Julius Velasco

Designing a Bed of Nails Tester

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Abstract

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This bachelor's thesis presents the design and implementation of a bed of nails tester. This type of tester is commonly used for measuring parameters such as voltage, current, or resistance on a circuit board. The bed of nails tester is intended for testing circuit boards made by students in the Embedded Electronics course at Metropolia University of Applied Sciences.

The work examines the advantages and challenges of various circuit board testing methods and explores how 3D-printing can offer flexibility in manufacturing and design within the electronics industry.

3D-printing was utilized to create the housing and mechanism of the testing device, which allows it to contact the circuit board using spring-loaded pogo pin connectors. The circuit board was designed in KiCad and Autodesk's Fusion 360 3D-modeling software was used for the design of 3D-printed parts.

As a result of the work, a low-cost test device meeting the predetermined requirements was produced. The device was implemented in such a way that it can be used in the course, and the 3D-model can be easily customized using Autodesk's Fusion 360 software if modifications are needed.

Keywords: Automated Test Equipment, Bed of Nails Tester, In-Circuit Testing, 3D-Printing

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Tässä opinnäytetyössä käydään läpi neulapetitestilaitteen suunnittelu ja toteutus. Kyseistä testeriä voidaan yleisesti käyttää esimerkiksi jännitteen, virran tai resistanssin mittaamiseen piirilevyltä. Neulapetitestilaitetta on tarkoitus käyttää Metropolia AMK:n Sulautettu elektroniikka kurssilla opiskelijoiden valmistamien piirilevyjen testaukseen.

Työssä tarkastellaan erilaisten piirilevytestausmenetelmien etuja ja haasteita ja sitä, miten 3D-tulostusta voidaan hyödyntää elektroniikkateollisuudessa tarjoamalla joustavuutta valmistuksessa ja suunnittelussa.

Työssä käytetään 3D-tulostusta testilaitteen kotelon sekä mekanismin luomiseen, mikä mahdollistaa neulapetitestilaitteen käytön jousikuormitetuilla testipiikeillä piirilevyn mittaamisen kanssa. 3D-mallin suunnittelussa käytettiin Autodesk Fusion 360 -3D-mallinnusohjelmaa. Laitteen piirilevy suunniteltiin KiCad- piirilevyjen suunnitteluohjelmistolla.

Opinnäytetyön tuloksena tuotettiin edullinen testilaite, joka vastaa etukäteen laadittuja vaatimuksia. Laite tuotettiin niin, että sitä voidaan käyttää sellaisenaan Sulautettu elektroniikka kurssilla piirilevyjen testaamiseen. Testilaite on helposti muokattavissa 3D-mallinnusohjelmistolla, mikäli tarve muutoksille ilmenee.

Avainsanat: automatisoitu testauslaitteisto, neulapetitesteri, piirilevytestaus, 3D-tulostus

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List of Abbreviations

ABS: Acrylonitrile Butadiene Styrene. A common thermoplastic polymer used in various applications, known for its strength, durability, and impact resistance.

BON: Bed of Nails. A type of in-circuit tester that uses pogo pin style nails to make contact with circuit boards for testing electronic components.

CAD: Computer Aided Design. The use of computer software to create detailed digital representations of objects or systems for design and engineering purposes.

DUT: Device Under Test. The specific electronic device or component being evaluated or tested within a larger system.

ESD: Electrostatic Discharge. The sudden discharge of static electricity, which can potentially damage electronic components or devices.

FPT: Flying Probe Testing. A method of electronic testing that employs moving probes to contact and test points on a printed circuit board without the need for test fixtures.

ICT: In-Circuit Testing. A testing technique that employs a bed of nails or other probes to assess the functionality of individual components on a printed circuit board.

PCB: Printed Circuit Board. A flat board made of insulating material with conductive pathways for connecting electronic components, forming the basis of many electronic devices.

PLA: Polylactic Acid. A biodegradable thermoplastic commonly used for 3D-printing.

PETG: Polyethylene Terephthalate Glycol. A thermoplastic, commonly used for 3D-printing and in the manufacturing of bottles and containers.

R&D: Research and Development. The process of exploring and creating new technologies, products, or processes.

1 Introduction

Testing and inspecting multiple points and components on various circuit boards can be laborious and often imprecise. Manual testing, especially in scenarios involving multiple circuit boards with numerous measurement points, often proves impractical. As a solution to these challenges, the automation of in-circuit testing becomes essential, and one effective approach is through the utilization of a bed of nails tester.

The bed of nails tester is designed to streamline the testing process by employing an array of spring-loaded pins to establish contact with predetermined test points on the circuit board, measuring the electrical properties to ensure correct fabrication. This bachelor's thesis aims to present the design and implementation of a bed of nails tester, complete with a customized 3D-printed housing tailored to a specific printed circuit board (PCB) application. The tester is to be used by students enrolled in an Embedded Design course at Metropolia University of Applied Sciences.

These test points have not been predetermined for the design. Instead, the tester will utilise a matrix of test points, which will be implemented into future designs based on the testers design developed in this thesis work. The dimensions of this tester align with an already existing 3D-printed housing for the device under test (DUT).

2 Testing in Electronics Manufacturing

Testing in electronics manufacturing as a process cannot be overlooked. It ensures the quality, safety, and reliability of electronic products while also contributing to cost efficiency overall. [1.]

There are many reasons to test electronic components and circuits during manufacturing. The earlier a fault is found, the easier it is to mitigate the issues that can arise from any type of fault.

In manufacturing, testing is the only way to identify faults that could compromise the electrical safety of a product after it has been taken into use. Thorough testing protects against the risk of electrical shock, so that products can be used for their intended purpose with minimal chance of injury occurring. [1.]

Testing electrical components aims to achieve a number of objectives, including:

- Stress screening and accelerated life testing: These methods can be used to find parts that break down quickly.
- Electrical testing: Used to confirm that parts meet their electrical requirements.
- Reliability testing: Performed on batches of components and PCB assemblies to confirm that they can tolerate mechanical or environmental stress.
- Functional testing: Can be performed both during the life cycle of the product's manufacture and following the fabrication of a prototype or proof of concept. [2.]

3 In-Circuit Test Methods

This chapter discusses different methods of testing printed circuit boards and the importance of in-circuit testing in manufacturing and product development, while comparing some key differences between test methods.

3.1 In-Circuit Testing

In-circuit Testing is a crucial tool in electronics manufacturing. It is used to detect defective components or other errors in the manufacturing or research and development (R&D) phase of electronic devices and integrated circuits (IC) [3]. These test fixtures measure contact points on circuit boards during manual or automated testing [4]. Some of the things that can be checked are components markings and correct spacing, proper soldering joints, short or open circuits. Measuring component values is also possible, such as resistor, capacitance, and inductance values. [3.] In-circuit testing can be performed while the device under test is powered on to measure for example that there are correct voltages and proper current flowing through the components. Testing like this can save costs in manufacturing phases as it can detect faults in the processes and can be adjusted to the changing needs in design. [4.]

3.1.1 Bed of Nails

The need for in-circuit testing of printed circuit boards can emerge in any point of product development, manufacturing or during R&D. A bed of nails tester can be used to access multiple test points on the printed circuit boards. An example of a bed of nails tester setup can be seen in figure 1.

A bed of nails tester is a tool used to measure electronic signals from a printed circuit board with repeatability and accuracy. [5.] The tester uses spring-loaded pins, known as pogo pins, to contact designated parts on the board, which act as measurement points. These test points can be copper pads that are located on the printed circuit board. They need to be positioned such that the head of the pogo pin can make proper contact with the pads, or any point in a component where proper contact can be made, to ensure good contact for precise and accurate measurements.

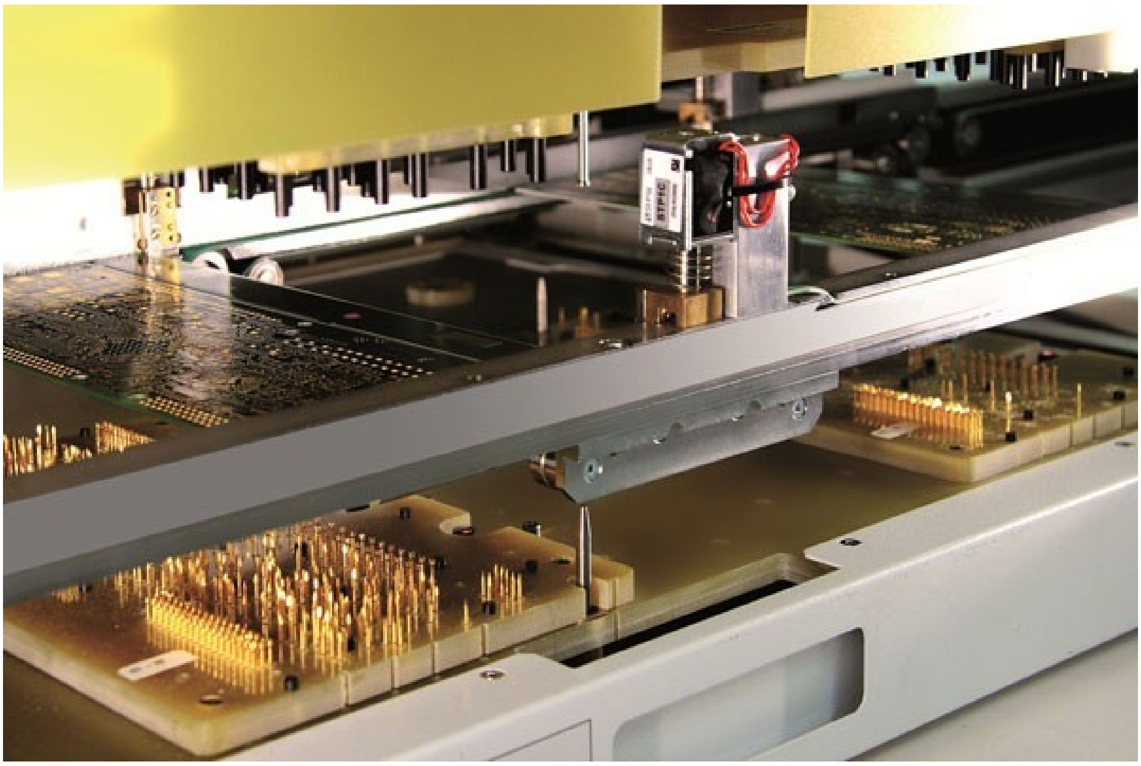

Figure 1 A large bed of nails circuit board tester can measure multiple points on a board at the same time. [6]

Usually, any device, component or a circuit board that is measured with a test system is referred as a device under test. Using bed of nails in-circuit test equipment it is possible to gain access to the circuit nodes on a board and measure the components regardless of any other components connected to them. Parameters such as voltage, current, resistance, capacitance and inductance can all be measured along with the operation of analogue components such as operational amplifiers. Some functionality of digital circuits can also be measured, although their complexity usually makes a full check uneconomic. [7.] With sufficient access points, a bed of nails tester can transmit test signals at high speed to perform evaluation of components and circuits.

3.1.2 Flying Probe

In contrast to a bed of nails tester, flying probe testing (FPT) makes it simple to perform concurrent in-circuit test of a PCB's top and bottom side using a limited number of movable and fixed probes, as seen in figure 2 [8.]

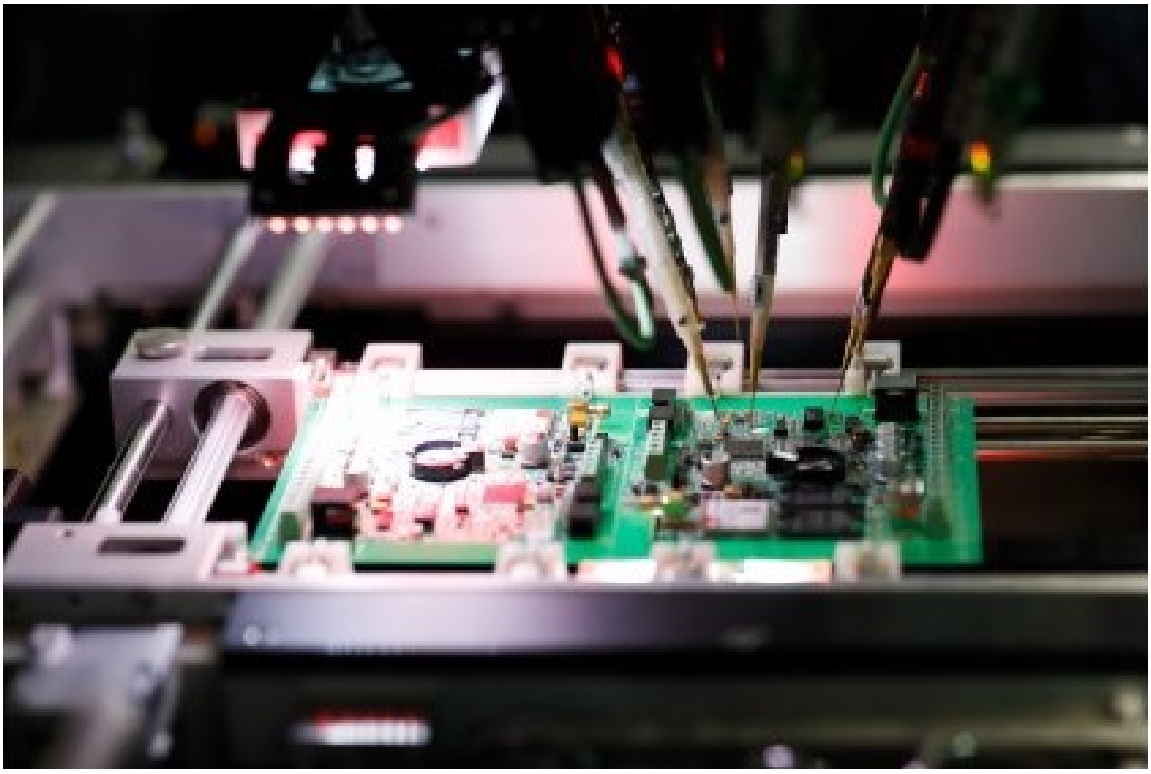

Figure 2 Flying probe tester machine can test multiple points on a circuit board. [9]

These probes can move freely on to any part of the board to measure for shorts circuits, opens as in a discontinuity in a PCB trace, and measure values from any point in a PCB [10]. Flying probe testing is suitable for products that are in the initial stages of development as well as for low-volume orders. In addition, most FPT systems can perform an optical inspection during the testing process making it more versatile. [8.]

The upfront costs of designing and implementing a FPT setup solution are commonly cheaper than a traditional bed of nails setup. However, once the bed of nails tester setup is complete, the cost per unit tends to be lower compared to FPT. This is because each test cycle can be completed in less than a minute, and the testing time does not increase with the number of test points. This contrasts with FPT test systems, where the total test duration can be affected by the number of test points. As seen in table 1 with FPT it can take up to 15 minutes per board due to the limited number of probes in a single test system. [8; 11.]

Table 1 Comparison of attributes of in circuit testing and flying probe testing [11].

		In Circuit Test (ICT)	Common to both	Flying Probe
Design	No test pads required on PCB			✓
	Samples required for development		✓	
	CAD & schematics required		✓	
Costs	Programming cost similar		✓	
	No fixture cost			✓
	Lead time < 2 weeks			✓
	Test time < 1 minute	✓		
	Low test cost per unit	✓		
	If product design changes programme charge only			✓
Coverage	Opens/Shorts test		✓	
	Passive tests (measures values)		✓	
	Optical inspection			✓
	Power rail measurements		✓	
	Integrated Circuits: multiple test options	✓		

3.2 3D-Printing and Design in Electronics Prototyping

In the electronics industry, 3D-printing is increasing design flexibility and speed. For instance, it enables the design and production of casings with quality comparable to more conventional injection-moulded plastics, which can, for example, precisely match the circuit board they are intended to house. This allows for more creative solutions with complex shapes in design that were previously impossible with injection moulded plastics.

In general, 3D-printing offers design flexibility, enabling rapid prototyping and the production of small series, limited editions, and spare parts in small batches. [12.] This flexibility and cost-effectiveness of a 3D-printed bed of nails tester poses as a challenger to flying probe testing, as 3D-printed testers emerge as more economical systems for smaller batches of PCB testing.

However, there are limitations to 3D-printing, often the size of the printed object that can be produced with a commercially available 3D-printer is rather small. Meaning that larger circuit boards or testing a panel of multiple circuit boards at a same time may not be reasonable with this style of tester. Larger 3D-printers exist, but the cost of accurate large printers can be so high that acquiring them would not make sense financially when comparing to smaller printers.

4 Designing the Bed of Nails Tester: Methodology and Components

This chapter describes the design process and criteria for the bed of nails tester, including the selection of pogo pins, print material, wiring, and hold-down mechanism while also covering the PCB design and components, the 3D-printed design, and the assembly of the prototype.

The requirements for this application were given at the start of the design phase these requirements are shown in table 2:

Table 2 The predetermined requirements for the project.

#	Requirement
1	A matrix of contact points for pogo pins to make on the DUT - in this application twelve points of contact were deemed sufficient.
2	A 3D-printed housing for the circuit board that also houses the mechanism to press the pogo pins to the DUT board.
3	The testers housing should fit the already existing 3D-printed housing.
4	A test board with resistors in series and points for the pogo pins to make contact for testing the design.

Based on what needs to be measured on the DUT, this tester can be connected for example to a digital multimeter for quick analysis or to a data acquisition system for logging measured values and data.

A multimeter combines an ohmmeter, voltmeter, and an ammeter. Internally, either the voltmeter or ammeter is implemented which then performs the other functions. An ohmmeter can be used to determine a connection point or lack thereof when tracing wires in a circuit [13, 72-74].

4.1 PCB Design

The bed of nails testers circuit schematic and component layout were designed for this application using KiCad PCB design software. It is an open-source electronics design software that is available for free for windows, macOS and Linux. It contains tools for schematic design for electronic circuits and their conversion to PCB designs. [14.] The circuit board designer in KiCad was used to design a two-sided circuit board with a way to connect to the housing using screws mounts and springs. Details on the circuit boards design can be seen in Appendix 4. The PCB was manufactured with an LPKF brand PCB milling machine. It works by using a set of drills on a plane to selectively remove the top layer of the copper on a circuit board the conductive paths and components can be created from the design [15]. The PCB design layout is exported from KiCad as a set of Gerber (.gbr) format files. These are a set of instructions that the LPKF software uses to plan the routing for the milling bits and selects the correct drill sizes for the machine's operation. The schematics of this bed of nails tester’s circuit board can be seen in appendix 4: figure 15.

KiCad allows a 3D-rendered view of the designed PCB for visual analysis before milling or ordering the board from a 3rd party. The design can be exported as an image for reference as seen in figures 3 and 7.

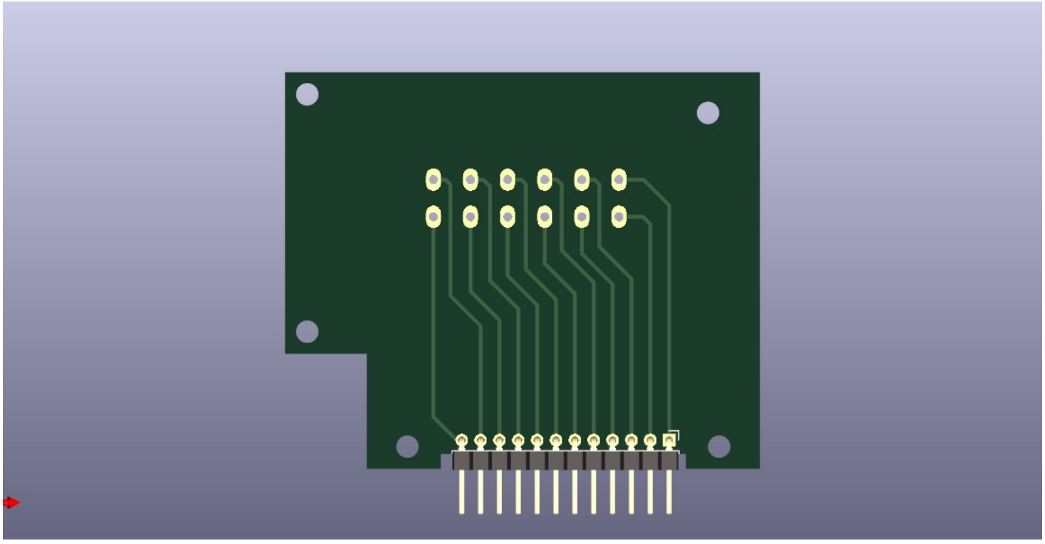

Figure 3 3D-rendered view of the circuit board in KiCad.

After the electrical design of the bed of nails tester it can be manufactured using a two-sided copper board using a desktop circuit board prototyping mill. The PCB itself was milled rapidly in minutes using the milling machine. LPKF circuit board plotters feature mechanical fiducial systems or cameras for automatic position detection to assist in drilling and milling of double-sided PCBs. This ensures that the structures on both sides of the board are matching [16.]. After the milling process the board was cleaned and the components; connectors and pogo pins, were soldered onto the circuit board as shown is figures 4 and 5.

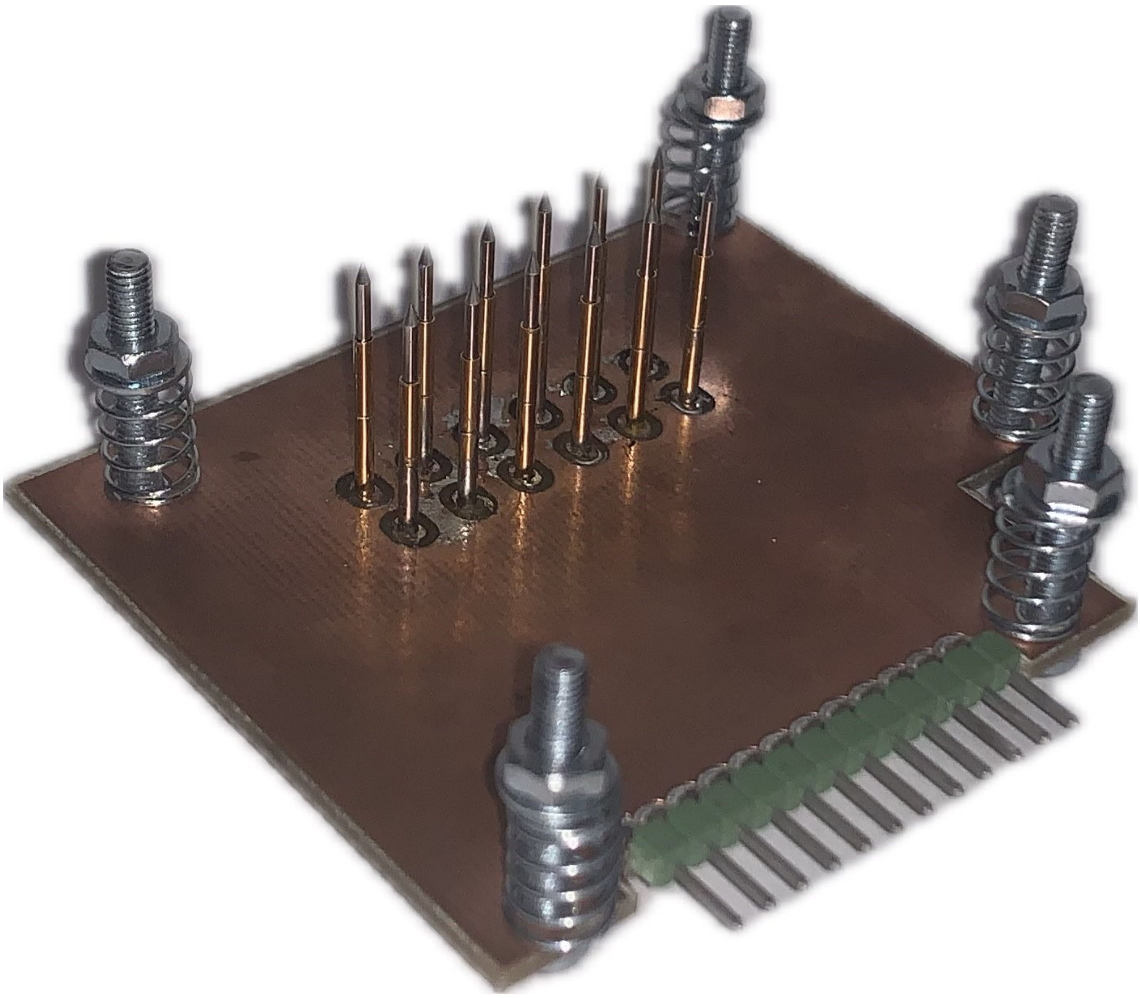

Figure 4 The populated PCB with the components soldered.

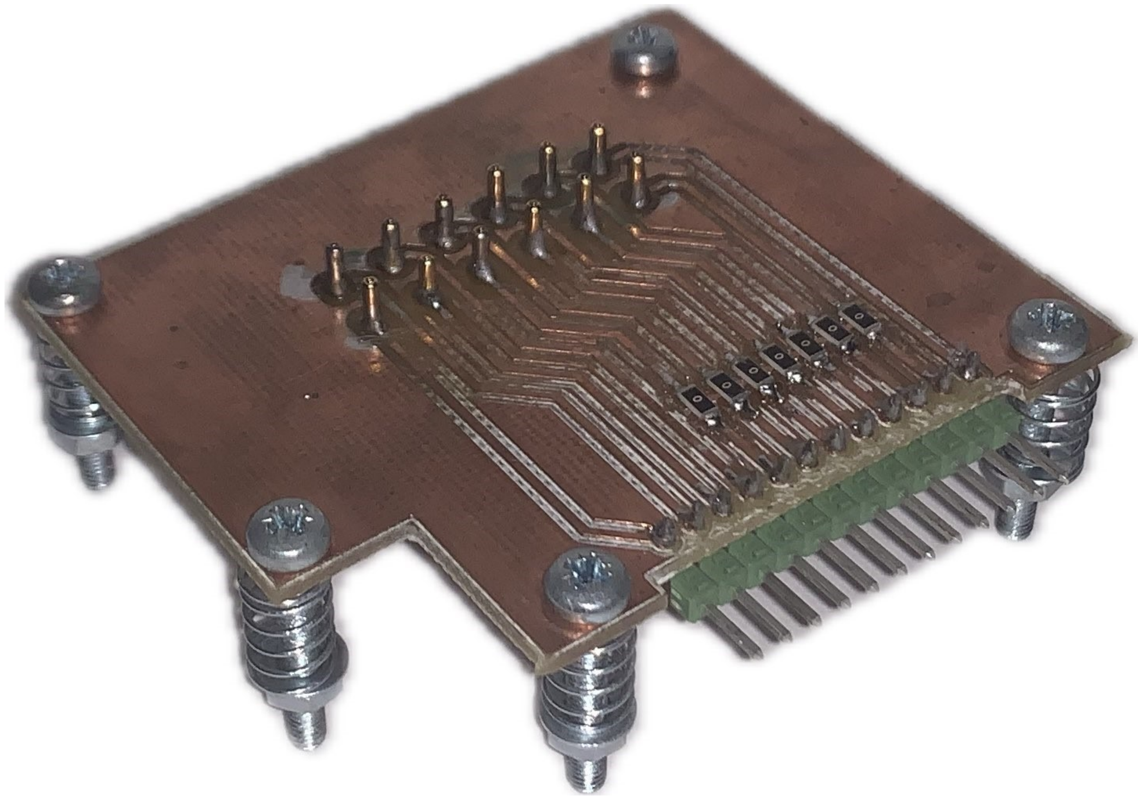

Figure 5 The resistors used are zero Ω resistors. The resistors are only used as jumpers as they are not needed in the actual design of the circuit board.

To confirm the functionality of the bed of nails tester it was necessary to design and mill another test board. The process of milling the secondary test board was similar to the main test board with the design done in KiCad. Instead of pogo pins the test board would have dozen 2.0 mm by 2.0 mm test pads located on the same point on the board as the pogo pins. The schematics of this circuit board can be seen in appendix 4: figure 16.

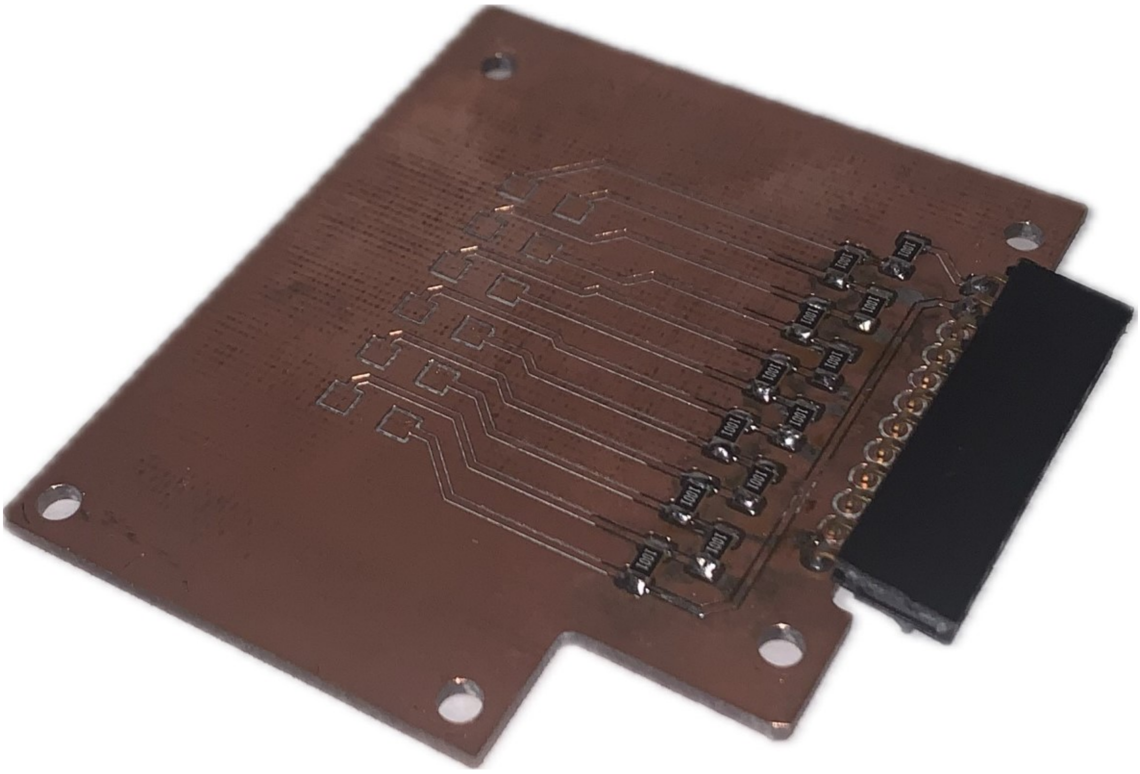

Figure 6 The populated board of the circuit board that is used in assessing the functionality of the Bed of Nails-tester.

A dozen size 1206 (3.0 by 1.5 mm) surface mounted 1000 Ω resistors were soldered in a ladder array with the test pads at each point after a resistor connection, as seen in figure 6, the pads act as points for the pogo pins to make contact. This board also uses the same sized and type of connector as the main board with the difference that only two pins are in use for connecting the test board to power. The aim was to generate measurable values for the BoN-tester to confirm its functionality.

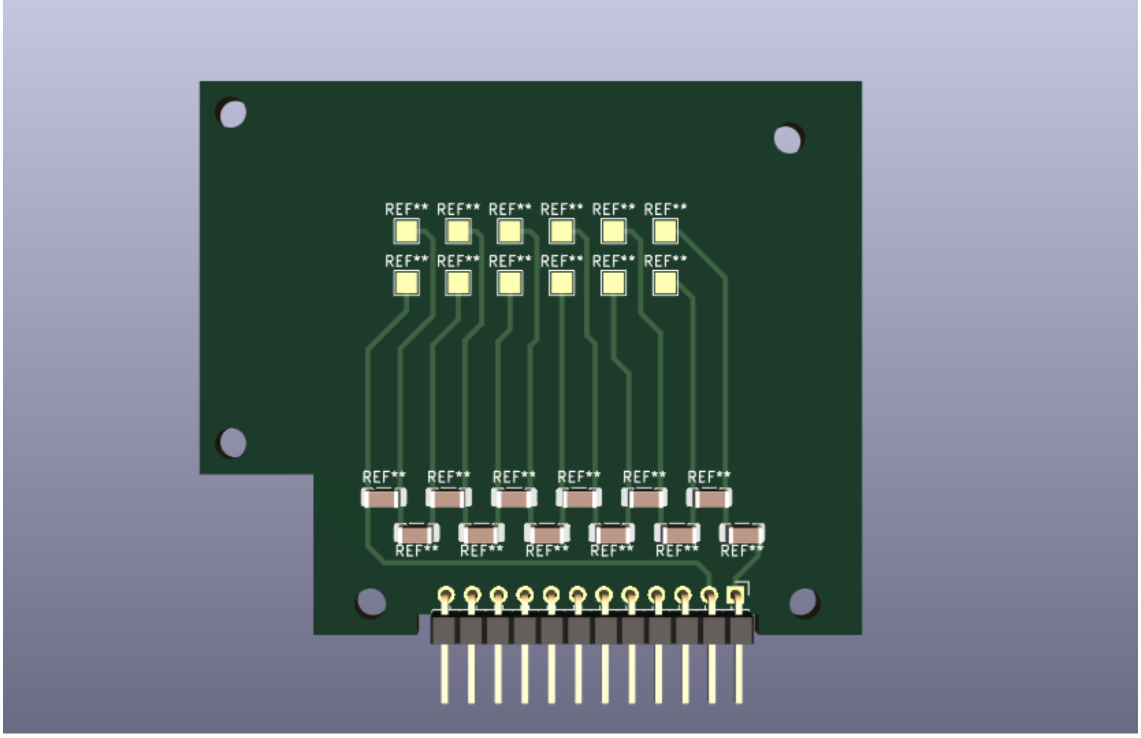

Figure 7 3D -rendered view in KiCad of the circuit board that is used in assessing the functionality of the Bed of Nails-tester.

4.1.1 Pogo Pins

Pogo pins are spring-loaded contacts that come in very handy when creating electrically solid but momentary jigs [17]. Pogo pins come in different shapes and sizes, as in figure 8, to fit the requirements laid for a design.

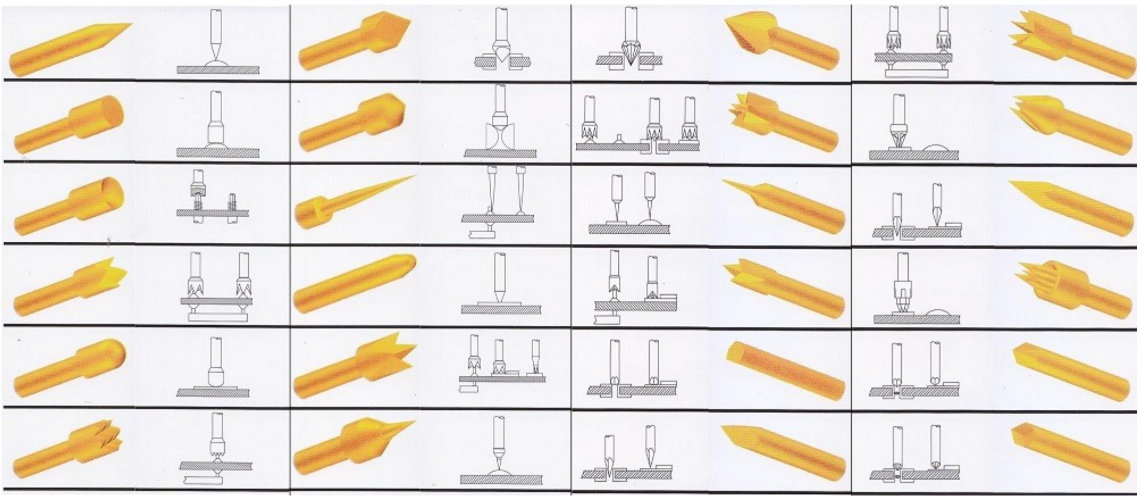

Figure 8 Various shapes and sizes exist for pogo pin style connectors. [18]

A pogo pin consists of the following parts: a barrel, a spring, and a plunger. The plunger part makes contact with a PCB, usually with a specific test pad designed for that specific use, using the pressure from the spring to form an electrically stable connection. [19.]

Unlike other types of connectors, pogo pins are only compressed in one direction. When compared to connectors where two sheets of metal scratch each other to make contact, the rubbing in this process will deteriorate the connector's outer plating over time, thereby reducing its current-carrying capacity. With a pogo pin the only friction generated is between the plunger and barrel. The friction of the internal spring force can then be specified in the design process. [20.]

The pogo pins selected for this tester are RS PRO Test Pin 3A, as detailed in the datasheet provided in Appendix 1. The choice was based on the seller's assertion that the probe is ideally suited for both development and production purposes in automatic test equipment and test jigs [21]. This is particularly beneficial for fast testing of PCBs and sub-assemblies, aligning well with the requirements of this project.

Another reason for choosing this style of pogo pins is that this style of head is ideal for test pads and holes. The needle head penetrates oxides and fluxes as well as dirt from the board [21]. As this type of small tester can be handled, often there is a risk of oils and other contaminants when handling the tester.

4.1.2 Connectors

The connectors used in this tester board are 2.54 mm pin headers, as specified in the accompanying datasheet found in Appendix 3. These were chosen as they are readily available, and the price is relatively cheap. The connectors chosen were RS PRO branded Right Angle Through Hole Pin Headers. [22.]

4.2 3D-Printed Design

The benefits of 3D-printing in electronics design manufacturing and R&D include, but are not limited to, rapid prototyping, which allows for the ability to design, manufacture, and test a customized part in as little time as possible using various materials that are available to use in 3D -printing. Also, if the need arises, the design can be modified without negatively affecting the speed of the manufacturing process. [23.]

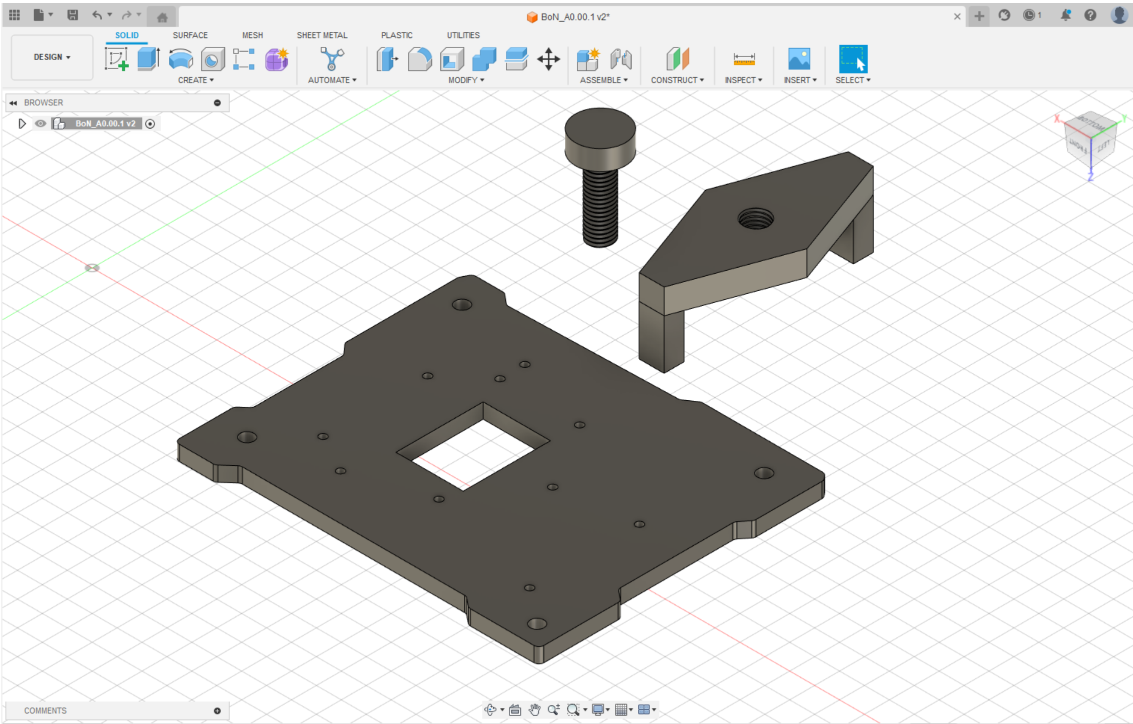

Figure 9 Image of a 3D render of the designed parts to be printed as a housing for the bed of nails tester in Autodesk Fusion 360

The housing for the Bed of Nails-tester, including the screw mechanism that presses the pogo pins to corresponding test pads on the testable board, was designed using Autodesk Fusion 360. Fusion 360 is developed by Autodesk and offers a cloud-based CAD tool for product development [24]. The schematics for the design of the model are provided in Appendix 2, while the conclusive representation of these components can be seen in Figure 9.

4.2.1 BoN Tester Housing

The design of this bed of nails tester's housing was based on a previously designed 3D-printed case shown in figure 10. It houses the PCB to be tested with the BoN tester of this project. The PCB that the tester will be used to measure is designed by the students enrolled in the Embedded Design course.

Figure 10 The housing that the BoN testers design was based on.

One of the requirements that led to this style of housing design for this BoN tester was to create a housing that can be placed on top of the existing bottom part of the housing that holds the DUT PCB, without having to remove the PCB from the housing for testing. The existing cover is 3D-printed; therefore, to match the style and keep costs down, this BoN-tester housing is also 3D-printed. This includes the mechanism to press the pogo pins to the DUT PCB. The screw mechanism was chosen due to its rigidity as there are fewer moving parts than in a 3D-printed hinge. This emphasizes the accessibility possible for 3D-printed parts to utilize in product design and prototyping. The exception are screws and springs that hold the PCB in place and to allow the PCB return to its original position.

4.2.2 Filament Materials in Electronics Testing

One example of a group of filaments that can be 3D-printed includes ESD-safe plastics, but is not limited to:

- ESD PLA, Polylactic acid
- ESD PETG, Polyethylene Terephthalate Glycol
- ESD ABS, Acrylonitrile Butadiene Styrene
- ESD Flex, a brand name for Thermoplastic Polyurethane.

These types of filaments often have carbon additives specifically designed to be ESD safe. Adding conductive graphene, carbon, carbon fibre or carbon nanotubes to the plastic polymer decreases its resistivity enabling it to dissipate electric current. [25.]. These special filaments are more costly than their regular counterparts without additives that make them ESD safe. In this tester it was deemed sufficient to use regular PLA plastic instead of ESD safe materials, as PLA is non-conductive in its normal operating temperature. [26.]

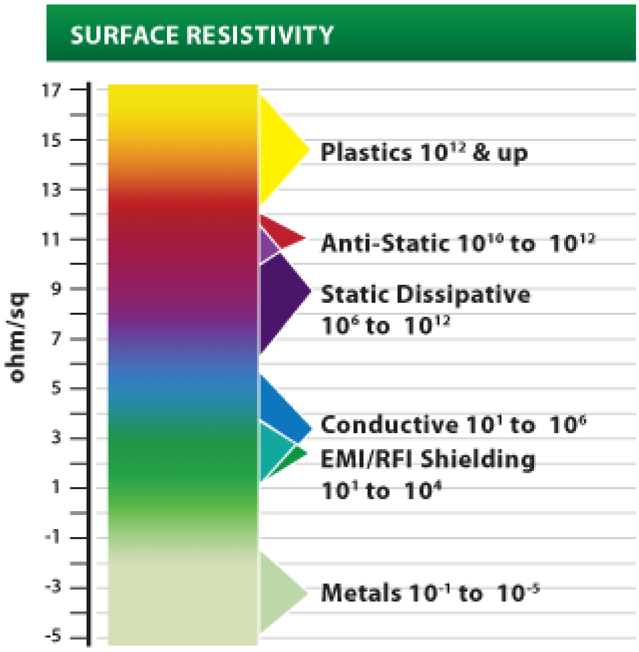

Figure 11 Surface resistivity of different materials. [28]

When comparing the surface resistance values of different ESD filaments to regular ESD materials, 3DXSTAT [27] states that the ESD PLA in their catalogue has a surface resistivity value of $10^7 \ldots 10^9$ Ω, which is in the same range as regular ESD materials in the market. Instead, regular PLA is non-conductive and has a surface resistivity of 10^{16} Ω, which is similar to more traditional injected plastics that are 10^{12} Ωm and up as seen in figure 12. [28; 29.]

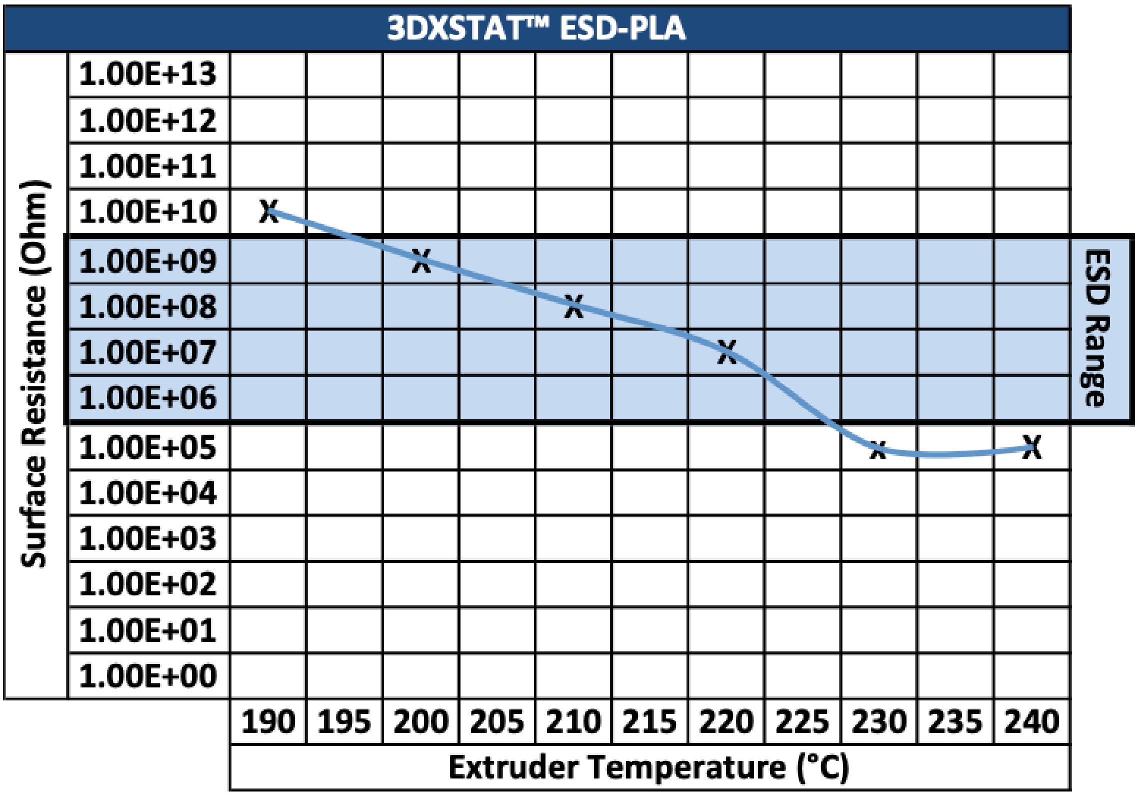

Figure 12 Extruder temperature and surface resistance relation. [27]

To achieve the proper surface resistance 3DXSTAT ESD PLA has a specific printing temperature, as it needs to be printed at the correct temperature, which, according to figure 11, is in the 200 ºC to 225 ºC area. [27.]

In regard to regular PLA, the colour of the filament can affect its surface resistivity, for example black coloured PLA as it often has additives in the dye that can be more conductive than other colour dyes.

The filament that was used in this project was a cheap no name brand roll of filament that came in a metallic rainbow colour. The parts were printed on a 3D-printer with its nozzle heated to 220 °C while the printer’s glass bed temperature was heated to 60 °C. These temperatures are quite typical for printing PLA plastic.

Considering the significantly lower cost of non-ESD PLA, approximately 20 € / kg in this instance, it was sufficient for this project, especially when contrasted with ESD PLA from 3DXTech that is priced at over 100 € / kg. [27.]

Furthermore, the decision to opt PLA as the material of choice was justified by the limited contact points between the tester and the printed plastic. The primary interaction between the parts occurs in the screw mechanism, where the screw applies pressure to the PCB. As the PCB is only resting by screws on the plastic housing.

When using PLA with electronics there is a risk of danger in the form of the plastic melting due to electrical fault or even a fire thanks to PLA’s low glass transition temperature and melting point, which causes the conductivity to increase with temperature increase. [26.] Based on this, use of PLA is not recommended in test setups where a stable temperature cannot be guaranteed or if there are high power consuming components in a system without proper cooling.

5 Results

After the design and prototyping phase of the tester the final assembly of the tester was done, and the tester is ready for test use.

5.1 Testing Functionality

With all the components, in place the PCB was placed on the 3D-printed housing using M3 screws and springs. With the springs the PCB is tensioned such that the PCB can return to its original position when the screw mechanic is turned counterclockwise to release the pogo pins contact from the testable board. The tester is placed on top of the DUT housing using M5 screws and nuts to secure it in place during testing.

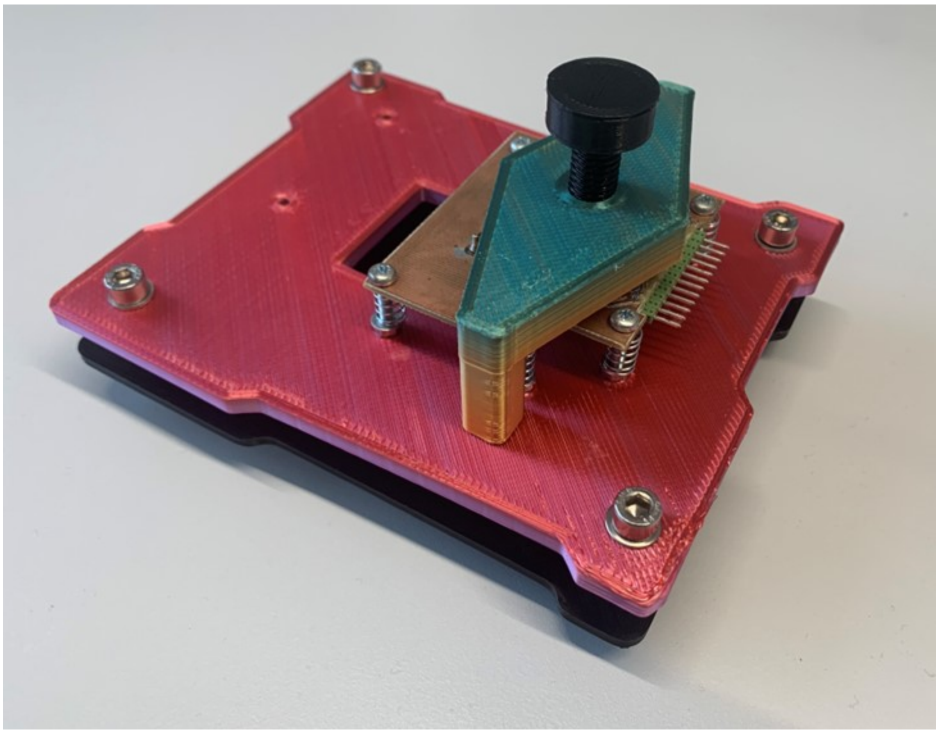

Figure 13 The assembled BoN tester.

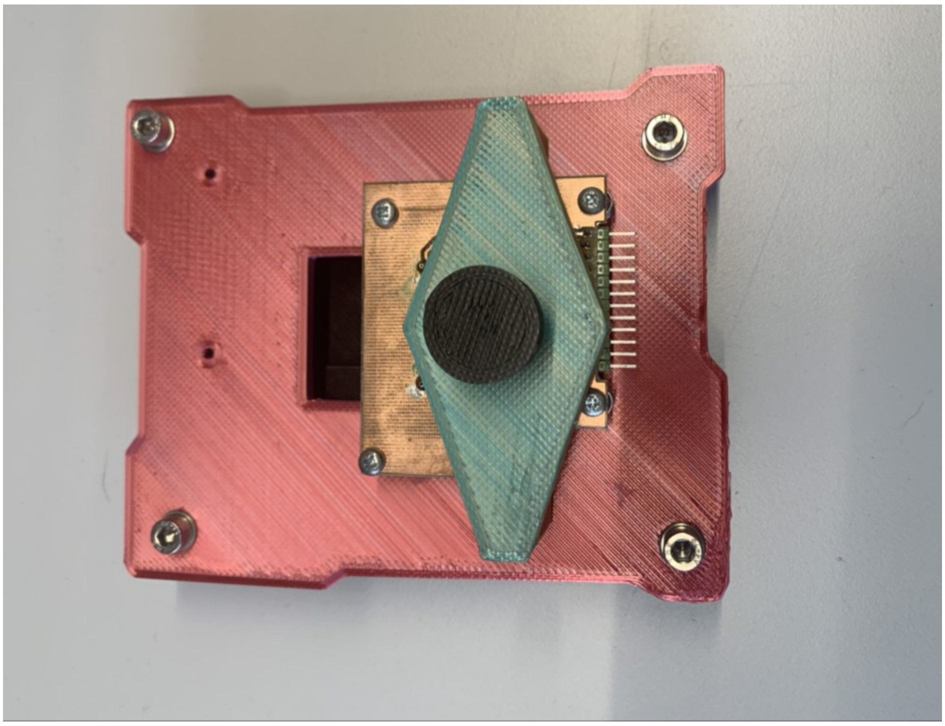

Figure 14 Top-down view of the BoN tester.

The footprint of the tester matches the 3D-printed housing of the DUT. Figures 13 and 14 show the tester installed on top of the DUT.

5.2 PCB Measurement Performance

The bed of nails testers functionality was confirmed by connecting it to a 12 V power supply and using a Fluke 179 multimeter to measure the Voltage values on each pad before connecting the tester on top. After connecting the tester and doing the measurements again the results were compared. The output of the power source was measured to be 12.2 V. The measured values were identical when measuring from the tester's connector pins.

Calculating each pads voltage value and comparing these to measured values allows to confirm the proper functionality of the tester. In a series circuit, the total resistance is the sum of the resistances of each component. In this case, with 12 resistors, each with a resistance of 1000 Ω. Total resistance was calculated as:

$$R_{total} = 12 \times 1000\ \Omega = 12000\ \Omega \quad (1)$$

The voltage source being 12.2 V. According to Ohm's law $V = I \times R$, the current in the circuit was calculated as:

$$I = \frac{V}{R_{total}} = \frac{12.2\ V}{12000\ \Omega} \approx 0.0010167\ A \approx 1.017\ mA \qquad (2)$$

In a series circuit, the current is the same through all components. Therefore, the voltage drop across each resistor was calculated using Ohm's law:

$$V_{drop} = I \times R = 0.0010167\ A \times 1000\ \Omega \approx 1.017\ V \quad (3)$$

The voltage drops approximately 1.02 V across each resistor in the series.

As seen in the measured values in table 3 the results align quite well with the calculated value. The effect of the tester to resistance measurement was measured after unplugging the power source with the finding that there was no change to the resistance of any point measured by the multimeter.

Table 3 The measurement results

Measurement pad # of 12. Starting from nearest to source.	**Measured Voltage without tester on top of board. (V)**	**Measured Voltage with tester from test points on BoN tester. (V)**	**Measured resistance without tester on top of board. (kΩ)**	**Measured resistance with tester from test points on BoN tester. (kΩ)**
1	11.60	11.60	0.99	0.99
2	10.14	10.14	0.99	0.99
3	9.13	9.13	0.99	0.99
4	8.11	8.11	0.99	0.99
5	7.10	7.10	1	0.99
6	8.09	8.09	0.99	0.99
7	5.07	5.07	0.99	0.99
8	4.06	4.06	0.99	0.99
9	3.05	3.05	0.99	1
10	2.03	2.03	0.99	0.99
11	1.02	1.02	1	0.99
12	0.00	0.00	0.99	1

6 Future improvements

In later revisions of the testers design the screw mechanism could be altered to be more ergonomic. This could be achieved with a wing nut style top and the thread of the screw be larger such that the motion of connecting the pogo pins would require less pinching and twisting of hand, thus being more ergonomic.

The connection between the tester's housing and the DUT housing at the four corners can be simplified by utilizing plastic push pins with compression springs. These plastic push pins function by being pushed through designated holes in both housings, securing them together. The compression springs within the push pins allow for flexibility, ensuring a secure yet adjustable connection. Importantly, the design also facilitates easy removal by allowing users to grasp and pull the pins, simplifying the disassembly process when needed. This modification not only streamlines attachment but also enhances the overall convenience of the housing connection. The pogo pins can also be misaligned due to the small size of the pads, making the pads larger should allow more room for the small movements of the pogo pins.

7 Conclusion

The goal of this project was to create a proof-of-concept bed of nails tester implementing the use of 3D -printing to create a much more affordable alternative to an industry standard professional in-circuit tester. 3D-printing has made it possible to create testers that conform to the rapidly changing needs in product development and R&D phases, as small batches of circuit boards can be tested without a large investment upfront or external testing that is not ideal with varying batch sizes. There are limitations in 3D-printing, often the size that can be reasonably produced with a consumer grade 3D-printer is rather small so larger circuit boards or testing a panel of multiple circuit boards at a same time may not be reasonable with this style of tester.

Due to design changes and external delays, this thesis work, which had a deadline for the BoN tester to be used in the Embedded Electronics course by Metropolia UAS students in autumn 2023, fell behind to winter 2023. The designing and production of this tester was challenging at first due to the learning curve of the required 3D-modelling skills. 3D-modelling was something I had not done before this and learning it was quite difficult at first, however as a skill it has become particularly useful in work, and I believe it is a useful skill for any electronics engineer working in R&D or manufacturing.

Further designs could improve the plunger mechanism and add more test points for the PCB. The tester design at its current state is a proof-of-concept tester that can be used in the course as it is. However, some alterations could be required depending on the needs of the testable boards design in the Embedded Electronics course.

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Appendix 1 - RS PRO Needle, Test Probe, 3A – Datasheet

Obtained from https://fi.rsdelivers.com/product/rs-pro/rs-pro-test-pin-3a/5424990
28.11.2022

Spring Test Probes

FEATURES

- Pitch spring test probe
- Pitch of 2.54 mm
- Length of 24.7 mm
- Phosphor bronze body material
- Gold plated
- Current rating of 3 A
- Contact resistance of 30 mΩ
- Needle probe tip

RS PRO Needle, Test Probe, 3A

RS Stock No.: 542-4990

RS Professionally Approved Products bring to you professional quality parts across all product categories. Our product range has been tested by engineers and provides a comparable quality to the leading brands without paying a premium price.

Spring Test Probes

Product Description

When it comes to safely testing out contacts in an electrical circuit, this pitch spring test probe is the perfect solution. Consisting of a spring, plunger and tubular barrel, the probe is designed to be wired into a receptacle, which can be housed. Having the probe and receptacle separated in this manner allows you to easily replace or repair it in case of damage.
The probe is made from strong and resilient phosphor bronze material. Its gold-plated finish further enhances this and offers excellent conductivity for reliable testing. The product's 24.7 mm length means you can test contacts from a distance using its spring-loaded needle tip.

General Specifications

Body Material	Phosphor bronze
Probe Tip Type	Needle
Body Plating	Gold
Applications	Test lands, pads, leads and holes Penetrates oxides and fluxes as well as contaminated boards

Electrical Specifications

Current Rating	3A
Contact Resistance	30mΩ

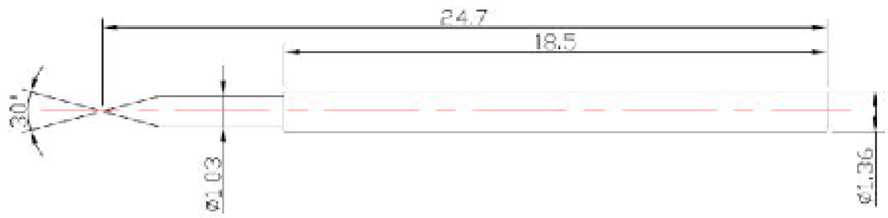
Mechanical Specifications

Pitch	2.54mm
Length	24.7mm

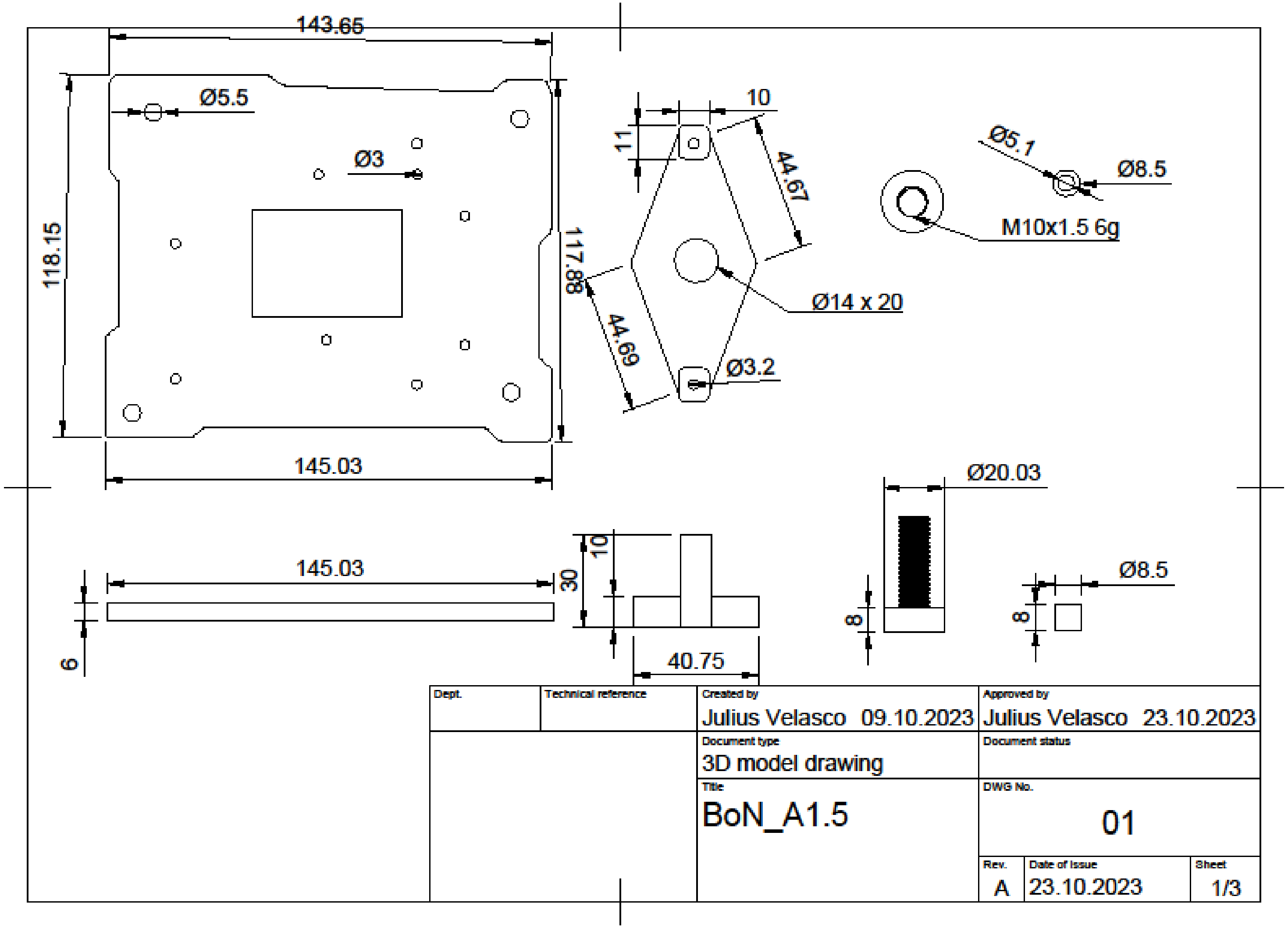
Approvals

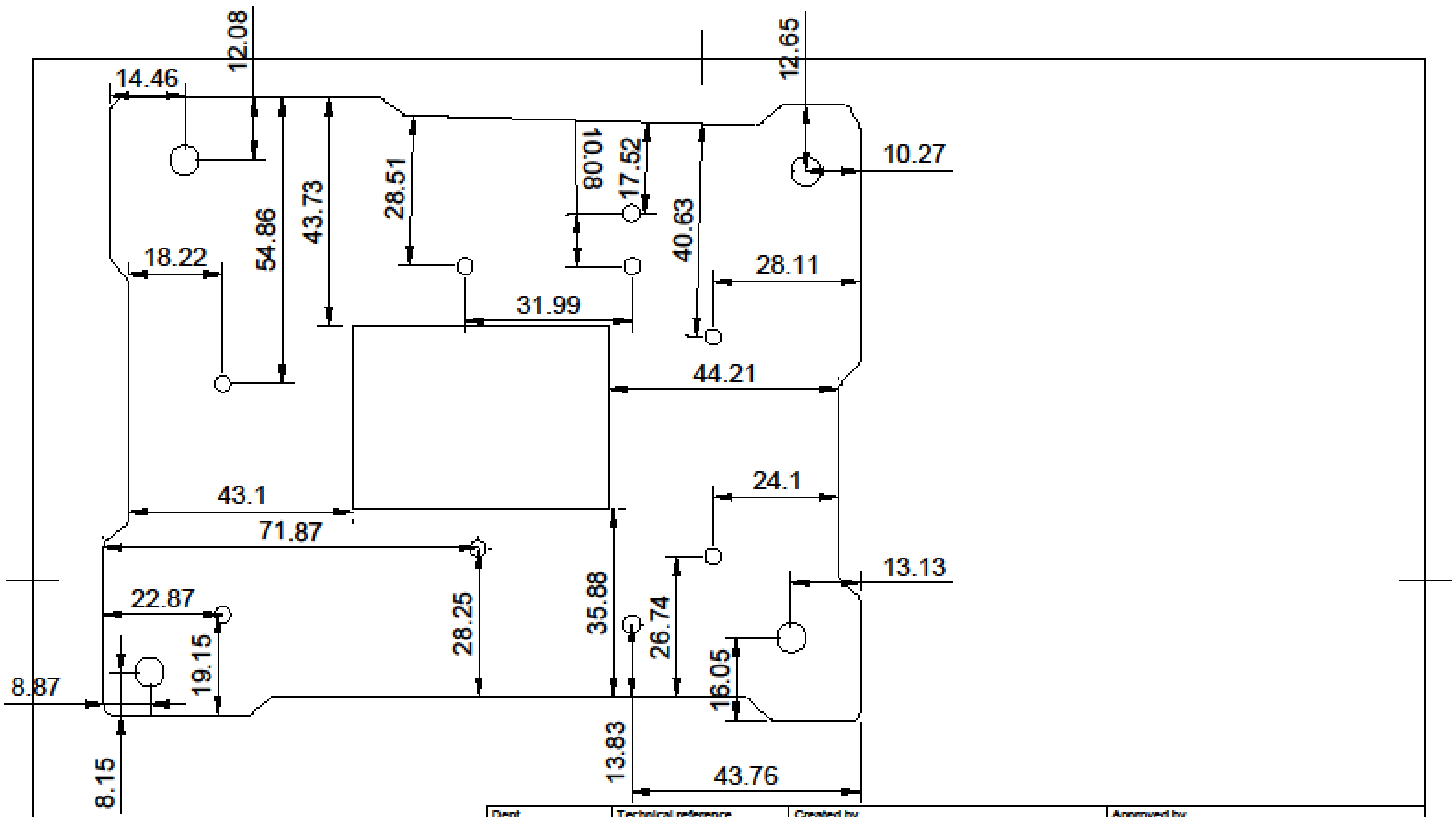
Compliance/Certifications	EN61340

Spring Test Probes



Appendix 2 - Schematics of the 3D-printed housing.





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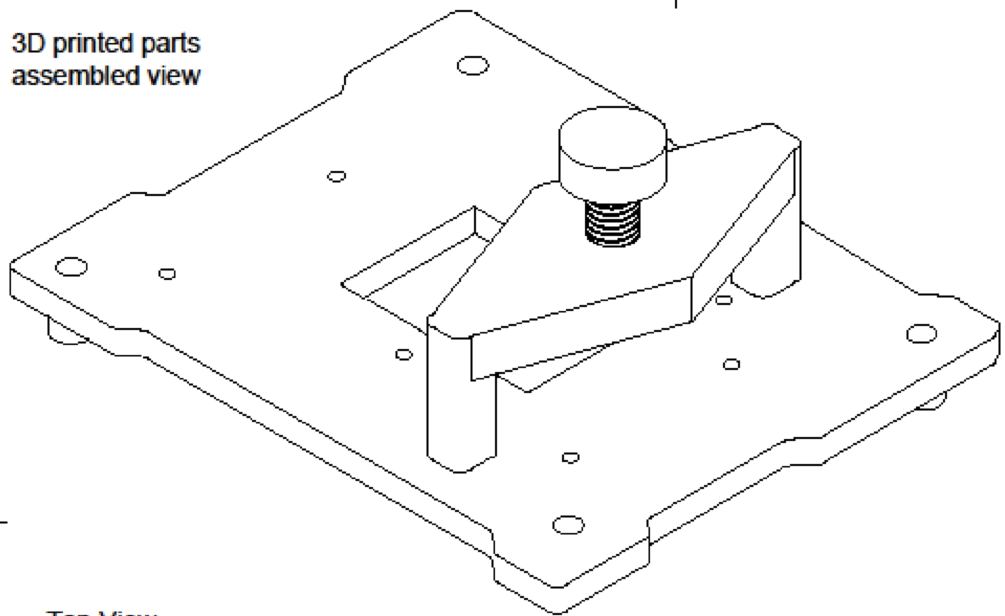
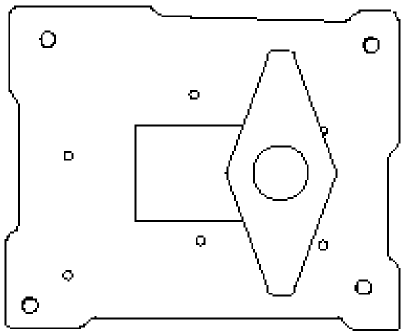
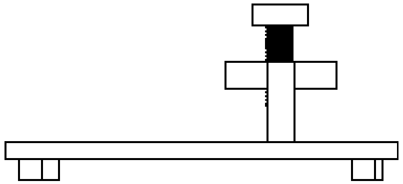
		Document type	Document status		
		3D model drawing			
		Title	DWG No.		
		BoN_A1.5	02		
			Rev.	Date of issue	Sheet
			A	23.10.2023	2/3

3D printed parts assembled view



Top View





Side View

Dept.	Technical reference	Created by	Approved by
		Julius Velasco 09.10.2023	Julius Velasco 23.10.2023
		Document type: 3D model drawing	Document status:
		Title: BoN_A1.5	DWG No.: 03
			Rev.: A; Date of issue: 23.10.2023; Sheet: 3/3

Appendix 3 - RS PRO Pin Header, 2.54 mm, 90º right angle – Datasheet

Obtained from https://uk.rs-online.com/web/p/pcb-headers/2518452 13.11.2023.

ENGLISH

Datasheet

Stock No: 251-8452

RS Pro RS Pro W81136 Series, 2.54mm Pitch 36 Way 1 Row Right Angle PCB Header, Solder Termination

Product Details

90° Headers

- Various pin heights and PCB tail lengths
- Can be snapped to desired length

Current Rating	4 A max
Temperature Range	-55° C to +125 ° C
Pin Material	Tin Plated Brass
Insulation	PBT 30% Glass UL94V-0
Pin Size	0.64mm Square

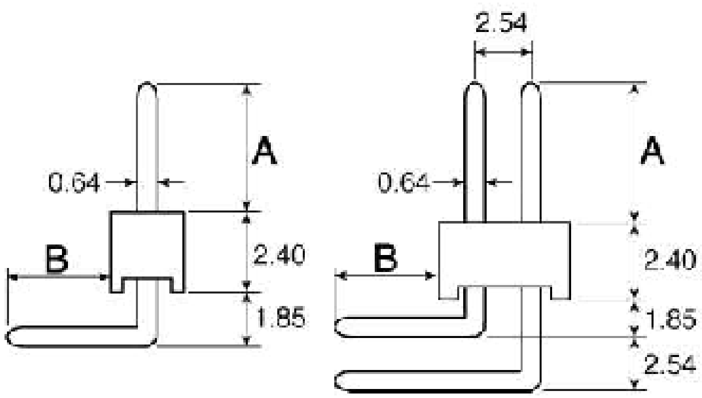
Specifications:

Number of Contacts	36
Pitch	2.54mm
Number of Rows	1
Type	Unshrouded Header
Body Orientation	Right Angle
Termination Method	Solder
Series	W81136

RS PRO

ENGLISH

Dimensions:



2.54mm PCB Connector RS Range

A large variety of connector options, to cover the majority of board-to-board, bussing and programming requirements

Appendix 4 – Circuit board layout of the bed of nails tester.

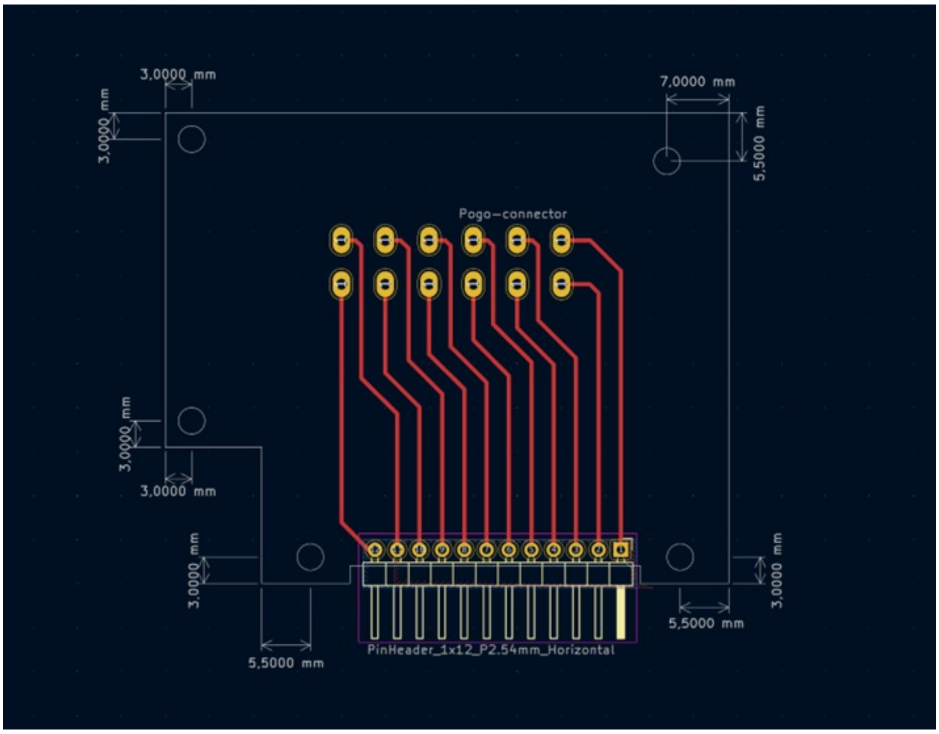


Figure 15 PCB layout view of the tester board in KiCad

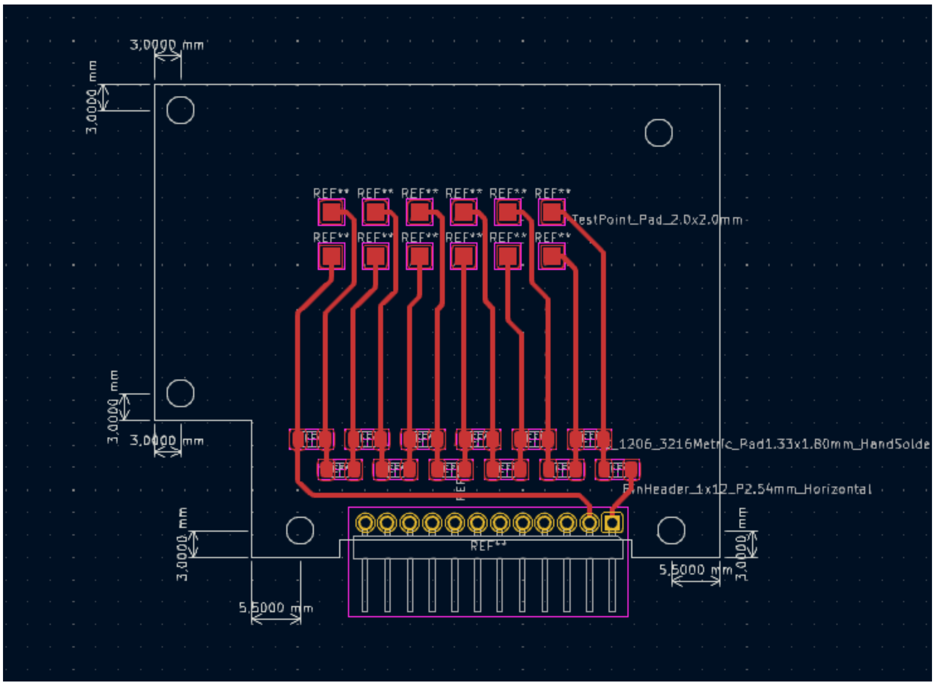


Figure 16 PCB layout view in KiCad of the circuit board that is used in assessing the functionality of the BoN-tester.