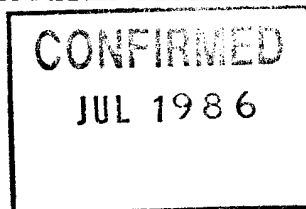


BRITISH STANDARD 9025 : 1970

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CONFIRMED DECEMBER 1980



SPECIFICATION FOR TRAVELLING-WAVE AMPLIFIER TUBES OF ASSESSED QUALITY: GENERIC DATA AND METHODS OF TEST

BS 9025 : 1970
SPECIFICATION FOR
TRAVELLING-WAVE AMPLIFIER
TUBES OF ASSESSED QUALITY:
GENERIC DATA AND
METHODS OF TEST

Incorporating amendments issued July 1971 (AMD 756), February 1972 (AMD 857),
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BRITISH STANDARDS INSTITUTION

Incorporated by Royal Charter

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Committee reference TLE/5 Draft for comment 68/17559

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United Kingdom Atomic Energy Authority

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BRITISH STANDARD SPECIFICATION FOR TRAVELLING-WAVE AMPLIFIER TUBES OF ASSESSED QUALITY : GENERIC DATA AND METHODS OF TEST

FOREWORD

This British Standard which has been prepared under the authority of the Telecommunication Industry Standards Committee is the generic specification for travelling-wave tubes in the system of standards for electronic parts of assessed quality.

SPECIFICATION

1. GENERAL MATTERS

1.1 Scope. This British Standard forms part of the system of common standard specifications for electronic parts of assessed quality and should be read in conjunction with the standards in the series BS 9000 to BS 9009.

It applies to forward travelling-wave amplifier tubes as defined in 1.3 and gives the terms, definitions, symbols, test methods, and other information necessary to implement fully the detail specifications for these parts. It also applies to units consisting of assemblies of travelling-wave amplifier tubes and other subsidiary components which are associated and electrically interconnected such that, for the purposes of specification, testing, commerce and maintenance, each unit is considered indivisible. The material herein shall be applicable only when called up by the detail specification, except for 1.6 to 1.18 which are mandatory requirements.

1.2 Related documents. The following publications are referred to in the text of this British Standard :

- BS 204. Glossary of terms used in telecommunications (including radio) and electronics.
- BS 448. Dimensions of electronic tubes and valves.
- BS 1409. Letter symbols for electronic valves.
- BS 1991. Letter symbols, signs and abbreviations.
- BS 2011. (IEC Publication 68). Methods for the environmental testing of electronic components and electronic equipment.
- BS 3939. Graphical symbols for electrical power, telecommunication and electronic diagrams (see also IEC Publication 117).
- BS 4478. Methods of measurement of intermodulation products in electronic tubes or valves intended for use in colour television transposers.
- BS 9000. General requirements for electronic parts of assessed quality.
- BS 9001. Sampling procedures and tables for inspection by attributes for electronic parts of assessed quality.

1.3 Terminology. For the purpose of this British Standard, the following terms and their definitions apply, in addition to those from BS 204.

(1) *Forward travelling-wave amplifier tube.* A tube in which both the initial velocity modulation of a previously accelerated electron beam and the subsequent extraction of amplified r.f. power from the beam are achieved by interaction of the beam with an electromagnetic wave whose direction of energy propagation (direction of group velocity) along the structure (usually a helix) is the same as the direction of the electron velocity.

(2) *Low noise signal amplifier tube.* A forward travelling-wave amplifier tube where low noise factor is a primary design feature and which is therefore suitable for use in broad-band receivers or other systems where the noise factor is important.

(3) *Noise factor.* The ratio (a) carrier/noise ratio at input to (b) carrier/noise ratio at output.

(4) *Power gain.* The ratio of (a) the output power of an amplifier tube under given conditions to (b) the input power.

(5) *Input power.* The power which is supplied to the input reference plane (or connection) of the amplifier tube.

- (6) *Output power.* The power supplied to a stated load from the output reference plane (or connection) of the amplifier tube.
- (7) *Gain flatness.* The difference between maximum and minimum values of gain over a given range of frequency.
- (8) *Small signal gain.* Gain in the input power range in which a decrease of the driving power has no effect on the gain.
- (9) *Saturation output power.* The first maximum value of output power observed as the input power is gradually increased with the tube operated under stated conditions.
- (10) *Insertion loss.* The attenuation which occurs between the r.f. connections of a microwave amplifier tube under specified conditions.
- (11) *Input or output v.s.w.r.* The v.s.w.r. at the input/output of the amplifier tube observed under stated operating conditions.
- (12) *Mismatch stability and short circuit stability.* The ability of an amplifier tube to operate satisfactorily with the r.f. input and/or output mismatched or short circuited.
- (13) *Frequency range.* The frequency range over which the amplifier tube can be adjusted to meet the stated performance requirements.
- (14) *Slow-wave structure.* An extended circuit network construction, for example a conductive helical winding, so disposed in an electron beam tube that energy from the electrons in the beam is transferred to an electromagnetic wave travelling through the network.
- (15) *Integral magnet tube.* An assembly incorporating the tube focusing system and r.f. connections so that the tube cannot be replaced in the assembly by the user.
- (16) *Periodic permanent magnet focusing.* Magnetic focusing derived from a periodic array of permanent magnets of alternately reversed polarity.
- (17) *Gain linearity.* Gain linearity is the difference between the maximum and the minimum change of gain per unit change of input power (dB) over a specified range of input power when the tube is operating under stated conditions.
- (18) *Hot (or operating) conditions.* Conditions in which supply voltages are applied to the heater or filament and to all electrodes, with or without the application of an r.f. input.
- (19) *Stand-by conditions.* Conditions under which the heater or filament voltage alone is applied to the tube.
- (20) *Cold conditions.* Conditions under which no supply voltages are applied to the tube.
- (21) *Matched load.* A load which theoretically gives rise to a v.s.w.r. of unity. In practice it is necessary to accept a 'mismatched' load which for the purposes of this specification shall not give rise to a v.s.w.r. greater than 1.05:1 over the frequency range of the tube being measured.
- (22) *Focusing.* The means by which the electron beam is constrained to flow through the inter-action region.
- (23) *Mount.* The additional equipment necessary to operate the tube but excluding power supplies.
- (24) *Harmonic output power.* The output power of a microwave amplifier tube at stated harmonic frequencies of the driving signal.
- (25) *Cross-modulation.* The modulating of a wanted signal by an unwanted signal on a different carrier frequency arising from the interaction of the signals due to the non-linear characteristics of the tube.
- (26) *Intermodulation.* The modulation of the components of a frequency spectrum by each other in a non-linear system, resulting in the generation of new frequency components.
- (27) *AM-PM conversion coefficient.* The rate of change of (a) the phase of the output voltage relative to the r.f. input voltage with respect to (b) the r.f. driving power at a continuous mean value of r.f. output power.
- (28) *Phase sensitivity to voltage or current.* The rate of change of (a) the phase of the r.f. output voltage relative to the r.f. input voltage with respect to (b) the voltage or current of a specified electrode, whilst the driving power and all the other operating voltages are maintained constant.

(29) *Stability*. The ability of an amplifier tube, when operated under stated conditions, to re-establish its original performance after an interruption of the h.t. supply. The change in performance is usually expressed as a percentage of the initial value.

NOTE. This may apply to phase or power.

(30) *Instantaneous bandwidth or operating band*. The frequency range over which the amplifier tube meets the specified performance requirements under specified fixed operating conditions.

1.4 Letter symbols, signs and abbreviations. For the purposes of this standard and specifications associated with it the following symbols apply in addition to those specified in BS 1991:

Helix voltage = V_{hel}

Collector voltage = V_{col}

Helix current = I_{hel}

Collector current = I_{col}

Noise factor = F

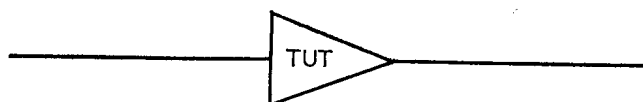
Saturation output power = $P_{\text{o(sat)}}$

Gain flatness = ΔG

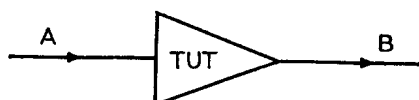
Tube under test = TUT

1.5 Graphical symbols. For the purposes of this standard, graphical symbols shall be in accordance with BS 3939.

The graphical symbol for the tube under test (TUT) in the following test methods is as shown below:



The r.f. input to the travelling-wave amplifier tube shall be in the direction of Arrow A and the r.f. amplified output shall be in the direction of Arrow B:



1.6 Marking of the tube and packing. The following symbols or codes shall be clearly and durably marked on the tube in the following order of preference as space permits. All symbols and codes except terminal marking and operating conditions shall also appear on the primary pack, e.g. carton, box, plastic envelope, etc., used as initial protection or wrapping for delivery:

- (1) Manufacturer's part designation number and special marking related to hazard and special operating conditions.
- (2) Manufacturer's factory identification code.
- (3) Date code.
- (4) BS number of the detail specification.

1.7 Eligibility for qualification approval. The first stage of processing in accordance with 2.3.2(3) of BS 9000 is: Activation or formation of the cathode; all joining together of piece parts.

The use of 2.3.2(3)(ii) of BS 9000 is excluded.

1.8 Structurally similar tubes. When several variants of any one type are being produced simultaneously, or in uninterrupted succession, the total production may be sampled for all common features and characteristics but each of the variant types shall be fully inspected, in accordance with the relevant detail specification with regard to the deliberately varying feature or features.

Such tubes should preferably be included on the same detail specification but in any case the claim for grouping shall be declared in the qualification approval test report.

1.9

When simultaneous or successive production is proceeding on several types of tube having common features, those common features may be sampled from the complete range of types instead of from each lot of each type.

1.9 Delayed delivery. Tubes held by the manufacturer for a period exceeding twelve months following acceptance inspection shall be re-examined for all Group A, subgroup A2 requirements prior to release.

1.10 Supplementary procedure for qualification approval. The following table supersedes the sample size requirements of 2.3.1 of BS 9000 : Part 1. When using the table a second sample, as shown, shall be taken when the quantity of rejects exceeds the acceptance quantity but is less than the reject quantity.

Group	Lot size	Sample size	Accept	Reject	2nd sample	Total sample	Accept	Reject
A	1-5	100 % (see Note)	0	1				
	6-280	5	0	2	3	8	1	2
B	1-5	100 % (see Note)	0	1				
	6-280	5	0	2	3	8	1	2
<i>Subgroup</i>								
C1	1-5	100 % (see Note)	0	1				
	6-280	5	1	2				
C2	As for C1							
C3	1-5	2 (see Note)	0	1				
	6-280	2	0	2	2	4	1	2
C4	1-5	2 (see Note)	0	1				
	6-280	2	0	1				
C5	1-3	100 % (see Note)	0	1				
	4-280	3	0	2	2	5	1	2
D1	1-5	100 % (see Note)	0	1				
	6-280	5	0	2	3	8	1	2
D2	1-5	100 % (see Note)	0	1				
	6-280	5	0	2	3	8	1	2
D3	1-280	2 (see Note)	0	2	2	4	1	2
D4	As for D3							
D5	(Endurance) As specified							

NOTE. Qualification approval depends on at least two tubes being tested.

1.11 Certified test records. The requirements of 2.8 of BS 9000 : Part 1 shall apply.

1.12 Standard ratings and characteristics. Not applicable.

1.13 Unchecked parameters. Not applicable.

1.14 Procedure to be followed in the event of failure at Group C or D inspection. The requirements of 2.6.4.1 and 2.6.4.2 of BS 9000 : Part 1 shall apply.

1.15 Ordering information. This will be found in the appropriate detail specification.

1.16 Release prior to completion of Group B tests. Not applicable.

1.17 Inspection procedures for low rates of production. Where the production rates are low, with the result that lots are acceptable on zero rejects the alternative procedure in 2.5.12 of BS 9000 : Part 1 shall apply.

1.18 Continuous production. This shall be defined as in 2.5.1.1(5) of BS 9000 : Part 1, except that in (iii) of that subclause the period shall be increased to six months.

2. TEST PROCEDURES

2.1 Test and measurement conditions. All tests and measurements shall be carried out under the standard atmospheric conditions for testing as specified in 5.3 of BS 2011, Part 1.

The limits quoted in detail specifications are absolute. Tolerances of measurements shall be taken into account when determining the actual limits.

2.2 Visual inspection. Unless otherwise specified, visual inspection shall be performed under normal factory lighting conditions and without visual aids.

Visual inspection shall be carried out for good appearance and workmanship, and shall include the following items where applicable:

Shape.

Alignment of connectors.

Straightness of pins or leads.

Freedom from loose elements.

Clarity of marking.

Correctness of marking including marked values.

Position of marking.

Finish.

Material (the materials and finish for external parts shall be seen to conform with the requirements of the detail specification and/or the quality of the qualification approval samples).

2.3 Dimensions and gauging procedures. Dimensional measurements shall be carried out either by the use of conventional measuring instruments (vernier calipers, rules, micrometers, etc.) or by gauges. Gauges shall be in accordance with BS 448 where applicable or shall have dimensions and characteristics which conform with the requirements given on the inspection drawing of the tube. Tolerances or dimensions shall be in accordance with BS 308. All drawings shall state the projection used.

2.4 Electrical test procedures

2.4.1 Alternative methods of test. See 2.4.2 of BS 9000 : Part 1.

2.4.2 Measuring equipment. All microwave measuring equipment shall be verified to ensure satisfactory operation over the required frequency band. This should be carried out using swept frequency techniques.

2.4.3

The measuring equipment shall be such that the time constants or pulse response characteristics shall not significantly affect the measurement results.

Care shall be taken to ensure that any stray electromagnetic fields do not significantly affect the measurement results.

2.4.3 Temperature measurement. Where the measurement of temperature is required for operating conditions, the body temperature of the tube shall be measured when the temperature at all parts of the tube has reached equilibrium conditions.

2.4.4 Forced cooling. When forced cooling is required the following shall be checked:

- (1) Type of coolant.
- (2) Method of application.
- (3) Rate of flow, or pressure difference between inlet and outlet at stated ambient conditions.
- (4) Limits of inlet temperature.
- (5) Maximum permitted body temperature of the tube at a stated point.

2.4.5 Pressurizing. Where pressurizing is required, the following items shall receive attention before and during operation of the tube:

- (1) The system shall be clean and free from condensation and be capable of adequate sealing to maintain gas purity.
- (2) The minimum or maximum limits of gas pressure to which the microwave components can be subjected without damage or mechanical distortion, shall be observed.
- (3) The nature, purity, dryness and temperature of the gas shall be within stated limits.

2.4.6 Reference point. Unless otherwise stated the polarity of all voltages applied to the electrodes shall be relative to the cathode.

2.4.7 V.S.W.R. measurement. Voltage standing wave ratios are expressed as a value greater than 1.

2.4.8 R.F. loads. The r.f. load shall not cause a v.s.w.r. exceeding 1.05:1 over the specified frequency band.

2.4.9 General. The following general procedures shall be followed:

- (1) The manufacturer's setting-up procedure shall be rigorously adhered to.
- (2) The tube shall not be operated without the focusing arrangement associated with it.
- (3) The signal source shall be sufficiently decoupled from its load.
- (4) The harmonic content of the input signal shall not significantly affect the accuracy of measurement.
- (5) Screening shall be provided where stray r.f. radiation is likely to affect the measurements.
- (6) Isolators may be required at the input and output of the tube under test.

2.4.10 Index of test methods. For convenience of identification in detail specifications the following numbering system for test methods has been used. These methods follow 2.7.3 of this standard.

Title	Method
Gain	1001
Gain flatness	1002
Noise factor	1003
Noise factor	1004
Saturation output power	1005
Amplitude modulation	1006
R.F. leakage	1007
R.F. pickup	1008
R.F. isolation	1009
Input and output v.s.w.r.	1010
Operating loss (hot reverse attenuation)	1011
Mismatch stability and short circuit stability	1012
Effect of external magnetic shielding	1013

2.4.11

Title	Method
Gain linearity	1014
Output power variation and gain variation	1015
Input and output power	1016
Power bandwidth	1017
Insertion loss	1018
Phase shift	1019
Phase linearity with frequency	1020
Phase sensitivity	1021
Phase stability	1022
Gross modulation	1023
Intermodulation	1024

NOTE. In these test methods and in the absence of any indication to the contrary, the term 'tube under test' (TUT) includes the mount.

2.4.11 Electrode numbering. With the exception of the slow wave structure (helix) collector and cathode, all electrodes are termed grids and are numbered 1, 2, 3, etc., according to their position relative to the cathode, the lowest number being closest to the cathode.

2.4.11 Colour code for flying leads. The following code is to be used with travelling-wave tubes equipped with flying leads:

Body colour	Tracer colour	Tube elements
Black	None	Earth, or earthed elements
Yellow	None	Cathode also heater cathode lead if common
Brown	None	Heaters or filament off cathode
Brown	Yellow	Heater internally connected to cathode, if additional to cathode lead
Red	None	Collector
Orange	None	Slow wave structure (Helix) 1
Orange	Green	Slow wave structure (Helix) 2
Orange	Blue	Slow wave structure (Helix) 3
Orange	Grey	Slow wave structure (Helix) 4
Green	None	Grid 1
Blue	None	Grid 2
Grey	None	Grid 3
White	None	Grid 4
Green	Black	Grid 5
Blue	Black	Grid 6
Grey	Black	Grid 7
White	Black	Grid 8

2.4.13 Reference frequency tolerance. For general measurement the allowable tolerance for the reference frequency is $\pm 0.1\%$.

Where it is desired to convert frequency to wavelength, the value $c = 299.8 \times 10^6$ m/s shall be used.

2.4.14 Power supplies for testing power tubes. Unless otherwise stated in the setting-up procedures in the detail specification:

- (1) The electrode d.c. supply voltages shall be within $\pm 2\%$ of the specified (or marked) values;
- (2) The stability (long term variation) and ripple (short term variation) of the electrode supply voltages shall not exceed the following:

Slow wave structure (Helix) voltage	Stability better than $\pm 0.5\%$. Peak-to-peak ripple less than 0.5% .
Collector voltage	Stability better than $\pm 2\%$. Peak-to-peak ripple less than 1% .
Other grid voltages	Stability better than $\pm 1\%$. Peak-to-peak ripple less than 0.5% .
For tubes with solenoids:	
Solenoid current	Stability better than $\pm 5\%$. Peak-to-peak ripple less than 2% .

2.5 Mechanical test procedures. None are applicable.

2.6 Environmental test procedures. The following tests shall be performed as required by the detail specification which shall state the severity and whether or not the test is destructive. Tests specified in 2.6.2 to 2.6.11 refer to BS 2011.

2.6.1 Magnetic influence

2.6.1.1 Purpose. The purpose of the test is to determine the ability of a tube to survive in a given magnetic field.

2.6.1.2 Procedure. The specified tests shall first be performed to determine the performance of the tube. It shall then be immersed non-operating into a magnetic field of given strength and direction for a stated period.

The tube shall then be removed from the magnetic field and the specified tests shall be performed to measure any change in its performance.

2.6.1.3 Specified conditions. The values of the following conditions are given in the detail specification.

- (1) The direction and strength of the magnetic field.
- (2) Tests to be performed before and after immersion in the magnetic field.

2.6.2 Test Na. Rapid change of temperature. The tube shall be non-operating and the duration at each extreme temperature shall be as given in the following table:

Mass of tube	Minimum period
kg	h
0.15 and less	0.5
Above 0.15 to 1.5 incl.	1.0
Above 1.5 to 15 incl.	2.0
Above 15 to 150 incl.	4.0

Where the required changes in temperature can be achieved with one chamber, this is permissible.
The preferred number of cycles is five.

2.6.3 Test C. Damp heat. The drying conditions shall be in accordance with the detail specification.
The marking shall be legible at the completion of the test.

2.6.4 Test D. Accelerated damp heat (cyclic). The drying conditions shall be in accordance with the detail specification.

The preferred number of cycles is two.

2.6.5 Test Ea. Shock. The preferred severities are those values shown in BS 2011 : Part 2Ea with the addition of 147 m/s² for 3 ms.

The wave shape shall be 'half sine' unless otherwise specified in the detail specification.

2.6.6 Test Fc. Vibration (swept frequency). This test shall be performed in accordance with Procedure B4.

2.6.7 Test Fc. Vibration (fixed frequency). This test shall be performed in accordance with Procedure B2.

2.6.8. Test K. Salt mist. The preferred severity is Severity 2.

2.6.9. Test U. Robustness of terminations

2.6.9.1 Purpose. The purpose of the test is to determine the ability of terminations to withstand the mechanical strains likely to be applied during normal assembly of the tube into the equipment.

2.6.9.2 Procedure. The following tests shall be applied as appropriate:

- (1) *Torque.* Test Ud.
- (2) *Tensile.* Test Ua.
- (3) *Bending.* Test Ub.

2.6.10

The loading to nominal wire size shall be as shown in the table:

Nominal wire size (diam.)	Mass
mm	kg
Up to and including 0.5	0.25
Above 0.5 and up to 0.8	0.5
Above 0.8 and up to 1.25	1.0
Above 1.25	2.5

NOTE. Tests for r.f. connectors and waveguide are under consideration.

2.6.10 Test A. Low temperature. The severity shall be as stated in the detail specification.

2.6.11 Test B. Dry heat. The severity shall be as stated in the detail specification.

2.6.12 Test Eb. Bump. The severity shall be as stated in the detail specification.

2.7 Endurance test procedures

2.7.1 Non-operating endurance test (holding test). After completion of manufacture all tubes shall be held in storage for a specified holding period during which they shall not be operated.

Where holding period is not specified in the detail specification the tubes shall undergo a minimum holding period of 48 h duration.

2.7.1.1 Specified conditions. The values of the following conditions are given in the detail specification:

- (1) Tests to be performed before the holding period.
- (2) Test to be performed after the holding period.
- (3) Duration of holding period if other than 48 h.
- (4) Environmental conditions during the holding period if other than standard atmospheric.

2.7.2 Non-operating endurance test (storage test). Where storage is prescribed the period shall be twelve months under standard atmospheric conditions for testing as given in BS 2011 : Part 1.

2.7.3 Operating endurance test. The tube shall be set up and operated in accordance with the setting-up procedure given in the detail specification.

Unless otherwise specified, tubes undergoing life test shall be measured at the following time intervals:

0 h, 160 h, 500 h, 1000 h (these are minimum)

and thereafter at 1000 h intervals, to within + 48 h and – 24 h.

The manufacturer may perform measurements at additional time intervals at his own discretion.

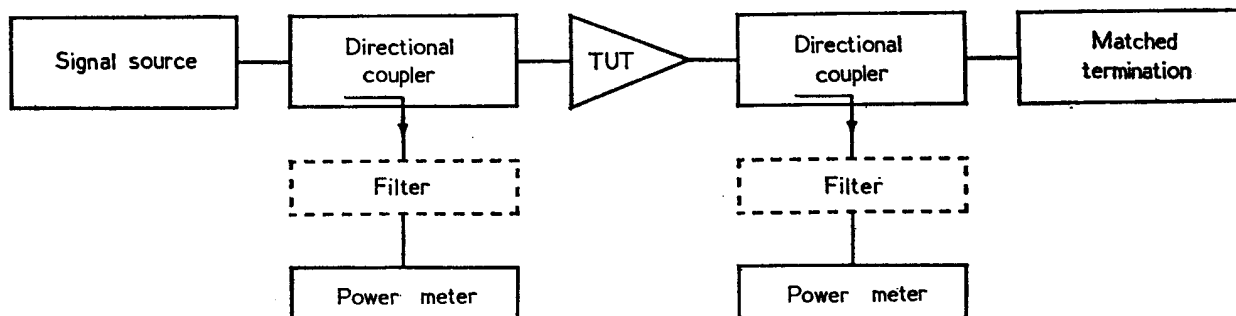
Rejects for those characteristics which are not the subject of post endurance tests may be used for this test.

GAIN

Purpose. To measure gain at a stated input or output power and at stated frequencies.

Method A

Test circuit



Procedure. The input power shall be adjusted to obtain either the specified input or output power and the gain shall be computed from:

$$G = 10 \log_{10} \frac{P_o}{P_i}$$

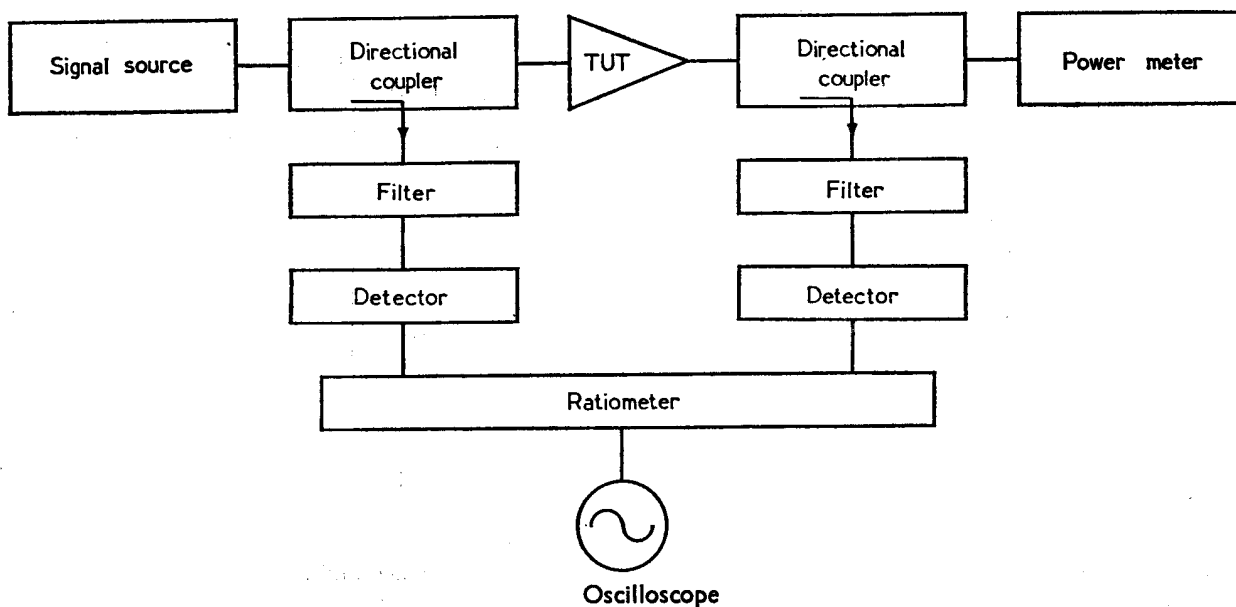
where G = gain in decibels

P_i = input power in watts

P_o = output power in watts

Method B

Test circuit



Procedure. The input power shall be adjusted to obtain either the specified input or output power.

The gain shall be computed from:

$$G = \text{dB}_R - \text{dB}_i + \text{dB}_o$$

1001/2

where G = gain of tube in decibels

dB_R = ratio, in decibels, determined by the ratiometer,

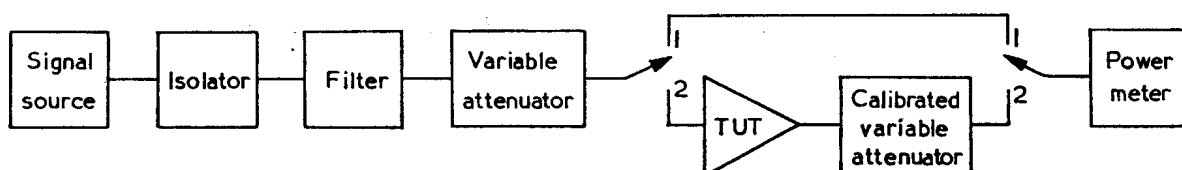
dB_1 = ratio, in decibels, of the tube input power to that portion of the tube input power fed to ratiometer,

dB_0 = ratio in decibels of the tube output power to that portion of the output power fed to the ratiometer (the sum in decibels of the losses of the directional coupler and filter (if fitted)).

Method C (low power tubes)

NOTE: This test may be used instead of Methods A or B for low power tubes.

Test circuit



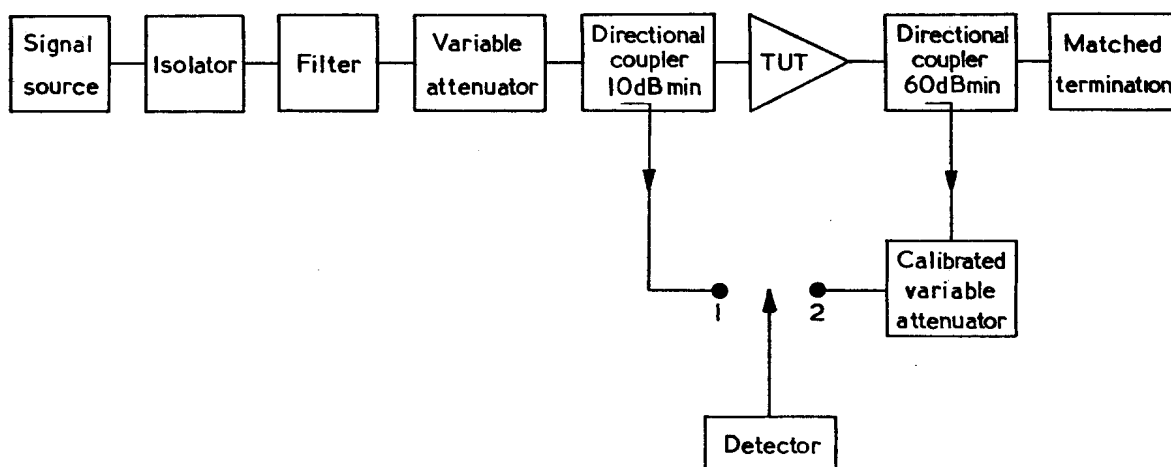
Procedure. With both switches in position 1, the variable attenuator shall be adjusted to give the specified input conditions as read on the power meter. The calibrated variable attenuator shall be set to zero.

With both switches in position 2 and the tube operating under the specified conditions, adjust the calibrated variable attenuator to produce the original reading on the power meter.

The attenuation introduced by the calibrated variable attenuator is equal to the gain of the tube.

Method D (high power tubes)

Test circuit



Procedure. With the switch in position 1, set the input conditions as specified and note the detector level.

With the switch in position 2, adjust the calibrated variable attenuator to obtain the same level on the detector.

The attenuation introduced by the calibrated variable attenuator plus the difference in attenuation of the two directional couplers, is equal to the gain of the tube.

Precautions (applicable to all methods). Where second harmonics may significantly affect the result appropriate filters shall be used.

In the case of high gain broad-band amplifiers, the broad-band noise power output of the tube may significantly affect the results of measurements. Spurious output signals can also be of significant magnitude. Simple subtraction of the noise or spurious contributions to the output power can give an incorrect result. In this case band limiting filters shall be used ahead of power measuring devices.

Conditions prescribed in the detail specification

- (1) Electrode voltages/currents.
- (2) Frequencies at which gain shall be evaluated.
- (3) Input or output power.

