ACCURACY TEST AND COMPLIANCE REPORT

EnAccess Open-Source Meter Project

(Milestone 4)

Abstract

This document summarizes the technical specification, accuracy tests and comparison with regulatory standards.

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1. OVERVIEW

The purpose of this document is to showcase the accuracy of the AC meter developed under this EnAccess opensource project. This will be primarily achieved by comparing the meter accuracy with international best practices by IEC standards, NEMSA metering guidelines and Nigerian smart meter regulation.

2. METER DATASHEET

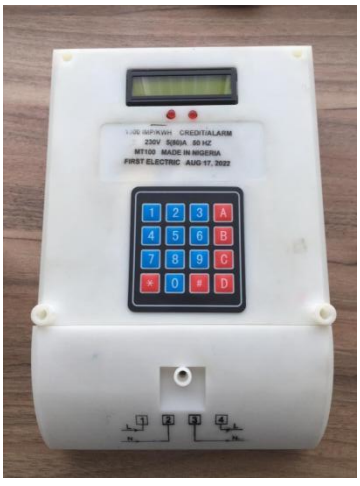
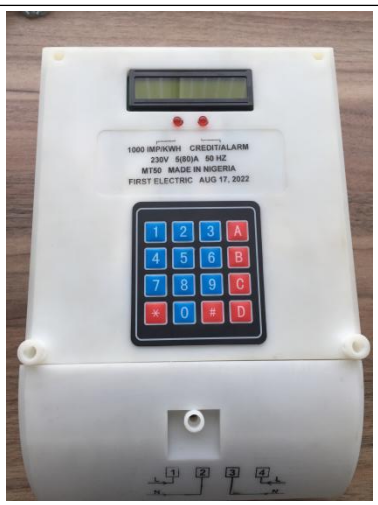
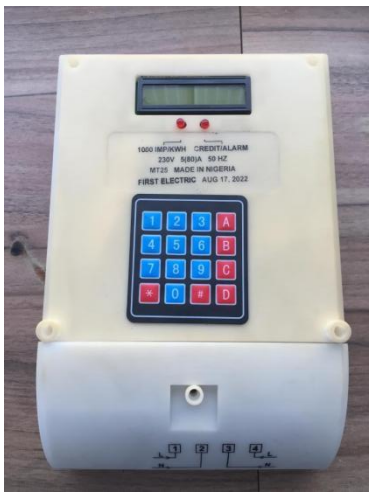
S. NO.	DESCRIPTION	UNITS	AS FURNISHED BY BIDDER
1	Type of meter		Single phase two wire
2	Accuracy Class of the meter		Class 1
3	Ib & Imax	A	5(80)
4	Operating Voltage	V	230
5	Operating Frequency	Hz	50
6	Power Consumption		2watts
7	Starting Current	mA	50
8	Short time over current	A	1000
9	Rated impulse withstand voltage	KV	1.5 (CAT II)
10	Resistance to heat and fire (As per specification		Fire retardant material was used in manufacturing the exterior casing
11	Degree of protection		IP51
12	Accuracy requirements (As per IEC 62053-21/22		Class 1
13	Power factor range		Zero lag to Zero.
14	Energy measurement		Fundamental energy +Energy due to Harmonics
15	Connection Diagram for system on terminal cover	Yes/No	Yes
16	Self-diagnostic feature		(i) Time and calendar.

			(ii) Real Time Clock. (iii) RTC battery. Non-Volatile Memory.
17	Initial start-up of meter (meter shall be fully functional within 5 sec after reference voltage is applied to the meter terminals)		Yes
18	Terminal block a) Depth of the Terminal holes. b) Internal diameter of terminal holes c) Clearance between adjacent terminals	 Mm Mm Mm	9.5mm (minimum). 25 mm.
19	Communication capabilities as per clause 4.31		RS485
20	Immunity against HV ESD as defined in Cl. 4.32.2		(CBM) charged body model 2000V
21	DC Immunity as defined in Cl. 4.33		
22	Grade of material for a) Meter base. b) Meter cove. c) Terminal block. d) Terminal cover		Epoxy
23	Tamper counts		yes
24	Recording forward energy in all conditions as per annexure I (Including current/potential reversal)	Yes/No	yes
25	Makes of all components used in the meter.	Yes/No	
26	Non-Volatile memory (Retention period)		100 years
27	Measuring elements used in the meter		AFE chip
28	Power supply to circuit in case		Battery

	of supply failure		
29	Display of measured values (As per specification –clause 5.8)	Yes/No	Yes
30	LCD display (Type and viewing angle)		16x2 LCD display
31	Pulse rate	Imp/kWh,Imp/kVArh	1000
32	Name plate marking	Yes/No	Yes
33	Routine test certificates	Yes/No	No
34	Acceptance test certificates	Yes/No	No
35	Type test certificates	Yes/No	No
36	Guarantee certificates	Yes/No	No

3. ACCURACY TEST

Three sample prototype meters were manufactured in as required by the Nigerian Electricity Management Services Agency (NEMSA). These meters will be sent to NEMSA for an official type test and report will be provided accordingly.
Tested meters: MT100, MT50 and MT25

MT100	MT50	MT25
		

MT100

Test point (%)	Voltage supplied	Actual voltage	Current supplied	Actual current	Expected power	Actual power (W)	Error (%)

	(V)	(V)	(A)	(A)	(W)		
Imax 1.0	239.869	240	79.9683	79.96	19085.1	19190.4	-0.2752
Imax 0.5L	240.002	240	80.0044	80	9522.3	9600	0.191
1200 (1.0)	240.012	240	59.9996	59.99	14237.1	14397.6	0.442
1200	240.116	240	60.0088	60.02	7156.7	7202.4	0.0364
(0.5L)	240.018	240	30.0005	30.01	7194.11	7202.4	0.1744
(600 (0.5L)	240.015	240	30.0007	29.98	3598.5	3597.6	0.0154
(100 (1.0)	240.015	240	5.0063	5	1199.91	1200	-0.0602
100 (0.5L)	240.141	240	5.0033	5	602.67	600	-0.0475
5 (1.0)	0	0	0	0	0	0	0
5 (0.5L)	0	0	0	0	0	0	0

Table 1: Accuracy Test Result of Meter MT100

MT50

Test point (%)	**Voltage supplied (V)**	**Actual voltage (V)**	**Current supplied (A)**	**Actual current (A)**	**Expected power (W)**	**Actual power (W)**	**Error (%)**
Imax 1.0	240.008	240	79.995	79.74	19111.03	19137.6	0.4149
Imax 0.5L	240.19	240	80.2	79.94	9633.12	9592.8	-0.4011
1200 (1.0)	240.003	240	60.0051	59.91	14362.01	14378.4	0.0199
1200	239.99	240	59.9019	59.84	7307.49	7180.8	0.2463
(0.5L)	240.001	240	30.00014	29.97	7167.161	7192.8	0.038
(600 (0.5L)	240.19	240	30.00016	29.27	3601 5	3512.4	0.824
(100 (1.0)	239.998	240	5.00011	4.97	1190.211	1192.8	-0.0874
100 (0.5L)	240.027	240	5.00001	5.01	602.7	601.2	0.0351
5 (1.0)	0	0	0	0	0	0	0
5 (0.5L)	0	0	0	0	0	0	0

Table 2: Accuracy Test Result of Meter MT50

MT25

Test point (%)	**Voltage supplied (V)**	**Actual voltage (V)**	**Current supplied (A)**	**Actual current (A)**	**Expected power (W)**	**Actual power (W)**	**Error (%)**
Imax 1.0	240.062	240.8	80.0008	79.61	19151.99	19170.09	-0.5233
Imax 0.5L	240.135	240.8	80.0002	79.66	9621.6	9591.064	-0.3491
1200 (1.0)	240.003	240.9	60.0075	59.73	14382.55	14388 96	-0.1144
1200	239.863	240.9	59.9754	59.73	7111.8	7194.479	0.5069

(0.5L)	239.993	240.9	30	29.85	7192.41	7190.865	0.0542
(600 (0.5L)	239.999	241	29.9999	29.82	3612.74	3593.31	0.3466
(100 (1.0)	240.032	241	5.0064	4.99	1196.21	1202.59	0.2996
100 (0.5L)	240.039	241.1	5.00036	4.96	613.66	597.928	-0.0689
5 (1.0)	0	0	0	0	0	0	0
5 (0.5L)	0	0	0	0	0	0	0

Table 3: Accuracy Test Result of Meter MT50

4. IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION) Metering Specification

Short overview of IEC:

The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The objective of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non- governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations. (webstore.iec.ch, n.d.). The IEC addresses safety aspects by establishing basic group and product safety publications. A *basic safety publication* covers a specific safety-related matter, applicable to many electrotechnical products. It is primarily intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51. It is not intended for use by manufacturers or certification bodies. One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications. The requirements, test methods or test conditions of basic safety publications will not apply unless specifically referred to or included in the relevant publications. The IEC standard codes highlighted below are the plumbline for a design engineer as related to meter design. (webstore.iec.ch, n.d.).

A. IEC 62052-11. (webstore.iec.ch, n.d.).

B. IEC 62053-22. (webstore.iec.ch, n.d.).

IEC 62053-11 (Publication date: 2020-06-17) **:**

IEC 62052-11: 2020 specifies requirements and associated tests, with their appropriate conditions for type testing of AC and DC electricity meters. This document details functional, mechanical, electrical and marking requirements, test methods, and test conditions, including immunity to external influences covering electromagnetic and climatic environments.

This document applies to electricity metering equipment designed to:

- Measure and control electrical energy on electrical networks (mains) with voltage up to 1000VAC, or 1500 VDC.
- Have all functional elements, including add-on modules, enclosed in, or forming a single meter case with exception of indicating displays.
- Operate with integrated displays (electromechanical or static meters);
- Operate with detached indicating displays, or without an indicating display (static meters only).
- Be installed in a specified matching socket or racks;
- Optionally, provide additional functions other than those for measurement of electrical energy.

Meters designed for operation with Low Power Instrument Transformers (LPITs as defined in the IEC 61869 series) may be tested for compliance with this document and the relevant IEC 62053 series documents only if such meters and their LPITs are tested together as directly connected meters. This document is also applicable to auxiliary input and output circuits, operation indicators, and test outputs of equipment for electrical energy measurement. This document also covers the common aspects of accuracy testing such as reference conditions, repeatability and measurement of uncertainty.

This document does not apply to:

- Meters for which the voltage line-to-neutral derived from nominal voltages exceeds 1 000 V AC, or 1 500 V DC;
- Meters intended for connection with low power instrument transformers (LPITs as defined in the IEC 61869 series of standards) when tested without such transformers;
- Metering systems comprising multiple devices (except of LPITs) physically remote from one another;
- Portable meters;

- Meters used in rolling stock, vehicles, ships and airplanes
- Laboratory and meter test equipment;
- Reference standard meters;
- Data interfaces to the register of the meter;
- Matching sockets or racks used for installation of electricity metering equipment;
- Any additional functions provided in electrical energy meters.

This document does not cover measures for the detection and prevention of fraudulent attempts to compromise a meter's performance (tampering).
This second edition cancels and replaces the first edition published in 2003, and its amendment 1:2016. This edition constitutes a technical revision.
This edition includes the following significant technical changes with respect to the previous edition :

a) Removed all meter safety requirements; the meter safety requirements are covered in IEC 62052-31:2015;
b) Included requirements for meter power consumption and voltage requirements from IEC 62053-61; IEC 62053-61 is withdrawn;
c) Included requirements for meter symbols from IEC 62053-52; IEC 62053-52 is withdrawn;
d) Included requirements for meter pulse output devices from IEC 62053-31; IEC 62053-31 is withdrawn;
e) Added new requirements and tests including: meters with detached indicating displays, and meters without indicating displays, meter sealing provisions; measurement uncertainty and repeatability; time-keeping accuracy; type test report
f) Updated and clarified acceptance criteria for testing of external influences;
g) Revised and updated tests for immunity to electromagnetic influences and disturbances as per the latest editions of the basic EMC publications. (webstore.iec.ch, n.d.).

IEC 62053-22 (Publication date : 2020-06-17) **:**
Applies only to transformer operated static watt-hour meters of accuracy classes 0,1 S, 0,2 S and 0,5 S for the measurement of alternating current electrical active energy in 50 Hz or 60 Hz networks and it applies to their type tests only.

This document applies to electricity metering equipment designed to:

- Measure and control electrical energy on electrical networks (mains) with voltage up to 1 000 V AC;

- Have all functional elements, including add-on modules, enclosed in, or forming a single meter case with exception of indicating displays;
- Operate with integrated or detached indicating displays, or without an indicating display;
- Be installed in a specified matching socket or rack;
- Optionally, provide additional functions other than those for measurement of electrical energy.

This document does not apply to:

- meters for which the voltage line-to-neutral derived from nominal voltages exceeds 1 000 V AC;
- Meters intended for connection with low power instrument transformers (LPITs as defined in the IEC 61869 series) when tested without such transformers;
- Metering systems comprising multiple devices physically remote from one another.
- Portable meters;
- Meters used in rolling stock, vehicles, ships and airplanes;
- Laboratory and meter test equipment;
- Reference standard meters;
- Data interfaces to the register of the meter;
- Matching sockets or racks used for installation of electricity metering equipment
- Any additional functions provided in electrical energy meters.

This document does not cover measures for the detection and prevention of fraudulent attempts to compromise a meter's performance (tampering)

This second edition cancels and replaces the first edition published in 2003 and its amendment 1: 2016. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Removed all meter safety requirements; the meter safety requirements are covered in IEC 62052-31: 2015.

b) Moved the descriptions of all general requirements and test methods from IEC 62053-21: 2003, IEC 62053-22: 2003, IEC 62053-23: 2003, IEC 62053-24: 2003 to IEC 62052-11:2020; IEC 62053-21:2020, IEC 62053-22:2020, IEC 62053-23:2020, IEC 62053-24:2020 contain only accuracy class specific requirements.

c) Added new requirements and tests concerning:

1) active energy meters of accuracy class 0,1S;

2) measurement uncertainty and repeatability (7.3, 7.8);

3) influence of fast load current variations (9.4.12);

4) immunity to conducted differential current disturbances in the 2 kHz to 150 kHz frequency range (9.3.8). (webstore.iec.ch, n.d.).

5. DESIGN JUSTIFICATION ACCORDING TO THE STATED IEC METERING STANDARD

ELECTRICAL DESIGN JUSTIFICATION:

According to the IEC design specification and standard highlighted above, **First Electric** has been able to achieve and meet the standards in Hardware design as related to CATII for high voltage handling capability, invariably the AFE (Analog Front End) chip used (ATM90e26) to measure all metering parameter have a high accuracy fitting for a class 0.1 meter, maximum measurement error of ±0.5%, Human Body Model (HBM) of 2000V according to JESD22-A114 test condition, Charged Device Model (CDM) of 500V according to JESD22-C101 test condition. We carried out meter accuracy-test according to the IEC metering specification standard using a reference meter test-bench, we were able to achieve an accuracy level of **±0.5%,** as highlighted in the percentage error row of the type test results in table 1,2 and 3. The accuracy test was done across different voltage, current and power factor range, with the result of three piece of meter highlighted above.

MECHANICAL DESIGN JUSTIFICATION:

Haven gone through the IEC specification as related to metering exterior casing and mechanical related design, the following was highlighted as designed in the meter.

i. IP rating.
ii. Exterior casing material flammability.

IP Rating:

The IP rating as specified in IEC metering standard is IP51, First Electric successfully designed and manufactured and IP51 exterior casing from JLCPCB.

Exterior casing material flammability:

According to IEC 62052-21/22, designed energy meter should have a high tolerance to fire, meaning the exterior casing, terminal block/connector shall not fuel the increase in fire in situations where there is fire outbreak or any relating event.

First Electric designed the exterior casing to be used alongside a terminal block bought in the market which ensure proper insulation as related to the relevant IEC standard.

6. COMPARISON WITH NIGERIAN METERING CODE

Nigeria Metering Code Version 02

GENERAL

The technical specifications enunciated herein are a summary of minimum requirements for energy meters and metering accessories approved for use in Nigeria's electricity network. It is aimed at promoting quality of energy metering in Nigeria to ensure fair play in energy transactions among utilities and customers and safety of all meter users. Among different meter specification highlighted in the Nigeria metering code version2, First Electric highlighted the below as relevant to the meter type constructed.

The specifications cover the following as extracted from Nigeria metering code version 2:

i. Electronic Meters.
ii. Prepaid Meters.
iii. Smart Metering.

This Code recognizes all the existing meter technologies however the framework for future deployment of meters shall be smart metering.

The specifications are prepared in accordance with the following International Standards:

I. IEC 62052-11.
II. IEC 62053-11,21,22 and 23.
III. IEC 62055-41 and 52.
IV. IEC 62056.
V. IEC 60044-1,2 and 3.

TECHNICAL SPECIFICATIONS FOR STATIC/ELECTRONIC METERS. GENERAL CONSTRUCTION AND COMPONENT SPECIFICATIONS FOR STATIC ENERGY METERS.

METERING CODE REF: 4.4.1

SN	PARAMETERS	TECHNICAL REQUIREMENTS	COMMENT
1	Body of Meter	Bakelite or Polycarbonate	Not applicable

2	Terminal Block	Made of polycarbonate grade and shall form integral part of the Meter base, brass or copper current terminals with star head brass screws as well as bimetallic contacts.	Comply
3	Terminal cover	Transparent terminal cover with external provision of sealing through sealing screws.	Not applicable
4	Diagram of connections	Diagram of external connections to be shown inside the terminal cover.	Comply
5	Marking on name plates	Meter shall have clearly visible, indelible and distinct name plate.	Comply
6	Meter Sealing	One seal shall be affixed on one side of Meter body	
7	Guarantee/Warranty	5 years	Comply
8	Resistance to heat and fire	The terminal block of Meter case shall be protected against the spread of fire. They shall not be ignited by thermal overload of live parts in contact with them.	Comply

OTHER GENERAL COMPONENT SPECIFICATIONS.

METERING CODE REF: 4.4.2.

SN	COMPONENT FUNCTION	TECHNICAL REQUIREMENTS	COMMENT
1	Measurement or computing chips	The Measurement or computing chips used in the Meter shall be with the Surface mount type along with the ASCIIs.	Comply
2	Memory Chips	The memory chips shall not be affected by the external parameters like sparking, high voltage spikes or electrostatic discharges.	Comply

3	Display Modules	a) The display modules shall be well protected from the external Ultra-Violet (UV) radiations. b) The display visibility shall be sufficient to read the Meter mounted at a height of 0.5 meter as well as at the height of 2 meters.	Comply
4	Communication Modules	Communication modules shall be compatible for the two RS 232/485 ports one for optical port for communication with Meter reading instruments & the other, for the hardware. RS 232/485 port to communicate with various modems for AMR such as mobile telephony, radio frequency, fixed line, satellite, or power line communication technology with IEC 62056-21 DLMS/COSEM protocol.	Not applicable
5	Optical Port	Optical port shall be used to transfer the Meter data to Meter reading instrument. The mechanical construction of the port shall be such to facilitate the data transfer easily.	Not comply
6	Power Supply	The power supply shall be with the capabilities as per the relevant standards. The power supply unit of the Meter shall not be affected in case the maximum voltage of the system appears to the terminals due to faults or due to wrong connections.	Comply
7	Electronic Components	The active and passive components shall be of the surface mount type to be handled and soldered by the state-of-the-art assembly processes. The components shall	Not comply

		be positioned in such a way that the leads of components shall not be under stress and not touching the internal wires.	
8	Mechanical Parts	The internal electrical components shall be of electrolytic copper and shall be protected from corrosion, rust, etc. The other mechanical components shall be protected from rust, corrosion, etc.by suitable plating and painting methods.	Comply
9	Battery	Lithium with minimum guaranteed life of 10 years and can last without recharging for 60 days	Comply
10	RTC & Micro Controller	The accuracy of Real Time Clock shall be as per relevant IEC standards	Comply
11	P.C.B	Glass Epoxy, fire resistance grade FR4, with minimum thickness of 1.6mm	Comply

GENERAL REQUIREMENTS.

METERING CODE REF: 4.4.4.

SN	PARAMETER	TECHNICAL REQUIREMENTS	COMMENT
1	On the Meter name-plate:	a) Indelible Meter serial number shall not be more than twelve (12) digits and legibly printed. b) Size of the digit of the Meter serial number shall be a minimum of 5mm x	Comply Comply

		3mm. c) Bar code shall be printed below the Meter serial number d) Manufacturer's Name and Trade mark. e) Place of manufacture. f) Year of manufacture. g) Reference Voltage, Current and Frequency. h) Class index. i) Meter Constant. j) Owner/Utility'sIdentity.	Not applicable Comply Comply
		The manufacturer shall affix one seal on one side of the Meter	Not applicable
		The internal potential links shall be in closed position or link- less. Meters will be preferred and there shall not be any external link.	Not applicable
		Terminal cover shall be fixed on Meter before dispatch	Comply
		The operation manual and the inscriptions on the name plate shall be provided in English Language.	Comply

SINGLE PHASE (2Wire) 5(60) AMPS CREDIT STATIC METER

METERING CODE REF : 4.4.5

SN	PARAMETERS	TECHNICAL REQUIREMENTS	COMMENT

1	Standards	IEC 62052-11,62053-21	Comply
2	Accuracy Class	1.0	Comply
3	Frequency	50Hz ± 2%	Comply
4	Operating Temp.	Up to 600C	Comply
5	Storage Temp.	Up to 700C	Comply
6	Relative Humidity	96% at 450C non-condensing	Comply
7	Life Span	Minimum of 10 years	Comply
8	Impulse withstand voltage	Not less than 6KV	Not tested
9	Reference Voltage	240 volts (P-N), -40% to +10% Vref, however the Meter shall withstand the maximum system voltage i.e. 415 Volts continuously	Comply
10	Display	k) LCD(Six digits) l) Height:9mm x 4.5mm minimum m) Viewing angle160 degrees minimum	Comply
11	Power factor range	Zero lag – unity – zero lead	Comply
12	Display parameters	Display Parameters: LCD test, KWH, Date & Time (Cumulative KWH will be indicated continuously by default and other parameters through push-button) Display order shall be as shown on S/N 24	Comply

		below.	
13	Burden	Less than 2VA in voltage circuit and 1VA for current circuit	Not applicable, CT used.
14	Starting current	0.4% of Ib.	Not comply(1% of Ib)
15	Test Output Device	Flashing LED visible from the front	Comply
16	Billing data	Meter serial number, Date and time, KWh and history for last 6 months. All these data shall be accessible for reading, recording and spot billing by downloading through IR port on universal CMRI or Laptop computers at site.	Not applicable
17	Terminal Configuration	Ph-N, N-Ph(Symmetrical)	Comply
18	Security feature	Programmable facility to restrict the access to the information recorded at different security levels such as read communication, communication write etc	Comply
19	Memory	Non-volatile memory independent of battery backup. Information stored in the memory shall be retained for a minimum of 10 years in case of power failure.	Comply
20	Software & communication compatibility	IR port to transfer locally through Common Meter Reading Instrument (CMRI) or laptop. The service provider shall supply Software required for CMRI. He shall also provide training for the use of software. The software shall be compatible to Microsoft Windows systems latest version. The Service Provider shall provide Meter-reading protocols and jointly work	Not applicable

		with the Utility to develop CMRI software for downloading and further uploading on computer. The service provider has to give an undertaking in this regard.	
21	Terminal hole Diameter	Shall be 9mm.	Comply
22	TAMPER EVENTS Phase & neutral interchanged I/C disconnected, Neutral & connected to earth neutral O/G load I/C neutral disconnected, O/G neutral connected to earth through a resistor. I/C phase & neutral interchanged, load connected to earth	METER BEHAVIOUR Meter shall record forward energy	Comply
23	Influence parameters	The Meter shall work satisfactorily with guaranteed accuracy limit under the presence of following influence quantities as per IEC 61036. ➢ External magnetic fields. ➢ Electromagnetic field induction. ➢ Radio frequency interference. ➢ Vibration etc. ➢ Waveform 10% of 3rd harmonics. ➢ Electromagnetic High Frequency ➢ (H.F.)Fields. ➢ DC Immunity test.	Not tested
24	**Display Sequence for parameters**	**DEFAULT DISPLAY** Cumulative KWh(cumulative KWh to be displayed continuously without decimal)	Comply

		ON DEMAND DISPLAY After pressing the push button, the following parameters shall be displayed LCD Test Date Real time Last month billing date Last month billing KWh reading Meter serial number	

PREPAYMENT METERING SYSTEM

All Prepayment Metering Installations shall be of the split type and conform to the details below.

KEYPAD SINGLE &THREE PHASE ELECTRICITY DISPENSER

METERING CODE REF : 4.5.1

SN	PARAMETERS	TECHNICAL REQUIREMENTS	COMMENT
1	Nominal Voltage	1Ø-240V,1-ph,2-wire system	Comply
2	Operating Voltage	-40% to +10% Nominal Voltage	Comply
3	Current Rating	5(60)A	Comply

4	Frequency	50 ±2%Hz	Comply
5	Accuracy Class	1	Comply
6	Encryption Algorithm	Standard Transfer Specification (STS)	Not applicable
7	Operating Temp.	Up to 600C	Comply
8	Storage Temp.	Up to 700C	Comply
9	Relative Humidity	96% at 450C non- condensing	Comply
10	Maximum KWH credit stored	99,999.9 KWh(1Ø)	Comply
11	Credit transfer number	20 Digits encryption	Comply
12	Protection	High resistance to short circuit	Comply
13	Impulse withstand voltage	Preferably greater than 6 KV	Not tested
14	Insulation withstand voltage	2 KV per minute	Not tested
15	Name plate	a) Indelible Meter serial number shall not be more than twelve(12) digits and legibly printed b) Size of the digit of the Meter serial number shall be a minimum of 5mm	Comply Comply

		x 3mm. c) Barcode shall be printed below the Meter serial number d) Manufacturer's name and Trade mark. e) Place of manufacture. f) Year of manufacture. g) Reference Voltage, Current and frequency. h) Class index. i) Meter Constant. j) Owner/Utility'sIdentity.	Not applicable Comply Comply Comply Comply Comply Comply Not applicable
16	Front panel Indication/Display	Include but not limited to the following: Three level credit LED display ✓ Green-when energy stored is full . ✓ Yellow-when remaining credit will last for 3- days. The red flashes when the remaining energy will last for 11/2 days. ✓ Blue-Consumption rate indicator. LCD credit status display. Credit transfer number accept/reject Tamper.	Comply Not comply Comply
17	Special Mode Display for Engineering/Management	Display up to 3 parameters according to programming to be specified: a) Normal display –LCD	Comply

		Duplicate copy of token inserted Credit Dispensing Unit identification number and KWh (or voucher serial number) inserted. Electricity Dispenser (ED) full of units. No power ON ED No credit on ED Credit rejects or accepts. Remaining Credit. Instantaneous Power Total KWh used in the past 24 hrs. Total KWh used in the past 30 days. Total KWh used since the ED was installed. b) Display only available with valid codes. c) Display only available within chosen programming or engineering mode. For the purpose of these specifications, items b) and c) above are treated as one. These shall staff. be accessible only to utility Over current trip level. Green-Yellow Light emitting diode (LED) display change over level in KWh (high). Yellow-Red LED display change over level in KWh (low).	Comply Comply

		Test on LED for tripping function. Display of LED number. Electronics faulty. Power failure counter (Number of times power supply failed or disconnected)-400 cycles and back to Zero. Enabling of disabled LED caused by tampering. Number of days/hour into the current 30 days when there was power and total KWh used during the period.	Not comply Not comply Not comply Not comply
18	EMC Compliance	Relevant section of IEC 61036.	Comply
19	Burden	Preferably less than 2 VA per phase.	Not applicable
20	Terminals	Extended cover type. Hole diameter shall be a minimum of 9mm.	Comply
21	Casing/Cover Material	Fire retardant-bakelite or polycarbonate	Not applicable
22	Sealing	Provision must be adequate to prevent tampering.	Comply
23	Power Factor Range	-1 to +1	Comply
24	Data Storage	Non-Volatile EPROM	Comply
25	Switching	Latching contactor.	Comply

26	EMC Susceptibility	According to IEC 61036, 61268.Not adversely affected by external magnetic fields.	Not tested
27	Life Span	Minimum 10 years	Comply

7. COMPARISON WITH NIGERIAN ELECTRICITY SMART METERING REGULATION

NIGERIAN ELECTRICITY SMART METERING REGULATION V01

PHYSICAL REQUIREMENTS

METERING CODE REF : 2

METERING CODE REF	DESCRIPTION	REQUIREMENT	COMMENT
2.1	A Smart Metering System shall, as a minimum, include the following components:	a Clock; a Data Store; an Electricity Meter; a HAN Interface; a Load Switch; a User Interface; and a WAN Interface. Back-up battery	Comply
2.2.		A Smart Metering System shall be mains powered and be capable of operating at a nominal voltage of 230VAC and consuming no more than an average of 4 watts of electricity under normal operating conditions.	Comply
2.3		A Smart Metering System shall be capable of automatically resuming operation after a power failure in its operating state prior to such failure.	Comply
2.4		The electricity smart meter shall comply with the provisions of the Nigeria Electricity Metering Code as amended.	Comply

FUNCTIONAL REQUIRMENENTS

METERING CODE REF : 3

METERING CODE REF	DESCRIPTION	REQUIREMENT	COMMENT
3.1	**Clock**	The Clock forming part of a Smart Metering System shall be capable of operating so as to be accurate to within 10 seconds of UTC+1 at all times.	Comply
3.3	**Data storage**	A SMS shall be capable of retaining all information held in its Data Store when in operation and during loss of power.	Comply
3.5	**Monitoring**	A SMS shall be capable of determining when the Active Power Import (5.3.2) exceeds, for a continuous period of thirty seconds or more, the *Load Limit Power Threshold* (5.2.11) and on such an occurrence the SMS shall be capable of:	Comply
3.10	**Voltage quality measurements**	***3.10.1 Average RMS voltage*** A SMS shall be capable of calculating the average value of RMS voltage over a configurable period as defined in the *Average RMS Voltage Measurement Period* (*5.2.3*), and: Recording the value so calculated (including details of the period to which the value relates) in the *Average RMS Voltage Profile Data Log* (*5.3.4*). Detecting when the value so calculated is above the *Average RMS Over Voltage Threshold* (*5.2.1*), and on detection:Generating an entry to that effect in the *Event Log (5.3.10)*; Counting the number of such occurrences in the *Average RMS Over Voltage*	Comply Not applicable Comply Not

		Counter (*5.3.4*); and Sending an Alert to that effect via its WAN Interface. Detecting when the value so calculated is below the *Average RMS Under Voltage Threshold* (*5.2.2*), and on detection: Generating an entry to that effect in the *Event Log (5.3.10)*; Counting the number of such occurrences in the *Average RMS Under Voltage Counter* (*5.3.5*); and Sending an Alert to that effect via its WAN Interface. ***RMS extreme over voltage detection*** A SMS shall be capable of detecting when the RMS voltage is above the *RMS Extreme Over Voltage Threshold* (*5.2.20*) for longer than the continuous period defined in the *RMS Extreme Over Voltage Measurement Period(5.2.18)*, and on detection: Generating an entry to that effect in the *Event Log*(*5.3.10*); and Sending an Alert to that effect via its WAN Interface. Disable supply until RMS voltage normalizes	applicable Comply Not applicable Comply Not applicable Comply
		RMS extreme under voltage detection A SMS shall be capable of detecting when the RMS voltage is below the *RMS Extreme Under Voltage Threshold* (*5.2.21*) for longer than the continuous period defined in the *RMS Extreme Under Voltage Measurement Period (5.2.19)*,	Comply

		and on detection: Generating an entry to that effect in the *Event Log*(*5.3.10*); and Sending an Alert to that effect via its WAN Interface. disable supply until RMS voltage normalizes.	Not applicable Comply

INTERFACE REQUIREMENTS

METERING CODE REF : 4 & 5

METERING CODE REF	DESCRIPTION	REQUIREMENT	COMMENT
4.1	**HAN Interface Consumer Device Information Provision**	A SMS shall be capable of providing the following information immediately upon establishment of a Communications Link with a Consumer Device (as set out in *3.2.4*), with updates of any changes to the instantaneous Active Power measurement every 10 seconds thereafter, and timely updates of any changes to the other information to that Consumer Device: the *Credit Balance* (*5.3.13*); the date and time of the last update of the *Credit Balance* (*5.3.13*); the Clock time in UTC+1; the *Total Active Import Register* (*5.3.21*); the *Tariff TOU Register Matrix* (*5.3.18*) and *Tariff Block Counter Matrix* (*5.3.17*); the *Tariff Switching Table* (*5.2.31*); the *Daily Read Log (5.3.8*); the *Emergency Credit Balance* (*5.3.9*) if Emergency Credit is activated;	Comply Not applicable

		the *Tariff TOU Price Matrix* (*5.2.33*) and *Tariff Block Price Matrix* (*5.2.30*) with an indication of the active Tariff Price; the Time-based Debts from the *Time Debt Registers [1 ... 2]* (*5.3.19*); the Time-based Debt Recovery rates from the *Debt Recovery Rates [1 ... 2]* (*5.2.6*); the Payment-based Debt from the *Payment Debt Register (5.3.14)*; the accumulated debt from the *Accumulated Debt Register* (*5.3.1*); the *Low Medium Power Threshold* (*5.2.14*) and *Medium High Power Threshold* (*5.2.15*); the instantaneous Active Power measurement; the *Low Credit Threshold* (*5.2.13*); the *Profile Data Log* (*5.3.15*); *and* the *Payment Mode (5.2.17)*.	
5.3.9	*Emergency Credit Balance*	The amount of Emergency Credit available to the Consumer after it has been activated by the Consumer.	Not applicable
5.3.13	*Credit Balance*	The amount of money in Currency Units as determined by the SMS. If operating in Prepayment Mode, the Credit Balance represents the SMS's determination of the amount of credit available to the Consumer (other than any *Emergency Credit Balance (5.3.9)*). If operating in Credit Mode, it represents the SMS's determination of the amount of money due from the Consumer since the Credit Balance was last reset.	Not applicable

SMART METER SPECIFICATIONS AND SMS OWNERSHIP

METERING CODE REF : 7

METERING CODE REF	DESCRIPTION	REQUIREMENT	COMMENT
7.1	**Smart Meter**	Meter specifications are particularly essential to provide for the technical functionalities stipulated in the Nigeria Metering Code and this regulation. 7.1.2. The smart meter shall have the ability to function as multi-source meter [utility, generator]. 7.1.3. **Metering Standards** The following are the minimum standards for electric smart meters: **IEC Standard 62052-11**: General Requirements for meters. **IEC Standard 62053-21**: Alternating current static meters for active energy (classes 1 and 2). **IEC Standard 62053-22**: Alternating current static meters for active energy (classes 0.2 S and 0.5 S). **IEC Standard 62053-23**: Alternating current static meters for reactive energy (classes 2 and 3). **IEC Standard 62054 – 21**: Electricity metering (a.c.) - Tariff and load control - Part 21: Particular requirements for time switches ; **IEC Standard 62056 – 21**: Electricity metering (a.c.) - Data exchange for meter reading, tariff and load control - Part 21: Direct local data exchange. **IEC Standards 62056-61**: Electricity metering - Data exchange for meter reading, tariff and load control - Part 61: Object identification system	Comply Comply Not applicable

		OBIS- For G, H, W, meters OBIS codes are specified in EN 13757-1 (CEN TC 294), interface objects are common. The maximum service life of Meters and Metering Equipment shall be specified by the manufacturer of such equipment taking into account the technology obsolescence. The maximum service life should take into account the roll out of all meters. The Electric Smart Meter shall be suitable for operation under the following conditions: Operating range voltage input : 230 V ± 15% ; Basic current (maximum current) : 5 A (100 A) ; Reference frequency : 50 Hz ± 5% ; Operating temperature: -40°C to +70°C Average relative humidity: up to 95%, non-condensing The meter shall be equipped with a battery to maintain minimal time during minimal function. The meter shall consume no more than 2 Watts on average during normal operational conditions. Meter should be integrated with in-built communication modem (s) for all its communication interfaces.	Comply Comply
7.2	**Meter Protection and design**	The meter shall be installable in current existing meter locations at consumer premises. 7.2.2. The smart metering system components shall support local access and	Not applicable Comply

		configuration by authorized personnel. The smart metering system shall be installed and maintained in a manner that protects public safety. The smart metering system shall display energy supply status (enabled or disabled) and origin of supply (grid or generator). The smart metering system shall be protected from physical tampering or interference, e.g. security seals, tamper switches, etc. The smart metering system should integrate a tampering detector, recognizing the following signals: Removal of terminal cover when the meter is powered as well as when it is not powered Reverse current flow Phase inversion (single-phase meters) Current flow with no voltage The meter and its measurement technology shall be highly resistant to tamper attempts with DC magnetic fields Phase rotation (for three phase meters) Single phasing (for three phase meters)	

8. CONCLUSION

The open-source AC meter has been designed according to IEC Standards and follows majority of the requirements of the Nigerian metering code-02. There are a few design features that do not confirm to the metering code as listed in sections above. For those reasons, First Electric will be unable to obtain a compliance or test certification from NEMSA. Invariably, First Electric has been able to fulfill the design requirements of a standard energy meter with additional smart IOT feature for top-up and parameter monitoring following the relevant IEC specification standard for meter design. More as regards compliance to metering code alongside IEC standard is highlighted below in sections above.

9. SINGLE-PHASE CALIBRATOR MULTI-FUNCTION ELECTRIC ENERGY METER TEST BENCH

Technical specification of test bench used:

Description	Equipment value
Model Number	FYL-SS1000
Brand Name	Forlong
Accuracy	Grade 0.05/0.1/0.2
Frequency	45Hz-65Hz
Output power	voltage (200 VA-1000 VA)
Power supply	single-phase AC220V ±15%
Output capacity Voltage	15 VA/station
Output current	0.1-100A(200A available)
Output voltage	220 V (120 V and 240 V)
Environmental conditions	Working temperature : 20 ℃ ± 5 ℃; Ambient humidity : 40%- 60% R.H.
Harmonic output	2nd-21st harmonic, content≤40%; 3rd, 5th, 7th, or any 3 harmonics superposition, accumulative content≤40% ; Odd harmonic: sub-harmonic.
Load characteristics	Resistive, inductive, and capacitive (less than 4uF).
Item Name	Energy Meter Test Bench

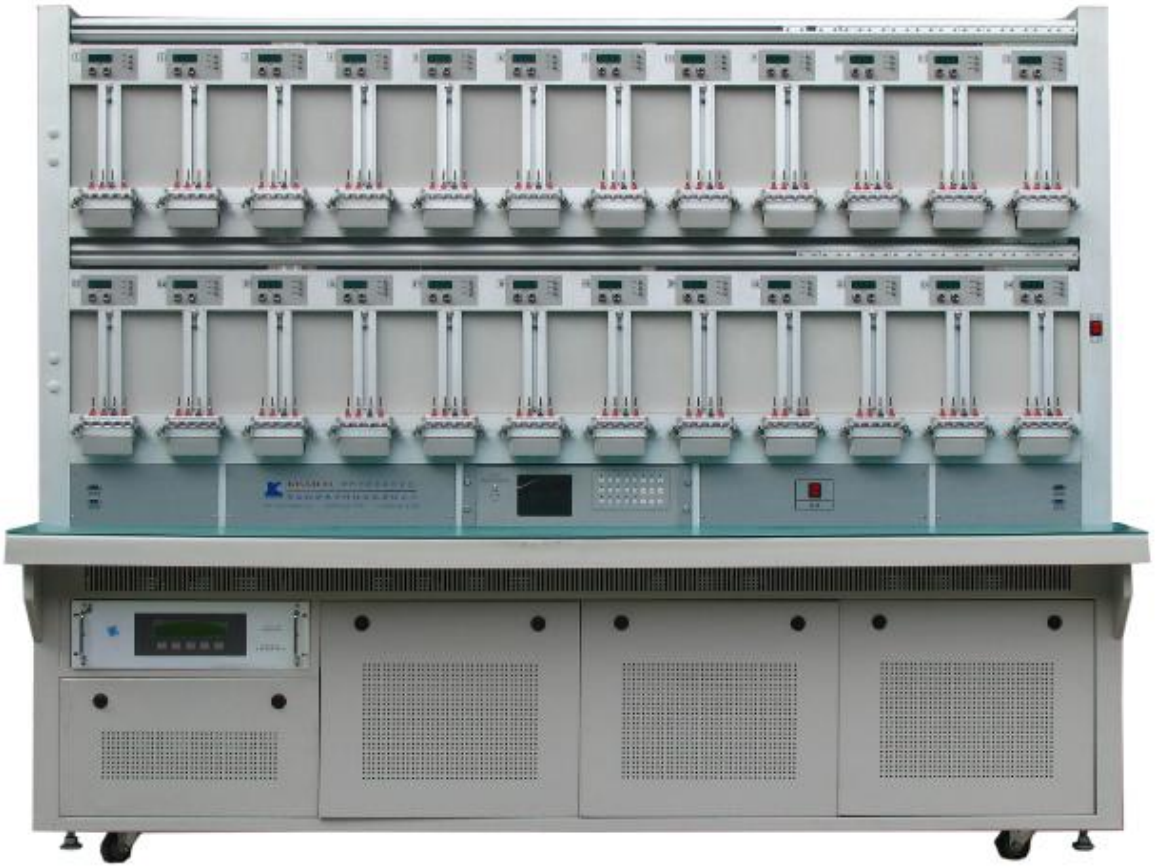


Figure 9.1: Image of test bench used in testing meter accuracy level.

10. REFERENCES

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