IEC 62153-4-5

Edition 2.0 2021-08

INTERNATIONAL STANDARD

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colour inside

Metallic communication cable test methods – Part 4-5: Electromagnetic compatibility (EMC) – Screening or coupling attenuation – Absorbing clamp method

Méthodes d'essai des câbles métalliques de communication – Partie 4-5: Compatibilité électromagnétique (CEM) – Affaiblissement d'écran ou de couplage – Méthode de la pince absorbante

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METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-5: Electromagnetic compatibility (EMC) – Screening or coupling attenuation – Absorbing clamp method

FOREWORD

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IEC 62153-4-5 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) reorganisation of clauses and annexes;
b) extension of frequency range to 2,4 GHz;
c) application of a virtual balun respectively balunless test procedure with multiport VNA.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
46/819/FDIS	46/829/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This standard is intended to be read in conjunction with IEC TS 62153-4-1:2014, which describes the theoretical background.

A list of all parts in the IEC 62153-4-n series, under the general title: *Metallic communication cable test methods − Electromagnetic Compatibility (EMC)* can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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METALLIC COMMUNICATION CABLE TEST METHODS –

Part 4-5: Electromagnetic compatibility (EMC) – Screening or coupling attenuation – Absorbing clamp method

1 Scope

The absorbing clamp method is suitable to determine the screening- or the coupling-attenuation of metallic communication cables in the frequency range of 30 MHz to 1 000 MHz (2 400 MHz), depending on the performance of the clamp. It is an alternative method to the triaxial method of IEC 62153-4-4 or IEC 62153-4-9. Due to the undefined outer circuit of this absorbing clamp method, the test results obtained at different places and laboratories could vary by at least ± 6 dB.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-726, *International Electrotechnical Vocabulary (IEV) – Part 726: Transmission lines and waveguides*

IEC TS 62153-4-1, *Metallic communication cable test methods – Part 4-1: Electromagnetic compatibility (EMC) – Introduction to electromagnetic screening measurements*

CISPR 16-1-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*

ITU-T G.117:1996, *Transmission aspects of unbalance about earth*

ITU-T O.9:1999, *Measuring arrangements to assess the degree of unbalance about earth*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-726 and IEC TS 62153-4-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
quasi-coaxial cable
cable construction with two or more inner conductors enclosed by cable screens acting as an outer conductor, connected together on both ends

Note 1 to entry: Screened balanced or multiconductor cables become a quasi-coaxial system by short circuiting the inner conductive elements.

4 Principles of the test method

The cable (for unbalanced respectively coaxial cables) or one cable pair (for balanced cables) is fed with the power P_1. Due to the electromagnetic coupling between the cable or pair and the environment, surface waves are exited which propagate in both directions along the screen surface (or the cable surface where there is not a screen). A surface current transformer is used for picking up the power of the surface waves in combination with an absorber (usually a ferrite tube) to suppress unwanted common mode currents. These kinds of combinations are known as absorbing clamps.

On the basis of the peak values of the measured surface currents, it is possible to calculate the maximum peak power, P_{2max}, in the secondary system formed by the screen of the cable (or the cable itself) and the environment.

The logarithmic ratio of the powers P_1 and P_{2max} is termed screening or coupling attenuation, expressed in dB.

In case of balunless measurement, coupling attenuation is termed by the logarithmic ratio of the powers P_{diff} and $P_{com,max}$.

For unbalanced (coaxial) or quasicoaxial cables, the measurement result is the screening attenuation. For balanced (symmetrical) cables, we have to consider two cases:

a) disturbing power fed in differential mode: the measurement result is the coupling attenuation, which is the combined result of both unbalance attenuation and screening attenuation;

b) disturbing power fed in common mode: the measurement result is the screening attenuation.

To measure coupling attenuation, a balanced signal is required to feed the balanced pair under test. This can be achieved by using a two port VNA and a balun to transform unbalanced (usually 50 Ω) generator signal into the balanced (usually 100 Ω) signal of the balanced cable.

Another option is the “balun-less” test method by using a 4 port vector network analyser or similar test equipment. The preferred method is the balunless (virtual balun) method.

The surface current is measured on a swept-frequency basis with a stationary clamp.

Taking into account the maximum effect of either near or far end surface waves, the coupling attenuation a_c (or the screening attenuation a_S) is defined by:

$$a_c = 10\log_{10}\left(\frac{P_1}{\max\left[P_{2n};P_{2f}\right]}\right) \quad (1)$$

where

P_1 is the input power of inner circuit of the sample;

P_{2n} is the maximum near end coupling peak power;

P_{2f} is the maximum far end coupling peak power.

A detailed description of the physical background of screening attenuation and coupling attenuation measurement is given in IEC TS 62153-4-1.

5 Equipment

5.1 General

The test set-up shall have a noise floor at least 6 dB better than the instrument reading required for the value to be reported. This means, for instance, that a test with an equipment dynamic range of at least 115 dB is required for measuring coupling attenuation or screening attenuation up to approximately 90 dB, when the full attenuation of a normal absorbing clamp and balun or TP-connecting unit (if applicable) are taken into account. The accuracy of any equipment shall be better than ± 1 dB.

To measure high values of screening and coupling attenuation, in general higher than 80 dB, it is recommended to carry out the measurements in a screened room (e.g. anechoic chamber).

The equipment shall be capable of measuring coupling attenuation or screening attenuation in the full frequency range from 30 MHz to 1 GHz and/or 500 MHz to 2,4 GHz if not specified otherwise in the relevant cable specification. For measurements at frequencies above 1 GHz, it is recommended to use the balunless test procedure.

The measurement set-up can be performed using a network analyser or alternatively a discrete signal generator and selective measuring receiver.

To measure the coupling attenuation as well as to measure the unbalance attenuation, a differential signal is required. This can, for example, be generated using a balun which converts the unbalanced signal of a 50 Ω network analyser into a balanced signal, see Figure 1 and Figure 2.

Alternatively, a balanced signal may be obtained by using a vector network analyser (VNA) having two generators with a phase shift of 180°. Another alternative is to measure with a multi-port VNA (virtual balun). The properties of balanced pairs are determined mathematically from the measured values of each single conductor of the pair against reference ground. The coverable frequency range for the determination of the reflection and transmissions characteristics of symmetrical pairs is no longer limited by the balun but by the VNA and the connection technique.

A detailed definition of mixed mode S-parameters for measurements with virtual balun is given in Annex E.

NOTE Impedance matching adapters (Annex B) and accounting for mismatch loss (Annex D) can be replaced by the calibration and fixture de-embedding functions, which are included with multi-port VNA measurements.

A vertical metallic reflector plate whose height and width shall both be at least 800 mm shall be placed directly in front of the generator. The plate shall have a central hole to accommodate the cable under test.

The measuring set-up for the maximum radiated power at the near end (using discrete instruments) is shown in Figure 1 to Figure 3 and consists of:

a) an absorbing clamp with a minimum frequency range from 30 MHz to 1 GHz, see CISPR 16-1-3:2004. An alternative absorbing clamp may be required if measurements are performed outside this frequency range, e.g. from 500 MHz to 2,4 GHz;
b) a ferrite absorber with a minimum frequency range from 30 MHz to 1 GHz with a minimum attenuation of 10 dB;
c) a reflector plate (min. 800 mm × 800 mm);
d) a signal generator or vector network analyser with the same characteristic impedance as the unbalanced port of the balun (if applicable), coupled by a power amplifier if necessary for very high dynamic range requirements;

or alternatively:

e) a receiver with a calibrated step attenuator or vector network analyser, coupled by a low noise amplifier if necessary for very high dynamic range requirements;

f) a 4-port vector network analyser or similar test equipment. Such a configuration allows testing with both a common or differential mode stimulus and responses;

g) an electronic calibration kit in case of a 4-port vector network analyser;

h) a twisted pair (TP)-connecting unit to connect multiport VNA to the balanced DUT;

i) a printing facility;

j) load resistance networks which terminate the nominal characteristic common and differential mode impedances (if applicable);

k) if the equipment does not observe the requirement for the level of noise floor, when well screened and balanced cables are measured, the dynamic range of the set-up may be improved by the use of an external amplifier. The amplifier shall be well screened and the enclosure shall be connected to the reflector plate.

   The gain of the amplifier shall be measured and corrected for in the test result. When the gain of the amplifier is measured, precautions shall be taken not to saturate the amplifier. In order not to overload the equipment, an attenuator may be needed in front of the receiving input during the measurement. The attenuation of this attenuator shall be measured and used for correction of the result.

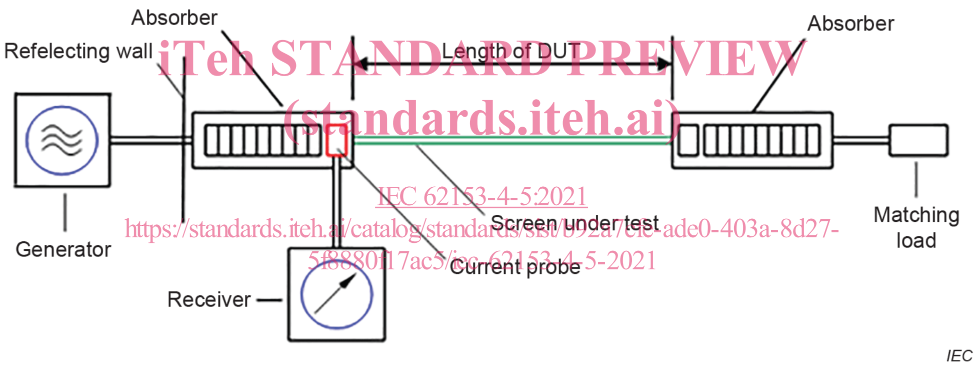

Figure 1 – Measurement of near end screening attenuation, principle

5.2 Balun requirements

For the measurement of symmetrical cables, a balun is required for conversion of the primary impedance of the unbalanced output from the signal generator to the nominal characteristic impedance of the balanced cable pair under test. The minimum requirements of the balun are specified in Table 1 (up to 1 GHz) and Table 2 (up to 2,4 GHz). For measurements above 1 GHz, it is recommended to use the balunless test procedure.

The attenuation of the balun shall be kept as low as possible because it will limit the dynamic range of the coupling attenuation measurements.

Table 1 – Balun performance characteristics (30 MHz to 1,0 GHz)

Parameter	Value
Impedance, primary [a]	50 Ω (unbalanced)
Impedance, secondary [b]	100 Ω or 150 Ω (balanced)
Insertion loss [c] (including matching pads if used)	≤ 10 dB
Return loss, bi-directional	≥ 6 dB
Power rating	To accommodate the power of the generator and amplifier (if applicable)
Output signal balance [d]	≥ 50 dB from 30 MHz to 100 MHz ≥ 30 dB from 100 MHz to 1 GHz

[a] Primary impedance may differ if necessary to accommodate analyser outputs other than 50 Ω.

[b] Balanced outputs of the test baluns shall be matched to the nominal impedance of the symmetrical cable pair. 100 Ω shall be used for termination of 120 Ω cabling. The error introduced by the mismatch between 100 Ω test system and 120 Ω cabling is neglectable.

[c] The operational attenuation of a balun shall be mathematically deduced from 3 operational attenuation measurements with 3 baluns back-to-back.

[d] Measured per ITU-T Recommendations G.117 and O.9.

Table 2 – Balun performance characteristics (30 MHz to 2,4 GHz)

Parameter	Value
Impedance, primary [a]	50 Ω (unbalanced)
Impedance, secondary [b]	100 Ω (balanced)
Insertion loss [c] (including matching pads if used)	≤ 2,0 dB (30 MHz to 2 000 MHz) ≤ 3,0 dB (2 000 MHz to 2 400 MHz)
Return loss, bi-directional	≥ 20 dB (30 MHz to 2 000 MHz), ≥ 15 dB (2 000 MHz to 2 400 MHz)
Common mode return loss	≥ 20 dB (30 MHz to 400 MHz), ≥ 15 dB (400 MHz to 2 000 MHz) ≥ 12 dB (2 000 MHz to 2 400 MHz)
Minimum power	0.1 Watt, (30 MHz to 2 400 GHz)
Longitudinal signal balance	≥ 60 dB (30 MHz to 100 MHz), ≥ 50 dB (100 MHz to 2 000 MHz) ≥ 40 dB (2 000 MHz to 2 400 MHz)
Output signal balance [d]	≥ 50 dB (30 MHz to 2 000 MHz), ≥ 40 dB (2 000 MHz to 2 400 MHz)
Common mode rejection	≥ 50 dB (30 MHz to 2 000 MHz), ≥ 40 dB (2 000 MHz to 2 400 MHz)

[a] Primary impedance may differ if necessary to accommodate analyser outputs other than 50 Ω.

[b] Balanced outputs of the test baluns shall be matched to the nominal impedance of the symmetrical cable pair. 100 Ω shall be used for termination of 120 Ω cabling.

[c] The operational attenuation of a balun shall be mathematically deduced from 3 operational attenuation measurements with 3 baluns back-to-back.

[d] Measured per ITU-T Recommendations G.117 and O.9.

NOTE For measurements at frequencies above 1 GHz, the preferred procedure is the balunless test procedure.

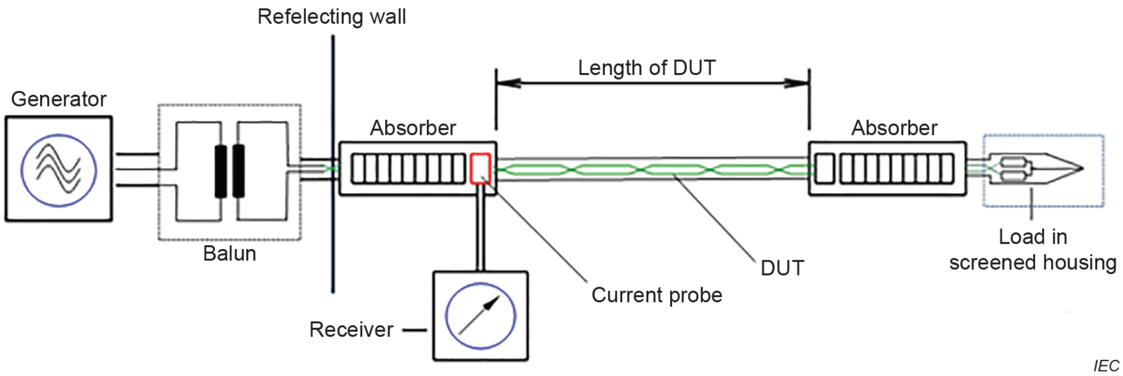

Figure 2 – Measurement of near end coupling attenuation with balun

5.3 TP connecting unit requirements

When measuring with balunless, respectively with “virtual balun”, a TP connecting unit is required. See Table 3.

Table 3 – TP-connecting unit performance characteristics (30 MHz to 2,4 GHz)

Parameter	Value
Characteristic impedance, primary side (single ended)[a]	50 Ω
Characteristic impedance, secondary side (differential)[a]	1 × 100 Ω (differential)
Return loss, differential mode[b]	> 20 dB
Attenuation, differential mode[c]	< 0,3 dB
Unbalance attenuation (TCTL)[d]	> 60 dB-10*log (f), 40 dB max.

[a] Two ports with single ended impedances of 50 Ω generate a common mode impedance of 25 Ω and a differential mode impedance of 100 Ω.

[b] To be measured e.g. with a 4 port mixed mode network analyser. One logical port is generated by the combination of two single ended ports. A second logical port is generated by the combination of two other single ended ports. The absolute dB value of the S-parameter S_{dd11} then represents the return loss of the differential mode.

[c] With the test set-up according to [b], the absolute dB value of the S-parameter S_{dd21} then represents the attenuation of the differential mode.

[d] With the test set-up according to [b], the absolute dB value of the S-parameter S_{cd21} then represents the unbalance attenuation (TCTL).

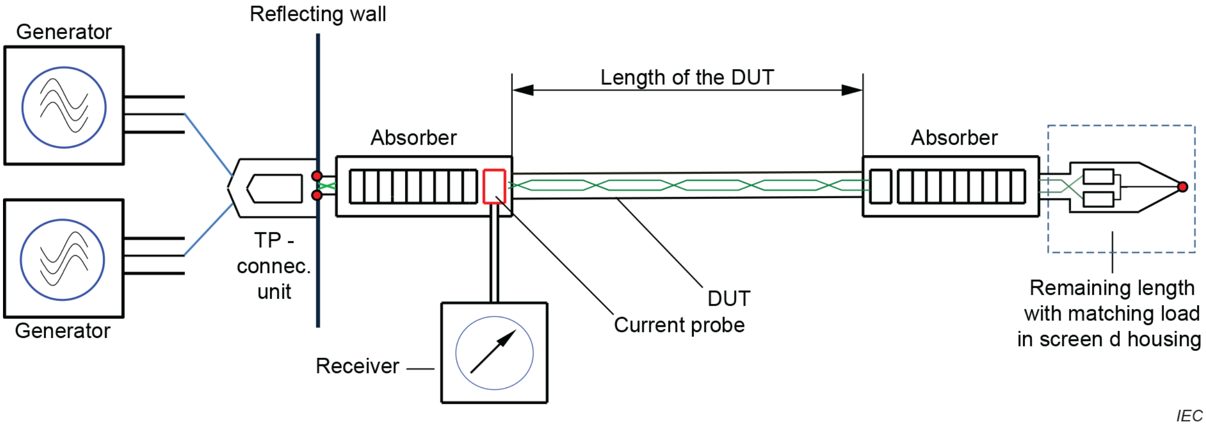

Figure 3 – Balunless measuring of near end coupling attenuation with multiport VNA

5.4 Test sample

5.4.1 Tested cable length

The effective length of the test specimen is limited by the absorbing clamp and the ferrite tube, as shown in Figure 3. The minimum test length depends on the lowest frequency to be measured. For the lowest frequency of 30 MHz, the minimum length shall be 600 cm + 2 × the length of the absorber ± 10 cm.

5.4.2 Preparation of test sample

5.4.2.1 General

If the bore of the absorbing clamp is smaller than the diameter of the test specimen, it shall be extended at both ends by means of smaller indicator lines. The extension lines shall have a much better screening attenuation than the test specimen. If possible, lines with a tubular outer conductor should be used. The characteristic impedance and the velocity of propagation of the extension cables shall correspond to the cable under test (same type of insulation, e.g. foamed or solid).

5.4.2.2 Symmetrical cables

The entire length of the cable shall be at least 100 m. The tested cable length (from absorbing clamp to the absorber) shall comply with 5.4.1.

A differential mode termination is required for each pair at the near and far end of the cable.

$$R_1 = R_{\mathrm{DM}} = \frac{Z_{\mathrm{diff}}}{2} \qquad (2)$$

The termination of the common mode shall be 25 Ω, i.e. two resistors of value R_{DM} in series with the centre point connected to ground, see Figure 4.

NOTE Modern mixed mode VNAs use a 25 Ω generator and receiver impedance as default value for the common mode (see Clause E.2).

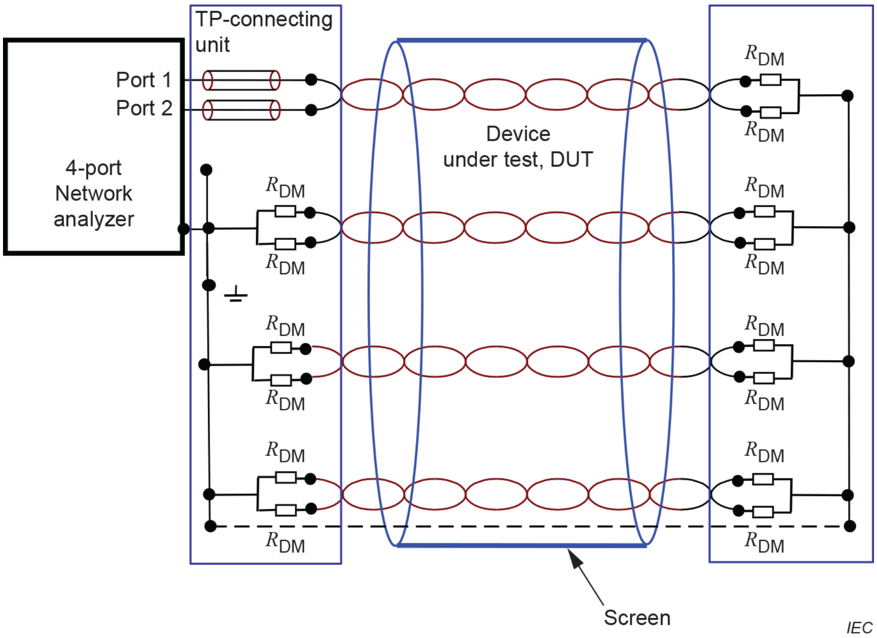

Figure 4 – Termination of a screened symmetrical cable

5.4.2.3 Preparation for the measurement of the screening attenuation for coaxial or quasi-coaxial cables

The entire length of the cable need not be longer than the tested cable length plus the length of the clamp and the absorber. The tested cable length (from absorbing clamp to absorber) shall comply with 5.4.1.

Screened symmetrical or screened multiconductor cables are treated as quasi-coaxial cables. Therefore, all conductors (of all pairs if applicable) shall be connected together at both ends. All screens, also those of individually screened pairs or quads, shall be connected together at both ends. The screens shall be connected over the whole circumference (see Figure 5).

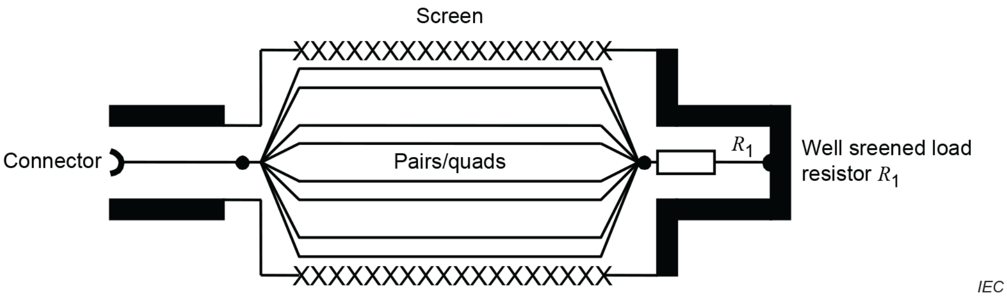

Figure 5 – Preparation of test sample (symmetrical and multi conductor cables)

The quasi coaxial system shall be terminated with its nominal characteristic impedance. The termination shall be well screened, so that the test results are not falsified. The impedance of the quasi coaxial system can either be measured by using a TDR with maximum 200 ps rise time or using below described method. Furthermore, an impedance matching adapter is necessary to match the impedance of the generator and the impedance of the quasi coaxial system.