Operator's Manual

Model SMU2060   7-½ Digit Digital USB Multimeter
Model SMU2064   7-½ Digit High Work Load USB Digital Multimeter

Signametrics Corporation

June, 2010
Rev 1.70 driver and Rev F Hardware.

CAUTION

In no event shall Signametrics or its Representatives are liable for any consequential damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or other loss) arising out of the use of or inability to use Signametrics products, even if Signametrics has been advised of the possibility of such damages. Because some states do not allow the exclusion or limitation of liability for consequential damages, the above limitations may not apply to you.

TABLE OF CONTENTS

1.0 Introduction

Congratulations! You have purchased a Personal Computer (PC) USB with analog and systems performance that rivals the best Digital Multimeters on the market. These all-in-one Digital Multimeters (DMM's) are easy to setup and use, have sophisticated analog and digital circuitry to provide very repeatable and super accurate 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 SMU2060 and SMU2064 DMMs.

1.1 Safety Considerations

Safety Considerations

The SMU2060 series of USB Digital Multimeters (DMMs) are capable of measuring up to 330 VDC or 330 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 330 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.**

The DMM enclosure must not be tempered or disassembled for any reason. Doing so will result in performance degradation and will present a safety risk. Improper handeling of these products can result in lethal voltages that may effect the computer this product is connected to.

Warning

No probes or any other wiring should be connected to the DMMs during installation or removal of the USB to the DMM or to the Computer. Not doing so may apply lethal measurement voltages to your computer and USB cable, causing electrocution and/or damage to your computer and/or your DMM.

To avoid shock hazard, connect the USB cable only to 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

These USB DMMs are precision plug-in modules that are compatible with personal computers (PCs). It requires as a minimum a Pentiums computer. A mouse or a compatible pointing device must be installed when controlling the DMM from the Windows Control Panel provided with this product. These DMMs comes with a Windows' DLL, for operation with Windows' Version 95/98/Me/2000/XP and Milenium.

1.3 Feature Set

The base unit, the SMU2060, 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 SMU2064 adds timing, capacitance, inductance, sourcing , leakage and more speed. With its specialized measurements, it can replace several costly instruments, shrinking the size and cost of a test system. It is possible to deploy several SMU2060s, SMU2064s and

SMU2055 DMMs in a single computer, in any mix. Multiple units add both, overall system throughput and comlexity.

SMU2060 and SMU2064 7½ Digit DMM's feature table:

Function	SMU2055	SMU2060	SMU2064
DCV five ranges 240mV to 330V	√ (-330V)	√	√
ACV five ranges 240mV to 330V	√ (-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 types; B, E, J, K, N, R, S, T		√	√
High Dynamic range; ±24,000,000 counts		√	√
Frequency / Period measurement		√	√
Measurement rate: (rdngs/sec)	375	1350	20,000
Capacitance, ramp type, eight ranges, 1 nF to 10 mF		√	√
RTD types: pt385, 3911, 3916, 3926, Copper, variable Ro		√	√
Internal DMM temperature sensor		√	√
Component Handler Interface (for volume prouction)		√	√
Capacitance, In-Circuit method five ranges, 24nF to 2.4mF			√
Inductance, six ranges 33 μH to 3.3 H			√
Offset Ohms			√
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, 0.5 Hz to 200 KHz			√
DC current source, 1 nA to 12.5 mA			√
Leakage at ±10.0V, 240nA, 2.4uA and 25uA ranges.			√
2-Wire Ohms two additional ranges 24 Ω and 240 MΩ			√
4-Wire Ohms additional range 24 Ω			√
Extended Resistance with V&I limits (to 100GΩ)			√
DC Current , additional ranges 240nA, 2.4μA, 24μA, 240μA			√
Two auxiliary VDC inputs			√
Source 0 - ±10V / Measure to 0 - ±24mA			√
Stimulate and Measure Load cells and Strain gauges			√
Average AC Voltage, 240mV, 2.4V, 24V, 240V, 330V (1Hz to 1kHz)			√
Low frequency true RMS (0.2Hz to 66Hz)			√

2.0 Specifications

The following specifications should be considered under the environment specified.

To meet its specified accuracy specs, allow a warm up for at least one-half hour.

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, or sensitivity 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 + 4 μV	0.003 + 5 μV
24 V	24.000000 V	1 μV	0.004 + 120 μV	0.005 + 130 μV	0.006 + 150 μV
240 V	240.00000 V	10 μV	0.003 + 250 μV	0.004 + 300 μV	0.005 + 0.5 mV
330 V	330.00000 V	10 μV	0.0075 + 550 μV	0.01+ 700 μV	0.015 + 0.8 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 SMU2060, SMU2064	Maximum reading rate	Resolution	
Aperture ≥ 0.5 s	2 / second	7-1/2 digits	25 bits
Aperture 10 ms	100 / second	6-1/2 digits	22 bits
Aperture 625μs	1200 / second	5-1/2 digits	18 bits
Aperture ≥ 2.5us [2]	20,000 / second [2]	4 digits	14 bits

[2] Available only with the SMU2064.

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 SMU2064, two in the SMU2060
- **Burden Voltage** 240mV max.
- **Protected** with 2.5A Fast blow fuse

Accuracy ± (% of reading + Amps) [1]

Range	Full Scale Reading	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 SMU2064.

2.3 Resistance Measurements

Input Characteristics

- **Number of Current Sources** seven in SMU2064, five in the SMU2060
- **Burden Voltage** 240mV or 2.4V max, depending on range.

Range	Full Scale Reading	Resolution	Test current	Maximum Test Voltage (at Full Scale)
24 Ω [1]	24.000000 Ω	1 μΩ	10 mA	240mV
240 Ω	240.00000 Ω	10 μΩ	1 mA	240mV
2.4 kΩ	2.4000000 kΩ	100 μΩ	1 mA	2.4V
24 kΩ	24.000000 kΩ	1 mΩ	100 μA	2.4V
240 kΩ	240.00000 kΩ	10 mΩ	10 μA	2.4V
2.4 MΩ	2.4000000 MΩ	100 mΩ	1 μA	2.4V
24 MΩ	24.0000 MΩ	100 Ω	100 nA	2.4V
240 MΩ[1]	240.000 MΩ	1 kΩ	4 nA	1.0V

[1] Ranges are only available in the SMU2064.

2.3.1 2-wire

Accuracy ± (% of reading + Ω) [1]

Range	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
24 Ω	0.0038 + 1.4 mΩ [2]	0.005 + 1.6 mΩ [2]	0.008 + 2 mΩ [2]
240 Ω	0.0037 + 4.5 mΩ [2]	0.0046 + 5 mΩ [2]	0.007 + 6 mΩ [2]
2.4 kΩ	0.0023 + 28 mΩ	0.004 + 32 mΩ	0.006 + 33 mΩ
24 kΩ	0.0025 + 300 mΩ	0.004 + 330 mΩ	0.006 + 350 mΩ
240 kΩ	0.0055 + 3.2 Ω	0.006 + 4 Ω	0.007 + 5 Ω
2.4 MΩ	0.018 + 40 Ω	0.03 + 50 Ω	0.04 + 70 Ω
24 MΩ	0.12 + 400 Ω	0.13 + 500 Ω	0.2 + 600 Ω
240 MΩ	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.

2.3.2 4-wire

Accuracy ± (% of reading + Ω) [1]

Range	Maximum Lead Resistance	24 hours 23°C ± 1°C	90 Days 23°C ± 5°C	One Year 23°C ± 5°C
24 Ω	50 Ω	0.0038 + 0.7 mΩ [2]	0.005 + 0.8 mΩ [2]	0.008 + 1 mΩ [2]
240 Ω	500 Ω	0.0037 + 3 mΩ [2]	0.0046 + 4 mΩ [2]	0.007 + 5 mΩ [2]
2.4 kΩ	500 Ω	0.0023 + 28 mΩ	0.004 + 32 mΩ	0.006 + 33 mΩ
24 kΩ	5 kΩ	0.0025 + 300 mΩ	0.004 + 330 mΩ	0.006 + 350 mΩ
240 kΩ	50k Ω	0.0055 + 3.2 Ω	0.007 + 4 Ω	0.007 + 5 Ω
2.4 MΩ	50 kΩ	0.018 + 40 Ω	0.03 + 50 Ω	0.04 + 70 Ω
24 MΩ	50 kΩ	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).

2.3.3 6-wire Guarded Resistance Measurement (SMU2064)

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	Max Guard forced current	One Year 23°C ± 5°C [1] (adder)
24 Ω	20 mA	0.3 + 4 mΩ
240 Ω	20 mA	0.003 + 20 mΩ
2.4 kΩ	20 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 (SMU2064)

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.

2.3.5 Offset Ohms Measurements (SMU2064)

The purpose of Offset Ohms is to compensate for errors due to DC voltages which are in series with the resistance being measured. **DMMSetOffsetOhms()** function provides the means to control this operation. It is disabled by default.

Characteristics

- **Offset correction range:** 240mV or 2.4V depending on selected range
- **Application:** 2-Wire and 4-Wire Ohms
- **Offset voltage:** Depends on head-room; range and measured resistance value.

Range	Vo limits [1]	Measurement limits [2]
24Ω & 240Ω	-230mV to 230mV	I*R + Vo < +220mV
2.4k to 24MΩ	-2.3V to 2.3V	I*R + Vo < +2.2V

[1] With resistance, R, less than 10% of range.
[2] R – Measured resistance, I – Test current, Voofset – Offset Voltage

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	20 mV	1 μV
24 V	24.00000 V	200 mV	10 μV
240 V	240.0000 V	2 V	100 μV
330 V	330.0000 V	2.5 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.

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 disabled (default). With Fast RMS disabled, settling time to rated accuracy is within 0.5s:

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	0.37 + 150 µV	0.38 + 170 µV	0.4 + 200 µV
	47 Hz - 10 kHz	0.2 + 100 µV	0.21 + 110 µV	022 + 120 µV
	10 kHz - 50 kHz	0.25 + 160 µV	0.26 + 200 µV	0.27 + 230 µV
	50 kHz - 100 kHz	1.9 + 350 µV	1.95 + 370 µV	2.0 + 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	0.37 + 1.3 mV	0.38 + 1.5 mV	0.4 + 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	0.32 + 1.2 mV	0.33 + 1.3 mV	0.35 + 1.5 mV
	50 kHz - 100 kHz	1.9 + 1.5 mV	2.0 + 1.7 mV	2.1 + 2 mV
24 V	10 Hz - 20 Hz	3.0 + 14 mV	3.1 + 16 mV	3.3 + 20 mV
	20 Hz - 47 Hz	0.37 + 12 mV	0.37 + 14 mV	0.4 + 16 mV
	47 Hz - 10 kHz	0.06 + 10 mV	0.065 + 11 mV	0.073 + 13 mV
	10 kHz - 50 kHz	0.18 + 18 mV	0.2 + 21 mV	0.22 + 25 mV
	50 kHz - 100 kHz	1.3 + 30 mV	1.4 + 35 mV	1.5 + 40 mV
240 V	10 Hz - 20 Hz	3.0 + 140 mV	3.1 + 160 mV	3.3 + 200 mV
	20 Hz - 47 Hz	0.37 + 120 mV	0.38 + 130 mV	0.4 + 150 mV
	47 Hz - 10 kHz	0.04 + 100 mV	0.045 + 110 mV	0.06 + 130 mV
	10 kHz - 50 kHz	0.28 + 150 mV	0.29 + 170 mV	0.30 + 200 mV
	50 kHz - 100 kHz	1.4 + 200 mV	1.5 + 240 mV	1.6 + 300 mV
330 V	10 Hz - 20 Hz	3.0 + 200 mV	3.1 + 160 mV	3.3 + 200 mV
	20 Hz - 47 Hz	0.43 + 180 mV	0.44 + 200 mV	0.45 + 250 mV
	47 Hz - 10 kHz	0.07 + 150 mV	0.08 + 200 mV	0.09 + 230 mV
	10 kHz - 50 kHz	0.28 + 200 mV	0.30 + 250 mV	0.32 + 300 mV
	50 kHz - 100 kHz	1.3 + 270 mV	2.4 + 350 mV	1.6 + 400 mV

[1] With Aperture set to ≥ 0.5 Sec

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

[1] With Aperture set to ≥ 0.16 Sec

2.4.2 AC Peak-to-Peak Measurement (SMU2064)

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

ACV Range	Lowest specified input voltage (Vp-p)	Full Scale [2] reading (Vp-p)	Resolution	Typical Accuracy 23°C ± 5°C One Year [1]
240 mV	0.1 V	1.900 V	1 mV	0.5 ± 3 mV
2.4 V	1.0 V	16.00 V	10 mV	0.5 ± 40 mV
24 V	10 V	190.0 V	100 mV	0.5 ± 700 mV
240 V	100 V	850.0 V	1 V	0.55 ± 6 V

[1] Signal frequency range 30 Hz to 60 kHz.
[2] USB power level greatly effects full scale reading.

2.4.3 AC Crest Factor Measurement (SMU2064)

- 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

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

2.4.4 AC Median Value Measurement (SMU2064)

- 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

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

2.4.5 Average AC Voltage Measurement (2064)

- Measures the average AC voltage
- Frequency range 1Hz to 1kHz

Range	Specified input voltage [1]	Full Scale reading: sine wave	Resolution	Typical Accuracy 23°C ± 5°C One Year [2]
240 mV	±240 mV	150.0 mV	10 µV	1.5% ± 60 µV
2.4 V	±2.4 V	1.500 V	100 µV	1.2% ± 1 mV
24 V	±24 V	15.00 V	1 mV	1% ± 15 mV
240 V	±240 V	150.0 V	10 mV	1% ± 130 mV
330 V	±330 V	±200.0 V	10 mV	1% ± 150 mV

[1] Requires selection of a DC Voltage range, and entry of signal frequency. Signal is repetitive.
[2] Specified for a sine wave. More abrupt signals such as square wave, pulse, and triangle will degrade the accuracy relative to frequency contents of waveform.

2.4.6 Low frequency RMS Voltage Measurement (2064)

- Measures the RMS value of a low frequency voltage
- Frequency range 0.2Hz to 66Hz

Range	Specified input voltage [1]	Full Scale reading: sine wave	Resolution	Typical Accuracy 23°C ± 5°C One Year [2]
240 mV	±240 mV	240.00 mV	10 µV	0.3% ± 50 µV
2.4 V	±2.4 V	2.4000 V	100 µV	0.2% ± 500 µV
24 V	±24 V	24.000 V	1 mV	0.2% ± 5 mV
240 V	±240 V	240.00 V	10 mV	0.2% ± 50 mV
330 V	±330 V	330.00 V	10 mV	0.2% ± 70 mV

[1] Requires selection of a DC Voltage range, and entry of signal frequency. Signal is repetitive.
[2] Specified for a sine wave. More abrupt signals such as square wave, pulse, and triangle will degrade the accuracy relative to frequency contents of waveform.

2.5 AC Current Measurement, True RMS

Input Characteristics

- **Crest Factor** 4 at Full Scale, increasing to 10 at Lowest Specified Current
- **Burden Voltage** 240mV max.
- **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 (SMU2064)

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	0.07 + 40pA	0.1 + 45pA	0.17 + 60pA
2.4 μA	2.400000 μA	1 pA	0.05 + 70pA	0.08 + 90pA	0.21 + 150pA
24 μA	24.00000 μA	10 pA	0.05 + 400pA	0.08 + 600pA	0.13 + 0.8nA

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

2.7 RTD Temperature Measurement

- **Ro:** Variable 10 Ω to 10 kΩ
- **Measurement Method:** 4-Wire
- **Temperature units:** Selectable ^{o}C or ^{o}F

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

- **Cold Junction Compensation:** By Sensor measurement or soft entry.
- **Cold Junction Temperature range:** 0 °C to 50 °C
- **Cold Junction Sensor:** Use SMX40T or SM40T Isothermal unit, or define sensor equation
- **Isothermal Block compatibility:** SM4022, SM4042, SMX4032, SM40T, SMX40T
- **Temperature units:** Selectable °C or °F

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 Test currents** 100 ηA, 1 µA, 10 µA, 100 µA and 1 mA
- **SMU2064 add variable current** of 10 ηA to 12.5 mA
- **One Year Current Source Uncertainty** 2.5%.+ 2ηA
- **One Year Voltage Measurement Uncertainty** 0.01% + 50uV
- **Voltage measurement range** 0V to 2.4V

2.9.2 Capacitance

- **Method** Charge Balance.
- **Speed** Very high, for high volume production

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

Range	Full Scale Reading (SMU2064)	SMU2060 Resolution	SMU2064 Resolution	One Year 23°C ± 5°C
1,200 pF	1,199.9 pF	1 pF	0.1 pF	1 ± 1 pF [2]
12 ηF	11.999 ηF	10 pF	1 pF	1.2 ± 5 pF [3]
120 ηF	119.99 ηF	100 pF	10 pF	1.0 [3]
1.2 µF	1.1999 µF	1 nF	100 pF	1.0 [3]
12 µF	11.999 µF	10 ηF	1 ηF	1.0 [3]
120 µF	119.99 µF	100 ηF	10 ηF	1.0 [3]
1.2 mF	1.1999 mF	1 µF	100 ηF	1.2 [3]
12 mF	50.000 mF	10 µF	1 µF	2 [3]

[1] Within one hour of zero, using Relative control. Specified at DMM input terminals.
[2] Accuracy is specified for values higher than 5% of the selected range.
[3] For values between 200pf and 500pf the floor is 2.5pf rather than 1pf.

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	Typical Measurement Time [1]	Typical Measurement speed (rps) [1]
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

[1] This time depends on the value measured capacitance. The SMU2060 is about 10 times slower than the SMU2064.

2.9.3 Capacitance, In-Circuit Method (SMU2064)

- **Method** Variable frequency AC
- **Adjustable Peak Voltages Stimulus** 100mV to 5.0V
- **Parallel Load Resistance** as low as 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	5 ± 200 pF
240 ηF	239.9 ηF	100 pF	5 ± 1 ηF
2.4 μF	2.399 μF	1000 pF	3 ± 5 ηF
24 μF	23.99 μF	10 ηF	3 ± 50 ηF
240 μF	239.9 μF	100 ηF	5 ± 500 ηF
2.4 mF	2.399 mF	1 μF	6 ± 5 μF

[1] Within one hour of AC Caps Open Cal operation, and relative correction.
[2] Specified for values higher than 5% of the selected range with Aperture > 0.2s

2.9.4 Inductance Measurement (SMU2064)

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

Range	Test frequency	Full Scale 4 ½ Digits	Resolution	Accuracy 23°C ± 5°C One Year [2]
33 μH	100 kHz	33.000 μH	1 ηH	3.0% + 500 ηH
330 μH	50 kHz	330.00 μH	10 ηH	2.0% + 3 μH
3.3 mH	4 kHz	3.3000 mH	100 ηH	1.5% + 25 μH
33 mH	1.5 kHz	33.000 mH	1 μH	1.5% + 200 μH
330 mH	1 kHz	330.00 mH	10 μH	2.5 + 3 mH
3.3 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 (SMU2064)

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

Accuracy ± (% 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 Measurements

- **Input Impedance** 1 MΩ with < 300 pF for voltage, 0.15Ω to 10Ω for current.
- **Ranging** Auto-Ranging (default) or Range-Lock
- **Maximum acquisition time while in Auto-Ranging mode** 7s
- **Acquisition Time in Range Locked mode** 35ms to 2s

Frequency	One Year accuracy (% of reading + Hz)	Resolution (Hz)	Minimum amplitued (VRMS)
1Hz – 130Hz	0.025% + 0.0015Hz	1 mHz	30mV or 5% of range, whichever is greater
130Hz – 640Hz	0.025% + 0.02Hz	6.5 mHz	
640Hz – 2.5kHz	0.03% + 0.075Hz	25 mHz	
2.5kHz – 40kHz	0.03% + 1.2Hz	0.4 Hz	
40kHz – 200kHz	0.05% + 7Hz	2.5 Hz	25% of range
200kHz – 300kHz	0.07% + 5Hz	1.5 Hz	

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 (SMU2064)

- **Selectable edge polarity:** Positive or negative edge transition
- **Maximum count:** 10,000,000,000
- **Allowed rate:** 0.2 to 45,000 events per second
- **Threshold:** Set Threshold DAC
- **Accuracy:** ±2 counts

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.
Minimum Trigger Pulse Width	1/Aperture + 50µS
Minimum trigger input current	1 mA
Internal Reading Buffer	Circular; 80 or 120 readings depending on resolution.
Edge	Selectable positive or negative edge.
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 SMU2064)
- **Read Interval range:** 1/Aperture to 65ms
- **Post-Trigger readings:** Selectable from 0 to buffer size.
- **Pre-trigger readings:** Selectable from 0 to buffer size.
- **Triggered Sample:** Retrievable from DMM.

2.11.3 Long Trigger (SMU2064 with Option 'R')

- **Trigger point:** Positive edge on selected trigger source (PXI or DIN-7)
- **Trigger Pulse Width:** Minimum 50µs
- **Samples per Trigger event:** 1 to 50,000
- **Number of Triggers:** 1 to 50,000
- **Sample to Sample delay:** 100µs to 3,600s
- **Aperture range:** 160ms to 2.5µS
- **Read Interval:** Must be set to zero

2.11.4 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 Times

2.12.1 Measurement Apertures and Read Interval

Both Aperture and The Read Interval may be set. The range of values depends 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 constitute an overhead, which limits the minimum Read Interval to a value that is greater than the Aperture. Setting it to zero, the default, results in fastest measurement rates. The faster SMU2064 has lower overhead and therefore a shorter minimum Read Interval than the SMU2060. For instance, with Aperture set to 625us and Read Interval set to zero, in command/response operation the SMU2060 measurement rate is about 1,090/s while that of the SMU2064 is 1,370/s. This indicates overhead of about 300µs for the SMU2060 and 100µs for the SMU2064. Another method of setting the Aperture is by use of the DMMSetPLC(), which sets the aperture to a multiple of the power line cycle.

The SMU2064 has 31 apertures, and the SMU2060 has 30 available. The following table lists all available measurement apertures and the corresponding minimum read time (including data transfers overhead etc..) and measurement rates for the various operations DMMRead(), DMMReadNorm(), DMMReadNsamples() and triggered operaton.

	Power Line Rejection			Single reading Command/Response time/rate (1/s)	DMMRadNsamples () time/rate (1/s)	Triggered operations time/rate (/s)
Aperture	60Hz	50Hz	400Hz			
5.1200s [1]	√	√	√	5.121s / 0.2	5.121s / 0.2	N/A
5.0666s [1]	√			5.0677s / 0.2	5.0677s / 0.2	N/A
2.08s [1]		√	√	2.081s / 0.5	2.081s / 0.5	N/A
2.0s [1]	√	√	√	2.001s / 0.5	2.001s / 0.5	N/A
1.06666s [1]	√			1.067s / 1	1.067s / 1	N/A
960ms [1]		√	√	0.9605s / 1	0.9605s / 1	N/A
533.33ms [1]	√			533.6ms / 2	533.6ms / 2	N/A
480ms [1]		√	√	480.2ms / 2	480.2ms / 2	N/A
266.666ms [1]	√			268ms / 4	268ms / 4	N/A
160.0ms	√	√	√	166ms / 6	160.2 ms / 6.2	160.3 ms / 6
133.33ms	√			137ms / 7.3	133.5 ms / 7.5	133.5 ms / 8
80.00ms		√	√	83.3ms / 12	80.19 ms / 12.5	80.2 ms / 13
66.6667ms	√			70,4ms / 14	67.11 ms / 14.9	66.713 ms / 15
40.00ms		√	√	43ms / 23	40.19 ms / 24.88	40.32 ms / 24.8
33.333ms	√			37 ms / 27	33.56ms / 29.8	33.38 ms / 30
20.00ms		√	√	22 ms / 45	20.16 ms / 49.6	20.33 ms / 50
16.6667ms	√			18 ms / 55	16.86 ms / 59.3	16.89 ms / 59
10ms				12 ms / 83	10.15 ms / 98.5	10.25 ms / 97
8.333ms				10 ms / 100	8.489 ms / 117.8	8.503 ms / 115
5ms				7 ms / 142	5.192 ms / 192.6	5.187 ms / 185
4.16667ms				6 ms / 165	4.36 ms / 229.38	4.274 ms / 220
2.5ms				4 ms / 250	2.67 ms / 375	2.614 ms / 350
2.0833ms				4 ms / 250	2.25 ms / 444	2.216 ms / 410
1.25ms				3 ms / 331	1.42 ms / 700	1.380 ms / 625
1.0417ms				3 ms / 333	1.21 ms / 820	1.158 ms / 864
625µS				2 ms / 490	800 µs / 1250	728 µs / 1,370
520.83µS				2 ms / 500	690 µs /1450	622 µs / 1,610
312.5µS				2 ms / 500	488 µs / 2050	414 µs / 2,445
260.42µS				2 ms / 500	430 µs / 2350	358 µs / 2,825
130.21µS				2 ms / 500	290 µs / 3400	217 µs / 4,660
2.5µS [2]				2 ms / 500	82 µs / 12200	45 µs / 22,200

[1] Aperture is not available with any of the Triggered modes.
[2] Not available with the SMU2060

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

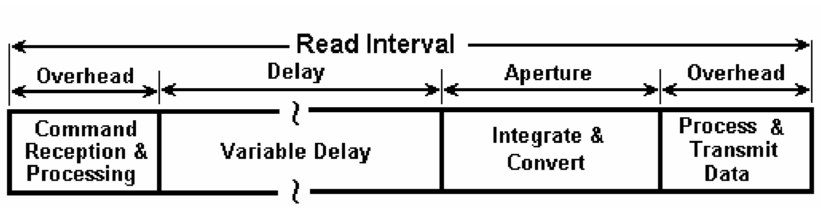


Figure 2-1: Time frame of a single measurement.

2.12.2 Range and Function Transition Times

The transition times between functions, and between ranges are important parameters. Iincluding all permutations of all functions and ranges could be extensive. therefore, the following are few of the values for the functions that are used the most. Most of these values depend on the set Aperture, and are therefore more complex to calculate. It is assumed that the Read Interval is set to 0 (default). The following numbers may vary from system to system.

Range switching within Volts DC, using DMMSetRange()

The time to switch ranges with the aperture set to 20ms or lower, is equal to 0.2 * Aperture + 15ms. For all other apertures it is equal to the Aperture + 15.6ms.

Range switching in Resistance (2-W or 4-W), using DMMSetRange()

The time to switch ranges while the set aperture is 33.3ms and higher is equals to the Aperture + 13ms. For all other apertures it is equal to 0.05 * Aperture + 15.5ms.

Switching between VDC and Resistance, using DMMSetFuncRange()

The transition time is 15.6ms for apertures smaller than 16.6ms, and is equal to the Aperture + 25ms for all other apertures.

Switching between Ohms and IDC, using DMMSetFuncRange()

For apertures of 66.66ms and higher the function switching time is equal to 45ms + 0.51 * Aperture. For Apertures of 16.66ms to 40ms it is 0.65 * Aperture. For all other apertures it is 7.8ms.

Switching between VDC and Capacitance, using DMMSetFuncRange()

For apertures smaller than 33.3ms the function switching time is 23.4ms. It is 0.65 * Aperture + 50ms for all other apertures.

Switching between Ohms and Capacitance, using DMMSetFuncRange()

For apertures of 160ms and higher, the function switching time is 160ms. For Apertures of 33.33ms to 80ms it is 2 * Aperture + 35ms. For all other apertures it is 23.4ms.

Switching ranges within DC Current using DMMSetRange()

This time is 1ms if switching does not include the 240mA and 2.4A. Switching to and from these two ranges and the other ranges takes 4.2ms for apertures of 40ms and lower, and 15.7ms for all other apertures.

Switching Capacitance ranges using DMMSetRange()

This time is 12ms regardless of set aperture.

2.13 Source Functions (2064)

- Isolated to 300 V DC from the Chassis
- DMM Measures output voltage while sourcing.
- Multiple SMU2064 units can be placed in series or parallel to increase output Voltage or current
- Two auxiliary voltage inputs can be used to monitor UUT DC voltages while in this mode.

2.13.1 DC Voltage, Measure DC Voltage

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 Source DC Voltage, Measure DC Current

The following specifications are typical. See source measure limit plot in section 4.

- Source resistance of the voltage source is approximately 200 Ohms.
- It is required to perform DMMOpenTerminalCal operation prior using this function.
- Multiple assertions of the DMMSetDCVSource operation is required to arrive at the specified voltage.

Parameter	
Voltage source range [1]	-10.0 V to +10.0 V
DC Current measurement range	0 mA to+/-24mA
Voltage setting resolution	5mV
Voltage setting accuracy 23°C ± 10°C One Year	1% ± 35 mV
Typical settling time	3s [2]
DC Current measurement accuracy	0.1% + 1 µA

[1] See the performance envalop for limitations of the voltage and current values.

[2] Issue DMMSetDCVSource operation at least five times to arrive at the specified accuracy. Use aperture of 133ms or higher.

2.13.3 Source AC Voltage, Measure AC Voltage

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

Parameter	Specification 18°C to 28°C One Year	
Ranges	900mV and 8V	
Output Voltage, sine wave	30mV to 7.2 V RMS (0.14 to 20.0V peak-to-peak)	
Typical Current Drive at 3.5V RMS	3 mA RMS	
Frequency range	10 Hz to 200 kHz	
Frequency resolution	2 mHz	
Frequency stability	100 ppm ± 2 mHz	
SFDR (spurious free dynamic range)	60dBc	
THD (total harmonic distortion)	59dBc	
Typical settling time	100 µs	
Approximate source resistance	250 Ω	
	Closed Loop	**Open Loop**
DAC resolution	16 bits	12 bits
Amplitude accuracy	ACV spec + 0.1% ± 5 mV	ACV spec + 0.1% ± 20 mV

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

2.13.4 Source DC Current Measure DC Voltage

- Sensing: Selectable, at source terminals or sense inputs (remote)
- Range: 10nA to 12.5mA
- Voltage Measurement range: 0 to ±2.4V

Range	Compliance Voltage [1]	Resolution [2]	Minimum level	Accuracy 23°C ± 10°C One Year
1.25 µA	4.2 V	500 pA	10 ηA	1% + 10 ηA
12.5 µA	4.2 V	5 ηA	50 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] Compliance voltage is the range at which the current source is linear. It does not imply a measurement range. Wile in this mode, the DMM measures the load voltage ranging from 0V to 2.4V.
[2] 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.

2.13.5 Pulse Generator

- Settable Negative and Positive Pulse widths: 25us to 3s
- Resolution: 1µs or 100µs
- Amplitude range: settable 0 to ±10V
- Pulse Base level: 0V
- Modes: 1 to 32,000 burts of pulses or continuous.
- Requires driver version 1.60, and Microcode version 1.29 and higher.

Parameter	Range	Typical Resolution
Positive and negative pulse widths	25µs to 65.5ms	1µs
	65.5ms to 3s	100µs
Number of Pulses	1 to 32,000	1
Amplitude	0V to +10V or 0V to -10V	5mV

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.

Since the DMM is powered via a USB calbe (AM/BM 6' cable), it is important to make sure it gets the required 5V supply. Using the right USB cable is very important. Make sure this cable has a 24 AWG wires for power supply, indicated by marking on the cable such as 28/1P + 24/2C. Be aware that there are a lot of cables which are marked 28/1P + 28/2C. These have high resistance, and will not be adequate. Another issue can be with powered USB hubs. Some of the lower quality units can have upwords of 8V rather than the required 5V +/-5%. On initialization (DMMInint) the DMM measures its internal supply voltage and returnes an error or warning code if the power is inadequate. See DMMGetSupplyV function.

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)

- 625µs to 2s in 26 discrete values, SMU2060 (approx. 0.5 to 4,500 readings per second)
- 2.5µs to 2s in 31 discrete values, SMU2064 (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, SMU2064
- 730µs to 65ms, 1us steps in Trigger modes, SMU2060
- 47µs to 1s, 1µs steps below 65ms, in command/response modes, SMU2064
- 916µs to 1s, 1µs steps below 65ms, in command/response modes, SMU2060

Hardware Interface	Single USB Port, maximum cable length 6'
Overload Protection (voltage inputs)	330 VDC, 330 VAC
Isolation	330 VDC, 250 V AC 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*** inside a computer which is at about 23°C. 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
Relative Humidity	80% at 37°C
Size	SMU2060, SMU2064: 4.5" X 8.5"
DMM Internal Temperature sensor accuracy	±1°C (SMU2064)
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 SMU2060 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:

- 6 ft. USB 2.0 AM/BM cable SMU-CBL6ft
- 3 ft. USB 2.0 AM/BM cable SMU-CBL3ft
- 10 ft. USB 2.0 AM/BM cable SMU-CBL10ft
- DMM probes SM-PRB
- DMM probe kit SM-PRK
- Deluxe probe kit SM-PRD
- Shielded SMT Tweezers Probes SM-PRSMT
- Multi Stacking Double Banana shielded cable 36" SM-CBL36 and 48" SM-CBL48
- Mini DIN for Trigger, 6-Wire Ohms and Guarding connector SMU2060-CON7
- Lab View VI's library SMU206X.llb (included).
- Extended 3 Year warrantee (does not include calibration).
- USB Instrumentation Switching modules: SMU4030, SMU4032

- PXI Instrumentation Switching modules: SMX4030, SMX4032
- IVI-COM driver

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 package includes the Digital Multimeter; Installation CD, a floppy disk containing the calibration and verification records, a 6' USB cable and a Certificate of Calibration.

3.1 Setting up the DMM

The DMM is provided with plug-and-play installation software, and does not require any switch settings, or other adjustments prior to installation.

3.2 Installing the Software.

Before connecting the DMM Hardware, it is necessary to install the DMM software. Insert the Signametrics Product Installation CD into your CD drive. A menu will appear automatically on most computers. Otherwise, double-click on the autorun.exe file in the root directory of the Installation CD.

A menu will appear, allowing you to choose which Signametrics product to install. Select the product you would like to install, "SMU2055/2060/2064 USB DMMs". A Software Setup Wizard will begin. Follow the installation process, selecting which components you would like installed, and where they should be installed. The Hardware Driver and the Front Panel are required components to run and test the product. On the last page of the wizard, click Install.

After the software has been installed, The Signametrics USB Driver Wizard will appear. Click "next". A windows message may appear asking if you are sure you wish to install this driver. Continue the installation. Afterwards, you should now see a screen that indicates the drivers have been sucsessfully installed on this computer.

3.3 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.

Use extreme care when plugging the DMM module(s) into a USB port on your computer. Make sure no cable is connected to the front panel of the DMM while you plug it into the USB port.

Connect the SMU2055/2060/2064 to one of the USB ports on your computer. On Windows 2000, XP, or Vista a "Found New Hardware" Wizard dialog box should appear. On Windows 7, the drivers may automatically be detected and installed without a Found New Hardware Wizard Appearing.

The Wizard asks "Can Windows connect to Windows Update to search for software?" Select "No, not this time" and click on "Next". Select "Install the software automatically" and click on "Next". Windows should be able to find the drivers automatically since they were copied to the system (section 3.2). Windows may double check whether you want to install the software. If this is the case, click "Continue Anyways". The Wizard should say "The wizard has finished installing software for: [multimeter product name]". Click "Finish" to complete the installation.

3.4 Calibration File

The **SM60CAL.DAT** file supplied with your DMM has a unique calibration record for that DMM (See "**Calibration**" at the end of this manual.). In most cases, the installation of the calibration file is handled automatically by the DMM software.

A copy of the calibration file resides on an EEProm on the DMM and is copied to your computer the first time you use the instrument. A backup copy of the calibration file is included on a diskette that comes with the DMM.

The default location of the Calibration File is "C:\SM60CAL.DAT". If your system uses multiple DMMs, the software will append the Calibration Records of each DMM into a single SM60CAL.DAT file. The SM60CAL.DAT file is a text file, and can be opened using a text editor such as Notepad, should it be necessary.

3.5 DMM Terminals

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.**

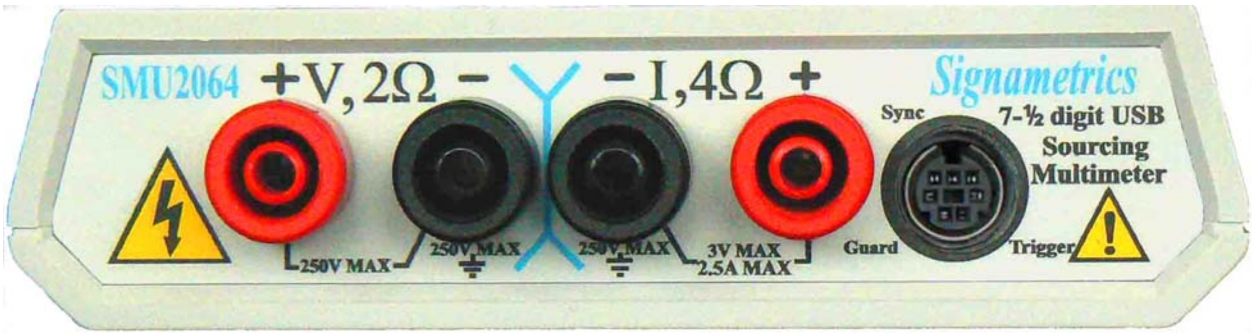


Figure 3-1. The DMM input terminals include both, four Banana and a DIN-7 connector.

V, 2Ω + This is the positive terminal for all Volts, 2-Wire Resistance and diode test. When in 4-Wire resistance measurement mode, it serves as the positive terminal of the current source. The maximum input across **V, 2Ω +** and **V, 2Ω -** is 240 VDC or 240 VAC**.**

V, 2Ω - This is the negative terminal for all Volts, 2-Wire Resistance and diode test. When in 4-Wire resistance measurement mode, it serves as the negative terminal of the current source. **Do not float this terminal or any other DMM terminal more than 240 VDC or 240 VAC above Earth Ground.**

I , 4Ω + This is the positive terminal for all Current measurements. While in 4-Wire resistance measurement mode it is the high sense as well as the SMU2064 6WΩ guarded sense. The maximum input across **I, 4Ω +** and **I, 4Ω -** is **2.5 A**. Do not apply more than 5 V peak across the I,4Ω+ and I,4Ω- terminals. While the SMU2064 is in DCV or DCI source mode this terminal may be used as an additional voltage measurement input which is limited to of ±2.4V range.

I,4Ω - This is the negative terminal for Current measurements. While in 4-Wire resistance measurement mode it serves as the low sense. 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!. While the SMU2064 is in DCV or DCI source mode this terminal may be used as an additional voltage measurement input which is limited to ±2.4V range.

The I,4Ω - Current function is protected by a 2.5 A, 250 V Fast Blow fuse (PCT type).

TRIG / SYNC / GUARD The Trigger input, Sync output and the two Guard signals are available at the DIN-7 connector located to the right of the **I , 4Ω + terminal**. This group of pins includes the trigger input (7) line, the Sync output line (2), the Trigger and Sync lines commong (4), and in the case of the SMU2064, the Guarded Source (1) and Sense (6) signals. The Trigger can be setup to trigger reading(s) into the onboard buffer, or for immediate response. The Sync line can be used to issue or synchronize operations with an external device, such as Componenet Handlers. The Six Wire Guard signals facilitate in-circuit resistor measurements by means of isolating a loading node. A mating male DIN-7 plug can be ordered from Signametrics. The connector is generically referred to as a mini DIN-7 male.

To activate the Trigger input, apply 3.5 V to 12 V (max). Connect the positve to the Trigger pin and the negative to the Trigger and Sync Common pin.

The Sync output is an open collector capable of upto 20V. Typical current sinking is 0.5mA with a current limit of 3mA. The width of the Sync signal depends on the selected Aperture. The minimum width is about 200us when the Aperture is set to 130us. It can be enabled or disabled (default), set to a positive or negative pulse, be set low or high using functions such as **DMMOutputSync** and **DMMSetSync**

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. 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 line
1	Guard Source [1]
6	Guard Sense [1]

[1] Available with the SMU2064 model.

Figure 3-2. The DIN-7 connector pinout table.

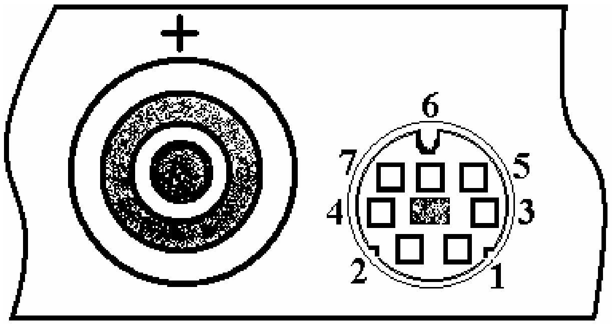


Figure 3-3. The DIN-7 connector pin diagram as viewed from the front of the DMM.

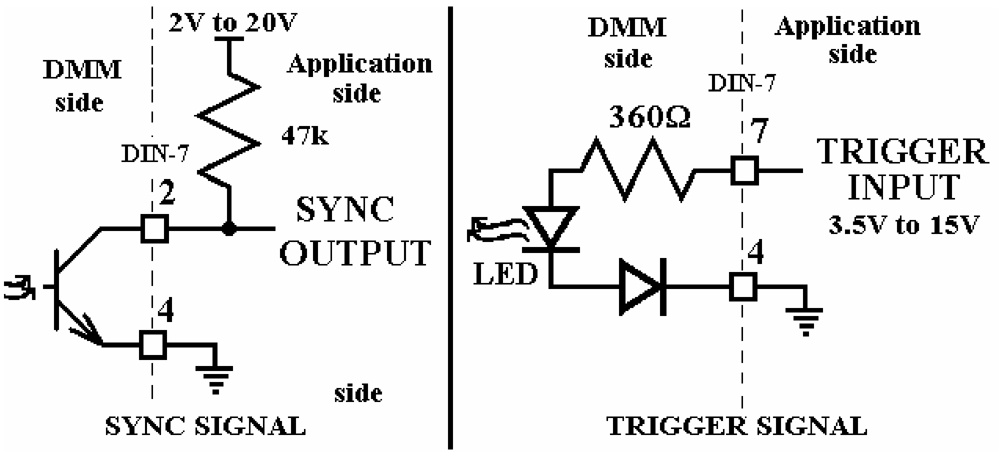


Figure 3-4. The Sync and Trigger lines interface and application

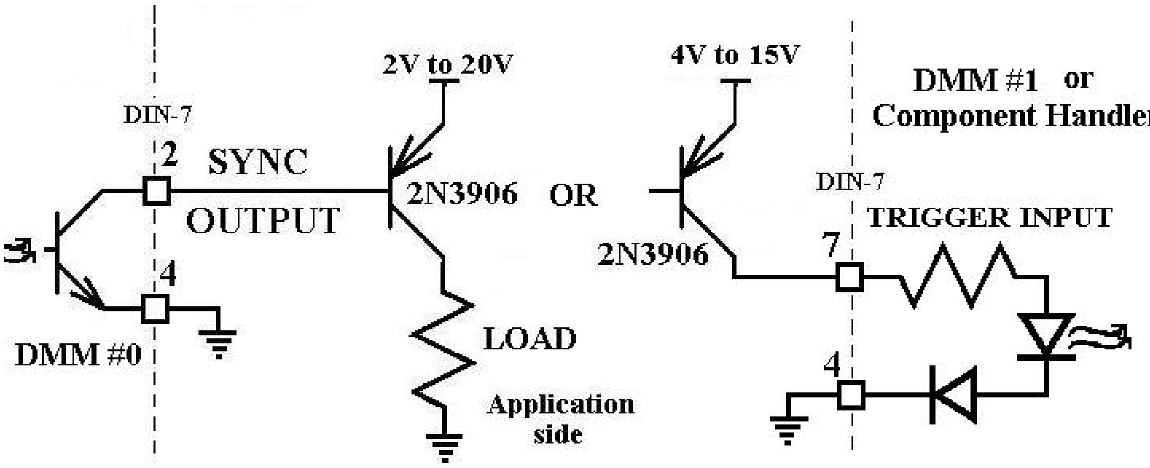


Figure 3-5. Boosting Sync output current with a single external PNP Transistor.

The following functions should be reviewd for use when interfacing to external devices such as Switches, other DMMs, Component Handlers etc.. They provide a complete handshake facility to make programming very simple and efficient. Look up functions such as **DMMArmTrigger, DMMOutputSync, DMMWaitForTrigger, DMMGetTrigger DMMArmTrigger, DMMTrigger, DMMReady, ArmAnalogTrigger, DMMDisarmTrigger, DMMSetSync, DMMSetTrigPolarity,** and **DMMGetTriggerInfo**.

3.6 DMM Rear Panel

The rear panel includes various compliance and warning text and graphics, the unit serial number, its modle number and the installed options. The USB connector provides for both, compueter interface and power to run the DMM..

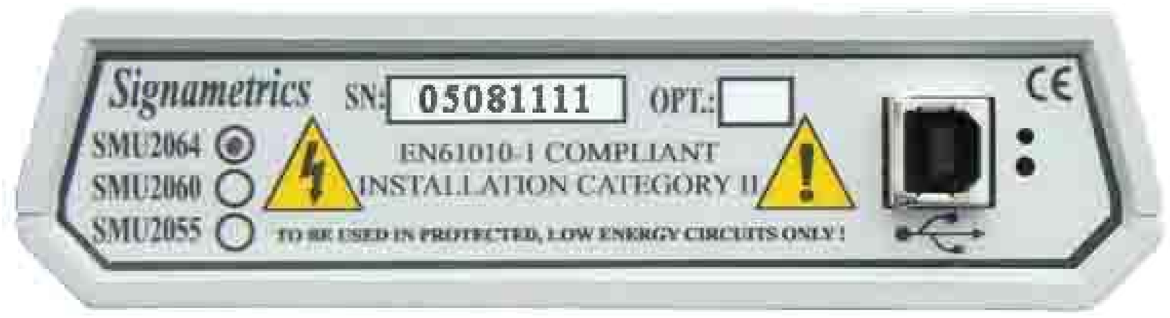


Figure 3-6. The Rear panel has the USB BF type connector. Compatible with BM cable.

3.7 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, Start→SMU2060 Series Multimeters→SMU2064 Multimeter. 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 for the first time, it takes a few extra seconds to extract its calibration data from the on-board memory, and write it to the calibration 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 SMU2055 front panelstarts up in DCV, 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 wth high end DMM's such as the SMU2060. 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 SMU2060 will change ranges, causing the range switching. This is normal.

3.8 Using the Control Panel

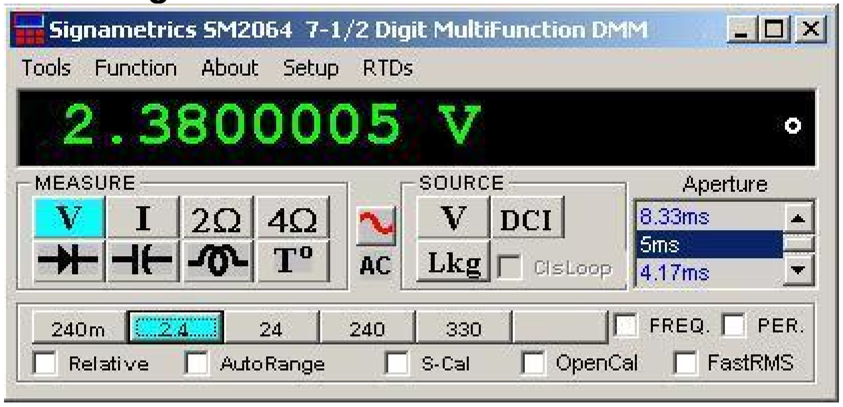
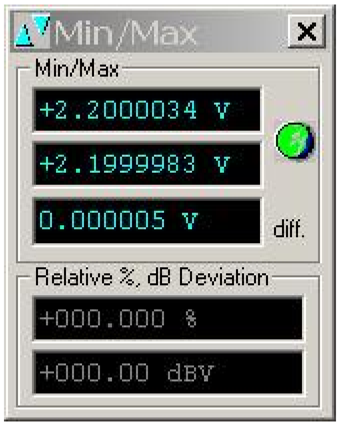


Figure 3-6**.** The Control Panel for the SMU2064. The three main groups include Measure, Source and Range buttons. The Range buttons are context sensitive such that only "240m, 2.4, 24, 240 and 330 appear when in AC Voltage Function is selected, and 2.4m, 24m, 240m and 2.4 appear when AC Current functions 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 SMU2060 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 SMU2060. 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.


Min/Max

Min/Max

+2.2000034 V

+2.1999983 V

0.000005 V diff.

Relative %, dB Deviation

+000.000 %

+000.00 dBV

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 SMU2060 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.

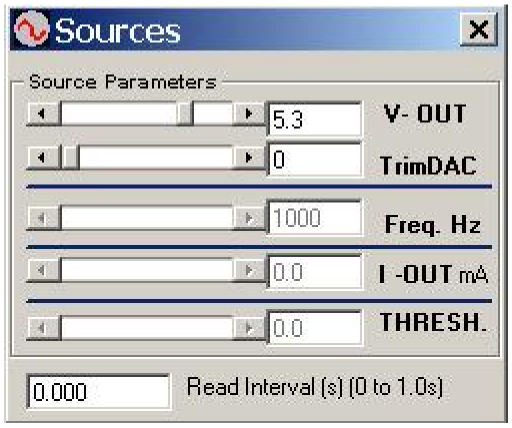
Range: Can be set to **Autorange** or manual by clicking on the appropriate range in the lower part of the Windows panel. Auto ranging is best used for bench top application and is **not recommended** for an automated test application due to the uncertainty of the DMM range, as well as the extra time 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 SMU2060 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 SMU2064 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 SMU2064. 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 (SMU2064 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.



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 Measurements Tutorial

Most of the DMM's 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 SMU2060 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,2Ω +** and **V, 2Ω -** terminals, being certain to always leave the **I,4Ω+ and I,4Ω-** 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, 2Ω +** and **V, 2Ω -** 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 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 SMU2060. 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 SMU2060 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 DMM may not read a perfect zero with a shorted input. This is normal.

In ACV measurements it is important to conenct NEUTRAL or GROUND signal being measured to the DMM's **V,2Ω -** terminal. This prevents any "Common Mode" problems from occurring (Common Mode refers to floating the DMM **V,2Ω-** voltage referenced to 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 frequency limits of the RMS functions (AC Voltage and current) are effected by the state of the **Fast RMS** control circuit. This function is off as a default. When **Fast RMS** is selected (see **DMMSetFastRMS**), the RMS settling time is about 10 times faster, but the low frequency cutoff point is increased significantly. For minimum error engage the Fast RMS at signals frequencies higher than 400Hz. Using the Read Interval (**DMMSetReadInterval**) in conjunction with aperture (**DMMSetAperture**) will facilitate accurate control over the settling and measuring times. For instance, when measuring 1.5V 1kHz signal using the 2.4V ACV range, optimize speed by setting the DMM for Fast RMS, set Aperture to 66.6ms and the Read Interval to 116.6ms. This will provide the required RMS processing time of 50ms.

Consideration must be given to the selected Aperture. This is particularly important at signal frequencies lower than 100Hz. Two error sources are suppresssed using the right Aperture, the RMS converter low frequency cutoff and signal aliasing with the Aperture. At these lower frequencies make sure to set the Aperture to a value that is at least ten (10) times the period of the measured signal.

4.1.3 AC Peak-to-Peak and Crest Factor (SMU2064)

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 (SMU2064)

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 SMU2064 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.

4.1.5 Average AC Voltage Measurement (2064)

To make average AC voltage measurement, the 2064 model DMM should be set to DC voltage measurement, and the appropriate range be selected. This is followed by executing the **DMMGetAverageVAC()** command, which returns the average value of the input voltage.

Average AC voltage is the mean of the rectified voltage over one period of the waveform. For a sinusoidal waveform V_{RMS} = 0.707Vpk and V_{AVG} = 0.637Vpk. It is necessary to enter the frequency of the signal while using **DMMGetAverageVAC()**. If it is not known, use the DMM’s frequency counter to measure it prior to performing this measurement. The frequency range of this measurement is from **0.5Hz to 1kHz**. It is important to select the appropriate DC voltage range. For instance, a sinewave with 2V RMS value has a peak voltage of 2.828V, and therefore the 24V range mus be selected.

The more abrupt the signal, the less stable the measurement will be. Therefore a measurement of a square wave will be noisier than that of a sine.

This function requires a repetitive signal. Connect the input signal between the **V+** and the **V-** terminals.

4.1.6 Low frequency RMS Voltage Measurement (2064)

A special function is provided to make RMS voltage measurements at low frequencies. To use it, set the 2064 model DMM to DC voltage measurement, and select the appropriate range for the intended input voltage. Follow this with the executing the **DMMGetLowFreqVRMS()** command, which returns the RMS value of the input voltage.

It is necessary to enter the frequency of the signal while using **DMMGetLowFreqVRMS ()**. If it is not known, use the DMM’s frequency counter to measure it. The frequency range of this measurement is from **0.1Hz to 66Hz**. It is important to select the appropriate DC voltage range. For instance, a sinewave with 2V RMS value has a peak value of 2.828V, and therefore the 24V range is required.

The more abrupt the signal, the less stable the measurement will be. Therefore a measurement of a square wave will be noisier than that of a sine.

This function requires a repetitive signal. Connect the input signal between the **V+** and the **V-** terminals.

4.2 Current Measurements

The SMU2060 measures AC and DC currents between 100 ηA and 2.5 A. Use the **±I, 4WΩ** terminals, being certain to always leave all other 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 internal to the DMM. 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 maximum burden voltage is about 250mV.

4.2.1 Extended DC Current Measurements (SMU2064)

In addition to the 2.4mA, 24mA, 240mA and 2.4A, the SMU2064 has four additional ranges; 240nA, 2.4uA, 24uA and 240uA ranges. The lower three ranges are implemented with a "Virtual Zero Shunt" technology, commonly associated with specialized Nanoameters. It has an ultra low noise low leakage electronic shunt that renders it useful for measuring down to few Pico-amperes. This means that super low currents from such circuits as Current output DACs, commonly found in implanted medical devices such as heart pace makers and defibrillators, 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). It is also a good idea to zero the measurement function using 'Relative' control.

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

4.2.2 Improving DC Current Measurements

When making sensitive DC current measurements disconnect all terminals not associated with the measurement. Use 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 SMU2060 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 SMU2064. It measures low level DC currents with a specified DC voltage applied to the DUT.

4.3 Resistance Measurements

The key to resistance measurements is the number of stable current sources available. The SMU2064 utilizes eight, and the SMU2060 has six stable current sources. The **V, 2Ω +** provides the positive terminal and the **V, 2Ω-** negative terminal of this current source. The DMM measures resistance by forcing a current, and measuring a voltage, which the DMM converts and displays as a 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

In the 2-Wire resistance measurement the DMM sources current and measure resuting voltage. The SMU2060 measure Resistance using six ranges; 240Ω to 24 MΩ. The SMU2064 adds two ranges; 24 Ω and 240 MΩ. It also has a specialized extended resistance measurement of. Connect the resistor to be measured to the top two terminals; **V,2Ω+, V,2Ω-.** Disconnect the **I,2Ω+** and **I,2Ω-** terminals in order to reduce error due to leakage and noise, as well as better safety.

If the resistor to be measured is less than 24 kΩ, you may null out any lead resistance errors by first shorting the ends of the **V,2Ω+** and **V,2Ω-** test leads together and performing a **Relative** operation (**DMMSetRelative** under program control). Making measurements above 200 kΩ, you should consider shielded or twisted leads to minimize noise pickup. Further improvement can be achieved using guarding (section 4.3.5).

It is a good idea to be aware of the test voltages, particularly when measuring a circuite that includes semiconductors. To reduce this voltage, select a higher resistance range (lower current). For instance, measuring 10k resistor using the 24k range (100uA), results in 1V test voltage, which will turn on semiconductor junctions, resulting in lower resistance reading. To avoid this error, select the 240k range (10uA), which will result in 100mV and will read the 10k a lot more accurately (see section 2.3 for resistance ranges vs. current). For characterizing semiconductor part types, use the Diode measurement function.

For applications requiring voltage and current controlled resistance measurements, use the Extended Resistance Measurement function as well as active guarding is available with the SMU2064.

4.3.2 4-Wire Ohm Measurements

4-wire Ohms measurements are advantageous for making measurements below 200 kΩ, eliminating lead resistance errors. The **V,2Ω+** and **V,2Ω-** terminals apply a current source stimulus to the resistance, and the **I,4Ω+** and I,**4Ω-** 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 4-1 for the proper connection. The sense leads should be closest to the body of the resistor. Observe the limits on the lead resistance of the test current source lines spelled out in section 2.3.2.

4-wire Ohm makes very repeatable low ohms measurements, from 100 μΩ (10 μΩ for SMU2064) to 240 kΩ. It is not recommended to use **4WΩ** when making measurements above 100 kΩ, although 4-wire ohms measurements are facilitated up to 240 kΩ. 4-wire measurements are disabled above 240 kΩ since the extra set of leads can actually *degrade* the accuracy, due to additional leakage and noise paths.

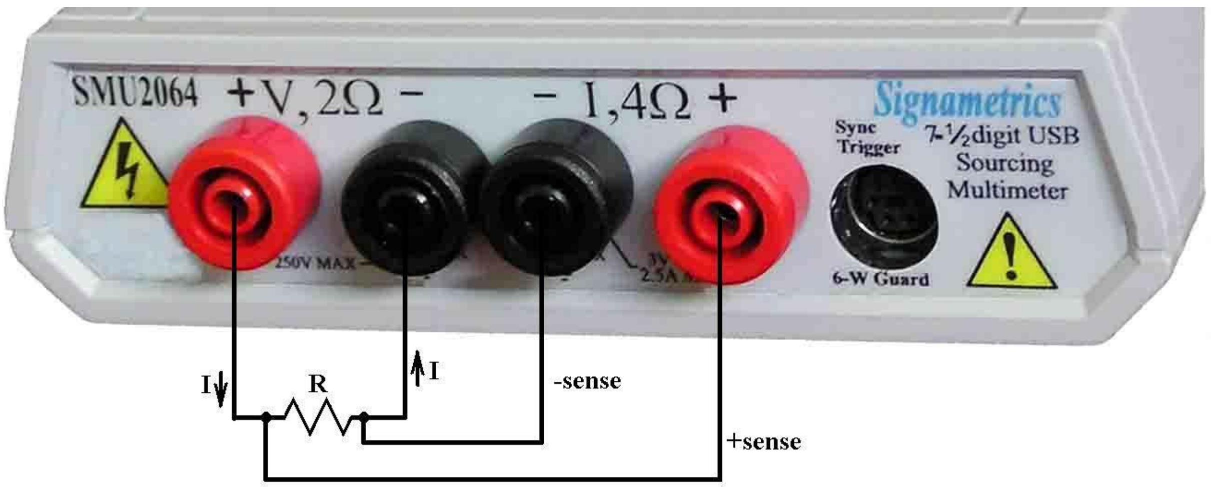


Figure 4-1. The **I,4Ω-** and **I,4Ω+** sense leads should be closest to the body of the resistor when making 4WΩ measurements. Mind the lead resistance of the **V,2Ω+** and **V,2Ω-** lines.

4.3.3 Using Offset Ohms function (SMU2064)

There are many cases where the resistance bening measured has a series voltage. This can be while using multiplexers with high Thermo-Voltaic voltage (due to poor relays). These errors are also associated iwht measuring devices that by design have a series voltage such as Peltier devices, thermocouples etc.. The presence of these voltages can cause significant measurement error. These errors effect both 2-Wire and 4-Wire measurements. Engaging the Offset Ohms mode reduces most of this error at the cost of slower measurement speeds. Note that with this function, the internal resistance of low voltage sources such as batteries can be measured. This function is disabled by default. The **DMMSetOffsetOhms()** function controls the operation of the Offset Ohms mode. To enable it, enter TRUE (1). The result is an effective measurement rate that is approximately twice as slow. To disable this function enter FALSE (0).

Both negative and positive offset voltages can be corrected for. There are some limits however. For one, the absolute value of the offset voltage, **Vo**, must be smaller than 230mV for the 24Ω and 240Ω ranges, and smaller than 2.3V for all other ranges. Also, the value of **I*R + Vo** must be smaller than 220mV for the 24Ω and 240Ω ranges and 2.2V for other ranges. **I** is the resistance test current (see sectin 2.3) and **R** is the resistance being measured.

Example: Measuring a 20kΩ resistor using the 24k range, provides test current, **I** = 100µA (section 2.3). Therefore the maximum positive offset voltage **Vo** = 2.2V – (100 µA * 20k) = **+200mV**. The maximum negative voltage **Vo** = -2.2V - (100 µA * 20k) = -4.2V, however, since the limit on **Vo** is -2.3V, (see section 2.3.5), the most negative value of **Vo** is only **-2.3V**.

With aperture times lower than 5ms, an increasing error will be observed. It is therefore recommended to use this function in conjunction with apertures greater than 5ms.

4.3.4 6-wire Guarded Resistance Measurement (SMU2064)

The 6-Wire Guarded resistance measurement provides means to make resistance measurements in-circuite, or where the resistor being measured is connected to other circuite elemens which are loading it. DMMs not capable of Guarding will exhibit very large errors in this type of measurement, where the 2060 isolates the resistor-under-test by maintaining a guard voltage at a user-defined node. The guard voltage prevents the shunting of the DMM test 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 SMU2064 accurately measures the 30 kΩ resistor.

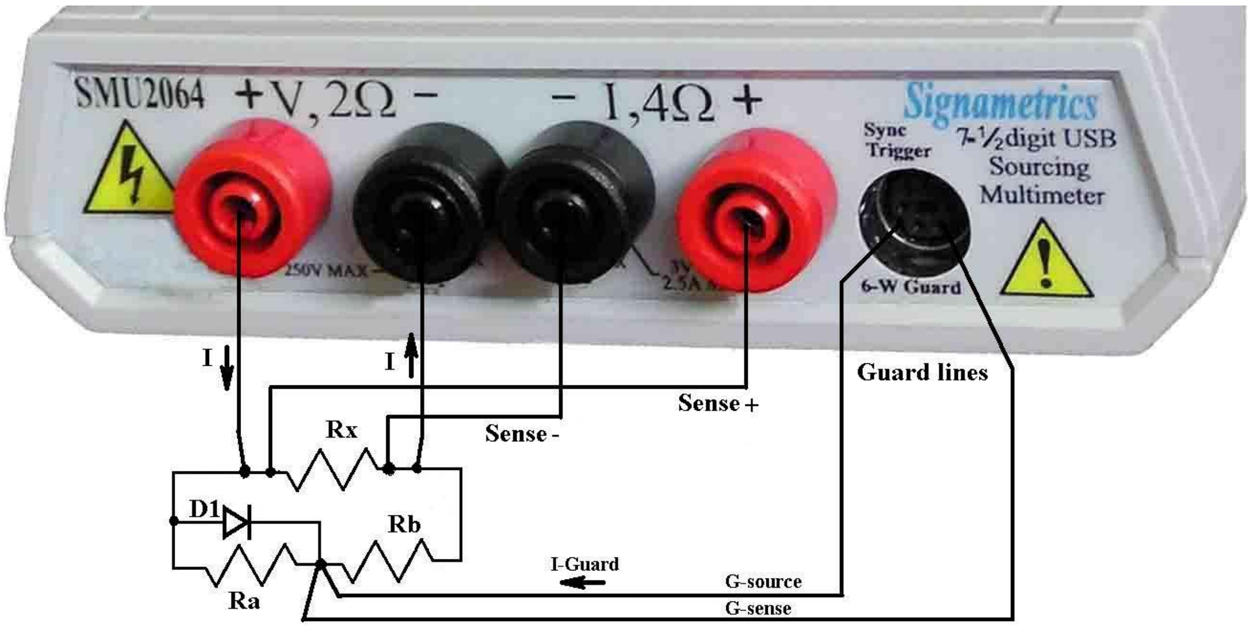


Figure 4-4. 6-wire guarded in-circuit ohms measurement configuration.

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 240 Ω range and measuring a 220 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 240 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 (SMU2064)

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. A 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 400kΩ. With the test voltage set to 0.1V the minimum value is about 4kΩ. The next range's limit is

2.4µA which corresponds with 4MΩ at 10V and 40kΩ with 0.1V. The highest range current is limited to 240nA, which implies that the lowest resistance it can measure with 10V source is 40MΩ and the lowest resistance it can measure with 0.1V is 400kΩ. The highest range practical measurement limit is as high as 10GΩ. The connection topology with optional active guarding is depicted in Figure 4-5.

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	Range Code	Measurement range	Resolution	Voltage Range	Current Limit
400kΩ	0	1kΩ to 100MΩ	10Ω	±0.02V to ±10.0V	25µA
4MΩ	1	10kΩ to 1GΩ	100Ω	±0.02V to ±10.0V	2.5µA
40MΩ	2	100kΩ to 10GΩ	1kΩ	±0.02V to ±10.0V	250nA

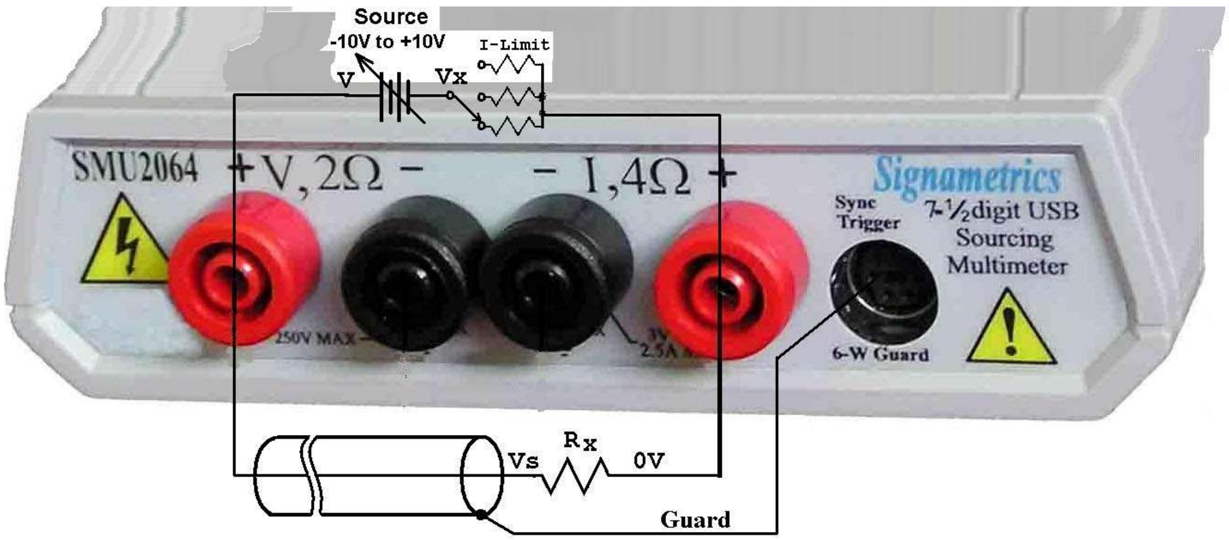


Figure 4-5. Guarding improves accuracy when measuring high value resistors using the Extended Resistance measurement method.

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 switches having more than 100 µV. With several relay contacts in the path, the error compounds, which could be much worst in matrix type switches. This error can be measured using the SMU2060 240mV DC range. To do this, close a channel which is shorted on the application side. Wait for about 2 minutes, than measure the voltage on the DMM side of the multiplexer. 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. The SMU2064 can source ten times the test current of most DMMs, resulting in ten fold reduction in error. At 1µV the

Signametrics SMX4032, SM4022 and SM4020 switching cards have a hundred times lower Thermal EMF than most other switches. Even the lower grade Signametrics switches will be 10 times better. Ohms law is used to provide the conversion of the thermal voltage to resistance error. If you can't tolerate 100mΩ error, you should consider using the Signametrics SMX4030, SMX4032, SM4022 or SM4042 switches, as well as use the SMU2064 or SMU2064 DMM.

SMU2064 Range	Ohms Current	DMM Resolution	Error due to 10 µV EMF	Error due to 100 µV EMF	Error due to 1mV EMF
24 Ω	10 mA	10 µΩ	1 mΩ	10 mΩ	100 mΩ
240 Ω	1 mA	100 µΩ	10 mΩ	100 mΩ	1 Ω
2.4 kΩ	1 mA	1 mΩ	10 mΩ	100 mΩ	1 Ω
24 kΩ	100 uA	10 mΩ	100 mΩ	1 Ω	10 Ω
240 kΩ	10 uA	100 mΩ	1 Ω	10 Ω	100 Ω
2.4 MΩ	1 uA	1 Ω	10 Ω	100 Ω	10 Ω
24 MΩ	100 nA	100 Ω	100 Ω	1 kΩ	100 Ω
240 MΩ	10 nA	10 kΩ	1 kΩ	10 kΩ	100 kΩ

Figure 4-6. Resistance measurement errors contributed by Thermo-Voltaic offset.

4.3.7 Guarding High Value Resistance Measurements (SMU2064)

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 4-6 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.

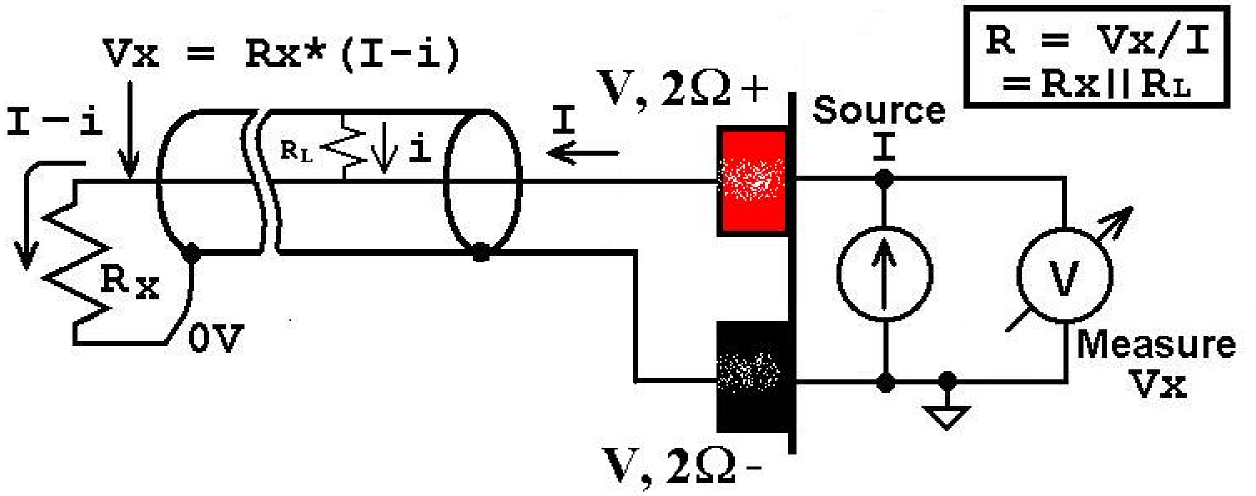


Figure 4-7. Depiction of the error caused the cable leakage, R_L.

The SMU2064 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 4-7, there is 0V between the shield and the high sense wire, and therefore no current flows through R_L.

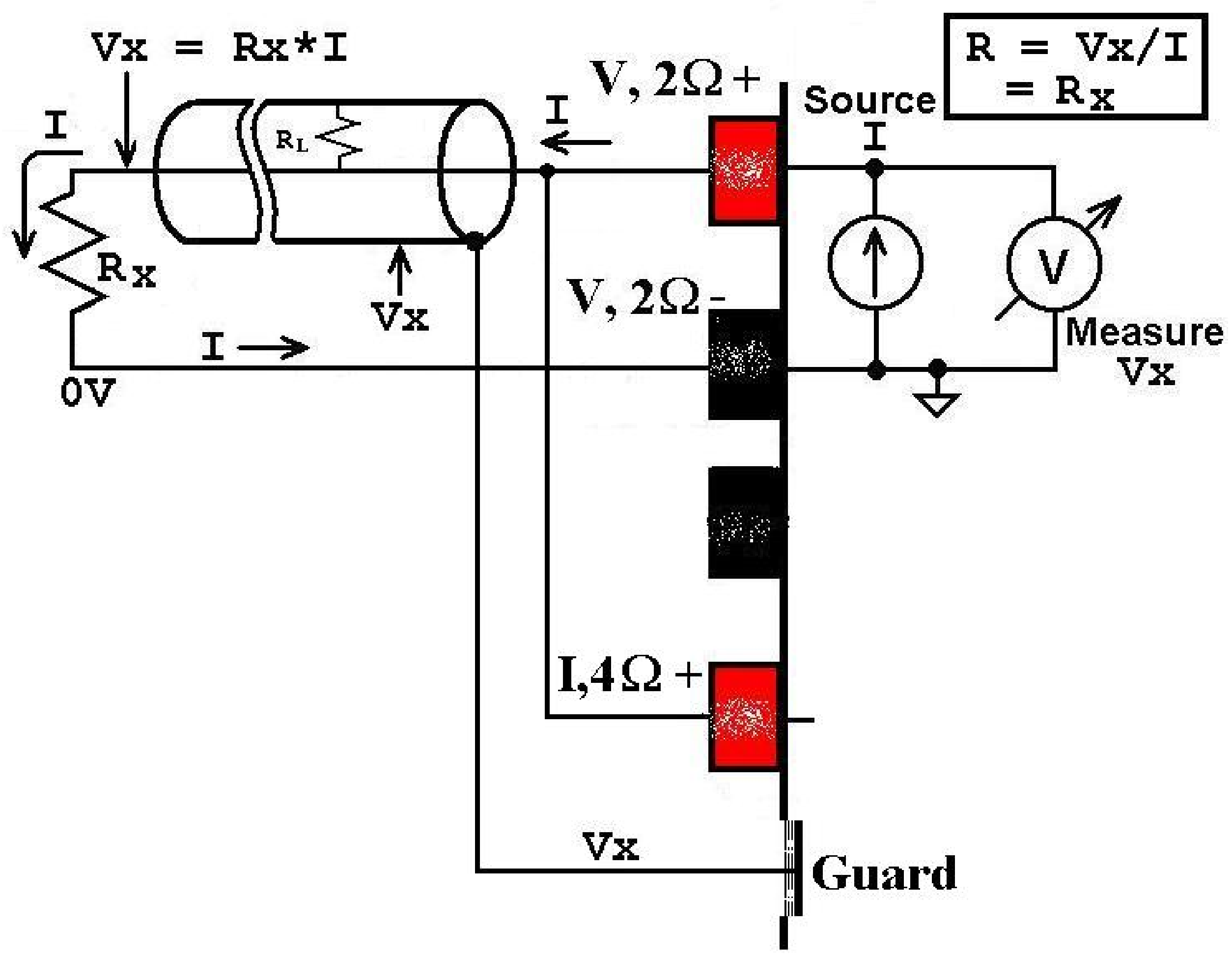


Figure 4-8. Guarding improves high value resistance measurement accuracy by reducing leakage errors.

4.4 Leakage Measurements (SMU2064)

The SMU2064 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 4-8 for connection. The DC voltage at which leakage is measured is set using **DMMSetDCVSource()**. Leakage current is read using **DMMRead(), DMMReadStr()** or **DMMReadNorm()** functions. Use **DMMReadTestV** to measure precisely the test voltage being applied.

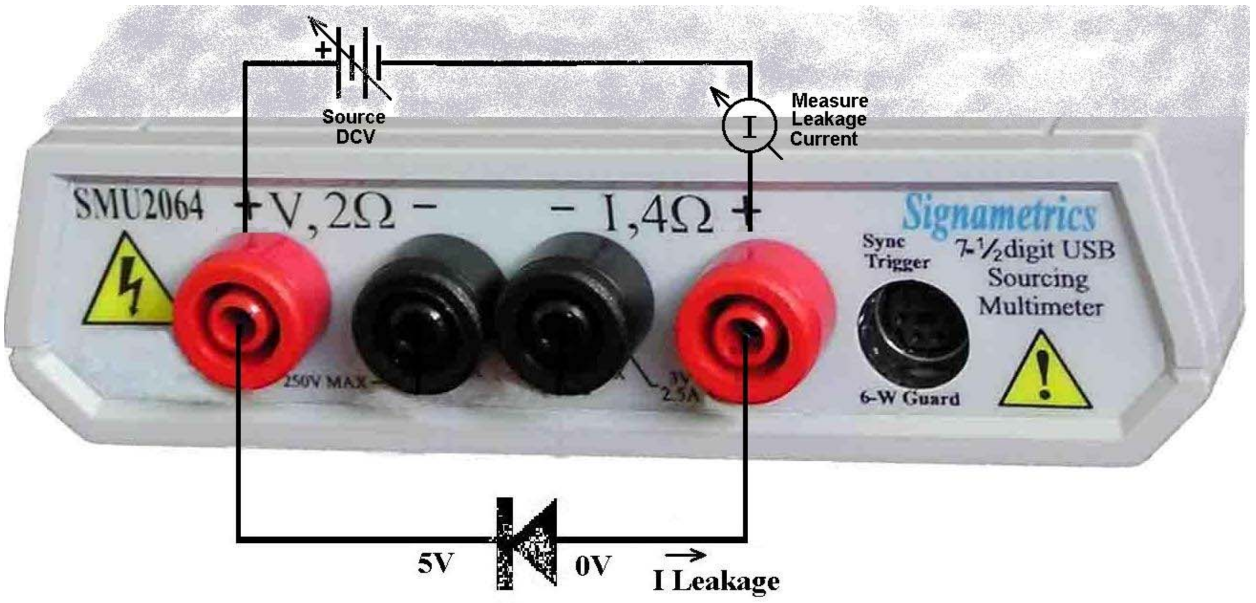


Figure 4-9. Leakage test configuration; reverse diode leakage at 5V.

4.5 Anatomy of measurement timing

4.5.1 Aperture

The SMU2060 and SMU2064 DMM's have several parameters governing measurement timing, including Aperture (section 2.12), 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. The time during which it integrates (averages) the input is the 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.

There are two DMM functions that set the Aperture. The DMMSetAperture() and DMMSetPLC(). The DMMSetAperture() sets the SMU2064 Aperture to one of 31 possible values between 2.5us and 5.066s, and the SMU2060 can be to 26 values between 625us and 5.066s. While using the various Trigger modes, the Aperture time must be set to 160ms or a lower value. The DMMSetPLC() sets the Aperture to a value that is the multiple of power line cycles. It specifies the power line to be used, 50Hz, 60Hz or 400Hz, and the number of cycles to integrate (1 to 50).

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 4-10 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.

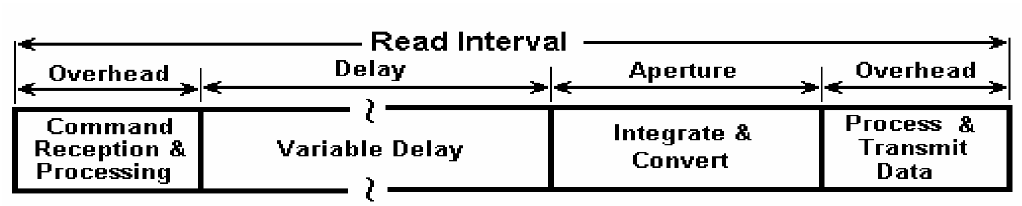


Figure 4-10. Anatomy of a measurement

4.6 RTD Temperature Measurement (SMU2064)

For temperature measurements, the SMU2064 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 (SMU2064)

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 temperatures. When used properly, this internal temperature measurement can enhance the accuracy and stability of various measurements. It also allows monitoring of the PC internal temperature, which is important for checking other instruments in a PC-based test system. To use this function use **DMMSetFunction()** with the **TEMP**_LCL (43) parameter, followed by a read function (**DMMRead, DMMReadNorm or DMMReadStr**).

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 forces a current and measures voltage drop. 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 SMU2064 have an additional 10 mA range. The SMU2064 also has a variable current source that may 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, Charge Balance method

The DMMs measure capacitance using a differential charge balance method, where variable currents are utilized to stimulate a dV/dt response. This method is very fast, and will adapt for the best speed and accuracy at a given range and capacitance value. With the exception of the 1,200 pF range, which measures down to 0pf, all ranges have 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, 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 1,200 pF range. The effect of the cable quality, stability and total capacitance is profound particularly on low value capacitors. For testing surface mount parts, use the optional Signametrics SMT Tweeter probes. You may trade off accuracy for speed in the SMU2064 by using the **DMMSetCapsAveSamp()** function. See figure 4-11 for connection.

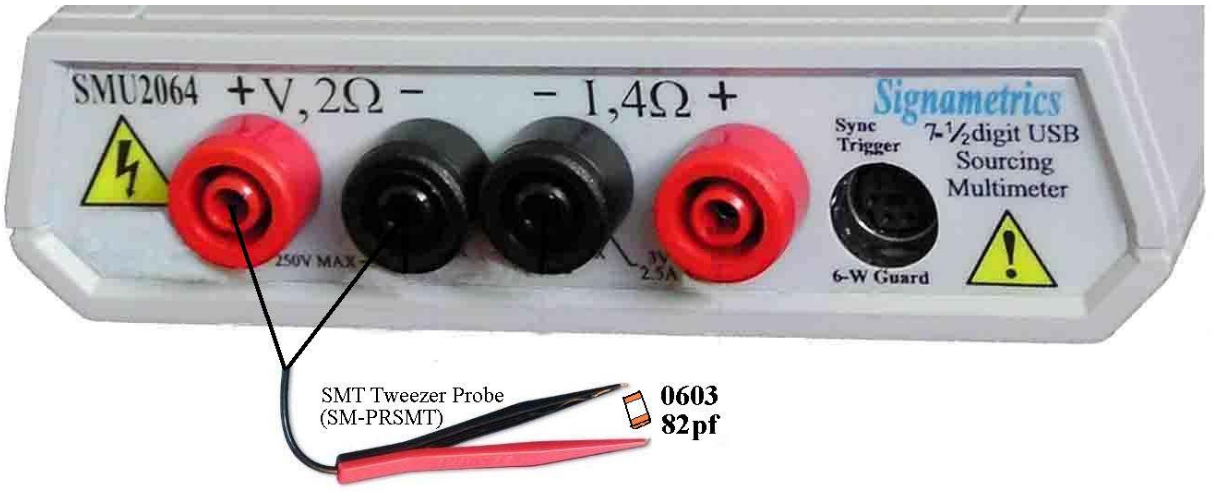


Figure 4-11. Measuring capacitors or inductors is best handled with low capacitance shielded probes.

4.10 In-Circuit Capacitance Measurement (SMU2064)

A second method for measuring capacitance is the AC based method. This function consists of six ranges, 24nF to 24mF. Though not as accurate or fast as the above function, it is able to measure capacitance which is burdened with low parallel impedance. This function is more comlex for use, and should only be used if the Charge Balance method does not work. The default stimulus is set at 0.45V peak, preventing semiconductor junctions to conduct. It is also possible to control the stimulus voltage. This test function operates by measuring 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 depending on range. Following the selection of this function (**DMMSetFunction(0, 82)**), use **DMMRead()**, **DMMReadStr()** and **DMMReadNorm()** to measure the capacitance value. The resistive component can be read using **DMMGetACCapsR()** following a reading. It is necessary to calibrate each range prior to making measurements. This is done by selecting the desiered range (**DMMSetRange()**) and performing open terminal calibration using **DMMOpenCalACCaps()** function. Make sure nothing is connected to the test leads while doing this. This process will calibrate only the selected range. It is best to use the default stimulus level. However, if this level is changed **(DMMSetACCapsLevel()**), repeate the open terminal calibration. The calibration factors are preserved, for each range as long as the driver (DLL) remains loaded. The **DMMSetACCapsDelay()** is provided to allow control over the internal measurement delay, as well as range limits. A delay value of 0 to 10s can be set (it has little effect on the three upper ranges). To remove range limits (i.e. measure 5uF while in the 2.4uF range), the delay is set to a negative value. For instance setting it to -0.1 will result in 100ms delay and no range limits. With the test leads connected to the DMM terminals, use the Relative function (**DMMSetRelative()**) to take out any offset due to cables. The stimulus frequency may be read using the **DMMGetSourceFreq()** function. The default frequencies, starting at the lowest range are: 100kHz, 10KHz, 1kHz, 100Hz, 20Hz and 4Hz. For best results Set the DMM Aperture for 33ms or higher. Or use the delay in conjuncton with a smaller aperture. An additional modifier to this function is the **DMMSetSourceRes()** function.

Additional considerations

Lead resistance (overall path resistance, including swithing and interconnects) should be kept below 1 Ohm. The selected aperture must be an integer value multiple of 1/test frequency. When testing polarized capacitors the DMM's positive terminal must be connected to the corresponding terminal of the capacitor. Capacitors with high ESR will read lower than their nominal value.

4.11 Measuring the resistance in a series RC network (2064)

A method for measuring the resistance of a series RC network is provided, which comlements the two Capacitance measurement methods. The value of the resistor (ESR) is measured using an AC source in a ratiometric method, which relies on a calibrated and characterized internal source resistance. To perform this measurement use the following sequence of commands:

1) Set the DMM for this measurement: **DMMSetFunction(nDmm, ESR);** (ESR = 100).
2) Set the Aperture to the desiered value: **DMMSetAperture();** (should be 160ms or greater)
3) The default test amplitude is 0.5V RMS. It is best to keep this value. If you must change it use **DMMSetDMMSetACVSource()**. (the frequency value entered is ingnored in this mode). Stimulus level can be set between 30mV and 900mV RMS. Change in stimulus level with requires Open Compensation **DMMOpenCalACCaps()**.
4) Perform Open Compensation using **DMMOpenCalACCaps()** with open test leads. This operation is only required onece. The parameter generates remain valid while the DMM is active.
5) Read the resistance using **DMMReadSR(nDmm, C, R)**. Entering the nominal value of C will improve measurement accuracy. This calue can be a previously measured, or some nominal value. If C is not known, set it to 0.0. The returned resistance value is stored at a location pointed to by R.

For shortest measurement time, measure the values of all capacitors associated with a network using the Charge Balanced method (CAPS = 44) due to its superb accuracy and speed. Follow it with **DMMReadSR()** to measure all resistors associated with each network.

The **DMMSetSourceRes**() function can modify the source impedance of the 2064, which will effect the measurement. It may be used with a reference RC network as a way to improve accuracy.

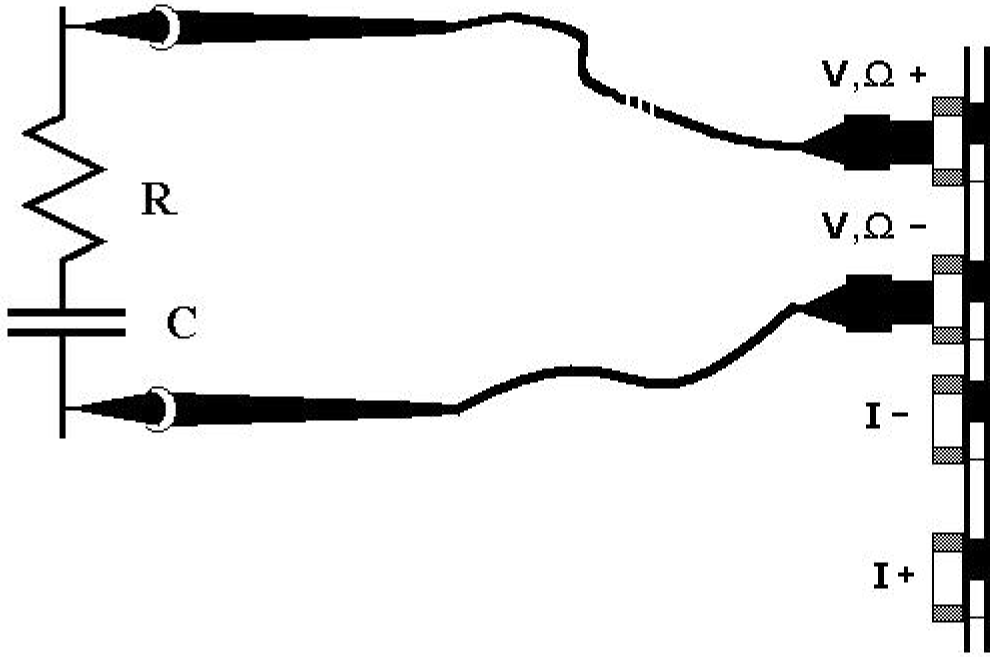


Figure 4-12. Measuring R in a series RC network..

4.12 Inductance Measurement (SMU2064)

The SMU2064 measures inductance using a precision AC source with a frequency range of 100Hz to 100kHz depending on selected range. Since inductors can vary greatly with frequency, you may wish to override the default frequency and adjust the test frequency using **DMMSetInductFreq()**. Following an inductnace measurement operation (**DMMRead, DMMReadNorm, DMMReadStr**), you may retrieve the value of the inductor’s Q using **DMMReadInductorQ**. The inductor’s series equivalent resistnace can also be read using the **DMMReadInductorR** function.

The use of a high quality coaxial or at least a shielded cable is highly recommended. For best accuracy, perform the Open Terminal Calibration **DMMOpenTerminalCal** function within an hour of inductance measurements. The Open Terminal Calibration function must be performed with the test cable plugged into the DMM, and open at the application side. This process characterizes the signal path including both, DMM and cable. Set the Aperture to 160ms or to higher for better accuracy.

Particularly for low inductor values (<300uH), it is important to zero the DMM by using the '**Relative**' function (**DMMSetRelative()**) while the leads shorted. This must be done following Open Terminal Calibration operation. This Relative action measures and removes the inductance of the DMM signal path and that of the application cable. The following is the general proceedure to accomplish the above:

1) Select Inductance: **DMMSetFunction**(nDmm, INDUCTANCE);
2) With cable open at its test end perform Open compensation: **DMMOpenTerminalCal**(nDmm);
3) Select a range: **DMMSetRange**(nDmm, _33uH); // 33uH range
4) Perform Short compensation: **DMMRead**(); **DMMRead**(); **DMMSetRelative**(nDmm,TRUE);
5) You are now ready to measure inductance.

Range	Range symbol	Range selection code	Default test frequency
33µH	_33uH	0	100kHz
330µH	_330uH	1	50kHz
3.3mH	_3300uH	2	4kHz
33mH	_33mH	3	1.5kHz
330mH	_330mH	4	1kHz
3.3H	_3300mH	5	100Hz

Figure 4-12. Inductance measrement function default frequencies.

4.13 Characteristic Impedance Measurement (SMU2064)

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 SMU2064.

4.14 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.

4.14.1 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.

4.14.1.1 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**()). 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**() 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.

4.14.1.2 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.

4.14.1.3 Long Trigger Operation (SMU2064 with 'R' option installed)

In this hardware trigger mode the DMM can handle multiple trigger events. The DMMLongTrigger() function provides the facility to receiv multiple trigger pulses, responding to each with multiple samples taken at precise times relative to the trigger. The trigger signal source can be selected from either one of the PXI trigger inputs or from the DIN-7 source at the panel of the SMU2064 DMM. The hardware responds to a positive edge on the trigger input. The trigger pulse must be at least 50µs wide. The Long Trigger function will accept one to 50,000 trigger events (Tc), responding to each trigger it takes 1 to 50,000 samples (Sc), or a total of Tc * Sc samples (1 to 2.5e9). The time from the positive edge of the trigger signal to the first sample, and the sample to sample time interval, (Td), can be a value between 100us and 3,600s, settable in increments of 1µs. The total time required for acquisition following each trigger event is Sc * Td. To prevent timing conflicts and data over-runs, set Td to a value greater than the Aperture plus the time to transmit the measurements and the overhead time to process each measurement. The latter is specified in the manual as overhead time. The DMM Sync output may be activated to monitor and observe these relations. To prevent overrun errors it is required that readings are retrieved in real time, as they become available. This is particularly important when running fast and long. To improve performance use a tight reading loop and set a high Thread priority. Apperture must be set to 160ms or lower value. Read Interval must be set to zero (default).

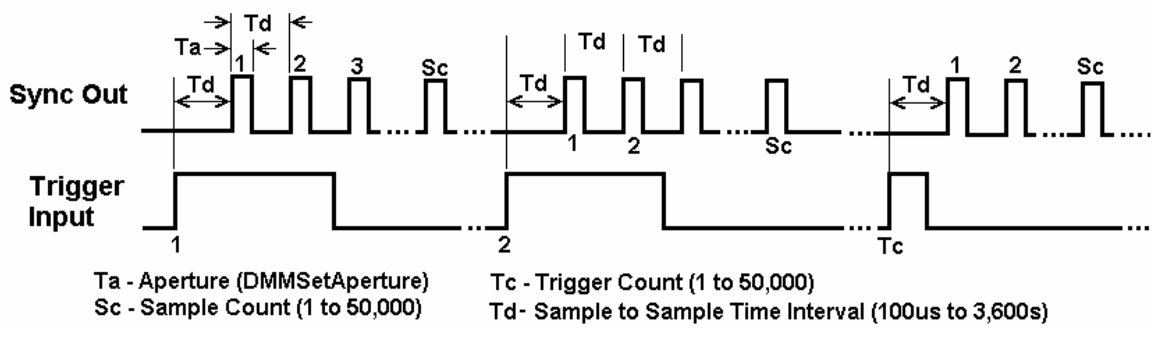

Ta
Td
Sync Out
Trigger Input
1
2
3
Sc
Tc
Ta - Aperture (DMMSetAperture)
Sc - Sample Count (1 to 50,000)
Tc - Trigger Count (1 to 50,000)
Td- Sample to Sample Time Interval (100us to 3,600s)

Figure 4-13. DMMLongTrigger timing diagram.

4.14.2 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.

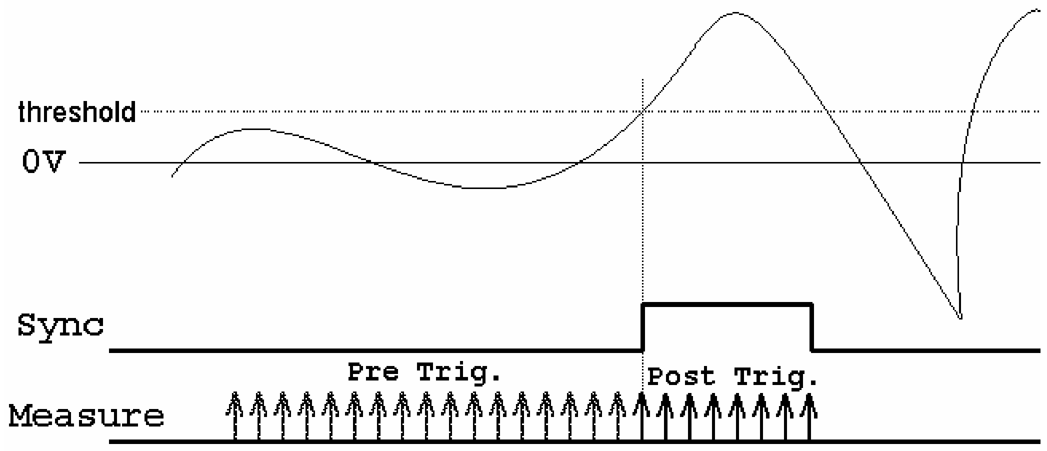


Figure 4-14. Analog Threshold Trigger operation with Positive Edge and Sync enabled.

4.14.3 Software Initiated 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.

4.14.3.1 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 sample, 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 of 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 communication 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 settling 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
```

4.14.3.2 Multiple Trigger Capture Operation

In response to the **DMMSetBuffTrigRead (*nDmm*, *iSettle*, *iSamples, iEdge*)** command, the DMM waits 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 from 0 to 250. The total number of measurements, *iSamples,* must be between 1 and 80 for Aperture 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 settling readings, 50 samples and positive Edge.
  While DMMReady (0) = No       ' wait for completion
  Wend

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

4.14.3.3 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 of 0 to 250. The total number of measurements, *iSamples,* must be between 1 and 80 for Aperture 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 settling readings, 50 samples and positive Edge.
  While DMMReady (0) = No       ' wait for completion of capture process
  Wend
  For i = 0 To 50 - 1      'Read measurements from on-board buffer.
        DMMReadBuffer 0, rd(i)
  Next
```

4.14.3.4 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 from 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
```

4.14.4 External Trigger and Sync Handshake

The Trigger and Sync signals, in conjunction with their commands provide means to synchronize operation, yealding a fast and accurate handshake with external devices. These devices may include switching modules, or a Component handler in a manufacturing environment. The DMM initiates an operation by generating a short Sync pulse to the Handler (**DMMOutputSync()**), causing it to go move to its first position (an off position, or a component). When it is in position, the Handler acknowledges by sending the DMM a Trigger pulse. The DMM waits for this pulse (**DMMWaitForTrigger()**), and responds to it by making a measurement. The DMM generates the next Sync pulse, and this process repeats for as many steps as required.

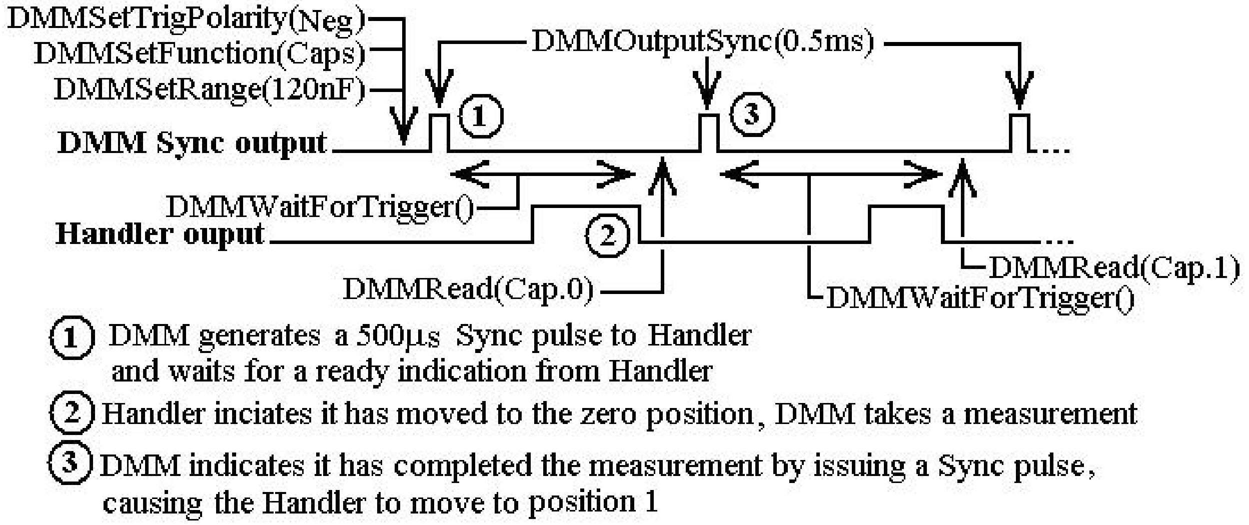

DMMSetTrigPolarity(Neg)
DMMSetFunction(Caps)
DMMSetRange(120nF)
DMMOutputSync(0.5ms)
DMM Sync output
1
3
DMMWaitForTrigger()
Handler ouput
2
DMMRead(Cap.0)
DMMRead(Cap.1)
DMMWaitForTrigger()
1 DMM generates a 500µs Sync pulse to Handler and waits for a ready indication from Handler
2 Handler inciates it has moved to the zero position, DMM takes a measurement
3 DMM indicates it has completed the measurement by issuing a Sync pulse, causing the Handler to move to position 1

Figure 4-15. Interface timing diagram of a Component Handler interface and a DMM. The DMM is the master, or the controlling device.

4.15 Time and Frequency 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 3 times the selected range.

4.15.1 Threshold DAC (SMU2064)

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 SMU2064 hase 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 SMU2064 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.

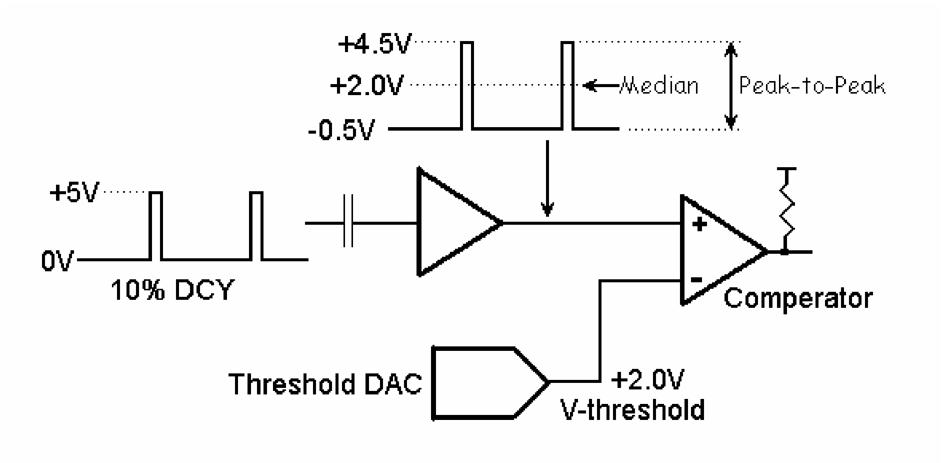


Figure 4-15. AC coupled timing measurements with Threshold DAC.

In Figure 4-15, the DMM is set to the 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 between –0.5 V to + 4.5 V. The Median Value is +2.0 V, which would be the optimal Threshold value.

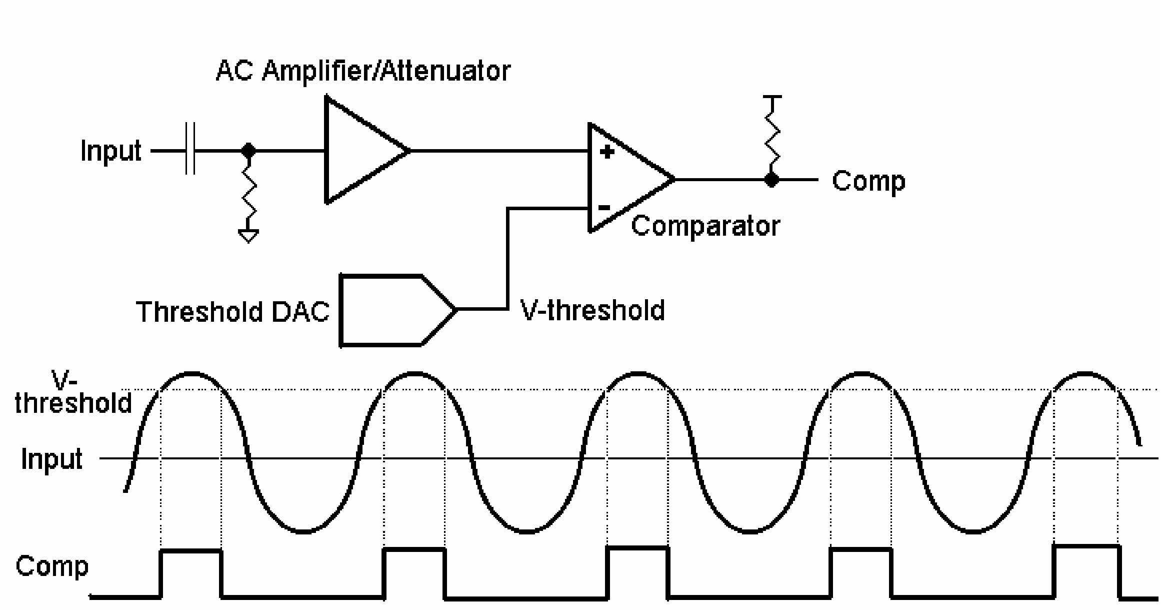


Figure 4-16. Comparator and Threshold DAC Settings

4.15.2 Using the Frequency counter

Both frequency and period measurements are available when the DMM is in ACV or ACI functions. Frequencies between 2 Hz to 300 kHz can be measured. Use the **DMMReadFrequency**. **DMMFrequencyStr DMMReadPeriod** and **DMMPeriodStr** functions to read the frequency and period. Following the execution of one of these functions, the frequency counter range is automatically adjusted to optimize it for the measurement. It may take up to six measurements before the correct frequency range is auto-selected. Once within range, the next frequency measurement is made at the last selected range. Measurement time can vary from about 0.2s to 1s unless the Range lock feature is used.

For applications where frequency measurement speed is required, select the frequency range by using **DMMSetCounterRng**. This function locks the frequency counter range to the ranges indicated in Fugyre 4,17, preventing it from auto-ranging. The benefit is that it makes it much faster by eliminating the time necessary for the counter to range. A significant improvement in counter speed can be realized by selecting a range lower than the signal frequency. The tradeoff in in counter resolution. For instance, to improve frequency counter speed while measuring 100Hz to 500Hz, set it to COUNTER_20HZ. The result is a measurement time of 16ms at 500Hz and 31ms at 100Hz. Doing this increases the peak to peak measurement error to 0.2% and 0.07% respectively.

To return to the frequency counter to its normal, auto ranging mode, issue **DMMUnlockCounter** ccommand, or select VAC. Counter ranges are defined in ***USBDMMUser.h*** file.

Range Symbol	Range Value	Frequency Range	Period Range
COUNTR_20HZ	0	1.9 Hz to 19.9 Hz	50.3 ms to 526 ms
COUNTR_130HZ	1	19.9 Hz to 128.8 Hz	7.76 ms to 50.3 ms
COUNTR_640HZ	2	128.8 Hz to 640 Hz	1.563 ms to 7.76 ms
COUNTR_2500HZ	3	640 Hz to 2.56 kHz	390.6 µs to 1.563 ms
COUNTR_10kHZ	4	2.56 kHz to 10.24 kHz	97.66 µs to 390.6 µs
COUNTR_40kHZ	5	10.24 kHz to 40.96 kHz	24.41 µs to 97.66 µs
COUNTR_200kHZ	6	40.96 kHz to 200 kHz	5 µs to 24.41 µs
COUNTR_500kHZ	7	200 kHz to 500 kHz	2 µs to 5 µs

Figure 4.17. Frequency counter range definition.

The selected frequency range is the indicator of the maximum frequency that range can measure. When selecting/locking a range, the frequency the range can indicate is between the lowest indicated for that range, but above the upper limit of the range. For instance, while in the 20Hz range, the lowest frequency that can be measured 1.9 Hz, while at the high end frequencies as high as 10 kHz can be measured, provided the diminished resolution at that frequency is acceptable.

Both Frequency and Period measurement performance can be improved by properly setting the SMU2064 Threshold DAC. See “Threshold DAC”, “AC Median Value”, and “Peak-to-Peak” measurements for further details.

4.15.3 Duty Cycle Measurement (SMU2064)

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 SMU2064, 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.

4.15.4 Pulse Width (SMU2064)

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.

4.15.5 Totalizer Event Counter (SMU2064)

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. Use **DMMStartTotalized** to start it, **DMMReadTotalizer** to read the accumulated count, and **DMMStorTotalizer** to terminate the accumulation.
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 4-14 below.

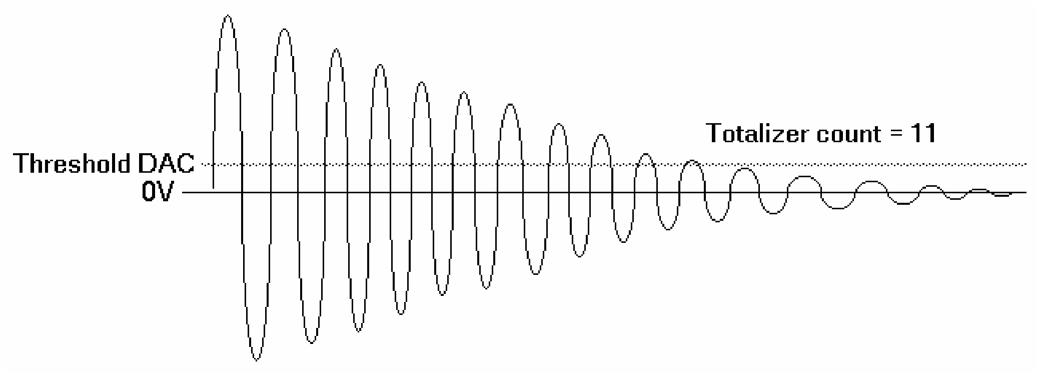


Figure 4-18. Testing inductor Q by counting the number of transitions of decaying resonance.

It should be taken in considerations that the signal being measured is AC coupled. This means that the wave shape and its duty cycle can affect the DC average of the signal, and the effective value of the threshold DAC which is being utilized. See section 4.15.1 (Threshold DAC) and figure 4.15 for details.

4.16 Source Functions (2064)

The SMU2064 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 SMU2064 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 SMU2064.

4.16.1 DC Voltage Source

The SMU2064 has a fully isolated bipolar DC voltage source with span of -10V to +10V. Its current output is limited to about 5mA, and it has a source impedance of about 120Ω. This source is very fast, setteling in less than 10µs. Its resolution is 12 bits or about 5mV. For a more accurate DCV source, select the Closed-Loop mode. Int this mode the aplitude is monitored and adjusted using an additional DAC (trim dac) resulting in 18 bits of resolution. It is necessary to perform repetitive measurements while in this mode. Use **DMMRead** or **DMMReadNorm** to allow the DMM to make the adjustments. The trade off is setteling time, which is reduced to a couple of seconds. Use an Aperture of 160ms or higher when in the Closed-Loop mode. Maximum drive of the VDC source is 10 mA. The output source resistance of the DCV source is approximately 220 Ω. The source voltage is available at V,2Ω+ and V,2Ω- terminals.

It is possible to improves the voltage accuracy delivered to the load by use of a Kelvin connection. This eliminates the effect of the source lead wires resistance. To do this, connect the I,4Ω+ and I,4Ω- terminals to the load and use **DMMReadHiLoSense** to monitor the voltage level at the load. Read about this measurement function it in section 4.19.

4.16.2 Source DC Voltage and measure DC Current

Select this function by using **DMMSetFunction(nDmm, SrceV_MsrI)**. While in this function, perform open calibration using **DMMOpenTerminalCal()**, which calibrates the source resistance. Set the voltage using **DMMSetDCVSource().** Repeat the **DMMSetDCVSouce()** for at least five times in order to arrive at the correct voltage. Using **DMMRead()** or **DMMReadNorm()** will read the DC current through the load. The Voltage can be set from 0 to +/-10.0V, but the available current is limited depending on the set voltage, as depicted in figure 4-20 below. It is necessary to repeat both **DMMRead()** and

DMMSetDCVSource() since the value of the voltage is incrementaly set to the load. It takes about 10 iterations to reach the final voltage value. If a more accurate voltage is required, calibrate the source resistace (Rs). Connect a resistor and set a voltage (within the operation envalop below), while monitoring the voltage with an external DMM. Repeatedly make readings and set the DC voltage (as above), while adjusting the Rs value using **DMMSetSourceRes()**. Using this function overrides the **DMMOpenTermianlCal()** operation above. The nominal value for Rs is between 150Ω and 300Ω.

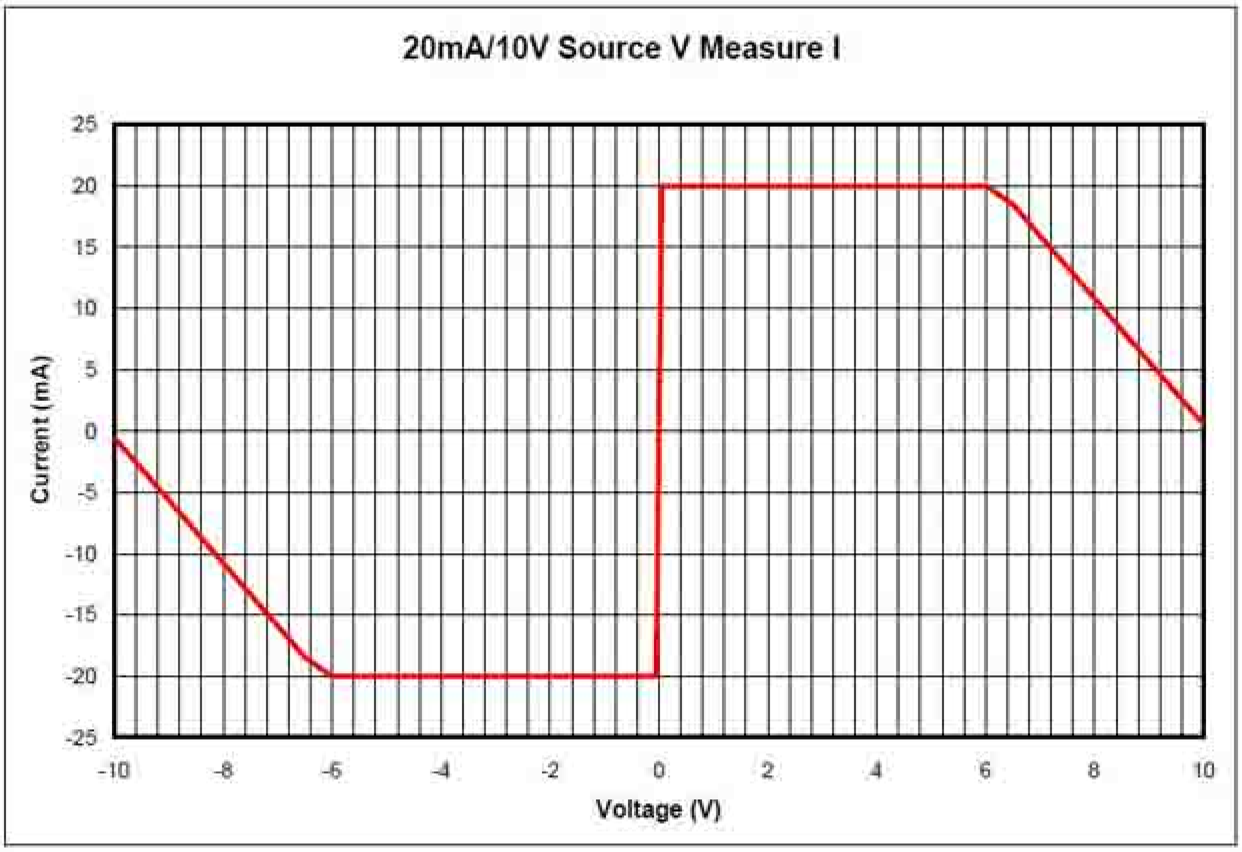


Figure 4-20. The allowed Envalop of operation for V-source/I-measure funciton.

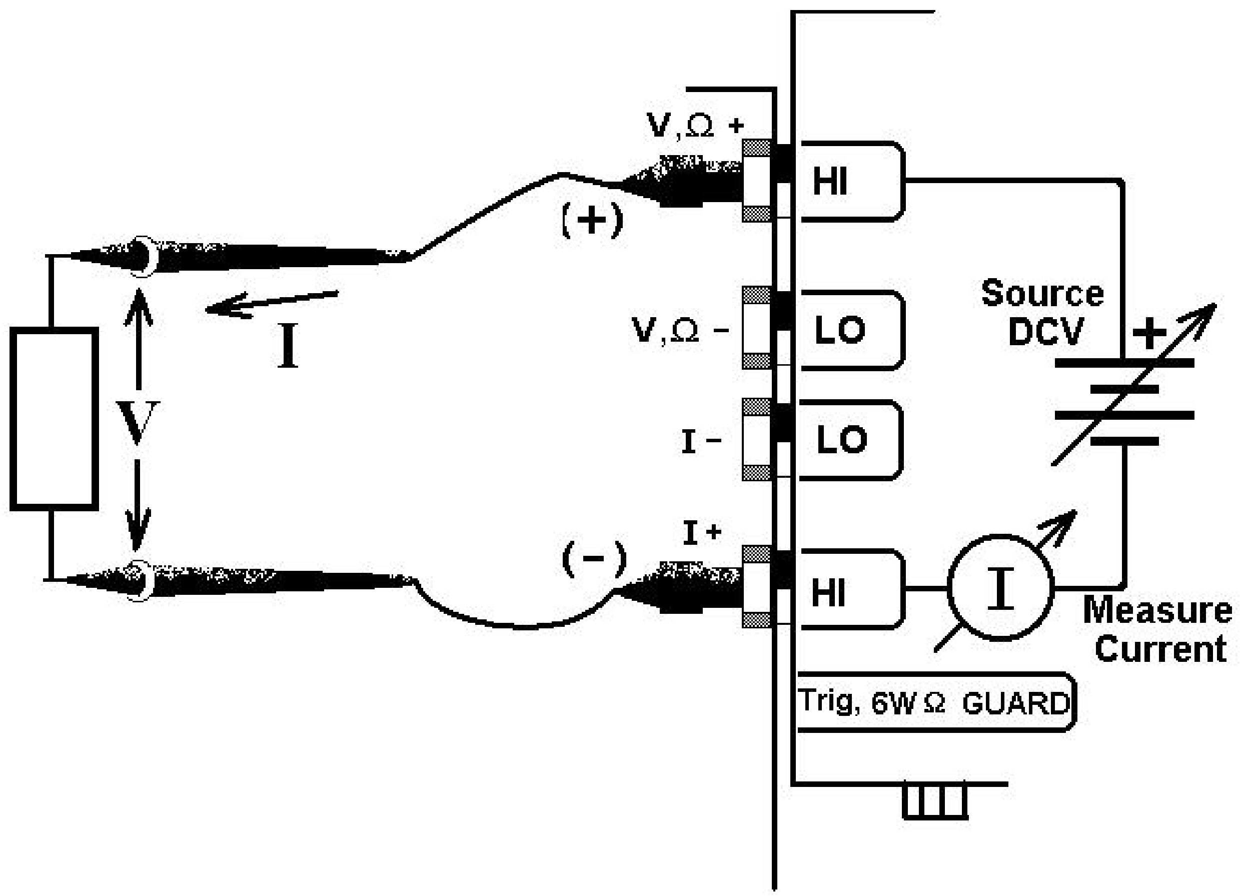


Figure 4-21. Connection topology, and symbolic diagram of the V-source/I-measure function.

4.16.3 AC Voltage Source

The AC voltage source is fully isolated. Both amplitude and frequency can be set. The frequency range is 10 Hz to 200kHz with 2mHz frequency resolution. The amplitude can be set from 30mV RMS to 7.2V RMS by selecting one of two ranges. The source voltage and frequency settle in less than 10µs and its amplitude setting provides 12 bits of resolution, or about 5mV steps. In the Closed-Loop mode of operation the amplitude is monitor and adjusted while measurements are made, achving an effective resolution of 18 bits or less than 200µV. In this mode it is necessary to perform measurements using D**MMRead** or **DMMReadNorm**. This result is a very accurate output but a much longer setteling time of about 2s. While in the Closed-Loop mode the Aperture should be set to a value that is higher than 160ms. The maximum peak current is 10 mA. The source impedance is approximately 120 Ω. The source voltage is available at V,2Ω+ and V,2Ω- terminals.

4.16.4 DC Current Source

The SMU2064 has a fully isolated unipolar DC current source with five ranges. It uses the internal 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. Use the **DMMSetDCISource** to set the value of the current.

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 section 6.

When in OPEN_LOOP (see **DMMSetSourceMode()**), the voltage generated by the current source is measured at the source terminals (upper two terminals). When set to CLOSED_LOOP the voltage is measured by the sense terminals (lower two terminals) of the DMM, allowing remote voltage sense. The last provides a true 4-Wire voltage sensing at the load, which improves accuracy by eliminating the effect of lead wires. The source current is available at V,2Ω+ and V,2Ω- terminals.

4.16.5 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. The source compliance voltage is limited to 4V in both configurations. The maximum measurable voltage is ±2.4V.

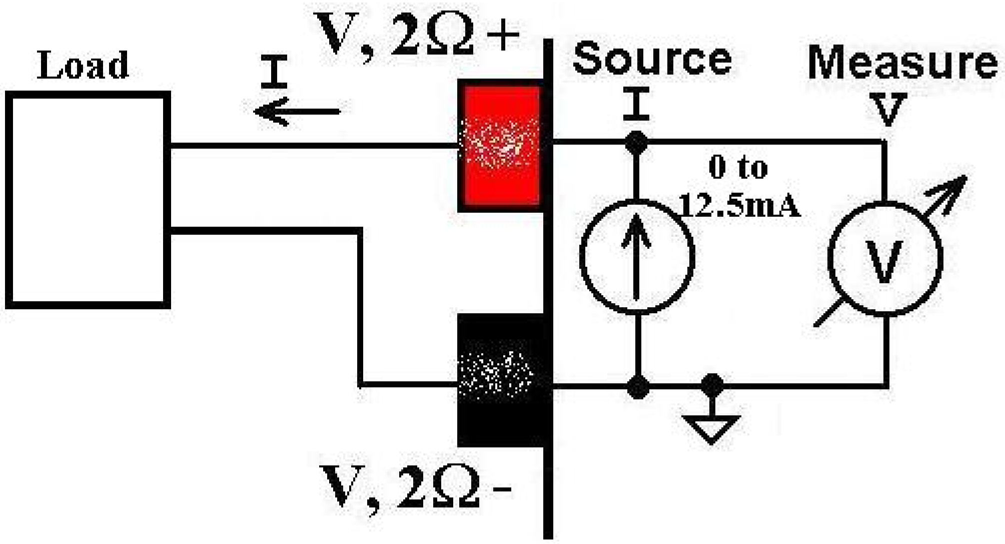


Figure 4-19. Sourcing DC current and measuring voltage in the two-wire configuration. This function can be used for semiconductor parametric tests.

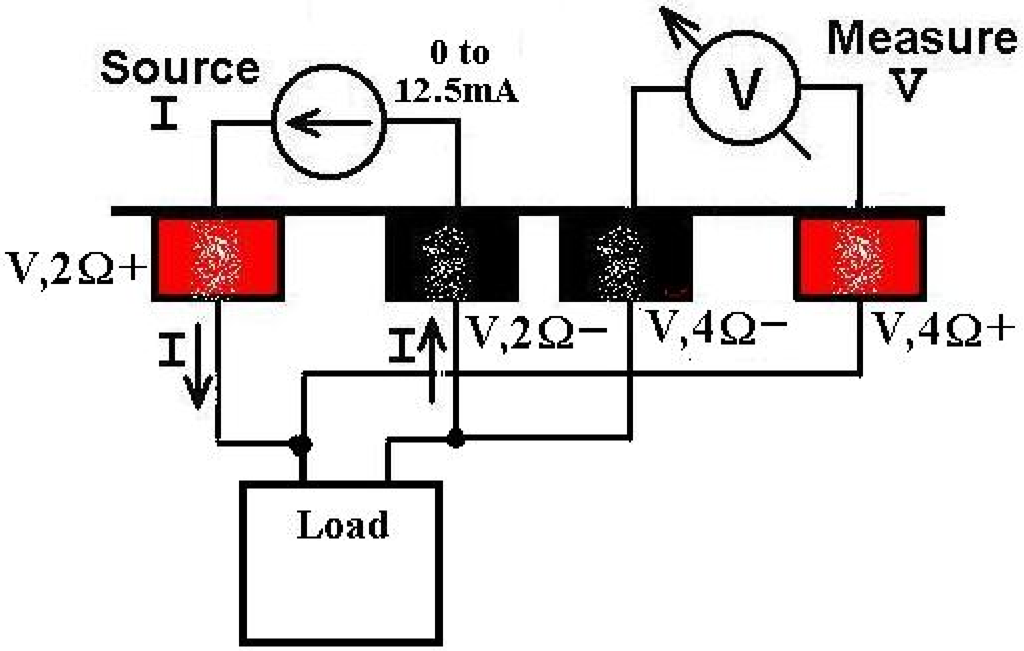


Figure 4-20. Sourcing DC current and measuring voltage in the four-wire configuration eliminates the error due to lead voltage drop.

4.16.6 Pulse Generator

For applications requiring a low frequency pulses at specific width use the built in pulse generator. It can generate a burst of one to 32,000 pulses, or run continuously. To generate pulses use the **DMMSetFunction(***Pulse_Gen***)**, followed by **DMMSetPulseGen()**. Once in Pulse generator mode, **DMMSetPulseGen** can be repeated to adjust the pulse parameters. **DMMSetPulseGen** sets the positive and negative widths of the pulse, as well as the number of pulses to be generated. Use **DMMSetDCVSource** to set the pulse amplitude. The latter can be set to a level of -10V to +10V. The inactive (or negative) portion is always at 0V while the active (positive width) is set to the specified level. The widths can be set between 25µs and 3s. The widths values are set in base units (i.e. 0.05 for 50ms). To stop the generator, issue **DMMDisableTrimDAC** command. The pulse generator function requires Driver version 1.60 and Microcode version 1.29 or higher.

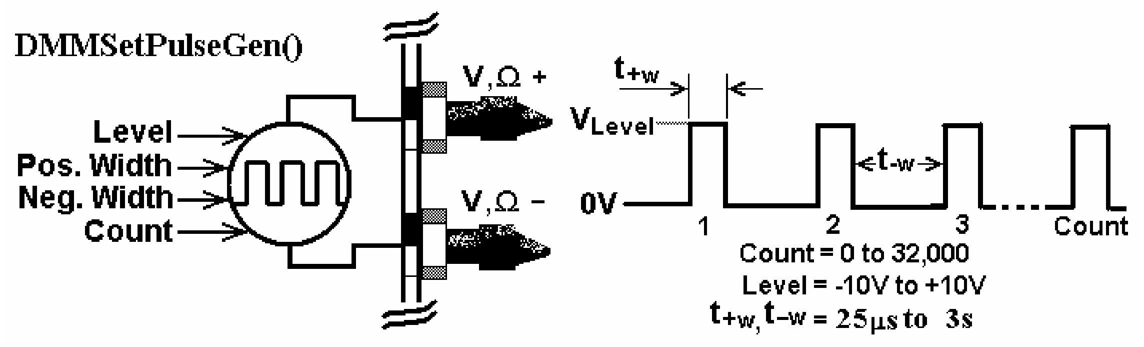


Figure 4-21. Generating pulses is straight forward. It can be used for various test applications.

While the DMM is in this mode, it is possible to make DC voltage measurements. Using **DMMRead** will measure the average DC at the generator output. **DMMReadHiSense**, **DMMReadLoSense** and **DMMReadHiLoSense** will measure the lower two terminals.

4.17 Interfacing to an external device

The SMU2060 series of Digital Multimeters are designed to interface to various external devices, be it Multiplexers or component Handlers. A complete handshake can be established with either devices triggering the other, with a response scheme. The following section describes both, the hardware interface and the software functions required to implement a synchronized operation.

The SMU2060 series can provide a complete handshake with external devices such as SMU4030 series Relays Scanners/Multiplexers, a component Handlers or another SMU2060 series DMM. The interface can be as simple as a single line. For instance, connecting the SMU4032 **TrigOut** line to the SMU2060 **Trigger** input. The SMU4032 is setup to provide a ready signal, indicating to the DMM it can take a measurement. The interface can also be a two way handshake, where the a DMM **Sync** pulse steps the Scanner to the next point in it's Scan List, and the SMU4032 generates a ready signal after the relays are stable, indicating to the DMM to make a measurement etc.. The SMU2060 series can accept a trigger input from many sources, and send out s Sync pulse of variable width. The trigger input can be setup as positive or negetive edge or level. Due to the limited current the Sync output can provide, it may be necessary to boost it with a single NPN or PNP transistor (see Figure 22).

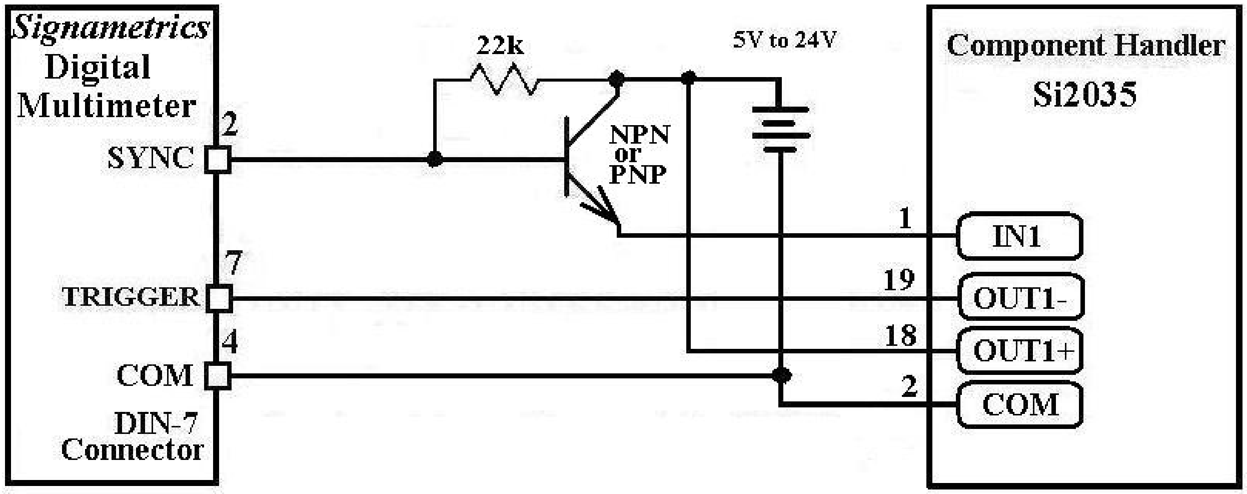


Figure 4-22. A DMM two-way handshake with a component handler requires current boos due to handler's high current requirements, to drive its optically-insolated input.

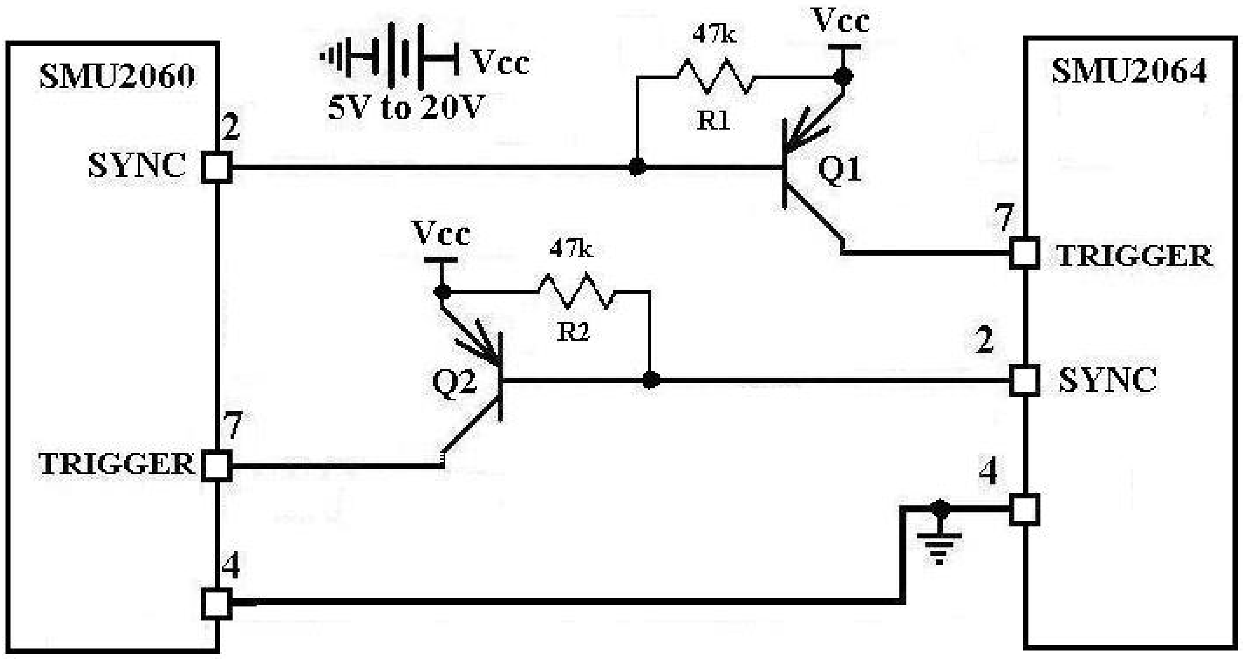


Figure 4-23. Two DMM two way handshake interface.

4.18 Measuring Thermocouples' Temperature

The SMU2060 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 ^{o}C and ^{o}F. 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^{o}C to 50^{o}C. 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.

4.19 Auxiliary VDC inputs (2064)

In addition to the main voltage input terminals (V+ and V-), the SMU2064 provides two auxiliary voltage measurement inputs, see Figure 4.25. While the DMM is in 2-Wire Ohms, DCI source or DCV source functions, invoking one of the standard measurement functions (**DMMRead, DMMReadStr** or **DMMReadNorm**) results in voltage measurement of the top two terminals (V+ and V-). In cases where additional voltage measurement points are required while in these operations, the I+ and I- terminals can also be measured by using the **DMMReadHiSense** function, which returns the voltage present at the I+ terminal relative to the V- terminal. The **DMMReadLoSense** function returns the voltage present at the I- terminal referenced to the V- terminal when the DMM is set for 2-Wire or 4-Wire Ohms. The **DMMReadHiLoSense** function reads the differential voltage between the I+ and I- terminals. The range of measurements is limited to of ±2.4V. The accuracy is the same as is specified for the 2.4VDC range. For higher voltages, it is necessary to provide an external divider network (Figure 4.26). When not in the above functions, make sure these terminals are disconnected from the application.

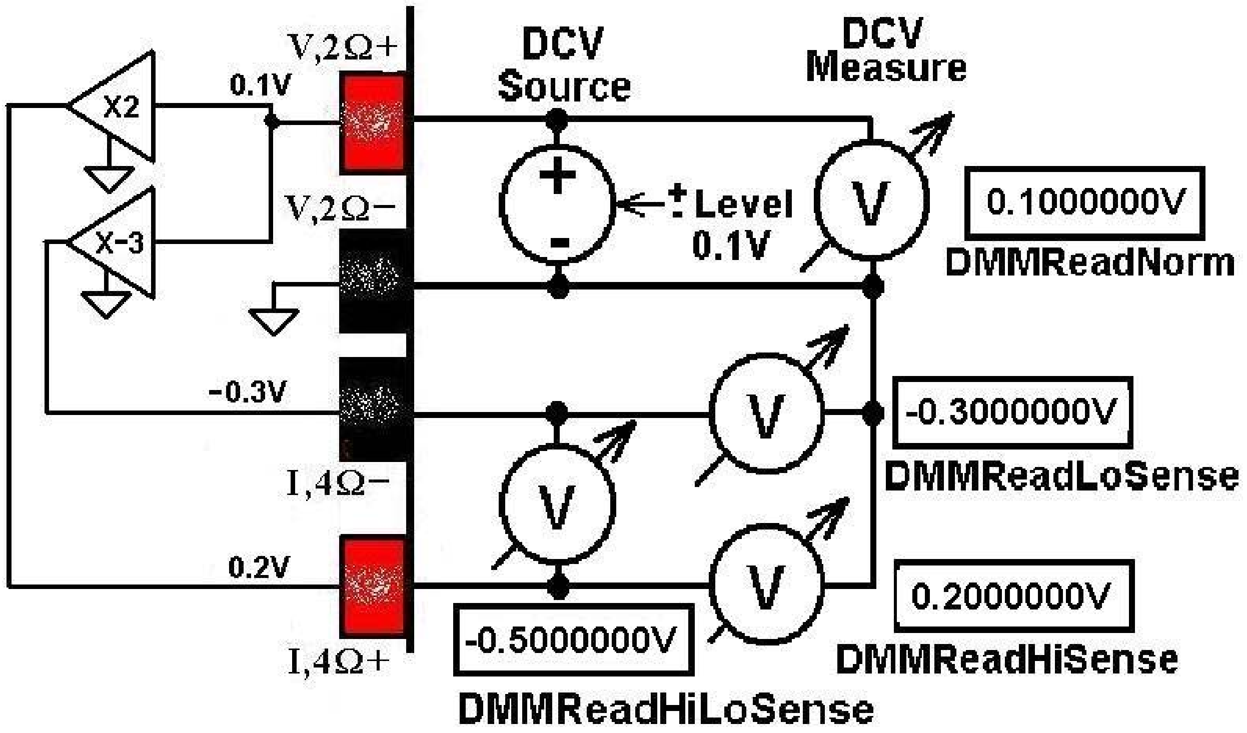


Figure 4.24. Testing Amplifier gain and offset using the Auxiliary inputs.

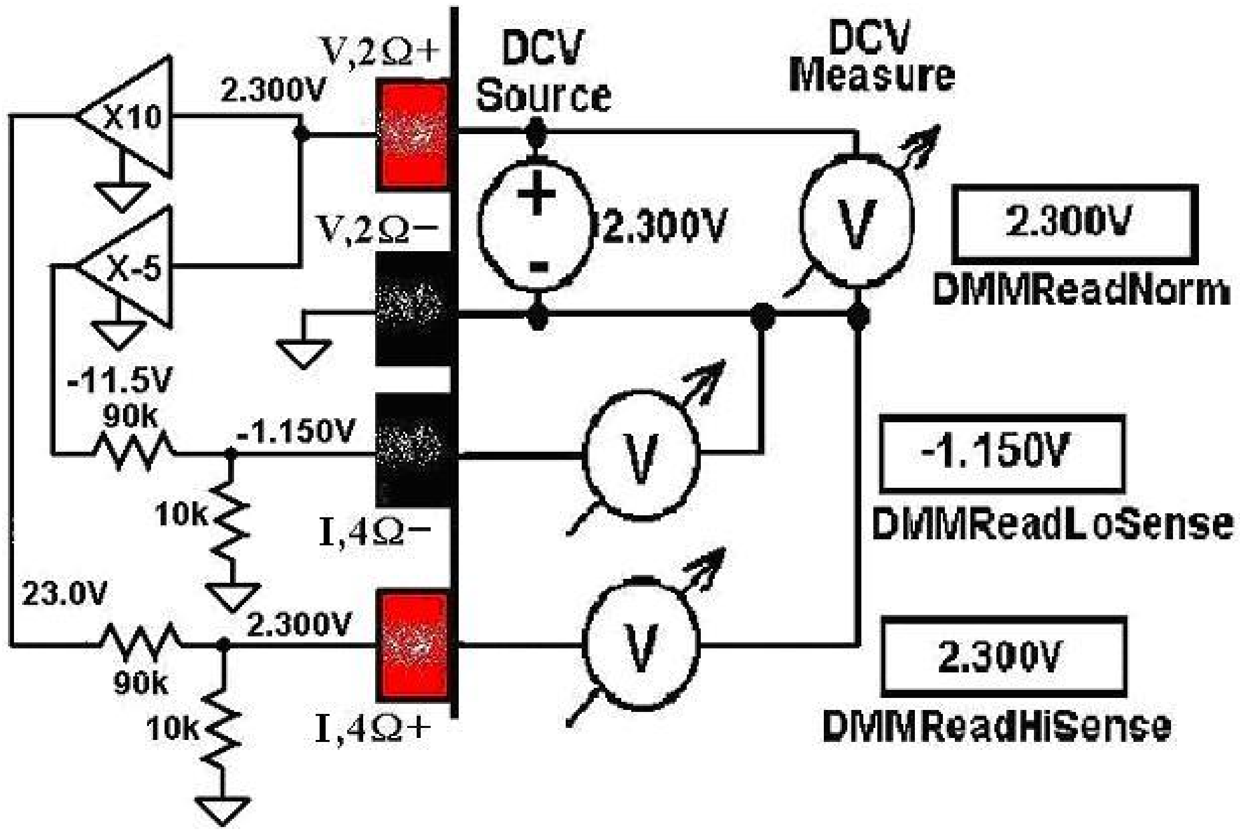


Figure 4.25. Extending voltage range of auxiliary inputs by using external attenuator.

A further limitation of these function is that their common mode voltage is limited to ±3V relative to the V- terminal. This means that to preserve accuracy and proper operation, neither terminals should have a voltage higher than this value as it is measured between the respective terminal and the V- terminal. For instance, while measuring a differential output voltage of 10mV of a load cell, which is stimulated by the DMM internal DCV source, both terminals as at a common mode voltage of about 2.5V, which is within the 3V limit. Actually the I+ terminal's common mode is 2.505V. Provided the stimulus applied to the cell would have been 10V, a common mode voltage of 5V would have resulted, exceeding the 3V limit. In Figure 4.26 the stimulus voltage to the load cell is measured using the **DMMRead** function and the output of the cell is measured using **DMMReadHiLoSense** function.

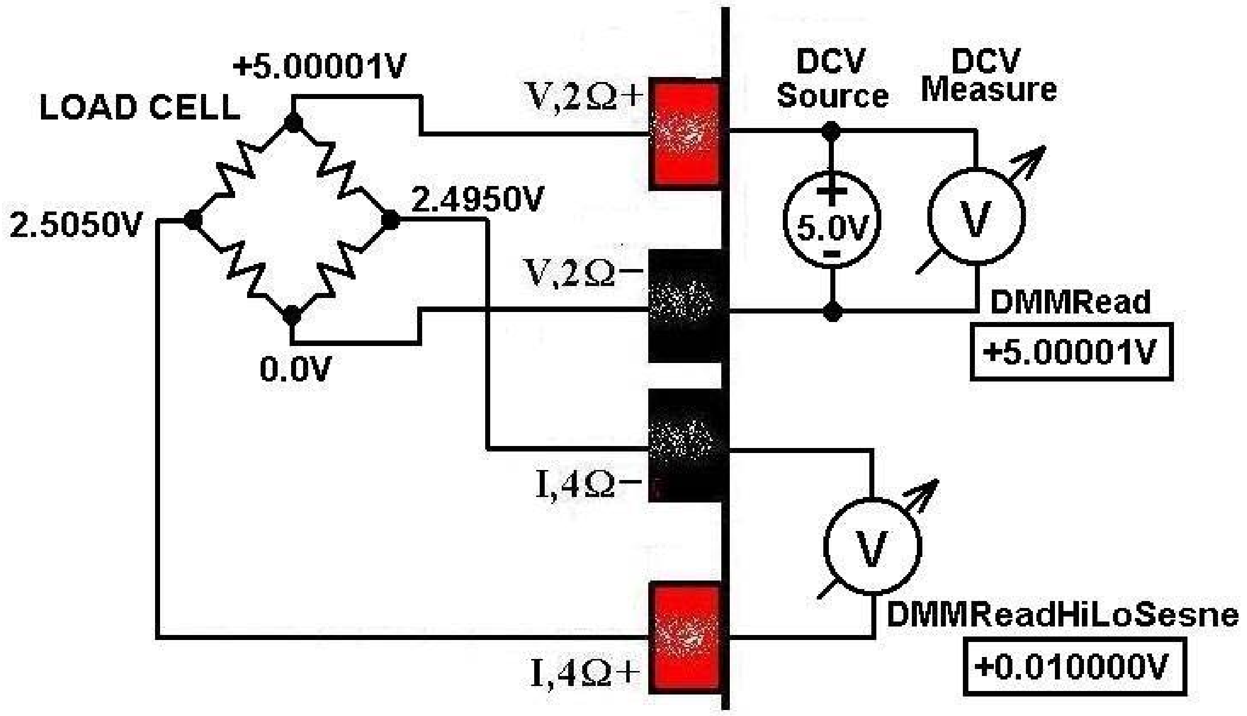


Figure 4.26. A load cell application maintains common mode limits on I+ and I-.

The table below (Fig. 4-28) lists which of the above auxiliary DCV terminals and measurement functions are available for use during various measurement and sourcing operations. It is important to adhere to the following since an unavailable terminal implies that is likely to be shorted to the V,Ω- terminal.

SMX2064 Function	**DMMReadHiSense()**	**DMMReadLoSense()**	**DMMReadHiLoSense()**
VDC	√		
Diode Test	√	√	√
2-Wire Ohms	√	√	√
VDC Source	√	√	√
VAC Source		√	
IDC Source	√	√	√
Leakage		√	
Extended Ohms		√	
Caps		√	
Inductance		√	

Figure 4.28. Auxiliary DCV measurement functions availability during various DMM operations.

5.0 Windows Interface

The SMU2060 Windows interface package provided, contains all required componenets for the following products: SMU2055, SMU2060 and SMU2064. It is a 32bit DLL based modules, which includes windows Kernel driver. This package is sufficient for most windows based software applications.

5.1 Distribution Files

The distribution CD 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 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	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 the first time the DMM is used. It may contain calibration records for several DMM's.
SMU2060.LIB	The Windows import library. Install in a directory pointed to by your **LIB** environment variable.
SMU2060.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**).
SMU2060.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.
USBDMMUser.H	Header file containing all of the necessary DMM's function, range, rate definitions to be used with the various measure and source functions.

File	Description
SMU2064.exe	Soft control panel executable

5.1.1 Calibration Record

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 several DMMs. Following installation, starting the DMM via the provided graphical user interface, or by executing DMMInit() operation, this calibration record is extracted from the on-board none volatile store, and written to the above file. Each record starts with a header line, followed by calibration data.

```
card_id   8123      type 2064 calibration_date     06/25/2008
ad        ; A/D compensation
72.0      20.0      1.0
vdc       ; VDC 240mV, 2.4V, 24V,… 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
-2.3      1.00001
vac       ; VAC 1st line - DC offset. Subsequent lines: 1st entry is Offset the 2nd is gain, 3rd freq. comp
5.303     ; starting with the 240mV range, and last line is for the 330V range.
0.84                1.015461 23
0.0043              1.0256              23
0.1                 1.02205             2
0.4                 1.031386 1
3.0                 1.034601 2
idc       ; IDC 240nA 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
-10.0  1.00083
-16.0  1.00222
-50.0  1.0034
-176.0  1.0
iac       ; IAC 2.4mA to 2.4A 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,...,240Meg ranges, offsetUand gain
12700.0             1.002259 ;in the SMUX2060 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 on each DMM. During initialization the driver reads it from the DMM and matches it to that in the calibration record. A qualified technician may modify individual entries in the calibration file, then reload them using the D**MMLoadCalFile** command.

DMMInit() function loads the calibration factors for the DMM from this file to initialize the DMM. **DMMInit** accepts the calibration file name and path parameter. The default file name is SM60CAL.DAT, and the dafault path is C:\: root directory. The first time the DMM is run, it extract the calibration record from its on-board storage, and saves it to this file. Subsequent invocations of the DMM driver will search for a calibration record in this file.

During initialization (**DMMInit()**), the driver reads various parameters such as DMM type (SMU2060/64), and serial number, and then reads the corresponding calibration information from the

5.2 Using the SMU2060 Driver With C++ or Similar Software

Install the **SMU2060.H** and **USBDMMUser.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 **SMU2060.DEF** and **SMU2060.LIB** using **ImpDef.exe** and **ImpLib.exe**, provided with the compiler. Install **SMU2060.LIB** in a directory that will be searched by the linker for import libraries. The SMU2060 software must be installed prior to running any executable code. Install the **SMU2060.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 SMU2060 driver, first call **DMMInit** which read the calibration information, performs self test and auto-calibration. Call **DMMSetFunction** to set the DMM to a measurement function. The DMM function constants are defined in the **USBDMMUser.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. This value, **nDmm**, is used to identify the DMM number in a multiple DMM system. This value will be 0,1,2.. n. Most functions return an error or warning code, which can be retrieved as a string using **DMMErrStr().**

5.3 Visual Basic DMM Panel Application

The Visual Basic front panel application, **SMU2064.EXE,** is an interactive control panel for the SMU2060 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 SMU2064 panel has additional capabilities, which are disabled if an SMU2060 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 SMU2060.H file.
Declare Function DMMInit Lib "SMU2060.dll" (ByVal nDmm as long, ByVal calFile As String) As Long
Declare Function DMMSetAperture Lib "SMU2060.dll" (ByVal nDmm As Long, ByVal nAperture As Long) _
As Long
Declare Function DMMSetFunction Lib "SMU2060.dll" (ByVal nDmm As Long, ByVal nFunc As Long) As Long
Declare Function DMMSetRange Lib "SMU2060.dll" (ByVal nDmm As Long, ByVal nRange As Long) As Long
Declare Function DMMRead Lib "SMU2060.dll" (ByVal nDmm As Long, dResult As Double) As Long

' Definitions from USBDMMUser.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
- Counter Auto Ranging: On
- Function: DC Volts
- Range: 240V
- Relative: Off
- Measurement Aperture:160ms
- Read Interval: 0ms
- Temperature units set to ºC
- Offset Ohms: Off
- In-Circuit Caps level: 0.45V Peak.
- Source mode: OPEN_LOOP
- Trigger polarity: Positive Edge
- Sync output polarity: Positive
- Sync output: Disabled
- Fast RMS: off
- Thermocouple type: 'K'

5.5 Using the SMU2060 DLL with LabWindows/CVI

When using the SMU2060 DLL with LabWindows/CVI, you should read the **LabWin.txt** file included with the software diskette.

An example application of SMU2060 DLL calls from LabWindows/CVI is shown below. It contains functions **measure_ohms()** and **measure_vdc()**, with sample calls to the SMU2060.

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 SMU2060 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 **SMU2060.H** header file. The **USBDMMUser.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). In C++, TRUE = 1 and FALSE = 0 (which is different from VisualBasic where True is –1 and False is 0).

Grayed out functions are either, untested or unimplemented.

DMMArmAnalogTrigger

2060 ☑ SMU2064 ☑

Description

Arm DMM for analog level trigger operation.

#include "SMU2060.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 and 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));          // Wait for capture
for(i=0; i < 80 ; i++)
j = DMMReadBuffer(0, &Buffer[i]);
```

DMMArmTrigger

2060 ☑ SMU2064 ☑

Description Arm DMM for external trigger operation.

#include "SMU2060.h"

#include "SMU2060.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, storing 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 none composite measurements such as 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);          // Setup to capture 70 post trigger samp.
while( ! DMMReady(0));        // wait for ready
for(i=0; i < 70 ; i++)        // read measurements from internal buffer
j = DMMReadBuffer(0, &Buffer[i]);
```

DMMBurstBuffRead

2060 ☑ 2064 ☑

Description

Setup the DMM for Triggered operation.

#include "SMU2060.h"
#include "USBDMMUser.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 preceded by iSettle readings, which are discarded. Therefore 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 auto ranging 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 buff.
      j = DMMReadBuffer(0, &Buffer[i]);
```

DMMBurstRead

SMU2060 ☑ M2064 ☑

Description

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

#include "SMU2060.h"
#include "USBDMMUser.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 consistent sampling rate. Use it carefully 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, 2, 250); // take 2 measurements prior to each
                         // sample. Take a total of 250 samples
for(i=0; i < 250 ; i++) // read them as as they come
      while( ! DMMReadMeasurement(0 , Reading[i]) );
```

DMMCalibrate

SMU2060 ☑ SMU2064 ☑

Description Internally calibrate the DMM.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Clean specified relay.

#include "SMU2060.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
```

DMMClearMinMax

SMU2060 ☑ SMU2064 ☑

Description Clears the Min/Max storage.

#include "SMU2060.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);
```

DMMCloseUSB

SMU2060 ☑ SMU2064 ☑

Description Close the USB DMM for communications. Not for user application.

#include "SMU2060.h"

int DMMCloseUSB(int *nDmm*)

Remarks This function is provided for servicing the DMM. It has no use in normal DMM operation since **DMMTerminate()** takes care of device closing. See also **DMMOpnenUSB()** 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 = DMMCloseUSB(0);
```

DMMDelayedTrigger

SMU2060 ☑ SMU2064 ☑

Description

Arm DMM for delayed external trigger operation.

#include "SMU2060.h"

#include "SMU2060.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**.

<u>**Parameter**</u>	<u>**Type/Description**</u>
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

SMU2060 ☐

Description Terminate the operation of the Trim DAC.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Abort trigger operation.

#include "SMU2060.h"

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

SMU2060 ☐ SMU2064 ☑

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

#include "SMU2060.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
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMErrString

SMU2060 ☑ SMU2064 ☑

Description Return the string describing the warning or error code.

#include "SMU2060.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
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMFrequencyStr

SMU2060 ☑ SMU2064 ☑

Description

Return the next DMM frequency reading, formatted for printing.

#include "SMU2060.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 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
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMGetACCapsR

SMU2060 ☐ SMU2064 ☑

Description Return the resistance component of the last AC Caps measurement.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Get DMM reading rate

#include "SMU2060.h"

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

Remarks This function returns a double floating point value of the currently selected Aperture. It is not available with the SMX2055 DMM.

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);
```

DMMGetAverageVAC

SMU2060 ☐ SMU2064 ☑

Description Measure average of an AC voltage

#include "SMX2060.h"

int DMMGetAverageVAC(int *nDmm,* **double** *dFrequency*, **double** **lpdAvg***)**

Remarks This function returns a double floating value of the AC average voltage of a signal. The Signale is converted to its absolute value (rectified) and averaged over one or more periods. The DMM must be in the DC voltage measurement mode, and the appropriate range selected. The signal frequency *dFrequency*, must be entered.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dFrequency	**Double** The signal frequency
lpdAvg	**double *** Pointer where the AC Average is saved at.

Return Value Integer value version code or an error code.

Value	**Meaning**
Negative Value	Error code

Example

```
int status; double  ACAverage;
status = DMMGetAverageVAC(0, 60.0, & ACAverage);
```

DMMGetBufferSize

SMU2060 ☑ SMU2064 ☑

Description Return the currently selected internal buffer size.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

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 scans the hardware for this informaiton.

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

SMU2060 ☑ SMU2064 ☑

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
Negative Value	Error code
Positive Value < 100	The length of the returned string

Postive Value ≥ 100	Warning code

Example

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

DMMGetdB

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMGetCJTemp

SMU2060 ☑ SMU2064 ☑

Description Retrieve the currently set cold junction temperature.

#include "SMU2060.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);
```

DMMGetCounterRange

SMU2060 ☑ SMU2064 ☑

Description Returns the currently set frequency counter range.

#include "SMU2060.h"

#include "USBDMMUser.h"

int DMMGetCounterRange(**int** *nDmm*)

Remarks This function returns the currently set frequency counter range. Look up the frequency counter reange definitions in the **USBDMMUser.h** file.

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**
0 to 7	Valid DMM frequency range.
Other value	Error code

Example

```
int fRange; // Find on which bus, and slot the DMM is at
DMMGetCounterRange(0); // Get range
```

DMMGetDeviation

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMGetDevLocation

SMU2060 ☑ SMU2064 ☑

Description Get a string containing the location of the DMM in the USB structure.

#include "SMU2060.h"

int DMMGetDevLocation(int *nDmm*, **LPCSTR** *lpszLoc***)**

Remarks This service function retrieves the location of the USB DMM specified by *nDmm* in the USB bus. A zero terminated string of length 8 is returned in *lpszLoc*. This function must be used prior to opening the DMM. That is, prior to initializing or opening it by **DMMInit()** or **DMMOpenUSB()**.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpszLoc	**LPCSTR** Points to a buffer (at least 8 characters long) to hold the result.

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

Value	Meaning
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

```
char cBuf[8];
int i = DMMGetDevLocation(0, cBuf);
```

DMMGetDiffMnMxStr

SMU2060 ☑ SMU2064 ☑

Description Returns the difference between the max and min values as string.

#include "SMU2060.h"

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

Remarks This function return the difference between the current Max. and Min values, which is the peak-to-peak range of recent readings. It returns the result as a string formatted for printing. The print format is determined by the range and function.

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**
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMGetFuncRange

SMU2060 ☑ SMU2064 ☑

Description Get DMM range code.

#include "SMU2060.h"
#include "USBDMMUser.h"

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

Remarks This function returns the combined DMM function/range code. See **USBDMMUser.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 USBDMMUser.h for function/range codes.
Negative Value	Error code

Example

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

DMMGetFunction

SMU2060 ☑ SMU2064 ☑

Description Get DMM function code.

#include "SMU2060.h"
#include "USBDMMUser.h"

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

Remarks This function returns the DMM function code. The codes are defined in the USBDMMUser.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 USBDMMUser.h for function/range codes.
Negative Value	Error code

Example

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

DMMGetGrdVer

SMU2060 ☑ SMU2064 ☑

Description Get DMM firmware version.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Get the hardware version of the DMM.

#include "SMU2060.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);
```

DMMGetHwOption

SMU2060 ☑ SMU2064 ☑

Description Get the hardware option installed in the DMM.

#include "SMU2060.h"

int DMMGetHwOption(**int** *nDmm*)

Remarks This function returns the hardware options installed. It returns a single character value corresponding to the option. For instance, if option 'R' in installed, 0X12, the ASCII equivalent or the letter 'R' is returned.

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 HWOption = DMMGetHwOption(0);
```

DMMGetID

SMU2060 ☑ SMU2064 ☑

Description Get DMM ID code.

#include "SMU2060.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);
```

DMMGetLowFreqVRMS

SMU2060 ☐ SMU2064 ☑

Description Measure average of an AC voltage

#include "SMX2060.h"

int DMMGetLowFreqVRMS(int *nDmm*, **double** *dFrequency*, **double** **lpdVRMS***)**

Remarks This function returns a double floating value of a low frequency RMS voltage. The DMM must be in the DC voltage measurement mode, and the appropriate range selected. The signal frequency *dFrequency*, must be entered.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dFrequency	**Double** The signal frequency
lpdVRMS	**double *** Pointer where the RMS result is saved at.

Return Value Integer value version code or an error code.

Value	Meaning
Negative Value	Error code

Example

```
int status; double  VRMS;
status = DMMGetLowFreqVRMS(0, 10.0, & VRMS);
```

DMMGetManDate

SMU2060 ☑ SMU2064 ☑

Description Get Manufacturing date stamp from the DMM hardware

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Get Maximum reading history.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Returns the maximum as a formatted string.

#include "SMU2060.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**
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMGetMin

SMU2060 ☑ SMU2064 ☑

Description Get Minimum reading history.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Returns the minimum as a formatted string.

#include "SMU2060.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
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMGetNumDevices

SMU2060 ☑ SMU2064 ☑

Description Get the number of USB DMM devices connected to the USB structure.

#include "SMU2060.h"

int DMMGetNumDevices(int * *nDevices***)**

Remarks This function retrieves the number of USB DMM devices connected to the USB bus. The number of devices is saved at a location pointed to by *nDevices*. This function must be used prior to opening the DMM. That is, prior to initialized or opening it by **DMMInit()** or **DMMOpenUSB()**. See also **DMMGetDevLocation()**.

Parameter	**Type/Description**
nDevices	*** int** Points to a location at which the number of devices is saved.

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

Value	**Meaning**
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

```
int I; int number;
I = DMMGetNumDevices(& number);
```

DMMGetRange

SMU2060 ☑ SMU2064 ☑

Description Get DMM range code.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description Get Read Interval value.

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

Description Get the currently set ACV Source frequency.

#include "SMU2060.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 SMU2064. It can be used to display or verify the default frequency of the stimulus for the various Inductance and AC based capacitance 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**

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

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

DMMGetStoredReading

SMU2060 ☐ SMU2064 ☑

Description

Get a single stored reding.

#include "SMU2060.h"

int DMMGetStoredReading(int *nDmm*, **int** *iIndex*, **double ****lpdRdng***)**

Remarks

User this function to retrieve readings previously captured by **DMMReadNsamples.** Return a double precision reading number *iIndex* by placing it at a location pointed to by lpdRdng. iIndex can have a value between 0 and the total number of measuremens taken by **DMMReadNsamples** minus 1 (iN – 1).

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iIndex	**int** Index to the stored reading, can be 0 to the total of number of readings taken mins 1.
lpdRdmg	**double *** Pointer where the reading value is to be saved.

Return Value

Integer error code..

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double  v;

int status = DMMGetStoredReading(0, 0, &v); // get the 1st
reading
```

DMMGetSourceMode

SMU2060 ☐ SMU2064 ☑

Description

Get the operation mode of the source.

#include "SMU2060.h"
#include "USBDMMUser.h"

int DMMGetSourceMode(**int** *nDmm*)

Remarks

This function returns the currently set source mode.

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

Return Value Source mode code.

Value	Meaning
'O'	OPEN_LOOP mode is selected
'C'	CLOSED_LOOP mode is selected
Negative Value	Error code

Example

```
if(DMMGetSourceMode(0) == CLOSED_LOOP)
      Mode = 4Wire;
```

DMMGetTCType

SMU2060 ☑ SMU2064 ☑

Description Get the themocouple type currently selected.

#include "SMU2060.h"
#include "USBDMMUser.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 USBDMMUser.h file
Negative Value	Error code

Example

```
int TCtype = DMMGetTCType(0);
```

DMMGetTrigger

SMU2060 ☑ SMU2064 ☑

Description Get the logic level of the external Trigger input line.

#include "SMU2060.h"

int DMMGetTrigger(**int** *nDmm*)

Remarks This function returns the logic level of the external Trigger line. Iit returns 0 wen the line is at a low logic level or unenergized, it returns 1 if the line is energized, or at a voltage that is higher than 3.5V. This function provide means to handshake with external devices such as Component Handlers and other instruments. See also **DMMOutputSync()** and **DMMWaitForTrigger()**

Parameter **Type/Description**

nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.

Return Value Integer error code or.

Value	Meaning
0	Trigger line is at a low logic level (< 0.7V).
1	Trigger line is at a high logic level (> 3.5V).
Negative value	If an error detected.
Positive value > 100	If warning

Example

```
status = DMMGetTrigger(0);
```

DMMGetTriggerInfo

SMU2060 ☑ SMU2064 ☑

Description Get Capture Infromation following Trigger operation.

#include "SMU2060.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 beginning 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 equate 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
```
DMMGetTriggerInfo(0, &Empty, &Pre, &wraps);
```

DMMGetType

SMU2060 ☑ SMU2064 ☑

Description Get the type of the DMM.

#include "SMU2060.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	SMU2060 is at nDmm slot
2064	SMU2064 is at nDmm slot
Negative Value	Error code

Example
```
int DMMtype = DMMGetType(0);
```

DMMGetVer

SMU2060 ☑ SMU2064 ☑

Description Get DMM software driver version.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Initialize a DMM.#include "SMU2060.h"

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

Remarks This function 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*. If a calibration file is not found or it is invalid, it reads the calibration record from its on-board store and also saves it to a file specified in *lpszCal*. Following, it performs self calibration. If the calibration record is outdated, it returns an error as well as display a warning window indicating this. If any 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

SMU2060 ☑ SMU2064 ☑

Description Get the status of the autorange flag.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Get the status of the DMM.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Get the status of the Relative flag.

#include "SMU2060.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);
```

DMMLongTrigger

SMU2060 ☐ SMU2064 ☐ SMU2064-R ☑

Description Arm DMM for long trigger operation. Only available with Option 'R'

#include "SMU2060.h"

int DMMLongTrigger(**int** *nDmm,* **int** *iTrigCnt,* **int** *iSampl,* **double** *dTd*)

Remarks This function sets up the DMM for hardware trigger operation. The trigger source can be from either the front panel (DIN-7 connector) or from the selected PXI trigger bus. In response to this command the DMM enters a wait state for trigger. In response to a positive trigger edge, it takes *iSampl* samples, spaced by *dTd* seconds from each other. This is repeated for a total of *iTrigCnt* trigger events. All measurements are sent back from the DMM to the PCI bus as soon as they become available. Failure to retrieve all samples sufficiently fast will result in communication error. The value of *iTrigCnt* and *iSampl* must be between 1 and 50,000. The time delay between samples, *dTd*, should be set to a value that is greater than the set aperture and up to 3,600s. All samples must be read using the **DMMLongTrigRead()** function. The total number of samples is *iTrigCnt* * *iSampl*. The minimum trigger period must be greater than the set aperture or *dTd*.

This trigger mode is usable for VDC, VAC, Ohms, IAC IDC and Leakage. The DMM Read Interval must be set to zero (default) during this operation. Aperture must be set between 160ms and 2.5us. Use the **DMMLongTrigRead()** too monitor completion of this operation, as sell as read the samples.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iTrigCnt	**int** The number of trigger events the DMM will respond to. This number must be between 1 and 50,000.
iSampl	**int** The number of samples the DMM takes following each trigger event. This number must be between 1 and 50,000.
dTd	**double** Sample to sample delay time in seconds.

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

Value	Meaning

DMM_OKAY	Operation successfully terminated
Positive value > 100	Warning code.
Negative value	Error code.

Example

```
double Buffer[3000];
DMMSetAperture(0, APR_625us);
DMMSetReadInterval(0, 0.0);    // Must be zero to use this function
DMMLongTrigger(0, 100, 30, 0.01 ); //expect 100 triggers, take 30 samples
                                   // for each trigger, space samples by 10ms.
for(i=0 ;  i < 3000 ; i++){        // read a total of iTrigCnt * iSampl samples.
   while( ! DMMLongTrigRead(0, &r)); // Wait and read 3000 samples
   Buffer[i] = r ;
}
```

DMMLongTrigRead

SMU2060 ☐ SMU2064 ☐ SMU2064-R ☑

Description

Read samples generated by DMMLongTrigger operation. Available with Option 'R'

#include "SMU2060.h"

int DMMLongTrigRead(int *nDmm,* **double *** *lpdReading*)

Remarks

This function does two things, it checks for the availability of a sample resulting from a **DMMLongTrigger** operation, as well as reading it. If a sample is not ready a FALSE (0) is retunred, if it is available it returns TRUE (1) as well as save the sample at a location pointed to by *lpdReading*. Therefore, when ready is indicated the reading must be read from this location and saved in a buffer. Failing to do so will result in this value being overwritten by a subsequent sample. Use a tight loop to check for samples availability and saving the sample at a safe location. All triggered samples must be read using this function. The total number of samples is equal to *iTrigCnt* times *iSampl*. Look up these parameters in the **DMMLongTrigger()** description above.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdReading	**double *** The location at which the reading is saved when TRUE is returned.

Return Value

The return value is one of the following constants.

Value	Meaning
TRUE	A sample is ready. It is located at location *lpdReading*
FALSE	Not ready. A reading is available yet.
Positive value	Warning code
Negative value	Error code.

Example

```
double Buffer[3000];
DMMLongTrigger(0, 100, 30, 0.01 ); //expect 100 trigger pulses, take 30 samples
                                        // for each trigger, space samples by 10ms.
```

```
for(i=0 ;  i < 3000 ; i++){                  // read a total of iTrigCnt * iSampl (3000) samples.
   while( ! DMMLongTrigRead(0, &r)); // Wait for a sample
   Buffer[i] = r ;
}
```

DMMOpenCalACCaps

SMU2060 ☐ SMU2064 ☑

Description Calibrate the AC based in circuit capacitance function.

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

Description Calibrate the Inductance measurement function with open terminals.

#include "SMU2060.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);
```

DMMOpenUSB

SMU2060 ☑ SMU2064 ☑

Description Open the USB DMM for communications. Not for user application.

#include "SMU2060.h"

int DMMOpenUSB(int *nDmm*)

Remarks This function is provided for servicing the DMM. It has no use in normal DMM operation since **DMMInit()** takes care of device opening. See also **DMMCloseUSB()** 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 = DMMOpenUSB(0);
```

DMMOutputSync

SMU2060 ☑ SMU2064 ☑

Description Generate as Sync output pulse or level.

#include "SMU2060.h"

int DMMOutputSync(int *nDmm* **int** *iMode,* **double** *dWide*)

Remarks This function has three modes. It sets the Sync output line low (*iMode*=0), it can set it high (*iMode*=1) or generate a pulse of *dWide* in width (*iMode* = 2). In modes 0 and 1 the value of dWide is ignored. If iMode = 2 the polarity of the Sync pulse is determined by its previously setting by the **DMMSetSync()** function. The pulse width (*dWide*) can be set from 100us to 1.04s. In all three modes the Sync pulse gets set regardless if it was enabled by **DMMSetSync()**. The sync can also be activated to synchronize measurements with other instruments. The DMMOutputSync enhances this capability by providing full control over is behavior.

High setting, implies the Open Collector Sync line is turned off.

Low setting high, implies the Open Collector Sync line is turned on.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iMode	**int** Identifies the operation, be it setting high or low or generation a pulse.
dWide	**Doubl**e Sets the width of the pulse in mode 2. Can take a value from 100e-6 to 1.04. Ignored in modes 0 and 1.

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code
Positive Value	Warning code

Example

```
int status = DMMOutputSync(0, 2, 10e-6); // Generate a 10ms pulse
```

DMMPeriodStr

SMU2060 ☐ SMU2064 ☑

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

#include "SMU2060.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
Negative Value	Error code
Positive Value < 100	The length of the returned string

Postive Value ≥ 100	Warning code

Example

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

DMMQuickInit

SMU2060 ☑ SMU2064 ☑

Description Initialize a DMM without tests.

#include "SMU2060.h"

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

Remarks It is not recommended to use this function for initialization since it is a short cut and does not do all that is necessary for proper initialization. Use **DMMInit** instead. 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

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.h"

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

Remarks

Executing the **DMMRead** function triggers the DMM to perform a single measurement 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 normalized 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 240k Ω range. Alternatively use the **DMMReadNorm()** function for base units read function, or **DMMReadStr()** to return the results as formatted 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

SMU2060 ☑ SMU2064 ☑

Description

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

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Return the next reading, formatted for printing.

#include "SMU2060.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
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMReadCJTemp

SMU2060 ☑ SMU2064 ☑

Description Read cold junction temperature for thermocouple measurement.

#include "SMU2060.h"

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

Remarks Read the cold junction temperature sensor 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 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 temperature 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

SMU2060 ☐ SMU2064 ☑

Description Return ACV signal's Crest Factor.

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

Description Return percent duty cycle of ACV signal.

#include "SMU2060.h"

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

Remarks To use this function the DMM must be in AC measurement mode, and a valid range must be selected. 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);
```

DMMReadSR

SM2060 ☐ SM2064 ☑

Description Measure the value of a resistor which is in series with a capacitor.

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

int DMMReadSR(int *nDmm,* **double** *dC,* **double** ******lpdR*)

Remarks

This function makes a single resistance reading. The funciton uses the value of C to help measure the resistance in series with it. If C is unknown enter 0.0 for C. The measurement result is stored as double-precision floating-point numbers in the location pointed to by *lpdR*. The DMM must be set to the ESR function during this operation. It assumes that an DMMOpenCalACCaps() was performed prior to using this funciton. Note: Avilable with DLL Version 1.52 and higher.

Parameter	**Type/Description**
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dC	**double** Phas the nominal value of the capacior. Can be set to a value between 0 and 1uF (1.0e-6).
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 R;
DMMReadSR(0, 47e-9, &R); // Read the resistor in series with
47nF
```

DMMReadFrequency

SMU2060 ☑ SMU2064 ☑

Description

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

#include "SMU2060.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 initialized prior to using any function.
DMM_E_DMM	Invalid DMM number.

Example

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

DMMReadHiLoSense

SMU2060 ☐ SMU2064 ☑

Description Measure the differential voltage present between the I+ and I- termials.

#include "SMU2060.h"

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

Remarks This function returns a double floating-point reading indicating the voltage present between the I- and the I+ terminals. It is valid while the DMM is in 2-Wire Ohms, VDC or IDC source modes. The returned value is in base units. That is in the range of range of ±2.4V. Very large values are indication of over range condition. See also **DMMReadLoSense**.

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
POS_FS, NEG_FS	Positive or Negative Full Scale, or overrange
Negative Value	Error code
DMM_OKAY	Valid return.

Example

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

DMMReadHiSense

SMU2060 ☐ SMU2064 ☑

Description Measure the voltage present at the I+ termial.

#include "SMU2060.h"

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

Remarks This function returns a double floating-point reading indicating the voltage present between the V- and the I+ terminal. It is valid while the DMM is in 2-Wire, VDC or IDC source modes. The returned value is in base units. That is in the range of range of ±2.4V. Very large values are indication of over range condition. See also **DMMReadLoSense**.

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
POS_FS or **NEG_FS**	Positive or Negative Full Scale, or overrange
Negative Value	Error code
DMM_OKAY	Valid return.

Example

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

DMMReadInductorQ

SMU2060 ☐ SMU2064 ☑

Description Return inductor's Q value.

#include "SMU2060.h"

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

Remarks To use this function the DMM must be in the Inductance measurement mode, 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*. To read the inductors series resistance use **DMMReadIndcutorR**.

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);
```

DMMReadInductorR

SMU2060 ☐ SMU2064 ☑

Description Return inductor's Rs value.

#include "SMX2060.h"

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

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

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 Rs.

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

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
double Rs;
int status = DMMReadInductorR(0, &Rs);
```

DMMReadLoSense

SMU2060 ☐ SMU2064 ☑

Description Measure the DC voltage present at the I+ termial.

#include "SMU2060.h"

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

Remarks This function returns a double floating-point reading indicating the voltage present between the V- and the I- terminals. It is valid while the DMM is in 2-Wire Ohms, VDC or IDC source mode. The returned value is in base units. That is in the range of range of ±2.4V. Values above this are an indication of over range condition. See also **DMMReadHiSense**.

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
POS_FS or **NEG_FS**	Positive or Negative Full Scale, or overrange
Negative Value	Error code
DMM_OKAY	Valid return.

Example

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

DMMReadMeasurement

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

Description Return ACV signal's Median value.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Take a reading that is in base value.

#include "SMU2060.h"

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

Remarks This function returns a double floating-point reading. Unlike **DMMRead()** 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**
POS_FS or **NEG_FS**	Positive or Negative Full Scale, or overrange
Negative Value	Error code
DMM_OKAY	Valid return.

Example

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

DMMReadNsamples

SMU2060 ☑ SMU2064 ☑

Description Take a reading that is in base value.

#include "SMU2060.h"

int DMMReadNsamples(int *nDmm*, **int** *iN*)

Remarks In response to this command the DMM take *iN* measurements, and sends them back to the USB bus. In order not to loose any, and cause overrun, use **DMMGetStoredReading()** in a tight loop. Measurements are made using the currently selected function, range and aperture.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iN	**Int** The number of measurements to be taken. This value must be between 2 and 10,000.

Return Value Integer value version code or an error code.

Value	Meaning
POS_FS or **NEG_FS**	Positive or Negative Full Scale, or overrange
Negative Value	Error code
DMM_OKAY	No error

Example

```
int status = DMMReadNsamples(0, 100);
```

DMMReadPeakToPeak

SMU2060 ☐ SMU2064 ☑

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

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

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

#include "SMU2060.h"

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

Remarks To use this function the DMM must be in ACV measurement mode, 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

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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 leaset 64 characters long) to hold the converted results. The return value will consist of a leading sign, a floating-point value in exponential notation, and a untis specifer.

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

Value	**Meaning**
Negative Value	Error code
Positive value < 100	The length of the returned string.
Positive value ≥ 100	Warning code

Example

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

DMMReadTestV

SMU2060 ☐ SMU2064 ☑

Description Return the exact voltage applied during Leakage test.

#include "SMU2060.h"

int DMMReadTestV(int *nDmm*, **double** *****lpdTestV*)

Remarks This is function requires the DMM to be in LEAKAGE measurement. It measres the voltage applied to the device during leakage measurement, placing the double-precision floating-point result in a location pointed to by *lpdTestV*. The starndard measurement functions, **DMMRead()**, **DMMReadStr()** and **DMMReadNorm()** return the value of the leakage.

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

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

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

Example

```
double Vt; int state; state = DMMReadTestV(0, &Vt);
```

DMMReadTotalizer

SMU2060 ☐ SMU2064 ☑

Description Read the totalized value accumulated by the Totalizer function.

#include "SMU2060.h"

int DMMReadTotalizer(int *nDmm,* **int** * *lpiTotal*)

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.
lpiTotal	**int *** Pointer at which the totalized accumulated value is stored.

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

Value	**Meaning**
Negative Value	Error code

Example

```
int val; int err = DMMReadTotalizer(0, &val);
```

DMMReadWidth

SMU2060 ☐ SMU2064 ☑

Description Return the pulse width of the input signal.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

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

#include "SMU2060.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**, and **DMMReadBuffer** 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

SMU2060 ☐ SMU2064 ☑

Description Set the measurement delay of AC based Capacitance.

#include "SMU2060.h"
#include "USBDMMUser.h"

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

Remarks This function sets the AC based capacitance measurement delay, which is the time the measurement system settles. The default value is 0s. This function can set this value 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. A negative delay value causes the range limits to be disabled, making it possible to measure values greater than defined by the selected range. For instance a value of -0.01 will set the delay to 0.01s and remove the range limit. The default is hat range limits are enabled.

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 -10.0 and 10.0 seconds. A negative value disables range limits.

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

SMU2060 ☐ SMU2064 ☑

Description Set the level of the AC voltage source for a peak value during In-Circuit caps.

#include "SMU2060.h"
#include "USBDMMUser.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 default value, it is recommended not to use this function, maintaining 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

SMU2060 ☐ SMU2064 ☑

Description

Set the ACV source output level and frequency.

#include "SMU2060.h"
#include "USBDMMUser.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** Frequency to be set; 0.5Hz 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

SMU2060 ☑ SMU2064 ☑

Description Set the measurement Aperture.

#include "SMU2060.h"
#include "USBDMMUser.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 USBDMMUser.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. See also DMMSetPLC() function.

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

SMU2060 ☑ SMU2064 ☑

Description Enable/Disable autorange operation of DMM

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Setup the DMM for Triggered operation.

#include "SMU2060.h"
#include "USBDMMUser.h"

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

Remarks Setup the SMU2060 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

SMU2060 ☐ SMU2064 ☑

Description Tunes the capacitance measurement function parameters for higher measurement speed.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Set cold junction temperature for thermocouple measurement.

#include "SMU2060.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^{o}C and 50^{o}C or the corresponding ^{o}F.

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

SMU2060 ☐ SMU2064 ☑

Description Set the Threshold DAC level.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description Set the frequency counter to a specific range.

#include "SMU2060.h"
#include "USBDMMUser.h"

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

Remarks This function **locks** the auto-ranging frequency counter to a specific range, *fRange*. Use this function if the approximate frequency to be measured is known. This eliminate the time necessary for the counter to autorange to the optimal range for the input frequency. This function can also be used to trade off counter resolution for higher measurement speed. For instance, to improve frequency counter speed while measuring 500Hz, set it to COUNTER_20HZ. This funciton locks the counter to the selected range. In order to return to the normal/default autoraning mode use the **DMMUnlockCounter** function. Couner ranges are defind in ***USBDMMUser.h*** file. Entering VAC also unlocks the range-lock.

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

<u>**Parameter**</u> <u>**Type/Description**</u>

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 ***USBDMMUser.h***

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code

Example

```
DMMSetCounterRng(0, COUNTR_640HZ); // Set counter to measure a
frequency between 130Hz to 640Hz
```

DMMSetDCISource

SMU2060 ☐ SMU2064 ☑

Description Set the DCI source output level.

#include "SMU2060.h"
#include "USBDMMUser.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 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 2.4 V range at either the source terminals or the sense terminals, depending on the state of the mode flag (see **DMMSetSourceMode**).

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

SMU2060 ☐ SMU2064 ☑

Description

Set the DCV source output level.

#include "SMU2060.h"
#include "USBDMMUser.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**. 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 18 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 160ms 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

SMU2060 ☑ SMU2064 ☑

Description Set the DMM RMS filter response time.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Set the DMM function and range.

#include "SMU2060.h"
#include "USBDMMUser.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 USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description Set the DMM function.

#include "SMU2060.h"
#include "USBDMMUser.h"

int DMMSetFunction(int *nDmm,* **int** *nFunc*)

Remarks This function sets the function used by the DMM. The USBDMMUser.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. USBDMMUser.h lists the specific function values.

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

SMU2060 ☐ SMU2064 ☑

Description Set the frequency of the Inductance Source.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Enable/Disable Offset Ohms operation

#include "SMU2060.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 */

DMMSetPLC

SMU2060 ☑ SMU2064 ☑

Description Set the Aperture to a power line multiple

#include "SMU2060.h"

int DMMSetPLC(int *nDmm,* **int** *iLineFreq,* **int** *iMultiple*)

Remarks This function sets the Aperture to an integer multiple, *iMultiple*, of the specified power line cycle. The line frequency, iLineFreq, can be 50Hz, 60Hz or 400Hz. The multiple range can be 1 to 50. Also see DMMSetAperture().

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
iLineFreq	**int** Identifies the powr line frequnecy. Can take a value of 50, 60 or 400.
bMultiple	**int** Defines the Aperture value as a multiple of power line cycles. Can be set between 1 and 50.

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

Value	Meaning
DMM_OKAY	Function succeeded.
Negative Value	Error code

Example status = DMMSetPLC(0, 60, 10); /* Set aperture to 166.667ms */

DMMSetPulseGen

2060 ☐ 2064 ☑

Description Set the parameter of the pulse generator output.

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

int DMMSetPulseGen(int *nDmm,* **double** *dPwidth,* **double** *dNwidth,* **int** *nPulses*)

Remarks This function sets the parameters of the pulse generator source. *dPwidth* sets the positive, or active width portion of the of the pulse, d*Nwidth* sets the negative (0V) portion of the pulse. *nPulses* sets the number of pulses to be generated, as well as the mode. Both d*Pwidth* and *dNwidth* are in seconds. *dPwidth* and *dNwidth* can be set between 25µ (25.0e-6) and 3s (3.0). The value of *nPulses* can be set between 0 to 32,000. A value of 0 sets the pulse generator to a free running mode. Other values set the number of pulses in a burst. The DMM must be set to the **PULSE_GEN** function prior to using this function. The **DMMSetDCVSource** function controls the amplitude of the pulse (-10V to +10V) while in pulse generator mode. If either dNwidth or dPwidth are greater than 0.0655s, the width resolution becomes 100us, and the minimum value of dNwidth and/or dPwidth is 1.5ms. This function requires Driver version 1.60 and Microcode version 1.29 or higher.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
dPwidth	**double** Sets the width of the active part of the pulse in seconds.
dNwidth	**double** Sets the width of the (0V) portion of the pulse in secondss.
nPulses	**int** Sets the generation mode and pulse count to be issued.

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

Example

```
DMMSetFunction(0, PULSE_GEN);
DMMSetPulseGen(0, 0.0005, 0.0005, 0); // 1kHz square wave
DMMSetDCVSource(0, 5.0); // 5V amplitued (0V to 5V)
```

DMMSetRange

SMU2060 ☑ SMU2064 ☑

Description Set the DMM range for the present function.

#include "SMU2060.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 *_240mV, _2400uA, 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 SMU2064 has a 24 Ohms and 240Meg range, while the SMU2060 and 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_RNG	Invalid DMM range value.

Example

```
status = DMMSetRange(0, _240mA);
```

DMMSetReadInterval

SMU2060 ☑ SMU2064 ☑

Description Set the measurement cycle time parameter.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description

Set measurement reference value for deviation measurements.

#include "SMU2060.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 by 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

SMU2060 ☑ SMU2064 ☑

Description Set the DMM relative reading mode for the present function

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

Description Set the RTD parameters.

#include "SMU2060.h"
#include "USBDMMUser.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. Connect your RTD using a 4-wire connection. *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.
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, _pt385);      // Select RTD
DMMSetRTD(0, 1000.0); // Set Ro = 1k Ohms
```

DMMSetSensorParams

SMU2060 ☑ SMU2064 ☑

Description Set the cold junction temperature sensor equation parameters.

#include "SMU2060.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

SMU2060 ☐ SMU2064 ☑

Description Set the DCV and ACV sources to ClosedLoop, or OpenLoop mode.

#include "SMU2060.h"
#include "USBDMMUser.h"

int DMMSetSourceMode(int *nDmm***, int** *iMode***)**

Remarks This function sets the DC voltage sources to either **OPEN_LOOP** ('O', default) or **CLOSED_LOOP** ('C'). 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 18 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. Another function effected by this function is the DC Currents souce. When in OPEN_LOOP, the voltage generated by the DC current source is measured at the source terminals (upper two), when in CLOSED_LOOP the voltage is measured at the sense terminals (lower two) of the DMM. This allows a 2-Wire or 4-Wire measurement of the current source.

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`

DMMSetSourceRes

2060 ☐ 2064 ☑

Description Set the value of the DMM's source resistance.

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

int DMMSetSourceRes(int *nDmm*, **double** *ldRs***)**

Remarks This function sets the value of the DMM's source impedance. This value is used by various source and measurement function. It is normally measured by DMMOpenTerminalCal() function. This provides an external means to calibrate some of the measurements such as ESR (DMMReadSR()) and the Sosurce V / Measure I function, resulting in improved accuracy. The nominal value of ldRs is about 200Ω. It can be set from 1Ω to 400Ω. See also DMMReadSR() and the SRC_V_MSR_I function.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
ldrS	**double** The value of the source resistance. Can be 0 to 400 (Ohms)

Return Value Integer error code.

Value	Meaning
DMM_OKAY	Operation successfully completed.
Negative Value	Error code
Positve Value	Value over 100 is a warning code

Example `DMMSetSourceRes(0, 199.0); // Set source resistance to 199 Ohms`

DMMSetSync

SMU2060 ☑ SMU2064 ☑

Description Enables and sets polarity of Sync output line.

#include "SMU2060.h"

int DMMSetSync(int *nDmm,* **int** *bEnable,* **int** *iPolarity*)

Remarks This function enables or disables the Sync output (available at the DIN7). To enable it, set *bEnable* **TRUE (1),** or **FALSE (0)** to disable. ***iP****olarity* effects the sync output level. iPolarity set to 0 causes low going pulse, and 1 sets to high or positive 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. When enabled, all measurement funcitons generate a pulse corresponding to their measurement cycle.

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

SMU2060 ☑ SMU2064 ☑

Description Set Thermocouple type.

#include "SMU2060.h"
#include "USBDMMUser.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 USBDMMUser.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 USBDMMUser.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

SMU2060 ☐ SMU2064 ☑

Description Set temperature units to °C or °F.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description Sets the polarity of the trigger input.

#include "SMU2060.h"

int DMMSetTrigPolarity(**int** *nDmm*, **int** *iPolarity*)

Remarks This function sets the external hardware and soft 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.

Positive Edge is imlied by a transition from 0V to a voltage over 3.5V at the Trigger input line. Negative edge is implied by transition from a voltage over 3.5V to 0V.

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

SMU2060 ☑ SMU2064 ☑

Description Setup the DMM for mutiple Triggered readings operation.

#include "SMU2060.h"
#include "USBDMMUser.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[100];
DMMSetTrigRead(0,4,100,0);// neg. edge, 4setteling readings
                                    // and 100 samples/triggers
for(i=0;i<100;i++)                  // read measurement buffer
      while( ! DMMReadMeasurement(0, Reading[i]);
```

DMMSetTrimDAC

SMU2060 ☐ SMU2064 ☑

Description Set the Trim DAC level.

#include "SMU2060.h"
#include "USBDMMUser.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 <u>must</u> 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.

<u>Parameter</u>	**<u>Type/Description</u>**
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.

<u>Value</u>	**<u>Meaning</u>**
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

SMU2060 ☐ SMU2064 ☑

Description Clear the totalized value and start the totalizer.

#include "USBDMMUser.h"
#include "SMU2060.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 30,000 events per second. If reads are performed during the accumulation period, this rate could be as low as 20,000 events per second. The Threshold DAC sets the threshold 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, after the required time stop and read the accumulated count. The total number of events is limited to 1,000,000,000. The SMU2064 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

SMU2060 ☐ SMU2064 ☑

Description Terminate the accumulation process of the Totalizer.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Terminate DMM operation (DLL)

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Software Trigger the DMM. Take *iSamples*.

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description Hardware multi sample trigger operation.

#include "SMU2060.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]) );
```

DMMUnlockCounter

SMU2060 ☑ SMU2064 ☑

Description Return the indicated pulse width in string format.

#include "SMU2060.h"

int DMMUnlockCounter(int *nDm*)

Remarks This function unlocks the freqency counter range, allowing it to autorange. This is the default mode of operation for the frequency coutner. User this function to release the range lock which was caused by using the **DMMSetCounterRange** 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**
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

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

DMMWaitForTrigger

SMU2060 ☑ SMU2064 ☑

Description Put the DMM in a wait state which gets relesed on trigger event.

#include "SMU2060.h"

int DMMWaitForTrigger(**int** *nDmm*)

Remarks Setup the DMM for external hardware trigger (Trigger input DIN7 connector). Following reception of this command the DMM enters a wait state. It waits until the selected trigger edge, previously defined by **DMMSetTrigPolarity() i**s detected. During the wait, no other command except for **DMMReady()** or **DMMDisarmTrigger()** should be issued. Prior to issuing this command the DMM may be set up for a composit function such as Capacitance or any other measurement mode. Monitor readyness using the **DMMReady()** command. While no trigger is received, it will return a FALSE (0). If trigger event occured it will returne a TRUE (1). It is possible to terminate the wait for trigger by issuing **DMMDisarmTrigger()** command. Also see **DMMArmTrigger()**, **DMMDisarmTrigger()** and **DMMSetTrigPolarity()**.

Positive Edge is imlied by a transition from 0V to a voltage over 3.5V at the Trigger input line. Negative edge is implied by transition from a voltage over 3.5V to 0V.

Parameter	Type/Description
nDmm	**int** Identifies the DMM.

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

Value	Meaning
Negative Value	Error code
DMM_OKAY	Normal response
Postive Value	Warning code

Example

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

DMMWidthStr

SMU2060 ☐ SMU2064 ☑

Description Return the indicated pulse width in string format.

#include "SMU2060.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
Negative Value	Error code
Positive Value < 100	The length of the returned string
Postive Value ≥ 100	Warning code

Example

```
char W[64]; int status = DMMWidthStr(0, 0, W);
```

5.7 Calibration and Service Commands

AC_zero

SMU2060 ☑ SMU2064 ☑

Description Disable AC measurement zero funciton.

#include "SMU2060.h"
#include "USBDMMUser.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.
```

EraseCalStore

SMU2060 ☑ SMU2064 ☑

Description Service function that wipes the Calibration record off the internal memory.
#include "SMU2060.h"

int EraseCalStore(int *nDmm***)**

Remarks This function reformats the none volatile calibration store on-board the DMM, preparing it for storing a calibration record. This function will remove the currently stored calibration record and is not necessary during calibration.

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

Return Value Integer error code.

Value	Meaning

Any value	**int** Eror or warning code.

Example int i = EraseCalStore(0); `// Erase/Format cal store EEProm`

DMMLoadCalFile

SMU2060 ☑ SMU2064 ☑

Description Reload calibration record from file.

#include "SMU2060.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");
```

SetGain

SMU2060 ☑ SMU2064 ☑

Description Set currently set gain during service.

#include "SMU2060.h"
#include "UseroDMM.h"

int SetGain(int *nDmm*, **doulbe** *Gain***)**

Remarks This function sets the currently set gain,. Sets the gain of the the currently selected function and range. The gain is returned as double-precision floating-point number *Gaint*. This function is useful while performaing calibration. Set **GetGain()** 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** the gain.
DMM_OKAY	Valid return.
Negative Value	Error code

Example

```
SetGain(0, 1.00023); // set gain
```

GetGain

SMU2060 ☑ SMU2064 ☑

Description Retrieve currently set gain.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description Retrieve currently set gain.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description Set the ACV Frequency compensation factor
#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description

Set the the offset correction factor

#include "SMU2060.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

SMU2060 ☑ SMU2064 ☑

Description

Activate/Deactivate A/D linearization correction.

#include "SMU2060.h"
#include "USBDMMUser.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

SMU2060 ☑ SMU2064 ☑

Description

Read A/D offset counts.
#include "SMU2060.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
```

WrCalFileToStore

SMU2060 ☑ SMU2064 ☑

Description

Transfer the contents of a cal file to the on-board cal store.
#include "SMU2060.h"

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

Remarks

This function copies the specified calibration file, pointed to by lpszCal, to the on-board none volatile store of the DMM. This is appropriate following calibration operation. The currently stored on-board record is replaced with the contents of the speified file. Make sure that the calibration file only contains only one record, for the specified DMM.

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 C:\ root directory.

Return Value

Integer error code.

Value	Meaning
Any value not 0	**int** Eror or warning code

Example int i = **WrCalFileToStore** (0, `"C:\\SM60CAL.dat");`

WrCalStoreToFile

SMU2060 ☑ SMU2064 ☑

Description Transfer the contents of the on-board cal store to a file.

#include "SMU2060.h"

int WrCalStoreToFile (int *nDmm,***LPCSTR** *lpszCal,* **int** *mode***)**

Remarks This function copies the calibration record stored in the on-board none volatile memory of the DMM to the specified calibration file, pointed to by lpszCal. If *mode* is 'a' and a file exists, the record is appended to the end of this file. If *mode* is 'w', a new file is created, wiping out the old if it exists.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
mode	**int** Sets the file creation mode.
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 C:\ root directory.

Return Value Integer error code.

Value	Meaning
Any value not 0	**int** Eror or warning code

Example int i = **WrCalStoreToFile** (0, `"C:\\SM60CAL.dat", 'a');`

DMMGetSupplyV

SMU2060 ☑ SMU2064 ☑

Description Returns the one of the DMM supplies voltages.

#include "SMU2060.H"

int DMMGetSupplyV(int *nDmm,* **, double ****lpdVoltage*)

Remarks This function makes a measurement of one of the DMM power supplies voltages as an indication of the USB supply voltage level. The nominal value is -12V. The USB interconnect and some off the shelve hubs can make this voltage higher or lower than is required. The acceptable value should be -10.5 to -13.5V. Voltages higher than -13.5V may damage the SMU2055 and voltages below -9.0 are inadequate for proper operation, and is usually indicative of poor USB cable. The value of this voltage is stored at a double precision location pointed to by *lpdVoltage*.

Parameter	Type/Description
nDmm	**int** Identifies the DMM. DMMs are numbered starting with zero.
lpdVp;tage	**LPSTD** Points to a double 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
Positive Value	Warning code

Example

```
double v;
int status = DMMGetSupplyV(0, @v);
```

5.8 Service Commands

GrdXingTest

SMU2060 ☑ SMU2064 ☑

Description Perform the specified test
#include "SMU2060.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 (SMU2064).
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

ClearBuffer

SMU2060 ☑ SMU2064 ☑

Description Clears the contents of the internal buffer.

#include "SMU2060.h"

int DMMClearBuffer(int *nDmm,* **int** *iNumber,* **int** *iValue***)**

Remarks This function fills the internal buffer with *iValue*. It is useful when testing the various trigger functions. Novmally *iVlaue* is set to zero.

Parameter	Type/Description
iValuet	**int** Value to fill into the buffer. Normally zero. Can be any value from 0 to 255 (0XFF)
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, 0);
```

5.9 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. There values are included in the SMU2060.H file.

DMM_OKAY	0	// no error
DMM_E_INIT	-1	// Dmm not initialized
DMM_E_CAL_R	-2	// cannot find valid calibration record
DMM_ERR_AD_HW	-3	// A/D does not respond. H/W error
DMM_NO_CAL_RECORD	-4	// can't find cal record for DMM
DMM_TRIG_ERR	-5	// Trigger circuit error
DMM_GUARD_COM	-6	// Microcontroller communication error
DMM_TIMEOUT	-7	// process timed out Error
DMM_GUARD_XING	-8	// Guard crossing is broken
DMM_WRONG_TYPE	-9	// Wrong Cal record for DMM type
DMM_UNKNOWN_ERROR	-10	// Undefined Error
DMM_CANT_OPEN_USB	-11	// Can't open USB device. Already open
DMM_GENERAL_ERR	-12	// General Error
DMM_CAL_STORE	-13	// Error reading Cal record from local storage
DMM_CREAT_CAL_FILE	-14	// Can't create named cal file to write to
DMM_OPEN_CAL_FILE	-15	// Can't open cal file for reading cal record
DMM_CREAT_CAL_RCRD	-16	// Can't create on-board Cal Record
DMM_ERROR_EEPROM_DTYPE	-17	// Invalid dmm type in EEProm
DMM_ERROR_READBYTES	-18	// unexpected number of bytes read
DMM_ERROR_WRITEBYTES	-19	// unexpected number of bytes written

DMM_ERROR_DTYPE	-20	// invalid input, bad DMM Type parameter
DMM_ERROR_READ_EEPROM	-21	// invalid data on the EEPROM
DMM_ERROR_USB_IO	-22	// I/O error from USB bus
DMM_ERROR_USB_PWR	-23	// USB 5V supply is too low
DMM_MCU_COM_ERROR	-24	// Microcontroller communication error
DMM_USB_DEV_COUNT	-25	// Wrong USB number of Devices encountered

5.10 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 additional, or the POS_FS and NEG_FS are indication that the signal level is too high for the selected range, which is normal.

DMM_APERTR_TOO_HIGH	101	// Aperture is too high (code too low) for this 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 is already initialized: in use
DMM_CAP_RATE_ERR	106	// Can't change Aperture or Read Interval in Cap mode.
DMM_ERR_FUNC	107	// Illegal function selection
DMM_ERR_APERTURE	108	// Wrong Aperture selected, see rate definition
DMM_TRIG_SAMPL_ERR	109	// Wrong number of Trigger samples
DMM_ERR_PARAMETER	110	// wrong parameter value
DMM_UN_CALIBRATED	111	// Expired Calibration. Needs service
DMM_TOO_COLD	112	// Temperature too low
DMM_TOO_HOT	113	// Temperature too high
DMM_BAD_TC_TYPE	114	// Wrong TC type
DMM_MC_STOP	115	// Microcontroller was stopped/interruped during an operation
DMM_POS_FS	116	// Positive Over Range
DMM_NEG_FS	117	// Negative Over Range
DMM_BUSY	118	// DMM is busy, wait for ready
DMM_FUNC_INACTIVE	119	// Function can not be selected, or not available for this model
DMM_READ_INTERVL	120	// Read Interval value incompatible with Aperture,
DMM_FAIL_OPEN_CAL	121	// Failed to perform Open-Cal operation
DMM_CAL_2usOffset	122	// Failed to Cal offset in 2.5uS Aperture
DMM_CAL_2usGain	123	// Failed to Cal gain in 2.5uS Aperture
DMM_USB_LOW_POWER	124	// USB supply is too low for this opereation
DMM_USB_HIGH_POWER	125	// USB supply is too high
DMM_WRONG_GRD_VER	126	// MCU Firmwhare does not support operation

5.11 Parameter List

The following definitions are from the USBDMMUser.h file.

5.11.1 Measurement and Source Functions

The following list contains values that set the DMM functions. Use the **DMMSetFuncction()** function to set these values. Use **DMMGetFunction()** to retrieve the value of the currently set function

#define VDC	0	DC Volts
#define VAC	5	AC Volts
#define IAC	10	AC Current
#define IDC	14	DC Current

#define OHMS4W	22	2-Wire resistance
#define OHMS2W	29	4-Wire resistance
#define DIODE	37	Diode test
#define TEMP_LCL	43	DMM Internal temperature
#define CAPS	44	Capacitance
#define RTD	52	4-Wire RTD
#define VDC_SRC	57	Source DC Voltage
#define VAC_SRC	58	Source AC Voltage
#define IDC_SRC	60	Source DC Current
#define LEAKAGE	65	Leakage test
#define INDUCTANCE	68	Inductance
#define VDCSRC_IDCSNS	63	Source Voltage, Measure Current
#define EXTEND_OHMS	75	Extended Ohms
#define SYNTH_OHMS	78	Synthesized Resistance (not implemented yet)
#define THERMO_COUPLE	81	Thermocouple Temperature
#define AC_CAPS	82	In-Circuit Capacitance
#define RinMeasure	91	10Meg High V ranges input resistance measure (open terminals)
#define SRC_V_MSR_I	98	Source VDC to +/-10V & measure IDC to +/-24mA
#define MsrER	100	Measures the resistance in a series RC network

5.11.2 Composite Function-Range

The following list contains values that set composite function and range. Use the **DMMSetFuncRange()** function to set these values. **DMMGetFuncRange()** will retrieve the value of the currently set composite function-range parameter. This function is useful when there is a need to switch the measurement function, and select a specific range. Using this function is a faster alternative to using both, **DMMSetFunction()** and **DMMSetRrange()**, to set a function and a range. Keep in mind that some functions only have a single range and therefore there is no advantage in using **DMMSetFuncRgange()** for those.

/* VDC */		
#define VDC_240mV	0	// Volts DC 240mV range
#define VDC_2400mV	1	// Volts DC 2.4 range
#define VDC_24V	2	// Volts DC 24V range
#define VDC_240V	3	// Volts DC 240V range
#define VDC_330V	4	// Volts DC 330V range
/* VAC */		
#define VAC_240mV	5	// Volts AC 240mV range
#define VAC_2400mV	6	// Volts AC 2.4 range
#define VAC_24V	7	// Volts AC 24V range
#define VAC_240V	8	// Volts AC 240V range
#define VAC_330V	9	// Volts AC 330V range
/* IAC */		
#define IAC_2400uA	10	// Current AC 2.4mA range
#define IAC_24mA	11	// Current AC 24mA range
#define IAC_240mA	12	// Current AC 240mA range
#define IAC_2400mA	13	// Current AC 2.4A range
/* IDC */		
#define IDC_240nA	14	// Current DC 240nA range (2064 models)
#define IDC_2400nA	15	// Current DC 2.4uA range (2064 models)
#define IDC_24uA	16	// Current DC 24uA range (2064 models)
#define IDC_240uA	17	// Current DC 240uA range (2064 models)
#define IDC_2400uA	18	// Current DC 2.4mA range
#define IDC_24mA	19	// Current DC 24mA range
#define IDC_240mA	20	// Current DC 240mA range

```
#define  IDC_2400mA             21                  // Current DC 2.4A range
/* 4-Wire Ohms */
#define  OHM_4W_24              22                  // 4 Wire 24 Ohms range
#define  OHM_4W_24023                          // 4 Wire 240 Ohms range
#define  OHM_4W_2400            24                  // 4 Wire 2.4k Ohms range
#define  OHM_4W_24K             25                  // 4 Wire 24k Ohms range
#define  OHM_4W_240K            26                  // 4 Wire 240k Ohms range
#define  OHM_4W_2400K           27                  // 4 Wire 2.4M Ohms range
#define  OHM_4W_24MEG           28                  // 4 Wire 24M Ohms range
/* 2-Wire Ohms */
#define  OHM_2W_24              29                  // 2 Wire 24 Ohms range
#define  OHM_2W_24030                          // 2 Wire 240 Ohms range
#define  OHM_2W_2400            31                  // 2 Wire 2.4k Ohms range
#define  OHM_2W_24K             32                  // 2 Wire 24k Ohms range
#define  OHM_2W_240K            33                  // 2 Wire 240k Ohms range
#define  OHM_2W_2400K           34                  // 2 Wire 2.4M Ohms range
#define  OHM_2W_24MEG           35                  // 2 Wire 24M Ohms range
#define  OHM_2W_240MEG          36                  // 2 Wire 240M Ohms range
/* Diodes */
#define  DIODE_100n             37                  //Test current = 100nA
#define  DIODE_1u               38                  // 1uA
#define  DIODE_10u              39                  // 10uA
#define  DIODE_100u             40                  // 100uA
#define  DIODE_1m               41                  // 1mA
#define  DIODE_10m              42                  // 10mA (2064 only)
// All functions below are only for 2064 type DMM.
// Module internal temperature sensor
#define  LOCAL_TEMP             43                  // Internal temperature measurement
/* Ramp type Capacitance */
#define  CAPS_1200p             44                  // 1,200pF range
#define  CAPS_12n               45                  // 12,000pF range
#define  CAPS_120n              46                  // 0.12uF range
#define  CAPS_1200n             47                  // 1.2uF range
#define  CAPS_12u               48                  // 12uF range
#define  CAPS_120u              49                  // 120uF range
#define  CAPS_1200u             50                  // 1,200uF
#define  CAPS_12m               51                  // 12,000uF
// RTD Types. Resistance 4 wire config. Set Ro parameters
// to be set using DMMSetRTD(nDmm, Rzero)
#define  pt385                  52                  // pt385 RTD
#define  pt3911                 53                  // pt3911 RTD
#define  pt3916                 54                  // pt3916 RTD
#define  pt3926                 55                  // pt3926 RTD
#define  cu                     56                  // 10 or 100 Ohms Copper RTD
// VDC source
#define  VDCSource              57                  // VDC source 0 to +/-10V
// VAC source
#define  VACSrc900mV            58                  // VAC source 0 to 3.3V RMS
#define  VACSrc8V               59                  // VAC source 0 to 7.25 RMS (20V p-p)
// DC Current source ranges. User DMMSetIDCSource() to set value
#define  IDCSource1200n         60                  // IDC source 1.25uA
#define  IDCSource12u           61                  // IDC source 12.5uA
#define  IDCSource120u          62                  // IDC source 125uA
#define  IDCSource1200u         63                  // IDC source 1.25mA
#define  IDCSource12m           64                  // IDC source 12.5mA
```

```
// Leakage test with variable Voltage
#define  Leak240n             65              // Leakage 240nA range, 0 to +/-10V source
#define  Leak2400n            66              // Leakage 2.4uA range, 0 to +/-10V source
#define  Leak24u              67              // Leakage 24uA range, 0 to +/-10V source
// Inductance Function
#define  Induct33u            68      // 33uH range for inductors
#define  Induct330u           69      // 330uH range for inductors
#define  Induct3300u          70      // 3.3mH range for inductors
#define  Induct33m            71      // 33mH range for inductors
#define  Induct330m           72      // 330mH range for inductors
#define  Induct3300m          73      // 3.3H range for inductors
//
#define  VsourceIsense        74      // Source +/-5V, measure current (<20mA)
//
// Extended Ohms ranges using the three internal shunts as current limiters
#define  ExOhms400k           75      // 400k range with 24uA current limit
#define  ExOhms4M             76      // 4Meg range with 2.4uA  current limit
#define  ExOhms40M            77      // 40Meg range with 240nA current limit
//
// Synthesized Resistance using the three internal shunts as references
#define  SynthRes400k         78      // Synthesized Resistance, 400k range with 24uA  limit
#define  SynthRes4M           79      // 4Meg with 2.4uA limit
#define  SynthRes40M          80      // 40Meg with 240nA limit
//
#define  ThermoCouple         81      // Thermocouples
// AC based capacitance measurement function
#define  AC_Cap24n            82      // AC based capacitance 24nF range
#define  AC_Cap240n           83      // AC based capacitance 240nF range
#define  AC_Cap2400n          84      // AC based capacitance 2.4uF range
#define  AC_Cap24u            85      // AC based capacitance 24uF range
#define  AC_Cap240u           86      // AC based capacitance 240uF range
#define  AC_Cap2400u          87      // AC based capacitance 2,400uF range
#define  MsrRin               91      // Measure 10Meg input divider. Open all terminals for this.
```

5.11.3 Function Values

The following list contains values that set the measurement or source functions. Use the **DMMSetFunction()** function to set these values. **DMMGetFunction()** will retrieve the value of the currently set function parameter.

```
#define  VDC                  0       //DC Volts
#define  VAC                  5       //AC Volts
#define  IAC                  10      //Current
#define  IDC                  14      //Current
#define  OHMS4W               22      //2-Wire resistance
#define  OHMS2W               29      //4-Wire resistance
#define  DIODE                37      //Diode test
#define  TEMP_LCL             43      //DMM Internal temperature
#define  CAPS                 44      //Capacitance
#define  RTD                  52      //4-Wire RTD
#define  VDC_SRC              57      //Source DC Voltage
#define  VAC_SRC              58      //Source AC Voltage
#define  IDC_SRC              60      //Source DC Current
#define  LEAKAGE              65      //Leakage test
#define  INDUCTANCE           68      //Inductance
```

```
#define  VDCSRC_IDCSNS      74      // V Source I Sense (for future implementation)
#define EXTEND_OHMS         75      //Extended Ohms
#define SYNTH_OHMS          78      // Synthesized Resistance (for future implementation)
#define THERMO_COUPLE       81      //Thermocouple Temperature
#define  AC_CAPS            82      //In-Circuit Capacitance
#define  RinMeasure         91      //10Meg input resistance measure (w / open terminals)
```

5.11.4 Range Values

The following list contains the allowed values for range setting with **DMMSetRange()** function. Use the **DMMGetRange()** function to retrieve the currently set range

```
// AC and DC Volts
#define  _240mV             0               // five DCV ranges
#define  _2400mV            1
#define  _24V               2
#define  _240V              3
#define  _330V              4
// AC Current
#define  _2400uAAC          0               // 2.4mA
#define  _24mAAC            1               // 24mA
#define  _240mAAC           2
#define  _2400mAAC          3               // 2.4A
// DC Current
#define  _240nA             0               // 240nA (2064 only)
#define  _2400nA            1               // 2.4uA (2064 only)
#define  _24uA              2               // 24uA (2064 only)
#define  _240uA             3               // 240uA (2064 only)
#define  _2400uA            4               // 2.4mA
#define  _24mA              5               // 24mA
#define  _240mA             6               // 240mA
#define  _2400mA            7               // 2.4A
// 2 Wire and 4 Wire Ohms
#define  _24                0               // 24 Ohms range (2064 only)
#define  _240               1
#define  _2400              2
#define  _24k               3
#define  _240k              4
#define  _2400k             5               // Two Meg range
#define  _24MEG             6               // 2-Wire
#define  _240MEG            7               // 2-Wire (2064 only)
// Diode test
#define  _D100n             0               //Test current = 100nA
#define  _D1u               1               // 1uA
#define  _D10u              2               // 10uA
#define  _D100u             3               // 100uA
#define  _D1m               4               // 1mA
#define  _D10m              5               // 10mA test current (2064 only)
//  Capacitance: Standard Ramp type
#define  _1200p        0            // 1,200pF range
#define  _12n               0               // 12nF
#define  _120n              1               // 120nF
#define  _1200n        2            // 1.2uF
#define  _12u               3               // 12uF
```

```
#define  _120u                    4                      // 120uF
#define  _1200u          5                    // 1,200uF
#define  _12m                     6                      // 12,000uF
//  Capacitance: AC Based Caps.
#define  _10n                     0          // 0.01uF (10nF)
#define  _100n                    1          // 0.1uF
#define  _1u                      2
#define  _10u                     3          // 10uF
#define  _100u                    4
#define  _1m                      5
#define  _10m                     6
// 4-wire RTDs: five basic types. No auto-ranging allowed
// Use DMMSetRTD to modify the default Ro form 100 Ohms
#define  _pt385                   0          // pt385 100 ohms
#define  _3911                    1          // pt3911 100 ohms
#define  _3916                    2          // pt3916 100 ohms
#define  _3926                    3          // pt3926 100 ohms
#define  _cu                      4          // cooper 9.035 Ohms
//  VAC Source two ranges
#define  _900mVsrc                0          // selectes the 900mV range
#define  _8Vsrc                   1          // select the 8V range
//  IDC Source five ranges
#define  _1uA                     0
#define  _10uA                    1   // 10uA source (to 12.5uA)
#define  _100uA                   2
#define  _1mA                     3
#define  _10mA                    4          // 10mA source (to 12.5mA)
//  Inductance measurements: six ranges
#define  _33uH                    0
#define  _330uH                   1
#define  _3300uH                  2
#define  _33mH                    3
#define  _330mH                   4
#define  _3300mH                  5
//  Extended Resistance and Synthesized Resistance ranges
#define  _400k                    0
#define  _4M                      1
#define  _40M                     2
```

5.11.5 Aperture parameters

The following list contains the definitions for the available Apertures. Use **DMMSetAperture()** and **DMMGetAperture()** to set and retrieve the apertures.

```
#define APR_5p066s               0                      // 5.0666s apreture, 60Hz rejection (~0.2rps)
#define APR_5p12s                1                      // 5.1200s aperture, 50Hz rejection (~0.2rps)
#define APR_2s                   2                      // 2.0s aperture, 60Hz rejection (~0.5rps)
#define APR_2p08s                3                      // 2.080s aperture, 50Hz rejection (~0.5rps)
#define APR_1p0666s              4                      // 1.06666s aperture, 60Hz rejection (~1rps)
#define APR_p96s                 5                      // 960ms aperture, 50Hz rejection (~1rps)
#define APR_p5333s               6                      // 533.33ms aperture, 60Hz rejection (~2rps)
#define APR_p48s                 7                      // 480ms aperture, 50Hz rejection (~2rps)
#define APR_p2666s               8                      // 266.666ms aperture, 60Hz rejection (~4rps)
// For Trigger Operations and all measurements involving the DMM buffer, use Apertures to a value
// between APR_p16s (160ms) and APR_2p5us (2.5us)
```

```
#define APR_p16s          9        // 160.0ms aperture, 50Hz rejection (~6rps) 8PLC
#define APR_p1333s        10       // 133.33ms aperture, 60Hz rejection (~8rps) 8PLC
#define APR_80ms          11       // 80.00ms aperture, 50Hz rejection (~13rps) 4PLC
#define APR_66p67ms       12       // 66.6667ms aperture, 60Hz rejection (~15rps) 4PLC
#define APR_40ms          13       // 40.00ms aperture, 50Hz rejection (~25rps) 2PLC
#define APR_33p33ms       14       // 33.333ms aperture, 60Hz rejection (~30rps) 2PLC
#define APR_20ms          15       // 20.00ms aperture, 50Hz rejection (~50rps) 1PLC
#define APR_16p67ms       16       // 16.6667ms aperture, 60Hz rejection (~60rps) 1PLC
#define APR_10ms          17       // 10ms aperture, 400Hz rejection (~100rps)
#define APR_8p333ms       18       // 8.333ms aperture (~120rps)
#define APR_5ms           19       // 5ms aperture, 400Hz rejection
#define APR_4p167ms       20       // 4.16667ms aperture
#define APR_2p5ms         21       // 2.5ms aperture, 400Hz rejection
#define APR_2p08ms        22       // 2.0833ms aperture
#define APR_1p25ms        23       // 1.25ms aperture,
#define APR_1p04ms        24       // 1.0417ms aperture
#define APR_625us         25       // 625us aperture minimum aperture of SMU2060
#define APR_521us         26       // 520.83us aperture SMU2064 only.
#define APR_313us         27       // 312.5us aperture SMU2064 only.
#define APR_260us         28       // 260.42us aperture SMU2064 only.
#define APR_130us         29       // 130.21us aperture SMU2064 only.
#define APR_2p5us         30       // 2.5us aperture SMU2064 only.
```

5.11.6 Additional parameters

// Setting source mode to closed loop or open loop, for VDCSource. Use with **DMMSetSourceMode()**

```
#define CLOSED_LOOP       'C'
#define OPEN_LOOP         'O'
```

// Temperature units for RTD, Thermocouples and On-board temp. Use with **DMMSetTempUnits()**.

```
#define DEG_F             'F'
#define DEG_C             'C'
```

```
/* Totalizer and trigger related parameter */
#define LEADING           1
#define TRAILING          0
```

/* Frequency counter Range definitions for use with **DMMSetCounterRng()** function */

```
#define COUNTR_20HZ       0     // 1.9 Hz to 19.9Hz range (select 20Hz range)
#define COUNTR_130HZ      1     // 19.9 Hz to 128.8Hz range
#define COUNTR_640HZ      2     // 128.8Hz to 640Hz range
#define COUNTR_2500HZ     3     // 640Hz to 2.56kHz range
#define COUNTR_10kHZ      4     // 2.56kHz to 10.24kHz range
#define COUNTR_40kHZ      5     // 10.24kHz to 40.96kHz range
#define COUNTR_200kHZ     6     // 40.96kHz to 200 kHz range
#define COUNTR_500kHZ     7     // 200.0kHz to 500 kHz range
```

```
// Thermocouple type definitions:
// for use with the DMMSetTCType() function.
#define BType       'B'
#define EType       'E'
#define JType       'J'
#define KType       'K'
#define NType       'N'
#define RType       'R'
```

```
#define SType            'S'
#define TType            'T'
```

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: 0-240 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 SMU2060/64 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 SMU2060 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 SMU2060/64 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 SMU2060/64 **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 SMU2060/64 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 SMU2060/64 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 SMU2060 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 SMU2060 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 (SMU2064 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 SMU2064 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 (SMU2064 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 (SMU2064 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 SMU2064 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 SMU2060/64 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 SMU2060 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 SMU2064 since the SMU2060 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 SMU2060/64 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 SMU2060 and SMU2064 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 SMU2060/64 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