มาตรฐานผลิตภัณฑ์อุตสาหกรรม

THAI INDUSTRIAL STANDARD

มอก. 1612 เล่ม 1 ตอนที่ 3 – 2552

IEC 169 – 1 – 3(1988)

(Amendment 1(1996))

ขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ

เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด

ส่วนที่ 3 กระบวนการทดสอบและวัดทางไฟฟ้า : ประสิทธิผลการกรอง

RADIO FREQUENCY CONNECTORS

PART 1 : GENERAL REQUIREMENTS AND MEASURING METHODS

SECTION THREE - ELECTRICAL TESTS AND MEASURING PROCEDURES : SCREENING EFFECTIVENESS

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม ICS 33.120.30 ISBN 978-616-231-271-7

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
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สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม
กระทรวงอุตสาหกรรม ถนนพระรามที่ 6 กรุงเทพฯ 10400
โทรศัพท์ 02 202 3300

ประกาศในราชกิจจานุเบกษา ฉบับประกาศและงานทั่วไป เล่ม 127 ตอนพิเศษ 136ง
วันที่ 26 พฤศจิกายน พุทธศักราช 2553

มาตรฐานผลิตภัณฑ์อุตสาหกรรมขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด ส่วนที่ 3 กระบวนการทดสอบและวัดทางไฟฟ้า: ประสิทธิผลการกรอง ได้ประกาศใช้ครั้งแรกโดยรับ IEC 169-1-3 (1998) (Amendment 1(1996)) Radio frequency connectors-Part1: General requirement and measuring methods-Section Three-Electrical tests and measuring procedures: Screening effectiveness มาใช้ในระดับเหมือนกันทุกประการ (Identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก โดยประกาศในราชกิจจานุเบกษา ฉบับประกาศทั่วไป เล่มที่116 ตอนพิเศษที่ 108ง วันที่ 27 ธันวาคม พุทธศักราช 2543

เนื่องจาก IEC ได้แก้ไขปรับปรุงมาตรฐาน IEC 169-1-3 (1998) (Amendment 1(1996)) เป็น IEC 60169-1-3 (1998) (Amendment 1(1996)) จึงได้ยกเลิกมาตรฐานเดิมและกำหนดมาตรฐานใหม่โดยรับ IEC 60169-1-3 (1998) (Amendment 1(1996)) Radio frequency connectors-Part 1: General requirement and measuring methods-Section Three-Electrical tests and measuring procedures: Screening effectiveness มาใช้ในระดับเหมือนกันทุกประการโดยใช้มาตรฐาน IEC ฉบับภาษาอังกฤษเป็นหลัก

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 4239 (พ.ศ. 2553)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง ยกเลิกและกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

ขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ

เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด

ตอนที่ 3 กระบวนการทดสอบและวัดทางไฟฟ้า : ประสิทธิผลการกรอง

โดยที่เป็นการสมควรปรับปรุงมาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด ตอนที่ 3 กระบวนการทดสอบและวัดทางไฟฟ้า : ประสิทธิผลการกรอง มาตรฐานเลขที่ มอก.1612 เล่ม 1 ตอนที่ 3-2541

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศยกเลิกประกาศกระทรวงอุตสาหกรรม ฉบับที่ 2522 (พ.ศ.2542) ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ.2511 เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด ตอนที่ 3 กระบวนการทดสอบและวัดทางไฟฟ้า : ประสิทธิผลการกรอง ลงวันที่ 26 สิงหาคม พ.ศ.2542 และออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด ตอนที่ 3 กระบวนการทดสอบและวัดทางไฟฟ้า : ประสิทธิผลการกรอง มาตรฐานเลขที่ มอก.1612 เล่ม 1 ตอนที่ 3-2552 ขึ้นใหม่ ดังมีรายละเอียดต่อท้ายประกาศนี้

ทั้งนี้ให้มีผลตั้งแต่วันถัดจากวันที่ประกาศในราชกิจจานุเบกษา เป็นต้นไป

ประกาศ ณ วันที่ 31 สิงหาคม พ.ศ. 2553

ชัยวุฒิ บรรณวัฒน์

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ขั้วต่อสำหรับใช้ในงานรับส่งคลื่นความถี่วิทยุ
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มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ IEC 169-1-3 (1998) (Amendment 1(1996)) Radio frequency connectors-Part1: General requirements and measuring methods-Section Three-Electrical tests and measuring procedures: Screening effectivenessมาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ กำหนดวิธีทดสอบและวัดทางไฟฟ้า: ตัวประกอบการสะท้อนกลับเพื่อใช้ประกอบกับ มาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใช้ในงาน รับส่งความถี่วิทยุ เล่ม 1 ข้อกำหนดทั่วไปและวิธีวัด รายละเอียดให้เป็นไปตาม IEC 169-1-3(1988) (Amendment 1(1996))รายละเอียดให้เป็นไปตาม IEC 169-1-3 (1998) (Amendment 1(1996))

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RADIO-FREQUENCY CONNECTORS

Part 1 : General requirements and measuring methods
Section Three — Electrical tests and measuring procedures: Screening effectiveness

FOREWORD

1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.

2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.

3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendation and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This standard has been prepared by Sub-Committee 46D: Connectors for R.F. Cables, of IEC Technical Committee No. 46: Cables, Wires and Waveguides for Telecommunication Equipment.

This standard forms Section Three of the second edition of IEC Publication 169-1 and consists of the completely revised Sub-clause 14.8: Screening effectiveness, of the first edition (1965). It should be used in conjunction with Part 1 (Publication 169-1).

As mentioned in the Preface to the second edition of Part 1: General Requirements and Measuring Methods, this new edition uses the same general layout as the first edition, with the same numbering of the subject clauses, in order to maintain compatibility with the clause numbering in the existing parts: the sectional specifications.

For convenience, however, some clauses or sub-clauses dealing with recently prepared or completely revised standardization subjects are issued in separate sections.

The text of this standard is based on the following documents:

Six Months' Rule	Report on Voting
46D(CO)109	46D(CO)125

Full information on the voting for the approval of this standard can be found in the Voting Report indicated in the above table.

The following IEC publication is quoted in this standard:

Publication No. 169-1 (1987): Radio-frequency Connectors, Part 1: General Requirements and Measuring Methods.

RADIO-FREQUENCY CONNECTORS

Part 1: General requirements and measuring methods
Section Three — Electrical tests and measuring procedures: Screening effectiveness

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14.8 *Screening effectiveness*

14.8.1 *General considerations*

Screening effectiveness in the context of radio-frequency coaxial transmission lines is the ability of the outer conductor to protect the transmission line from being disturbed by outside electromagnetic fields, and vice-versa. With respect to r.f. coaxial connectors a longitudinal current flowing on the outer shell should not cause an undue voltage in the coaxial circuit.

The quotient of the transferred electromotive force, or the equivalent voltage U_t, by the outside longitudinal current I_l: $\frac{U_t}{I_l} = Z_t$, is called the transfer impedance and is generally an adequate quantity for defining the screening effectiveness of r.f. coaxial connectors.

A connector assembly with properly mounted cables or lines has three major possible leakage areas: the region around the mating face, the coupling device and the two cable entries. Since in IEC Publication 169 only mating face and locking (coupling) mechanisms are standardized, the primary interest concerns the screening effectiveness of this part of the connector assembly. This does not, however, exclude that the measuring methods may also be used either for determining the transfer impedance at any individual spots of leakage if due care is taken to eliminate coupling contributions from the other leakages, or for total transfer impedance. In the latter case, and especially at high frequencies, the occurrence of directional effects has to be taken into account.

It must be emphasized that the transfer impedance of r.f. connectors, and thus the screening effectiveness, has by no means a stable, fixed value applicable to each particular specimen or pair. In particular, Z_t is mostly much dependent on mechanical and contact circumstances. For instance, the value may be considerably lowered by stronger tightening of the coupling nut. Moreover, the exact value normally cannot be reproduced. A fresh connector pair in general shows a reduction of Z_t with repeated disengagement and re-engagement, but the value may increase again after some dozens of cycles, perhaps due to wear and tear. Very little is also yet known on the behaviour during use and ageing of connectors.

For radio-frequency applications, the transfer impedance Z_t shall be expressed as a function of frequency and, in general, be measured in the frequency domain. While at higher frequencies no other practicable measuring method is known, at frequencies up to a few hundred MHz time domain measurement with pulse technique may be used, with, if appropriate, subsequent transformation of the result into the frequency domain.

In order to measure the screening effectiveness of the mating part of a connector pair, suitable cables are attached to the connectors in such a way as to exclude any leakage at the cable entries. For frequencies above 10 MHz, semi-rigid cables or solid tubular outer conductors are generally preferred. Below 10 MHz, cables with low leakage at low frequencies should be selected. The standardized test procedure in the frequency domain does not permit the inclusion of a fixing-flange style of connector as one-half of the connector pair to be tested, unless the flange is first removed.

The time domain pulse method is described in Sub-clause 14.8.3. It may be particularly useful in lower frequency bands up to a few hundred megahertz. If the appropriate test equipment (pulse generator combined with cathode ray oscilloscope) is readily available the test may be carried out very quickly, and, provided adequate precautions are being taken, with nearly the same sensitivity as in the frequency domain test. It has, further, the advantage that leakage spots may be identified in case of multiple leakages.

Various test methods may be used for the measurement of the transfer impedance in the frequency domain and in the time domain pulse method. In case of dispute, however, the method standardized in the following Sub-clause 14.8.2, using a tri-coaxial test set-up (or a set-up where the outer exciting line is formed by waveguides) shall govern as reference test method.

Note. — As a guiding rule the tri-coaxial set-up may be used up to approximately one-third of the upper frequency limit of the connector type to be tested, without the risk of disturbance by overmodes in the outer line. At higher frequencies the waveguide set-up should be applied, in which case the limit lies at about three-quarters of the connector limit. Experience shows that at these high frequencies the transfer impedance no longer varies appreciably with frequency.

For type testing, measurements shall always be carried out at the first engagement on a number of pairs of fresh connectors. It is not recommended that a standard test connector should be coupled to the specimen under test with the intention of attributing measured screening deficiencies to the specimen under test.

The relevant specification shall state the number of pairs to be measured, the tightening torque for the coupling nut and, where relevant, the frequency range.

14.8.2 *Measurement in the frequency domain*

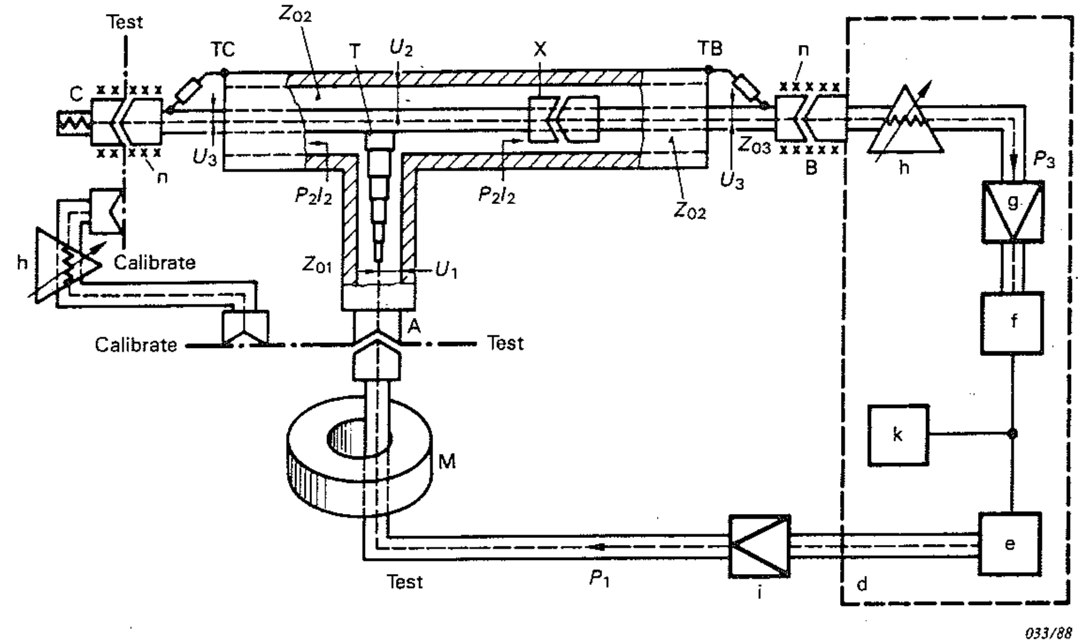
14.8.2.1 *Principle of the matched tri-coaxial test set-up*

The principle of the matched tri-coaxial test set-up is shown in Figure 1, page 11, and explained as follows:

In this tri-coaxial set-up both the inner and the outer coaxial systems are matched at their far ends, that is terminated by the characteristic impedance of the line, in order to avoid, or at least to minimize, the formation of standing waves. The outer system is fed at port A through a lateral arm, containing a matching transformer, to a T-junction acting as a power divider.

The multistep transformer serves to adapt the impedance ½ Z_{02} at the T-junction to the impedance Z_{01} of the feeding line in the frequency range of 1 GHz to 10 GHz. The transformer becomes less effective at lower frequencies. The resultant mismatch is, however, tolerable. Assuming the source impedance to be invariably equal to Z_{01}, calculation shows that the error introduced amounts to 0.5 dB only. This is small compared to the unavoidable measuring uncertainty and in particular the high dispersion of Z_t values themselves. The advantage, on the other hand, is to have only one mechanical feeding arrangement with the convenience of the same formula for calculating Z_t through the whole frequency range.*

* It could be argued that for the same reasons the multistep transformer might also be superfluous in the frequency range from 1 GHz to 10 GHz. However, at such high frequencies good matching proves even more critical in avoiding losses.



A Power feed connection
B, C Measuring ports
X Connector pair under test
TB, TC Outer system terminating devices with impedance Z_{02}
T Matched power dividing T-junction
M Ferrite rings
d Screened room
e Tracking generator or synthesized signal generator
f Spectrum analyzer
g Low noise preamplifier
h Calibrated variable attenuators
i Power amplifier (if needed)
k Bus controller
n Additional screening copper braid

FIG. 1. — Principle of the matched tri-coaxial test set-up (optimized condition for the frequency range 1 GHz to 10 GHz).

At the T-junction, reactance correcting stubs, not shown in Figure 1 but depicted in Figure 5, page 21, are necessary.

The signal voltages U_3 at the ports B and C of the inner line, caused by the injected voltage U_t, are alternately measured both at B and C. Incidentally their equality is a criterion for the symmetry of the system and the absence of directional effects.

For calibration of the set-up the input signal is fed with the aid of a separate branch of coaxial line, comprising a variable attenuator, to the port opposite to the measuring port (to C if U_3 is measured at B). This implies the equality $Z_{03} = Z_{01}$.

The quantitative relationships below make use of two approximations which, however, are fully justified, bearing in mind the practical accuracy needed: The transfer impedance Z_t is very small and thus negligible in comparison to Z_{02} and Z_{03}; further, the attenuation and losses in the coaxial lines and the multistep transformer are neglected.

The transferred voltage U_t results in two voltages U_3 of equal amplitude at the ports B and C:

$$U_3 = \frac{1}{2} U_t . \quad \text{Since } U_t = Z_t \cdot I_2, \quad U_3 = \frac{1}{2} Z_t \cdot I_2 \qquad (1)$$

The junction T acts as a lossless power divider and, since the multistep transformer is considered to be ideal, it follows:

$$P_2 = \frac{1}{2} P_1$$

Because: $P_1 = \dfrac{U_1^2}{Z_{01}}$, $P_2 = \dfrac{U_2^2}{Z_{02}}$; $\dfrac{U_2^2}{Z_{02}} = \dfrac{1}{2}\dfrac{U_1^2}{Z_{01}}$, thus $U_2 = U_1 \sqrt{\dfrac{1}{2}\dfrac{Z_{02}}{Z_{01}}}$

considering further that: $I_2 = \dfrac{U_2}{Z_{02}}$: $I_2 = \dfrac{U_1}{\sqrt{2\, Z_{01} \cdot Z_{02}}}$ (2)

combining equations (1) and (2):

$$U_3 = \frac{1}{2} \cdot Z_t \frac{U_1}{\sqrt{2 Z_{01} \cdot Z_{02}}} \ ; \quad Z_t = 2\sqrt{2}\,\sqrt{Z_{01} \cdot Z_{02}}\,\frac{U_3}{U_1}$$

Z_{02} might be chosen arbitrarily, the transformer being given the correct matching ratio. However, in general the adequate solution is to have $Z_{01} = Z_{02} = Z_0$.

This results in: $Z_t = 2\sqrt{2}\,\dfrac{U_3}{U_1} Z_0 = 2\sqrt{2}\sqrt{\dfrac{P_3}{P_1}} \cdot Z_0$

The measuring instrumentation consists of a tracking generator or synthesized signal generator followed by a power amplifier (if needed) on the feeding side; on the receiver side an input variable attenuator, a low noise preamplifier and a spectrum analyzer. A quick procedure is possible with computer controlled automatic driving (step by step) of the generator and the spectrum analyzer. When calibrating the system, sharing of the total attenuation between two attenuators allows an optimum compromise with regard to random noise and residual stray coupling to be achieved. The port at C has of course to be correctly terminated and both ports at B and C in general need additional shielding with copper braid.

At high screening effectiveness and for best performance it is recommended to use a screened room (Faraday cage) as indicated in Figure 1, page 11.

It is essential that the test set-up be checked for its limit capabilities by substituting the connector pair under test with a completely solid metal shell (for instance a copper tube) of the same outer dimensions as the connectors.

14.8.2.2 *Practical construction of the matched tri-coaxial set-up for the frequency range from 1 kHz to 10 GHz*

For the practical construction of the test set-up, a few items need more detailed specifications than are given in Sub-clause 14.8.2.1 and in Figure 1.

Figure 2, page 15, shows, besides other particularities of the tri-coaxial set-up, the procedures for feeding the input power in the two frequency ranges: from 10 MHz to 10 GHz and from 1 kHz to 10 MHz.

Above 10 MHz the feeding is quite normal and it is only necessary to take care of the feeding cable, which should have an approximate length of 1.5 m, in order to provide a sufficient impedance (mainly reactance) to the normally open "earth loop" (see Figure 1, page 11, at the input the earth is on the outer conductor, whereas at the measuring port the earth of the

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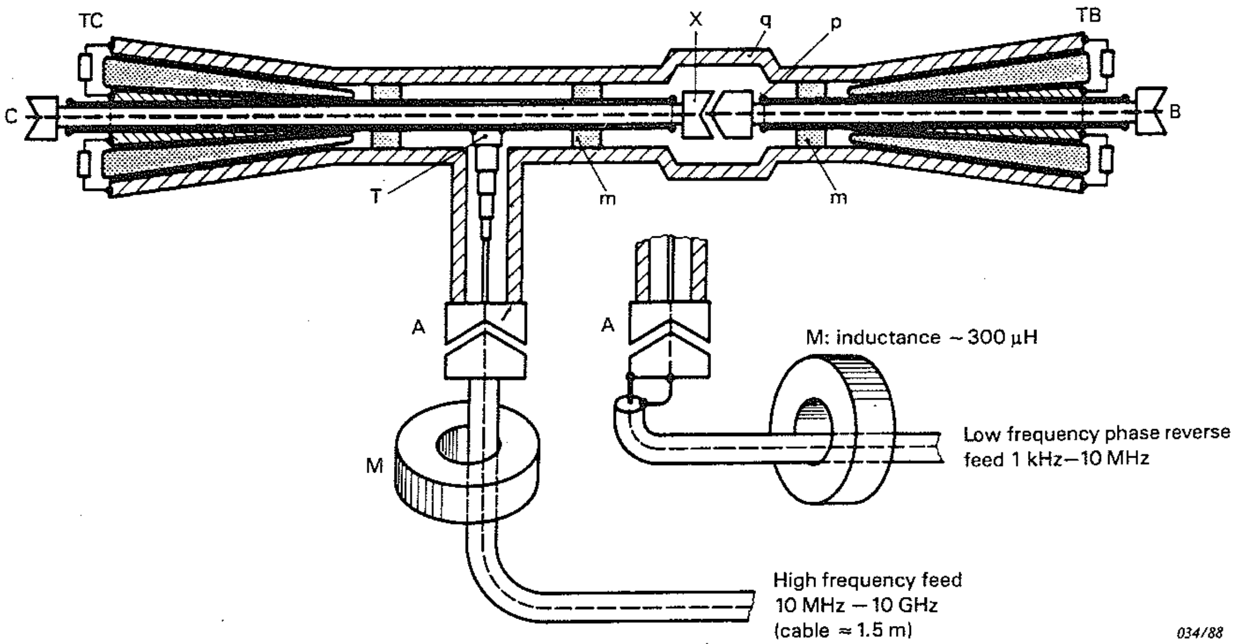


A	Power feed connection	T	Matched power dividing T-junction (detail Figure 3, page 17)
B	Measuring port (forward screening effectiveness)	M	Ferrite rings
C	Measuring port (backward screening effectiveness)	m	Foam dielectric beads
X	Connector pair under test	p	Solder junction between brass tubes and coaxial cable or line
TB, TC	Outer system terminating devices (detail Figure 4, page 19)	q	Bulge for measurement of larger connectors

FIG. 2. — Practical tri-coaxial test set-up for the two frequency ranges: 1 kHz to 10 MHz and 10 MHz to ~10 GHz.

screened room is connected with the middle tube at B). The inductance of the loop may be increased, if required, by ferrite rings, as shown in Figures 1 and 2.

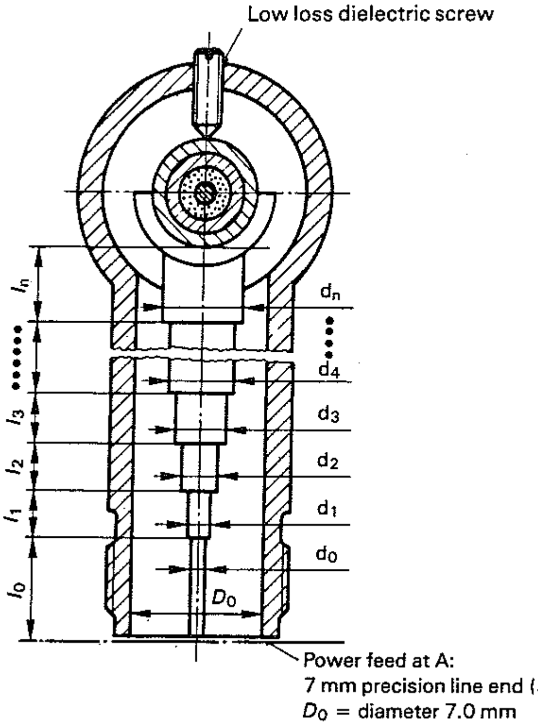
For frequencies below approximately 10 MHz down to 1 kHz, experience has shown that correct results are obtained by feeding with reversed polarity, as depicted in Figure 2. Ferrite rings may be necessary for decoupling, particularly towards the upper frequency region of the range.

The multistep matching transformer requires lengthy calculations to determine its dimensions. The data for a practical design are given in Figure 3.

An important detail is the construction of the terminations TB and TC, which are to cover the whole frequency range from 1 kHz to 10 GHz, see also Figure 4, page 19. At frequencies up to about 1 GHz each termination consists of four parallel resistors of 200 Ω (assuming Z_{02} = 50 Ω). At higher frequencies, up to 10 GHz, the wave energy is dissipated in the tunnel-shaped expansions (horns) filled with absorbing conical elements.

In comparison with Figure 1, Figure 2 shows also additional brass tubes, p, 4 mm to 6 mm in diameter, surrounding the semi-rigid cables and soldered to them near their mounting to the connector pair under test.

The outer conductor of the outer system has an inner diameter of 14 mm. Thus, SMA, APC-3.5 and similar sized connectors can be measured without the necessity of increasing this



steps n	l [mm]	Ø d [mm]
0	9.16	3.04
1	12.07	3.08
2	11.40	3.17
3	10.93	3.26
4	10.17	3.34
5	7.55	3.42
6	6.08	3.50
7	6.37	3.58
8	6.84	3.66
9	5.53	3.74
10	5.98	3.82
11	5.98	3.90
12	5.53	3.98
13	6.84	4.05
14	6.37	4.13
15	6.08	4.20
16	7.55	4.27
17	10.17	4.34
18	10.93	4.41
19	11.40	4.48
22	12.07	4.55
n = 23	10.00	4.58

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FIG. 3. — Multistep impedance transformer for T-junction, effective in the frequency range from 1 GHz to 10 GHz.

diameter in the region of the connector pair. The brass tubes surrounding the semi-rigid cables have about the same outer diameter as the SMA connector shell and maintain therefore the condition of constant characteristic impedance $Z_{02} = 50\ \Omega$. For the measurement of larger size connectors, APC-7 or N-types for example, the dimension of the outer coaxial tube has to be increased over approximately the length of the connector pair, forming a bulge q, as seen in Figure 2. The dimensions are not critical; reflection factors up to about 0.5 are acceptable (mismatch loss less than 1.2 dB).

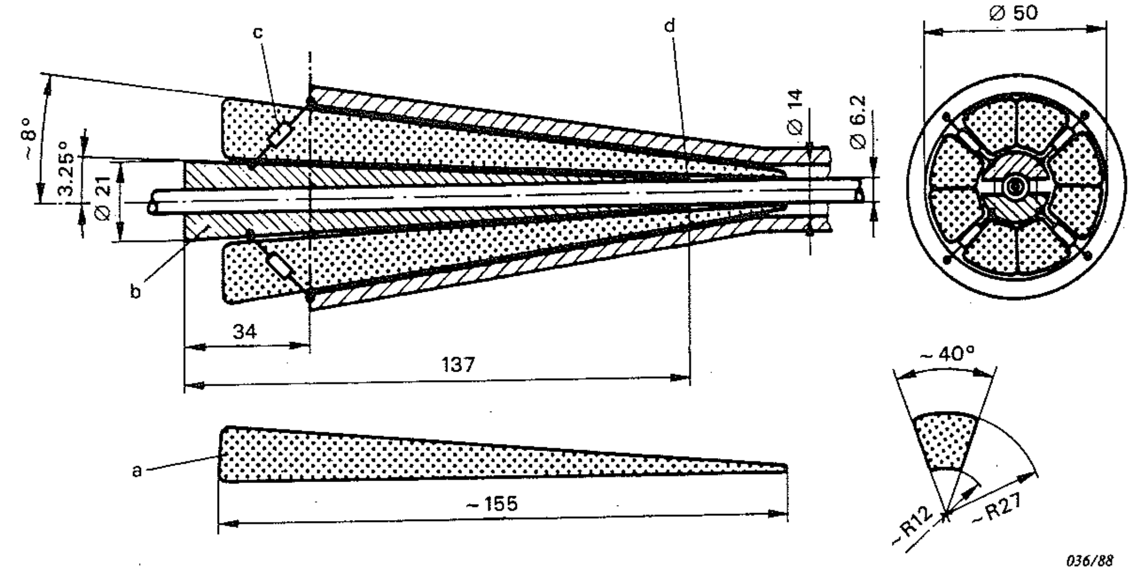
An example of the mechanical construction for the set-up according to Figure 2, page 15, is depicted in Figure 5, page 21. As an important detail this figure also shows the matching elements, e, at the feeding junction T.

14.8.2.3 *The matched waveguide assembly for the frequency range from 3 GHz to 18 GHz*

For a further extension of the frequency range beyond the capabilities of the matched tri-coaxial set-up, a relatively simple waveguide assembly has been produced which allows measurements up to about ¾ of the connector's upper frequency limit. According to Figure 6, page 23, it consists of two waveguides running side by side with each other, having a common broadside wall.

This wall has a longitudinal slot and a broader opening into which the connector pair with mounted semi-rigid cables fit.

The input signal is split by a 3 dB in-phase power divider and then launched in phase opposition into the two waveguide arms, these waveguides being terminated by a matched load at the opposite ends. If the assembly is symmetrical the field around the connector pair under test is quite similar to the TEM mode in a coaxial arrangement. The quasi TEM mode



a = Low loss dielectric foam cones, coated with one layer of an absorbing mixture of for example 17 g resin polymer (semi-flexible type) and 68 g iron powder (brush painted).

b = The inner conductor cone is mechanically screwed together to assure good contact pressure at the area d. The whole cone is longitudinally adjustable on the inner coaxial system to allow the overall reflection factor to be optimized from DC to the upper frequency limit of about 10 GHz (this must be measured at the feeding point A (Figure 1, page 11) through the whole assembly).

c = Four low power r.f. resistors 200 Ω.

FIG. 4. — Low and high frequency combining feed through terminations TB, TC, frequency range DC to ~ 10 GHz.

impedance Z_{02} of the outer system at the connector pair depends on the connector and the waveguide dimensions and may vary from $\frac{Z_{03}}{3}$ to $3 \cdot Z_{03}$; but this affects the overall accuracy even less than the wide dispersion of practically measured screening values, as occurring with repeated engaging and separation of the connectors under test.

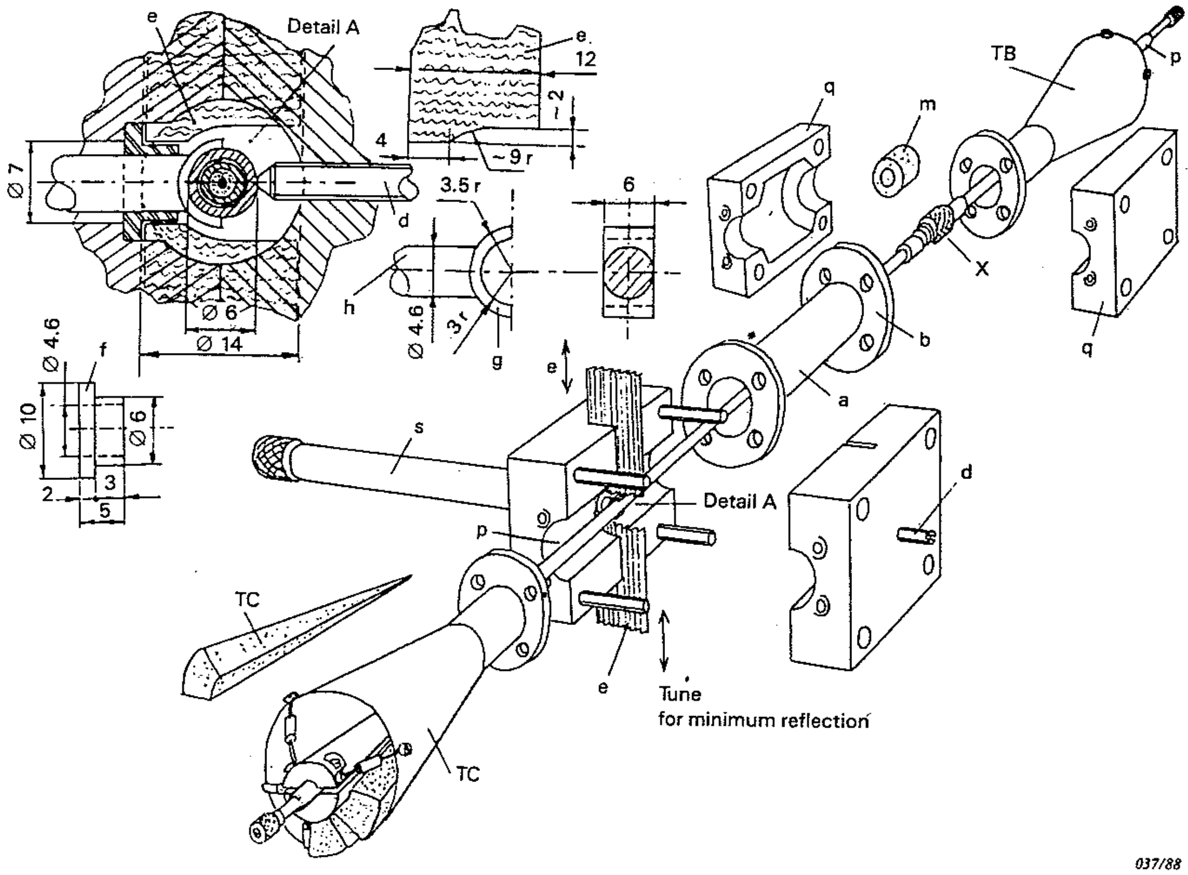
Assuming that the power divider and the launching devices do not cause losses, the total power P_2 flowing along the connector pair is equal to the input power P_1. Therefore, and assuming that $Z_{02} = Z_{03} = Z_0$, the relation for Z_t is:

$$Z_t \approx 2 \frac{U_3}{U_1} Z_0 = 2 \sqrt{\frac{P_3}{P_1}} Z_0$$

The entire measuring set-up is exactly the same as for the tri-coaxial arrangement and all information given there applies as well.

Comparison of results obtained in the overlapping frequency range of the tri-coaxial set-up and the waveguide assembly on a dummy with fixed and stable transfer impedance in place of a connector pair has proved agreement within 4 dB.

Figure 7, page 25, is an exploded view of the waveguide assembly. The residual leakage and the mismatch of the set-up can be tested before cutting the openings in the two tin sheets c.



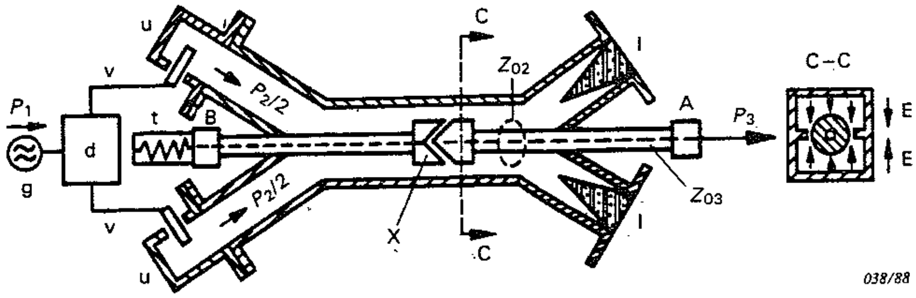
a Outer conductor of outer system with inner diameter of 14 mm
b Mounting flanges
d Dielectric fixing screw to assure contact pressure at T-junction
e T-junction adjusting matching stubs
f Axial fixing and centring solid low loss dielectric bead
g T-contact fork
h Inner conductor of multistep transformer, low impedance side
m Several centring low loss foam dielectric beads
p Solid brass tube of outer diameter of 6 mm surrounding semi-rigid cable
q Bulge in outer conductor for large connectors (size dependent)
s Outer conductor of feeding multistep transformer with inner diameter of 7 mm
TB, TC Conical terminations with absorbing layer coated foam segments and four resistors (200 Ω each in parallel)
X Connector pair under test

FIG. 5. — Example of a mechanical construction for the set-up according to Figure 2.

These apertures are cut with a knife such that there is a 1 mm spacing between the sheet edge d and the connector body X, thus enabling the longitudinal current to flow on the surfaces of the bodies of the connector pair.

In the zone of the connector pair under test each waveguide of the assembly works more or less similarly to a ridge guide (see on right side of Figure 6, page 23), with the maximum of magnetic field and current on the surfaces of the connector pair.

The dimensions of the trapezoidal openings in the two metal plates b depend on the wave-guide and connector sizes and are expressed as fractions of the connector, cable and wave-



A Measuring port
B, t Termination at opposite port
X Connector pair under test
E Electrical field in test area
d In-phase power divider
g Generator
l Matched waveguide load
u Coaxial to waveguide transition
v Semi-rigid coaxial cables with equal electrical lengths

Z_{03} $Z_{03} = Z_0$, Impedance of inner system
Z_{02} Quasi TEM impedance of outer system
P_1 Input power
P_2 Total power in outer system (both waveguides together)
P_3 Power delivered to terminations of system 3 (inner system)

FIG. 6. — Waveguide set-up.

guide dimensions, see Figure 8. The waveguide assembly has to be mechanically fixed by clamps and the connector pair and cable set-up must also be fastened to assure stable measuring conditions.

The admissible range of the outer diameter of the connector pair under test is approximately (0,25 ... 0,9) · a.

14.8.2.4 *Practical limits of measurable attenuation range and reproducibility*

In practice the lowest value of Z_t measurable by swept methods depends on the characteristics of the low noise preamplifier, the power amplifier and the spectrum analyzer. It may be expressed by the lowest ratio $\frac{P_3}{P_2}$ obtainable with adequate accuracy, where P_3 is the power delivered at each termination of the inner coaxial system, and P_2 the wave power flowing over the test connector pair in the outer system, the characteristic impedance being all of equal value Z_0. According to the derivation given earlier the relation between Z_t and $\frac{P_3}{P_2}$ is:

$$Z_t = 2\,\frac{U_3}{U_2}\,Z_0 = 2\sqrt{\frac{P_3}{P_2}}\cdot Z_0$$

The practical limit, $\frac{P_3}{P_2}$ expressed in decibels, in the whole frequency range from 1 kHz to 12 GHz, obtainable with the usual equipment, is about −155 dB. This corresponds to $Z_t \approx 2\ \mu\Omega$.

The measuring accuracy depends on the quality of the calibrated attenuator, the instrument stability and the (unwanted) reflections at several spots of the set-up. It is found to be about ± 3 dB. This seems to be adequate when considering the much wider dispersion of attenuation

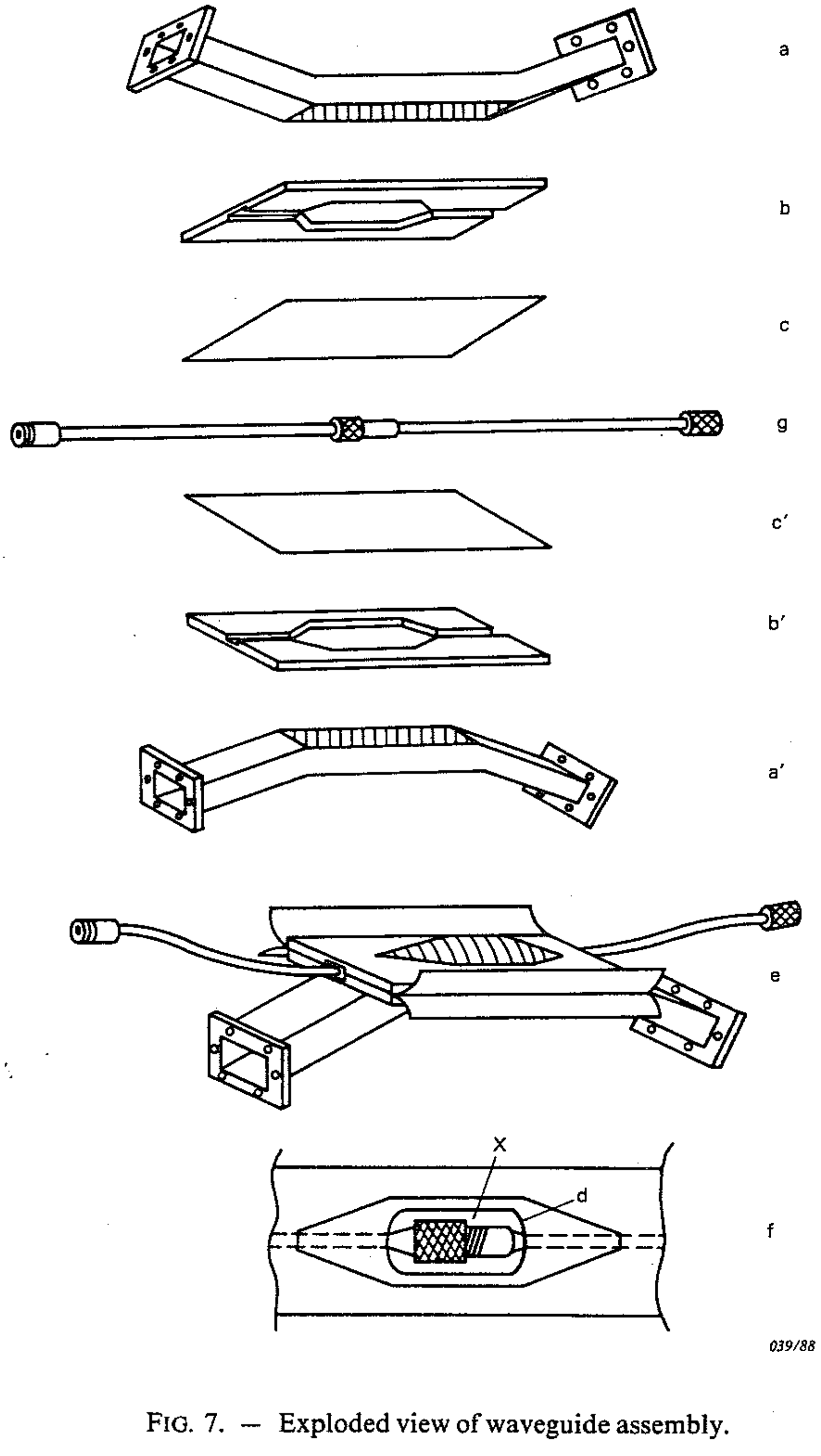
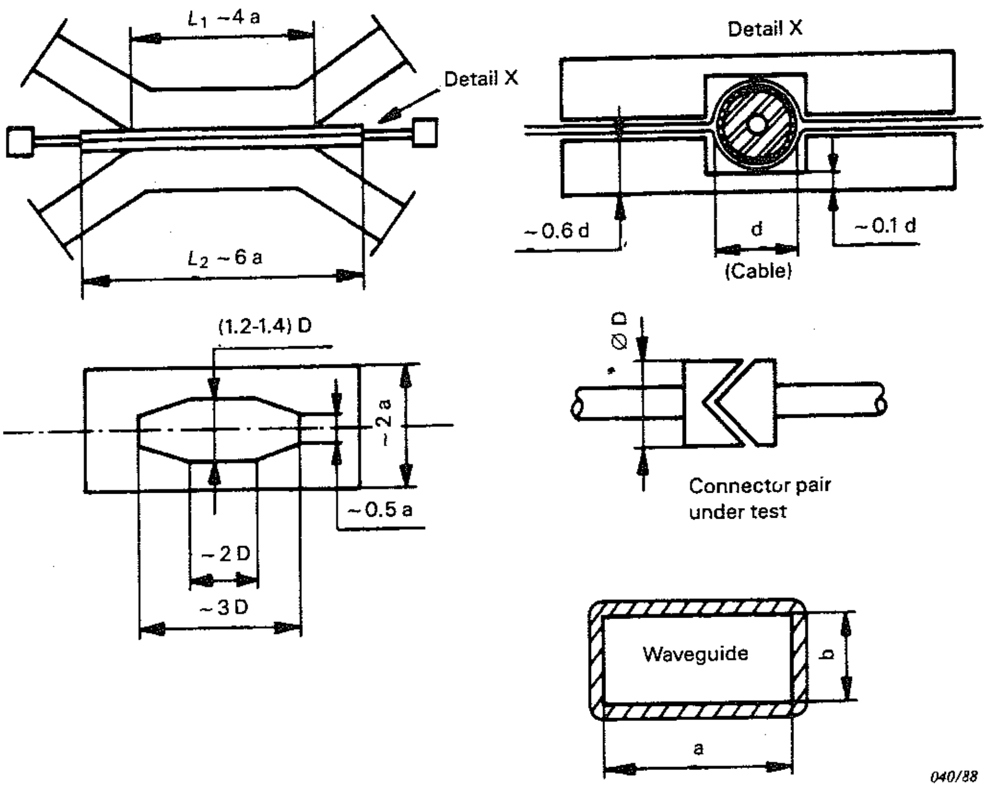


FIG. 7. — Exploded view of waveguide assembly.

a, a′ Upper and lower waveguides
b, b′ Upper and lower diaphragm plates
c, c′ Upper and lower tin sheets of ≈ 0.05 mm thickness
g Connector pair under test with mounted semi-rigid cables and terminating connectors
e Completed assembly (upper waveguide removed), tin sheets not yet cut, ready for leakage and mismatch test
f View of diaphragm within assembly
d Edge of tin sheet
X Connector pair under test



a, b Inner sizes of waveguides
d Outer diameter of cable

FIG. 8. — Waveguide assembly dimensions.

values resulting from problems such as the mechanical handling of the connector pairs. For instance, doubling the coupling torque when engaging an N-type connector pair may easily lower Z_t by 30 dB and more.

14.8.3 *Measurement in the time domain*

Under consideration.

FOREWORD

This amendment has been prepared by sub-committee 46D: RF connectors, of IEC technical committee 46: Cables, wires, waveguides, R.F. connectors and accessories for communication and signalling.

The text of this amendment is based on the following documents:

FDIS	Report on voting
46D/194/FDIS	46D/208/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

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Add the number (3) *next to the derived formulae for* U_3; Z_t.

After the final formula for Z_t, *add:*

and can be used to obtain the formula for screening effectiveness starting with the basic definition:

$$a_z\ (\text{dB}) = -10 \log_{10}\left[\frac{P_{\text{output}}}{P_{\text{input}}}\right] = -10 \log_{10}\left[\frac{P_3}{P_2}\right]$$

and since $P_2 = P_1/2$

$$a_z\ (\text{dB}) = -10 \log_{10}\left[\frac{2P_3}{P_1}\right]$$

also $P_3 = \dfrac{U_3^2}{Z_{03}}$ and $P_1 = \dfrac{U_1^2}{Z_{01}}$

thus $a_z\ (\text{dB}) = -10 \log_{10}\left[\dfrac{2U_3^2\, Z_{01}}{U_1^2\, Z_{03}}\right]$

or

$$a_z\ (\text{dB}) = -20 \log_{10}\left[\frac{U_3}{U_1}\sqrt{\frac{2Z_{01}}{Z_{03}}}\right] \qquad (4)$$

for equation (3)

$$\frac{U_3}{U_1} = \frac{Z_t}{2\sqrt{2}\sqrt{Z_{01}\, Z_{02}}} \qquad (5)$$

combining equations (4) and (5):

$$a_z\ (\text{dB}) = -20 \log_{10}\left[\frac{Z_t}{2\sqrt{2}\sqrt{Z_{01}\, Z_{02}}}\sqrt{\frac{2Z_{01}}{Z_{03}}}\right]$$

and finally

$$a_z\ (\text{dB}) = -20 \log_{10}\left[\frac{Z_t}{2\sqrt{Z_{02}\, Z_{03}}}\right] \qquad (6)$$
