

ISO 9001:2015	Doc No: IRS/TC/22/2021	Version No. 1.1	Date Effective:02-06-2021
Document Title:	Specification for V.F. and Signalling Transformers used for Derivation and Termination of Underground Telecommunication Cable Circuits		

 सत्यमेव जयते	TELECOM DIRECTORATE RESEARCH DESIGNS & STANDARDS ORGANIZATION Manaknagar, Lucknow – 226011
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IRS/TC/22/2021

Specification
For
V.F. and Signalling Transformers used
for Derivation and Termination of
Underground Telecommunication Cable
Circuits

Issued By	Director/Telecom-I	Page 1 of 18
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I. AMENDMENT/ REVISION HISTORY

Serial No.	Date of Amendment	Amendment / Revision	Reasons for Amendment
1.	1976		First Issue
2.	06-05-2021	Version 1.0	Reviewed as per directives of DG/RDSO vide note no. DG/Misc. dated 10.06.2020. Formatting done. Removal of obsolete references/Review of references. Incorporation of ISO clause.
3.	02-06-2021	Version 1.1	Correction in Clause numbering.

II. DOCUMENT DATA SHEET

Title of Document	:	Specification for V.F. and Signalling Transformers used for Derivation and Termination of Underground Telecommunication Cable Circuits.
Prepared By	:	Director / Tele -I
Approved By	:	Executive Director / Telecom-I
Abstract	:	This document specifies technical specifications for V.F. and Signalling Transformers

III. DOCUMENT CONTROL SHEET

Designation	Organization	Function	Level
JE/Designe	RDSO	Member	Prepare
Director/Telecom-I	RDSO	Member	Prepare, Review, Accept
ED/Telecom-I	RDSO	-	Approval

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1.0 FOREWARD :

This specification is issued under the fixed serial number TC: 22 the final number indicates the year of original adoption as standard or in the event of revision the year of last revision

1.1 This specification requires reference to the following Indian Railway standards (IRS) and Indian Standards (IS) specifications:

IRS	S 23	:	Electrical signalling and interlocking equipment.
BIS:IS	9000 Part 2, Part 3, Part 5, Part 7, Part 19	:	Basic Environmental Testing Procedures For Electronic And Electrical Items.

1.2 Wherever in this specification any of the above mentioned specifications is referred to by number only without mentioning the year of issue the latest issue to that specification is implied otherwise the particular issue referred to is meant.

1.3 This specification is intended chiefly to cover the technical provisions and the provisions relating to supply of the materials and does not include all the necessary provisions of contract.

2.0 SCOPE:

This specification covers the requirement of V.F. and signalling transformers used for termination and derivation of the circuit in the main aluminum sheathed telecommunication cables laid underground along the railway tracks.

3.0 TERMINOLOGY:

3.1 For the purpose of this specification the terminology given in IRS: S: 23 (Electrical Signalling and Interlocking Equipment) shall be applied.

3.2 The terms referred to in this specification but not covered in IRS: S: 23 (Electrical Signalling and Interlocking Equipment) shall be applied.

3.2.1 Lot: a lot is constituted by the Transformers of the same type manufactured in the same factory during the same period using the same process and materials.

4.0 GENERAL

4.1 The side circuits of the paper insulated V. F. quads, which are loaded, are used for transmission of speech and the unloaded phantom of the side circuits is used for transmission of interrupted 50 Hz ringing current for signaling.

4.2 The circuits carried in the main cable are derived at a number of points on the route by means of the V. F. and signalling Transformers. These transformers are contained in the inner metal case of the T- joins. The transformers used for the various cabled circuits shall be of the following type:

4.2.1 Type 1 -VF Transformers for loaded V. F. side circuits, impedance ratio 1120:1120 ohms.

4.2.2 Type 2 -50Hz Signalling Transformers for Phantom circuits turn ratio 1:2

4.2.3 Type 3 -VF terminating Transformers for unloaded VF side circuits (P E insulated quads), impedance ratio for 470:1120 ohms

4.2.4 Type 4 - VF Transformers for inter wire Telegraph loaded VF side circuits impedance ratio 1120:600 ohms.

4.2.5 Type 5 – VF Transformers for VF circuit isolation in Quad cable, if induced voltage is high.

4.2.6 Type 6 – VF Transformers for quad to Loaded VF side circuits.

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4.3 General requirements of workmanship, limits and fits, test and inspection and rejection shall be in accordance with IRS: S: 23 to the extent applicable.

5.0 DIMENSIONS AND CONSTRUCTION:

- 5.1.** The core and the windings of the transformers shall be completely enclosed in a hermetically sealed metallic case while the terminals shall be taken out on top of the transformer case through suitable seals.
- 5.2.** Each of the primary and secondary windings shall be splitted into two identical halves and terminated on 4 terminals provided on the top of the transformer case. An earth terminal in electrical contact with the Transformer case shall be provided as shown in figures 1 and 2 of Appendix F.
- 5.3.** The top of the transformer case shall be provided with 4 symmetrical fixing studs as shown in figures 1 and 2 of Appendix F.
- 5.4.** Transformer size shall not exceed the maximum dimensions shown in figures 1 and 2 of Appendix F.
- 5.5.** All exposed metallic surfaces /parts shall be painted or otherwise suitably protected against corrosion.
- 5.6.** The Transformer shall be manufactured in a thoroughly workmanlike manner in accordance with the best engineering practices.

6.0 ELECTRICAL CHARACTERISTICS:

6.1 The Transformers shall confirm to the electrical characteristics specified in Table 1.

7.0 TESTS:

7.1 The following shall constitute Type Test:

- a) Visual inspection. (Clause 7.5)
- b) Conformity to specified dimensions. (Clause 5)
- c) Test for Electrical characteristics. (Clause 6.1)
- d) Climatic tests. (Clause 7.4)
- e) Robustness of terminals. (Clause 7.6)
- f) Test for sealing of Transformers. (Clause 7.7)
- g) Bump test. (Clause 7.8)

Note- For the purpose of type test the return loss, insertion loss, bridging loss and winding balance test of transformer shall be conducted at input power levels from 0.1 to 10.0 m watts.

- 7.1.1** The manufacturer shall submit to the purchaser or his nominee 6 Transformers of each type for type approval.
- 7.1.2** A type approval certificate shall be issued to the manufacturer if the samples pass all the prescribed test.- The type approval certificate once issued shall not be valid if a change in the design, construction, material used for manufacturing process is made subsequently unless this change has the approval of the purchaser or his nominee.
- 7.1.3** The bulk manufacture shall be undertaken only after the type approval has been communicated by the purchaser or his nominee.

7.2 The following shall constitute Routine Test:

- a) Visual inspection. (Clause 7.5)
- b) Conformity to specified dimensions. (Clause 5)
- c) Test for Electrical characteristics. (Clause 6.1)
- d) Any other test considered necessary by the manufacturer to ensure that the Transformers confirm to the requirements of this specification

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Table-1

S No.	Characteristics	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Frequency/frequency band
		Terminating and tapping transformer for V.F. side circuits excluding telegraph	Terminating and tapping transformer for 50 Hz Signalling	Terminating transformer for Insulated V.F. quad	Terminating and tapping transformer for inter-wire telegraph	Isolation transformer for Quad cable	Terminating transformer for quad to 4W ckts (Equipment side)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i.	Impedance ratio	1120:1120 ± 2%	1:2 turn ratio ± 2%	470:1120 ± 2%	1120:600 ± 2%	470:470 ± 2%	470:600 ± 2%	Type 1,3,4,5 and 6 – 800 Hz Type 2 50 Hz
ii.	Insulation Resistance with 500 V dc Winding-Winding case	10,000 M Ω	10,000 M Ω	10,000 M Ω	10,000 M Ω	10,000 M Ω	10,000 M Ω	DC
iii.	Dielectric Strength Winding- Winding case	2000 V (r.m.s.) for 1 min	2000 V (r.m.s.) for 1 min	2000 V (r.m.s.) for 1 min	2000 V (r.m.s.) for 1 min	2000 V (r.m.s.) for 1 min	2000 V (r.m.s.) for 1 min	50 Hz
iv.	Return Loss	More than 20 dB	-----	More than 20 dB	More than 20 dB	More than 20 dB	More than 20 dB	Type 1- 300 Hz to 3.4 K Hz Type 3,4,5 and 6 150 Hz to 2.5 K Hz

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
v.	Insertion Loss	Not more than 0.6 dB	-----	Not more than 0.6 dB	Not more than 0.6 dB	Not more than 0.6 dB	Not more than 0.6 dB	Type 1- 300 Hz to 3.4 K Hz Type 3,4,5 and 6 150 Hz to 2.5 K Hz
vi.	Bridging Loss with secondary open	Not more than 0.015 dB	-----	-----	Not more than 0.015 dB	Not more than 0.015 dB	Not more than 0.015 dB	Type 1- 300 Hz to 3.4 K Hz Type 3,4,5 and 6 150 Hz to 2.5 K Hz
vii.	Attenuation distortion	Within ± 0.1 dB	-----	-----	Within ± 0.1 dB	Within ± 0.1 dB	Within ± 0.1 dB	Type 1- 300 Hz to 3.4 K Hz Type 3,4,5 and 6 150 Hz to 2.5 K Hz
viii.	Winding Balance	More than 60 dB	-----	More than 60 dB	More than 60 dB	More than 60 dB	More than 60 dB	Type 1- 300 Hz to 3.4 K Hz Type 3,4,5 and 6 150 Hz to 2.5 K Hz

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ix.	Open Circuit Drain	-----	2 N Side 5V<0.2 mA 100 V <0.7 mA N Side 5V < 0.5 mA 60 V <1.5 mA	-----	600 Ω side- open 1120 Ω side- 20V ≤ 2 mA 50V ≤ 7 mA	-----	-----	Type 2 -50 Hz Type 4 – 150 Hz
x.	Power efficiency	-----	Apply 30V, 50 Hz to N side terminate 2 N side with 1200 Ω Power efficiency >75%	-----	-----	-----	-----	50 Hz
xi.	Short circuit impedance	-----	Apply 20V, 50 Hz to N side, 2 N side being short circuited Impedance on N side less than 60 Ω	-----	-----	-----	-----	50 Hz
xii.	V A Rating	-----	10 VA (Min.)	-----	-----	-----	-----	50 Hz

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7.3 The following shall constitute Acceptance Test:

- a) Visual inspection. (Clause 7.5)
- b) Conformity to specified dimensions. (Clause 5)
- c) Test for Electrical characteristics. (Clause 6.1)
- d) Any other test considered necessary by the purchaser or his nominee.

7.3.1 Sampling plan- Unless otherwise agreed to by the purchaser and the supplier the double sample plan given in Table-2 below shall be adopted.

TABLE-2

Lot consisting of Transformers	1 st Sample Size (N1)	2 nd Sample Size (N2)	Combined Sample Size (N1+N2)	Acceptance Number. (C1)	Rejection Number (C2)
(1)	(2)	(3)	(4)	(5)	(6)
Under 25	3	6	9	0	2
25 to 50	7	14	21	0	3
51 to 100	10	20	30	0	3
101 to 200	13	26	39	0	5
201 to 300	20	40	60	1	5
301 to 500	25	50	75	1	6
501 to 800	35	70	105	2	7
801 to 1300	50	100	150	3	10
1301 to 3200	75	150	225	5	12
3201 to 8000	100	200	300	6	17
8001 and above	150	300	450	9	24

7.3.2 The number of Transformers (N1) as given in column 2 shall first be selected and subjected to the acceptance tests. If in the first sample the number of defective Transformers, that is, those failing in one or more acceptance test, is less than or equal to the corresponding number (C1) given in column 5 the lot shall be considered as conforming to the requirements of the acceptance test. If the number of defective Transformers in the first sample is greater than or equal to the rejection number (C2) given in column 6 the lot shall be considered as not conforming to the requirement of the acceptance tests. If the number of defective Transformers in the first sample lies between (C1) and (C2) a second sample of size (N2) As given in column 3 shall be selected and subjected to acceptance test if in the combined sample the number of defective transformer is less than (C2) the lot shall be considered as conforming to the requirement of acceptance tests.

7.3.3 The samples shall be selected at random from at least 10% of the packages. For random selection of packages all the packages in the lot shall be arranged in a serial order and every rth package shall be selected until the requisite number of packages is obtained.

'r' being the integral part of-

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Total number of packets in the Lot

Total number of packets to be selected

7.4 Climatic Tests:

7.4.1 The Transformer shall be tested for the climatic test as per Table 3 below the order in which the climatic test are to be conducted is indicated in Table 3.

Table 3

Climatic tests for V.F. and Signalling Transformers.

S No And order	Name of the test	Severity	Method of test	Duration of Recovery	Tests to be conducted on transformers after climatic test and result expected
(1)	(2)	(3)	(4)	(5)	(6)
i.	Dry Heat Test	+70 ⁰ C,16 Hrs.	IS 9000 Part III, Sec III	1 to 2 Hrs.	a) Visual Examination- No Damage b) Insulation Resistance – More than 5000 Mega ohms after recovery.
ii.	Damp Heat (Accelerated) tests First Cycle	1 Cycle 40 ⁰ C,95% RH	Part V, Sec II	1 to 2 Hrs.	a) Visual Examination- No Damage b) Insulation Resistance – More than 1000 Mega ohms. c) Insulation Resistance after 24 Hrs. recovery – More than 2500 Mega ohms.
iii.	Cold Test	-10 ⁰ C,2 Hrs.	Part II, Sec III	1.1/2 to 2 Hrs.	a) Visual Examination- No Damage b) Insulation Resistance – More than 5000 Mega ohms
iv.	Damp Heat (Accelerated) test.	5 Cycles 40 ⁰ C,95% RH 12+12 Hrs. Cycle	Part V, Sec II	1 to 2 Hrs.	a) Visual Examination- No Damage b) Insulation Resistance – More than 1000 Mega ohms. c) Insulation Resistance after 24 Hrs. recoveries – More than 2500 Mega ohms.

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Note - The transformers after being subjected to all the climatic test in the order given in Table 3 and above shall again be tested for Electrical characteristic, the variation in values shall not be more than $\pm 5\%$ except insulation resistance for which value have been specified in table.

7.5 Visual inspection:

7.5.1 Visual inspection shall be carried out as per class 14.2 of IRS: S: 23* to the extent applicable.

7.6 Test for robustness of terminations:

7.6.1 All the termination shall be subjected to a tensile test as per Sec 1 of IS-9000 Part-19 The loading weight shall be 2.0 kg are the weight of the transformer whichever is higher subject to a maximum of 4 kg, the duration of the test shall be 10 seconds.

7.6.2 All the termination shall be subjected to the bend test as per Sec 3 of IS-9000 Part-19 number of bends shall be one.

*Electrical signalling and interlocking equipment.

**Basic climatic and mechanical durability test for electronic components

7.6.3 The continuity of all the windings shall be checked after the tensile and bend test.

7.7 Test for sealing of Transformers:

7.7.1 There shall be no defect of sealing as indicated by the appearance of the air bubbles when the transformer is immersed in water containing suitable detergent (15gm per 4 liter) the water being raised to a temperature of 85°C to 90°C and maintained at the temperature for 15 minutes. For production test, a suitable high-temperature oil may be used instead of water.

7.8 Bump test:

7.8.1 The sample shall be mounted as specified in Cl 6.1.2.2 of IS-9000 Part 7 Sec 2 taking care that the terminations are not stressed and that equal number of samples are bumped in each of the three principal axes. Sample shall be subjected to bump test in accordance with the clause 7.3 of IS-9000 Part 7 Sec 2. After the test, the samples shall be visually examined and shall not show any sign of damage or deterioration

7.8.2 The Transformer Under test shall be firmly fixed to the mounting plate of the table of the Bump Test machine.

7.8.3 The continuity of the windings shall be checked. Insulation resistance, dielectric strength, insertion loss and return loss of the transformer shall be measured before and after the bump test and there shall not be any variation in the values of these parameters.

7.9 Testing Conditions:

7.9.1 All the measurements and checks, unless specified otherwise shall be carried out at any combination of temperature humidity and pressure with the following limits:

7.9.1.1 Temperature 15 °C to 35 °C

7.9.1.2 Relative Humidity 45 to 75%

7.9.1.3 Air Pressure 860 to 1060 mbar (700 to 800 mm of Mercury).

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Note- The temperature and humidity shall substantially be maintained constant during a series of measurements carried out as a part of one test on a lot.

7.10 Testing methods for Electrical of V.F. Transformers

7.10.1 Method for testing the V. F. Transformers shall be as follows:

a. Dielectric strength test- A 50 Hz sinusoidal alternating voltage shall be used for dielectric strength test. The voltage shall be raised at the rate not exceeding 500 V (rms) per second and shall be maintained at the maximum value for 1 minute. All windings not under test shall be connected to the case of the transformer

b. Insulation resistance test- The insulation resistance shall be measured by applying 500 V d.c. for 1 minute \pm 5 seconds between the case and each winding and also between windings.

Note - Insulation resistance test shall be conducted after the dielectric strength test.

c. Impedance ratio: As per Appendix A.

d. Return loss: As per Appendix B.

e. Insertion loss (Also for attenuation distortion) as per Appendix C

f. Bridging loss: As per Appendix D.

g. Winding balance: As per Appendix E.

8.0 INSPECTION:

8.1 The inspection and the tests shall be carried out to the satisfaction of the purchaser or his nominee.

8.2 Test certificates incorporating the results of the routine test must be furnished in quadruplicate prior to the inspection for the use of purchaser or his Nominee.

9.0 PACKING:

9.1 The transformer shall be suitably packed to facilitate handling and to prevent the likelihood of any loss or damage during transit and storage.

10.0 MANUFACTURER'S IDENTIFICATION:

10.1 The following information shall be marked on the Transformers:

a. Manufacturers name.

b. Year of manufacture

c. Type of Transformers

d. Terminal connections on diagram (See figures 1 and 2 of Appendix F).

11.0 All the provisions contained in RDSO's ISO procedures laid down in Document No. QO-D-8.1-11 (titled "Vendor-Changes in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendor/vendors in the contracts floated by Railways to maintain quality of products supplied to Railways.

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APPENDIX - A
(Clause 6.10.1)

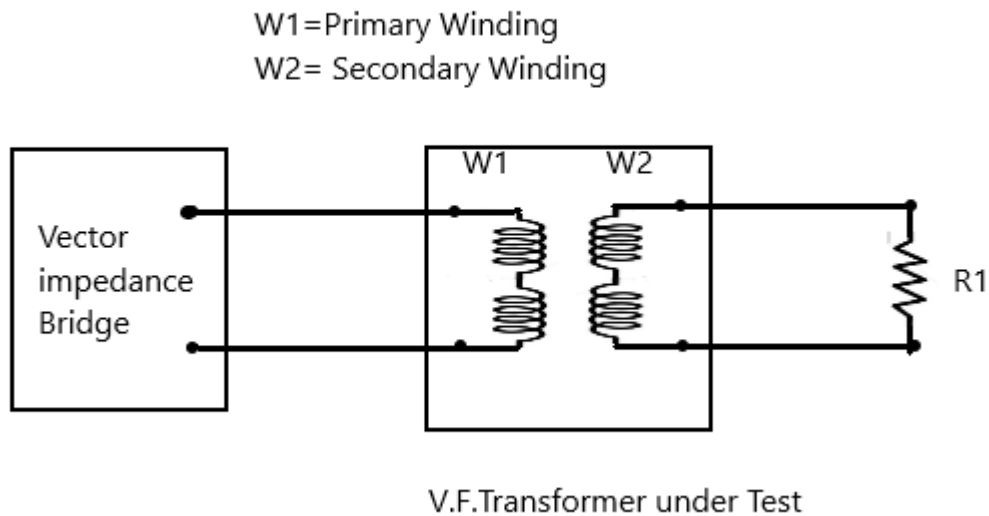
IMPEDANCE RATIO MEASUREMENT OF V.F. TRANSFORMERS

A-1. Method A

A-1.1 Equipment required:

- a. Vector Impedance Bridge.
- b. Resistors.

A-1.2 Circuit:



Impedance ratio = R_1/R_2 .

R_1 = Resistance equal to the nominal impedance of the primary side.

R_2 = Resistance equal to the nominal impedance of the secondary side.

Primary impedance = reading Z_1 indicated by the meter.

Similarly, for secondary impedance measurement, connect the meter on the secondary side and terminate primary by R_1 .

Secondary impedance = Reading Z_2 indicated by the meter.

A-1.3 Result: Impedance ratio = Z_1/Z_2 where-

Z_1 = Primary impedance measured when the secondary is terminated with resistance R_2

Z_2 = Secondary impedance measured when the primary is terminated with the resistance R_1 .

Note- The above measurement shall be made with an output power at level 0 dBm across the Transformer Under test. Method A should normally be used for the measurement. In case it is difficult to adjust then 0 dB on level across the Transformer by using method- A, method B given below may be employed for the measurement.

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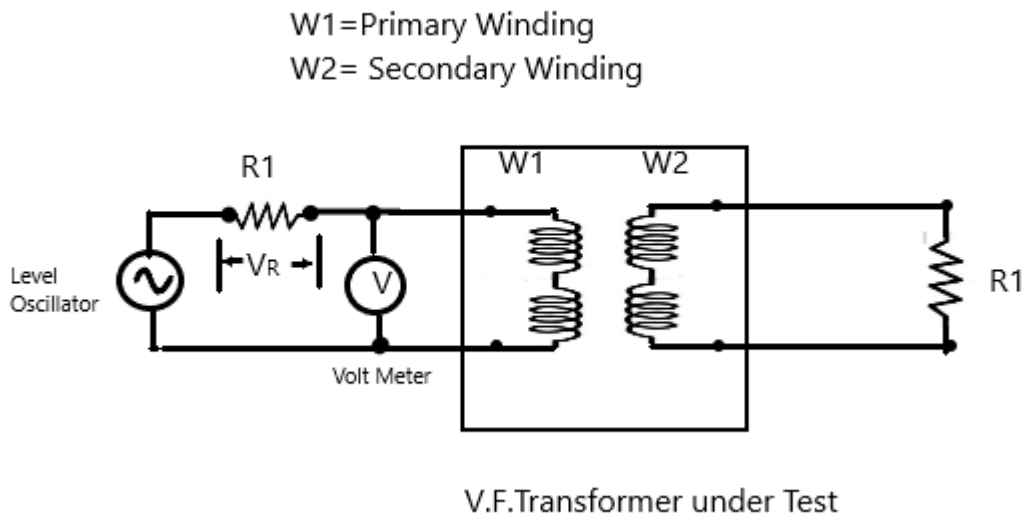
A-2

METHOD-B

A-2.1 Equipment required:

- a. Level Oscillator.
- b. Resistors.
- c. Voltmeter.

A-2.2 Circuit:



Adjust voltage V corresponding to 0 dBm level with reference to R₁. Measure V_R and thereby current

$$I = V_R / R_1$$

Primary impedance V/I ohms.

Similarly, the impedance of the secondary side shall be measured after changing W₁ for W₂ and terminating by R₁ for R₂.

Secondary impedance = V/I ohms.

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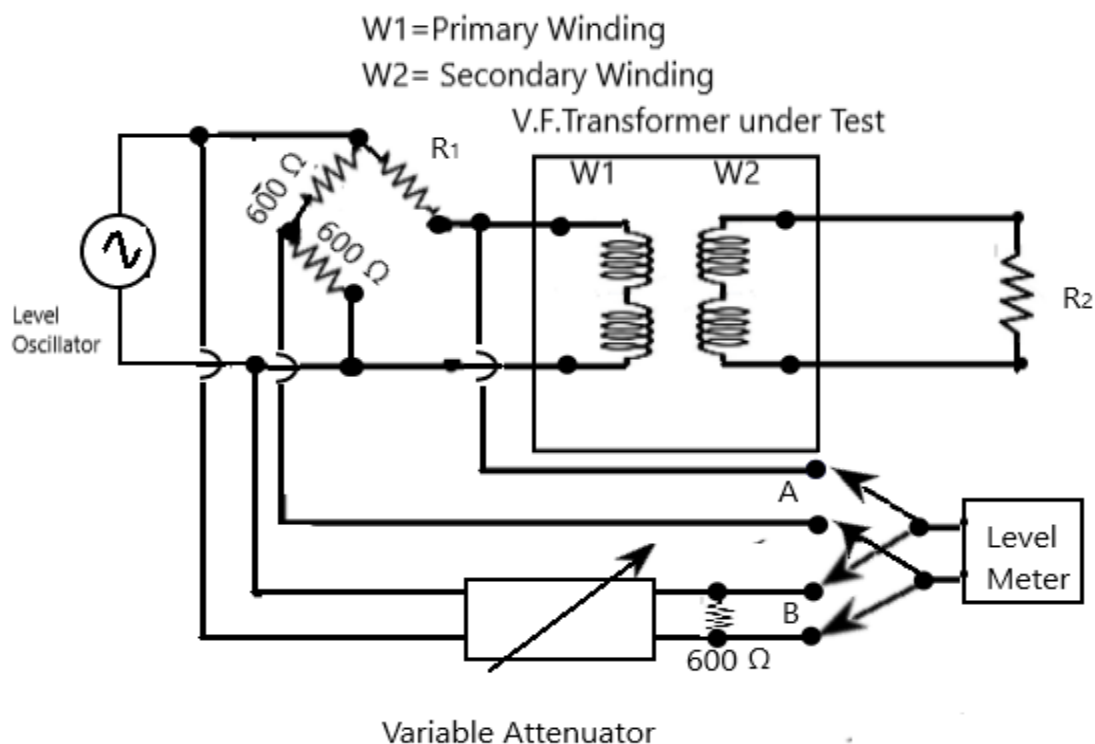
APPENDIX - B
(Clause 6.10.1)

RETURN LOSS MEASUREMENT OF V.F. TRANSFORMER

B-1 Equipment required:

- Low impedance level oscillator 100 Hz to 5 K Hz.
- Variable attenuator 0 to 100 dB.
- Level meter (high input impedance).
- Resistors.
- DPDT switch.

B-2 Circuit:



R₁ = Resistance equal to nominal impedance on primary side.
R₂ = Resistance equal to nominal impedance on secondary side.

With switch in position A note the reading indicated by LM, next with the switch in position B vary the attenuator to obtain the same reading of LM.

B-3 Result

Return loss = Reading of the attenuator -6 dB

Note: The above measurement shall be made with signal strength of 0 dBm level across the transformer under test.

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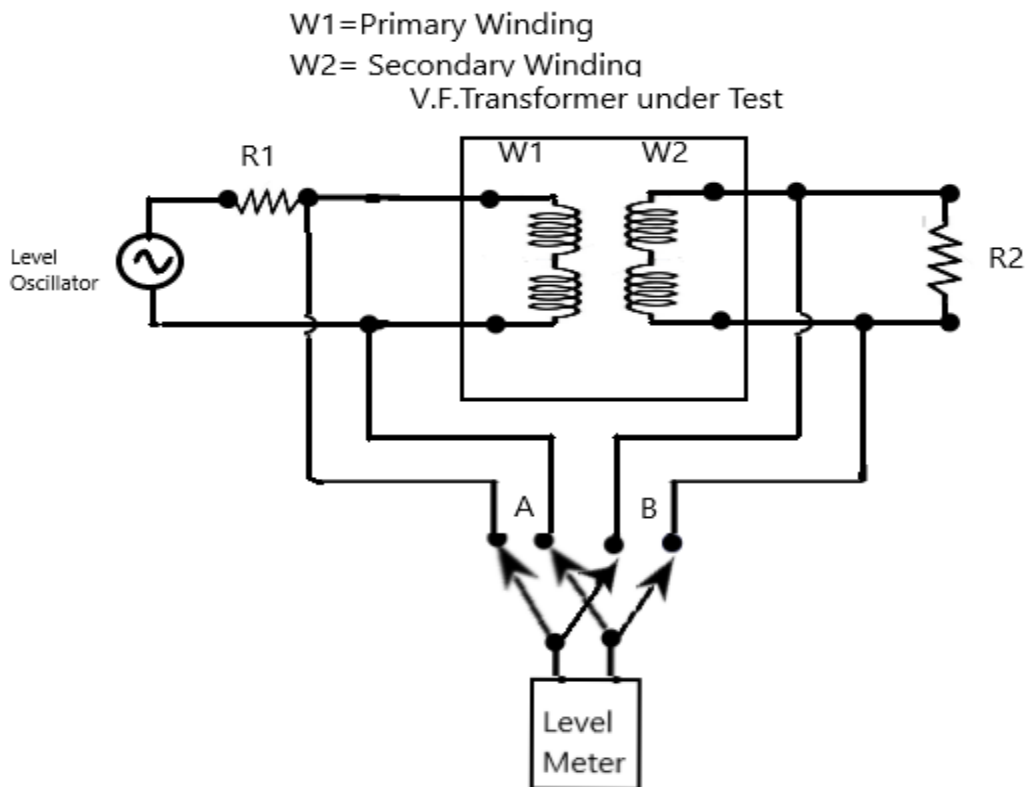
APPENDIX C
(Clause 6.10.1)

INSERTION LOSS MEASUREMENT OF V.F. TRANSFORMER

C-1 Equipment required:

- a. Low impedance level oscillator 100 Hz to 5 K Hz.
- b. Level meter (high input impedance).
- c. Resistors.
- d. DPDT switch.

C-2 Circuit:



- V_P = Voltage measured on the primary side.
 V_S = Voltage measured on the secondary side.
 R_1 = Resistance equal to the nominal impedance on primary side.
 R_2 = Resistance equal to the nominal impedance on secondary side.

C-3 Results:

The value of insertion loss of the transformer under test is to be calculated from the formula Insertion loss = $20 \log (V_P/V_S) - 10 \log (R_1/R_2)$ dB.

Note: Above measurement shall be made with signal strength at 0 dBm level across the transformer under test.

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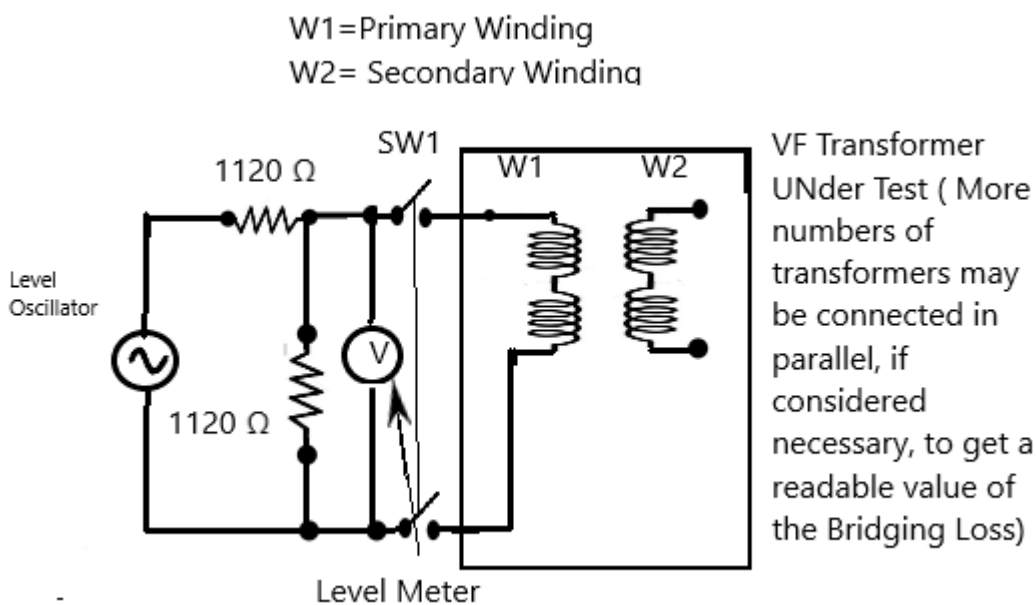
APPENDIX D
(Clause 6.10.1)

BRIDGING LOSS MEASUREMENT OF V.F. TRANSFORMER

D-1 Equipment required:

- a. Low impedance level oscillator 100 Hz to 5 K Hz.
- b. Level meter (high input impedance).
- c. Resistors.
- d. DPDT switch.

D-2 Circuit:



- a) Disconnect the switch SW and note the reading of the level meter in dB.
- b) Connect the switch SW and note the reading of the level meter in dB.

D-3 Result:

The difference in readings (D-2a) and (D-2b) gives the result value of the bridging loss, if there are 'n' Transformers connected in parallel then the difference of reading should be divided by 'n' to get the bridging loss of one transformer.

Note: The above measurement shall be made with signal strength at 0 dBm level across the Transformer under test.

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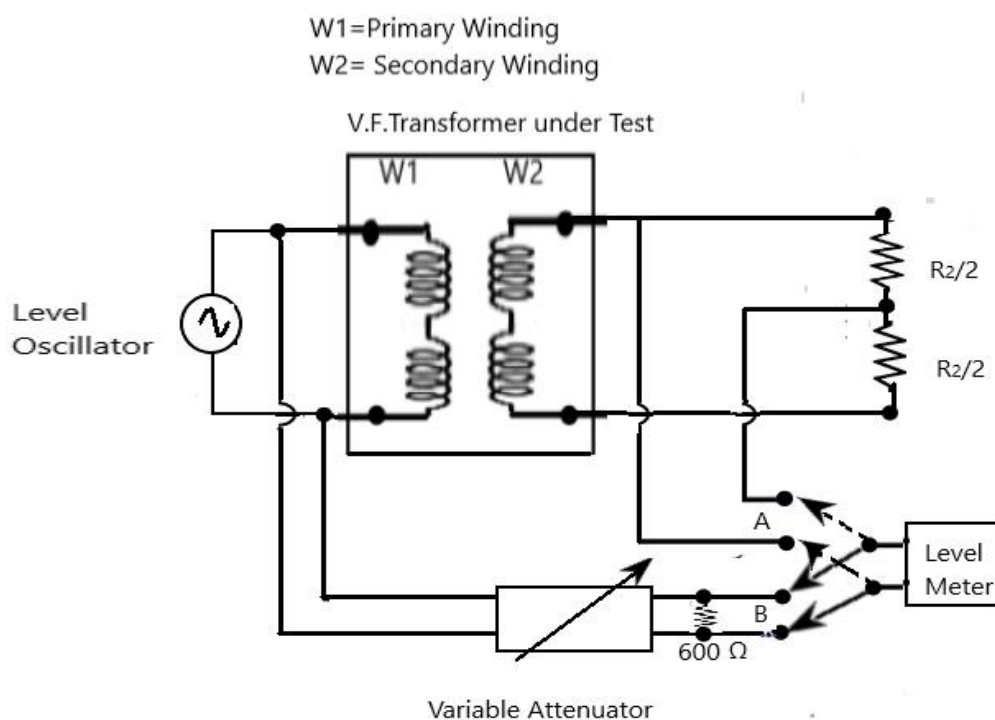
APPENDIX E
(Clause 6.10.1)

MEASUREMENT OF WINDING BALANCE OF V.F. TRANSFORMER

E-1 Equipment required:

- Low impedance level oscillator 100 Hz to 5 K Hz.
- Variable attenuator 0 to 100 dB.
- Level meter (high input impedance).
- Resistors.
- DPDT switch.

E-2 Circuit:



W1 = Primary Winding.

W2 = Secondary Winding.

R₁ = Resistance equal to the nominal impedance on primary side.

R₂ = Resistance equal to the nominal impedance on secondary side.

With switch in position A note the reading indicated by LM, next with the switch in position B vary the attenuator to obtain the same reading of LM. If the value of attenuator reading is bO, then:

Balance between two winding halves of secondary side = $bO + 20 \log_{10} R_2 / R_1 + 3$ dB.

Similarly the balance of two winding halves of primary side = $bO + 20 \log_{10} R_2 / R_1 + 3$ dB.

Note: The above measurement shall be made with signal strength of 0 dBm level across the transformer under test.

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APPENDIX-F
(Clause 4.2)

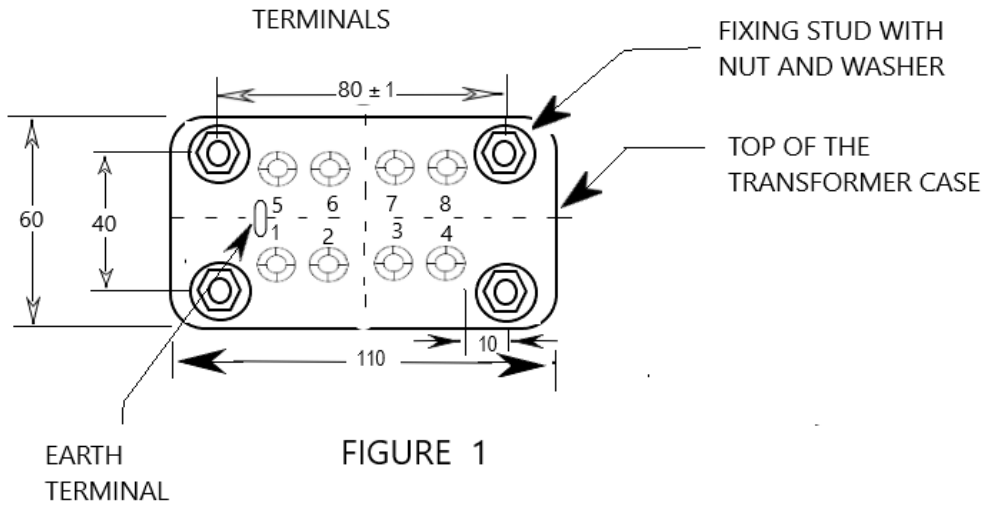


FIGURE 1

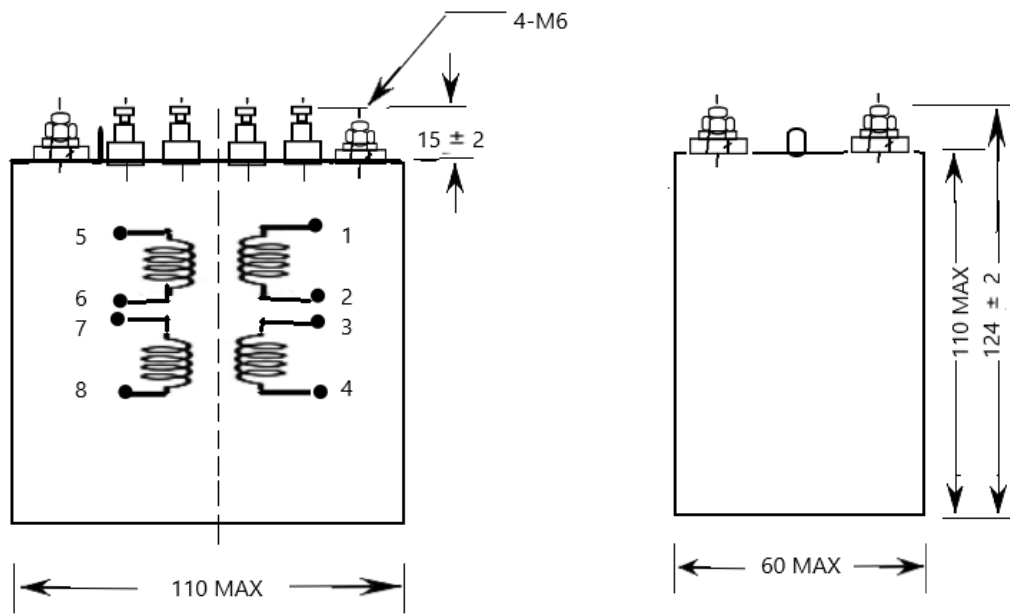


FIGURE 2

- NOTE: 1. ALL DIMENSIONS ARE IN MILIMETER
2. THE FIXING ARRANGEMENT SHALL BE AS SHOWN IN FIGURE 1

DIMENSIONAL DRAWING FOR V.F. & 50 Hz SIGNALLING TRANSFORMERS