

IPC 9252A Electrical Test Considerations & Military Specifications versus Electrical Test

(Know Your Specifications, Revisions and Amendments)

Todd L Kolmodin
VP Quality
Gardien Services USA Inc
5289 NE Elam Young Pkwy, Ste 120
Hillsboro, Oregon 97124

Abstracts

IPC 9252A Electrical Test Considerations

The PCB industry has advanced significantly in the recent millennium. OEM specifications and requirements have also advanced due to the maturing technologies. With this the requirements of Electrical Test of these higher technology products has advanced as well. Long gone are the “Pin in Hole” technology PCBs now surpassed by the large multilayer, blind/buried and Rigid Flex technologies. For the suppliers of Electrical Test, be it “in-house” or sub-contracted the industry specifications can be confusing, and at times non-comprehensible. The OEMs direct the IPC specification (6012, 9252A, AS9100, etc) for their fabrication to the manufacturer but do the OEMs/CMs really understand what they are asking? There are many variables associated with these specifications and requirements to their designated classes regarding Electrical Test. OEMs decide what IPC class they wish their product manufactured due to performance requirements but overlook the electrical requirements associated with those requirements. Manufacturing, plating, etching and all those processes may be within the class requirements they require but they overlook the Electrical Requirements associated with their required IPC class. This paper will outline and define what requirements must be adhered to for the OEM community to truly achieve the IPC class product from the Electrical Test standpoint. This will include the test point optimization matrix, Isolation (shorts) parameters and Continuity (opens) parameters. This paper will also address the IPC Class III/A additional requirements for Aerospace and Military Avionics. The disconnect exists between OEMs understanding the requirements of their specific IPC class design versus the signature that will be presented from their design. This results in many Class III builds failing at Electrical Test.

Military Specifications versus Electrical Test

Many PCB manufacturers are now gaining contracts from Military OEMs. From these new specifications are a required prerequisite above and beyond the standard IPC consortium. Military specifications have different requirements than the standard IPC requirements. With Electrical Test the manufacturer or sub-contractor must test this product in accordance with the designated military specification.

The disconnect here between the OEM and the Manufacturer or CM is that this information is not readily supplied to the Electrical Test department or sub-contractor. Just because the board is to be built to MIL 31032, Mil 50884 or MIL 55110 is not enough. DSCC, now the Defense Logistics Agency, Land and Maritime has for a long time required that not only shall a Military OEM state what specification the product should be built to, but also state the specific revision of that specification and amendment level. This paper will outline the Electrical Test Requirements for the specifications 55110, 50884 and 31032 up to the current revision and amendment level as of publish of this document. Electrical Test requirements have changed depending on the revision and amendment of each of these documents, and the use of Flying Probe Test vs. Fixture Test.

Introduction

Over the years many aspects of testing printed circuits have changed. Long have we come from single-sided breadboards, double-sided and PTH only builds to the massive layer counts, blind-buried vias, strict TDR requirements and even buried passives such as capacitance and resistance. The industry has expanded tremendously over the last 25 years and so has the technology. Time to market is crucial for many OEMs. They need their product out to the consumers and perform to the modeling the designers intended. This puts some constraints building and testing the product for conformance. Following we shall explore:

1. IPC Classes? Defined – Figure 1

2. Test Methods – Definitions
3. Requirements when testing Class I-III & 3A
4. Design concerns versus Class requirements

We shall also visit the impact of Military Specifications on Electrical Test

5. Knowing your specifications (31032, 50884, 55110)
6. DLA requirements for the Suitability Lab
7. OEM/Manufacturer DLA expectations
8. Closing and Q & A

1. IPC Classes II & III Defined

Class 1 General Electronic Products — Includes consumer products, some computer and computer peripherals suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed printed board.

Class 2 Dedicated Service Electronic Products — Includes communications equipment, sophisticated business machines, instruments where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.

Class 3 High Reliability Electronic Products — Includes the equipment and products where continued performance or performance on demand is critical. Equipment downtime cannot be tolerated and must function when required such as in life support items or flight control systems. Printed boards in this class are suitable for applications where high levels of assurance are required and service is essential.

Figure 1-1 – IPC Classes (IPC-6011)

2. Test Methods

Bare Board Electrical Testing today is done primarily by either of two methods. The Universal Grid Test Machine using fixtures or the use of Flying Probe Machines. Both options provide the Electrical Test but with some tradeoffs. These primarily being Speed versus Cost. Also within the IPC-9252A Specification definitions exist outlining Continuity, Isolation, Indirect Signature Comparison, Resistive Isolation Testing. Huh? You say? Okay Continuity, Isolation, Resistive Continuity and Resistive Isolation are best defined as used by Grid Test Machines. Indirect, Signature Comparison, Adjacency are all terms used in Flying Probes.

- a. Continuity – The value in Ohms Ω that may NOT be exceeded on any circuit or the machine will fail the circuit as “Open.”

- b. Isolation (Discontinuity) – The value in Ohms Ω (usually Meg Ohms) that two circuits should have in resistance between them as a minimum or the machine will fault the two circuits as “Shorted.”
- c. Adjacency Value – Used in Flying Probes. This value is 1.27mm (0.050 in.) What this means is that any two circuits that are 1.27mm in distance or less from one another at ANY point, they will get tested for possible “short” conditions. The number can be adjusted as agreed between user and supplier. (AABUS.) The IPC standard here states that only Horizontal or “Line of Sight” Adjacency is required, Vertical or Z-Axis Adjacency is not required unless specified. Adjacency both Horizontal and Vertical is outlined below in Figures 2-1 and 2 -2.

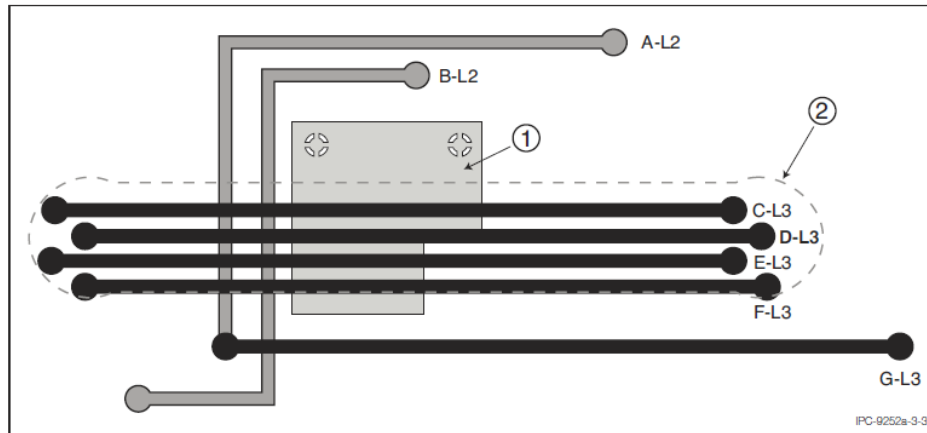


Figure 3-3 Horizontal Layer Adjacency

1. Segmented Ground/Layer 2
2. Adjacency Limit is from Edge of D-L3 Conductor
3. Adjacency Rules:

D-L3 is tested to C-L3, E-L3, and F-L3

D-L3 is not tested to G-L3, A-L2, B-L2, or to segmented ground/L2

B-L2 is tested against A-L2, G-L3, and to segmented ground/L2

B-L2 is not tested against C-L3, D-L3, E-L3, or F-L3

Figure 2-1 Horizontal Adjacency

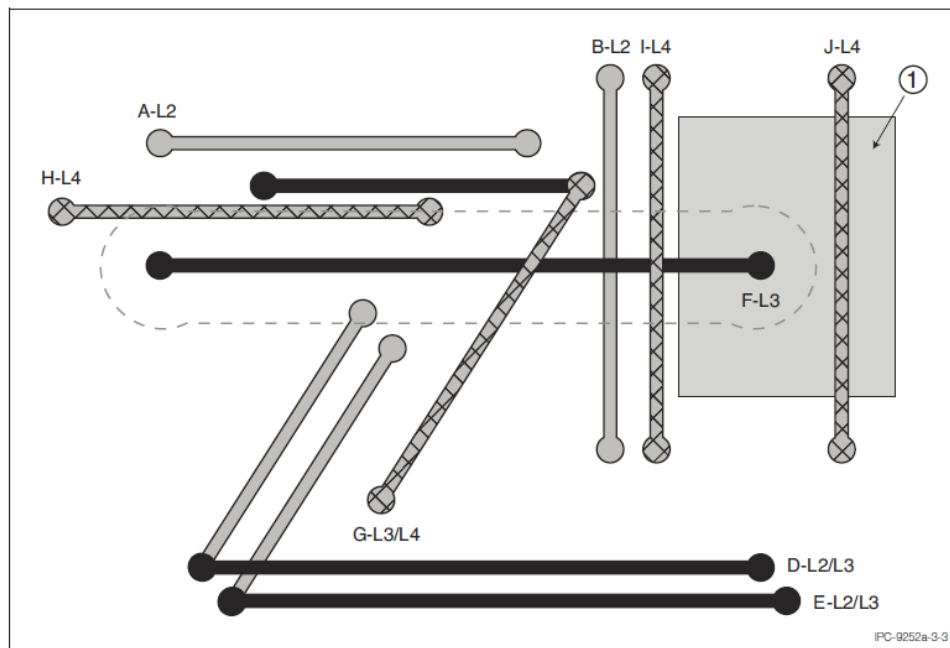


Figure 3-5 Vertical Layer Adjacency

1. Grounded plane: C-L2
2. Dotted area denotes vertical layer adjacency area for net F on layer L3
3. Nets to be included in the vertical layer adjacency list for net F: B-L2, C-L2, D-L2/L3, G-L3/L4, H-L4, I-L4

Figure 2-2 Vertical Adjacency

- d. Indirect Testing by Signature Comparison – This is how most Flying Probe machines gain their speed in testing along with Adjacency. The first board of the order goes through the signature gather (Capacitive Discharge) and will receive a full Resistive Continuity and Isolation (using Adjacency) test. If the board passes the master

value will be retained. The second and all subsequent boards will also receive the Capacitive Signature gather. However ONLY nets that have deviated beyond machine preset threshold against the master will receive the Resistive verify for possible Opens or Shorts. However the Flying Probe machines can provide full Resistive Continuity and Isolation testing. Again the Isolation Test is using Adjacency. In this case all boards will take the same time to test as the first board.

- e. Voltage – This parameter is probably the most misunderstood parameter in the Electrical Test arena. How much should be applied and when? Most Electrical Test machines use Voltage in both the Continuity and Isolation phases of the test. However they usually do not use the same in each. On many machines the Continuity Test Voltage is not configurable. This Voltage is very low, usually around 12-15 VDC. The reason for this is that higher Voltage is not necessary when checking for “Open” conditions. An “Open” will be open at 12 Volts as much as it will be at 250 Volts. Further the low Voltage is used to protect the circuit. Running high Voltage on a point to point network would cause high current runaway and most likely damage or scrap the circuit. However the higher Voltage is desired when checking for “Shorts.” Since theoretically there should not be a current path between isolated circuits the higher voltage is used to “sniff” the possibility of a “Short.” If the machine identifies a “leak” or a “dead short” it will identify the nets shorting but also shut down the test on those nets so as not to damage them. Electrical Test machines are not designed in principle to “Blow” shorts. So the question is how much should be applied to check for shorts? Figure 2-3 is an excerpt from the IPC-9252A Standard.

4.2.1 Resistive Isolation Testing This type of testing verifies that electrically isolated networks meet the minimum threshold in accordance with Table 4-1. Faults detected are defined as either shorts or leakages in accordance with Figure 4-2. For automated equipment the test voltage shall be as specified on the master drawing or, if this is not specified, it shall be the maximum rated voltage of the net being tested. If this is not stated, it shall be 40 volts minimum applied between each pair of nets under test. For manual testing the test voltage shall be 200 volts minimum applied between each pair of nets under test for a minimum of 5 seconds. If the resistance measured (isolation resistance) is higher than the minimum isolation resistance threshold, the network passes. All networks shall be tested against all other networks unless adjacency testing is used in accordance with Table 4-1.

Figure 2-3 Test Voltage

Still vague? Yes. This is why many Test Contractors have developed “Standard Parameters” that will meet and/or exceed the requirements of the IPC Standard. There are many times where the Master Drawing doesn’t say anything about Electrical Test but that it is required. In a case such as that the Test Machine only needs to use a MINIMUM of 40 Volts. Remember here that it says “Minimum.” This is why many Test Facilities use voltages such as 100VDC as their standard. This is a better test and exceeds the requirements.

3. Requirements when testing Class I-III & 3/A

Minimum Electrical Test requirements are different between the IPC classes. This does NOT mean that Opens or Shorts are allowed! However the electrical thresholds to identify these conditions are different. In the Electrical Test industry we are not only looking for the extreme cases (infinite Open or Direct Short) we are also looking for indicators of what MAY be a potential problem. This is why the minimum requirements are different between classes. Table 3-1 identifies this below:

Table 3-1

Requirements by Test Level

TEST LEVEL	A	B	C
Performance Class	1	2	3
Source Data	CAM, CAD	CAM, CAD	CAD ¹
TEST METHODS			
Resistive Continuity Testing	≤100Ω	≤50Ω	≤10Ω ⁴
Resistive Isolation Testing	≥500kΩ	≥2MΩ	≥10MΩ
Indirect Isolation & Continuity Testing by Signature Comparison	Yes	Yes	AABUS
Adjacency (for Isolation testing) ^{2,3}	Yes	Yes	AABUS

Note 1. See 5.1.2.

Note 2. Default minimum of 1.27 mm [0.050 in] or AABUS.

Note 3. Includes horizontal and/or line of sight adjacency; vertical adjacency is not required unless specified.

Note 4. For referee purposes, 0.5Ω maximum for each 25.0 mm [0.984 in] of circuit length shall apply.

As you can see from table 3-1 the Resistive Continuity and Resistive Isolation requirements are much different between Class I and Class III. You will also notice that Indirect Continuity and Isolation Testing by Signature Comparison is allowed in Classes I and II but AABUS in Class III. This does not mean that it cannot be used but it does require authorization from the OEM or Customer for that method to be used on Class III product.

Class 3/A Exception – Space and Military Avionics IPC-6012 Appendix A

This is an exception beyond the standard Class III requirement for Electrical Test. In this case there are parameters specified when testing product under this class. These requirements need to be on the Master Drawing and communicated from the OEM to the manufacturer or this type of test may be overlooked. The differences with Class 3/A are below in table 3-2.

Table 3-2 Class 3/A

Electrical Continuity and Isolation Resistance	3.8.2	Net List Testing - 250 Vdc - 100 Megohms Min	IPC-9252
Continuity	3.8.2.1	Net List Testing - 250 Vdc - 10 Ohms Max	IPC-9252 & IPC-2221
Isolation Resistance	3.8.2.2	Net List Testing - 250 Vdc - 100 Megohms Min	IPC-9252

4. Design concerns versus Class requirements

From an OEM or Designers perspective one must be aware of constraints they may build into the board design that may cause some difficulty during Electrical Test. We find this most prominent with Class III product designs. From the information previous (Table 3-1) we see that for Continuity Resistance there must be no circuit in the board whose Resistance is greater than 10 Ohms. That is the standard. Now there are a couple problems that come into play here. If you will look back to note 4 below Table 3-1 you will see a statement regarding referee calculations for circuit length. With that said, a board may be out of tolerance to Class III with any net having a length exceeding 500mm (19.68 in.) Compounding this is that some OEMs not only want Class III but Continuity Resistance to not exceed 5 Ohms and have net lengths in their board exceeding 750mm (29.53 in.) This usually leads to delays in Final Inspection and or shipping of product until a waiver or master drawing deviation is obtained.

Military Specifications versus Electrical Test

5. Know your specification – 31032, 50884 and 55110

Many manufacturers are building Military product. As with the Military of course there are their own specifications for building and testing their product. Two main specifications that are seen today that have impact on Electrical Test are MIL-PRF-31032 and MIL-P-50884. 31032 is the Performance Specification covering a full range of

product builds. This covers multilayer, blind/buried vias, flex, rigid flex and Thermoplastic with or without plated holes for High Frequency. 50884 is the General Performance Specification for Flex. I also noted above the 55110. Some Military POs and prints may still call on this one but it was superseded by 31032 for any new builds after 31 Dec 1997. It is still an active document for builds still being done with designs prior to the 31 Dec 1997 deadline.

6. DLA requirements for the Suitability Lab

The disconnect that the Independent or even in-house Electrical Test organization has with regard to the Military specification is WHICH specification of MIL-PRF-31032 are we supposed to test? Folks there are 7 of them! MIL-PRF-31032 B, 1C, 2B, 3B, 4B, 5 and 6! For the Test Certification to be compliant with DLA requirements the Specification, Revision and amendment level must be stated on the Certificate of Compliance. Table 6-1 outlines the current requirements as of the date of this presentation.

Table 6-1 Military Requirements

Specification	Revision	Voltage Minimum*	Isolation Minimum	Continuity Maximum	Indirect Test Allowed
MIL-PRF-31032	B	40 VDC Minimum	> 2 Meg Ohm	10 Ohms	-
Mil-PRF-31032	/1C	40 VDC Minimum	> 2 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/2B	40 VDC Minimum	> 2 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/3B	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/4B	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/5	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/6	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	No
MIL-P-50884	E	40 VDC Minimum	> 10 Meg Ohm	20 Ohms (Qual) 10 Ohms Production	Yes*
MIL-PRF-55110	G	40 VDC Minimum	> 2 Meg Ohm	20 Ohms (Qual) 10 Ohms Production	No

*In these instances the allowance of Indirect Testing must be Agreed Between User and Supplier, as noted in IPC9252 (latest revision) as AABUS. This means that it must be stipulated up front via the PO or Procurement Document. Although the MIL specifications noted allow this, it is not inferred or allowed without the written consent of the manufacturer requiring such test.

7. OEM/Manufacturer DLA Expectations

Test Centers and manufactures continue to move to gain suitability via the DLA. With this come requirements on reporting, record retention and traceability. Further as noted above the Certificate of Compliance needs to state what Specification, Revision and amendment level of the specification was used to test the product. This information must be given to the manufacturer and also to the Electrical Test organization, whether they are independent or in-house to guarantee the product was built and tested to the required specification.

8. Closing and Q & A

- For our OEMs we see that understanding what the IPC-9252A specification requires is very important. Design within the guidelines of acceptance is very crucial for your design to pass.
- Know what your Electrical Test Center or Contractor will be using to test your design. Get involved with this! Do you allow Flying Probe or Fixture Grid Machine Test?
- Know what you are asking on your Master Drawing. Remember Continuity Resistance is to check resistance for “Opens.” Isolation Resistance is for “Shorts.”
- What Class are you designing your product to adhere to? Refer to Figure 1-1 of this presentation. I cannot stress this enough. Configure your design auto-routers to minimize net copper length with regard to Table 3-1, Note 4. This will ensure compliance to the class of board you are designing and minimize manufacturing and/or shipping delays due to non-conformance. It is very difficult for Electrical Test Machines on the bare board level to segregate non-conforming nets from conforming to allow a “Pass” condition. IPC-9252A Class III requires that all nets within the board **shall** pass at 10 Ohms or less. If they do not, the board is NOT Class III compliant. Again this is the standard. You will have to work these non-conformance deviations with your CM and/or Manufacturer.
- MILITARY – Identify your specification to your manufacturer, including revision and amendment level. This will ensure you that you have full compliance to DLA and the customer you are building for. This is another big “take away” point.
- Document, Document, Document! Know your product class you are building. Document specifications required. Convey these requirements to your manufacturer/CM.
- Understand the requirements that you may be asking against what you know of your build.



**IPC 9252A Electrical Test Considerations
&
Military Specifications versus Electrical Test
(Know your specifications, revisions and amendments)**

**Todd L Kolmodin
VP Quality
Gardien Services USA Inc
5289 NE Elam Young Pkwy, Ste 120
Hillsboro, Oregon 97124**



Abstracts

- **IPC 9252A Electrical Test Considerations**
- The PCB industry has advanced significantly in the recent millennium. OEM specifications and requirements have also advanced due to the maturing technologies. With this the requirements of Electrical Test of these higher technology products has advanced as well. Long gone are the “Pin in Hole” technology PCBs now surpassed by the large multilayer, blind/buried and Rigid Flex technologies. For the suppliers of Electrical Test, be it “in-house” or sub-contracted the industry specifications can be confusing, and at times non-comprehensible. The OEMs direct the IPC specification (6012, 9252A, AS9100, etc) for their fabrication to the manufacturer but do the OEMs/CMs really understand what they are asking? There are many variables associated with these specifications and requirements to their designated classes regarding Electrical Test. OEMs decide what IPC class they wish their product manufactured due to performance requirements but overlook the electrical requirements associated with those requirements. Manufacturing, plating, etching and all those processes may be within the class requirements they require but they overlook the Electrical Requirements associated with their required IPC class. This paper will outline and define what requirements must be adhered to for the OEM community to truly achieve the IPC class product from the Electrical Test standpoint. This will include the test point optimization matrix, Isolation (shorts) parameters and Continuity (opens) parameters. This paper will also address the IPC Class III/A additional requirements for Aerospace and Military Avionics. The disconnect exists between OEMs understanding the requirements of their specific IPC class design versus the signature that will be presented from their design. This results in many Class III builds failing at Electrical Test.

Abstracts Con't



- **Military Specifications versus Electrical Test**
- Many PCB manufacturers are now gaining contracts from Military OEMs. From these new specifications are a required prerequisite above and beyond the standard IPC consortium. Military specifications have different requirements than the standard IPC requirements. With Electrical Test the manufacturer or sub-contractor must test this product in accordance with the designated military specification.
- The disconnect here between the OEM and the Manufacturer or CM is that this information is not readily supplied to the Electrical Test department or sub-contractor. Just because the board is to be built to MIL 31032, Mil 50884 or MIL 55110 is not enough. DSCC, now the Defense Logistics Agency, Land and Maritime has for a long time required that not only shall a Military OEM state what specification the product should be built to, but also state the specific revision of that specification and amendment level. This paper will outline the Electrical Test Requirements for the specifications 55110, 50884 and 31032 up to the current revision and amendment level as of publish of this document. Electrical Test requirements have changed depending on the revision and amendment of each of these documents, and the use of Flying Probe Test vs. Fixture Test.



Introduction

- Over the years many aspects of testing printed circuits have changed. Long have we come from single-sided breadboards, double-sided and PTH only builds to the massive layer counts, blind-buried vias, strict TDR requirements and even buried passives such as capacitance and resistance. The industry has expanded tremendously over the last 25 years and so has the technology. Time to market is crucial for many OEMs. They need their product out to the consumers and perform to the modeling the designers intended. This puts some constraints building and testing the product for conformance. Following we shall explore:
 - 1.0 IPC Classes? Defined – Figure 1
 - 2.0 Test Methods – Definitions
 - 3.0 Requirements when testing Class I-III & 3A
 - 4.0 Design concerns versus Class requirements
- We shall also visit the impact of Military Specifications on Electrical Test
 - 5.0 Knowing your specifications (31032, 50884, 55110)
 - 6.0 DLA requirements for the Suitability Lab
 - 7.0 OEM/Manufacturer DLA expectations
- 8.0 Closing and Q & A



1. IPC Classes II and III

Class 1 General Electronic Products — Includes consumer products, some computer and computer peripherals suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed printed board.

Class 2 Dedicated Service Electronic Products — Includes communications equipment, sophisticated business machines, instruments where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.

Class 3 High Reliability Electronic Products — Includes the equipment and products where continued performance or performance on demand is critical. Equipment downtime cannot be tolerated and must function when required such as in life support items or flight control systems. Printed boards in this class are suitable for applications where high levels of assurance are required and service is essential.



2. Test Methods

- Bare Board Electrical Testing today is done primarily by either of two methods. The Universal Grid Test Machine using fixtures or the use of Flying Probe Machines. Both options provide the Electrical Test but with some tradeoffs. These primarily being Speed versus Cost. Also within the IPC-9252A Specification definitions exist outlining Continuity, Isolation, Indirect Signature Comparison, Resistive Isolation Testing. Huh? You say? Okay Continuity, Isolation, Resistive Continuity and Resistive Isolation are best defined as used by Grid Test Machines. Indirect, Signature Comparison, Adjacency are all terms used in Flying Probes.
- Continuity – The value in Ohms Ω that may NOT be exceeded on any circuit or the machine will fail the circuit as “Open.”
- Isolation (Discontinuity) – The value in Ohms Ω (usually Meg Ohms) that two circuits should have in resistance between them as a minimum or the machine will fault the two circuits as “Shorted.”
- Adjacency Value – Used in Flying Probes. This value is 1.27mm (0.050 in.) What this means is that any two circuits that are 1.27mm in distance or less from one another at ANY point, they will get tested for possible “short” conditions. The number can be adjusted as agreed between user and supplier. (AABUS.) The IPC standard here states that only Horizontal or “Line of Sight” Adjacency is required, Vertical or Z-Axis Adjacency is not required unless specified. Adjacency both Horizontal and Vertical is outlined below in Figures 2-1 and 2 -2.
- Figure 2-1 Horizontal Adjacency
- Figure 2-2 Vertical Adjacency
- Indirect Testing by Signature Comparison – This is how most Flying Probe machines gain their speed in testing along with Adjacency. The first board of the order goes through the signature gather (Capacitive Discharge) and will receive a full Resistive Continuity and Isolation (using Adjacency) test. If the board passes the master value will be retained. The second and all subsequent boards will also receive the Capacitive Signature gather. However ONLY nets that have deviated beyond machine preset threshold against the master will receive the Resistive verify for possible Opens or Shorts. However the Flying Probe machines can provide full Resistive Continuity and Isolation testing. Again the Isolation Test is using Adjacency. In this case all boards will take the same time to test as the first board.



- Voltage – This parameter is probably the most misunderstood parameter in the Electrical Test arena. How much should be applied and when? Most Electrical Test machines use Voltage in both the Continuity and Isolation phases of the test. However they usually do not use the same in each. On many machines the Continuity Test Voltage is not configurable. This Voltage is very low, usually around 12-15 VDC. The reason for this is that higher Voltage is not necessary when checking for “Open” conditions. An “Open” will be open at 12 Volts as much as it will be at 250 Volts. Further the low Voltage is used to protect the circuit. Running high Voltage on a point to point network would cause high current runaway and most likely damage or scrap the circuit. However the higher Voltage is desired when checking for “Shorts.” Since theoretically there should not be a current path between isolated circuits the higher voltage is used to “sniff” the possibility of a “Short.” If the machine identifies a “leak” or a “dead short” it will identify the nets shorting but also shut down the test on those nets so as not to damage them. Electrical Test machines are not designed in principle to “Blow” shorts. So the question is how much should be applied to check for shorts? Figure 2-3 is an excerpt from the IPC-9252A Standard.

4.2.1 Resistive Isolation Testing This type of testing verifies that electrically isolated networks meet the minimum threshold in accordance with Table 4-1. Faults detected are defined as either shorts or leakages in accordance with Figure 4-2. For automated equipment the test voltage **shall** be as specified on the master drawing or, if this is not specified, it **shall** be the maximum rated voltage of the net being tested. If this is not stated, it **shall** be 40 volts minimum applied between each pair of nets under test. For manual testing the test voltage **shall** be 200 volts minimum applied between each pair of nets under test for a minimum of 5 seconds. If the resistance measured (isolation resistance) is higher than the minimum isolation resistance threshold, the network passes. All networks **shall** be tested against all other networks unless adjacency testing is used in accordance with Table 4-1.

- Figure 2-3 Test Voltage

- Still vague? Yes. This is why many Test Contractors have developed “Standard Parameters” that will meet and/or exceed the requirements of the IPC Standard. There are many times where the Master Drawing doesn’t say anything about Electrical Test but that it is required. In a case such as that the Test Machine only needs to use a MINIMUM of 40 Volts. Remember here that it says “Minimum.” This is why many Test Facilities use voltages such as 100VDC as their standard. This is a better test and exceeds the requirements.



3. Requirements when testing Class I-III and 3/A

- Minimum Electrical Test requirements are different between the IPC classes. This does NOT mean that Opens or Shorts are allowed! However the electrical thresholds to identify these conditions are different. In the Electrical Test industry we are not only looking for the extreme cases (infinite Open or Direct Short) we are also looking for indicators of what MAY be a potential problem. This is why the minimum requirements are different between classes. Table 3-1 identifies this below:

Requirements by Test Level			
TEST LEVEL	A	B	C
Performance Class	1	2	3
Source Data	CAM, CAD	CAM, CAD	CAD ¹
TEST METHODS			
Resistive Continuity Testing	$\leq 100\Omega$	$\leq 50\Omega$	$\leq 10\Omega^4$
Resistive Isolation Testing	$\geq 500k\Omega$	$\geq 2M\Omega$	$\geq 10M\Omega$
Indirect Isolation & Continuity Testing by Signature Comparison	Yes	Yes	AABUS
Adjacency (for Isolation testing) ^{2,3}	Yes	Yes	AABUS

Note 1. See 5.1.2.

Note 2. Default minimum of 1.27 mm [0.050 in] or AABUS.

Note 3. Includes horizontal and/or line of sight adjacency; vertical adjacency is not required unless specified.

Note 4. For referee purposes, 0.5 Ω maximum for each 25.0 mm [0.984 in] of circuit length shall apply.

Table 3-1

- As you can see from table 3-1 the Resistive Continuity and Resistive Isolation requirements are much different between Class I and Class III. You will also notice that Indirect Continuity and Isolation Testing by Signature Comparison is allowed in Classes I and II but AABUS in Class III. This does not mean that it cannot be used but it does require authorization from the OEM or Customer for that method to be used on Class III product.



Table 3-2 Class 3/A

- **Class 3/A Exception – Space and Military Avionics
IPC-6012 Appendix A**

Table 3-2 Class 3/A

Electrical Continuity and Isolation Resistance	3.8.2	Net List Testing - 250 Vdc - 100 Megohms Min	IPC-9252
Continuity	3.8.2.1	Net List Testing - 250 Vdc - 10 Ohms Max	IPC-9252 & IPC-2221
Isolation Resistance	3.8.2.2	Net List Testing - 250 Vdc - 100 Megohms Min	IPC-9252

- This is an exception beyond the standard Class III requirement for Electrical Test. In this case there are parameters specified when testing product under this class. These requirements need to be on the Master Drawing and communicated from the OEM to the manufacturer or this type of test may be overlooked. The differences with Class 3/A are below in table 3-2.



4.0 Design Concerns versus Class requirements

- From an OEM or Designers perspective one must be aware of constraints they may build into the board design that may cause some difficulty during Electrical Test. We find this most prominent with Class III product designs. From the information previous (Table 3-1) we see that for Continuity Resistance there must be no circuit in the board whose Resistance is greater than 10 Ohms. That is the standard. Now there are a couple problems that come into play here. If you will look back to note 4 below Table 3-1 you will see a statement regarding referee calculations for circuit length. With that said, a board may be out of tolerance to Class III with any net having a length exceeding 500mm (19.68 in.) Compounding this is that some OEMs not only want Class III but Continuity Resistance to not exceed 5 Ohms and have net lengths in their board exceeding 750mm (29.53 in.) This usually leads to delays in Final Inspection and or shipping of product until a waiver or master drawing deviation is obtained.

Military Specifications versus Electrical Test



5.0 Know your specification – 31032, 50884 and 55110

- Many manufacturers are building Military product. As with the Military of course there are their own specifications for building and testing their product. Two main specifications that are seen today that have impact on Electrical Test are MIL-PRF-31032 and MIL-P-50884. 31032 is the Performance Specification covering a full range of product builds. This covers multilayer, blind/buried vias, flex, rigid flex and Thermoplastic with or without plated holes for High Frequency. 50884 is the General Performance Specification for Flex. I also noted above the 55110. Some Military POs and prints may still call on this one but it was superseded by 31032 for any new builds after 31 Dec 1997. It is still an active document for builds still being done with designs prior to the 31 Dec 1997 deadline.



6.0 DLA requirements for the Suitability Lab

- The disconnect that the Independent or even in-house Electrical Test organization has with regard to the Military specification is WHICH specification of MIL-PRF-31032 are we supposed to test? Folks there are 7 of them! MIL-PRF-31032 B, 1C, 2B, 3B, 4B, 5 and 6! For the Test Certification to be compliant with DLA requirements the Specification, Revision and amendment level must be stated on the Certificate of Compliance. Table 6-1 outlines the current requirements as of the date of this presentation.

Table 6-1

Specification	Revision	Voltage Minimum*	Isolation Minimum	Continuity Maximum	Indirect Test Allowed
MIL-PRF-31032	B	40 VDC Minimum	> 2 Meg Ohm	10 Ohms	-
MIL-PRF-31032	/1C	40 VDC Minimum	> 2 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/2B	40 VDC Minimum	> 2 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/3B	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/4B	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/5	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	Yes*
MIL-PRF-31032	/6	40 VDC Minimum	> 100 Meg Ohm	10 Ohms	No
MIL-P-50884	E	40 VDC Minimum	> 10 Meg Ohm	20 Ohms (Qual) 10 Ohms Production	Yes*
MIL-PRF-55110	G	40 VDC Minimum	> 2 Meg Ohm	20 Ohms (Qual) 10 Ohms Production	No

*In these instances the allowance of Indirect Testing must be Agreed Between User and Supplier, as noted in IPC9252 (latest revision) as AABUS. This means that it must be stipulated up front via the PO or Procurement Document. Although the MIL specifications noted allow this, it is not inferred or allowed without the written consent of the manufacturer requiring such test.



7.0 OEM/Manufacturer DLA Expectations

- Test Centers and manufactures continue to move to gain suitability via the DLA. With this come requirements on reporting, record retention and traceability. Further as noted above the Certificate of Compliance needs to state what Specification, Revision and amendment level of the specification was used to test the product. This information must be given to the manufacturer and also to the Electrical Test organization, whether they are independent or in-house to guarantee the product was built and tested to the required specification.



8.0 Closing and Q & A

- For our OEMs we see that understanding what the IPC-9252A specification requires is very important. Design within the guidelines of acceptance is very crucial for your design to pass.
- Know what your Electrical Test Center or Contractor will be using to test your design. Get involved with this! Do you allow Flying Probe or Fixture Grid Machine Test?
- Know what you are asking on your Master Drawing. Remember Continuity Resistance is to check resistance for “Opens.” Isolation Resistance is for “Shorts.”
- What Class are you designing your product to adhere to? Refer to Figure 1-1 of this presentation. I cannot stress this enough. Configure your design auto-routers to minimize net copper length with regard to Table 3-1, Note 4. This will ensure compliance to the class of board you are designing and minimize manufacturing and/or shipping delays due to non-conformance. It is very difficult for Electrical Test Machines on the bare board level to segregate non-conforming nets from conforming to allow a “Pass” condition. IPC-9252A Class III requires that all nets within the board **shall** pass at 10 Ohms or less. If they do not, the board is NOT Class III compliant. Again this is the standard. You will have to work these non-conformance deviations with your CM and/or Manufacturer.
- MILITARY – Identify your specification to your manufacturer, including revision and amendment level. This will ensure you that you have full compliance to DLA and the customer you are building for. This is another big “take away” point.
- Document, Document, Document! Know your product class you are building. Document specifications required. Convey these requirements to your manufacturer/CM.
- Understand the requirements that you may be asking against what you know of your build.



Thank you!

- Open Floor ??