-point reading from the DMM internal buffer.

#include "SM206032.h"

int DMMReadBuffer(**int** *nDmm,* **double ****lpdResult*)

Remarks Read the next measurement from the DMM internal buffer, pointed to by an internal buffer pointer, and increment the pointer. Store the measurement as a 64-bit double-precision floating-point number in the location pointed to by *lpdResult*. Limit using this operation to the number of samples (size) of the buffer. See **DMMArmAnalogTrigger()** functions for more information about the buffer size.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location which holds the stored measuremnt.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error Code

Example

```
double Buffer[10];
int status;
DMMArmTrigger(0,10);    // Set up for 10 triggered samples
while( ! DMMReady(0));
for(i=0; i < 10 ; i++)
      status = DMMReadBuffer(0, &Buffer[i]);
```

DMMReadBufferStr

SM2060 ☑ SM2064 ☑

Description Return the next reading, formatted for printing.

#include "SM206032.h"

int DMMReadBufferStr(**int** *nDmm*, , **LPSTR** *lpszReading*)

Remarks The same as **DMMReadBuffer()** except the reading is formatted as a string with units. Measurements are stored as a null terminated string at the location pointed to by *lpszReading*.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to the location which holds the formatted reading string. Allow minimum of 64.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
char Buf[64];
DMMArmTrigger(0,1);     // take a single triggered sample
while( !DMMReady(0));
DMMReadBufferStr(0, Buf);
```

DMMReadCJTemp

SM2060 ☑ SM2064 ☑

Description Read cold junction temperature for thermocouple measurement.

#include "SM206032.h"

int DMMReadCJTemp(int *nDmm*, **double ***lpd*Temp***)**

Remarks Read the cold juncion temperature sensor for subsequent thrermocouple measurements. When measuring temperature using thermocouples it is necessary to establish a reference or cold junction temperaturem. This is the temperature at which the themocouple wires are connected to the DMM or to the switching card's cooper wires. One way to do this is by measuring the cold junction sensor using this function. **DMMReadCJTemp()** function reads the sensor output voltage (0 to +/-3.3V), and converts it to cold junction temperature using the built in equation Temp = b + (Vcjs – a)/m. The default values of a, b and m are designed specifically for the temperarute sensor of the SM40T terminal block. The value of the cold junction temperature is saved internally for subsequent thermocouple measurements as well as return at the location pointed to by lp*dTemp*.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdTemp	**double *** Points to the location to hold the temperature.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
DMMReadCJTemp(0, &temp);
```

DMMReadCrestFactor

SM2060 ☐ SM2064 ☑

Description Return ACV signal's Crest Factor.

#include "SM206032.h"

int DMMReadCrestFactor(int *nDmm*, **double ****lpdResult*)

Remarks To use this function the DMM must be in ACV measurement function, and a valid range must be selected. A double-precision floating-point Crest Factor is stored in the location pointed to by *lpdResult*. This measurement is a composite function, utilizing several sub functions, and could take over 10 seconds to perform. See the Crest Factor measurement section of the manual for more detail.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the Crest Factor.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example `double CF; int status = DMMReadCrestFactor(0, &CF);`

DMMReadDutyCycle

SM2060 ☐ SM2064 ☑

Description Return percent duty cycle of ACV signal.

#include "SM206032.h"

int DMMReadDutyCycle(int *nDmm,* **double ****lpdDcy*)

Remarks This is a **Secondary** function and the DMM must be in AC measurement function, and a valid range must be set. It returns percent duty cycle of the signal. It is stored as double-precision floating-point numbers in the location pointed to by *lpdDcy*. The measured duty cycle is effected by the setting of the Threshold DAC.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdDcy	**double *** Points to the location which holds the duty cycle.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example `double dcy; int state; state = DMMReadDutyCycle(0, &dcy);`

DMMReadFrequency

SM2060 ☑ SM2064 ☑

Description Return the next double floating-point frequency reading from the DMM.

#include "SM206032.h"

int DMMReadFrequency(int *nDmm,* **double ****lpdResult*)

Remarks This is function, that is the DMM must be in ACV measurement function, and a valid range must be selected for proper operation. If the frequency counter is not engaged, select it. Make a single frequency measurement, and store the result as a 64-bit double-precision floating-point number in the location pointed to by *lpdResult*. See **DMMFrequencyStr()** for more details. In cases where the of frequency being measured is approximately known, use **DMMSetCounterRng** to select the appropriate range. This will eliminate the self ranging of the counter, resulting in a single measurement to acquire the frequency.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the frequency.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
DMM_E_INIT	DMM is uninitialized. Must be initialize prior to using any function.
DMM_E_DMM	Invalid DMM number.

Example

```
double d;
int status = DMMReadFrequency(0, &d);
```

DMMReadInductorQ

SM2060 ☐ SM2064 ☑

Description Return inductor's Q value.

#include "SM206032.h"

int DMMReadInductorQ(**int** *nDmm,* **double** ******lpdResult*)

Remarks To use this function the DMM must be in the Inductance measurement function, and a valid inductance value must have been read prior to using this function. Resulting Q is stored as double-precision floating-point number in the location pointed to by *lpdResult*.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the inductor's Q.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double Q;
int status = DMMReadInductorQ(0, &Q);
```

DMMReadMeasurement

SM2060 ☑ SM2064 ☑

Description Return a reading which is the result of **DMMSetTrigRead** operation.

#include "SM206032.h"

int DMMReadMeasurement(int *nDmm*, **double ****lpdRead***)**

Remarks This measurement reading function is designed to read triggered measurements from the DMM. It returns **FALSE** if reading is not ready to be read. If a reading is ready, **TRUE** is returned, and the result in the form of a 64-bit double-precision floating-point number is placed at the location pointed to by *lpdRead*.The returned value is in base units, meaning it returns 0.3 for a 300mV input and 1e6 for 1.0 Mohm measurement. This function is designed to read bursting measurements form the DMM, resulting from **DMMSetTrigRead** and **DMMBurstRead** operations. For proper communications with the DMM this function must read the same number as is set by the burst or trigger functions above.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdRead	**double *** Pointer to a location where the reading is saved.

Return Value Integer value version code or an error code.

Value	Meaning
TRUE	Measurement was read into **lpdRead*
FALSE	No measurement is available
TIMEOUT	Communication timeout. No reading available within 9s.
OVERRUN	Communication overrun. PC did not keep up with DMM transmission.
Other Negative Value	Error code.

Example

```
double Reading[150];
DMMBurstRead(0, 4, 150); // 4 settle., 150 samples
for(i=0; i < 150 ; i++)       // read 150 measurements
      while( DMMReadMeasurement(0 , Reading[i]) == FALSE );
// wait for all measurements to be ready, and read them.
```

DMMReadMedian

SM2060 ☐ SM2064 ☑

Description Return ACV signal's Median value.

#include "SM206032.h"

int DMMReadMedian(**int** *nDmm*, **double ****lpdResult*)

Remarks To use this function the DMM must be in ACV measurement function, and a valid range must be selected. A double-precision floating-point Median voltage result is stored in the location pointed to by *lpdResult*. This measurement is a composite function which utilizes several sub functions, and could take over 10 seconds to perform. See the Median measurement section of the manual for more detail.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the median voltage.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double Median; int status = DMMReadMedian(0, &Median);
```

DMMReadNorm

SM2060 ☑ SM2064 ☑

Description Take a reading that is in base value.

#include "SM206032.h"

int DMMReadNorm(int *nDmm*, **double ****lpdRead***)**

Remarks This function is similar to **DMMRead()**. It returns a double floating-point reading. The returned value is in base units. That is, it returns 0.2 for a 200 mV input and 1e6 for a 1.0 MΩ. Very large values are indication of over range condition.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdRead	**double *** Pointer to a location where the reading is saved.

Return Value Integer value version code or an error code.

Value	Meaning
DMM_E_RANGE	Over/Under range error.
Negative Value	Error code
DMM_OKAY	Valid return.

Example

```
double reading; int status = DMMReadNorm(0, &reading);
```

DMMReadPeakToPeak

SM2060 ☐ SM2064 ☑

Description Return ACV signal’s peak-to-peak value.

#include "SM206032.h"

int DMMReadPeakToPeak(int *nDmm,* **double ***lpdResult*)

Remarks To use this function, the DMM must be in ACV measurement function, and a valid range must be selected. A double-precision floating-point peak-to-peak voltage result is stored in the location pointed to by *lpdResult*. This measurement is a composite function which utilizes several sub functions, and could take over 10 seconds to perform.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location to hold the Peak-to-Peak value.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double ptp; int status = DMMReadPeakToPeak(0, &ptp);
```

DMMReadPeriod

SM2060 ☐ SM2064 ☑

Description Return the next double floating-point period reading from the DMM.

#include "SM206032.h"

int DMMReadPeriod(int *nDmm,* **double ***lpdResult*)

Remarks This is a **Secondary** function, that is the DMM must be in ACV measurement function, and a valid range must be selected for this operation. It makes a single period measurement, and stores the result as a double-precision floating-point number in the location pointed to by *lpdResult*. See **DMMFrequencyStr()** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdResult	**double *** Points to the location which holds the period.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double d;
int status;
status = DMMReadPeriod(0, &d);
```

DMMReadStr

SM2060 ☑ SM2064 ☑

Description Return the next reading from the DMM formatted for printing.

#include "SM206032.h"

int DMMReadStr(**int** *nDmm,* **LPSTR** *lpszReading*)

Remarks This function is the string version of **DMMRead()**. It reads the next measurement result, performs all scaling and conversion required, and returns the result as a string formatted for printing. The print format is determined by the range and function. See **DMMRead()** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszReading	**LPSTR** Points to a buffer (at least 64 characters long) to hold the converted result. The return value will consist of a leading sign, a floating-point value in exponential notation, and a units specifier.

Return Value The return value is one of the following constants, or the string length is OK.

Value	Meaning
DMM_OKAY	Valid return.
Negative Value	Error code
DMM_E_RANGE	DMM over range error occurred.

Example

```
char cBuf[64]; int status = DMMReadingStr(0, cBuf);
```

DMMReadTotalizer

SM2060 ☐ SM2064 ☑

Description Read the totalized value accumulated by the Totalizer function.

#include "SM206032.h"

long DMMReadTotalizer(int *nDmm*)

Remarks This function reads the total value accumulated by the Totalizer function. For details see **DMMStartTotalize**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value The return value is the totalized count, or if negative one of the following constants.

Value	Meaning
Negative Value	Error code

Example

```
long total = DMMReadTotalizer(0);
```

DMMReadWidth

SM2060 ☐ SM2064 ☑

Description Return the pulse width of the input signal.

#include "SM206032.h"

int DMMReadWidth(**int** *nDmm,* **int** i*Pol,* **double** ******lpdWidth*)

Remarks This is function requires the DMM to be in ACV measurement range appropriate for the input signal amplitude. It makes a Positive or Negative signal width measurements, depending on the value of *iPol*, placing the double-precision floating-point result in a location pointed to by *lpdWidth* . The measured widths are affected by the setting of the Threshold DAC.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iPol	**int** 0 indicates to the DMM to measure the negative part of the signal, 1 indicates the positive width.
lpdNwid	**double *** Points to the location which holds the negative width.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double w; int state; state = DMMReadWidth(0, 1, &w);
```

DMMReady

SM2060 ☑ SM2064 ☑

Description Return the ready state of the DMM following trigger operation.

#include "SM206032.h"

int DMMReady(int *nDmm*)

Remarks Following the completion of a triggered measurement event, be it hardware or software, the **DMMReady** function is used to detect completion. The **DMMReady** function checks the DMM and returns TRUE (1) if ready, and FALSE (0) otherwise. Once a TRUE status is returned, the **DMMReady** function should not be used again since the **DMMReady** function clears some flags in preparation for data transfer when it detects a ready state. See **DMMArmAnalogTrigger**, **DMMArmTrigger**, **DMMTrigger**, **DMMReadBuffer** and **DMMPolledReaed** for more details on this function.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value The return value is one of the following constants.

Value	Meaning
TRUE	DMM is done and buffer is ready to be read.
FALSE	DMM is not ready.
Negative Value	Error code

Example

```
double Buffer[10];
DMMTrigger(0,10);
while( ! DMMReady(0) );
      for(i=0; i < 10 ; i++) j = DMMReadBuffer(0, &Buffer[i]);
```

DMMSetACCapsDelay

SM2060 ☐ SM2064 ☑

Description Set the measurement delay of AC based Capacitance.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetACCapsDelay(int *nDmm***, double** *ldDelay***)**

Remarks This **Secondary** function sets the AC based capacitance measurement delay, which is the time the measurement system settles. The DMM's default value is 2.0s. This function can set this function from 0.0 to 10.0 seconds. Since the DMM is optimized for the defalut value, it is possible that changing this value will introduce additional error.

Parameter	Type/Description

nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldDelay	**double** The time the DMM is allowed to settle the measurement. Can be set beetween 0 and 10.0 seconds.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetACCapsDelay(0, 0.25); // Set measurement delay to 0.25s
```

DMMSetACCapsLevel

SM2060 ☐ SM2064 ☑

Description Set the DCV source output level.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetACCapsLevel(int *nDmm*, **double** *ldVolts***)**

Remarks This function sets the AC peak voltage level for the In-Circuit Capacitance measurement function. This value is used on any of the AC Caps calibration and measurement. Following setting of this function, it is necessary to perform open calibration of the AC Capacitance ranges to be used. Since the DMM is optimized for the defalut value, it is recommended not to use this function and keep the default 0.45V peak value.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldVolts	**double** Peak value of AC voltage to be set. Can be 0.1V to 5.0V

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetACCapsLevel(0, 0.35); // Set stimulus to 0.35V peak
```

DMMSetACVSource

SM2060 ☐

Description Set the ACV source output level and frequency.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetACVSource(int *nDmm*, **double** *ldVolts*, **double** *ldFreq***)**

Remarks This function sets the AC voltage source to RMS amplitude of *ldVolts*, and the frequency to *ldFreq*. The DMM must be in **VAC_SRC** operation for this function to execute properly. Reading the DMM **(DMMRead, DMMReadStr**) will return the measurement of the output voltage. This function acts on the main 12 bit source DAC. Two ranges are available in VAC_SRC mode, the 0.9 V and the 7 V.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldVolts	**double** AC RMS voltage to be set. Range: 0.05 to 7.25 V RMS
ldFreq	**double** DC voltage to be set. Range: 1 Hz to 200 kHz

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double reading; int I;
DMMSetACVSource(0, 7.0, 1000.0); // source 7V and 1kHz
DMMSetSourceMode(0, CLOSED_LOOP); // Closed loop mode
for(I=0;I<100;I++) DMMRead(0,&reading); // update 100 times
```

DMMSetAperture

SM2060 ☑ SM2064 ☑

Description Set the measurement Aperture.

#include "SMX2060.h"
#include "DMMUser.h"

int DMMSetAperture(**int** *nDmm,* **int** *iAperture*)

Remarks This function sets the measurement Aperture. This is the the integration time of the A/D or the timer during which the A/D makes a measurement. The allowed values are defined in the DMMUser.h file. Depending on DMM model and mode of operation, the highest Aperture can be set as high as 5.066s (APR_5p066s) and the lowest 2.5µs (APR_2p5us). See sections 2.11 and 4.4 for details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iAperture	**int** A pre-defined constant corresponding to the desired integration time.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code
ERR_APERTURE	Invalid aperture value.

Example

```
status = DMMSetAperture(0, APR_16p67ms);  // Set to 16.66ms
```

DMMSetAutoRange

SM2060 ☑ SM2064 ☑

Description Enable/Disable autorange operation of DMM

#include "SM206032.h"

int DMMSetAutoRange(int *nDmm*, **int** *bAuto*)

Remarks This function enables or disables autorange operation of the DMM.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
bAuto	**int** Determines whether or not autoranging is done. The value TRUE (1) enables autoranging, FALSE (0) disables it.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example

```
status = DMMSetAutoRange(0, TRUE); /* enable autoranging */
```

DMMSetBuffTrigRead

SM2060 ☑ SM2064 ☑

Description Setup the DMM for Triggered operation.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetBuffTrigRead(int *nDmm***, int** *iSettle***, int** *iSamples***, int** *iEdge***)**

Remarks

Setup the SM2060 for external hardware trigger operation. Following reception of this command the DMM enters a wait state. After reception of an external trigger edge of *iEdge* polarity, the DMM takes *iSettle* + 1 readings at the set measurement function, range, Aperture and Read Interval; and stores the last reading in the in an internal buffer. This process is repeated for *iSamples*. This function is particularly useful in conjunction with a triggering instruments such as the SM4042 or SMX4032 relay scanner. No autoranging, function or ranges changes allowed while the DMM is waiting for triggers. The number of trigger edges must be equal or greater than *iSamples* to properly terminate this mode. Any trigger received following iSamples is ignored. Between the time this command is issued and the time the buffer is read, no other command should be sent to the DMM with the exception of **DMMDisarmTrigger** command, which terminates this mode, and **DMMReady** which monitors readyness. This function is usable for VDC, VAC, Ohms, IAC, IDC and RTD measurements.

Use the **DMMReady** to monitor when the DMM is ready (following trigger(s) and the reading of *iSamples*). When ready, you can read up to *iSamples*, using **DMMReadBuffer** or **DMMReadBufferStr** functions. Once **DMMReady** returns **TRUE**, it should not be used again prior to reading the buffer, since it prepares the buffer for reading when it detects a ready condition.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iSettle	**int** The number of setteling measurements, prior to read value. Must be set between 0 and 250.
iSamples	**int** The number of samples the DMM takes following the same number of trigger pulses. This number must be between 1 and 80 or 120 depending on aperture.
iEdge	**Int** The edge polarity of the trigger signal. 1 for Positive, or leading edge, and 0 for negative or trailing edge trigger.

Return Value

The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
double Buffer[120];
DMMSetBuffTrigRead(0, 4, 50, 0); // Negative edge, 4
//setteling readings, and 50 samples/trigger
while( ! DMMReady(0) );       // wait for completion
for(i=0; i < 50 ; i++)        // read buffer
      j  = DMMReadBuffer(0, &Buffer[i]);
```

DMMSetCapsAveSamp

SM2060 ☐ SM2064 ☑

Description

Tunes the capacitance measurement function parameters for higher measurement speed.

#include "SM206032.h"

Int DMMSetCapsAveSamp(int *nDmm,* **int** *iAverage,* **int** *iSamples*)

Remarks

This function should be used carefully since it modifies the capacitance function basic measurement parameters; the averages value, *iAverage*, and the number of points sampled, *iSamples*. This function is provided only for cases where it is necessary to improve measurement speed. When using this function keep in mind that the accuracy specification provided for capacitance is not guaranteed. Also, modifying these values could have profound efect on the operation of the function. Any time a capacitance range is change, these values are set to the default values. For instance, values of 1 and 3 for *iAverage*, and *iSamples* will reduce measurement time on the 12nF range from 0.8s to about 50ms.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iAverage	**int** The average value, must be set between 1 and 100.
iSamples	**int** The number of samples must be set to at least 3.

Return Value

The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
int status = DMMSetCapsAveSamp(0,1,3);
```

DMMSetCJTemp

SM2060 ☑ SM2064 ☑

Description

Set cold junction temperature for thermocouple measurement.

#include "SM206032.h"

int DMMSetCJTemp(int *nDmm***, double** *dTemp***)**

Remarks

This function sets the cold junction temperature for subsequent thermocouple measurements. When measuring temperature using thermocouples it is necessary to establish a reference or cold junction temperature. This is the temperature at which the thermocouple wires are connected to the DMM or to the switching card's cooper wires. One way to do this is by simply entering this value using this function. Another is by measuring using a temperture sensor located at the connection point. *dTemp* must be entered using the currently set temperature units. See **DMMSetTempUnits** function for details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dTemp	**double** The cold junction temperature. Must be set between 0^oC and 50^oC or the corresponding ^oF.

Return Value

The return value is one of the following constants.

Value	Meaning

DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example `DMMSetCJTemp(0, 22.5);`

DMMSetCompThreshold

SM2060 ☐ SM2064 ☑

Description Set the Threshold DAC level.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetCompThreshold(int *nDmm***, double** *ldThreshold***)**

Remarks This function sets the output of the Threshold DAC. To use this function, the DMM must be in AC volts. This function sets the detection threshold of the AC comparator. It is compared by the comparator to the AC coupled input voltage. This function efffects the following functions: Totalizer, Frequency counter, Period, Pulse width and Duty Cycle measurements. *ldThreshold* range is determined by the selected ACV range. For instance, when the 240 V AC range is selected, the allowed range of *ldThreshold* is –500 V to +500 V. See the specification section for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldThreshold	**double** DC voltage to be set. Allowed range depends on selected ACV range.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example `DMMSetCompThreshold(0,28.5); // Set comp. threshold to 28.5V`

DMMSetCounterRng

SM2060 ☐ SM2064 ☑

Description Set the frequency counter to a specific range.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetCounterRng(int *nDmm***, int** *fRange***)**

Remarks This function forces the auto-ranging frequency counter to a specific range, *fRange*. Use this function if the approximate frequency to be measured is known. It will eliminate the time necessary for the counter to autorange to the appropriate range. It saves time by removing the requirement to make multiple frequency measurements in order to allow the counter to range. All ranges are defind in ***DMMUser.h*** file.

fRange Symbol	fRange Value	Frequency Range
COUNTR_20HZ	7	1.9 Hz to 19.9
COUNTR_130HZ	6	19.9 Hz to 128.8 Hz
COUNTR_640HZ	5	128.8 Hz to 640 Hz
COUNTR_2500HZ	4	640 Hz to 2.56 kHz
COUNTR_10kHZ	3	2.56 kHz to 10.24 kHz
COUNTR_40kHZ	2	10.24 kHz to 40.96 kHz
COUNTR_200kHZ	1	40.96 kHz to 200 kHz
COUNTR_500kHZ	0	200 kHz to 500 kHz

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
fRange	**int** The range to be set is a value between 0 and 7. See ***DMMUser.h***

Return Value Integer error code.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetCounterRng(0, COUNTR_320HZ); // Set counter to measure a
frequency between 65Hz to 320Hz
```

DMMSetDCISource

SM2060 ☐ SM2064 ☑

Description Set the DCI source output level.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetDCISource(int *nDmm***, double** *ldAmps***)**

Remarks This function sets the DC current source to *ldAmps*. The DMM must be in **IDC_SRC**, and an valid range must be selected for this function to execute properly. Reading the DMM **(DMMRead** or **DMMReadStr**) will return the voltage measurement at the terminals. This function acts on the main 12 bit source DAC. If better resolution is required it can be accomplished by setting the Trim DAC by using the **DMMSetTrimDAC** function. There are five current source ranges. The DMM reads the output (load) voltage using the 24 V range.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldAmps	**double** DC current to be set. Can be 0 to 1.25 X the selected range

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetRange(0, _1uA)          // Select 1uA source range
DMMSetDCISource(0, 1.1e-6);   // Set source to 1.1uA
```

DMMSetDCVSource

SM2060 ☐ SM2064 ☑

Description Set the DCV source output level.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetDCVSource(int *nDmm*, **double** *ldVolts***)**

Remarks This function sets the DC voltage source output to *ldVolts*. The DMM must be in **VDC_SRC** for this function to execute properly. Reading the DMM **(DMMRead** or **DMMReadStr**) will return the measurement of the output voltage at the DMM terminals. This function acts on the main 12 bit source DAC. If better accuracy is needed it can be accomplished by selecting the ClosedLoop mode (**DMMSetSourceMode**). This mode engages the Trim DAC, which augments the 12 bit DAC to produce 16 effective bits. In ClosedLoop mode, the source level is adjusted every time the DMM is read, making small corrections until the reading is equal to *ldVolts.* However, for the ClosedLoop mode to update the source level, it is necessary to read the DMM multiple times. Aperture should be set to 80ms or higher, with Read Interval set to 0 when using the Closed Loop mode. The DMM reads voltages using the 24 V range.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldVolts	**double** DC voltage to be set. Can be –10.5 to 10.5 V

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double reading; int I;
DMMSetDCVSource(0, 1.25); // Set source to 1.25V
DMMSetSourceMode(0, CLOSED_LOOP); // Closed loop mode
for(I=0;I<100;I++) DMMRead(0,&reading); // update 100 times
```

DMMSetFastRMS

SM2060 ☑ SM2064 ☑

Description Set the DMM RMS filter response time.

#include "SM206032.h"

int DMMSetFastRMS(int *nDmm*, **int** *bFast*)

Remarks This function selects between the fast and slow filter of the RMS measurement function. The default is FALSE, or slow RMS. Setting *bFast* TRUE (1) selects the fast responding filter, which provides for fast 25ms settling time, and limits the low frequency bandwidth to 400Hz. FALSE (0) selects the slow 500ms settling time, and limits the low frequency bandwidth to 10Hz.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
bRelative	**int** TRUE (1) to enter relative mode, FALSE (0) to clear mode.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM mode changed successfully.
Negative Value	Error code

Example

```
status = DMMSetFastRMS(0, TRUE);    // Set to fast RMS
```

DMMSetFuncRange

SM2060 ☑ SM2064 ☑

Description Set the DMM function and range.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetFuncRange(int *nDmm*, **int** *nFuncRnge*)

Remarks This function provies the ability to set both, function and range in a single instruction. Using it could save some execution time. The table of values is defined as *VDC*_240mV, *VAC*_2400mV, etc.. The definitions are in the DMMUser.h file.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
nFuncRnge	**int** A pre-defined constant corresponding to the desired function and range.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM initialized successfully.

Negative Value	Error code
DMM_E_FUNC	Invalid DMM function.

Example `status = DMMSetFuncRange(0, VDC_3V);`

DMMSetFunction

SM2060 ☑ SM2064 ☑

Description Set the DMM function.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetFunction(int *nDmm,* **int** *nFunc*)

Remarks This function sets the function used by the DMM. The DMMUser.h file contains a table of values defined as *VDC*, *VAC*, *IAC*, *IDC*, *OHMS4W*, *OHMS2W etc..*. Not all functions are available for all DMM types.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
nFunc	**int** A pre-defined constant corresponding to the desired function.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code
DMM_E_FUNC	Invalid DMM function.

Example `status = DMMSetFunction(0, INDUCTANCE);`

DMMSetInductFreq

SM2060 ☐ SM2064 ☑

Description Set the frequency of the Inductance Source.

#include "SM206032.h"

int DMMSetInductFreq(int *nDmm***, double** *lpdFreq***)**

Remarks This function sets the frequency of the Inductance measurement source. The value of the frequency should be between 20 Hz and 100kHz. This function overrides the default frequency for each of the inductance ranges. Therefore, setting a new Inductance measurement range changes this frequency, and may result in higher error than that at the default value. Use this function after setting the range.

Parameter	**Type/Description**

nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdFreq	**double** Frequency to be set.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
int status = DMMSetInductFreq(0, 10e3); // Set source to 10kHz
```

DMMSetOffsetOhms

SM2060 ☑ SM2064 ☑

Description Enable/Disable Offset Ohms operation

#include "SM206032.h"

int DMMSetOffsetOhms(**int** *nDmm,* **int** *bState*)

Remarks This function enables or disables the Offset Ohms compensation function. The default value is FALSE, or no Offset Ohms compensation. When set to TRUE the measurement rate reduced by about a factor of 2 from the set value.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
bState	**int** Determines whether or not Offset Ohms is enabled. The value TRUE enables, FALSE disables it.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example

```
status = DMMSetOffsetOhms(0, TRUE); /* enable OffsetOhms */
```

DMMSetPXITrigger

SM2060 ☐ SMX2064 ☑

Description Set the PXI Trigger input and output for the SMX2064.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetPXITrigger(int *nDmm*, **int** *iTrigIn*, **int** *iTrigOut*)

Remarks This function configures the SMX2064 PXI trigger input and output. *iTrigIn* value sets the PXI Trigger input to the DMM and *iTrigOut* sets the PXI Trigger output from the DMM. The range of values for both parameters is 0 to 7. On startup, the default value for both is 0, which disconnects both the input and output PXI trigger connections to the DMM. See section 4.18 for more details.

	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iTrigIn	**int** Selects the PXI Trigger input source. Value 0 to 7. 0 – default, deselects all trigger inputs from the PXI bus.
iTrigOut	**int** Selects the PXI Trigger line to which the DMM DMM Trigger out is connected. Value 0 to 7. 0 – default, disconncets the DMM Trigger oput from the PXI trigger bus.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetPXITrigger(0, 1, 0);
```

DMMSetRange

SM2060 ☑ SM2064 ☑

Description Set the DMM range for the present function.

#include "SM206032.h"

int DMMSetRange(**int** *nDmm*, **int** *nRange*)

Remarks This function sets the range used by the DMM for the present function. The table of values is defined by the *_330mV, _3mA, etc.* In general, the lowest range is 0, next is 1 etc. Each function has a pre defined number of ranges as specified in the specification section of this manual. Not all ranges are available for all DMM types. For instance the SM2064 has a 24 Ohms and 240Meg range, while the SM2060 does not.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
nRange	**int** A pre-defined constant corresponding to the desired range.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM initialized successfully.
Negative Value	Error code
DMM_E_RANGE	Invalid DMM range value.

Example

```
status = DMMSetRange(0, _330mA);
```

DMMSetReadInterval

SM2060 ☑ SM2064 ☑

Description Set the measurement cycle time parameter.

#include "SMX2060.h"
#include "DMMUser.h"

int DMMSetReadInterval(int *nDmm*, **double** *dReadInterval***)**

Remarks This function sets the reading interval (the time it takes to make a single reading). For Apretures between 625us and 5.066s it may be set between 0 to 1s. For Aperture values between 2.5us and 521us it can be set between 0 to 65ms. This value effects most measurement functions including the various triggered modes. The default of this parameter is set to 0, resulting in the fastest measurement rate at the selected Aperture. Use this function where precise control over the measurement time is necessary.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iReadInterval	**doulbe** This value can be from 0 to 1.0 depending on selected Aperture and operating mode..

Return Value Integer error code.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetReadInerval(0, 0.002); //Set read-interval to 2ms
```

DMMSetReference

SM2060 ☑ SM2064 ☑

Description Set measurement reference value for deviation measurements.

#include "SM206032.h"

int DMMSetReference(int *nDmm*, **double** *dRef***)**

Remarks This function sets a measurement reference. Unlike **DMMSetRelative**, which uses the current measurement as a reference, **DMMSetReference** provides the facility to set the reference to *dRef*. Once set, it is subtracted or divided from subsequent measurements. It effects both, normal measurements and percent diviation measurements using **DMMRead** and **DMMGetDeviation** functions respectively. The latter can be used for production sorting. For instance, to reject 1.00kΩ reistors that diviate from 0.5%, set the reference to 1,000.0. While measuring resistance, ascertain that absolute values returned by **DMMGetDeviation** are smaller than 0.5 (0.5%). To cancell the effect of this fuction, set relative to **FALSE** using the **DMMSetRelative** function.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

dRef	**double** Reference value.

Return Value Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double  error;
int status = DMMSetReferebce(0, 1000.0); // set 1k reference
```

DMMSetRelative

SM2060 ☑ SM2064 ☑

Description Set the DMM relative reading mode for the present function.

#include "SM206032.h"

int DMMSetRelative(int *nDmm,* **int** *bRelative*)

Remarks This function selects relative or absolute reading mode for the DMM. If the *bRelative* parameter value is TRUE (1), the DMM will change to relative reading mode. If FALSE, the DMM will change to absolute reading mode.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
bRelative	**int** TRUE (1) to enter relative mode, FALSE (0) to clear mode.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	DMM mode changed successfully.
Negative Value	Error code

Example
```
status = DMMSetRelative(0, TRUE);
```

DMMSetRTD

SM2060 ☐ SM2064 ☑

Description Set the RTD parameters.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetRTD(int *nDmm***, double** *ldRo***)**

Remarks This function sets the RTD parameters. The DMM must be in **RTD** measurement function for this function to execute properly. Use 4-wire RTD connection for best results. *ldRo* sets the RTD R_o (Ice point resistance). Since it modifies the default R_o parameter for the selected RTD, this function must follow the selection of the basic RTD type, using **DMMSetRange**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iWires	**int** RTD's number of connecting wires RTD_4_W or RTD_3_W
ldRo	**double** R_o resistance. See specs for allowed range for each RTD type.

Return Value Integer error code.

Value	Meaning

DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetFunction(0, RTD);        // RTD measurement function
DMMSetRange(0, 1 _pt385);      // Select RTD
DMMSetRTD(0, RTD_4_W, 1000.0); // Set Ro = 1k Ohms
```

DMMSetSensorParams

SM2060 ☑ SM2064 ☑

Description Set the cold junction temperature sensor equation parameters.

#include "SM206032.h"

int DMMSetSensorParams(int *nDmm***, double** *lda,* **double** *ldm,* ***double*** *ldb***)**

Remarks This function sets the parameters of the temperature sensor. It effects the cold junction termerature reading which is defined by ((Vcjs - *lda*) / *ldm)* + *ldb*, where Vcjs is the cold junction sensor output voltage. This function set the paramters for the sensor as to allow a wide range of sensors to be used. The default parameters are designed to work with the Signametrics Temperature sensor found on the SM40T and SMX40T screw terminals. The cold junction temperature is calculated by converting the sensor's voltage to temperature. For more information read about **DMMReadCJTemp().**

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lda	**double** the 'a' parameter.
ldm	**double** the 'm' parameter.
ldb	**double** the 'b' parameter.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetSensorParams(0, 0.558, -0.002, 22.0);// set parameters
```

DMMSetSourceMode

SM2060 ☐ SM2064 ☑

Description Set the DCV and ACV sources to ClosedLoop, or OpenLoop mode.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetSourceMode(int *nDmm***, int** *iMode***)**

Remarks This **Secondary** function sets the DC voltage sources to either **OPEN_LOOP** or **CLOSED_LOOP**. In **CLOSED_LOOP** the sources use the main 12 bit source DAC. In **CLOSED_LOOP** the Trim DAC is also used, which augments the 12 bit DAC to produce 16 effective bits. Open loop updates are very quick. In ClosedLoop mode the source level is adjusted every time the DMM is read, making small corrections until the reading is equal to the set voltage. However, for the ClosedLoop mode to update the source level, it is necessary to read the DMM multiple times. See **DMMSetDCVSource** for more details.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iMode	**int** Source adjustment mode: CLOSED_LOOP or OPEN_LOOP

Return Value Integer error code.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetSourceMode(0, CLOSED_LOOP); // Select closed loop mode
```

DMMSetSync

SM2060 ☑ SM2064 ☑

Description Enables and sets polarity of Sync output line.

#include "SM206032.h"

int DMMSetSync(int *nDmm,* **int** *bEnable,* **int** *iPolarity*)

Remarks This function enables or disables the Sync output (available at the DIN7). If *bEnable* is set **TRUE**, iPolarity effects the sync output level. iPolarity set to 0 asserts low level, and 1 sets to high level pulse. This signal can be used as a busy signal or to synchronize the DMM to other instruments. The default is a disabled output, and active low.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
bSync	**int** Determines whether or not the Sync output is enabled. TRUE enables and FALSE disables it. The default is FALSE.
iPolarity	**int** Determines the polarity of the output. 0 sets it to active low and 1 to active high level.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example

```
int status = DMMSetSync(0, TRUE, 1); //positive sync
```

DMMSetTCType

SM2060 ☑ SM2064 ☑

Description Set Thermocouple type.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetTCType(int *nDmm*, **int** *iType*)

Remarks This function selects the thermocouple type to be measured and linearized. It must be one of the following: B, E, J, K, N, R, S or T. See the definitions for these parameters in the DMMUser.h file. The default type is 'K'.

Parameter	**Type/Description**
NDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iTempUnits	**int** The thermocouple type to be selected. This value can be set from BTyppe to TType as defined in the DMMUser.H file.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example

```
int status = DMMSetTCType(0, NType) // select N type TC
```

DMMSetTempUnits

SM2060 ☐ SM2064 ☑

Description Set temperature units to °C or °F.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetTempUnits(int *nDmm*, **int** *iTempUnits*)

Remarks This function sets the temperature units to either °C or °F. This is applicable to both the on-board temperature sensor and the RTD measurements.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

iTempUnits	**int** Temperature units can be either DEG_F for °F, or DEG_C for °C. The default is °C.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example

```
int status = DMMSetTempUnits(0, DEG_F) // set units to °F
```

DMMSetTrigPolarity

SM2060 ☑ SM2064 ☑

Description Enables and sets polarity of DMM Sync output.

#include "SM206032.h"

int DMMSetTrigPolarity(**int** *nDmm*, **int** *iPolarity*)

Remarks This function sets the external hardware trigger polarity. For negative edge set iPolarity to 0, and 1 for positive edge. The default is negative polarity. This effects the various hardware trigger operations.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iPolarity	**int** Determines the polarity of the inut edge. 0 sets it to negative and 1 to positive edge.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example

```
int status = DMMSetTrigPolarity(0, 1); //set positive edge trigger
```

DMMSetTrigRead

SM2060 ☑ SM2064 ☑

Description Setup the DMM for mutiple Triggered readings operation.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetTrigRead(int *nDmm*, **int** *iSettle*, **int** *iSamples*, **int** *iEdge***)**

Remarks

Setup for external hardware trigger operation. Following reception of this command the DMM enters a wait state. In response to the detection of the selected *iEdge* polarity on its external trigger, the DMM makes *iSettle* + 1 readings and sends the last reading to the PC. It does it at the currently set measurement function, range, Aperture and Read Interval. This process is repeated for *iSamples* times. Therefore, *iSamples* Trigger pulses must be issued to complete this process. This function is particularly useful in conjunction with triggering instruments such as the SM4042 relay scanner. No auto ranging is allowed in this mode. Following the issue of this command and until *iSampels* measurements are read back, it is necessary to keep up with the DMM and read all *iSample* measurements as fast as they come. Failing to do so will result in communication overrun. The DMM has a small FIFO to reduce the likelihood of an overrun. This function is usable for VDC, VAC, Ohms, IAC, IDC and RTD measurements. Use the **DMMReadMeasurement** to monitor for data availability, and to read this data.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iSettle	**int** The number of setteling measurements, prior to read value. Must be set between 0 and 250.
iSamples	**int** The number of samples the DMM takes following the same number of trigger pulses. This number must be between 1 and 30,000.
iEdge	**Int** The edge polarity of the trigger signal. 1 for Positive, or leading edge, and 0 for negative or trailing edge trigger.

Return Value

The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
double Reading[150];
DMMSetTrigRead(0, 4, 150, 0); // Negative edge, 4
//setteling readings, and 150 samples/triggers
for(i=0; i < 150 ; i++)       // read buffer
      while( ! DMMReadMeasurement(0 , Reading[i]) );
```

DMMSetTrimDAC

SM2060 ☐ SM2064 ☑

Description

Set the Trim DAC level.

#include "SM206032.h"
#include "DMMUser.h"

int DMMSetTrimDAC(int *nDmm***, int** *iValue***)**

Remarks

This function sets the Trim DAC to a value between 0 and 100. The trim DAC can be set to augment the main 12 bit DAC, whenever it is not automatically performed, such as in VDC and VAC source while **OPEN_LOOP** mode is selected. An example would be in DCI source, or when setting the Comparator Threshold. This function consumes a lot of the on-board microcontroller's resources and must be turned off when not in use. Use **DMMDisableTrimDAC** to turn it off. With the Trim DAC the effective resolution of the composite DAC is increased to 16 bits. See **DMMSetDCVSource** and **DMMSetACVSource** for more details.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iValue	**int** Amplitude can be set from 0 to 100, corresponding to 0% to 100% Trim DAC level.

Return Value Integer error code.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetDCVSource(0, 5.0); // Set source to 5V
DMMSetTrimDAC(0, 50);    // add about 2.5mV to output
```

DMMStartTotalizer

SM2060 ☐ SM2064 ☑

Description Clear the totalized value and start the totalizer.

#include "DMMUser.h"
#include "SM206032.h"

int DMMStartTotalizer(**int** *nDmm*, **int** *Edge*)

Remarks To use this function the DMM must be in ACV measurement function, and a valid range must be selected. This function clears the Totalized count, sets the edge sense, and starts the Totalizer. The totalized value can be read during the accumulation period. However, it could affect the count by the interruption. If no reads are performed during accumulation, the input rate can be as high as 45 kHz. If reads are performed during the accumulation period, this rate could be as low as 20 kHz. The Threshold DAC sets the levels at which signals are counted. During accumulation, no other command (except **DMMReadTotalizer**) should be used. When done, this function must be turned off using **DMMStopTotalizer**. After the Totalizer is stopped, the accumulated result can be read using **DMMReadTotalizer**. A normal procedure would be to set the DMM to the ACV function, select voltage range, set the Threshold DAC, start the totalizer, wait for the time required, stop and read the total. The total number of events is limited to 1,000,000,000. The SM2064S product allows up to 90 kHz input, but reduces the resolution of the count.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
Edge	**int** Identifies the edge of the counter. If TRAILING (0) count negative edges, if LEADING (1) count positive edges

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
int status = DMMStartTotalizer(0, LEADING);
```

DMMStopTotalizer

SM2060 ☐ SM2064 ☑

Description Terminate the accumulation process of the Totalizer.

#include "SM206032.h"

int DMMStopTotalizer(int *nDmm*)

Remarks This function stops the accumulation process. Following this function, the totalized value can be read. For details see **DMMStartTotalizer**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation was successful.
Negative Value	Error code

Example

```
int status = DMMStopTotalizer(0);
```

DMMTerminate

SM2060 ☑ SM2064 ☑

Description Terminate DMM operation (DLL)

#include "SM206032.h"

int DMMTerminate(**int** *nDmm*)

Remarks Removes DMM number *nDmm*. This routine is used only where it is needed to terminate one DMM and start a new one at the same *nDmm* location. Otherwise, it is not recommended to use this function.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM to be suspended.

Return Value The return value is one of the following constants.

Value	**Meaning**
TRUE	DMM Terminated
FALSE	DMM was not initialized, termination is redundant.

Example
```
DMMTerminate(0); /* Terminate DMM # 0 */
```

DMMTrigger

SM2060 ☑ SM2064 ☑

Description Software Trigger the DMM. Take *iSamples*.

#include "SM206032.h"

int DMMTrigger(**int** *nDmm,* **int** *iSamples*)

Remarks Following reception of this function takes *iSamples* readings at the currently set function and range, and stores them in an internal buffer at the currenly set Aperture and Read Interval. No autoranging is allowed during this operation. Read Interval must be set between 0 (default) and 65ms. Aperture must be set between 160ms and 2.5us. The value of *iSamples* should be between 1 and 80 for an Aperture of 1.4ms to 160ms. It can be set between 1 and 120 for Apertures in the range of 625us to 2.5us. The highest Aperture allowed is 160ms. Between the times the **DMMTrigger** command is issued and the time the buffer is read, no other command should be sent to the DMM, with the exception of **DMMReady** function, which monitors the completion of the capture process. When **DMMReady** returns TRUE, the buffer can be read one reading at a time using **DMMReadBuffer.** The value of the Aperture is set using the **DMMSetAperture** function, and that of the Read Interval is set using the **DMMSetReadInteval**.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iSamples	**int** The number of samples the DMM takes following a trigger pulse. This number must be between 1 and 80 or 1 and 120. See above.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Operation successfully terminated.

DMM_E_INIT	DMM is uninitialized. Must be initialize prior to using any function.
DMM_TRIG_N	Measurement count is out of allowed range.
DMM_E_DMM	Invalid DMM number.

Example

```
double Buffer[60];
int state;
DMMTrigger(0,60);
while( ! DMMReady(0));
      for(i=0; i < 60 ; i++)
      state = DMMReadBuffer(0, &Buffer[i]);
```

DMMTriggerBurst

SM2060 ☑ SM2064 ☑

Description Hardware multi sample trigger operation.

#include "SM206032.h"

int DMMTriggerBurst(int *nDmm,* **int** *iSamples,* ***int*** *iEvents,* ***int*** *iEdge*)

Remarks Setup for external hardware trigger operation. Following reception of this command the DMM enters a wait state. In response to the detection of the selected *iEdge* polarity on its external trigger, the DMM makes *iSamples* readings and sends them back. It does it at the currently set measurement function, range, Aperture and Read Interval. This process is repeated for *iEvents* times. Therefore a total of *iEvents* Trigger pulses must be received, and iEvents * iSample measurements should be read to complete this process. This function is useful in conjunction with triggering instruments such as the SM4042 or SMX4032 relay scanner. No auto ranging is allowed in this mode. Until all measurements are read back, it is necessary to keep up with the DMM and read all measurements as fast as they become available. Failing to do so will result in communication overrun. The DMM has a small FIFO to reduce the likelihood of an overrun. This function is usable for VDC, VAC, Ohms, IAC, IDC and RTD measurements. Use the **DMMReadMeasurement** to monitor for data availability, and to read this data.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iSamples	**int** The number of samples to take following a Trigger events. Allowd range is 1 to 250.
iEvents	**int** The number of Trigger events to expect. Range 1 to 30,000.
iEdge	**Int** The edge polarity of the trigger signal. 1 for Positive, or leading edge, and 0 for negative or trailing edge trigger.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Operation successfully terminated
Negative Value	Error code.

Example

```
double Reading[150];
DMMTrigBurst(0, 10, 100, 0); // Negative edge, 10 samples
//per trigger event, total of 100 events
for(i=0; i < 150 ; i++)       // read buffer
       while( ! DMMReadMeasurement(0 , Reading[i]) );
```

DMMWidthStr

SM2060 ☐ SM2064 ☑

Description Return the indicated pulse width in string format.

#include "SM206032.h"

int DMMWidthStr(**int** *nDmm,* **int** *iPol,* **LPSTR** *lpszNeg*)

Remarks This function is the string equivalent of **DMMReadWidth**. The measurement results are stored at the location pointed to by *lpszWidth*. See **DMMReadWidth** for more details.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

iPol	**Int** This value indicates the polarity of the pulse to be measured. 1 indicates positive, 0 negative.
lpszWidth	**LPSTR** Points to a buffer (at least 64 characters long) to hold the positive width result.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
char W[64]; int status = DMMWidthStr(0, 0, W);
```

5.7 Calibration Service Commands

AC_zero

SM2060 ☑ SM2064 ☑

Description Disable AC measurement zero funciton.

#include "SM206032.h"
#include "UseroDMM.h"

int AC_zero(int *nDdmm,* **int** *bACZero* **)**

Remarks ith bACZero FALSE, the AC zero function is disabled. If TRUE it is enabled. The default value is TRUE. Diabeling the AC Zero funciton allows the derivation of the value to be set as offset parameter for the selected ACV range. This function is used during calibration.

Parameter	Type/Description
iDmm	Identifies the DMM. DMMs are numbered starting with zero.
bACZero	Forces the AC zero to be active or inactive. Allowed values are TRUE of FALSE.

Return Value The return value is one of the following constants.

Value	Meaning
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
int err;
Err = AC_zero(0, FALSE); // disable AC Zero.
```

DMMLoadCalFile

SM2060 ☑ SM2064 ☑

Description Reload calibration record from file.

#include "SM206032.h"

int DMMLoadCalFile(int *nDmm*, **LPCSTR** *lpszCal*)

Remarks This function provides the capability to reload the calibration record. This is useful in making limited calibration adjustments, and verifying them. By having a copy of the original calibration file '**SM60CAL.DAT**' open with an editor, modifying calibration parameters and then reloading using **DMMLoadCalFile**, one can instantly verify the corrections made. Make sure the '**SM60CAL.DAT**' file itself is not altered since that will void the calibration.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszCal	**LPCSTR** Points to the name of the file containing the calibration constants for the DMM.

Return Value The return value is one of the following constants.

Value	**Meaning**
DMM_OKAY	Cal record loaded successfully.
Negative Value	Error code

Example

```
/* Load a modified copy of the original calibration file to
verify correction made to a specific entry */
int i = DMMLoadCalFile(0, "C:\CAL_A.dat");
```

GetGain

SM2060 ☑ SM2064 ☑

Description Retrieve currently set gain.

#include "SM206032.h"
#include "UseroDMM.h"

int GetGain(int *nDmm,* **doulbe *** *lpdGain***)**

Remarks This function returns the currently set gain,. This is the gain associated with the currently selected function and range. The value should be the same as that set in the calibration record for this function and range. The gain is returned as a 64-bit double-precision floating-point number in the location pointed to by *lpdGaint*. This function is useful while performaing calibration. Set **SetGain()** function for additional details.

Parameter	**Type/Description**
iDmm	Identifies the DMM. DMMs are numbered starting with zero.

Return Value The return value is one of the following constants.

Value	**Meaning**
lpdGain	**double *** Points to the location to hold the gain.
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
double gain;
GetGain(0, &gain); // read gain
```

GetOffset

SM2060 ☑ SM2064 ☑

Description Retrieve currently set gain.

#include "SM206032.h"
#include "UseroDMM.h"

int GetOffset(int *nDmm,* **doulbe *** *lpdOffset***)**

Remarks This function returns the currently set offset,. This is the offset associated with the currently selected function and range. The value should be the same as that set in the calibration record for this function and range. The offset is returned as a 64-bit double-precision floating-point number in the location pointed to by *lpdOffsett*. This function is useful while performaing calibration. Set **SetOffset()** function for additional details.

Parameter	**Type/Description**
iDmm	Identifies the DMM. DMMs are numbered starting with zero.

Return Value The return value is one of the following constants.

Value	**Meaning**
lpdOffset	**double *** Points to the location to hold the offset.
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
double offst;
GetOffset(0, &offst); // read gain
```

SetFcomp

SM2060 ☑ SM2064 ☑

Description Set the ACV Frequency compensation factor
#include "SM206032.h"

int SetFcomp(int *nDmm,* **int** *iFcomp***)**

Remarks This function sets the value of the ACV frequency compensation DAC. It is used for calibration the ACV bandwidth..

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iFcomp	**int** Freqeuncy Compnensation DAC value to be set. Allowed value is between 0 and 31.

Return Value Integer error code.

Value **Meaning**

DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
SetFcomp(0, 12); // set the frequency compensation
```

SetOffset

SM2060 ☑ SM2064 ☑

Description

Set the the offset correction factor

#include "SM206032.h"

int SetOffset(int *nDmm*, **double** *dOffset***)**

Remarks

This function sets the value of the offset correction factor for the currently set function and range..

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dOffset	**double** Offset value to be set.

Return Value

Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
SetOffset(0, 11212.0); // Assert the offset factor
```

Linearize_AD

SM2060 ☑ SM2064 ☑

Description

Activate/Deactivate A/D linearization correction.

#include "SM206032.h"
#include "UseroDMM.h"

int Lineaize_AD(int *nDdmm*, **int** *bLinerize* **)**

Remarks

If *bLinerize* is set to FALSE disables the A/D Linearization correction. The default value is TRUE. Diabeling allows for the derivation of the parameters for calibration purposes. This function is used during calibration.

Parameter	Type/Description
iDmm	Identifies the DMM. DMMs are numbered starting with zero.
bACZero	Forces the AC zero to be active or inactive. Allowed values are TRUE of FALSE.

Return Value

The return value is one of the following constants.

Value	Meaning

DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
int err;
Err = Linearize_AD(0, FALSE); // disable AC Zero.
```

Read_ADcounts

SM2060 ☑ SM2064 ☑

Description

Read A/D offset counts.
#include "SM206032.h"

int Read_ADcounts(int *nDmm***)**

Remarks

This function returnes the A/D raw counts. It is useful for retrieving the offset parameter for various functions, including VDC, 2-W and 4-W ohms and DC current. It is limited for service use.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value

Integer error code.

Value	**Meaning**
Any value	**int** Offset reading.

Example

```
int i = Read_ADcounts(0); // read offset parameter
```

5.8 Maintanance Commands

GrdXingTest

SM2060 ☑ SM2064 ☑

Description Perform the specified test

#include "SM206032.h"

int GrdXingTgest(int *nDmm*, **int** *iNumber*, **int** *iTest*)

Remarks Perform the specified test as indicated by *iTest*. Repeat it for *iNumber* times. This function is used to perform basic H/W tests.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iTest	**int** Test type. 0: Basic Read/Write. 1: Toggle Reset line iNumber times. 2: High Speed Guard Crossing stimulation. 3: Guarded controller communication test. 4: Guard Crossing loopback test. 5: High Speed Guard Crossing test (SM2064).
iNumber	**int** Number of tests to be repeated.

Return Value Integer error code.

Value	**Meaning**
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example int i = `GrdXingTest(0, 1, 3); // Test Guarded controller`

5.7 Error Codes

Operation of the DMM may be impaired, should be aborted or is not possible following an Error. Use the **DMMErrString()** function, to retrieve the string describing the error.

DMM_OKAY	0	// no error
DMM_E_CAL	-1	// cannot open the calibration file at the specified location.
HI_SPD_XING	-2	// High Speed Guard Crossing error, SM2064
DMM_E_INIT	-3	// DMM must be initialized in order to execute the operation.
DMM_E_IO	-4	// I/O Error, DMM not responding
NOT_FOUND	-5	// DMM was not detected PCI bus
DMM_E_CAL_R	-6	// Not found a valid calibration record in specified file.
ERR_AD_HW	-7	// H/W Error, the A/D does not respond.
ERR_HW_INIT	-8	// H/W error, can't access H/W to initialize it. May be due to bad address
NO_CAL_RECORD	-9	// can't find a cal record for for this DMM in the specified cal file.
ID_HW_ERR	-10	// Can't read ID from DMM
TRIG_ERR	-11	// Trigger circuit error
GUARD_COM	-12	// Communication error with DMM uP
TIMEOUT	-13	// process timed out Error
GUARD_XING	-14	// Guard crossing is broken
CONTROLR_COM	-15	// Microcontroller communication error

OVERRUN	-16	// Communication Overrun error
FRAME	-17	// Communication Frame error
RCV_FIFO	-18	// Com receive Fifo error
PARITY	-19	// Com parity error
WRONG_TYPE	-20	// Wrong Cal record for DMM type
WRONG_GRD_VER	-21	// MCU Firmwhare does not support operation
CANT_OPEN_PCI	-22	// Can't open PCI device. Already open ?
PCI_ITEMS	-23	// Card does not have all PCI items.
GENERAL_ERR	-24	// General Error
NO_HS_OG	-25	// High speed Out Guard comm not operating/available
CAL_STORE	-26	// Error reading Cal record from local storage
CREAT_CAL_FILE	-27	// Can't create named cal file to write cal record to
OPEN_CAL_FILE	-28	// Can't open cal file for reading cal record
CREAT_CAL_RCRD	-29	// Can't create on-board Cal Record

5.8 Warning Codes

Following a warning, the DMM will continue to run normally with the exception of the fault indicated by the warning code. Use the **DMMErrString()** function, to retrieve the string describing the warning. This string may be used to notify the user. Based on it, an action may be taken to correct the source of the warning. Several of the warning codes are part of a normal operation. Such are DMM_CNT_RNG, which indicates that the counter requires more iterations, or the POS_FS and NEG_FS are indication that the signal level is too high for the selected range, which is normal.

APERTR_TOO_HIGH	101	// Aperture value is too high for operation
DMM_E_FUNC	102	// Invalid function value used
DMM_E_RNG	103	// Invalid range value used
DMM_CNT_RNG	104	// DMM counter out of range
DMM_E_IS_INIT	105	// Dmm already initialized: in use
CAP_RATE_ERR	106	// Can't change rate in Cap mode.
ERR_FUNC	107	// Illegal function selection
ERR_APERTURE	108	// Wrong Aperture selected, see rate definition
TRIG_SAMPL_ERR	109	// Wrong number of Trigger samples
ERR_PARAMETER	110	// wrong parameter value
UN_CALIBRATED	111	// Expired Calibration. Needs service
TOO_COLD	112	// Temperature too low
TOO_HOT	113	// Temperature too high
BAD_TC_TYPE	114	// Wrong TC type
MC_STOP	115	// Microcontroller was stopped/interruped during an operation
POS_FS	116	// Positive Over Range
NEG_FS	117	// Negative Over Range
BUSY	118	// DMM is busy, wait for ready
FUNC_INACTIVE	119	// Function can not be selected, or not available for this type DMM.
NOT_OPEN	120	// Test Terminals Are not Open during Open Cal operation,
READ_INTERVL	121	// Read Interval value incompatible with Aperture.
FAIL_OPEN_CAL	122	// Can't create on-board Cal Record
CAL_SML_APRTR	123	// Failed calibrating A/D at 2.5us Aperture

6.0 Maintenance

Warning

These service instructions are for use by qualified personnel only. To avoid electric shock, do not perform any procedures in this section unless you are qualified to do so.

This section presents maintenance information for the DMM.

Test equipment recommended for calibration is listed below. If the recommended equipment is not available, equipment that meets the indicated minimum specifications may be substituted. In general, the calibration equipment should be at least three times more accurate than the DMM specifications.

Recommended Test Equipment

Instrument Type	**Minimum Specifications**	**Recommended Model**
Multi-Function Calibrator	DC Voltage Range: 0-300 V Voltage Accuracy: 4 ppm AC Voltage Range: 0-250 V Voltage Accuracy: 0.007% Resistance Range: 0-330 MΩ Resistance Accuracy: 12 ppm DC Current Range: 0-2.5 A Current Accuracy: 0.004% AC Current Range: 50 uA – 2.5 A Current Accuracy: 0.025% Capacitance Range: 10 ηF – 10 mF Capacitance Accuracy: 0.19%	Fluke 5700A

6.1 Performance Tests

This test compares the performance of the SM2060/64 DMM with the specifications given in Section 2. The test is recommended as an acceptance test when the instrument is first received, and as a verification after performing the calibration procedure. To ensure proper performance, the test must be performed with the SM2060 installed in a personal computer, with the covers on. The ambient temperature must be between 18°C and 28°C. Allow the DMM to warm up at least one-half hour before performing any of the tests. The default reading rate of the DMM should be used in each test.

6.2 DC Voltage Test

The following procedure may be used to verify the accuracy of the DCV function:

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Apply a high quality copper wire short to the DMM **V,Ω + & -** inputs. Select the DCV function, Autorange. Allow the DMM to settle for several seconds, and perform the **Relative** function.

3. Apply the following DC voltages to the **V, Ω + & -** terminals. Check to see that the displayed reading on the DMM is within the indicated range.

DC Voltage Test

Step	Range	Input	Minimum Reading	Maximum Reading
1	240 mV	0V (short)	- 0.0020000 mV	0.0020000 mV
2	240 mV	200 mV	199.98800 mV	200.01200 mV
3	240 mV	- 200 mV	- 200.01200 mV	- 199.98800 mV
4	2.4 V	0V (short)	1.9999900 V	2.0000100 V
5	2.4 V	2 V	1.9999300 V	2.0000700 V
6	2.4 V	- 2 V	- 2.0000700 V	- 1.999930 V
7	24 V	0V (short)	19.999700 V	20.000300 V
8	24 V	20 V	19.998700 V	20.001300 V
9	24 V	- 20 V	- 20.001300 V	- 19.998700 V
10	240 V	0V (short)	199.99950 V	200.00050 V
11	240 V	200 V	199.98750 V	200.01250 V
12	240 V	-200 V	- 200.01250 V	- 199.98750 V
13	330 V	0V (short)	299.99930 V	300.00070 V
14	330 V	300 V	299.95430 V	300.04570 V
15	330V	-300V	- 300.04570 V	- 299.95430 V

6.3 Resistance Test, 2-wire

The following procedure may be used to verify the accuracy of the 2-wire function.

1. If you have not done so, install the SM2060/64 and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Connect the SM2060/64 **V,Ω** + **& -** terminals to the calibrator HI & LO Outputs. Output 0 Ω from the calibrator. Allow the DMM to settle for a few seconds, and perform the **Relative** function. (This effectively nulls out the lead resistance of your cabling. If you are using a Fluke 5700A or 5520A Calibrator, the 2-wire Compensation feature will give a more accurate 2-wire ohms measurement. See the *Fluke Operator's Manual* for further instructions.)

3. Apply the following Resistance values to the **V, Ω + & -** terminals . Check to see that the displayed reading on the DMM is within the indicated range.

Resistance Test, 2-wire

Step	Range	Input	Minimum Reading	Maximum Reading
1	24.000000 Ω	00.000000 Ω	00.000000 Ω	00.002000 Ω
2	24.000000 Ω	10.000000 Ω	09.997200 Ω	10.002800 Ω
3	240.00000 Ω	000.00000 Ω	000.00000 Ω	000.00600 Ω
4	240.00000 Ω	100.00000 Ω	099.98700 Ω	100.01300 Ω
5	2.4000000 kΩ	0.0000000 kΩ	0.0000000 kΩ	000.00003 kΩ
6	2.4000000 kΩ	1.0000000 kΩ	0.9999070 kΩ	1.0000950 kΩ
7	24.000000 kΩ	00.000000 kΩ	00.000000 kΩ	00.000350 kΩ
8	24.000000 kΩ	10.000000 kΩ	09.999050 kΩ	10.000950 kΩ
9	240.00000 kΩ	000.00000 kΩ	000.00000 kΩ	000.00500 kΩ
10	240.00000 kΩ	100.00000 kΩ	099.98800 kΩ	100.01200 kΩ
11	2.4000000 MΩ	0.0000000 MΩ	0.0000000 MΩ	0.0000700 MΩ
12	2.4000000 MΩ	1.0000000 MΩ	0.9995300 MΩ	1.0004700 MΩ
13	24.0000 MΩ	00.0000 MΩ	00.0000 MΩ	00.0006 MΩ
14	24.0000 MΩ	10.0000 MΩ	00.0998 MΩ	10.0206 MΩ
15	240.000 MΩ	000.000 MΩ	0.00000 MΩ	000.050 MΩ
16	240.000 MΩ	100.000 MΩ	098.650 MΩ	101.350 MΩ

Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

6.4 Resistance Test, 4-wire

The following procedure may be used to verify the accuracy of the 4-wire function.

1. If you have not done so, install the SM2060/64 DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Connect the DMM **V,Ω + & -** terminals to the calibrator HI & LO Output. Connect the DMM's **I, 4WΩ + & -** terminals to the HI & LO Sense terminals.

3. Select the 4WΩ function on the DMM, Autorange. Set the calibrator to 0 Ω. Be certain that the calibrator is set to external sense ("EX SNS" on the Fluke 5700A or "4-Wire Comp" on the 5520A). Allow the DMM to settle for a few seconds, and perform the **Relative** function.

4. Apply the following Resistance values to the **V, Ω + & -** terminals. Check to see that the displayed reading on the DMM is within the indicated range.

Table 9-4 Resistance Test, 4-wire

Step	Range	Input	Minimum Reading	Maximum Reading
1	24.000000 Ω	00.000000 Ω	00.000000 Ω	00.001000 Ω
2	24.000000 Ω	10.000000 Ω	09.98200 Ω	10.001800 Ω
3	240.00000 Ω	000.00000 Ω	000.00000 Ω	000.00500 Ω
4	240.00000 Ω	100.00000 Ω	099.98800 Ω	100.01200 Ω
5	2.4000000 kΩ	0.0000000 kΩ	0.0000000 kΩ	000.00003 kΩ
6	2.4000000 kΩ	1.0000000 kΩ	0.9999070 kΩ	1.0000930 kΩ
7	24.000000 kΩ	00.000000 kΩ	00.000000 kΩ	00.000350 kΩ
8	24.000000 kΩ	10.000000 kΩ	09.999050 kΩ	10.000950 kΩ
9	240.00000 kΩ	000.00000 kΩ	000.00000 kΩ	000.00500 kΩ
10	240.00000 kΩ	100.00000 kΩ	099.98800 kΩ	100.01200 kΩ
11	2.4000000 MΩ	0.0000000 MΩ	0.0000000 MΩ	0.0000700 MΩ
12	2.4000000 MΩ	1.0000000 MΩ	0.9995300 MΩ	1.0004700 MΩ
13	24.0000 MΩ	00.0000 MΩ	00.0000 MΩ	00.0006 MΩ
14	24.0000 MΩ	10.0000 MΩ	00.0998 MΩ	10.0206 MΩ

Note 1: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).
Note 2: The use of 4-wire Ohms for resistance values above 300 kΩ is not recommended.

6.5 AC Voltage Test

The following procedure may be used to verify the accuracy of the ACV function:

1. If you have not done so, install the SM2060/64 DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Apply the following AC voltages to the **V, Ω + & -** terminals. Check to see that the displayed reading on the DMM is within the indicated readings range.

Mid-Frequency AC Voltage Tests
All inputs are a sine wave at **1 KHz**.

Step	Range	Input	Minimum Reading	Maximum reading
1	240 mV	10 mV	009.86500 mV	010.13500 mV
2	240 mV	190 mV	189.59500 mV	190.40500 mV
4	2.4 V	100 mV	0.0987350 V	101.26500 V
5	2.4 V	1.9 V	1.8975650 V	1.9024350 V
6	24 V	1 V	0.9862700 V	1.0137300 V
7	24 V	19 V	18.973130 V	19.026870 V
8	240 V	10 V	9.8640000 V	10.136000 V
9	240 V	190 V	189.75600 V	190.24400 V
10	330V	10V	9.7620000 V	10.238000 V
11	330V	300V	299.53000 V	300.47000 V

Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

High-Frequency AC Voltage Tests
All inputs are at **50 kHz**.

Step	Range	Input	Minimum Reading	Maximum reading
1	240 mV	10 mV	009.0400 mV	010.9600 mV
2	240 mV	190 mV	178.96000 mV	201.0400 mV
4	2.4 V	100 mV	0.0927000 V	0.1073000 V
5	2.4 V	1.9 V	1.7973000 V	2.0027000 V
6	24 V	1 V	0.9360000 V	1.0640000 V
7	24 V	19 V	18.504000 V	19.496000 V
8	240 V	10 V	9.3800000 V	10.620000 V
9	240 V	190 V	183.62000 V	196.38000 V
10	330V	10V	9.2800000 V	10.720000 V
11	330V	300V	290.00000 V	310.00000 V

Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

6.6 DC Current Test

The following procedure may be used to verify the accuracy of the DCI function:

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Remove all connections from the DMM inputs. Select the DCI function and range. Allow the DMM to settle for a second, and perform the **Relative** function.

3. Apply the following DC currents to the **I,4Ω + & -** terminals. Check to see that the displayed reading on the SMX2040 is within the indicated readings range. For zero input, remove all connections from the DMM.

DC Current Test

Step	Range	Input	Minimum Reading	Maximum reading
1 [1]	240.0000 ηA	000.0000 ηA	-000.0600 ηA	000.0600 ηA
2 [1]	240.0000 ηA	200.0000 ηA	199.6000 ηA	200.4000 ηA
3 [1]	240.0000 ηA	-200.0000 ηA	-200.4000 ηA	-199.6000 ηA
4 [1]	2.400000 µA	0.000000 µA	-0.000150 µA	0.000150 µA
5 [1]	2.400000 µA	2.000000 µA	1.995650 µA	2.004350 µA
6 [1]	2.400000 µA	-2.000000 µA	-2.004350 µA	-1.995650 µA
7 [1]	24.00000 µA	0.000000 µA	-0.000800 µA	0.000800 µA
8 [1]	24.00000 µA	20.00000 µA	19.97320 µA	20.03680 µA
9 [1]	24.00000 µA	-20.00000 µA	-20.03680 µA	-19.97320 µA
10 [1]	240.000 µA	0.000000 µA	-0.400000 µA	0.400000 µA
11 [1]	240.000 µA	240.000 µA	199.4000 µA	200.6000 µA
12 [1]	240.000 µA	-240.000 µA	-200.6000 µA	-199.4000 µA
13	2.40000 mA	0.00000 mA	-0.00055 mA	0.00055 mA
14	2.40000 mA	2.00000 mA	1.99805 mA	2.00195 mA
15	2.40000 mA	- 2.00000 mA	-2.00195 mA	-1.99805 mA
16	24.0000 mA	0.00000 mA	-0.00055 mA	0.00055 mA
17	24.0000 mA	20.0000 mA	19.98345 mA	20.01655 mA
18	24.0000 mA	- 20.0000 mA	-20.01655 mA	-19.98345 mA
19	240.000 mA	0.00000 mA	-0.00008 mA	0.00008 mA
20	240.000 mA	200.000 mA	199.790 mA	200.210 mA
21	240.000 mA	-200.000 mA	-200.210 mA	-199.790 mA
22	2.40000 A	0.00000 A	-0.00009 A	0.00009 A
23	2.40000 A	2.00000 A	1.99091 A	2.00909 A
24	2.40000 A	-2.00000 A	-2.00909 A	-1.99091 A

[1] Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

6.7 AC Current Test

The following procedure may be used to verify the accuracy of the ACI function:

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Remove all connections from the DMM inputs. Select the ACI function, Autorange.

3. Apply the following AC currents to the **I,4Ω + & -** terminals. Check to see that the displayed reading on the SMX2040 is within the indicated readings range.

AC Current Test
All Inputs are at **400Hz**

Step	Range	Input	Minimum Reading	Maximum reading
1	2.4 mA	0.1 mA	0.095710 mA	0.104290 mA
2	2.4 mA	1 mA	0.993100 mA	1.006900 mA
3	24 mA	1 mA	0.995400 mA	1.004600 mA
4	24 mA	10 mA	9.981000 mA	10.01900 mA
5	240 mA	10 mA	9.760000 mA	10.24000 mA
6	240 mA	100 mA	99.58000 mA	100.4200 mA
7	2.4 A	100 mA	0.09565 A	0.10435 A
8	2.4 A	1 A	0.99250 A	1.00750 A

Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

AC Current Test
All Inputs are at **10KHz**

Step	Range	Input	Minimum Reading	Maximum reading
1	2.4 mA	0.1 mA	0.093800 mA	0.106200 mA
2	2.4 mA	1 mA	0.993800 mA	1.006200 mA
3	24 mA	1 mA	0.956000 mA	1.044000 mA
4	24 mA	10 mA	9.992000 mA	10.08000 mA
5	240 mA	10 mA	9.560000 mA	10.44000 mA
6	240 mA	100 mA	99.20000 mA	100.8000 mA
7	2.4 A	100 mA	0.09450 A	0.10550 A
8	2.4 A	1 A	0.99000 A	1.01000 A

Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

6.8 Capacitance Test (SM2064 only)

The following procedure may be used to verify the accuracy of the Capacitance function.

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Connect the DMM **V,Ω** + **& -** terminals to the calibrator HI & LO Outputs. Attach the test leads to the DMM, leaving the other end open circuited. Allow the DMM to settle for a few seconds, and perform the **Relative** function. (This effectively nulls out the lead capacitance of your cabling.

3. Apply the following Capacitance values to the **V, Ω + & -** terminals. Check to see that the displayed reading on the SM2064 is within the indicated range of readings.

Capacitance Test

Step	Range	Input	Minimum Reading	Maximum reading
1	1,200 pF	100 pF	0099.6 pF	0100.4 pF
2	1,200 pF	1,000 pF	0998.3 pF	1001.8 pF
3	12 ηF	1 ηF	10.994 ηF	01.620 ηF
4	12 ηF	10 ηF	09.938 ηF	10.017 ηF
5	120 ηF	10 ηF	009.90 ηF	010.10 ηF
6	120 ηF	100 ηF	099.00 ηF	101.00 ηF
7	1.2 µF	0.1 µF	0.0990 µF	0.1010 µF
8	1.2 µF	1.0 µF	0.9900 µF	1.0100 µF
9	12 µF	1 µF	00.990 µF	01.010 µF
10	12 µF	10 µF	09.900 µF	10.100 µF
11	120 µF	10 µF	009.90 µF	010.10 µF
12	120 µF	100 µF	099.00 µF	101.00 µF
13	1.2 mF	0.1 mF	0.0988 mF	0.1020 mF
14	1.2 mF	1 mF	0.9880 mF	1.0200 mF
15	12 mF	1 mF	00.988 mF	01.020 mF
16	12 mF	10 mF	09.880 mF	10.200 mF

Note: Some ranges apply to 2064 only. Please refer to chapter 2.0 (Specification).

6.8 Inductance Test (SM2064 only)

The following procedure may be used to verify the accuracy of the Capacitance function.

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.
2. Connect the test leads that you plan to use for the DMM **V,Ω +&-** terminals. Leave the other end of the test leads open.
3. Select the Inductance measurement function and a suitable range.
4. Perform an Open-Cal with the DMM.
5. After Open-Cal is completed, connect the test leads to a short circuit. Observe how much inductance the DMM reads, and then turn on the "relative" button.
6. Connect the DMM to the test inductor you wish to measure, and take your reading

Inductance Test

Step	Range	Input	Minimum Reading	Maximum reading
1	24 µH	10 µH	09.499 µH	10.500 µH
2	24 µH	22 µH	21.499 µH	22.500 µH
3	240 µH	100 µH	096.99 µH	103.00 µH
4	240 µH	220 µH	216.99 µH	223.00 µH
5	2.4 mH	1.0 mH	0.9749 mH	1.0250 mH
6	2.4 mH	2.2 mH	2.1749 mH	2.2250 mH
7	24 mH	10 mH	9.7980 mH	10.202 mH
8	24 mH	22 mH	21.795 mH	22.204 mH
9	240 mH	100 mH	096.70 mH	103.30 mH
10	240 mH	220 mH	216.34 mH	223.66 mH
11	2.4 H	1.0 H	0.9300 H	1.0700 H
12	2.4 H	2.2 H	2.0880 H	2.3120 H

Note: Applies to 2064 only.

6.9 Frequency Counter Test (SM2064 only)

The following procedure may be used to verify the accuracy of the Frequency Counter:

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Select the ACV function, autorange. Turn **freq** on.

3. Apply the following AC voltages to the **V, Ω + & -** terminals. Check to see that the displayed reading on the SM2064 is within the indicated range of readings.

ACV Frequency Counter Test

Step	Range	Input	Minimum Reading	Maximum reading
1	240 mV	33 mV, 40 Hz	39.9952 Hz	40.0048 Hz
2	2.4 V	240 mV, 40 Hz	39.9952 Hz	40.0048 Hz
3	24 V	2.4 V, 40 Hz	39.9952 Hz	40.0048 Hz
4	330 V	24 V, 40 Hz	39.9952 Hz	40.0048 Hz
5	240 mV	250 mV, 100 kHz	99.996 kHz	100.004 kHz
6	24 V	25 V, 100 kHz	99.996 kHz	100.004 kHz

For ACI Frequency Counter test:

1. If you have not done so, install the DMM and place the covers back on to the computer. Ensure that the computer has been on for at least one-half hour, with the covers on, before conducting this test.

2. Select the ACI function, autorange. Turn **freq** on.

3. Apply the following AC currents to the **I,4Ω + & -** terminals. Check to see that the displayed reading on the DMM is within the tolerance appropriate for your application (e.g. 90 day or 1 year accuracy).

ACI Frequency Counter Test

Step	Range	Input	Counter Reading	Tolerance
1	3.3 mA	330 uA, 40 Hz		
2	33 mA	15 mA, 40 Hz		
3	330 mA	150 mA, 40 Hz		

6.10 Calibration

Each SM2060/64 DMM uses its own **SM60CAL.DAT** calibration record to ensure the accuracy of its functions and ranges. The **SM60CAL.DAT** file is a text file that contains the DMM identification number, calibration date, and calibration constants for all DMM ranges. When the DMM is installed this file is generated from an internally stored record. Once extracted, the DMM reads it from a file rather than from its on-board record, since it is faster to read from a file. For most functions, the calibration constants are scale factor and offset terms that solve an "y = mx + b" equation for each range. An input "x" is corrected using a scale factor term "m" and an offset term "b"; this gives the desired DMM reading, "y". Keep in mind that for ranges and functions that are unavailable for a particular product in the SM2060 family, the calibration record contains a placeholder. An example **SM60CAL.DAT** is shown:

```
card_id  10123    type 2064 calibration_date 06/15/1999
ad       #A/D compensation
72.0     20.0    0.99995
vdc      #VDC 240mV, 2.4V,24V, 240V, 330V ranges, offset and gain parameters
-386.0   0.99961
-37.0    0.999991
-83.0    0.999795
-8.8     1.00015
44.5     1.000001
vac      #VAC 1st line - DC offset. Than offset, gain and freq each range240mV to 330V
5.303
0.84     1.015461          23
0.0043   1.0256            23
0.0      1.02205           0
0.0      1.031386          0
1.2      0.994999          2
idc      # IDC 240nA to 2.5A, 8 ranges, offset and gain
-22.3    1.000030
33.4     0.999939
32.0     0.993499
-54.3    1.000102
-1450.0  1.00103
-176.0   1.00602
-1450.0  1.00482
-176.0   1.00001
iac      # IAC 2.4mA to 2.5A ranges, offset and gain
1.6      1.02402
0.0      1.03357
1.69     1.00513
0.0      1.0142
2w-ohm #Ohms 24, 240, 2.4k,24k,240k,2.4M,24M,240Meg ranges, offset and gain
1.27e+4 1.002259
1256.0   1.002307
110.0    1.002665
0.0      1.006304
0.0      1.003066
0.0      1.001848
0.0      0.995664
0.0      1.00030
…
```

The first column under any function, e.g.,"`vdc`", is the offset term "b", expressed as a value proportional to analog-to-digital (a/d) counts. The second column is the scale factor term "m". Within each function, the "b" and "m" terms are listed with the lowest range at the beginning. For example, under "`2w-ohm`" above, "`1.27e+4 1.002259`" represents the offset term for the 33 Ω range, and "`1.002259`" is the scale factor for this range. This record must be for the SM2064 since the SM2060 does not have the 33 Ohms range, and therefore these values will be set to 0.0 and 1.0.

For the ACV function, the first line in the calibration record is the DC offset value. The rest of the lines contain the RMS offset, gain correction factor, and a third column that represents a digital code from 0 to 31 that controls the high frequency performance of each AC function. A large value, e.g., 31, implies high attenuation.

The **SM60CAL.DAT** file is created by performing external calibration. The general calibration algorithm consists of applying a zero value to the DMM followed by a value of 2/3rd of the top of each range. Calibration of your SM2060/64 is best performed using calibration software available from Signametrics.

When using multiple DMMs in a single chassis, the **SM60CAL.DAT** file must have a calibration record for each DMM. You can combine the unique calibration records of each DMM into one **SM60CAL.DAT** file using any ASCII text editor such as “notepad.exe”.

7.0 Warranty and Service

The SM2060, SM2064, SMX2060 and SMX2064 are warranted for a period of one year from date of purchase. Removal of any of the three external shields or any attempt to repair the unit by other than unauthorized Signametrics service personnel will invalidate your warranty. Operating the Signametrics products outside their specified limits will void the warranty. For in-warranty repairs, you must obtain a return materials authorization (RMA) from Signametrics prior to returning your unit. Customer ships products at customer's expense. Within the USA Signametrics will ship serviced or replaced unit at Signametrics' expense.

Warranty extensions are available at the time of purchase for terms up to 36 months, in increments of 12 months.

If your unit requires repair or calibration, contact your Signametrics representative. There are no user serviceable parts within these products.

8.0 Accessories

Several accessories are available for the SM2060/64 DMMs, which can be purchased directly from Signametrics, or one of its distributors or representatives. These include:

- Basic DMM probes
- DMM probe kit
- Deluxe DMM probe set
- Shielded SMT Tweezer Probes
- Multi Stacking Double Banana shielded cable 36"
- Multi Stacking Double Banana shielded cable 48"
- Mini DIN-7 Trigger, 6-Wire Ohms connector
- 4-Wire Kelvin probes