



IPC-2551

International Standard for Digital Twins

Developed by the Generic Requirements for Digital Twin Task Group (2-12a) of the Electronic Product Data Description Committee (2-10) of IPC

Users of this publication are encouraged to participate in the development of future revisions.

Contact:

IPC

Table of Contents

1	SCOPE	1	4	DIGITAL TWIN NAMED CELLS ARCHITECTURE	8
1.1	Purpose	1	4.1	Cell Definition: IPC Digital Twin	8
1.2	Application of This Standard	1	4.2	Digital Twin Product	8
1.3	Definition of Requirements	1	4.2.1	Digital Twin Product: Design Intent	9
1.4	Order of Precedence	1	4.2.2	Digital Twin Product: Product Structure	9
1.4.1	Conflict	2	4.2.3	Digital Twin Product: Mechanical Design	10
1.4.2	Clause References	2	4.2.4	Digital Twin Product: Electronic Design	10
1.4.3	Appendices	2	4.2.5	Digital Twin Product: Design BOM	10
1.5	Abbreviations and Acronyms	2	4.2.6	Digital Twin Product: Design Traceability	11
1.6	Benefits of Establishing a Digital Twin	2	4.3	Digital Twin Manufacturing	11
1.7	Hierarchy of a Digital Twin	2	4.3.1	Digital Twin Manufacturing: Configuration	12
1.8	Approach to Standardization of Digital Twin Elements	4	4.3.2	Digital Twin Manufacturing: Work Order	15
1.9	Interoperability	4	4.3.3	Digital Twin Manufacturing: Digital Thread	16
1.9.1	Mixed-Production Example	4	4.4	Digital Twin Lifecycle	17
1.9.2	Automated Design Augmentation Example	4	4.4.1	Digital Twin Lifecycle Supply Chain	18
1.9.3	Advanced Production Simulation Example	5	4.4.2	Digital Twin Lifecycle Usage	18
1.10	Sectional IPC Digital Twin Standards and the Maintenance of This Standard	5	4.4.3	Digital Twin Lifecycle Supply Chain Usage Normal Maintenance	19
1.11	Terms and Definitions	5	4.4.4	Digital Twin Lifecycle Recycle	20
1.11.1	Component	5	5	DIGITAL TWIN READINESS AND ASSESSMENT	20
1.11.2	Digital Thread	5	5.1	Digital Twin Readiness Levels	20
1.11.3	Digital Twin	5	5.2	Digital Twin Assessment	21
1.11.4	Digital Twin Architecture	5	APPENDIX A	Index of Acronyms	23
1.11.5	Digital Twin Lifecycle	5		Figures	
1.11.6	Digital Twin Manufacturing	5	Figure 1-1	High-Level Hierarchy of the Digital Twin	3
1.11.7	Digital Twin Product	6	Figure 1-2	Virtualization of Data Interoperability at Many Levels	5
1.11.8	Digital Twin Properties	6	Figure 3-1	Digital Twin Cell Architecture	7
1.11.9	Digital Twin Solution	6	Figure 4-1	Digital Twin Product Architecture	8
1.11.10	Path	6	Figure 4-2	Digital Twin Manufacturing Architecture	11
1.11.11	Site	6	Figure 4-3	Digital Twin Lifecycle Architecture	17
1.11.12	Station	6		Tables	
1.11.13	Station Assembly	6	Table 5-1	Digital Twin Readiness Levels	21
2	APPLICABLE DOCUMENTS	6	Table 5-2	Digital Twin Assessment Matrix	22
2.1	IPC	6			
2.2	JEDEC	6			
3	DIGITAL TWIN ARCHITECTURE	7			
3.1	Guidance on the Use of This Standard	7			
3.2	Digital Twin Cell Properties	7			

International Standard for Digital Twins

1 SCOPE

This standard establishes the IPC Digital Twin, which is comprised of the Digital Twin Product, Digital Twin Manufacturing and Digital Twin Lifecycle frameworks. Within the Digital Twin Architecture, this standard stipulates and defines Digital Twin properties, types, complexities and readiness levels. The IPC Digital Twin includes historical information about a product, including the history of design in terms of revision and engineering changes, and manufacturing information, that many refer to as the Digital Thread.

This standard enables any manufacturer, design organization or solution provider to initiate application interoperability to create smart value chains, as well as the mechanism to assess their current IPC Digital Twin readiness level.

This standard provides the information and guidance necessary to understand a full IPC Digital Twin, Digital Twin Product, Digital Twin Manufacturing and Digital Twin Lifecycle. This standard also provides information and guidance on how organizations benefit from the IPC Digital Twin, how to assess IPC Digital Twin readiness level and how to prepare an organization of any size or production volume to implement a full IPC Digital Twin approach to its organization and/or products.

1.1 Purpose The purpose of the standard is to enable interoperability of all forms of processing of digital data related to a product, that precisely match and represents the physical capabilities. In this way, any manufacturer is able to create and utilize the IPC Digital Twin to represent every process and possible actions taken on a product within the manufacturing and lifecycle environment, for engineering, modelling, planning, quality and reliability analysis, simulations, etc. Critical decisions for product, process and material design can be optimized within the digital realm with the certainty that the expected performance and benefits will exist in the physical world. The effect is that physical prototypes of any description can be avoided, including trial and error, resulting in vastly reduced lead-time and costs, as well as elimination of mistakes.

1.2 Application of This Standard This standard is applicable to all aspects of the product lifecycle, from initial design concept, through the final end of life. All associated physical and transactional operations are included. There are no restrictions in terms of product classification sector, size of operation or location. SMT production is not required to be a part of the factory. Though intended to support all aspects of printed board production, the use of IPC CFX can be extended downstream to include, for example, mechanical assembly, personalization, packing and shipping, as well as up-stream to include, for example, electrical and mechanical subassemblies.

1.3 Definition of Requirements The words **shall** or **shall not** are used in the text of this document wherever there is a requirement for materials, preparation, process control or acceptance.

The word “should” reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

Line drawings and illustrations are depicted herein to assist in the interpretation of the written requirements of this Standard. The text takes precedence over the figures.

1.4 Order of Precedence The contract **shall** take precedence over this Standard, referenced standards and drawings.

In the event of conflict, the following order of precedence applies:

1. Procurement as agreed and documented between customer and supplier.
2. Master drawing reflecting the customer’s detailed requirements.
3. When invoked by the customer or per contractual agreement, this standard.

When documents other than this standard are cited, the order of precedence **shall** be defined in the procurement documents.

The User has the opportunity to specify alternate acceptance criteria.