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Connected Factory Exchange (CFX)

An international standard developed by IPC

Association Connecting Electronics Industries



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IPC-2591

Connected Factory Exchange (CFX)

Developed by the Connected Factory Initiative Subcommittee (2-17) of the Connected Factory Initiative Subcommittee – China (2-17CN) of the Electronic Product Data Description Committee (2-10) of IPC

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Connected Factory Exchange (CFX)

1 SCOPE

This standard establishes the requirements for the omni-directional exchange of information between manufacturing processes and associated host systems for assembly manufacturing. This standard applies to communication between all executable processes in the manufacture of printed board assemblies, automated, semi-automated and manual, and is applicable to related mechanical assembly and transactional processes.

1.1 Purpose With the growth and acceptance of digital modelling and practices in manufacturing, the lack of a holistic IIoT (Industrial Internet of Things) standard for the transfer of information between machines, systems and processes has become a severe limitation to the growth of digitization and computerization in the electronics manufacturing industry, inhibiting technology innovations such as “Industry 4.0” and “Smart Factories” being available to all companies in the industry, regardless of size, sector and location.

The CFX standard provides a true “plug and play” IoT communication environment throughout manufacturing, where all equipment, manufacturing processes and transactional stations can communicate with each other without the need for the development and use of bespoke interfaces. CFX-enabled equipment and solutions from different vendors work seamlessly together. There are many types of users of the CFX standard, including equipment vendors, solution providers, in-house IT groups, etc. The many types of data included in CFX are used in different ways depending on the application; for example, closed-loop feedback systems, live production dashboards, traceability (IPC-1782), MES control, lean supply chain management, active quality management, production control and many more.

As CFX data is fully omni-directional, any CFX endpoint connection can consume data as well as create it. As an illustration, consider the scenario where a single machine from a certain vendor is connected in-line with other machines from different vendors. CFX messages are sent from the single machine to other machines in the line, and to host systems such as MES. The single machine can also receive CFX messages from all the other machines in the line, as well as from the host systems in order to optimize the machine operation and allow the vendor of the machines to create added-value functionality, such as to support machine-specific Industry 4.0. In this way, a smart, digital, Industry 4.0 factory will be comprised of many different Industry 4.0 computerization applications, each of which can be provided by different suppliers, at the machine, line, site and even enterprise levels, all working together, sharing data seamlessly through CFX.

The CFX standard supports the concept of “big data” by including data of different types from across the factory, including performance, materials, resources, users, quality events, product tracking, etc., all of which can be combined to create a “big data” environment. CFX, therefore, provides many kinds of added value opportunities to the whole manufacturing operation, including, for example, improving operational efficiency and productivity, quality and reliability, agility and responsiveness. The CFX standard helps organizations ensure that end users/consumers will receive products and services that meet or exceed their expectations and in the timeliest and most economically viable method.

1.2 Application of This Standard This standard defines the communication protocol and content across all assembly production processes, irrespective of type or method of operation. It can also be applied to transactional operations. 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 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 CFX and the Hermes Standard The CFX standard is complementary to The Hermes Standard (IPC-HERMES-9852). The Hermes Standard, as an advanced intelligent SMEMA replacement, provides near-instant line control, passing information about production units as they pass down the line. CFX provides vertical messaging that is complementary to Hermes.

2 APPLICABLE DOCUMENTS

2.1 IPC¹

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-1782 Standard for Manufacturing and Supply Chain Traceability of Electronic Products

IPC-HERMES-9852 The Hermes Standard for Vendor Independent Machine-to-Machine Communication in SMT Assembly

2.2 ECMA International²

Standard ECMA-262 3rd Edition – ECMAScript Language Specification

2.3 International Organization for Standardization (ISO)³

ISO 8601:2004 Data elements and interchange formats—Information interchange—Representation of dates and times

2.4 SEMI⁴

SEMI E58-0703 Automated Reliability, Availability, and Maintainability Standard (ARAMS): Concepts, Behavior, and Services

SEMI E10-0814E Specification for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM) and Utilization

3 TERMS AND DEFINITIONS

The following terms and acronyms are used in this document.

3.1 Definition of Terms

3.1.1 Activity An action performed by an endpoint in the course of performing its function. There are many different types of activities that may be performed, depending on the specific function of the endpoint. Activities may be value added (such as placing components on a printed board), or non-value added (such as a tool change by a pick and place machine).

3.1.2 Component The component is a single instance of a bulk material, such as a resistor, capacitor, IC, etc. Bulk components are normally supplied in material packages.

3.1.3 Dashboard An information management tool used to track key performance indicators (KPIs), metrics and other key data points relevant to a business, department or specific process. Through the use of data visualizations, dashboards simplify complex data sets to provide users with at-a-glance awareness of current performance.

3.1.4 Data Integrity Maintaining and ensuring accuracy and consistency of data over the data's entire lifecycle. Data integrity is a critical aspect to the design, implementation and usage of any system which stores, processes or retrieves data.

3.1.5 Endpoint A participant in a CFX network, which is a software instance that can both send and receive CFX messages. Each endpoint is a software program associated with a particular machine or process, used to exchange information related to the operation.

3.1.6 Factory Resource A physical location, machine, tool or device within the factory that performs any sort of function.

3.1.7 Lane A corridor within an endpoint down which production units flow through a series of production stages (see definition of Stage (3.1.23)). Many endpoints just have one, singular lane, but multiple production lanes on a production line are possible and supported by CFX.

1. www.ipc.org

2. www.ecma-international.org

3. www.iso.ch

4. <https://semi.org>

3.1.8 Lock A process “lock,” or “locked process,” is one where the endpoint must not continue any active operation.

3.1.9 Material Carrier The material carrier is the mechanism by which a material package is located for use at an endpoint. In the case of SMT, for example, a feeder is a common example of the material carrier.

3.1.10 Material Chain A set of two or more Material Packages connected together; e.g., by splicing them together

3.1.11 Material Location Identifies a specific location on an endpoint where material packages may be loaded or otherwise mounted (perhaps employing a material carrier to do so). For example, a single feeder slot on a feeder bank of a pick and place machine is a single material location.

3.1.12 Material Package The material package refers to the physical mechanism in which bulk materials are supplied; for example, on a reel, in a box, bag or on a tray. A single material package represents one singular package of material (one reel, one box, etc.) and is identified by a unique identifier that is typically labeled on to the package.

3.1.13 Material Traceability The ability to verify the history, location or application of an item by means of documented recorded identification.

3.1.14 Materials For purposes of this standard, all physical and nonphysical items which are combined together to create a final assembly.

3.1.15 Operator An operator is a production operator who can be actively working at an endpoint or is responsible for its operation.

3.1.16 Process Endpoint (Station) An endpoint associated with a production processes of any kind, whether automated or manual. Normally referred to as a “Station.”

3.1.17 Production Unit These refer to a singular instance of an item that is being produced via a production process. For printed board assembly, a single printed board would be considered a production unit. A single panelized printed board layout may contain multiple printed boards / production units on one single panel. For final assembly, the uppermost assembly would also be considered a production unit itself, perhaps containing one or more subassemblies, which are themselves production units produced by a different, previously executed process.

3.1.18 Recipe A set of instructions, data or documentation used to control or guide the activity at an endpoint. For an SMT machine, this would be the set of files that form the machine program.

3.1.19 Root The highest level in the structure, above level 1.

3.1.20 Setup The setup is a list of materials and tools that are required to be in place in specific locations at a station.

3.1.21 State (Production State) This refers to the state or mode of operation of a station. Possible states vary by process type, identified by the process state model.

3.1.22 Station (Process Endpoint) An endpoint associated with a production process of any kind, whether automated or manual.

3.1.23 Stage An area or zone within an endpoint through which units move sequentially in the course of production. Work may or may not be performed at a particular stage. For example, a pick and place machine might have four stages where components are placed, but two additional stages where printed boards are buffered, awaiting work or transfer to downstream endpoints. Such a machine would be said to have six stages (four work stages plus two buffer stages).

3.1.24 Subassembly A subassembly is defined as an assembly that will become a material of another assembly, whether they are made in the same environment as their peers in the hierarchical product BOM or transferred from outside as materials.

3.1.25 Symptom An indication that something may be wrong with a production unit under test.

3.1.26 Tool An item used by a person or automated endpoint in the course of performing a particular function. Examples of tools used by humans would be wrench, hammer, screwdriver, etc. Examples of tools used by automated endpoints would be stencil or squeegee (for a stencil printer), head or nozzle (for a pick and place machine).

3.1.27 Transactional Endpoint An endpoint associated with a production processes that manages or transacts, rather than being associated with an operational process. A transactional endpoint is usually a piece of software that performs some kind of visibility or control function, such as a material logistics terminal.

3.2 Acronyms The following acronyms are used in this standard:

- **AOI** – Automated Optical Inspection
- **AXI** – Automated X-Ray Inspection
- **BOM** – Bill of Materials
- **MES** – Manufacturing Execution System
- **MSD** – Moisture-Sensitive Device
- **SMT** – Surface Mount Technology
- **THT** – Through-Hole Technology (Pin Through Hole)

3.3 Units This document, and all CFX messages and data structures use SI (metric) units throughout.

4 GENERAL REQUIREMENTS

4.1 Guidance on the Use of This Standard This standard is comprised of two parts. The first part is this document, and the second part is available online, which describes the detailed technical specification of messages and data structures. The combination of both parts forms the complete documentation of the standard.

4.1.1 Technical Reference The link to the technical reference part of the standard is:

<http://www.connectedfactoryexchange.com/CFXDemo/sdk>

This link can also be used to access the CFX Software Development Kit (SDK).

4.1.2 Application Reference The CFX standard has a dedicated website that provides up to date information about the standard, applications and supporters. Information is also posted about any updates that may be made to the CFX messaging as the scope expands to cover additional and new technologies. The link to the website is:

<http://www.ipc-cfx.org>

4.2 Users of CFX There are many kinds of CFX endpoints that perform different purposes and roles within the overall CFX network. Each of them is able to create and receive CFX messages.

4.2.1 Automated Assembly Processes A CFX endpoint can be created as part of the software package that exists as part of or together with an automated machine process. This can be applied as a standard part of the machine software, or as an optional extra. CFX native support is expected to be built into new machines that appear on the market, and provided where practical for machines currently supported in the market. In certain environments, where multiple physical machines are managed within a specific single-vendor-provided software environment, the vendor software can provide a single access point for CFX communication, through which messages will flow as if directly to the machines. This emulation facility allows machine vendors to utilize CFX in line applications as well as machine applications.

The native CFX interface represents a single data exchange mechanism to provide information about the machine operation to users of the machines, replacing the need for additional proprietary interfaces.

Where there is no practical way to provide CFX native support, machine vendors as well as third-parties may consider the use of a simple inexpensive external hardware which can act as a CFX endpoint. It is connected to the machine through a combination of legacy native interface support and additional sensors and switches as required.