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HIGH-POWER WIDE-BAND TRANSFORMERS

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IEEE Standard for

HIGH-POWER WIDE-BAND TRANSFORMERS

1. SCOPE

This publication pertains to wide-band transformers, transmitting power of more than 100 watts.* Guides to application and test procedures are included. Appendices contain certain precautions and recommended practices. Provision is made for including data for use in the design of feedback amplifiers and control networks or other circuits in which knowledge of the transformer amplitude- and phase-frequency response is needed by the system designer. These transformers are required to transform voltage within specified tolerances of amplitude and phase when operating between specified impedances.

1.1 Specific types to which this Standard applies are as follows:

1.1.1 *Power Audio-Frequency Transformers* are operated from amplifier tube sources. The fundamental full power frequency range will normally fall within the band of 20-20,000 cycles per second. Performance characteristics one or more octaves beyond the specified range may be of interest and specified. Feedback windings or screen-grid windings or taps may be incorporated in the design.

The performance of these transformers is generally expected to be uniform over the specified range and not be the cause of undue distortion of the input wave shape.

1.1.2 *Transducer Service Transformers* normally require a step-down ratio transformer having one or more secondary windings with or without taps. The load impedance may be permitted to vary with frequency, or with other parameters, but the transformer performance is generally based on a specific load impedance.

1.1.3 *Random-Noise Transformers* are used in vibration machine applications. They are subject to random signals of varying amplitude and duration. Response may be expressed in terms of frequency spectrum but the amplitude variation allowable over the relevant frequency range is much greater than for audio transformers because of the Gaussian distribution of random noise. Random noise transformers are often included in feedback loops. When included in such a loop, their amplitude and phase response is of interest and all of the problems listed in Appendix VII must be solved in addition to producing a transformer capable of handling the amplitude of random noise.

1.1.4 *Modulation Transformers* are used in amplitude-modulated transmitters employing a modulation inductor (reactor) to bypass the final amplifier plate current. They are also used where the secondary carries the final amplifier plate current.

The transformer is used in a manner which makes it a part of a capacitance, resistance, and inductance network and it must have characteristics which permit it to match the network for proper over-all system performance. Phase angle, frequency response, and impedances are important measurements and are required to be made in the actual or substitute network with major elements in place to establish performance. Modulation transformers are usually designed for specific applications and large units are not considered suitable for general purpose use.

1.1.5 *Driver Transformers* are used to supply power to the grids of Class AB_2 and Class B amplifier tubes.

1.1.6 *Line-Matching Transformers* are used where power is received at one impedance level and delivered at another.

1.1.7 *Load-Matching Autotransformers* are used where power is received at one impedance level and provides output taps at various impedances, or vice versa.

1.1.8 *Control-System Transformers* are used in open- or closed-loop (feedback) control systems. The transformers used in the closed-loop system are subject to signals of a definite carrier frequency, modulated in accordance with error signals imposed by the control system requirements. The response of these transformers to control signals may be expressed either in terms of frequency and phase or in Laplace terms. In this Standard the phase and amplitude frequency response concepts are used.

1.1.9 *Ultrasonic Transformers* are used in various communication and industrial applica-

* Except in the cases of modulation transformers and inductors and driver transformers for class AB_2 and class B amplifiers where the power delivered may be less or equal to 100 watts as well as above 100 watts.

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tions, in which the lowest frequency is higher than 10 kilocycles per second.

1.1.10 *Carrier Transformers* transmit signals of specified frequency; which signals are modulated or varied in amplitude, frequency, or phase.

1.1.11 *Video Transformers* are characterized by an exceptionally wide-band transmission characteristic over part or all of the range from 10 cycles per second to 10 megacycles per second.

1.1.12 *Power Transistor Source Audio Transformers* are operated from solid-state power source devices. The use of Class AB or Class B current operation must be recognized.

1.1.13 *Inductors* (*Reactors*) are used in wide-band circuits. The required degree of linearity and self-resonance must be specified.

1.2 *Related Transformer Standards*

1.2.1 Standard for the Low-Power Wide-Band Transformer (IEEE No. 111, August 1964).

1.2.2 Proposed Standard for Narrow-Band Transformers (under preparation).

1.2.3 Corona Standard (under study).

1.2.4 Standard on Electric Strength Testing (under preparation).

1.2.5 Transformer Impulse Tests—IEEE No. 93.

2. DEFINITIONS

Electrical terms used in this Standard shall be in accordance with those given in the American Standards on Definitions of Electrical Terms, ASA C42.25-1956, C42.65-1957, and Proposed Definitions for Electronic Transformer Terms (under preparation).

2.1 *Control System*—A system in which a desired effect is achieved by operating on various inputs to the system until the output, which is a measure of the desired effect, falls within an acceptable range of values.

2.2 *Open-Loop Control System*—A system in which the controlled quantity is permitted to vary in accordance with the inherent characteristics of the control system and the controlled power apparatus for any given adjustment of the controller.

2.3 *Closed-Loop System* (Feedback Control System)—A system in which the controlled quantity is measured and compared with a standard representing the desired performance. Any deviation from the standard is fed back into the control system in such a sense that it will reduce the deviation of the controlled quantity from the standard.

2.4 *Transfer Function*—The complex ratio of the output of the device to its input. It is also the combined phase and frequency responses (See Figure 3).

3. SYMBOLS AS USED IN THIS STANDARD

Symbol	*Term Denoted*
a	Ratio of secondary to primary turns $\frac{N_2}{N_1}$ or $\frac{N_s}{N_p}$
A, B, C	Bridge corner designation.
C_A, C_D	Capacitance connected to bridge corner A and D respectively.
C_{AB}	Capacitance connected between bridge corners A and B.
C_p	Distributed capacitance of primary winding.
C_s	Distributed capacitance of secondary winding.
C_{sh}	Effective parallel capacitance.
d	$\sqrt{\frac{Y''_{sc}}{Y'_{sc}}} = \sqrt{\frac{Z_{sc}}{Z''_{sc}}}$
D	Bridge corner designation
E_{a-c}	Variable alternating-current power sources.
E_o	Output voltage.
E_I	Input voltage.
f	Frequency.
F_1	Low frequency 1 dB point, minimum response.
F_2	High frequency 1 dB point, minimum response.
F_{MB}	$\sqrt{F_1 F_2}$ Mid-band frequency.
G_{AB}	Conductance connected between bridge corners A and B.
G_{sh}	Conductance $1/R_{sh}$.
k	$\sqrt{1-\frac{Z_{sc}}{Z_{oc}}} = \sqrt{1-\frac{Y_{oc}}{Y_{sc}}}$

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l_p	Primary leakage inductance
l_s	Secondary leakage inductance.
L_{sh}	Inductance in shunt or parallel representation of a complex impedance.
L_{ser}	Inductance in series representation of a complex impedance.
L_{Xser}	Inductance in series representation of unknown impedance being determined by bridge measurement.
L_{Xsh}	Inductance in shunt representation of unknown impedance being determined by bridge measurement.
N_1	Primary turns.
N_2	Secondary turns.
PWV	Peak working voltage.
Q	$2\pi f\, L_{ser}/R_{ser} = R_{sh}/2\pi f\, L_{sh}$
r	Winding resistance at reference temperature t.
r_p	Primary winding resistance.
r_s	Secondary winding resistance.
R	Winding resistance at winding temperature T.
R_1, R_2, R_3, R_4	Terminating resistance.
R_A, R_B	Resistance connected to bridge corner A and B respectively.
R_{AD}, R_{AB}, R_{BC}	Resistance connected between bridge corners A and D, A and B B and C respectively.
R_L	Load resistance.
R_s	Source resistance.
R_{sh}	Resistance in shunt or parallel representation of a complex impedance.
R_{ser}	Resistance in series representation of a complex impedance.
R_{Xser}	Resistance in series representation of unknown impedance being determined by bridge measurement.
R_{Xsh}	Resistance in shunt representation of unknown impedance being determined by bridge measurement.
t	Reference temperature.
T	Temperature of winding.
X_{ser}	Reactance ($= 2\pi f L_{ser}$) in series representation of complex impedance.
X_{sh}	Reactance ($= 2\pi f L_{sh}$) in shunt representation of complex impedance.
Y_{oc}	Open-circuit admittance on primary side.
Y'_{oc}	Open-circuit admittance on secondary side.
Y''_{oc}	Secondary open-circuit admittance referred to primary.
Y'''_{oc}	Primary open-circuit admittance referred to secondary.
Y_{sc}	Short-circuit admittance on primary side.
Y'_{sc}	Short-circuit admittance on secondary side.
Y''_{sc}	Secondary short-circuit admittance referred to primary.
Y'''_{sc}	Primary short-circuit admittance referred to secondary.
Z_L	Load impedance.
Z_s	Source impedance.
Z_{std}	Standard source impedance.
Z_{oc}	Open-circuit impedance on primary side.
Z'_{oc}	Open-circuit impedance on secondary side.
Z''_{oc}	Secondary open-circuit impedance referred to primary.
Z'''_{oc}	Primary open-circuit impedance referred to secondary.
Z_{sc}	Short-circuit impedance on primary side.
Z'_{sc}	Short-circuit impedance on secondary side.
Z''_{sc}	Secondary short-circuit impedance referred to primary.
Z'''_{sc}	Primary short-circuit impedance referred to secondary.

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