



In-Circuit Test Standard Statement of Work

Revised 2013/06/14

Overview:

In-Circuit Test (ICT) using CheckSum equipment is intended to confirm the following:

- The product has been assembled with the correct parts
- There are no unexpected shorts between networks (nodes) on the product.
- Wrong or missing parts will be detected wherever possible with the test capabilities of the test system. Performing actual part fault insertion to confirm actual component coverage will be an extra charge.
- CheckSum does not specifically attempt to test components to their bill-of-materials tolerances. Such tests are not generally possible in an in-circuit environment and will result in false failures that will impact the customer's production yield.
- In all cases test coverage may be limited or reduced due to lack of test point access or the effect of unguardable devices such as integrated circuits.

Capacitor Tests:

All capacitors, except as noted below will be verified for their value with test limits set at the following percentages of the nominal value:

$10\text{pF} < C < 10\text{nF}$

Nominal value +/- 30%*

$10\text{nF} < C < 10\mu\text{F}$

Nominal value +/- 20%

$C > 10\mu\text{F}$

Nominal value +/- 25%**

* Minimum limits delta = 30pF. Values below 200 pF will have learned fixture capacitance offset included in the test step.

** If device tolerance is greater, limit will be extended to: device tolerance + 10%

Exceptions:

Capacitors in parallel

Total capacitance value used¹

Capacitors in parallel with ICs

No test or learned value

Capacitors in parallel with low value resistors

Learned value²

¹The variation of the actual capacitor values tends to not allow failure discrimination. When components are measured in parallel, some missing components may not be detected. For example, VCC to GND typically has a larger capacitor in parallel with a number of smaller capacitors. If one or more of the smaller capacitors is missing, the system is likely not to detect it since its value is small compared to the acceptable range of values of the large capacitor.

² If a low impedance path is in parallel with a high-impedance component, the high-impedance component may not be testable. An example is a capacitor in parallel with an inductor or transformer winding.

Continuity & Shorts Testing:

Checksum will probe each net once, unless otherwise specified by the customer. The continuity test will check for opens and shorts on the sample provided. The test system will “learn” the continuity map from the provided “good” sample assemblies. If the sample has errors, the test may end up with those same errors. To detect a missing connector with the continuity test, a test probe needs to contact the connector pins. All accessible networks (“nodes”) will be verified that there are no unexpected continuities to other networks defined as:

- Any resistance below 8 Ohms will be considered as a “Short”. These will be learned from a customer-supplied known-good board (KGB).
- Any resistance greater than 12 Ohms shall be considered as an “Open”.
- Any inter-network connections between 8 and 12 Ohms will be treated as “No-Cares”
- Any inter-network resistances that may vary between a short or open in normal instances (e.g. a switch or potentiometer) will be treated as a “No-Care” and will be verified by a separate test later in the test program.

Diode Tests:

All diodes will be tested for orientation by a reverse polarity test.

All diodes will be tested using a DC current stimulus of either 1 or 10 mA. The forward voltage of the device will be verified with default limits of +/- 200 mV of the diode type:

Silicon diodes	400 mV/ 800 mV
Germanium/ Schottky diodes	100 mV/ 500 mV
LEDs	Based on color and type*
Zener diodes	400 mV/ 800 mV

Zener diodes will be tested for their nominal zener voltage +/- 500 mV provided the zener voltage does not exceed 20V.

Exceptions:

Diodes in high power circuits may require more than 10 mA to test.

Diodes in parallel cannot be tested except as a group. Determining which device is missing or reversed is not possible.

Diodes mounted across relay coils may not be testable due to the low DC resistance of the coil.

Zener diodes whose zener voltages are greater than 20V may be tested only if quoted separately since external measurement hardware will be required.

*LEDs may be optionally tested for brightness and color. ***The customer may choose this option at the time of order. There is an additional charge for these tests.***

Inductor Tests:

Inductors will be tested as follows:

CONT/SHORTS

In all cases where the DC resistance is $< 10 \Omega$

$L < 1 \text{ mH}$

Nominal value $\pm 25\%$ ³

$1 \text{ mH} < L < 1 \text{ H}$

Nominal value $\pm 20\%$

$L > 1 \text{ H}$

Nominal value $\pm 25\%$

³ For values from 10-100 μH CheckSum will 4-wire the connections, assuming access to both sides. If additional test access is possible (more probe locations on the same net), the test will be more likely to come in.

Exceptions:

Components in parallel with other devices will be partially tested based on the combined AC impedance.

Integrated Circuits (ICs):

In-circuit testing of digital/mixed signal ICs is not possible with CheckSum testers. Vectorless testing using the **ICs** test type will be performed. This test checks for diodes between the low bus point (typically GND) and all points in the given range and between those points and any high bus point (i.e. 5V, 3.3V). This will detect the presence/absence of the ESD protection diodes within the IC. However, Checksum does not verify that the learned diode is internal to any one IC. This can be accomplished by the customer by injecting faults into the UUT and running the test. If the tester is equipped with the optional **TestJet** feature then **TestJ** can be used for SMT devices if the device package type supports testing by this method.

Exceptions:

Power and Ground device legs are not covered by these vectorless test methods. Simple power-on tests for simple SSI/MSI devices (inverters, NAND/NOR gates, level shifters, buffers) may be done at an extra cost.

LEDs

LEDs will be tested as diodes with the V (fwd) selected based on the type of LED. Reverse polarity testing will also be done during debugging. **Optional** testing for color, and/or brightness/intensity can be provided at extra cost.

Operational Amplifier Testing

Standard in-circuit test will not test operational amplifiers except by TestJet or the ICs test types.

Optional power-on tests may be implemented if ordered by the customer and assumes the target test system has the necessary configuration to perform such tests. Testing in the normal op amp configuration will consist of verifying the inverting (-) and non-inverting (+) inputs will cause the output(s) to swing to the V+ and V- levels when a 100mV voltage differential is applied. In the case of a voltage-follower configuration the output will be verified to follow the non-inverting (+) input voltage. More complex functional tests may be implemented if the customer provides a detailed and verified test specification/procedure.

Opto Isolators:

Opto Isolators will be tested using the **OPTO** test type. This test will verify the turn-on function of the device. The transfer function will be learned from the supplied samples.

Exceptions:

Devices whose configuration precludes testing due to output loading may be tested in a reduced manner by verifying the diode only.

Potentiometers:

The operator will be instructed to set all potentiometers to the mid-point prior to start of test. If the configuration supports testing the end-to-end value that will also be done as well as a very broad mid-point measurement. Adjustments can be made during testing, depending on the customer's press type.

Relay Tests:

All normally closed contacts will be verified as resistors with 0/10 Ohm limits.

All nominally open contacts will be verified as opens using a resistor test with 10M Ω /19M Ω limits

All relay coils will be tested for DC resistance at a learned value.

All relays whose nominal coil voltage is less than or equal to 24VDC will be functionally tested to activate the relay and verify contacts if possible.

Exceptions:

Relays whose coil voltage or power requirements exceed the tester's capabilities may not be tested for operation unless arrangements have been made for an **optional power-on** functional test

Resistor Tests:

All resistors, except as noted below will be verified for their value with test limits set at the following percentages of the nominal value:

0.1 Ohms $\leq R \leq$ 9.9 Ohms	Tested using 4-wire (if possible)
R < 100K	Nominal value +/- 10%
100K < R < 1M Ω	Nominal value +/- 15%
1M Ω < R < 14 M Ω	Nominal value +/- 25%
R > 14M Ω	Tested as Open
Exceptions:	
R < 10 Ohms without 4-wire access	Tested as Short in CONT and as resistor with +/- 5 Ω tolerance
10 Ohms < R < 50 Ohms without 4-wire test access	Tested as combined parallel resistance
Resistors in parallel	Tested at learned value +/- 10%-15%
Resistors in parallel with integrated circuits (ICs)	Nominal value +/- 5 Ω
Thermistors/Photoresistors	Requires customer test specifications
Resistors whose adjacent components results in a guard ratio >1000	No test or presence test only
Shunts and other low value precision resistors	Tested as SHORT unless CR-2 or other low-res measurement technique is specified

Switches:

Switches will be tested for either normally closed or normally open if the customer provides the default settings. In the absence of such settings the switches will be tested in the configuration of the supplied sample PCBA(s), unless these settings interfere with other component tests.

Transformer Tests:

Transformers will be tested for winding polarity using the **Xfmr** test type. **Implied** testing for coil continuity will be made as part of the routine **CONT** test. Explicit testing for the transformer coil DC resistance will be made based on learned values unless supplied by the customer. Such tests will have very loose tolerances (+/- 25%) unless 4-wire wiring can be implemented.

Exceptions:

Transformers that might produce voltages > 12V when energized will not be tested since they may result in system damage.

Transistor Tests:

Bi-polar transistors will be tested as diode junction pairs.

The BETA test type will be used on all transistors except as noted below. This test functionally verifies the proper operation of the transistor by observing the turn-on point of the device while the control input (base/gate) is stimulated. This test does not verify other device parameters such as turn-on speed, R(on)/R(off), current handling capabilities, etc.

Exceptions:

Power transistor circuits that will require greater than 10mA of current may not be tested using the BETA test type. In this case, two resistance tests with bias voltages on the Gate or Base may be used to show an Off resistance value and an On resistance value.

Darlington transistor arrays cannot be tested using the diode junction test method.

Phototransistors will require customer-specified test procedures.

Voltage Regulator Tests

Standard in-circuit test will not test voltage regulators except by TestJet or the ICs test types. **Optional** power-on tests may be implemented if ordered by the customer and assumes the target test system has the necessary configuration to perform such tests. Such tests will test the output voltage of the device to within the data book specifications or customer-supplied specifications, whichever is less stringent. Other characteristics such as noise, response time, etc. will not be performed.

Voltage Supervisor Chips

Standard in-circuit test will not test voltage supervisor chips except by TestJet or the ICs test types.

Optional power-on tests may be implemented if ordered by the customer and assumes the target test system has the necessary configuration to perform such tests. The customer must supply an exact, step-by-step verified test procedure for such devices.

Zener Diodes

See **Diode Tests** section on page 2