

NO-WIRE PCB WITH INTEGRATED CIRCUIT AND METHOD FOR TESTING USING THE SAME

TECHNICAL BACKGROUND

5

[001] The present invention relates to a no-wire printed circuit board (PCB) used in an in-circuit test system for performing in-circuit testing on a device under test (DUT). The present invention also relates to an in-circuit test system for carrying out in-circuit testing, which includes said no-wire PCB. In addition, the
10 present invention relates to a method for testing active components of a DUT using said in-circuit test system.

BACKGROUND OF THE INVENTION

15 **[002]** Presently, a large number of electronic components are integrated and mounted onto electrically interconnected planes, which are more commonly known as printed circuit boards (PCB). Prior to use, as each PCB has a large number of electrical components and connections thereon, the PCB must be tested to verify that all required electrical components and connections are laid out
20 correctly in their respective positions and are also in the correct orientation. Concurrently, the electronic components mounted on the PCB are also tested to determine whether the correct components are mounted thereon and whether these components have the correct values and function within their specified parameters. The testing process is typically known as in-circuit testing (ICT) and
25 the PCB undergoing said ICT is typically referred to as the device under test (DUT).

[003] ICT is generally considered to be a form of automatic electronic component-level testing to quickly detect and locate faulty DUTs using
30 corresponding ICT equipment. ICT equipment can isolate individual components of a DUT from their neighbouring connected components in order to achieve

individual component testing. ICT equipment is therefore capable of connecting with the circuit nodes of the DUT, and measuring the quantitative functionality each component of the DUT.

5 **[004]** Early, ICT technology was able to detect faults resulting from manufacturing processes, such as short circuits, open circuits, incorrectly placed or used components and missing components, for example. Subsequently, ICT technology has been developed to cater for the capability of verifying the degree of functionality of the various electronic components of the DUT. In ascertaining the
10 functionality of the electronic components, parameters such as the resistance, capacitance, inductance, voltage and, where applicable, diode characteristics of a given component are measured and compared against predetermined values to check if the component in question was indeed functioning as designed and intended.

15

[005] Generally, ICT equipment consists of two main parts. The first main part is the in-circuit tester, which includes a plurality of drivers and sensors along with probes (mint pins), which are electrically connected to contact points of a DUT during the testing phase. The drivers provide a voltage or current to drive a circuit
20 node of the DUT to a particular state, and the sensors correspondingly perform the above-mentioned measurements with regard to the appropriate parameters. The in-circuit tester also includes software for controlling and automating the testing process.

25 **[006]** The second main portion of the ICT equipment is an interface device between the in-circuit tester and the DUT. The interface device provides the in-circuit tester with access to the nodes (or contact points) of the DUT by using a “bed-of-nails” structure or a “flying probe” structure. Both structures comprise probes (double ended or otherwise), which establish an electrical connection
30 between the in-circuit tester and the nodes of the DUT. Accordingly, a test signal from the in-circuit tester is transferred to the DUT via the interface device, and the

response signal is also sent back to the in-circuit tester via the interface device for further analysis. Typical examples of the interface device are wired fixtures, wireless fixtures (or no-wire fixtures) with integrated PCB and no-wire fixtures with external PCB.

5

[007] As the density and quantity of components, especially active components on a DUT has, in general, been greatly increasing, the nodes on the DUT are much denser than before. In this respect, it is also becoming increasingly difficult to use wired fixtures in testing DUTs with a high density of nodes. 10 Therefore, a wireless fixture, with integrated or external PCB, replaces wires by having electrical trace patterns embedded in the internal or external PCB. Accordingly, the no-wire fixtures appear to be more capable of being effectively used with DUTs as compared to a wired fixture. In addition, usage of a wireless fixture in ICT equipment further improves signal integrity since the wireless fixture 15 provides for a better test signal transmission between the in-circuit tester and the DUT.

[008] US Patent application 2003/0016039 A1 discloses a wireless fixture as interface device that comprises a PCB integrated therein and a probe mounting 20 plate, in which spring-loaded probes are arranged. A DUT is electrically connected to the PCB arranged inside the wireless fixture via the spring-loaded probes. The wireless fixture further includes floating transfer pins that provide electrical signal paths between the PCB and probes of an in-circuit tester. The electrical connection paths are therefore completed between the device under test and the in-circuit 25 tester via the wireless fixture.

[009] As mentioned above, other known embodiments of interface devices include no-wire fixtures without an integrated PCB. In such embodiments, the PCB may be arranged externally to the no-wire fixture in a manner such that the PCB is 30 in electrical connection with the probes of the no-wire fixture. The externally connected PCB is generally known as a wireless PCB or no-wire PCB. The no-wire

PCB, with the no-wire fixture attached thereto, is typically arranged, in an ICT equipment, in parallel to an in-circuit tester, with the lateral surface of the no-wire PCB facing a lateral surface of the in-circuit tester. Typically, this lateral surface of the in-circuit tester is formed by a metal base plate with a plurality of holes therein,
5 in which the probes (mint pins) of the in-circuit tester are accommodated.

[010] The mint pins are accommodated within the in-circuit tester in a retractable manner. That is, when the in-circuit tester is not in operation, the mint pins are in a default position, said default position being such that the tips of the
10 mint pins are below the lateral surface formed by the metal base plate. In preparation of a DUT testing operation, the mint pins translate vertically upwards to protrude beyond said lateral surface, and in doing so, contact the contact points of the lower surface of the no-wire PCB, which is attached to the no-wire fixture. The protrusion of the mint pins beyond the lateral surface is restricted to at best, a few
15 millimeters, for example. Accordingly, the no-wire fixture and no-wire PCB attached thereto are lowered sufficiently to allow the contact points on the lower surface of the no-wire PCB to sufficiently contact the protruding mint pins of the in-circuit tester.

20 **[011]** The in-circuit test equipment described in the foregoing description generally caters for the in-circuit testing of passive electronic components of a DUT, such as resistors, capacitors and inductors, for example. However, if the DUT has active components, wherein some active components may be programmable active components, a corresponding in-circuit test equipment
25 capable of functional testing said active components would be required. In this regard, the functional testing of active components may include boundary scans and flash programming of the active and/or programmable components of the DUT, for example.

30 **[012]** In the case of carrying out said functional testing of an active component of the DUT, the ICT test equipment, which typically includes an in-

circuit tester having its own program module, writes data into the active component. The ICT test equipment later reads out the inputted data from the active component of the DUT to verify that the active component of the DUT operates correctly. The verification is carried out by the in-circuit tester, which is
5 electrically connected to the DUT as described earlier.

[013] However, due to memory, controlling and/or programming resource constraints of conventional in-circuit testers, writing of data to, or programming of active components of DUTs is time-consuming. This is especially so when, for
10 example, a large program code is to be written into a programmable component of a DUT.

[014] As such, there is a need to supplement the testing/programming resources of the in-circuit tester in a cost-effective manner to reduce the amount of
15 time spent on testing active components of the DUT and thereby speed up the DUT testing and production process.

[015] The above-mentioned problems are overcome by a no-wire PCB, according to the invention, and as described and defined in the following
20 description and appended claims below.

DETAILED DESCRIPTION OF THE INVENTION

[016] In the following, the invention is described in the context of an in-
25 circuit test system, which includes a no-wire fixture. However, it should be noted that the no-wire PCB according to the invention is applicable also in such in-circuit test systems in which it is connected via means other than a no-wire fixture or even directly to the device under test (DUT). It is to be further noted that the no-wire fixture referred to hereafter is taken to mean a no-wire fixture having an
30 external no-wire PCB electrically connected to the no-wire fixture, as is specifically used in ICT equipment, and may be implemented in test systems such as the

Agilent 3070 ICT system, for example.

[017] Accordingly the invention will now be described in conjunction with an in-circuit test system includes a no-wire fixture. The no-wire fixture of the in-circuit test system accommodates a plurality of double-ended probes. The double-ended probes are arranged in the no-wire fixture in alignment with a plurality of DUT contact points on the surface of the DUT. In other words, the double-ended probes are arranged such that each probe corresponds to, and may therefore contact a respective DUT contact point when the no-wire fixture is attached to the DUT for testing. Accordingly, the no-wire fixture is, in general, DUT specific. With the above arrangement of the DUT and the no-wire fixture, electrical signals can be transmitted between the no-wire fixture and the DUT.

[018] As mentioned above, the no-wire fixture is adapted to be attached to a surface of the DUT. Such an attachment is implemented along an upper surface of the no-wire fixture, i.e., the upper surface of the no-wire fixture faces the lateral surface of the DUT, said lateral surface having the DUT contact points.

[019] The DUT may be attached to the no-wire fixture via a plug-socket structure, wherein extrusions on the DUT have corresponding sockets (or recesses) in the upper surface of the no-wire fixture. As an alternative, the DUT may be clamped to the no-wire fixture.

[020] The in-circuit test system further includes an in-circuit tester, which comprises a lateral surface and a plurality of contact pins accommodated below said lateral surface and within said in-circuit tester. In the context of ICT, the contact pins of the in-circuit tester are also called mint pins. The lateral surface is formed by a metal base plate, below which the mint pins are located in a retractable fashion. Examples of such in-circuit testers can be selected from a range of products in the market, such as Agilent 3070 series, CheckSum's TR8 series and GenRad TestStation. The in-circuit tester may include software libraries

having predefined parameters for testing various DUTs. In this regard, predefined test signal patterns are generated in the in-circuit tester and transferred to the DUT during testing.

5 **[021]** The no-wire PCB according to the invention serves as an interface between the no-wire fixture and the in-circuit tester in the in-circuit test system. Alternatively the no-wire PCB may also serve as an interface, directly or indirectly, between the DUT and the in-circuit tester, in case the ICT equipment does not comprise a no-wire fixture.

10

[022] The no-wire PCB according to the invention includes a first plurality of electrical contact points, which are spatially arranged on a first portion of an upper surface of the no-wire PCB. The first plurality of electrical contact points is aligned with the plurality of double-ended probes of the no-wire fixture. In other
15 words, each of the first plurality of electrical contact points of the no-wire PCB corresponds to a respective double-ended probe of the no-wire fixture. Accordingly, the first portion of the upper surface of the no-wire PCB essentially corresponds to an area of the no-wire fixture containing the double-ended probes. During the testing phase, the no-wire PCB is attached along the first portion of its
20 upper surface to a lower surface of the no-wire fixture. Such an arrangement of the no-wire PCB with respect to the no-wire fixture allows the first plurality of electrical contact points of the no-wire PCB to contact the respective corresponding plurality of double-ended probes of the no-wire fixture. This contact establishes an electrical pathway between the no-wire PCB and the no-wire fixture and indirectly,
25 between the no-wire PCB and the DUT as well.

[023] On a lower surface of the no-wire PCB, a second plurality of electrical contact points is spatially arranged to align with the contact pins of the in-circuit tester. Thus, when the no-wire PCB, with the no-wire fixture attached on its
30 upper surface, is placed with its lower surface above the in-circuit tester and the contact pins (mint pins) of the in-circuit tester are translated out from below the

metal base plate to protrude outwardly, the contact pins of the in-circuit tester contact the corresponding second plurality of electrical contact points, thereby allowing electrical conduction between the no-wire PCB and the in-circuit tester.

5 **[024]** Typically, different types of DUTs usually have different contact point layouts and would normally require specific no-wire fixtures having double-ended probes of layouts that correspond to the DUT contact point layouts, and no-wire PCBs having electrical contact points on the first portion of the upper surface of the no-wire PCB with layouts that correspond to said layouts of the double-ended
10 probes of the no-wire fixture. In this regard, the first plurality of contact points of the no-wire PCB corresponds to the layout of the double-ended probes of the no-wire fixture. This means that the layout of the double-ended probes of the no-wire fixture and the contact points layout on the first portion of the upper surface of the no-wire PCB are DUT specific. The second plurality of contact points on the lower
15 surface of the no-wire PCB has a standard layout that corresponds to the layout of the mint pins of the in-circuit tester. Having DUT specific no-wire fixtures and no-wire PCBs, where the lower surface of said no-wire PCB is adapted to the in-circuit tester, ensure that the in-circuit tester can be used for testing various DUTs by simply using a no-wire fixture and a no-wire PCB that correspond to a specific
20 DUT.

[025] According to the invention, the no-wire PCB further includes a third plurality of electrical contact points arranged on a second portion of the upper surface thereof. The second portion of the upper surface of the no-wire PCB is
25 distinctively different from the first portion of the upper surface of the no-wire PCB where the first plurality of electrical contact points is located. In one exemplary embodiment, the first portion of the upper surface of the no-wire PCB may, at least partially, surround the second portion. Alternatively, the second portion may be adjacent to the first portion of the upper surface of the no-wire PCB.

30

[026] The no-wire PCB further comprises at least one integrated circuit (IC)

capable of testing active and/or programmable active components of the DUT. Such an IC is mounted on said second portion of the upper surface of the no-wire PCB, and is electrically connected to the third plurality of electrical contact points.

5 **[027]** Accordingly, the first portion having the first plurality of electrical contact points has a layout that corresponds only to the area of the no-wire fixture accommodating the double-ended probes and the IC is electrically connected with the in-circuit tester via the third plurality of electrical contact points.

10 **[028]** Furthermore, in the no-wire PCB according to the invention, each contact point of the first plurality of electrical contact points and the third plurality of electrical contact points on the upper surface of the no-wire PCB is connected to a contact point of the second plurality of electrical contact points on the lower surface of the no-wire PCB. Such a connection may be accomplished by electrical
15 trace patterns embedded in the PCB, and/or by metalized through-holes running along the thickness of the no-wire PCB. Accordingly, electrical test signals from the in-circuit tester are routed to the DUT with the no-wire fixture and no-wire PCB acting as intermediate connections, and vice versa. Furthermore, since the IC is electrically connected with the third plurality of contact points of the no-wire PCB, it
20 is also indirectly connected with the in-circuit tester and the no-wire fixture having the DUT mounted thereon.

[029] In an embodiment of the invention, when the dimensions of upper surface of the no-wire PCB correspond to those of the lower surface of the no-wire
25 fixture, the no-wire fixture comprises at least one recess that opens into the lower surface of the no-wire fixture, wherein the recess is adapted to receive the IC mounted on the second portion of the upper surface of the no-wire PCB. The shape and size of the recess are accordingly adapted to those of the IC(s). It is to be noted that there are no double-ended probes at the locations of the recesses in
30 the no-wire fixture, as the IC to be received therein does not allow it. In other words, portion of the lower surface of the no-wire fixture that overlaps the second

portion of the upper surface of the no-wire PCB does not have any double-ended probes accommodated therein.

[030] In another embodiment of the invention, when the upper surface of the no-wire PCB is larger than the lower surface of the no-wire fixture, the second portion of the upper surface of the PCB is formed by the surface portion of the no-wire PCB, which is not covered by the fixture, when the no-wire PCB is attached to the no-wire fixture. In this embodiment, the second portion of the upper surface of the no-wire PCB having the IC mounted thereon does not require the no-wire fixture to include the feature of the recess to receive the IC.

[031] The IC for testing active and/or programmable active components of the DUT may be installed on the second portion of the upper surface of the no-wire PCB using existing PCB technology such as surface-mounting technology.

15

[032] In a preferred embodiment, a micro-controller is selected as the IC and the in-circuit tester drives said micro-controller. Accordingly, the micro-controller is used to test active and/or programmable active components of the DUT under the control of the in-circuit tester, thereby sharing the test resources of the in-circuit tester and expediting the testing process of the active and/or programmable active components of the DUT. Depending on the requirements of the active and/or programmable active component to be tested, micro-controllers may be selected from commonly available models in the market, such as ZiLOG's eZ80F91, Philips LPC2000 and Intel 386EX, for example.

25

[033] The active component of the DUT may be of any type, including transistors, amplifiers, transmitters and LEDs, for example. Programmable active components may include, but are not limited to, memory devices and programmable logic devices. Typical examples of memory devices are erasable programmable read only memory (EPROM), electrically erasable programmable read only memory (EEPROM), flash memory and ferroelectric random access

memory (FRAM). Examples of programmable logic devices include generic array logic device (GAL), complex programmable logic device (CPLD) and field programmable gate array (FPGA).

5 **[034]** In an exemplary embodiment, when a plurality of programmable components are installed on the DUT, and said plurality of programmable components may be controlled by a single micro-controller mounted on the no-wire PCB. In another exemplary embodiment, several micro-controllers may be utilized on the no-wire PCB, wherein each micro-controller, along with the in-circuit tester,
10 programs and tests one or more corresponding programmable component of the DUT.

[035] As mentioned above, the no-wire PCB according to the invention can also be utilized in an in-circuit test system, which does not require a no-wire fixture.
15 In such an embodiment, the in-circuit test system has a no-wire printed circuit board (PCB) for electrically connecting a device under test (DUT) to an in-circuit tester in an in-circuit test system for testing the DUT. The in-circuit tester includes a plurality of contact pins. The no-wire PCB includes a first plurality of electrical contact points, which are spatially arranged on a first portion of an upper surface of
20 the no-wire PCB. The first plurality of contact points on the upper surface of the no-wire PCB electrically connects electrical contact points of the DUT to the no-wire PCB via said first plurality of contact points. The no-wire PCB also includes a second plurality of electrical contact points being spatially arranged on a lower surface of the no-wire PCB. The second plurality of contact points of the no-wire
25 PCB is aligned with said contact pins of the in-circuit tester such that, when the no-wire PCB is placed with its lower surface above the in-circuit tester, the contact pins of the in-circuit tester contact the second plurality of electrical contact points of the no-wire PCB. The no-wire PCB further includes a third plurality of electrical contact points being arranged on a second portion of the upper surface of the no-
30 wire PCB. The third plurality of electrical contact points is electrically connected with one or more IC mounted on the second portion of the upper surface of the no-

wire PCB. Each contact point of the first and the third plurality of electrical contact points of the no-wire PCB is connected to a contact point of the second plurality of electrical contact points of the no-wire PCB.

5 **[036]** The invention also provides for a method of testing at least one active component of a device under test (DUT) during in-circuit testing. According to the method of the present invention, an in-circuit test system as described in any of the above-mentioned embodiments is provided. Subsequently, the testing of at least one active component of the DUT is then carried out using at least one
10 microcontroller mounted on the no-wire PCB in conjunction with the in-circuit tester of the system.

[037] In an embodiment of the method according to the invention, the in-circuit tester controls the micro-controller of the no-wire PCB, thereby sharing the
15 test resources of the in-circuit tester with the micro-controller mounted on the no-wire PCB. The signals from the in-circuit tester are transferred to the micro-controller via the electrical contact between the contact pins of the in-circuit tester and the electrical connection points of the no-wire PCB.

20 **[038]** If the DUT has a programmable component, the testing of said programmable component according to an embodiment of the invention includes the following steps:

- (a) Sending a write-start signal from the in-circuit tester to the micro-controller;
- 25 (b) Writing data into the programmable component of the DUT;
- (c) Sending a write-stop signal to the in-circuit tester from the micro-controller;
- (d) Reading the data from the programmable component; and
- (e) Verifying the read data by the in-circuit tester.

30

[039] The following description based on the drawings serves to aid in the

understanding of the present invention and should not be construed as limiting the present invention to the embodiments illustrated and described below.

BRIEF DESCRIPTION OF THE DRAWINGS

5

[040] **Figure 1** shows a no-wire PCB with a micro-controller mounted thereon;

[041] **Figure 2** shows an in-circuit test system including a no-wire PCB of
10 **Figure 1** in one embodiment;

[042] **Figure 3** shows an in-circuit test system including a no-wire PCB of **Figure 1** in another embodiment; and

15 [043] **Figure 4** illustrates a programming process.

DETAILED DESCRIPTION OF THE DRAWINGS

[044] Referring to **Figure 1**, a side view of a no-wire PCB **100** is shown.
20 The no-wire PCB **101** includes a first plurality of electrical contact points **105** on a first portion **120** of its upper surface **150**. A second plurality of electrical contact points **107** is arranged on a lower surface **130** of the no-wire PCB **101**. In addition, a third plurality of contact points **109** is arranged on a second portion **140** of the upper surface **150** of the no-wire PCB **101**. A micro-controller **103** is mounted on
25 the second portion **140** of the upper surface **150** of the no-wire PCB **101**, wherein electrical contacts of the micro-controller **103** are connected to the third plurality of contact points **109**. The electrical contact points **105**, **107** and **109** are preferably either gold or copper contact points.

30 [045] **Figure 2** shows an in-circuit test system. The in-circuit test system comprises a no-wire fixture **400**, an in-circuit tester **310** and a no-wire PCB **210** according to the invention.

[046] The no-wire fixture **400** includes a mounting board **410** that accommodates double-ended probes **450** housed vertically in receptacles **470**. The no-wire fixture further includes a recess **430** in the mounting board **410** that opens to its lower surface **490**. As seen, the recess **430** is formed in a double-
5 ended probe-free portion of the lower surface **490** of the no-wire fixture **400**.

[047] The in-circuit tester **310** of the in-circuit test system has a plurality of contact pins **330** that are retractably mounted within the in-circuit tester **310**. In this regard, the retractable contact pins **330** can translate in a vertical direction from
10 their default position below a metal base plate (not shown), which constitutes the upper surface of the in-circuit tester **310**. Accordingly, the contact pins **330** protrude outwardly above the metal base plate through holes formed therein when in their contacting position during a testing operation.

[048] The no-wire PCB **210** comprises an upper surface **250** and a lower surface **270**. The upper surface **250** of the no-wire PCB **210** includes a first portion and a second portion having a first plurality of electrical contact points (not shown) and a third plurality of electrical contact points (not shown) respectively. The lower surface **270** of the no-wire PCB **210** has a second plurality of contact points (not
20 shown). In addition, the no-wire PCB **210** also has a micro-controller **230** mounted on the second portion of its upper surface **250**. The micro-controller **230** is electrically connected to the third plurality of contact points of the second portion of the upper surface **250** of the no-wire PCB **210**.

[049] During the testing operation, a DUT **510** is mounted on the upper surface of the no-wire fixture **400**. The DUT **510** may include a programmable active component **530**. The DUT is mounted on the no-wire fixture **400** such that one end of the double-ended probes **450** contact electrical contact points of the DUT **510**. The opposite ends of the double-ended probes **450**, during said testing
30 operation, contact the first plurality of electrical contact points of the first portion **120** of the upper surface **250** of the no-wire PCB **210**, when the no-wire PCB **210**

is attached with its upper surface **250** along a lower surface **490** of the no-wire fixture **400**. Accordingly, the spatial arrangement of the first plurality of electrical contact points of the no-wire PCB is aligned with the spatial arrangement of the double-ended probes **450**. In addition, the position the micro-controller **230**
5 mounted on the second portion of the upper surface **250** of the no-wire PCB **210** also corresponds to the recess **430** in the mounting board **410**. In this regard, the recess **430** is capable of receiving the micro-controller **230** therein during the testing operation.

10 **[050]** The in-circuit tester **310** contacts the lower surface **270** of the no-wire PCB, via the plurality of contact pins **330**. As mentioned, the contact pins **330** are mounted within the in-circuit tester **310** in a retractable manner and only extend to contact the contact points (not shown) on the lower surface **270** of the no-wire PCB **210** during the testing operation. In particular, the contact pins **330** contacts
15 the second plurality of electrical contact points (not shown) on the lower surface **270** of the no-wire PCB board **210**. Accordingly, the second plurality of contact points of the no-wire PCB **210** is spatially aligned with the contact pins **330** of the in-circuit tester **310**, so that test signals from the in-circuit tester **310** can be properly transmitted to the no-wire PCB board **210**.

20

[051] With regard to **Figure 2**, an electrical pathway is established between the in-circuit tester, DUT and the micro-controller **230**, via the no-wire PCB **210** and the no-wire fixture **400**. Accordingly, this enables the micro-controller **230** to leverage upon the existing resources of the in-circuit tester **310** to carry out
25 testing and programming functions on the programmable active component **530** of the DUT **510**.

[052] **Figure 3** shows an in-circuit test system according to another embodiment of the invention. The in-circuit test system of **Figure 3** comprises the
30 same features as the embodiment shown in **Figure 2**. Accordingly, the in-circuit test system comprises an in-circuit tester **310**, a no-wire PCB **210**, having a micro-

controller **230** mounted to a second portion of an upper surface **250** thereof, and a no-wire fixture **400**. The arrangement of said features is identical to the in-circuit test system of **Figure 2**, with the exception that the no-wire PCB and thereby its upper surface is larger than the no-wire fixture, resulting in that the micro-controller **230** of the no-wire PCB **210** can be arranged on the surface portion of the no-wire PCB (constituting the second portion of the upper surface **250** of the no-wire PCB **210**), which is not covered by the lower surface of the no-wire fixture when attached to the no-wire PCB **210**. Accordingly, a recess to accommodate the IC in the mounting board **410** of the no-wire fixture **400** is not needed in this embodiment.

10

[053] Accordingly, during a test operation, when the upper surface of the no-wire PCB **210** is attached along the lower surface of the no-wire fixture **400**, as previously described, the micro-controller **230** remains uncovered by the no-wire fixture **400**.

15

[054] **Figure 4** illustrates a method for testing, including programming a programmable active component **800** on a DUT using a no-wire PCB (not shown) with a micro-controller **600**, in conjunction with an in-circuit tester **700**.

20 [055] The micro-controller **600** is equipped with four groups of bidirectional General Purpose I/O pins (GPIO pins). Of the four groups, two groups of GPIO pins are used to communicate with the in-circuit tester **700** and the remaining two groups of GPIO pins are used to communicate with the programmable active component **800**. Of the two groups of GPIO pins in communication with the programmable active component **800**, one group of GPIO pins is for data transmission (SDA in **Figure 4**) and the other group is for clock signal transmission (SCL in **Figure 4**).

[056] During one programming cycle, the in-circuit tester **700** sends a write-start signal to the micro-controller **600**, which the micro-controller **600** receives via a first GPIO group in communication with the in-circuit tester **700**.

Upon receiving said write-start signal, the micro-controller **600** starts to program the programmable active component **800** with an I2C protocol, for example, using the two groups of GPIO pins that communicate with the programmable active component **800**.

5

[057] When the micro-controller **600** has finished programming the programmable active component **800**, the micro-controller **600** sends a write-stop signal through a second GPIO group in communication with the in-circuit tester **700**. When one programming cycle is completed, reading out and verification
10 operations take place, with respect to the programming, in order to complete the testing process. The next programming cycle begins with the in-circuit tester **700** sending a write-start signal to the micro-controller **600**.

[058] The in-circuit tester **700** in this exemplary illustration is selected from
15 Agilent 3070 series while the micro-controller **600** is the model eZ80F91 from ZiLOG, and the programmable active component **800** is an EEPROM using Inter-integrated Circuit (I2C) BUS.

[059] The no-wire PCB with the IC mounted thereon, according to the
20 invention, allows the existing testing/programming resources of the in-circuit tester to be supplemented in a cost-effective manner to reduce the amount of time spent on testing, including programming, active components of the DUT. The no-wire PCB of the present invention also allows for the DUT testing and production process to be accelerated through integrated resource sharing between the in-
25 circuit tester and the IC mounted on the no-wire PCB of the present invention.

[060] Although the present invention has been disclosed and illustrated with respect to preferred embodiments thereof, it is to be understood that the invention is not to be so limited and that other changes and modifications can be
30 made within the full intended scope of the invention as hereinafter claimed.

CLAIMS

What is claimed is:

- 5 1. A no-wire printed circuit board (PCB) for electrically connecting a device under test (DUT) to an in-circuit tester in an in-circuit test system for testing the DUT, the in-circuit tester having a plurality of contact pins, wherein the no-wire PCB comprises:
- 10 a first plurality of electrical contact points being spatially arranged on a first portion of an upper surface of the no-wire PCB for electrically connecting a plurality of electrical contact points of the DUT thereto,
- a second plurality of electrical contact points being spatially arranged on a lower surface of the no-wire PCB so as to align with said contact pins of the in-circuit tester, when the no-wire PCB is placed with its lower surface
- 15 above the in-circuit tester, thereby allowing the contact pins of the in-circuit tester to contact the second plurality of electrical contact points of the no-wire PCB,
- a third plurality of electrical contact points being arranged on a second portion of the upper surface of the no-wire PCB, wherein each
- 20 contact point of the first plurality of electrical contact points and the third plurality of electrical contact points of the no-wire PCB is connected to a contact point of the second plurality of electrical contact points of the no-wire PCB, and
- at least one integrated circuit (IC) for testing at least one active
- 25 component of the DUT, said IC being mounted on the second portion of the upper surface of the no-wire PCB such that electrical contacts thereof are connected to said third plurality of electrical contact points.
- 30 2. A no-wire printed circuit board (PCB) for electrically connecting a no-wire fixture to an in-circuit tester in an in-circuit test system for testing a device under test (DUT), the no-wire fixture being adapted to be attached along an

upper surface thereof to a surface of the DUT having a plurality of DUT contact points, and to accommodate therein a plurality of double-ended probes being in alignment with and contacting said plurality of DUT contact points, the in-circuit tester having a plurality of contact pins, wherein the no-wire PCB comprises:

5 a first plurality of electrical contact points being spatially arranged on a first portion of an upper surface of the no-wire PCB so as to align with and contact said plurality of double-ended probes of the no-wire fixture, when the no-wire PCB is attached along its upper surface to a lower surface of the no-wire fixture,

10 a second plurality of electrical contact points being spatially arranged on a lower surface of the no-wire PCB so as to align with said contact pins of the in-circuit tester, when the no-wire PCB with the no-wire fixture attached thereon is placed with its lower surface above the in-circuit tester, thereby allowing the contact pins of the in-circuit tester to contact the second plurality of electrical contact points of the no-wire PCB,

15 a third plurality of electrical contact points being arranged on a second portion of the upper surface of the no-wire PCB, wherein each contact point of the first plurality of electrical contact points and the third plurality of electrical contact points of the no-wire PCB is connected to a contact point of the second plurality of electrical contact points of the no-wire PCB, and

20 at least one integrated circuit (IC) for testing at least one active component of the DUT, said IC being mounted on the second portion of the upper surface of the no-wire PCB such that electrical contacts thereof are connected to said third plurality of electrical contact points.

3. The no-wire PCB of claims 1 and 2, wherein

the IC is a micro-controller driven by the in-circuit tester for testing the active component of the DUT.

4. The no-wire PCB of claim 2 or 3, wherein

the no-wire PCB and the no-wire fixture are adapted to each other such that the IC mounted on the no-wire PCB is accommodated in a one recess of the no-wire fixture, when the no-wire fixture is attached to the no-wire PCB, said recess being formed in a double-ended probes free portion of the no-wire fixture and opening into the lower surface of the no-wire fixture towards the upper surface of the no-wire PCB.

5. The no-wire PCB of claim 2 or 3, wherein

the no-wire PCB and the no-wire fixture are adapted to each other such that the IC is mounted on a portion of the no-wire PCB which is not covered by the no-wire fixture, when the no-wire fixture is attached to the no-wire PCB, said portion constituting said second portion of the upper surface of the no-wire PCB.

6. An in-circuit test system for testing a device under test (DUT), comprising

an in-circuit tester having a plurality of contact pins, and

a no-wire printed circuit board (PCB) for electrically connecting the DUT to the in-circuit tester, wherein the no-wire PCB comprises:

a first plurality of electrical contact points being spatially arranged on a first portion of an upper surface of the no-wire PCB for electrically connecting a plurality of electrical contact points of the DUT thereto,

a second plurality of electrical contact points being spatially arranged on a lower surface of the no-wire PCB so as to align with said contact pins of the in-circuit tester, when the no-wire PCB is placed with its lower surface above the in-circuit tester, thereby allowing the contact pins of the in-circuit tester to contact the second plurality of electrical contact points of the no-wire PCB,

a third plurality of electrical contact points being arranged on a second portion of the upper surface of the no-wire PCB, wherein

each contact point of the first plurality of electrical contact points and the third plurality of electrical contact points of the no-wire PCB is connected to a contact point of the second plurality of electrical contact points of the no-wire PCB, and

5 at least one integrated circuit (IC) for testing at least one active component of the DUT, said IC being mounted on the second portion of the upper surface of the no-wire PCB such that electrical contacts thereof are connected to said third plurality of electrical contact points.

10

7. The in-circuit test system of claim 6, further comprising:

a no-wire fixture being adapted to be attached along an upper surface thereof to a surface of the DUT having a plurality of DUT contact points, and to accommodate therein a plurality of double-ended probes

15

being in alignment with and contacting said plurality of DUT contact points, wherein the first plurality of electrical contact points of the no-wire PCB are spatially arranged on a first portion of an upper surface of the no-wire PCB so as to align with and contact said plurality of double-ended probes of the no-wire fixture, when the no-wire PCB is attached along its

20

upper surface to a lower surface of the no-wire fixture,

8. The in-circuit test system of claims 6 and 7, wherein

the IC is a micro-controller driven by the in-circuit tester for testing the active component of the DUT.

25

9. The in-circuit test system of claim 7 or 8, wherein

the no-wire PCB and the no-wire fixture are adapted to each other such that the IC mounted on the no-wire PCB is accommodated in at least one recess of the no-wire fixture when the no-wire fixture is attached to the no-wire PCB, said recess being formed in a double-ended probes free

30

portion of the no-wire fixture and opening into the lower surface of the no-

wire fixture towards the upper surface of the no-wire PCB.

10. The in-circuit test system of claim 7 or 8, wherein

5 the no-wire PCB and the no-wire fixture are adapted to each other such that the IC is mounted on a portion of the no-wire PCB which is not covered by the no-wire fixture, when the no-wire fixture is attached to the no-wire PCB, said portion constituting said second portion of the upper surface of the no-wire PCB.

10 11. A method for testing at least one active component of a device under test (DUT) during in-circuit testing, comprising:

providing an in-circuit test system as defined in claim 8, and

testing said active component of the DUT using said micro-controller, the micro-controller being controlled by the in-circuit tester.

15

12. The method of claim 11, wherein the active component of the DUT is a programmable component, the testing of said programmable component of the DUT comprising:

20 (a) Sending a write-start signal from the in-circuit tester to the micro-controller;

(b) Writing data into the programmable component of the DUT;

(c) Sending write-stop signal to the in-circuit tester by the micro-controller;

(d) Reading the data from the programmable component; and

25 (e) Verifying of the read data by the in-circuit tester.