

Title: **SPECIFICATION OF LOW
FREQUENCY TOWER FOOTING
IMPEDANCE METERS WITH
FLEXIBLE CURRENT SENSORS**

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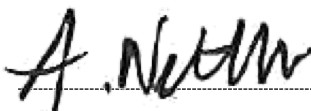
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Executive Summary

This document specifies the minimum requirements for the procurement of low frequency tower footing impedance measurement devices with flexible current sensors.

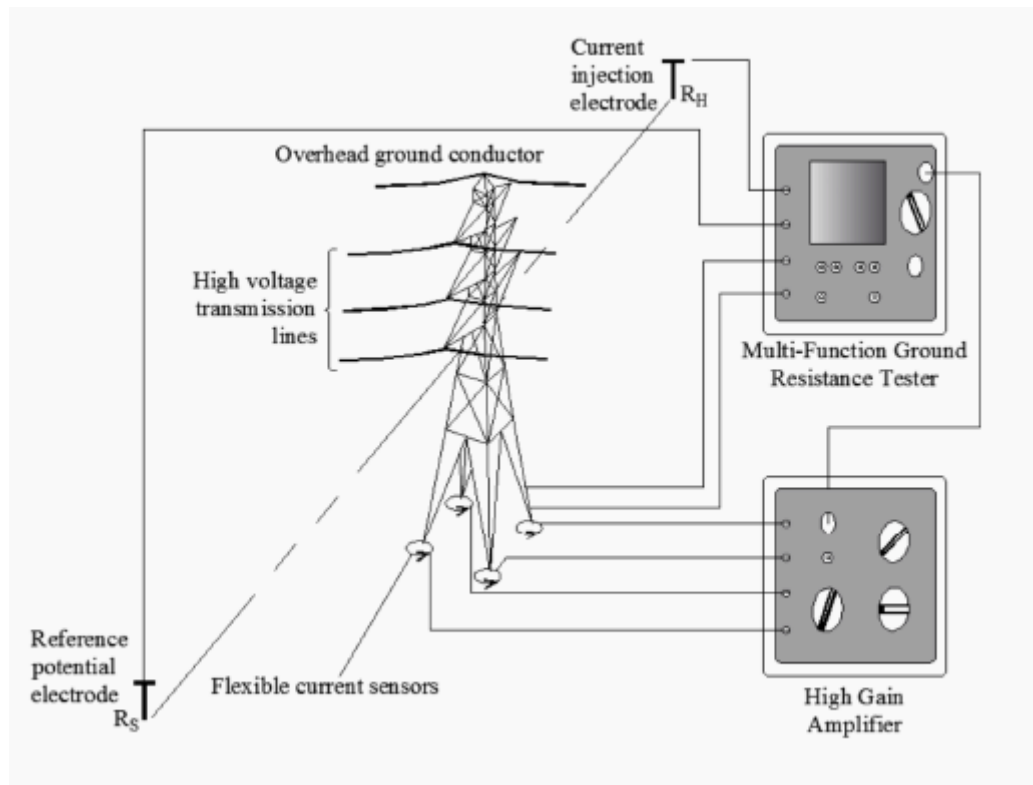


Figure 1: Sketch Illustrating The Proposed Measurement Of Tower Footing Impedance With Earthwires[3]

Figure 1 shows the proposed setup as per IEEE 81-2021[3]. The devices will consist of the primary instrument that could be used as a stand-alone device to measure tower footing impedances of lines that are not equipped with earthwires.

For lines equipped with earthwires a supplementary device which attaches to the primary instrument must contain four ports to which a minimum of four flexible current sensors could be connected to.

These device/s used in combination with the current sensors will be able to perform an accurate tower footing impedance measurement.

1. Introduction

The measurement of tower footing impedance is an important activity to provide assurance that the lightning performance of transmission lines will be within a specified target range. It is particularly important that the specified meter is able to accurately measure the tower footing impedance.

2. Supporting clauses

2.1 Scope

The transmission line earthing standard defines two types of measurement devices that are acceptable for measurements where earthwires are connected to the towers i.e. Impulse measurement devices as well as low frequency instruments with flexible current sensors that can fit around the tower legs and or guy anchors. This particular specification will focus on the latter.

2.1.1 Purpose

The purpose of this document is to provide the minimum specifications for the procurement of the low frequency instrument with current sensors.

2.1.2 Applicability

This document shall apply throughout Eskom Transmission Division.

2.2 Normative/informative references

2.2.1 Normative

- [1] ISO 9001, Quality Management Systems.
- [2] IEC 61557-1, Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC - Equipment for testing, measuring or monitoring of protective measures - Part 1: General requirements
- [3] IEEE 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

2.2.2 Informative

- [4] 240-130615862, Earthing of transmission lines

2.3 Definitions

2.3.1 General

None

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
AC	Alternating Current
CT's	Current Transformers
DC	Direct Current
Hz	Hertz
mA	Milliamps
V	Volts

2.5 Roles and responsibilities

Not applicable.

2.6 Process for monitoring

Not applicable.

2.7 Related/supporting documents

Transmission line earthing standard[4].

3. Minimum Requirements

As a minimum the meter should be capable in performing the following measurements : frequency, voltage, current, ac resistance and soil resistivity measurements.

3.1 Frequency Measurements

Measuring method must be digital with a sampling frequency of at least 4000Hz. The frequency of the strongest spectral component should be displayed.

The meter should be capable of measuring in a range of 5Hz to 450Hz with a resolution of 1Hz.

3.2 Voltage Measurements

Measuring method must be digital with a sampling frequency of at least 4000Hz. The frequency of the strongest spectral component should be displayed.

The meter should be capable of measuring in a range of 5Hz to 450Hz with a resolution of 1Hz.

The signal should be converted to true rms or the sum of all the harmonics within the frequency range.

For the range of 0 - 9.99V the resolution should be at least 0.01V and for the range of 10V – 65V should be at least 0.1V.

The instrument should be able to measure DC.

3.3 Current Measurements

Measuring method must be digital with a sampling frequency of at least 4000Hz. The meter should be capable of measuring in a range of 5Hz to 450Hz with a resolution of 1Hz.

The signal should be converted by the summation of all the harmonics within the frequency range. For the range of 0mA – 9.99mA the resolution should be at least 0.01mA. For the range of 10mA – 99.9mA the resolution should be at least 0.1mA. For the range of 100mA – 999mA the resolution be at least 1mA. For the range of 1A – 9.99A the resolution should be at least 10mA. For the range of 10A – 40A the resolution should be at least 100mA.

3.4 AC Resistance Measurements

Measuring method would consist of a ratio of the measured voltage and currents.

Open circuit test voltages should range between 10V and 60V rms and should be automatically selected depending on the load resistance. Test frequency should be selectable and range between 41 and 5000Hz. Short circuit current should be greater than 240mA.

Noise suppression should be up to 55 Volts peak. When performing the ac resistance measurements the meter should be able to indicate when the probe resistances are too high to enable an accurate measurement.

3.5 Soil Resistivity Measurements

Measuring method would consist of a ratio of the measured voltage and currents.

Open circuit test voltages should range between 10V and 60V rms and should be automatically selected depending on the load resistance. Test frequency should be selectable and range between 45 and 120Hz. Short circuit current should be greater than 240mA. The meter should be able to measure a soil resistivity up to 99kΩm. Noise suppression should be up to 55 Volts peak. The meter should also be able to handle probe resistances up to 100kΩ. Meter should also have the capability to check resistance overlap zones.

3.6 Safety Compliance

The meter must be CAT IV rated to at least 50V. It must be overvoltage protected to at least 250Vrms. No hazardous touch voltages shall appear during the measurements. Electrical safety according to EN 61010-1.

3.7 Terminal Marking

Marking on the equipment should be accordance with IEC 61557-1. Designation of the terminals should be as follows:

- E: terminal for the earth electrode;
- ES: terminal for the probe placed nearest to the earth electrode;
- S: terminal for a probe;
- H: terminal for the auxiliary earth electrode.

3.8 List Of Equipment

As a minimum the following list of equipment must be provided :

- 1) Four earth electrodes/spikes
- 2) Four flexible current sensors/ct's.
- 3) Primary injection set-main measurement device
- 4) Secondary measurement device(if applicable) to enable current sensor connection.
- 5) Hammer.
- 6) Two leads at least 100m in length with appropriate connectors to fit easily into equipment with appropriate connectors.
- 7) One lead at least 10m in length with appropriate connectors to fit easily into equipment with appropriate connectors.

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- 8) Two leads at least 25m in length with appropriate connectors to fit easily into equipment with appropriate connectors.

Equipment/cables not listed must be provided to enable the measurements to be done.

3.9 Power Requirements

Rechargeable battery, Recharging source should be 220V(50Hz).

3.10 Durability

IP53 and UL94V0 compliant.

3.11 Calibration Requirements

The meter must be supplied with a calibration certificate as well as calibration data.

4. Authorization

This document has been seen and accepted by:

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5. Revisions

Date	Rev.	Compiler	Remarks
Feb 2024	1	S. Ramadhin	New Document

6. Development team

The following people were involved in the development of this document:

- Transmission Lines Earthing Care Group

7. Acknowledgements

Not applicable.

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Annex A – Technical Evaluation Criteria

TECHNICAL EVALUATION CRITERIA FOR LOW FREQUENCY IMPEDANCE METERS WITH FLEXIBLE CURRENT SENSORS				
	Criteria		Weight	Score
1	Frequency Measurements			
	Measurement range 5Hz to 450Hz with 1Hz resolution		5	
	Sub Total		5	0
	Current Measurements			
2	Signal converted by sum of all harmonics in frequency range		1	
	Range of 0-9.9mA resolution to be 0.01mA		1	
	Range of 10-99.99mA resolution to be 0.1mA		1	
	Range of 100-999mA resolution to be 1mA		1	
	Range of 1-9.99A resolution to be 10mA		1	
	Range of 10-40A resolution to be 100mA		1	
	Sub Total		6	0
	AC Resistance Measurements			
3	Test frequency minimum range between 45Hz-5000Hz		10	
	Short circuit current minimum of 240mA		10	
	Meter to have capability to check resistance overlap zones		10	
	Meter to indicate when probe resistances are too high and should be able to handle probe resistance up to 100kohm.		10	
	Sub Total		40	0
	Voltage Measurements			
4	Signal converted to true rms or sum of all harmonics		1	
	Range of 0-9.99V resolution to be 0.01V		1	
	Range of 10-65V resolution to be 0.1V		1	
	Instrument must be able to measure DC		1	
	Sub Total		4	0
	Soil Resistivity			
5	Test frequency minimum range between 45Hz-120Hz		5	
	Meter to be able to measure soil resistivity at least up to 99kohmm.		1	
	Meter to indicate when probe resistances are too high and should be able to handle probe resistance up to 100kohm.		2	
	Sub Total		8	0
	Safety Compliance			
6	Meter to rated to CAT IV to at least 50V		3	
	Overvoltage protection at least up to 250Vrms		3	
	Sub Total		6	0
	Minimum Equipment Requirements			
7	Four earth electrodes/spikes, hammer, measuring tapes		1	
	Four current sensors		1	
	Primary injection set and secondary measurement device for current sensors with at least four input terminals		1	
	Two leads at least 25m in length, Two leads at least 100m in length, One lead at least 10m in length		1	
	Sub Total		4	0
	General Requirements			
8	Sampling frequency to be at least 4000Hz		1	
	Noise suppression to be at least 55 Volts peak		10	
	Terminal marking as per IEC61557-1 and digital display		1	
	IP53 and UL94V0 Compliance		1	
	Meter to be supplied with calibration certificate plus calibration data		3	
	Open circuit test voltage minimum range between 10V-60V		10	
	Rechargeable battery with rechargeable source at 220 Volts 50Hertz		1	
	Sub Total		27	0
	TOTAL		100	

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