

IEEE Standard for Digital Test Interchange Format (DTIF)

IEEE-SA Standards Board

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IEEE Standard for Digital Test Interchange Format (DTIF)

Sponsor

Standards Coordinating Committee 20 (SCC20)
of the
IEEE-SA Standards Board

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Abstract: The information content and the data formats for the interchange of digital test program data between digital automated test program generators (DATPGs) and automatic test equipment (ATE) for board-level printed circuit assemblies are defined. This information can be broadly grouped into data that defines the following: user under test (UUT) model, stimulus and response, fault dictionary, and probe.

Keywords: automatic test equipment, ATE, DATPG, digital automated test program generator, digital test interchange format, DTIF, fault dictionary data, IEEE 1445™

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Introduction

This introduction is not part of IEEE Std 1445-2016, IEEE Standard for Digital Test Interchange Format (DTIF).

A digital automated test program generator (DATPG) produces test pattern and diagnostic data that can be used for testing printed circuit assemblies on automatic test equipment (ATE). The use of several DATPGs, all with individual output formats, created a need for many unique post-processors to be developed and maintained for the life of the ATE. These post-processors supported the link from specific DATPGs to specific testers. The proliferation of unique formats and post-processors created logistical support problems and therefore identified a need for standardization. A DATPG and ATE independent output data format is required to limit the number of post-processors (one for each ATE) requiring life cycle support. The digital test interchange format (DTIF) was chosen because of its wide use and because it was becoming known in industry as the de facto standard.

This standard provides the basis to standardize digital test information for use on ATE. The digital test information consists of the unit under test (UUT) model information, stimulus and response data, fault dictionary data, and probe data.

DTIF is unique from IEEE Std 1450.1TM, IEEE Standard Test Interface Language (STIL) for Digital Test Vector Data [B2].¹ STIL was developed to standardize the output interface of existing computer-aided engineering (CAE) tools with the input interface of ATE for integrated circuit (IC) testing only. STIL does not provide board-level fault diagnostics.

Dedication

We, IEEE Standards Coordinating Committee 20 (SCC20), dedicate this standard to its major contributor, our departed colleague, William (Brit) Frank. Brit was in many ways a model for all engineers as he demonstrated through his dedication, tenacity, drive, persistence and commitment to his profession, colleagues, and faith.

¹The numbers in brackets correspond to those of the bibliography in Annex C.

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IEEE Standard for Digital Test Interchange Format (DTIF)

1. Overview

The digital test interchange format (DTIF) is designed to provide a mechanism for digital test data interchange independent of specific digital automated test program generators (DATPGs) and test systems. The DTIF provides a neutral database for the development and delivery of digital simulation based test program sets (TPSs). DTIF functionally supports the Unit Under Test (UUT) Model, Stimulus and Response, Fault Dictionary, and Probe databases.

1.1 Scope

This standard defines DATPG output data formats and informational content for UUT models, stimulus and response patterns, fault dictionaries, and diagnostic probing. These outputs provide a standard exchange format for automatic test equipment (ATE).

1.2 Purpose

This standard is to be used as the standard definition of DATPG output formats and informational content.

1.3 General

1.3.1 Application of this document's annexes

This document includes three annexes: [Annex A](#), [Annex B](#), and [Annex C](#), which are informative and are provided strictly as information for users, implementers, and maintainers of this document.

1.3.2 Word usage

In accordance with *the IEEE Standards Style Manual* [B1], the word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*). The use of the word *must* is used only to describe unavoidable situations. The use of the word *will* is only used in statements of fact.

The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability (*can* equals *is able to*).

1.3.3 Usage of X, Z, 0 and 1

Digital stimulus and responses are limited to four states. They are unknown (X), high impedance (Z), low (0), and high (1).

1.3.4 Date and time

Date and time shall be represented as follows:

dd-mmm-yyyy hh:mm

where:

“dd” shall either be one or two numerals, representative of the day of the month (example: 5 or 21)

“mmm” shall be three alphabetic characters, representative of the month of the year (examples: JAN shall be used for January, FEB shall be used for February, MAR shall be used for March, and so on through the 12 months of the calendar year)

“yyyy” shall be four numerals, representative of the calendar year (examples: 1999 or 2015)

“hh” shall be two numerals, representative of the hour of the day. This shall be a 24-h clock representation (example: 18 shall be used for 6 p.m.)

“mm” shall be two numerals, representative of the minute of the hour of the day (example: 07 or 49)

Examples:

4:21 p.m. on November 8, 2015 shall be represented as: 8-NOV-2015 16:21

3:30 a.m. on July 15, 1998 shall be represented as: 15-JUL-1998 03:30

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI X3.4, Information Systems—Coded Character Sets—7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).²

3. Definitions, acronyms and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.³

²ANSI publications are available from the American National Standards Institute, <http://www.ansi.org/>.

³*IEEE Standards Dictionary Online* subscription is available at: <http://dictionary.ieee.org>.

burst: A set of stimulus patterns and related unit under test (UUT) responses that are set up, applied, and read as a group. A test program may employ more than one burst to provide the stimuli and responses necessary to test the UUT.

channel: The tester electronics associated with a digital input/output (I/O) pin that either drives or senses a particular node on the unit under test (UUT).

circuit simulator: A software program that predicts a circuit's response to a given stimulus.

digital automatic test program generator (DATPG): A program, often based on simulation, that aids in the development of test patterns and diagnostic information from the model of a unit under test (UUT).

dynamic patterns: A set of controlled, time-variant patterns within a time interval.

edge: A logic state transition that is considered instantaneous for a given pattern in the simulation process.

end-to-end test: A test sequence to establish pass (functioning properly) or fail (not functioning properly) conditions. *Syn:* **go/nogo test**.

fault set: A group of one or more faults with the same fault signature.

fault signature: A set of unique primary output patterns in which the fault will produce a response different from the good machine response.

fault simulation: The process of simulating a unit under test (UUT) failure and observing its effects.

fault title: A two-part description that includes a node name and a fault type [i.e., <U5>6 SA 1 (component: U5, pin: 6, fault type: Stuck at 1)].

go/nogo test: *See:* **end-to-end test**.

LASAR™⁴: Simulation software, used for digital test program set (TPS) development. LASAR™ predicts the timing variability of signals and the behavior of the unit under test (UUT) when a physical or logic fault is present. LASAR™ builds an accurate diagnostic database for isolating faults on the UUT. LASAR™ also predicts the effect of the test fixture on the UUT, worst case timing problems and compatibility with the target tester. The name LASAR™ is an acronym for “logic automated stimulus and response.”

logic state: The representation a simulator uses to describe the state of a circuit during digital logic simulation. There are four types of logic states that exist in a typical simulator: 0, 1, Z, and X.

main model: The top-level unit under test (UUT) model description that includes a list of component packages and a netlist.

net-list: A point-to-point description of the interconnections between individual components in a circuit.

packet: A group of pointers in a file. The groups of pointers are used to provide chip pin information with other pin related data files.

patterns: A set of unit under test (UUT) stimulus and expected response states. A pattern contains one unit of logic state (0, 1, X, Z) data for each UUT input and each UUT output pin.

phase: The time within a timing cycle when a primary input is in transition between logic states.

⁴LASAR™ is a trademark of Teradyne Inc.

pin map: The interconnections between circuit pins and automatic test equipment (ATE) input/output (I/O) pins (tester channels).

primary input (PI): A node in a circuit in which the tester can apply stimulus.

primary output (PO): A node in a circuit in which the tester can observe a response.

primary output patterns (POPAT): A set of unique responses at the node in which a fault or a group of faults are detected.

probe: A tester instrument used to observe the state of a node.

probe window: The period of time during a pattern when a probe can capture activity on a node.

probeable node: Any node that is physically accessible to a tester probe.

probing: A fault diagnostic technique that incorporates the use of a portable device (hand-held or robotic) to monitor or capture unit under test (UUT) response data. The location of the probe placement is determined by the circuit response and the circuit topology.

simulation time unit (STU): A fixed unit of time that is utilized during simulation for evaluation of data.

skew: The timing ambiguity associated with the occurrence of an automatic test equipment (ATE) input/output (I/O) event that is due to the physical limitations of the ATE digital driver and detector electronics.

static patterns: A set of controlled, time-invariant patterns.

stimulus: The logic states within a pattern that drives a circuit model in simulation, or a unit under test (UUT) on an automatic test equipment (ATE).

strobe: To record or measure the state of a particular node at an instant in time. Strobing will have a skew associated with it.

timing ambiguity: The period of time in a nodal transition during which the state of the node cannot be guaranteed.

timing set (TSET): An automatic test equipment (ATE) timing-cycle during which stimuli are applied and unit under test (UUT) responses are measured. A timing set includes the specification of the pattern period, UUT input pin groupings that will transition at a specific time within a pattern, and UUT output pin groupings that share the same window.

user node: A physical point on a UUT that can be a primary input, primary output, or other net connection.

window: The period of time during a pattern cycle when a primary output is actively monitored by an automatic test equipment (ATE) channel.

wired net: A schema used to represent circuit nodes containing more than one source, which utilizes virtual and actual component connections and implementations.

3.2 Acronyms and abbreviations

ATE	automatic test equipment
CPP	clock pulses per pattern

DATPG	digital automated test program generator
DTIF	digital test interchange format
FLAP	fault set last analyzed POPAT
I/O	input/output
PI	primary input
PO	primary output
POPAT	primary output patterns
STU	simulation time unit
TPS	test program set
TSET	timing set
TU	timing unit
UUT	unit under test

4. Data organization overview of the DTIF standard environment

Digital circuit simulators for test, measurement, and diagnostic equipment provide an effective way to predict UUT behavior (good and bad) during test on an ATE. Results of the simulation can be used to generate the data necessary to produce a test program for the digital UUT. This standard defines the data generally available from test simulation and describes its structure for use in generating digital test programs for ATE.

Digital simulators typically provide data on the UUT Model, Stimulus and Response, Fault Dictionary, and Probe. [Figure 1](#) shows a total of 39 ANSI X3.4 files, which includes a header file and 38 data files.⁵

The header file provides summary information and a listing by name, of the DTIF file set generated by a simulator for a given digital circuit (not all 38 DTIF files are required to be in the data set).

The remaining 38 DTIF data files are organized into the four functional groups. This organization portrays the role of each functional group as it relates to UUT testing. They are:

- UUT Model Group (15 data files);
- Stimulus and Response Group (nine data files);
- Fault Dictionary Group (six data files);
- Probe Group (eight data files).

The UUT Model Group contains all the files required to define the topological database for diagnosing faults on the UUT. This includes component instantiations, component input/output (I/O) pins, primary inputs, primary outputs, and package interconnections.

The Stimulus and Response Group contains all the files required for fault detection testing (end-to-end). The intent of an end-to-end test of a UUT is to verify the overall functionality of the item and to indicate a failure if one exists and can be detected by the test pattern set developed for it. There is no explicit attempt to diagnose the cause of the failure.

⁵Information on references can be found in [Clause 2](#).

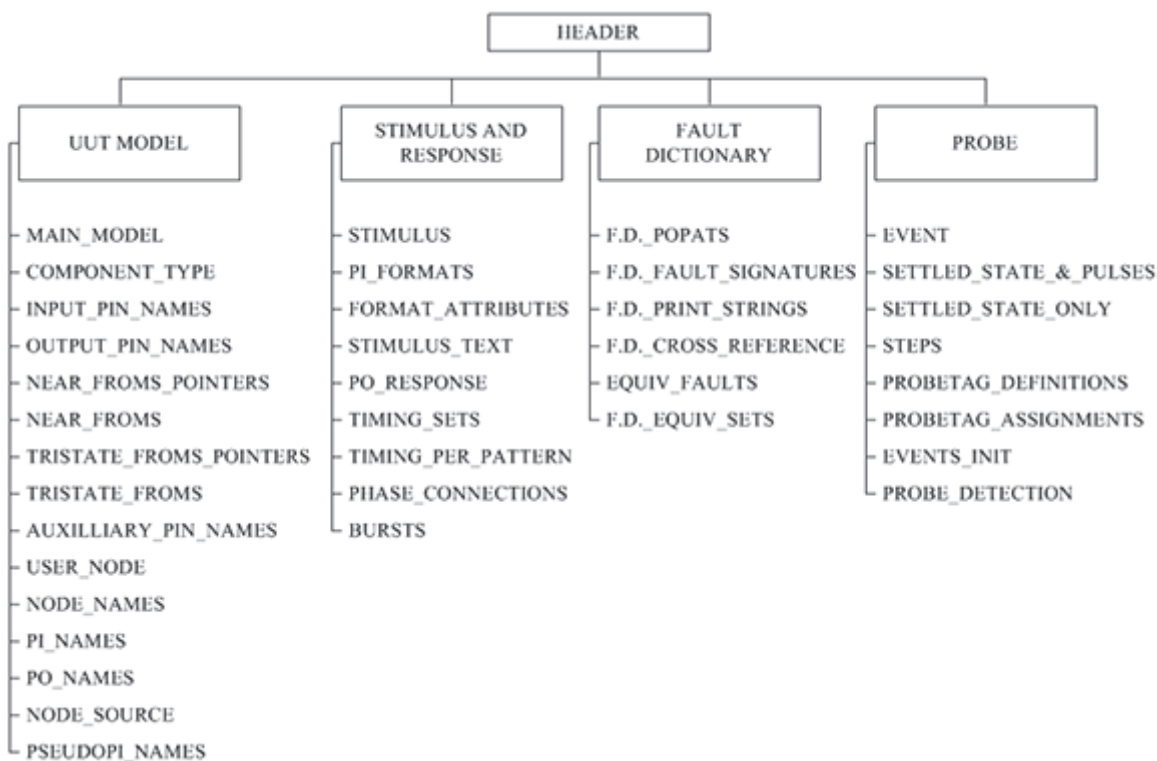


Figure 1—DTIF groups and file type names

The Fault Dictionary group contains all of the files required to support diagnostic test techniques that do not require physical probing of a circuit. Data generated by a fault simulator is analyzed and generally arranged into matrices that match fault indications with a characteristic failing response at the primary output pins of the UUT. Actual failing responses are captured on the ATE and compared to the fault dictionary matrix for fault isolation.

The Probe Group contains all of the files required to support isolating faults using a probe connected to the ATE to aid in isolating failures on the UUT. The information required to generate a probe diagnostic test includes a detailed description of the circuit that would help direct the test operator where to probe and provide the data necessary to determine whether or not a response monitored by the probe matched the good circuit response.

The three mutually independent areas for testing that are covered by the DTIF files are as follows:

- End-to-end, also referred to as go/nogo
- Diagnostics using fault dictionary
- Diagnostics using probe

The end-to-end testing is further broken down into static and dynamic modes. Diagnostics using fault dictionary and diagnostics using probe are both considered to only be dynamic modes.

4.1 UUT Model Group

The UUT Model Group consists of 15 data file types that define the UUT Model topology. These file types are used to identify:

- The UUT and ATE interface pins
- All the devices on the UUT
- The interconnections between devices and the structural dependencies between the inputs and outputs of a device
- Signal driving sources and their fan-out
- Functional dependencies of device outputs to their inputs

Each of the 15 data file types has an associated file name. [Table 1](#) identifies each of the DTIF file types and its associated DTIF file name.

Table 1—UUT Model group file types and file names

DTIF file type name	DTIF file name
PI_NAMES	pinames.tap
PO_NAMES	ponames.tap
MAIN_MODEL	mainmodel.tap
COMPONENT_TYPE	types.tap
USER_NODE	usernodes.tap
INPUT_PIN_NAMES	inputpins.tap
OUTPUT_PIN_NAMES	outputpin.tap
NEAR_FROMS_POINTERS	nerfrmptr.tap
NEAR_FROMS	nearfroms.tap
NODE_SOURCE	nodsource.tap
TRISTATE_FROMS_POINTERS	zfromptrs.tap
TRISTATE_FROMS	zfroms.tap
PSEUDOPI_NAMES	psupinams.tap
AUXILIARY_PIN_NAMES	auxpins.tap
NODE_NAMES	nodenames.tap

4.2 Stimulus and response group

The Stimulus and Response Group consists of nine data file types that define the logic value of applied stimulus and observed good circuit response. These data file types identify:

- The timing of stimulus edge transitions within a pattern
- The period of valid output responses within a pattern
- Groups of UUT pins with the same stimulus and response timing characteristics

Each of the nine data file types has an associated file name. [Table 2](#) identifies each of the DTIF file types and its associated DTIF file name.

Table 2—Stimulus and Response Group file types and file names

DTIF file type name	DTIF file name
STIMULUS	stimulus.tap
PO_RESPONSE	response.tap
TIMING_SETS	timesets.tap

Table continues

Table 2—Stimulus and Response Group file types and file names (continued)

DTIF file type name	DTIF file name
TIMING_PER_PATTERN	timperpat.tap
PHASE_CONNECTIONS	phaseconn.tap
PI_FORMATS	piformats.tap
FORMAT_ATTRIBUTES	formattrts.tap
BURSTS	bursts.tap
STIMULUS_TEXT	stimtext.tap

4.3 Fault Dictionary Group

The Fault Dictionary Group consists of six data file types that are used in comparing the actual UUT response produced by the ATE with the results predicted by the fault simulation process, to diagnose UUT failures.

This group identifies:

- All faults and groups of equivalent faults
- Fault signatures for all detected faults
- Faults grouped within a specific fault set

Each of the six data file types has an associated file name. [Table 3](#) identifies each of the DTIF file types and its associated DTIF file name.

Table 3—Fault Dictionary Group file types and file names

DTIF file type name	DTIF file name
F.D._POPATS	fdpopats.tap
F.D._FAULT_SIGNATURES	fdfltsig.tap
F.D._PRINT_STRINGS	fdprint.tap
F.D._CROSS_REFERENCE	fdxref.tap
EQUIV_FAULTS	equivflts.tap
F.D._EQUIV_FAULTS	fdeqvs.tap

4.4 Probe Group

The Probe Group consists of eight data file types that contain all the necessary information to generate probe diagnostics for an ATE.

This group identifies:

- A complete history of the logic state activity
- Signal timing at every device pin on the UUT
- Data that assists in specifying probe window placement and timing

Each of the eight data file types has an associated file name. [Table 4](#) identifies each of the DTIF file types and its associated DTIF file name.

Table 4—Probe Group file types and file names

DTIF file type name	DTIF file name
EVENT	events.tap
SETTLED_STATE_&_PULSES	setldpuls.tap
SETTLED_STATE_ONLY	setldonly.tap
STEPS	steps.tap
PROBETAG_DEFINITIONS	probetag.tap
PROBETAG_ASSIGNMENTS	probeasgn.tap
EVENTS_INIT	eventsinit.tap
PROBE_DETECTION	probedet.tap

5. File type specifications

The formats for each of the 39 file types specified by the DTIF standard are defined in 5.1 through 5.39.

Each file type consists of two or more records. The first record identifies the file type name, the DTIF file number, the file revision number (optional), the UUT name, and the date and time of origination. The first record in every DTIF file is formatted as follows:

- Each record is up to 80 B long. When file types are written, trailing blanks are truncated from the records to reduce the size of the resultant file type.
- All data shall be in the ANSI X3.4 format.
- The DTIF file names are not case sensitive.
- The file number of each file type is equal to the [Clause 5](#) subclause number (e.g., 5.1 HEADER is file number 1).
- All alphanumeric (character) fields are left justified. They are identified in every file description by the character “A,” and the size of each field is defined by a numeric value immediately following the character “A.” For example, (A4) describes a four-character alphanumeric field.
- All integer fields are right justified. They are identified in every file description by the character “I,” and the size of each field is defined by an integer value immediately following the character “I.” For example, (I6) describes a six-character integer field.
- Should it be required to repeat a particular field within the file description, a multiplier may be used. For example, 5(A16) describe a 16-character alphanumeric field that is repeated five times.

5.1 HEADER file type

File name: header.tap

Description: The HEADER file type provides a configuration accounting for all of the files that comprise the complete data set for a particular UUT by providing summary information and a listing of the total DTIF file set developed for a given UUT.

Format:

Line 1:	Columns	1:24	–	DTIF file type name (A24)
	Columns	25:27	–	DTIF file number (I3)
	Columns	28:31	–	File version number (optional value).(I4)
	Columns	32:55	–	UUT name (A24)
	Columns	56:72	–	File creation date and time (A17) (See Note 1)
	Columns	73:77	–	Either spaces or “ERROR” to indicate an error in file generation (A5)
Line 2:	Columns	1:24	–	Model compilation date and time (A24) (See Note 1)
Line 3:	Columns	1:10	–	Number of primary inputs (I10)
Line 4:	Columns	1:10	–	Number of primary outputs (I10)
Line 5:	Columns	1:10	–	Number of patterns (I10)
Line 6:	Columns	1:10	–	Number of packages (I10)
Line 7:	Columns	1:10	–	Number of main model (user) defined components (I10)
Line 8:	Columns	1:10	–	Number of component types (I10)
Line 9:	Not used			
Line 10:	Not used			
Line 11:	Columns	1:10	–	Number of wired nets (I10)
Line 12:	Columns	1:10	–	Number of user nodes (I10)
Line 13:	Columns	1:10	–	Highest user node number (I10) (See Note 2)
Line 14:	Columns	1:10	–	Number of DTIF files generated (I10)
Line 15:	Columns	1:10	–	Number of original faults considered (I10)
Line 16:	Columns	1:10	–	Number of final definite detects (I10)
Line 17:	Columns	1:10	–	Number of final possible detects (I10)
Line 18:	Columns	1:10	–	Pattern detection limit (maximum # of times a fault is detected) (I10)
Line 19–29:	Not used			
Line 30 to N:	Columns	1:24	–	DTIF file type name(A24) (See Note 3)
	Columns	25:27	–	DTIF file type number (I3)

NOTE 1—See 1.3.4.⁶

NOTE 2—The number of user nodes and the highest user node number may not be one and the same.

NOTE 3—One line is used for each file type.

5.2 STIMULUS file type

File name: stimulus.tap

Description: The STIMULUS file type contains all the input pin states required to test a UUT. Stimuli are limited to four logic states:

— Unknown (X)

⁶Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.