Metrology firmware 4.00.00 (PIC32CXMTC + MCP391x) simplified Test Report

A Leading Provider of Smart, Connected and Secure Embedded Control Solutions

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- Active Power Load Curves
- Reactive Power Load Curves
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Measurement Conditions - Summary

- **Meter Tester: WECO 4150**
- **Sensors: CT VAC 4629-X040**
- **Application Firmware: Demo Meter App v3.XX (SEF)**
- **Metrology Firmware: 4.00.00**
- **Hardware:**
  - PIC32CXMTC-DB + MCP3914 Eval Board
  - Demo board powered by External AC/DC
- **Calibration point: PF = 0.5L, Voltage = 220V, Current = 30A.**

Measurement Conditions – HW Setup

- **The measurements were done using 2 evaluation boards: PIC32CXMTC-DB and MCP3914.**
- **Changes for communicating and supplying the two boards:**
  - Flying wires for communication and supply (using a single 9V DC power supply):

MCP3914		PIC32CXMTC	
CONNECTOR	**SIGNAL**	**CONNECTOR**	**SIGNAL**
J8 – 1	RESET	J14 -14 (TP68)	PD12
J8 – 3	MOSI	J14-10	MCP3910_PD7 (MOSI)
J8 – 5	MISO	J14-8	MCP3910_PD6 (MISO)
J8 – 7	SCK	J14-7	MCP3910_PD5 (SPCK)
J8 – 9	CS0	J14-9	MCP3910_PD8 (NPCS)
J8 – 11	DR	U7 – 25	ITOUT (PD0)
J3 – 5	CLKI	U7 – 30	MCLK (PD4)
J10-	GND	J3-	GND
J10+	9V	J3+	9V
J8 – 9	CS1	EXT CONN	PD9

  - Modifications in MCP3914 evaluation board:
    - U10 removed
    - Jumper J9 changed to select “9V IN”
  - Modifications in PIC32CXMTC-DB board:
    - J15 removed
    - U7 removed

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Measurement Conditions – HW Setup

- **Changes for connecting the metrology inputs to the WECO tester:**
  - Channels CH0, CH1 and CH2 are configured to measure voltage in single-ended mode.
  - Channels CH3, CH4 and CH5 are configured to measure current in differential mode.
  - Voltage and current inputs include anti-aliasing filter with cut-off frequency of 16kHz.

COMPONENT CHANGES			
Component reference	**Old Value**	**New Value/ Action**	**Notes**
MCP3914 board			
C2, C9, C47	0.1u	3.3nF	CH0 (V1), CH1 (V2), CH2 (V3)
R4, R11, R19, R21, R18, R65	1k	Remove	CH0 (V1), CH1 (V2), CH2 (V3)
R3, R22, R16	1k	4.42k	CH0 (V1), CH1 (V2), CH2 (V3)
C51, C52, C53, C54, C55, C56	0.1u	10nF	CH3 (I1), CH4(I2), CH5 (I3)
R69, R71, R75, R77, R81, R83	1k	1.62	CH3 (I1), CH4(I2), CH5 (I3)
PIC32CXMTC board			
D1	Included	Remove	Power supply 12V (TRACO) disabled
R31, R43, R55	4.42k	Remove	
FLYING WIRES BETWEEN BOARDS			
TP25 (MTC) to CH0+ (MCP)	V1. Use a GND wire twisted with the signal wire. Connect the wire to J2 (MCP3914 board).		
TP28 (MTC) to CH1+ (MCP)	V2. Use a GND wire twisted with the signal wire. Connect the wire to J5 (MCP3914 board).		
TP31 (MTC) to CH2+ (MCP)	V3. Use a GND wire twisted with the signal wire. Connect the wire to J20 (MCP3914 board).		
METROLOGY INPUTS SOURCES CONNECTION			
Voltages	Voltage sources connected from WECO tester to PIC32CXMTC board voltage inputs V1, V2, V3, VN (J1, J2 connectors)		
Currents	Current sources connected from CT outputs to MCP3914 board channels CH3 (I1, J22 connector), CH4(I2, J24 connector), CH5 (I3, J26 connector)		

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Measurement Conditions – Metrology configuration

- **Multi-channel configuration:**

STEP 1: AFE SELECTION

SELECT THE AFE PART AND NUMBER. CHECK THE METROLOGY REFERENCE GUIDE

1 x MCP3914. 8 channels and up to 7 powers are allowed.

STEP 2: CHANNEL CONFIGURATION

CONFIGURE EACH CHANNEL AS A VOLTAGE OR CURRENT SOURCE, BY SELECTING

CH ID	0	1	2	3	4	5	6	7	8
I/V SEL	V	V	V	I(CT)	I(CT)	I(CT)	I(CT)	V	I(CT)

STEP 3: POWER NUMBER

SELECT THE NUMBER OF POWERS TO BE COMPUTED. THE NUMBER CAN EXCEED

3		Max. Power Number		7	Power number

STEP 4: POWER MATRIX

FOR EACH POWER, SELECT THE CHANNELS WITH THE CURRENT AND VOLTAGE IN

PW ID	V CH	I CH	Meaning:
0	0	3	Power number 0 is obtained from voltage
1	1	4	Power number 1 is obtained from voltage
2	2	5	...
3	0	0	...
4	0	0	...

- **MCP3914 key settings:**
  - PGA = 1
  - OSR = 128
  - Boost = x1
  - Dithering on, strength max
  - Clock = 8,192MHz

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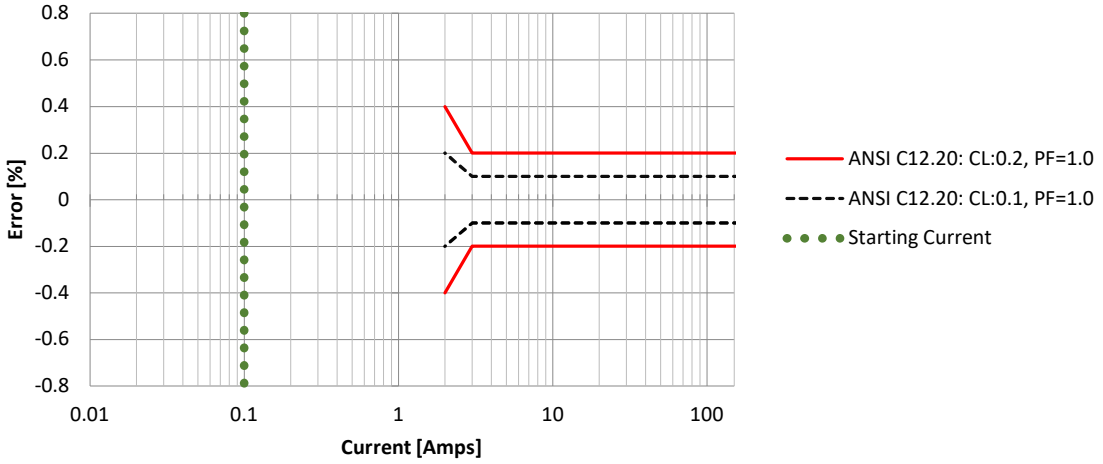
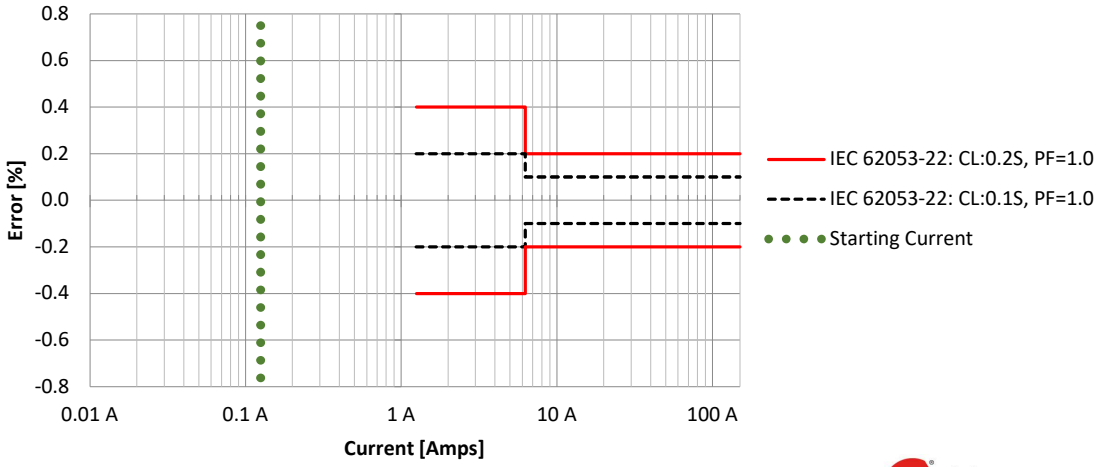
Load curves information

- **This report contains metrology measurements, which may include load curve representations for enhanced understanding.**
- **For the sake of clarity:**
  - The charts may feature data across various power factors.
  - Only the more stringent restrictions (PF=1.0) as outlined in the regulations are displayed.
  - The report typically reflects the limits set by ANSI regulations. However, the results are also compliant with IEC regulations. As an example, the top chart shows the constraints in accordance with ANSI C12:20 (200A, 0.1%/0.2%); and the bottom one considers IEC 62053-22 (1.25-125(150A) Class 0.1S/0.2S).





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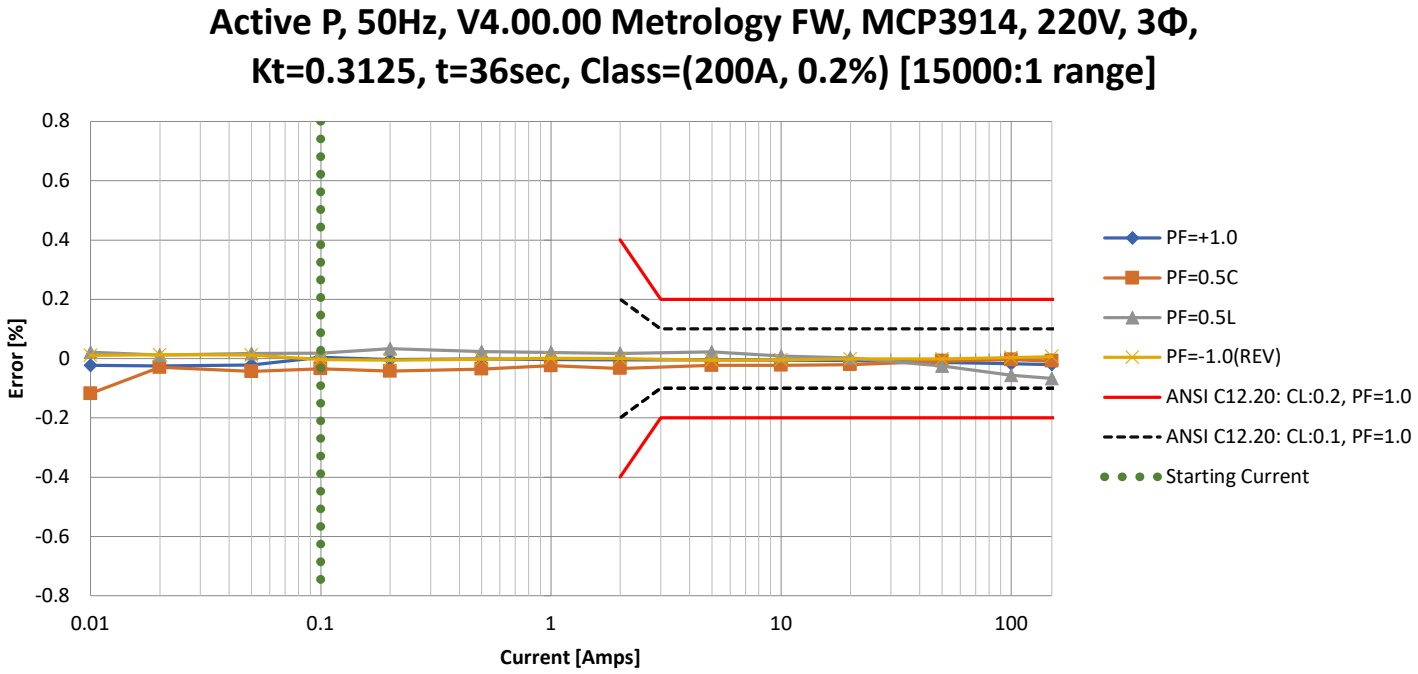
Active Power Load Curves

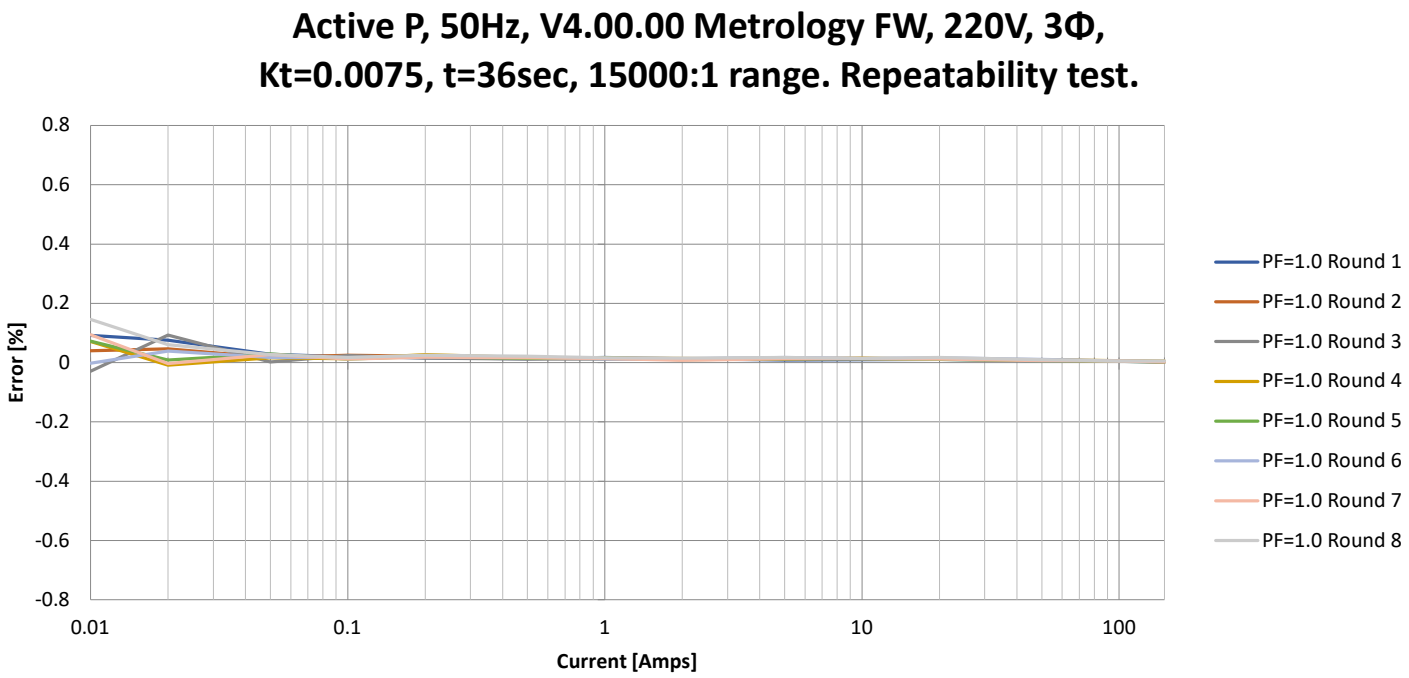
PIC32CXMTC + MCP3914. 50Hz.



Active Power offset disabled (0h/cycle).
Meter scaled to 260A. Integration period: 1 second.

Active Power Load Curves

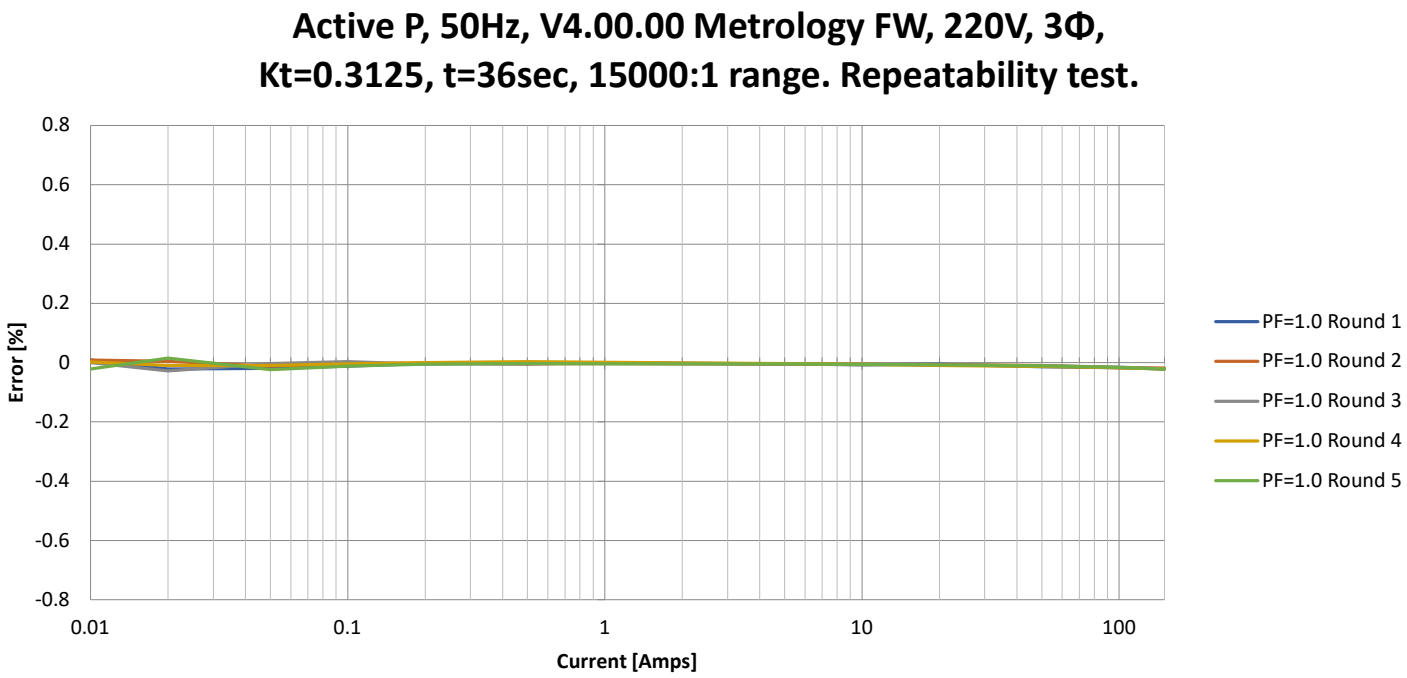
PIC32CXMTC + MCP3914. 50Hz. Repeatability.



Active Power offset disabled (0Wh/cycle).
Meter scaled to 260A. Integration period: 1 second.

Active Power Load Curves

PIC32CXMTC + MCP3914. 50Hz. Repeatability.

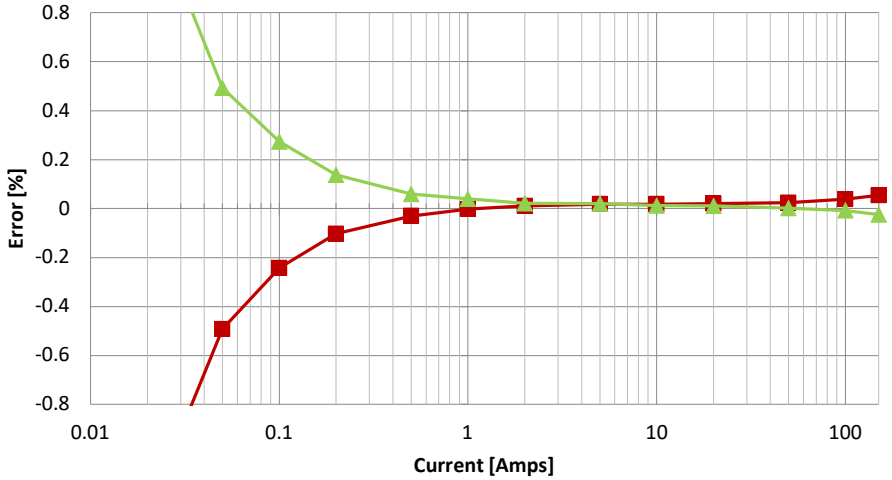


Active Power offset disabled (0Wh/cycle).
Meter scaled to 260A. Integration period: 1 second.

Reactive Power Load Curves

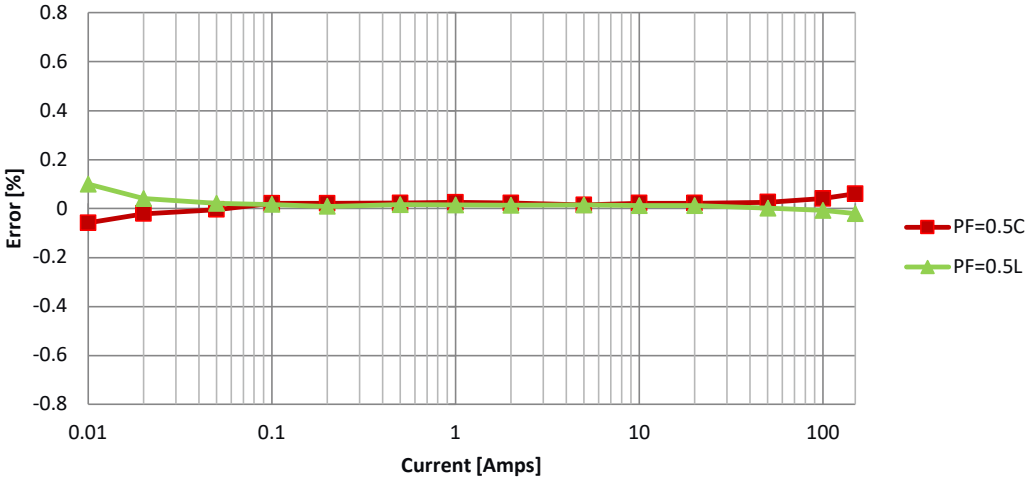
PIC32CXMTC + MCP3914. 50Hz.

Reactive Q, 50Hz, V4.00.00 Metrology FW, 220V, 3Φ, Kt=0.3125, t=36sec, Class=(200A, 0.2%) [15000:1 range]



Reactive Power offset disabled.
Meter scaled to 260A. Integration period: 1 second.

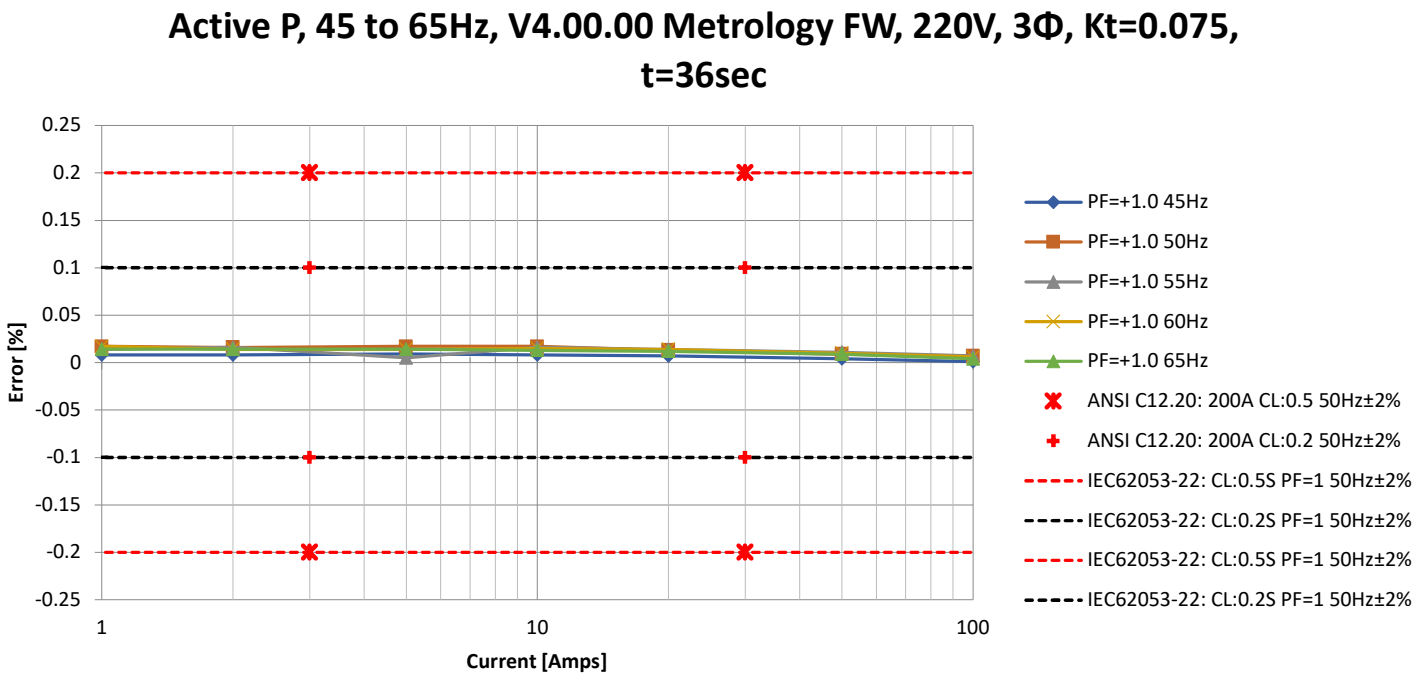
Reactive Q, 50Hz, V4.00.00 Metrology FW, 220V, 3Φ, Kt=0.3125, t=36sec, Class=(200A, 0.2%) [15000:1 range]



Reactive Power offset enabled (0.140363Varh/cycle).
Meter scaled to 260A. Integration period: 1 second.

Frequency Influence Test

PIC32CXMTC + MCP3914

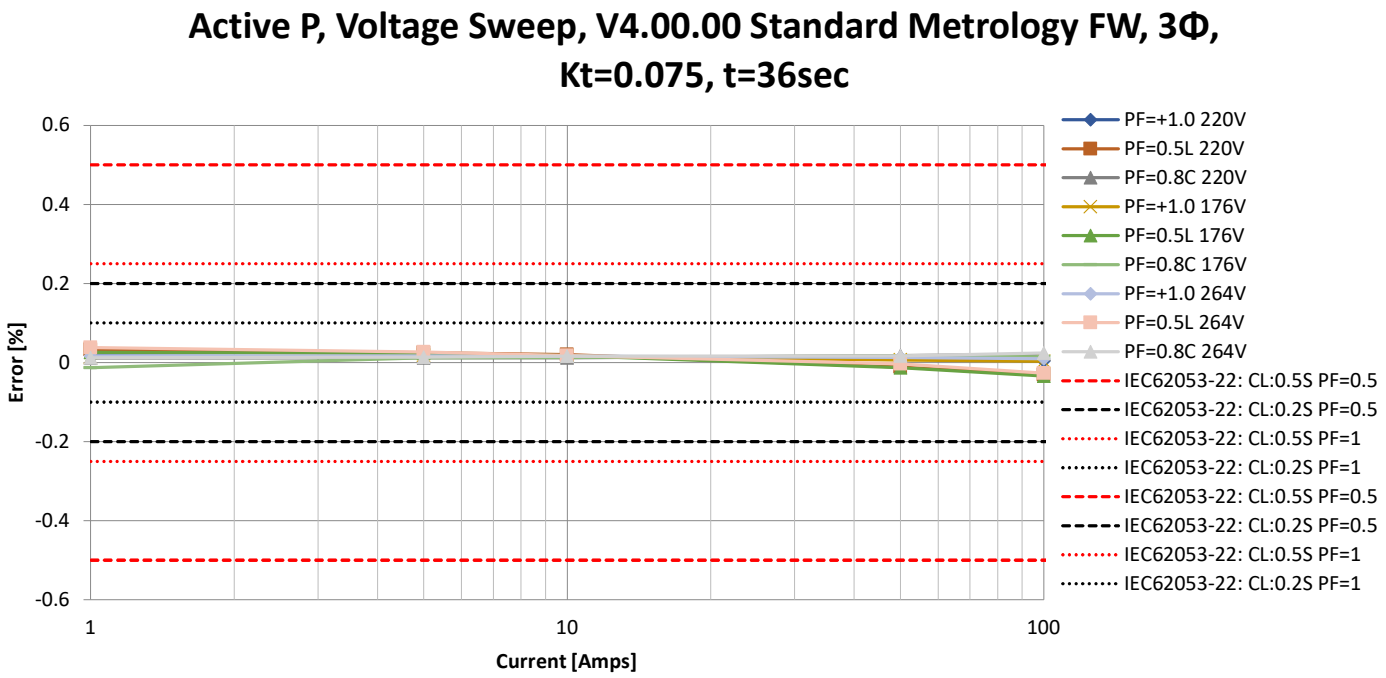


Power offset disabled (0Wh/cycle).
Meter scaled to 260A. Integration period: 1 second.

Conclusion: The system frequency will not influent the metrology performance.
Note: The performance of the CT could be affected by the frequency.

Voltage Influence Test

PIC32CXMTC + MCP3914. 50Hz



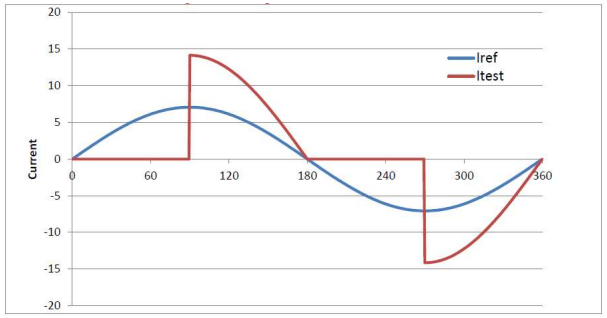
Voltage	Current	PF = 1.0	PF = 0.5L	PF = 0.8C
176	1	0.013	0.026	-0.013
220	1	0.018	0.033	0.011
264	1	0.017	0.038	0.012
176	5	0.018	0.024	0.012
220	5	0.013	0.025	0.012
264	5	0.017	0.027	0.014
176	10	0.016	0.018	0.013
220	10	0.016	0.02	0.012
264	10	0.016	0.018	0.016
176	50	0.007	-0.013	0.017
220	50	0.011	-0.011	0.018
264	50	0.013	-0.003	0.017
176	100	0.003	-0.034	0.015
220	100	0.004	-0.031	0.021
264	100	0.01	-0.027	0.024

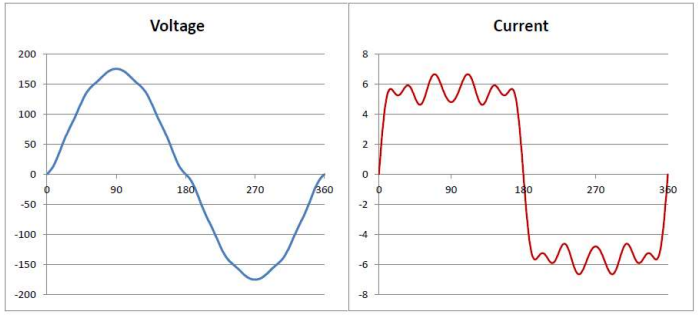
Power offset disabled (0Wh/cycle).
Meter scaled to 260A. Integration period: 1 second.

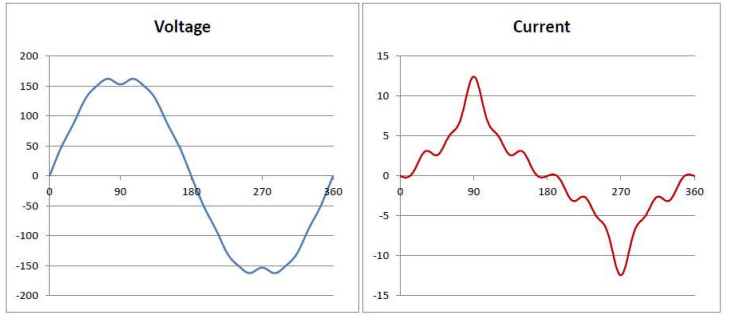
Conclusion: The system voltage will not influent the metrology performance.

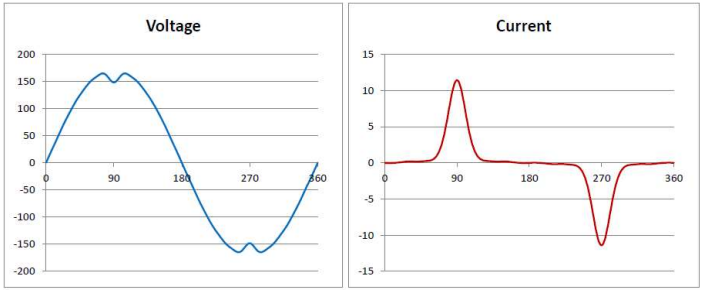
Harmonic performance

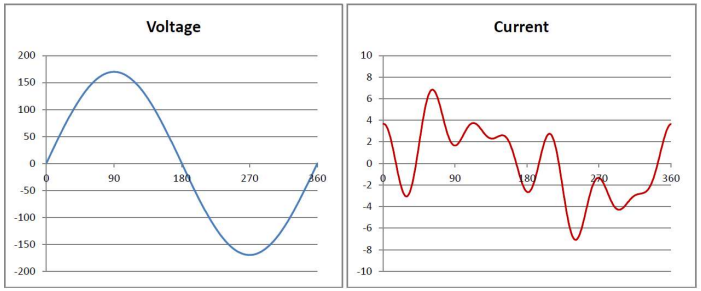
ANSI Harmonics Definitions. Waveforms summary

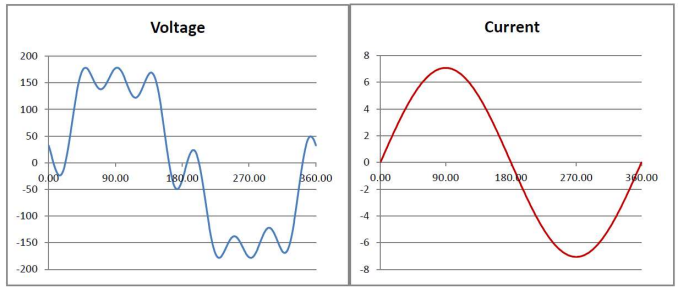








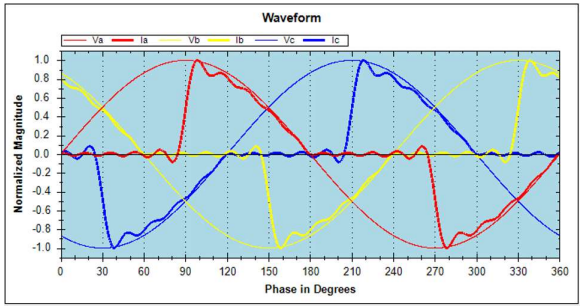




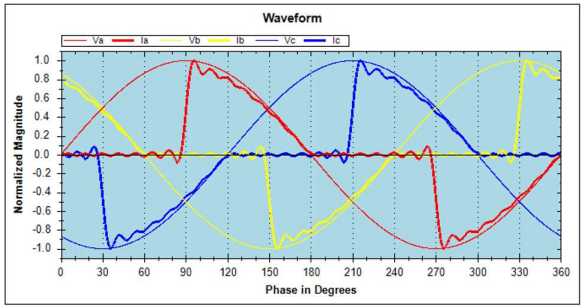
Harmonic performance

ANSI Harmonics Definitions. Waveforms detail

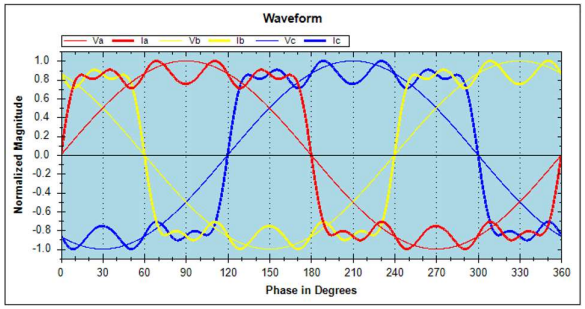
Phase Controlled – 90 Degree



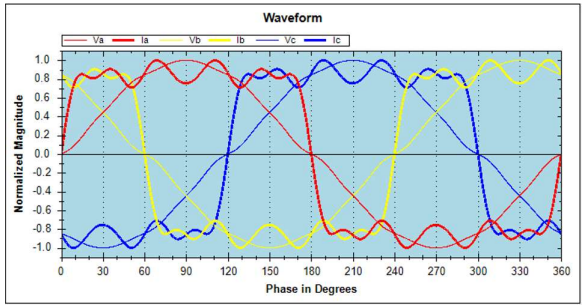
ANSI C12.20-2015 5.5.6.1 – Condition 2



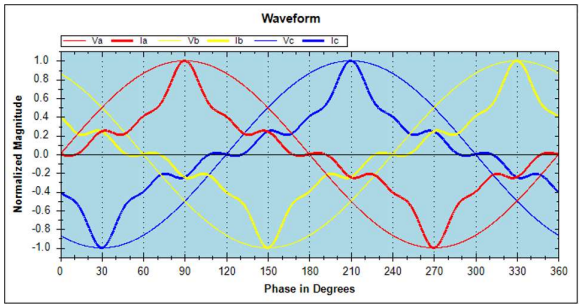
ANSI C12.20-2015 5.5.6.2 – Condition 2



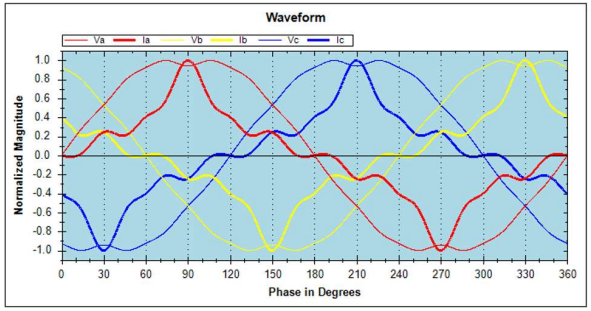
ANSI C12.20-2015 5.5.6.2 – Condition 3



ANSI C12.20-2015 5.5.6.3 – Condition 2



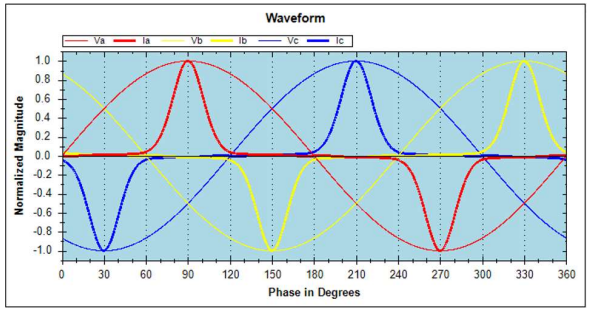
ANSI C12.20-2015 5.5.6.3 – Condition 3



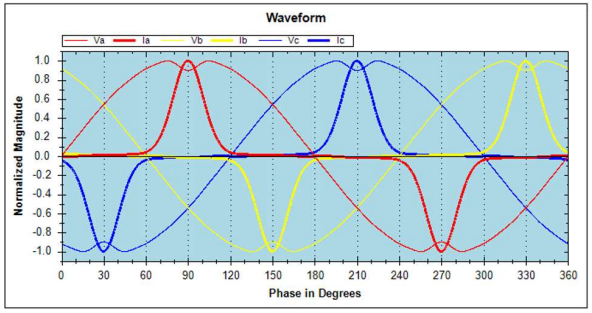
Harmonic performance

ANSI Harmonics Definitions. Waveforms detail

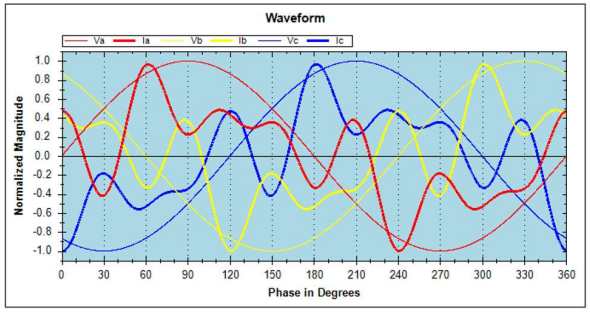
ANSI C12.20-2015 5.5.6.4 – Condition 2



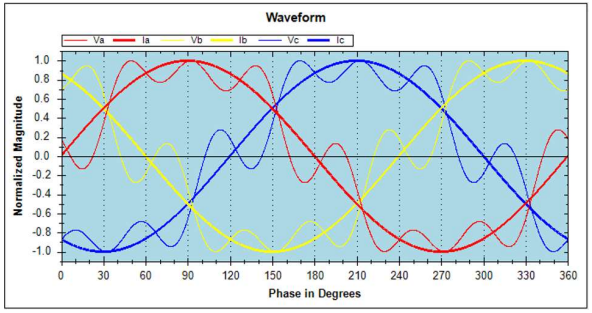
ANSI C12.20-2015 5.5.6.4 – Condition 3



ANSI C12.20-2015 5.5.6.5 – Condition 2



ANSI C12.20-2015 5.5.6.6 – Condition 2



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Harmonic performance

PIC32CXMTC + MCP3914. Fundamental Frequency = 50Hz.

Passed

Nameplate
Lookup Code:
Form No.: 16 S ? Kh: 0.075 Volts: 220 Amps: 30

Test Sequence: ANSI_Harmonic_Tests

Common Result Data

Test Code | Tester ID

	Step	Element	Test	As Found	As Left	Accuracy Status	Test Duration (Seconds)	Volts	Amps	Phase Angle	Optics	kh	Service	Energy Mode	Freq	Desired Accuracy	Harmonic Configuration
▸	1	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	2	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	PhaseControlled - 90 Degree
	3	S	FL	0.012	0.012	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	4	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.1 - Condition 2
	5	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	6	S	FL	0.012	0.012	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.2 - Condition 2
	7	S	FL	0.014	0.014	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.2 - Condition 3
	8	S	FL	0.013	0.013	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	9	S	FL	0.014	0.014	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.3 - Condition 2
	10	S	FL	0.015	0.015	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.3 - Condition 3
	11	S	FL	0.012	0.012	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	12	S	FL	0.013	0.013	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.4 - Condition 2
	13	S	FL	0.017	0.017	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.4 - Condition 3
	14	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	15	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.5 - Condition 2
	16	S	FL	0.011	0.011	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	Default (Sine)
	17	S	FL	0.012	0.012	Pass	36	220	30.0	0	Lower IR	0.075	3P Wye ABC	Watt Hrs	50.000	100	ANSI C12.20-2015 5.5.6.6 - Condition 2

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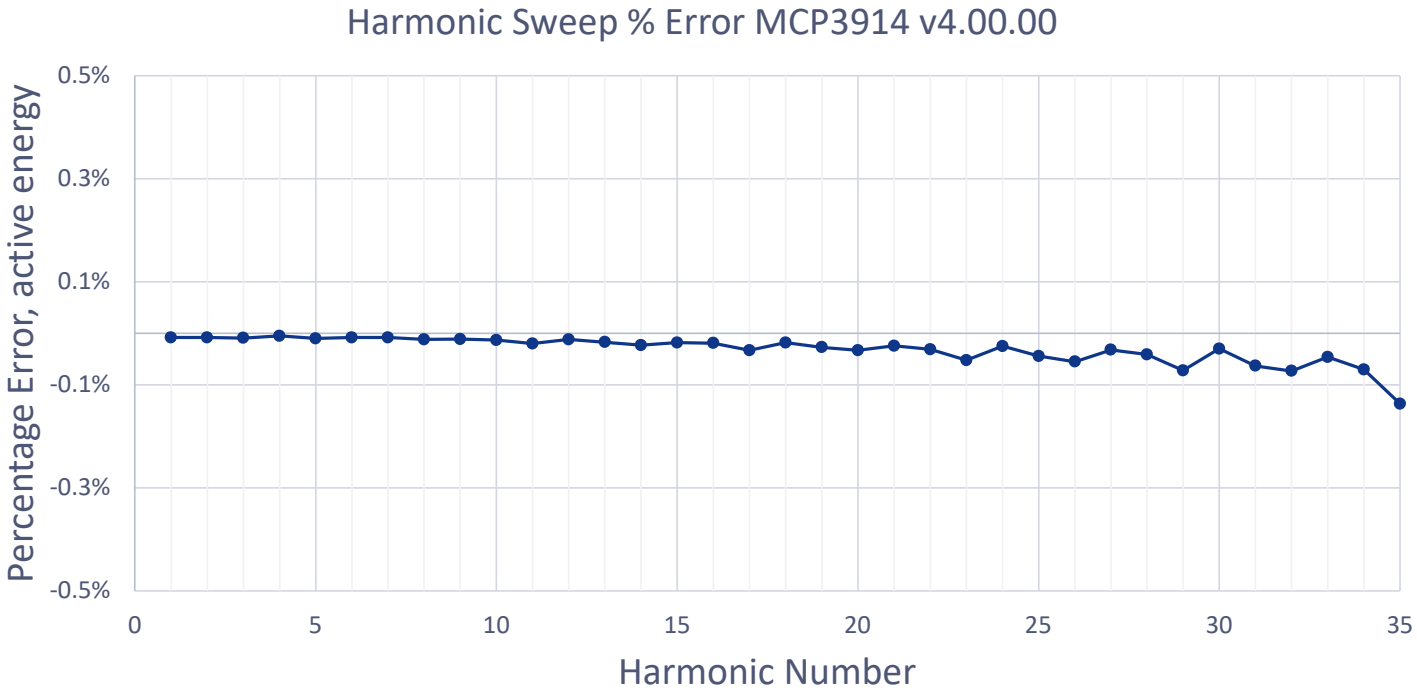
Single Harmonic Sweep

PIC32CXMTC + MCP3914. Fundamental Frequency = 50Hz.



- I_fundamental = 100%
- V_fundamental = 100%

- I_harmonic = 40%
- V_harmonic = 25%

- $\frac{\mathbf{P\_harmonic}}{\mathbf{P\_fundamental}} = \mathbf{10}\%$

Test conditions:
WECO 4150X, 30A, 220V
f_fundamental = 50Hz
3ΘNetwork Meter

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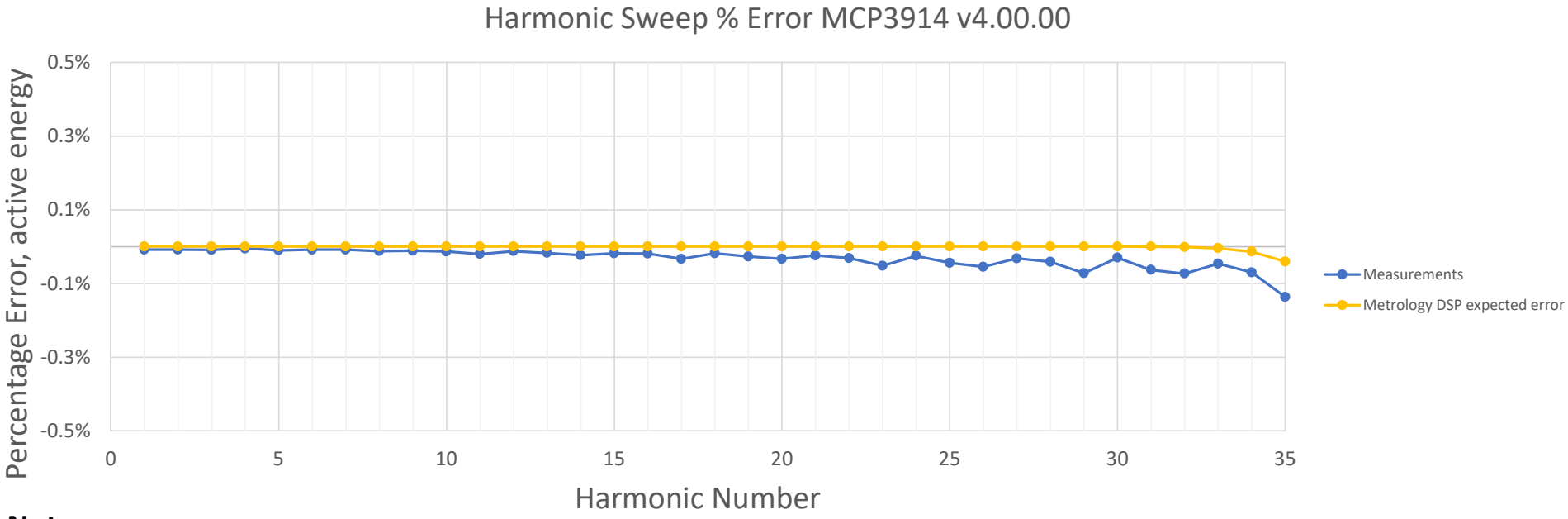
Single Harmonic Sweep

PIC32CXMTC + MCP3914. Fundamental Frequency = 50Hz.



Note:

- The anti-aliasing filter, having a cut-off frequency of approx. 16kHz, is affecting the accuracy of the high-order harmonics measurements.
- This is due to the attenuation of the RC filter in the measurement bandwidth.
- For applications where high accuracy in the high-order harmonics measurements is needed it could be useful to modify the cut-off frequency of the anti-aliasing filter.