CALIBRATION MANUAL

for the

VTR and CTR SERIES TRUE RMS MEASURING VOLTAGE and CURRENT TRANSDUCERS

By William D. Walden and David W. Miller
February 1999

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VTR & CTR Manual
OSI Drawing # A-7004-17, Rev. C, 10/2004

Preface to the VTR Voltage and CTR Current True rms

(Root Mean Square) Measuring Transducers.

By William D. Walden
Ohio Semitronics, Inc.

The rms value of the current or voltage is the effective or DC equivalent value of that current or voltage. The CTR current and VTR voltage transducers calculate the effective value of current and voltage using a very close approximation of the root mean square integral. These transducers should be used whenever distortion of a sine wave or discontinuity of a sine wave exists.

The Appendix A on page 10 and Appendix B on page 15 explain why these transducers should be used whenever distortion of the waveform exists or whenever the waveform is discontinuous as it would be when a phase angle fired SCR controller is used.

The VTR and CTR transducers are designed to be used for alternating current only. If the voltage or current being measured has DC components, then consider using the CT8 series of current transducers or the VT8 series of voltage transducer. The VT8 and CT8 will measure the rms value of voltage and current when DC components are present.

Please contact us if you have any questions regarding these or other products manufactured by Ohio Semitronics, Inc.

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VTR AND CTR SERIES TRUE RMS MEASURING

VOLTAGE AND CURRENT TRANSDUCERS

By William D. Walden and David W. Miller
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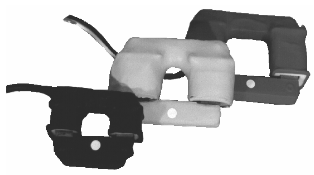
TRUE RMS MEASURING CURRENT TRANSDUCERS

THE CTR SERIES

SUBJECT

Calibrating the CTR series true rms measuring current transducers.

DESCRIPTION

These AC current transducers measure the true RMS (root mean square) value of the AC current over the operating range of 50 to 400 hertz.

The analog output is directly proportional to the true RMS value of the input current.

The type of analog output is specified by the suffix B, D, E or X5.

- **Option "B" 0 to 1mAdc**
- **Option "D" 0 to 10Vdc**
- **Option "E" 4 to 20mAdc**
- **Option "X5" 0 to 5Vdc**

All models require 120 volts AC instrument power or with option –22, 220 volts AC

SPECIFICATIONS

Input Current: direct connect models

CTR-001*	0 to 1 ampere
CTR-005*	0 to 5 amperes
CTR-010*	0 to 10 amperes
CTR-015*	0 to 15 amperes
CTR-020*	0 to 20 amperes

Input Current: Models supplied with split core current transformers.

CTR-005*Y34	0 to 5 amperes
CTR-010*Y34	0 to 10 amperes
CTR-015*Y34	0 to 15 amperes
CTR-020*Y34	0 to 20 amperes
CTR-025*Y34	0 to 25 amperes
CTR-050*Y34	0 to 50 amperes
CTR-101*Y34	0 to 100 amperes
CTR-201*Y34	0 to 200 amperes
CTR-301*Y34	0 to 300 amperes
CTR-401*Y34	0 to 400 amperes
CTR-501*Y34	0 to 500 amperes
CTR-102*Y34	0 to 1000 amperes

* Output option B, D, E, or X5 as described in the left column on this page.

Frequency Range: 48 to 420 Hertz

Dielectric Test (Input/Output/Case):1500 volts AC.

Accuracy: ± 0.25% of full scale except for model CTR-005*Y34 and CTR-010*Y34 the accuracy is ±0.5% of full scale @ 60Hz. Includes effects of linearity and repeatability. The accuracy over the frequency range of 50 to 400 hertz is ± 0.5%

I

Output:

- Option "B" 0 to 1mAdc
- Option "D" 0 to 10Vdc
- Option "E" 4 to 20mAdc
- Option "X5" 0 to 5Vdc

Output Response: 100 milliseconds

Instrument Power (STD.):
85-135Vac, 50-400Hz

Temperature Effect: (-10° C to 60°C):
±1.0% of reading.

Output Loading table

Option "B"	0 to 1mAdc	0 to 10000 Ω
Option "D"	0 to 10Vdc	2000 Ω or more
Option "E"	4 to 20mAdc	0 to 500 Ω
Option "X5"	0 to 5Vdc	2000 Ω or more

Field Adjustable Cal.: ± 10%

CALIBRATION

The CTR series current transducers are calibrated at the factory to the published specifications listed for that model and are tagged with a calibration sticker.

Periodic checks every 12 months are recommended.

TEST EQUIPMENT REQUIRED

1) AC sine wave current source capable of supplying 60 hertz (or desired frequency 50 to 400 hertz) at the full scale specified current

2) Ammeter to measure the input current with an accuracy of ±0.05% or better.

3) DC milliampere meter or voltmeter to measure the output with an accuracy of ±0.05% or better. A precision resistor may be substituted to measure transducers with a milliampere output. Recommended values are:

- For 0 to 1mADC use a 1000-ohm resistor.
- For 4 to 20 mADC use a 250-ohm resistor.
- Tolerances must be ±0.05% or better.

If a high current source is not available, multiple turns through the current transformer window may be used. For example if you are calibrating a CTR-101DY34 and have a 10-ampere source, you may use ten turns through the transformer window.

Please note that all CTR transducers with current ratings greater than 20 amperes are supplied with current transformers and all low current CTR supplied with split core current transformers are factory calibrated with the transformer supplied. To maintain the factory accuracy rating, these models must be calibrated with the current transformer supplied.

Calibrate at the frequency at which the transducer will be used.

CONNECTIONS AND ADJUSTMENTS

Make the connections as shown on page 5 for your model. All adjustments are made through the lid. Remove the plastic caps and use a 1/8-inch wide screwdriver to make the adjustments to the trimpots.

Zero Adjust

Options B, D, or X5

Apply instrument power and allow the transducer to "warm up" for 15 minutes. With no current applied to the input terminals, adjust the zero trimpot for 0.000 mADC on option B or 0.000 volts on models with options D or X5.

Option E or E2

Apply instrument power and allow the transducer to "warm up" for 15 minutes. With no current applied to the input terminals, adjust the zero trimpot for 4.000 mADC. (If you are using a 250-ohm load resistor, set the trimpot for 1.000 volt DC.)

Calibration Adjust

The "Cal" adjustment sets the output for the full-scale input current.

Option B:

1) Adjust the input current for the full scale rating of the transducer being calibrated.
2) If you are using a milliampere meter adjust the "Cal" trimpot for an output of 1.000 mADC.
3) If you are using a voltmeter and 1000 ohm resistor to load the output, adjust the "Cal" trimpot for 1 .000 volt.

Option D:

1) Adjust the input current for the full scale rating of the transducer being calibrated.
2) Adjust the "Cal" trimpot for an output of 10 volts.

Option X5:

1) Adjust the input current for the full scale rating of the transducer being calibrated.
2) Adjust the "Cal" trimpot for an output of 5 volts.

Option E:

1) Perform the zero adjust first.
2) Adjust the "Cal" trimpot for an output of 20 mADC
3) If you are using a 250-ohm load resistor and a voltmeter, adjust the "Cal" trimpot for an output of 5 volts.

Option E2 (Rare — not a standard model.)

This is the same, as E above except you must have a 24-volt DC supply in the output circuit as shown on page 5. A CTR transducer supplied with the loop powered 4 to 20 mADC output still requires instrument power of 120 volts AC.

LINEARITY CHECK

Starting at 100% of the full-scale current and measuring the analog output of the transducer one may check linearity of the current transducers.

Reduce the current in steps of 20% from full scale to 0 measuring the analog output at each step. Please refer to Table 1 on the next page.

Should a transducer fail to meet the linearity check, try adjusting the full scale output slightly up or down to bring the entire output range into the specified accuracy for the transducer. If this does not bring the linearity into specification, consider returning the transducer to Ohio Semitronics, Inc. for linearization.

This completes the calibration of the current transducer. Reinstall the plastic caps over the access holes.

	OUTPUT FROM TRANSDUCER.					
Rated Full Scale	**1 mADC**	**1 volt DC**	**5 volt DC**	**10 volt DC**	**4 to 20 mADC**	**1 to 5 volt DC**
Per Cent of Full Scale						
120% (Optional check)	1.2 mADC	1.2 volts DC	6.0 volts DC	12.0 volts DC	23.2 mA	5.8 volts
100%	1.0 mADC	1.0 volts DC	5.0 volts DC	10.0 volts DC	20.0 mA	5.0 volts
80%	0.8 mADC	0.8 volts DC	4.0 volts DC	8.0 volts DC	16.8 mA	4.2 volts
60%	0.6 mADC	0.6 volts DC	3.0 volts DC	6.0 volts DC	13.6 mA	3.4 volts
40%	0.4 mADC	0.4 volts DC	2.0 volts DC	4.0 volts DC	10.4 mA	2.6 volts
20%	0.2 mADC	0.2 volts DC	1.0 volts DC	2.0 volts DC	7.2 mA	1.8 volts
0%	0.0 mADC	0.0 volts DC	0.0 volts DC	0.0 volts DC	4.0 mA	1.0 volts
Allowed error 0.25% Units	±0.0025 mA	±0.0025 volts	±0.0125 volts	±0.025 volts	±0.04 mA	±0.01 volts
Allowed error 0.5% Units	±0.005 mA	±0.005 volts	±0.025 volts	±0.05 volts	±0.08 mA	±0.02 volts

Table 2 For Checking Linearity of Current Transducers

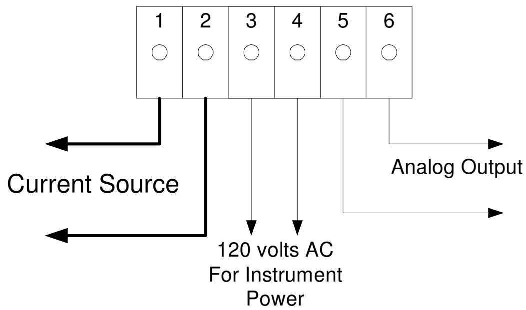
Calibration Equipment

Ohio Semitronics, Inc. recommends calibration equipment that sources the current. We suggest the following:

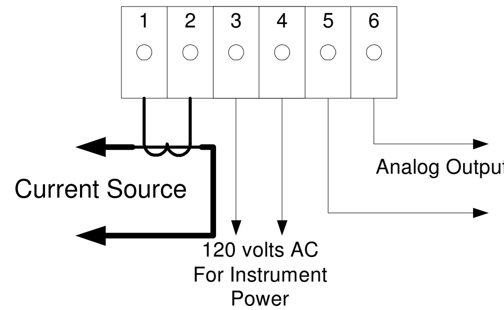
Rotek Model 8000 or 800
Rotek Instrument Corp.
390 Main Street
PO Box 504
Waltham, MA 02254-0504
617-899-4611
sales@rotek.com

Arbiter Model 931A Power Analyzer for a standard meter.
Arbiter Model 1040C Meter Calibrator.
Both Arbiter units are available for purchase from Ohio Semitronics, Inc.
Sales@ohiosemi.com.

CTR DIRECTLY
CONNECT TO A
CURRENT SOURCE



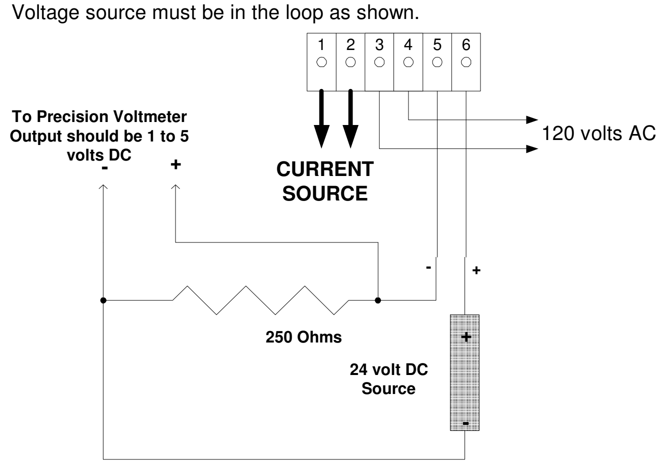
CTR-Y34 USING SPLIT
CORE CURRENT
TRANSFORMERS



Connections for calibrating the CTR series of current transducers. If you are calibrating a CTR with the Y34 suffix, the transformer must be calibrated with the green can. Current cannot be directly applied to terminals 1 and 2 with Y34 models.

TEST SETUP FOR CURRENT TRANSDUCERS WITH OPTION E2 -- THE LOOP POWERED 4 TO 20 mADC OUTPUT. THIS IS NOT A STANDARD OPTION WITH THE CTR SERIES.

Voltage source must be in the loop as shown.



TRUE RMS MEASURING VOLTAGE TRANSDUCERS

THE VTR SERIES

SUBJECT

Calibrating the VTR series true rms measuring voltage transducers.

DESCRIPTION

These AC voltage transducers measure the true RMS (root mean square) value of the AC voltage over the operating range of 50 to 400 hertz.

The analog output is directly proportional to the true RMS value of the input voltage.

The type of analog output is specified by the suffix B, D, E or X5.

- **Option "B" 0 to 1mAdc**
- **Option "D" 0 to 10Vdc**
- **Option "E" 4 to 20mAdc**
- **Option "X5" 0 to 5Vdc**

All models require 120 volts AC instrument power or with option –22, 220 volts AC

SPECIFICATIONS

Input Voltage Range

VTR-001*	0 to 150 volts
VTR-002*	0 to 300 volts
VTR-004*	0 to 600 volts

* Output option B, D, E, or X5 as described in the left column on this page.

Frequency Range: 48 to 420 Hertz

Dielectric Test (Input/Output/Case):1500 volts AC.

Accuracy: ± 0.25% of full scale except for model CTR-005*Y34 the accuracy is ±0.5% of full scale @ 60Hz. Includes effects of linearity and repeatability. The accuracy over the frequency range of 50 to 400 hertz is ± 0.5%

Output:

- Option "B" 0 to 1mAdc
- Option "D" 0 to 10Vdc
- Option "E" 4 to 20mAdc
- Option "X5" 0 to 5Vdc

Output Response: 100 milliseconds

Instrument Power (STD.):
85-135Vac, 50-400Hz

Temperature Effect: (-10° C to 60°C): ±1.0% of reading.

Output Loading table

Option "B"	0 to 1mAdc	0 to 10000 Ω
Option "D"	0 to 10Vdc	2000 Ω or more
Option "E"	4 to 20mAdc	0 to 500 Ω
Option "X5"	0 to 5Vdc	2000 Ω or more

Field Adjustable Cal.: ± 10%

CALIBRATION

The VTR series voltage transducers are calibrated at the factory to the published specifications listed for that model and are tagged with a calibration sticker.
Periodic checks every 12 months are recommended.

TEST EQUIPMENT REQUIRED

1. AC sine wave voltage source capable of supplying 60 hertz (or desired frequency 50 to 400 hertz) at the full scale specified voltage

2. Voltmeter (true rms measuring) to measure the input voltage with an accuracy of ±0.05% or better.

3. DC milliampere meter or voltmeter to measure the output with an accuracy of ±0.05% or better. A precision resistor may be substituted to measure transducers with a milliampere output. Recommended values are:

   - For 0 to 1mADC use a 1000-ohm resistor.
   - For 4 to 20 mADC use a 250-ohm resistor.
   - Tolerances must be ±0.05% or better.

Calibrate at the frequency at which the transducer will be used.

CONNECTIONS AND ADJUSTMENTS

Make the connections as shown on page 5 for your model. All adjustments are made through the lid. Remove the plastic caps and use a 1/8-inch wide screwdriver to make the adjustments to the trimpots.

Zero Adjust

Options B, D, or X5

Apply instrument power and allow the transducer to "warm up" for 15 minutes. With no current applied to the input terminals, adjust the zero trimpot for 0.000 mADC on option B or 0.000 volts on models with options D or X5.

Option E or E2

Apply instrument power and allow the transducer to "warm up" for 15 minutes. With no current applied to the input terminals, adjust the zero trimpot for 4.000 mADC. (If you are using a 250-ohm load resistor, set the trimpot for 1.000 volt DC.)

Calibration Adjust

The "Cal" adjustment sets the output for the full-scale input voltage.

Option B:

4) Adjust the input voltage for the full scale rating of the transducer being calibrated.
5) If you are using a milliampere meter adjust the "Cal" trimpot for an output of 1.000 mADC.
6) If you are using a voltmeter and 1000 ohm resistor to load the output, adjust the "Cal" trimpot for 1 .000 volt.

Option D:

3) Adjust the input voltage for the full scale rating of the transducer being calibrated.
4) Adjust the "Cal" trimpot for an output of 10 volts.

Option X5:

3) Adjust the input voltage for the full scale rating of the transducer being calibrated.
4) Adjust the "Cal" trimpot for an output of 5 volts.

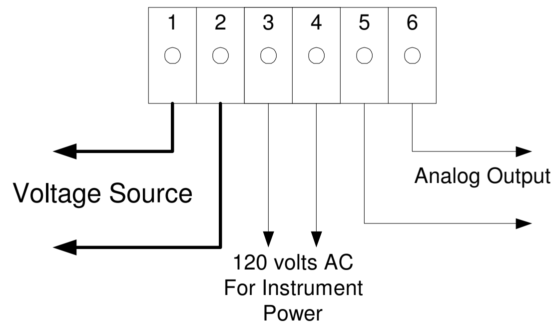
Option E:

4) Perform the zero adjust first.
5) Adjust the “Cal” trimpot for an output of 20 mADC
6) If you are using a 250-ohm load resistor and a voltmeter, adjust the “Cal” trimpot for an output of 5 volts.

Option E2 (Rare — not a standard model.)

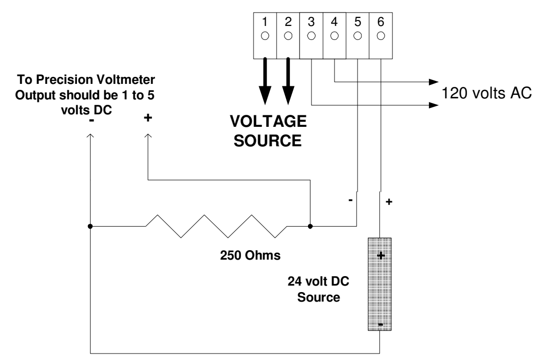
This is the same, as E above except you must have a 24-volt DC supply in the output circuit as shown on page 5. A VTR transducer supplied with the loop powered 4 to 20 mADC output still requires instrument power of 120 volts AC.

VTR CONNECTED TO A VOLTAGE SOURCE



TEST SETUP FOR VOLTAGE TRANSDUCERS WITH OPTION E2 -- THE LOOP POWERED 4 TO 20 mADC OUTPUT. THIS IS NOT A STANDARD OPTION WITH THE VTR SERIES.

24 volt DC voltage source must be in the 4 to 20 mA loop as shown.



LINEARITY CHECK

Starting at 100% of the full-scale voltage and measuring the analog output of the transducer one may check linearity of the voltage transducers.

Reduce the voltage in steps of 20% from full scale to 0 measuring the analog output at each step. Please refer to Table 3 on the next page.

Should a transducer fail to meet the linearity check, try adjusting the full scale output slightly up or down to bring the entire output range into the specified accuracy for the transducer. If this does not bring the linearity into specification, consider returning the transducer to Ohio Semitronics, Inc. for inearization.

This completes the calibration of the voltage transducer. Reinstall the plastic caps over the access holes.

	OUTPUT FROM TRANSDUCER.					
Rated Full Scale	**1 mADC**	**1 volt DC**	**5 volt DC**	**10 volt DC**	**4 to 20 mADC**	**1 to 5 volts DC**
Per Cent of Full Scale						
100%	1.0 mADC	1.0 volts DC	5.0 volts DC	10.0 volts DC	20.0 mA	5.0 volts
80%	0.8 mADC	0.8 volts DC	4.0 volts DC	8.0 volts DC	16.8 mA	4.2 volts
60%	0.6 mADC	0.6 volts DC	3.0 volts DC	6.0 volts DC	13.6 mA	3.4 volts
40%	0.4 mADC	0.4 volts DC	2.0 volts DC	4.0 volts DC	10.4 mA	2.6 volts
20%	0.2 mADC	0.2 volts DC	1.0 volts DC	2.0 volts DC	7.2 mA	1.8 volts
0%	0.0 mADC	0.0 volts DC	0.0 volts DC	0.0 volts DC	4.0 mA	1.0 volts
Allowed error 0.25% Units	±0.0025 mA	±0.0025 volts	±0.0125 volts	±0.025 volts	±0.04 mA	±0.01 volts

Table 3 For Checking Linearity of Voltage Transducers

TRUE RMS MEASURING
VERSUS
AVERAGE ABSOLUTE MEASURING
CURRENT AND VOLTAGE TRANSDUCERS
WHERE HARMONIC CONTENT EXISTS

By Bill Walden
Ohio Semitronics, Inc.
October 11, 1992
Revised November 2, 1998

Introduction

Ohio Semitronics, Inc. and other manufactures build and sell inexpensive current and voltage transducers that measure the average absolute value of the current or voltage and are calibrated in terms of the RMS value for sine wave input. These inexpensive transducers work well when the current or voltage being measured is a nice clean sine wave. What happens when there is distortion?

Appendix A examines the situation where third and second harmonics are present. Appendix B examines the situation where a phase angle fired SCR controller is used. In all three situations the software package Mathcad is used to mathematically simulate these situations.

In Appendix A I calculate both the average absolute value and the RMS value of one cycle of an AC waveform from zero harmonic distortion in steps of 1 to the same magnitude as the fundamental. I do this by stepping the value of a variable "a" from 0 to 100 and then multiplying the result by 100.

I define the fundamental and harmonic then sum the two with the iteration term ("a") added.

Next I do the integration for the root mean square and the average absolute 101 times (iteration from 0 through 100 in steps of 1), store the values and plot the graphs.

I defined the fundamental as $f(x) = \sqrt{2}*\cos(x)$. When evaluated by the RMS integral from 0 to π (0 to 180º), the result is 1 (one). This is for convenience and clarity.

The average absolute integral evaluation of this will be 0.9. To adjust for the RMS value for sine wave input I divide by 0.9. You will see this in the graph as A_a over .9.

The Calculations and Graphs
Third Harmonic

$a := 0, 1.0 .. 100$ Iteration (start, interval...stop)

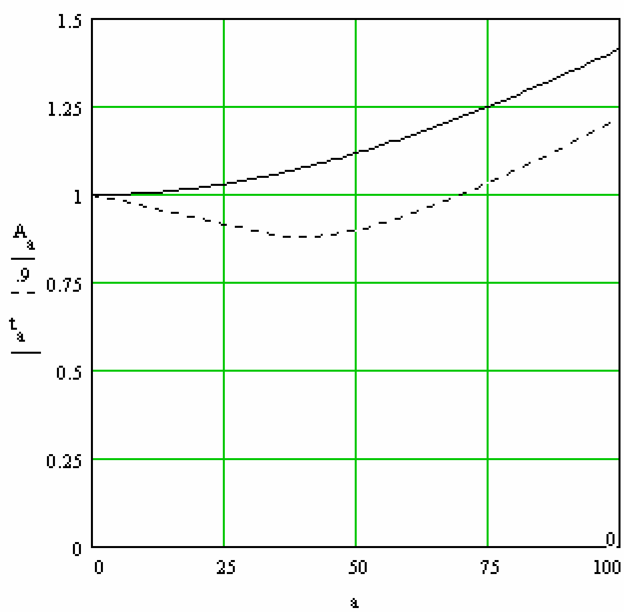
$f(x) := \sqrt{2} \cdot \cos(x)$ Fundamental

$h(x) := \sqrt{2} \cdot \cos(3 \cdot x)$ Third harmonic

$k(x) := f(x) + \frac{a}{100} \cdot h(x)$ Fundamental + Harmonic

$$t_a := \sqrt{\frac{\int_0^{\pi} k(x)^2 \, dx}{\pi}}$$ Root Mean Square Integral

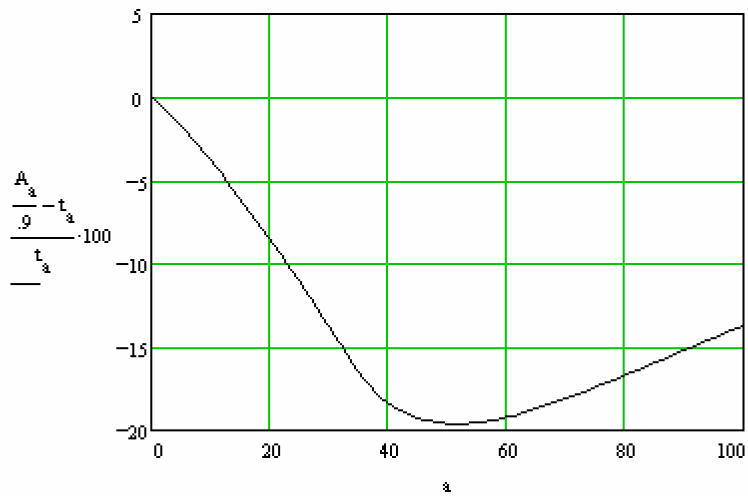
$$A_a := \frac{\int_0^{\pi} |k(x)| \, dx}{\pi}$$ Average Absolute Integral



Graph of rms Value versus Average Absolute value adjusted for RMS value of sine wave.

Solid line is true rms value.
Dashed line is average absolute value adjusted for value of sine wave of single frequency.

Percent of harmonic to fundamental. At 100% harmonic value is equal to the fundamental.



Error curve. This graph shows the per cent of reading error made by an average absolute measuring transducer when measuring a waveform with third harmonic content. Y-axis is percent error. X-axis is percent of harmonic to fundamental. At 100% harmonic value is equal to the fundamental.

Curve is negative because the average absolute reading is lower than the true RMS measurement.

Discussion

Note that the addition of a third harmonic waveform of the same magnitude as the fundamental does not result in an RMS value that is twice either the fundamental or harmonic but rather the √2 or 1.414…

The RMS value of a number of currents or voltages of different frequencies is:

- Total I_{rms} = square root of the sum of the squares of the individual rms values of the currents.
- Total V_{rms} = square root of the sum of the squares of the individual rms values of the voltages.

The Calculations and Graphs
Second Harmonic

$a := 0, 1.0 .. 100$ Iteration (start, interval...stop)

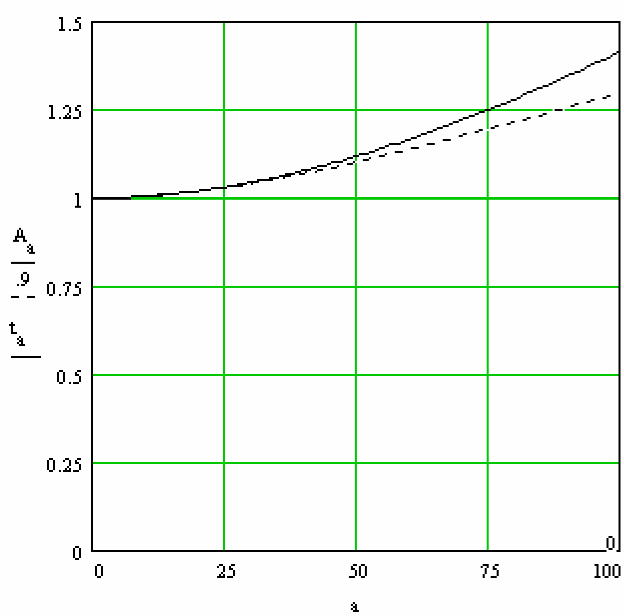
$f(x) := \sqrt{2} \cdot \cos(x)$ Fundamental

$h(x) := \sqrt{2} \cdot \cos(2 \cdot x)$ Second harmonic

$k(x) := f(x) + \frac{a}{100} \cdot h(x)$ Fundamental + Harmonic

$$t_a := \sqrt{\frac{\int_0^{\pi} k(x)^2 \, dx}{\pi}}$$ Root Mean Square Integral

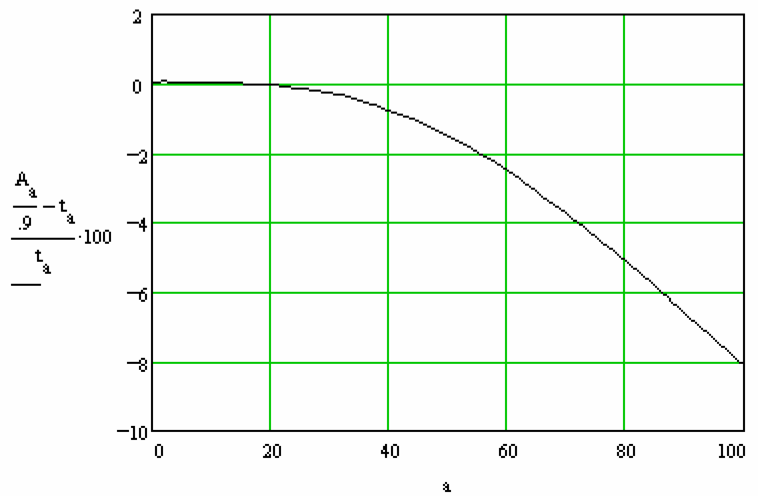
$$A_a := \frac{\int_0^{\pi} |k(x)| \, dx}{\pi}$$ Average Absolute Integral



Graph of rms Value versus Average Absolute value adjusted for RMS value of sine wave.

Solid line is true rms value.
Dashed line is average absolute value adjusted for value of sine wave of single frequency.

Percent of harmonic to fundamental.
At 100% harmonic value is equal to the fundamental.



Error curve. This graph shows the per cent of reading error made by an average absolute measuring transducer when measuring a waveform with second harmonic content. Y-axis is percent error. X-axis is percent of harmonic to fundamental. At 100% harmonic value is equal to the fundamental.

Discussion

Note that the introduction of second harmonic content does not have the dramatic consequence of third harmonic distortion. Significant error in reading by average absolute measuring transducers or meters does not occur until there is more than 20% second harmonic distortion. When second harmonic content is equal to the fundamental, such transducers will have 8% error.

Conclusion

Use true RMS measuring transducers such as the VTR-001D or CTR-005D for measuring where there is harmonic distortion. Use of the inexpensive average absolute measuring or mean measuring will give incorrect measurements when there is harmonic distortion present.

TRUE RMS MEASURING
VS
AVERAGE ABSOLUTE MEASURING
CURRENT AND VOLTAGE TRANSDUCERS

By Bill Walden
Ohio Semitronics, Inc.
October 11, 1992
Revised October 15, 1998

The most popular voltage and current transducers and meters actually measure the average abso value of the voltage or current and are calibrated for the RMS value for a sine wave input.

The OSI model series VT and CT5 transducers are such average absolute reading transducers w have their output signal calibrated in terms of the rms value for sine wave input. This is fine for continuous sine wave input. What happens if these transducers or the rms reading voltmeter or ammeters are used on a phase angle fired SCR controlled circuit?

The following analysis shows what happens:

$T := 0..\pi$ Integration range.

$f(x) := \cos(x)$ The function defined.

$$h(x) := \sqrt{\frac{\int_0^T f(x)^2 \, dx}{T}}$$

Root mean square integral

The integral to the right gives the root mean square value for one half of a sine wave.

$$\sqrt{\frac{\int_0^\pi f(x)^2 \, dx}{\pi}} = 0.707$$

$$k(x) := \frac{\int_0^T |f(x)| \, dx}{T}$$

Average absolute integral.

The integral to the right gives the average absolute value for one half of a sine wave.

$$\frac{\int_0^\pi |f(x)| \, dx}{\pi} = 0.637$$

$i := 0..180$ 0 to 180 degrees (pi)

Iteration range to evaluate integrals.

To simulate the phase angle fired SCR controller, the integrals below will be evaluated by varying the lower limit of integration in steps of 1 degree from 0 to 180 degrees. The results are displayed in the graphs.

$$h_i := \sqrt{\frac{\int_{\pi \cdot \frac{i}{180}}^{\pi} f(x)^2 \, dx}{\pi}}$$

RMS evaluation.

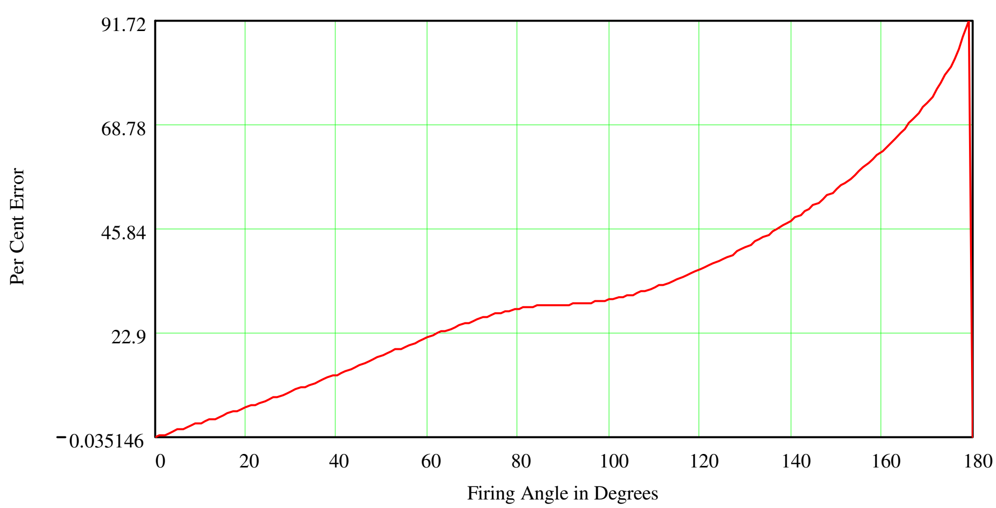
$$k_i := \frac{\int_{\pi \cdot \frac{i}{180}}^{\pi} |f(x)| \, dx}{\pi}$$

Average absolute evaluation.

The graph shows the error produced by one of these transducers when measuring a voltage or current which has been interrupted by a phase angle firing SCR controller. Since the software used will only accept interger values for a given range, I used 0 to 180 to represent 0 to pi radians.

The graph below gives the percent error of an average-abosulte measuring transducer as the firing angle is increased from 0 to pi (180 degrees). (CT5 and VT Type Transducers)

The Y-axis is in percent and the X-axis is in degrees.

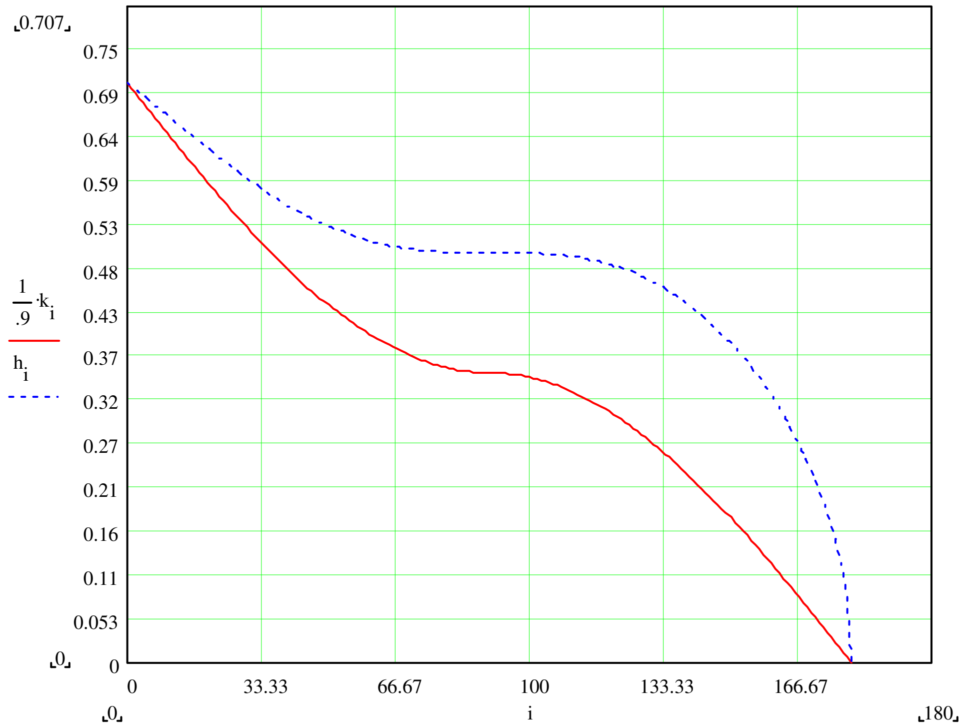


Y-axis is in percent **X-axis i = degrees** (0 to pi radians)

Y_axis shows percent error.

Note that at 180 degrees (pi) the error is again 0%.

In the graph below the solid line is the average absolute value and the dotted line is the true RMS value. The true RMS value is the effective or DC equivalent value. Always use true RMS measuring transducers like the OSI VTR true RMS voltage or CTR true RMS current transducer when measuring chopped or distorted wave shapes.



X-axis is in degrees. Represents chopping angle in degrees.

The bottom line -- RMS reading or average-absolute measuring current and voltage transducers such as the OSI model CT5-005A or VT-240E transducers provide an inexpensive means of measuring sine wave voltage or current but may provide incorrect values when the waveform is distorted.

Use true RMS measuring current and voltage transducers such as the CTR-005D or VTR-004E for measuring distorted current or voltage.