

## 71M6513 Harmonic Performance

Teridian Semiconductor Corporation has developed a custom compute engine firmware to support the energy metering in the presence of harmonics. The compute engine firmware was developed to provide the following capabilities:

1. Measurement of Wh information with harmonics and a separate Wh measurement register for fundamental component. These two sets of registers are available simultaneously for meter harmonic analysis.
  - The existing CE outputs, WSUM\_X (0x42), W0SUM\_X(0x43), WSUM1\_X(0x44), and WSUM2\_X(0x45) will be broadband Wh measurement registers
  - Four new output registers, WSUM\_F(0x5e), W0SUM\_F(0x5b), W1SUM\_F(0x5c) and W2SUM\_F(0x5d), will be fundamental Wh output only.
2. VSQh, ISQh, and VARh measurement will be selectable between either broadband or fundamental only.
  - When NB\_SELECT  $\geq 0$ , VRMS, IRMS, and VARh will be measurements of fundamental component only. That is the output registers V0SQH\_X(0x4e), V1SQH\_X(0x4f), V2SQH\_X(0x50), I0SQH\_X(0x4a), I1SQH\_X(0x4b), I2SQH\_X(0x4c), INSQH\_X(0x4d), VARSUM\_X(0x46), VAR0SUM\_X(0x47), VAR1SUM\_X(0x48), VAR2SUM\_X(0x49) all contain fundamental measurements only.
  - When NB\_SELECT  $< 0$ , VRMS, IRMS, and VARh will be broadband (inclusive harmonics). That is the output registers V0SQH\_X(0x4e), V1SQH\_X(0x4f), V2SQH\_X(0x50), I0SQH\_X(0x4a), I1SQH\_X(0x4b), I2SQH\_X(0x4c), INSQH\_X(0x4d), VARSUM\_X(0x46), VAR0SUM\_X(0x47), VAR1SUM\_X(0x48), VAR2SUM\_X(0x49) all contain fundamental and harmonic components in their measurements.
3. Only 3 phase 4 wire wye ( $V_a * I_a + V_b * I_b + V_c * I_c$ ) or 3phase 3 wire ( $V_a * I_a + V_b * I_b$ ) configurations are supported.

4. Compute engine will support only one pulse output, the WPULSE output.
  - a. This pulse output can be configurable for various pulse outputs thru the EXT\_PULSE register. Please refer to the data sheet or the 71M6513 demo board user manuals for further details.
  - b. The watt-hr pulse generator, when in internal mode, will output broadband Wh.
  - c. The maximum pulse rate is 1260Hz.
5. The neutral current measurement function is supported.
6. The voltage to voltage phase angle measurement is supported.
7. The line zero crossing detection for RTC adjustment using MainEdgeCount register is supported.
8. The SAG detection for early power fail warning for each phase voltage.

Harmonic performance is demonstrated in the following pages.

## Upgrading Firmware

Following are the files that can be used for achieving the above CE specifications.

1. CE13B10Harmonics.ce
2. CE13B10Harmonics.dat
3. CE13B10Harmonics\_ce.c
4. CE13B10Harmonics\_dat.c

How to use these files

One can easily upgrade the existing CE code to the new version by the following techniques

1. Using CE\_merge technique. and upgrade the current hexadecimal file. That is the existing CE files (\*.ce and \*.dat) files will be updated to the new hex file without modifying the existing hex file.
2. If one is in development stage where one can include the files (\*ce.c & \*dat.c) for building project in the compiler environment.

**Caution:** By upgrading this files to the new firmware one should be cautious about

- a. This CE firmware does not support Var pulse output.
- b. The pulse rate is limited to maximum of 1260Hz.
- c. The metering connections are limited to 3 phase 3 wire and 3 phase 4 Wire Wye..

## The New CE Performance for Harmonics

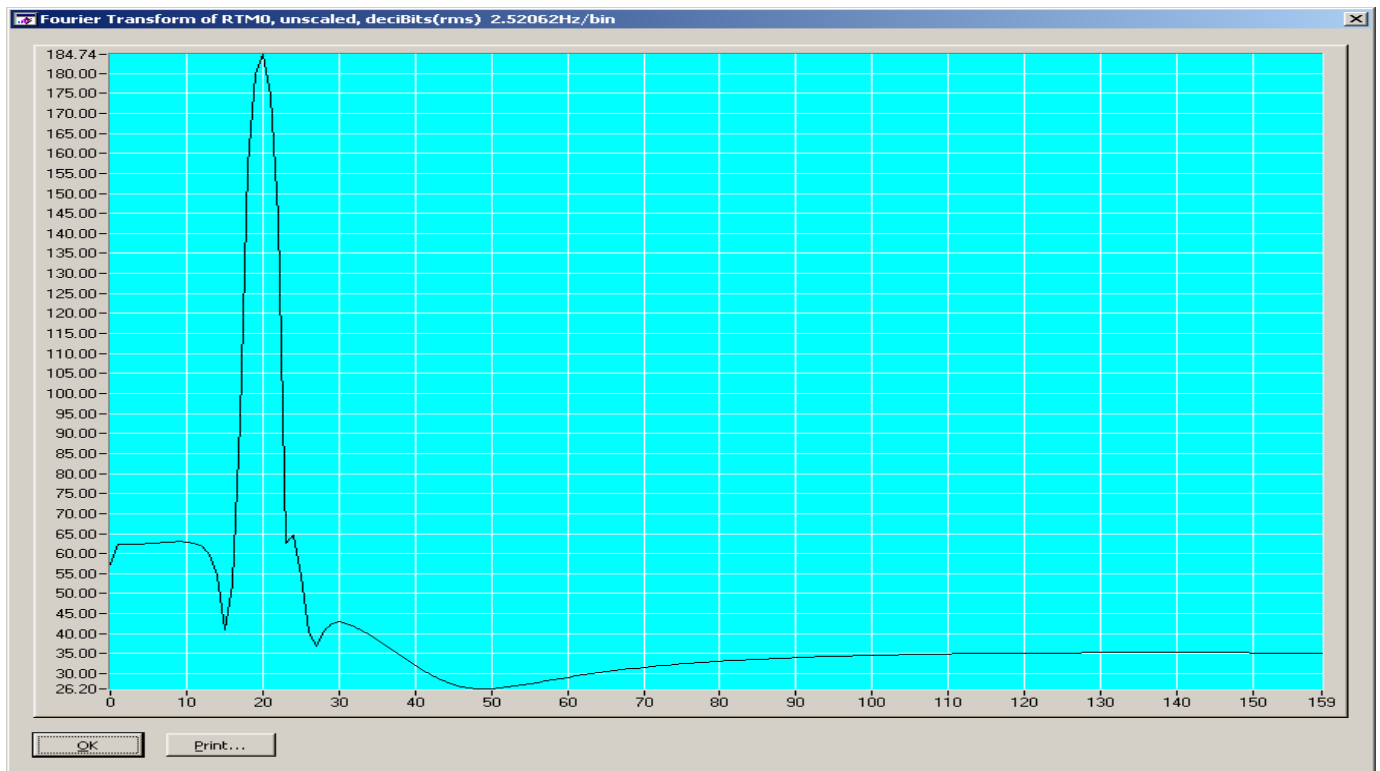
As per the IEC 62052/ IEC 62053 and ANSI C12.20 metering standards the Voltage applied to the meter was fed with 10% fundamental harmonic component along with 40% of fundamental current fed to the meter that is upgraded with the CE firmware to support harmonics. The following are the tools used for verifying the performance.

1. Fluke 6100A for phantom load with harmonic generation capability.
2. Fluke pulse input for capturing the pulse output from meter under test.

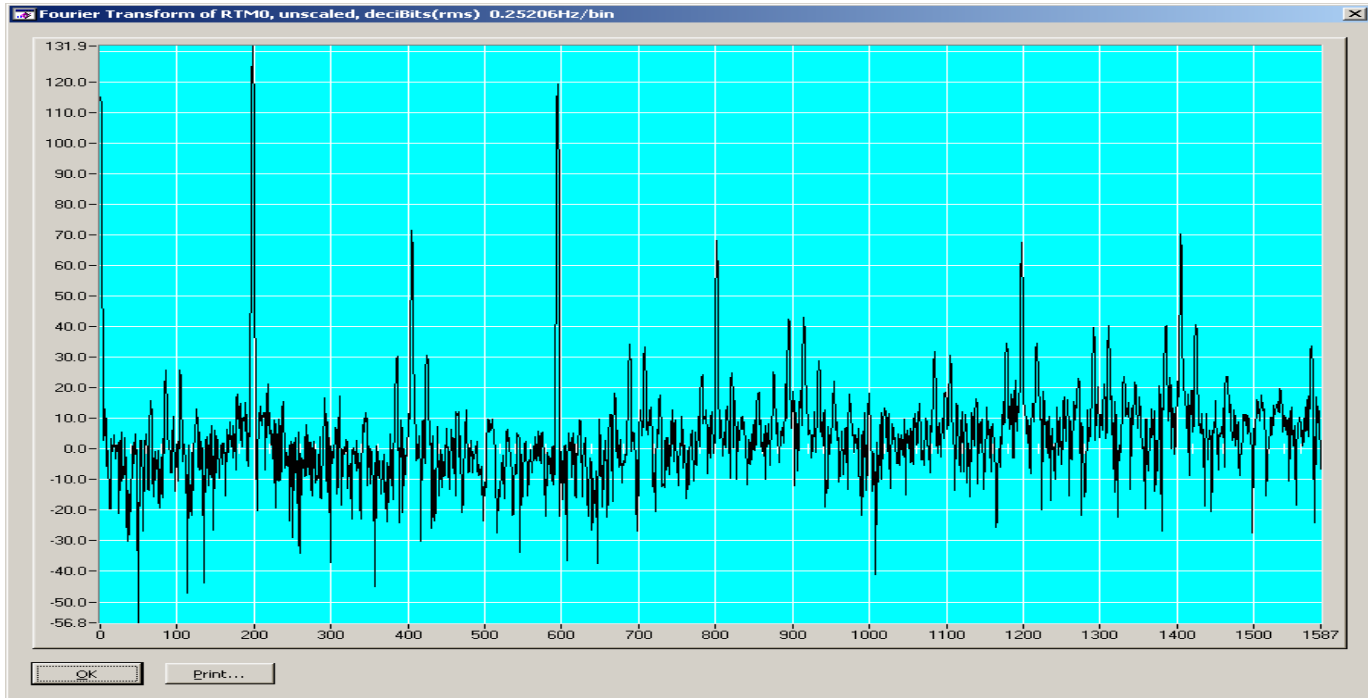
Following is the capture of the FFT of the input signals present at the output of ADC that were fed to the Compute Engine for processing.

## APPLICATION NOTE

ADC current Input at 10 Amperes without any harmonics. Please note the Y-axis is in deci-bits that is for the following spectrum the peak values is  $(2^{18.474})$  and the peak on x-axis is occurring at  $(20 \times 2.5206) \sim 50\text{Hz}$ .

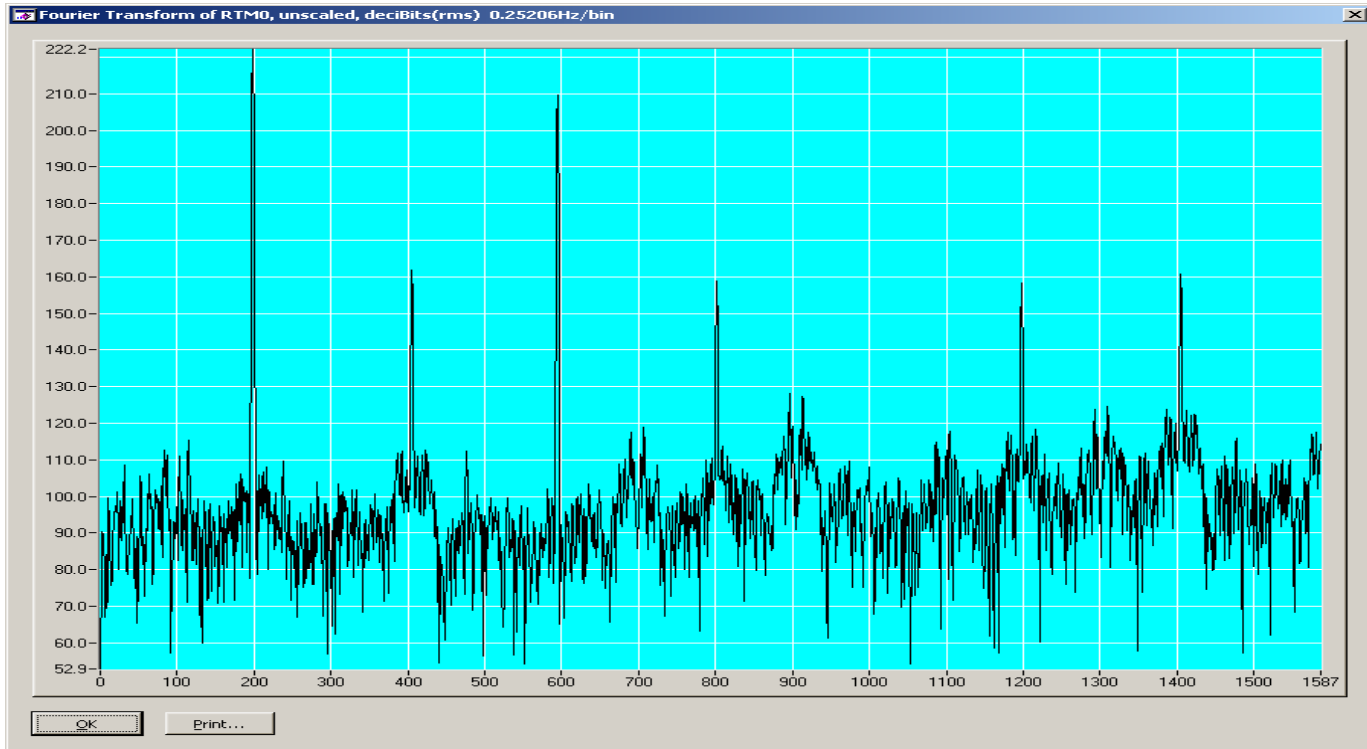


ADC current Input with 40% fundamental at the 3rd harmonic at 10A. The X-axis is in  $X\text{value} * 0.25206$ .



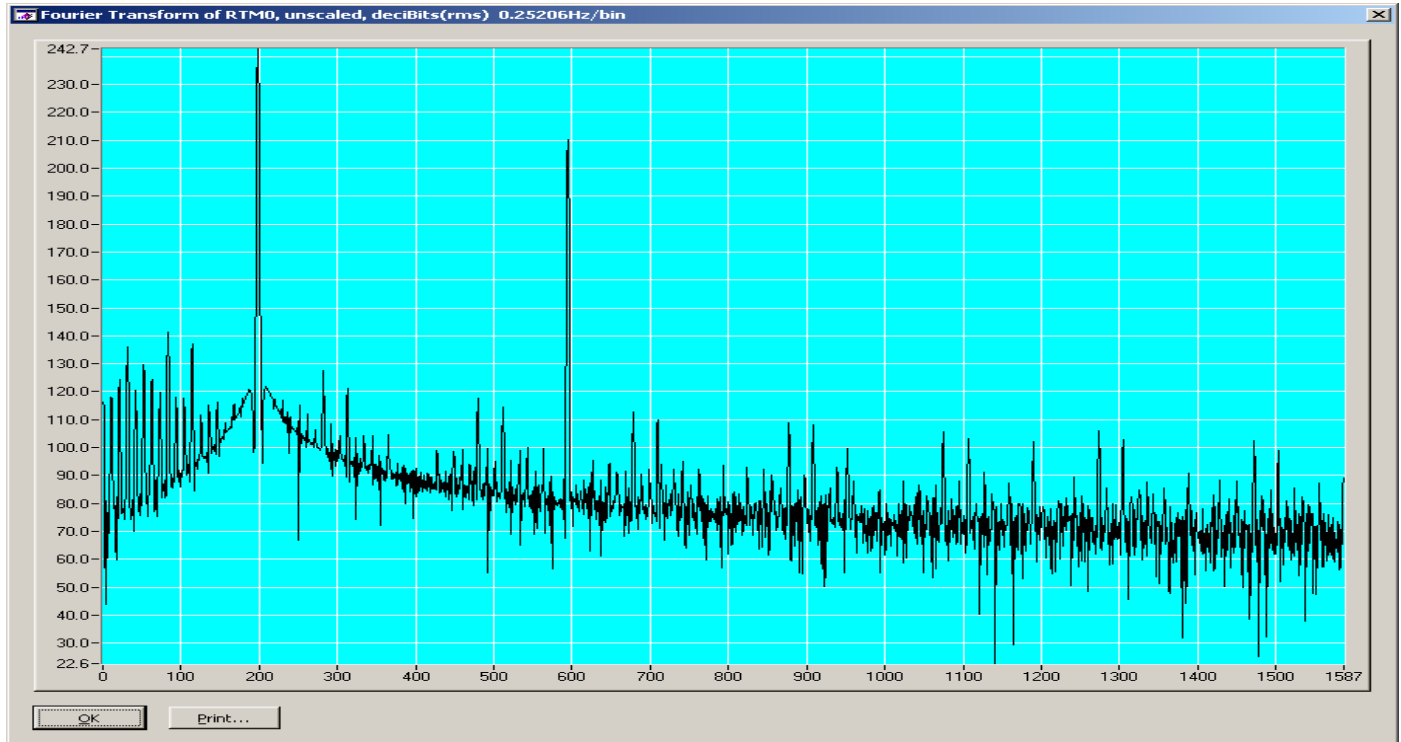
## APPLICATION NOTE

Processed current signal for the 3<sup>rd</sup> harmonic input for computing ISQH and WSUM registers is pictured below.



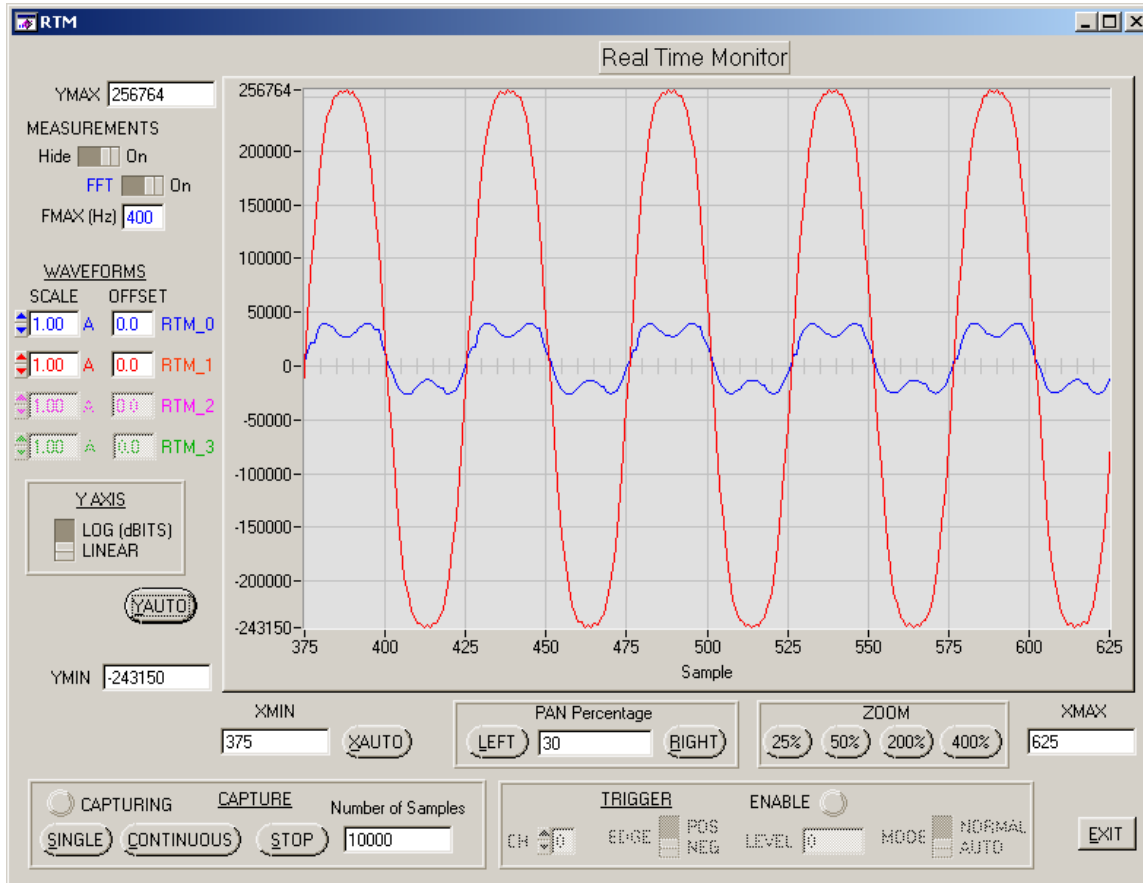
**APPLICATION NOTE**

The screen capture below shows the processed Voltage input with the 3<sup>rd</sup> harmonic for WH/VSQH computation.



## APPLICATION NOTE

The screen capture below shows the voltage and current in real time present at the ADC inputs.



Note that Orange (larger signal) is voltage and Blue is the current.



## APPLICATION NOTE

The data that follows shows Irms for fundamental and with harmonics. The fundamental current applied is 10A with 40% Nth harmonic component resulting 10.77033A.

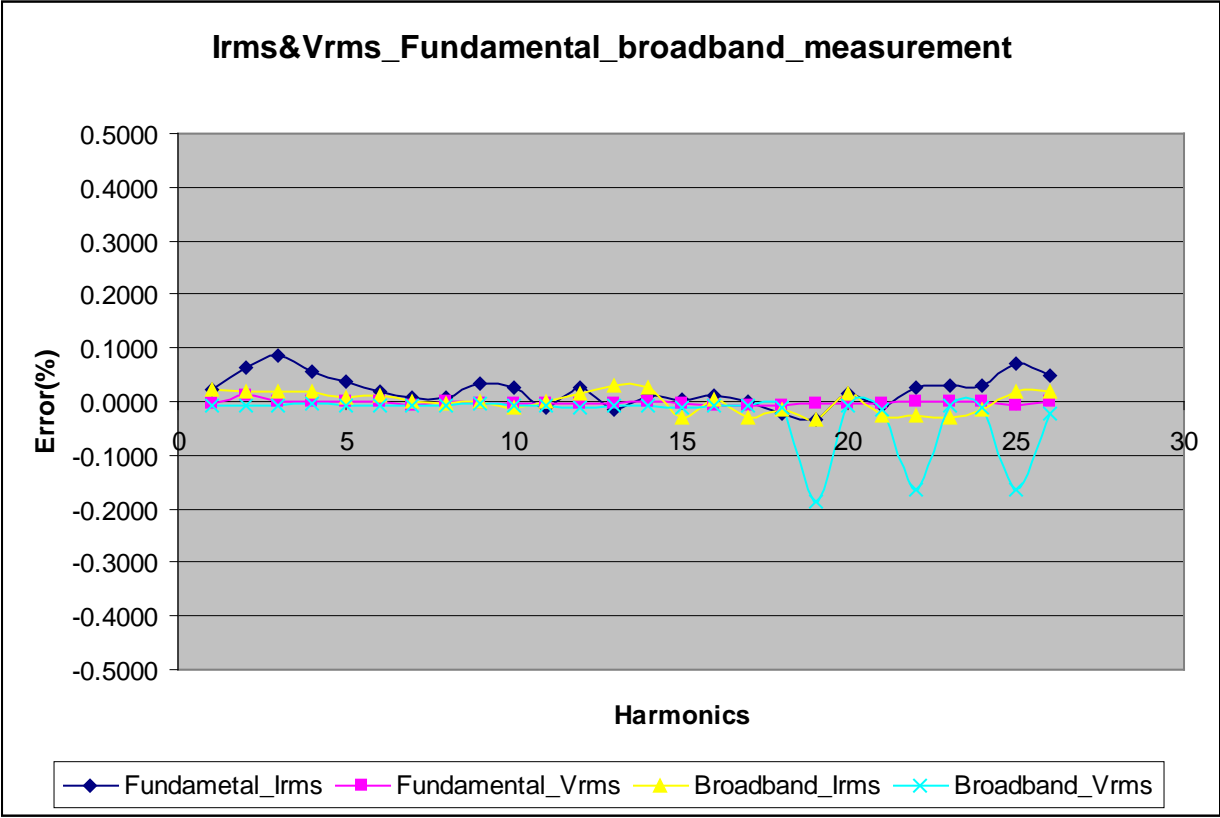
Voltage: 240V Current: 10A, 10% Un, 40% In, Frequency:50Hz

Harmonic	NB_SELECT =1		NB_SELECT <0		NB_SELECT =1		NB_SELECT <0	
	Irms_NB	%Error	Irsm_WB	%Error	Vrms_NB	%Error	Vrms_WB	%Error
1	10.0022	0.0221	10.0021	0.0210	239.9872	-0.0053	239.9844	-0.0065
2	10.0063	0.0629	10.7722	0.0171	240.0226	0.0094	241.1759	-0.0087
3	10.0084	0.0841	10.7725	0.0200	240.0015	0.0006	241.1825	-0.0060
4	10.0057	0.0575	10.7723	0.0181	239.9990	-0.0004	241.1853	-0.0048
5	10.0037	0.0369	10.7712	0.0081	240.0021	0.0009	241.1763	-0.0086
6	10.0019	0.0190	10.7714	0.0100	239.9976	-0.0010	241.1756	-0.0089
7	10.0007	0.0067	10.7705	0.0014	239.9806	-0.0081	241.1745	-0.0093
8	10.0007	0.0067	10.7701	-0.0024	240.0010	0.0004	241.1764	-0.0086
9	10.0032	0.0323	10.7704	0.0006	239.9934	-0.0028	241.1885	-0.0035
10	10.0027	0.0268	10.7690	-0.0124	239.9901	-0.0041	241.1819	-0.0063
11	9.9990	-0.0098	10.7704	0.0006	239.9870	-0.0054	241.1779	-0.0079
12	10.0026	0.0261	10.7720	0.0160	239.9898	-0.0042	241.1696	-0.0114
13	9.9983	-0.0166	10.7734	0.0281	239.9912	-0.0037	241.1831	-0.0058
14	10.0011	0.0114	10.7730	0.0247	240.0016	0.0007	241.1750	-0.0091
15	10.0004	0.0042	10.7670	-0.0312	239.9876	-0.0052	241.1726	-0.0101
16	10.0010	0.0103	10.7707	0.0031	239.9785	-0.0089	241.1746	-0.0093
17	10.0000	-0.0002	10.7670	-0.0312	239.9805	-0.0081	241.1763	-0.0086
18	9.9978	-0.0222	10.7688	-0.0140	239.9781	-0.0091	241.1703	-0.0111
19	9.9968	-0.0325	10.7668	-0.0328	239.9902	-0.0041	240.7483	-0.1860
20	10.0014	0.0144	10.7718	0.0136	239.9878	-0.0051	241.1764	-0.0086
21	9.9991	-0.0091	10.7677	-0.0245	239.9948	-0.0022	241.1618	-0.0146
22	10.0025	0.0248	10.7675	-0.0261	239.9981	-0.0008	240.8016	-0.1639
23	10.0030	0.0302	10.7671	-0.0298	240.0003	0.0001	241.1745	-0.0093
24	10.0030	0.0302	10.7689	-0.0132	240.0018	0.0008	241.1705	-0.0110
25	10.0072	0.0720	10.7723	0.0181	239.9830	-0.0071	240.8016	-0.1639
26	10.0049	0.0488	10.7722	0.0176	239.9975	-0.0010	241.1442	-0.0219

**Note:**

- With NB\_SELECT = 1 fundamental component is the only measured value for Irms and Vrms outputs.
- With NB\_SELECT < 0 fundamental + harmonic components are all included for Irms and Vrms outputs

**APPLICATION NOTE**



**Watt-Hour Performance:**

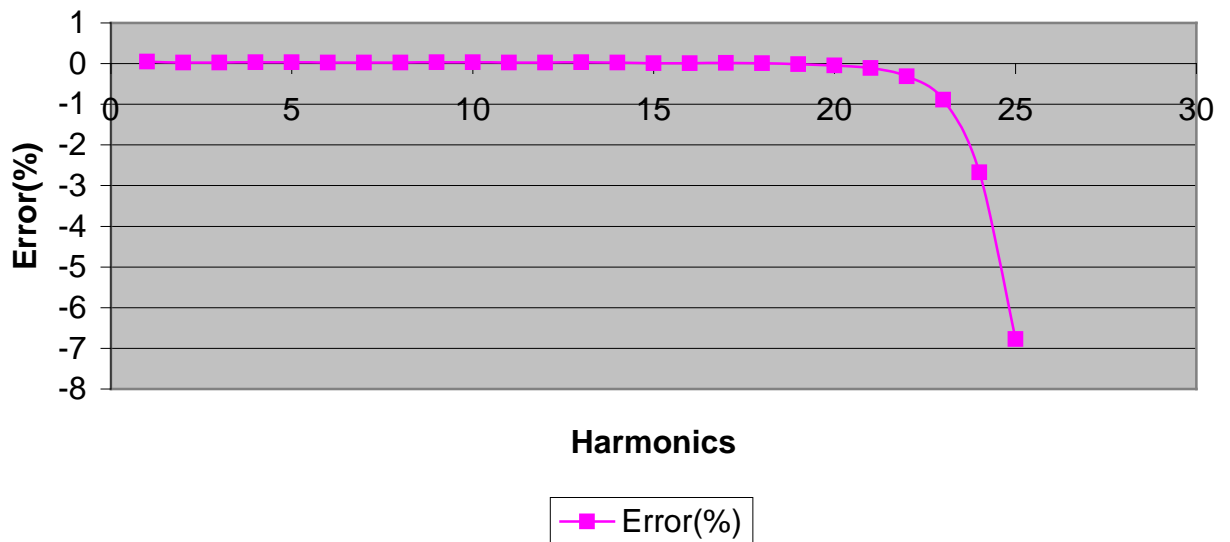
This register data for broadband watt-hour information is available simultaneously along with fundamental watt-hour information. The pulse output from the meter is used for testing. Alternatively the accumulation registers can also be used for testing the accuracy. Broadband and fundamental watt-hour accuracy test results will be displayed on the pages that follow.

**Broadband Watt-Hour Test Results**

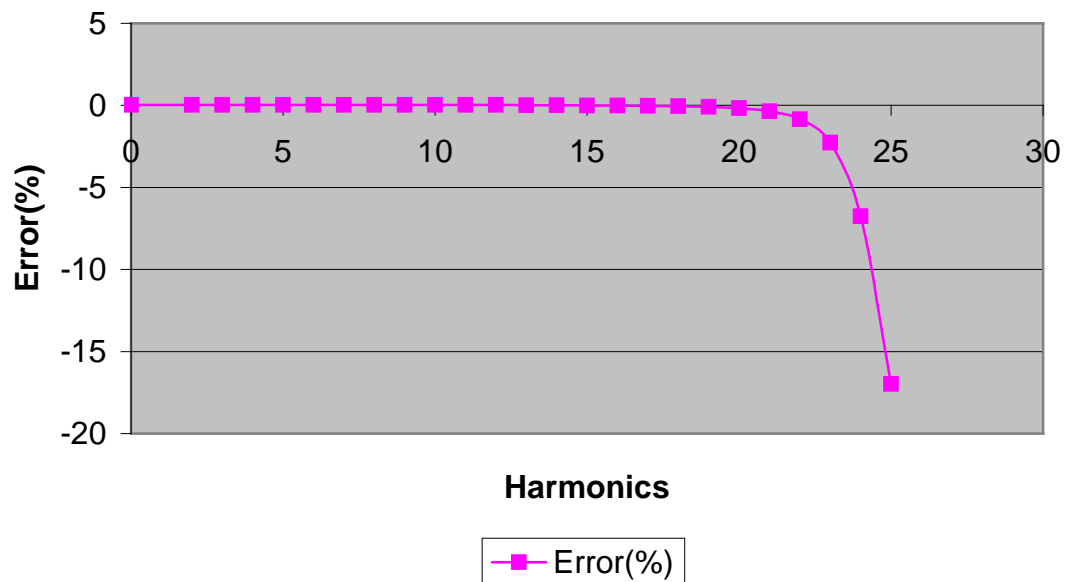
Broadband WHr Test  
Fundamental Voltage: 240V Current: 10A Frequency: 50Hz

VHarm%	IHarm%	NHarm	Error(%)
10	40	1	0.048
10	40	2	0.027
10	40	3	0.024
10	40	4	0.036
10	40	5	0.033
10	40	6	0.027
10	40	7	0.024
10	40	8	0.027
10	40	9	0.036
10	40	10	0.033
10	40	11	0.027
10	40	12	0.021
10	40	13	0.03
10	40	14	0.024
10	40	15	0.012
10	40	16	0.012
10	40	17	0.018
10	40	18	0.006
10	40	19	-0.015
10	40	20	-0.044
10	40	21	-0.113
10	40	22	-0.315
10	40	23	-0.892
10	40	24	-2.676
10	40	25	-6.776

**Broadband Watthour (40%In10%Un) Performance**



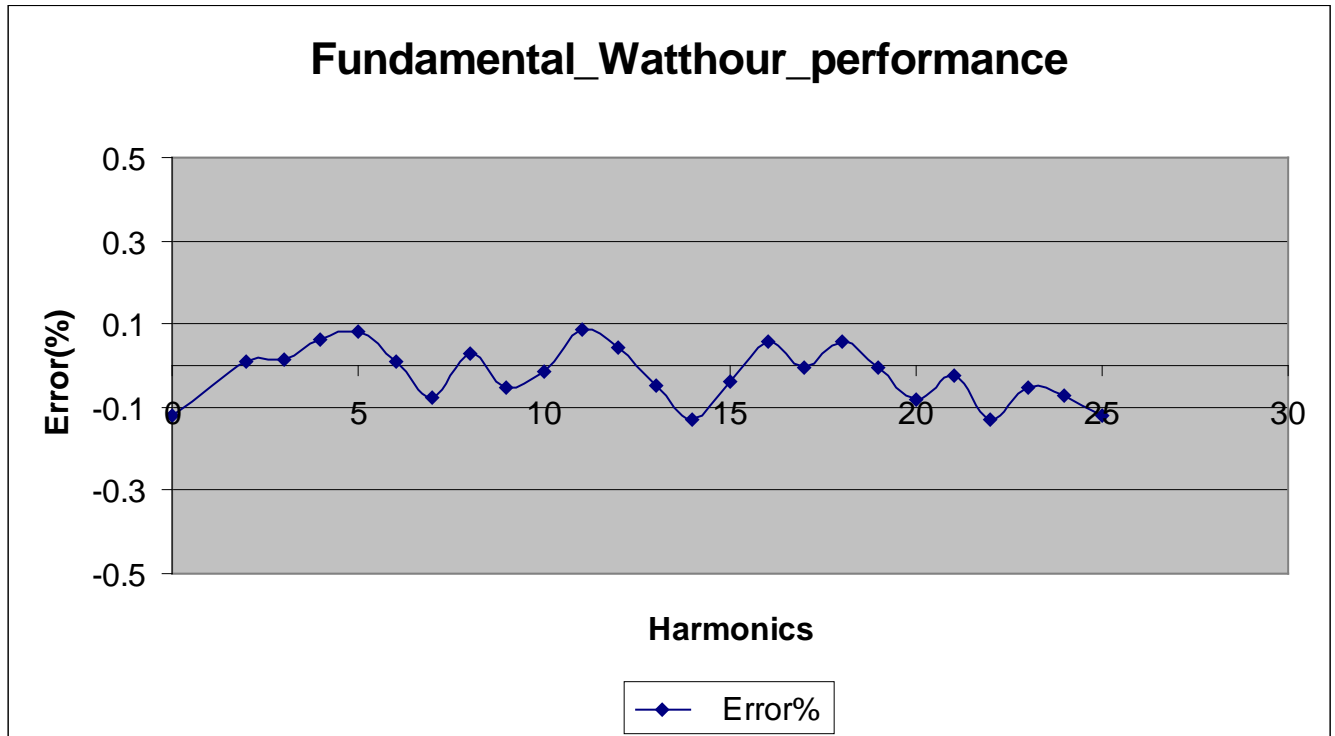
**Broadband\_Watthour (50%In20%Un) Performance**



**Fundamental Watt-hour Test Results**

Fundamental WHr Test  
Fundamental Voltage Voltage with harmonic: 241.37V, Current: 10.773A

VHarm%	IHarm%	NHarm	Error%
0	0	0	-0.12
10	40	2	0.009
10	40	3	0.015
10	40	4	0.064
10	40	5	0.084
10	40	6	0.009
10	40	7	-0.076
10	40	8	0.031
10	40	9	-0.054
10	40	10	-0.013
10	40	11	0.086
10	40	12	0.045
10	40	13	-0.046
10	40	14	-0.128
10	40	15	-0.04
10	40	16	0.059
10	40	17	-0.007
10	40	18	0.059
10	40	19	-0.005
10	40	20	-0.082
10	40	21	-0.024
10	40	22	-0.131
10	40	23	-0.051
10	40	24	-0.073
10	40	25	-0.12



The capability of the 71M6513 with the new CE code for broadband and fundamental watt-hour measurement has been demonstrated. Requests for further details can be sent to: [meter.support@teridian.com](mailto:meter.support@teridian.com).

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