

TECHNICAL REPORT



Flexible printed circuit boards (FPCBs) – Method of compensation of impedance variations

IECNORM.COM : Click to view the full PDF of IEC TR 63017:2015



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2015 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IECNORM.COM : Click to view the full text of IEC 63017:2015

TECHNICAL REPORT



Flexible printed circuit boards (FPCBs) – Method of compensation of impedance variations

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.180

ISBN 978-2-8322-3083-1

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	3
1 Scope.....	5
2 Normative references	5
3 Apparatus.....	5
3.1 Time domain reflectometry.....	5
3.2 Block diagram for impedance measuring.....	5
4 Test specimen	6
4.1 General.....	6
4.2 Structure.....	6
4.3 Test method.....	7
4.4 Calculation.....	8
5 Report	9
Annex A (normative) Block diagram for impedance measuring with TDR.....	10
Annex B (informative) Theoretical background.....	11
Annex C (informative) Example of an impedance measurement with TDR.....	12
Annex D (informative) Hand contact effect.....	13
Annex E (informative) Test result.....	14
E.1 Shield 1 FPCB	14
E.2 Shield 2 FPCB	15
Bibliography.....	16
Figure 1 – TDR test system.....	5
Figure 2 – Two types of impedance structure of FPCB.....	6
Figure 3 – Schematic diagram of a test specimen	7
Figure 4 – Impedance value of two type FPCB (bare and shield)	8
Figure 5 – Compensation value (ΔL) of the Cu line width for the shield FPCB	9
Figure A.1 – TDR test system according to IPC 2141a-9-1.....	10
Figure A.2 – TDR test system according to Agilent TDR 54754A.....	10
Figure B.1 – Two types of impedance structure of FPCBs.....	11
Figure B.2 – Comparison of the impedance value of a bare FPCB versus a shield FPCB.....	11
Figure C.1 – Photographic view of the impedance measurement with TDR	12
Figure D.1 – Effect of impedance variation by hand contact for bare FPCB	13
Figure E.1 – Measurement result of the test specimen for shield 1 FPCB.....	14
Figure E.2 – Measurement result of the test specimen for shield 2 FPCB.....	15
Table E.1 – Cross-section of test specimen with using shield 1 FPCB.....	14
Table E.2 – Cross-section of test specimen with using shield 2 FPCB.....	15

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**FLEXIBLE PRINTED CIRCUIT BOARDS (FPCBs) –
METHOD OF COMPENSATION OF IMPEDANCE VARIATIONS**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

IEC TR 63017, which is a technical report, has been prepared by IEC technical committee 91: Electronics assembly technology.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
91/1283/DTR	91/1308/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

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

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

IECNORM.COM : Click to view the full PDF of IEC TR 63017:2015

FLEXIBLE PRINTED CIRCUIT BOARDS (FPCBs) – METHOD OF COMPENSATION OF IMPEDANCE VARIATIONS

1 Scope

This Technical Report specifies a compensation method of Cu linewidth according to impedance reduction by using noise suppression materials (hereafter referred to as NSMs) for FPCBs.

This Technical Report presents an optimum result for maintaining a designated performance of FPCBs by using NSMs. It also indicates a measuring method for an impedance variation of FPCBs using NSMs with the prevailing TDR (time domain reflectometry) method. This method is restricted to measuring only the variation of an impedance value in accordance with the variation of the Cu linewidth by using NSMs for FPCBs. This report, however, neither determines nor indicates the structure or material of FPCBs.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IPC 2141A *Design Guide for High-Speed Controlled Impedance Circuits Boards*
<http://www.ipc.org/>

3 Apparatus

3.1 Time domain reflectometry

Time domain reflectometry (hereafter referred to as TDR) is utilized to identify the impedance data at the specific frequency range of FPCBs.

3.2 Block diagram for impedance measuring

Figure 1 gives one example of a TDR setup.

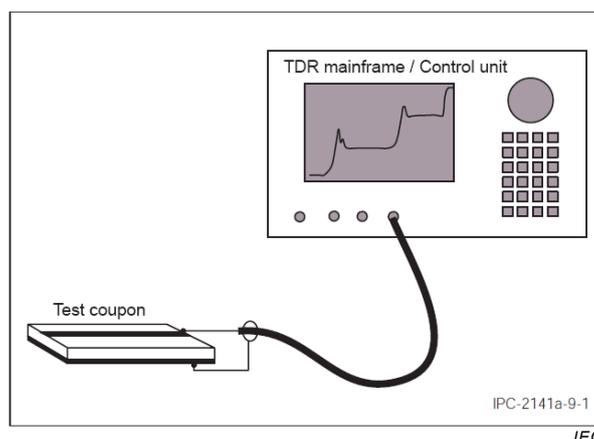


Figure 1 – TDR test system

NOTE A guideline for TDR is provided in Annex A.

4 Test specimen

4.1 General

FPCBs using NSMs should reduce the effect of electro-magnetic interference. However, without appropriate application of NSMs, it may cause poor signal quality on the FPCB due to the impedance variation of Cu circuit lines.

A major factor of impedance variation using NSMs is due to the structure variation of FPCBs, as shown in Figure 2.

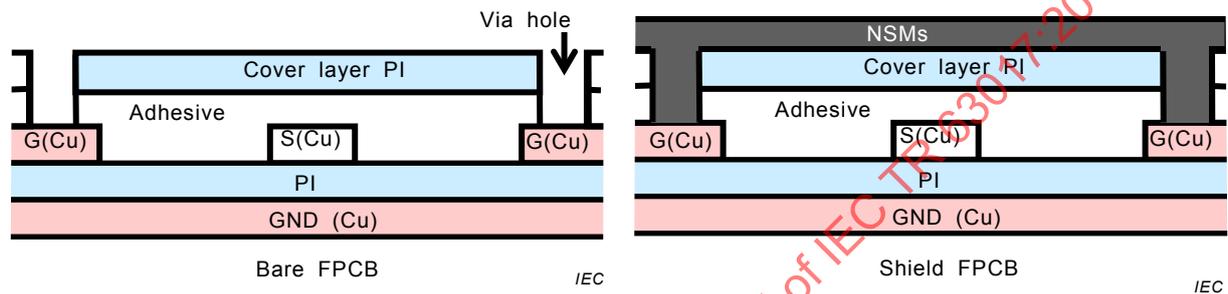


Figure 2a – <Micro strip line structure without NSMs>

Figure 2b – <Strip line structure with NSMs>

NOTE A guideline for the theoretical background of impedance variation is provided in Annex B.

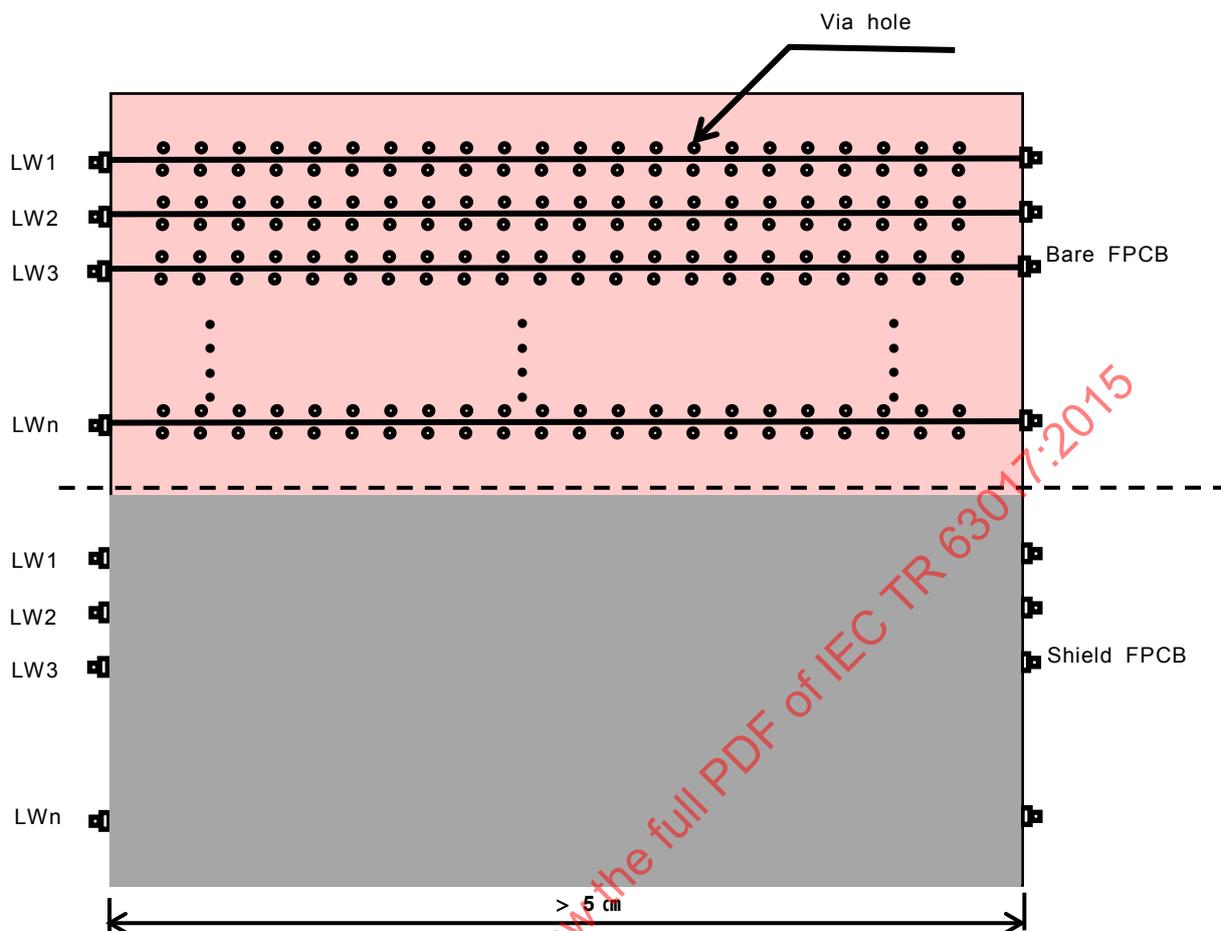
Figure 2 – Two types of impedance structure of FPCB

4.2 Structure

Test specimens shall be designed by two structures, i.e. with and without using NSMs in one FPCB board. Test specimens shall be divided into two halves with one board (consisting of the two parts of one bare FPCB and one shield FPCB) for equitable estimation. This structure has the merit of uniformly measuring at once a bare and a shield FPCB under the same condition. One FPCB without using NSMs has a structure of a micro-strip line. This type is called bare FPCB. Another FPCB using NSMs has a structure of a strip line. This type is called shield FPCB (see Figure 3).

A Cu line is formed with a linear distance direction, because the variation of the shield effect is very weak for a curved line.

Generally, the number of Cu patterns of the test specimen can be over the 5 (for example LW1 ~ LW5) for verification of the characteristic impedance (Z_0). But the number and width of the Cu line shall vary in accordance with the supplier's activity.



IEC

Figure 3 – Schematic diagram of a test specimen

Size, spacing and number of via holes for test specimens shall not be limited, but sufficiently represented. Especially, via holes offer an important role to contact the NSMs with the ground plan of shield FPCB. The number of via holes shall be as agreed between user and supplier (hereafter referred to as AABUS).

The length of the test specimen shall be over 5 cm in order to obtain stable values from the measuring equipment. Each end of the test specimen should consist of SMA (subminiature A) connectors. For discernment of a Cu line-width, write each – number to the bare – end of the test specimen near the SMA connector.

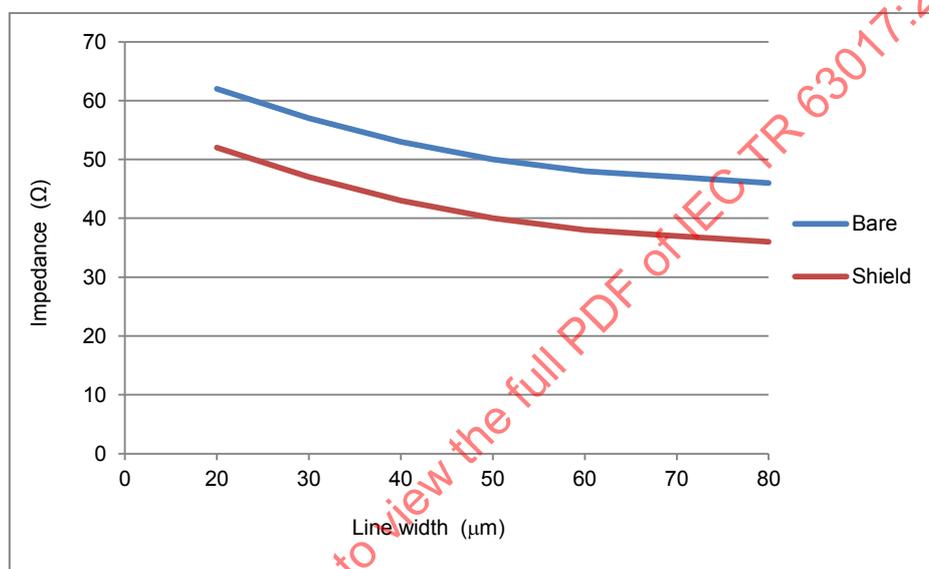
The decision of width and thickness of a test specimen shall depend on to the pitch or the number of the Cu line or according to the requirements of the user. However, generally the structure of the test coupon shall be AABUS.

An impedance value for FPCBs shall be changed with respect to the Cu pattern width, layer structure, thickness and materials. The structure and materials of the test specimens is required depending on the user's sample specifications. But the variation of these test specimens is not important, because the user of FPCBs shall check only the impedance variation effect by using NSMs for the user's sample specification.

4.3 Test method

In order to measure the proper impedance value for the test specimen, the following procedures shall be employed.

- a) Impedance values of the test specimen shall be measured by employing TDR, test specimen and coaxial cable according to IPC 2141A.
 - b) Measurement conditions shall be set by means of the TDR, such as dielectric constant, measurement point, rising time, pulse width, etc.
 - c) The impedance value of the test specimen shall be measured according to the Cu line width for bare FPCB.
 - d) The measurement of the above process according to Cu line width shall be repeated for the shield FPCB (see Figure 4).
- NOTE The guideline of the test method is provided in Annex C.
- e) The measuring value of the two types FPCBs (bare and shield) shall be presented in form of a diagram (line chart using excel).



IEC

Figure 4 – Impedance value of two type FPCB (bare and shield)

- f) In order to obtain the correct data, a direct hand contact to the specimen should be avoided as the electrostatic capacity varies.

NOTE The effect of hand contact with the test specimen is provided in Annex D.

4.4 Calculation

The following applies to the calculation of the compensation values.

- a) Generally, a demand of the characteristic impedance value (Z_0) is 50 Ω for a single Cu line, 100 Ω for a differential Cu line.
- b) In the case of a single Cu line, draw a straight base line corresponding to a characteristic impedance value (50 Ω) on a excel chart (see Figure 5).
- c) Find a cross point of the Cu line width for a characteristic impedance value (50 Ω) with each curve of bare and shield FPCB.
- d) Especially, check the Cu line width in the point to meet the 50 Ω impedance value from the shield FPCB curve.
- e) Calculate a difference (ΔL) of the Cu line width between two points.
- f) Reduce ΔL by degrees to the Cu line width of the bare FPCB.
- g) Show this value in a new design of a Cu line width for the bare FPCB.

NOTE A detailed test result is provided in Annex E.

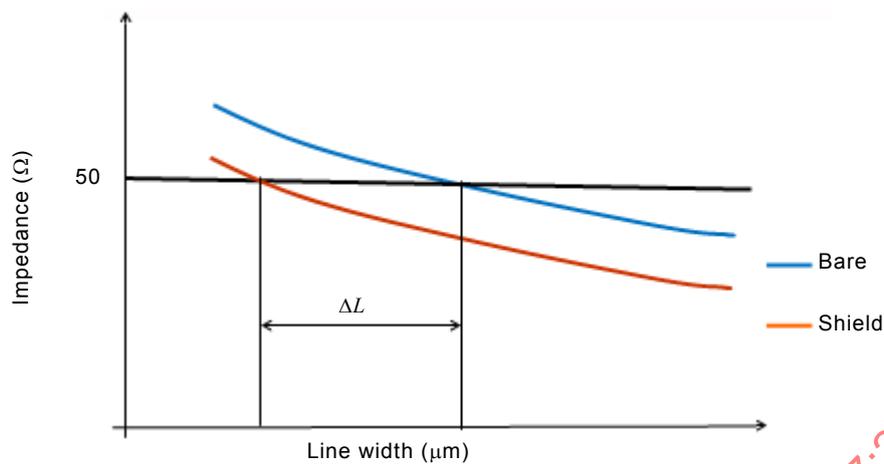


Figure 5 – Compensation value (ΔL) of the Cu line width for the shield FPCB

5 Report

In case that the specification of the measurement is contained in the report, it shall be provided with the details as specified below.

- Type of TDR equipment.
- Type of shield materials (structure, thickness, maker).
- Type of base materials (structure, maker).
- The range of Cu line width.
- The range of impedance (Z) variation according to the Cu line width of the test specimen.
- Impedance value data according to the Cu line width.

Annex A (normative)

Block diagram for impedance measuring with TDR

Time Domain Reflectometry (TDR) shall be used for impedance measurements according to IPC 2141A.

The TDR setup (IPC 2141A) is presented in Figure A.1.

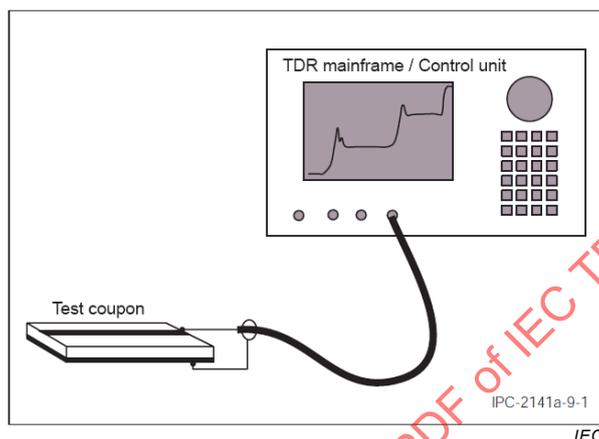


Figure A.1 – TDR test system according to IPC 2141a-9-1

Test setup by Agilent TDR 54754A¹ is presented in Figure A.2.



Figure A.2 – TDR test system according to Agilent TDR 54754A

¹ Agilent TDR 54754A is the trade name of a product supplied by Agilent Technologies.

This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Annex B (informative)

Theoretical background

The application of shield FPCB (with using NSMs) in electronic devices (or equipment) shall be able to reduce the effect of electro-magnetic interference, but it will eventually result in bad signal quality of FPCBs, because of the impedance variation of Cu circuit lines.

The purpose of this Technical Report is to settle the problem that FPCBs using NSMs suffer from, i.e. to eliminate an impedance mismatch by means of impedance compensation.

A major factor causing the impedance variation by using NSMs is due to the structure variation of FPCBs as shown in Figure B.1.

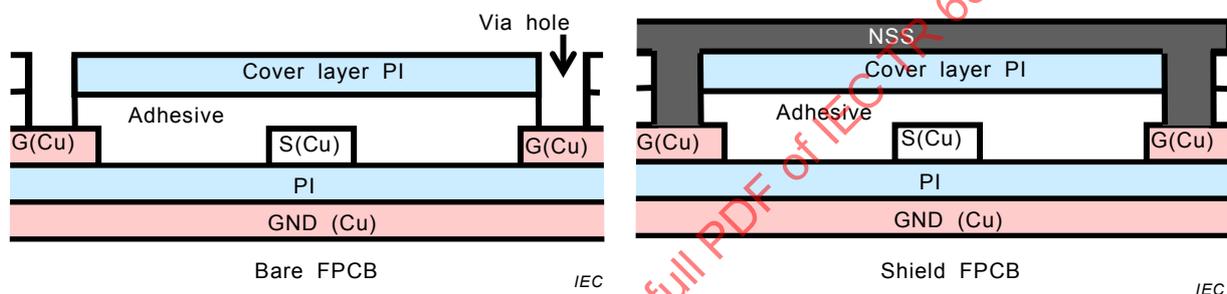


Figure B.1 a – <Micro strip line structure>

Figure B.1 b – <Strip line structure>

Figure B.1 – Two types of impedance structure of FPCBs

The impedance value of the strip line structure for FPCBs is lower than that of the micro-strip line structure, as shown in Figure B.2. NSMs shall play a role with respect of the metal layer, because they are composed of a metal component. Accordingly, the micro-strip line structure for bare FPCBs shall be changed to the strip line structure after application of NSMs for bare FPCB.

The impedance value decreases, as the Cu line width increases.

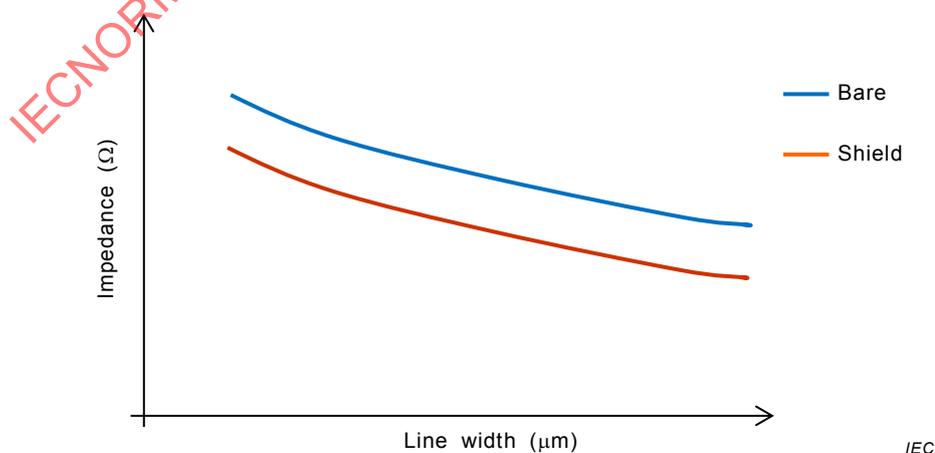


Figure B.2 – Comparison of the impedance value of a bare FPCB versus a shield FPCB

FPCB suppliers have to produce a new reduction design of Cu line width for new impedance matching (Z_0 , 50 Ω).

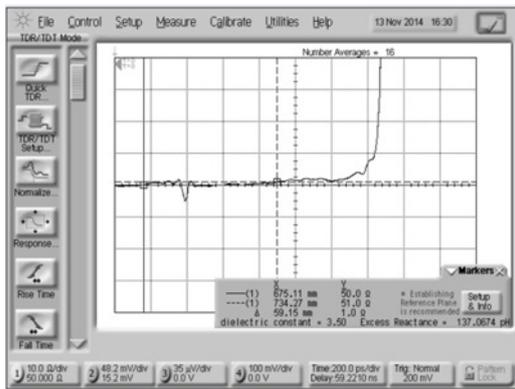
Annex C (informative)

Example of an impedance measurement with TDR

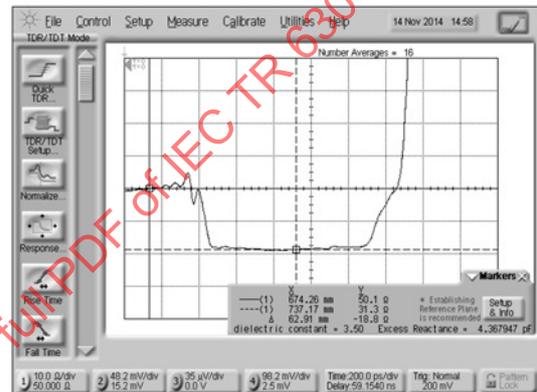
The test specimen shows two different impedance values according to the structure variation between a bare FPCB and a shield FPCB, as depicted in Figure C.1.

Example: test specimen: 8 cm (bare) +8 cm (shield), 100 μm Cu line width, with the following values:

- impedance value with bare FPCB: 50,9 Ω;
- impedance value with shield FPCB: 31,3 Ω;
- the impedance difference between two types: ΔZ (19,6 Ω).



IEC



IEC

Figure C.1 a - <Bare FPCB>

Figure C.1 b - <Shield FPCB>

Figure C.1 - Photographic view of the impedance measurement with TDR

IECNORM.COM : Click to view the full PDF of IEC TR 63017:2015

Annex D (informative)

Hand contact effect

The impedance value for a shield FPCB is not influenced by hand contact. But the impedance value for a bare FPCB is able to vary due to hand contact, as shown in Figure D.1. Especially, the effect of hand contact is more increased by a small line width.

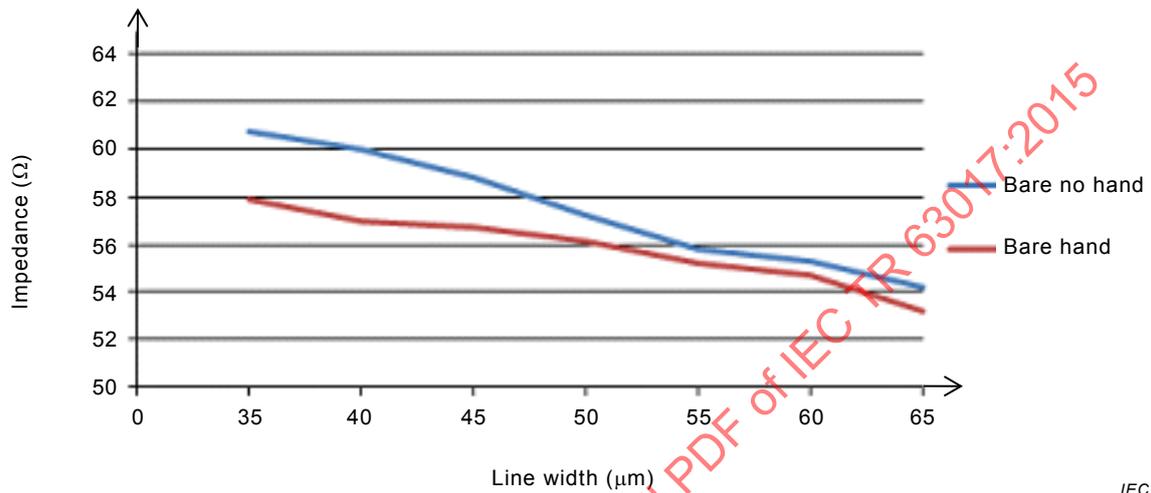


Figure D.1 – Effect of impedance variation by hand contact for bare FPCB

Annex E (informative)

Test result

E.1 Shield 1 FPCB

Figure E.1 shows the result of a test specimen that uses an 8 cm length shield (8 cm (bare) +8 cm (shield 1)).

To satisfy the 50 Ω condition for shield 1 FPCB, the Cu line width shall be near 40 μm.

The range of impedance (Z) reduction with NSMs: 16 Ω ~ 30 Ω (within the range of 30 μm ~ 150 μm Cu line width).

- Need of a reduction of the line width for new impedance matching ($Z_0 = 50 \Omega$).
- (example) Bare FPCB (100 μm) ⇒ Shield 1 FPCB (40 μm): 60 μm wide difference (ΔL).

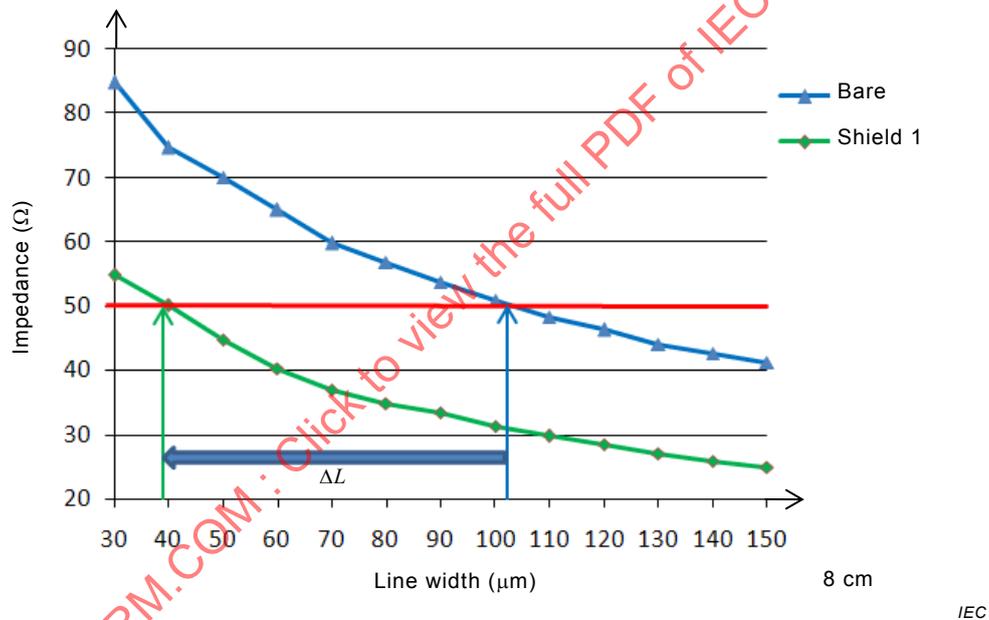


Figure E.1 – Measurement result of the test specimen for shield 1 FPCB

A cross-section of a test specimen using shield 1 FPCB is as shown in Table E.1. Where, a Cu thickness of NSMs for shield 1 FPCB is 2 μm.

Table E.1 – Cross-section of test specimen with using shield 1 FPCB

FPCB	FCCL (Flexible Copper Clad Laminate)	PI 50 μm, Cu 12 μm
	Cu thickness	24 μm (Cu plating 12 μm)
	CIL	PI 12 μm, Adhesive 25 μm
	Pattern space	200 μm
NSMs	Material	Cu
	Thickness	2 μm