

PROJECT PROPOSAL - DESIGN AND VALIDATION OF USB 3.0 INSERTER FOR USE IN AUTOMATED TEST EQUIPMENT - MICHAEL HOWELLS

by Michael Howells

Submission date: 20-Oct-2023 02:30PM (UTC+0100)

Submission ID: 213777922

File name: 33525_Michael_Howells_PROJECT_PROPOSAL_-
_DESIGN_AND_VALIDATION_OF_USB_3.0_INSERTER_FOR_USE_IN_AUTOMATED_TEST_EQUIPMENT_1468492249.pdf
(1.27M)

Word count: 2693

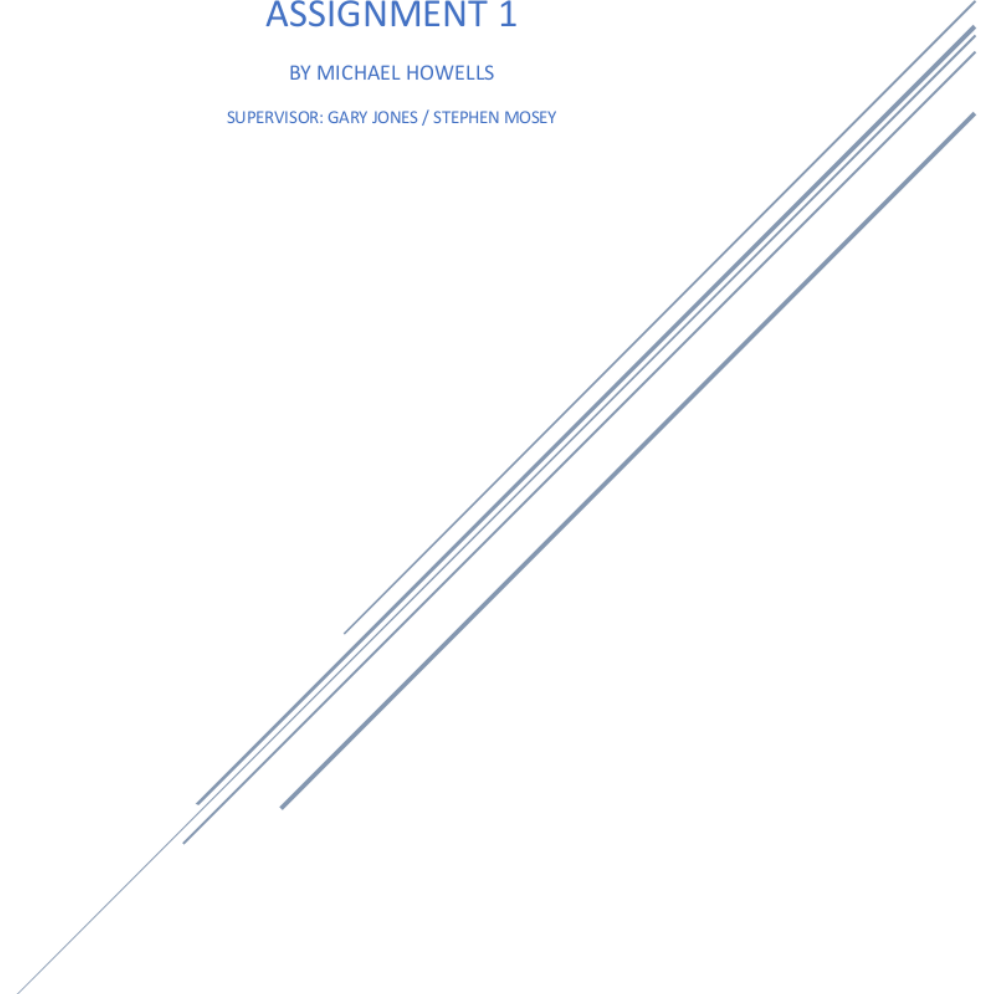
Character count: 17940

PROJECT PROPOSAL: DESIGN AND VALIDATION OF USB 3.0 INSERTER FOR USE IN AUTOMATED TEST EQUIPMENT

ASSIGNMENT 1

BY MICHAEL HOWELLS

SUPERVISOR: GARY JONES / STEPHEN MOSEY

An abstract graphic consisting of several parallel diagonal lines in a light blue-grey color, extending from the lower-left towards the upper-right of the page.

UNIVERSITY OF WALES TRINITY SAINT DAVID
INDEPENDENT PROJECT

CONTENTS

1	INTRODUCTION	4
1.1	SONY UK TECHNOLOGY CENTRE	4
2	BACKGROUND	5
2.1	AUTOMATION	5
2.1.1	CURRENT TEST SETUP	6
2.2	PROBLEM	8
2.3	DESIGN BRIEF	8
2.4	EVALUATION CRITERIA.....	8
2.4.1	FUNCTION	8
2.4.2	DAMAGE.....	8
2.4.3	ROBUSTNESS	8
2.4.4	RELIABILITY.....	9
2.4.5	MAINTAINABILITY	9
2.5	ETHICAL CONCERNS	9
3	LITERATURE REVIEW	10
3.1	MARKET RESEARCH.....	10
3.1.1	INGUN - 51377	10
3.1.2	INGUN - 55130	10
3.1.3	FEINMETALL CONTACT TECHNOLOGIES - 2112159	11
3.1.4	ENGMATIC - 1552-89-000	11
3.1.5	EXISTING DESIGN.....	11
3.2	COMPARISON.....	12
3.3	USB DESIGN CONSIDERATIONS.....	14
4	PROJECT DESIGN	15
4.1	DEVELOPMENT METHOD	15
4.2	RESOURCES REQUIRED	16
4.2.1	PCB CAD SOFTWARE	16
4.2.2	MECHANICAL SUPPORT	16
4.2.3	PCB FABRICATION FACILITY	16
4.2.4	DATA SOURCES.....	16
5	PLANNING	17
5.1	DELIVERABLES	17

5.2	GANTT CHART	18
6	APPENDICES	19
6.1	QUOTATION AND PRICES	19
6.1.1	SONY INSERTER COSTING.....	19
6.1.2	INGUN – 51377 and INGUN – 55130 COSTING	21
6.1.3	ENGMATIC - 1552-89-000 COSTING.....	22
7	REFERENCES.....	24



1 INTRODUCTION

1.1 SONY UK TECHNOLOGY CENTRE

Sony UK Technology Centre is a manufacturing facility located in South Wales. The main function of the facility is to manufacture high-end broadcast and professional technology designed by Sony [1].

However, in recent years they have offered contract manufacturing services to 3rd party companies. One product that is manufactured in this part of the business is the Raspberry Pi, which is a low-cost single board computer. There are many different variants of the raspberry pi, such as the Raspberry Pi 4 [2] and Raspberry Pi Zero 2 W [3].

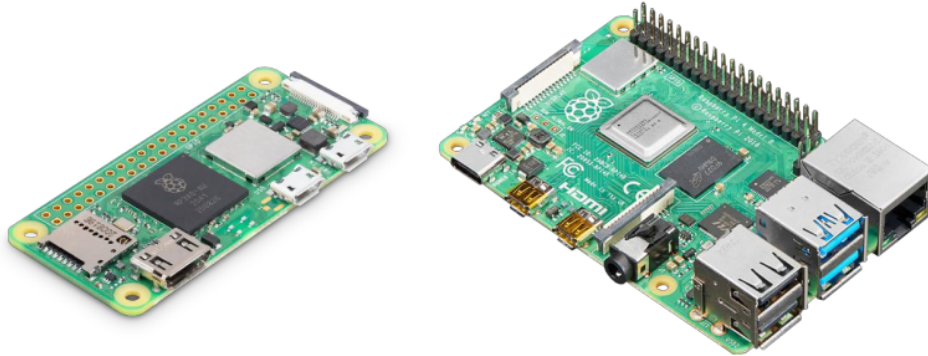


Figure 1 - Raspberry Pi Zero 2 W (left) [3] and Raspberry Pi 4 (right) [12]

2 BACKGROUND

2.1 AUTOMATION

Some products are processed on automated lines within the factory. This means that it would go through an SMT process, routing process, test process and packing process without a human touching it.



Figure 2 - Automated line test pod input conveyor system [4]

One product which goes through the automated process is the Raspberry Pi4 and the Raspberry Pi5. The automated test equipment is located within a “test pod”. The test pod contains 4 “test heads”, which is where the product is automatically loaded onto a bed of nails test jig and has numerous peripherals connected to the DUT (device under test) such as an SD card extension, HDMI cables, USB C cable and USB extension. All are required for the test to function correctly.

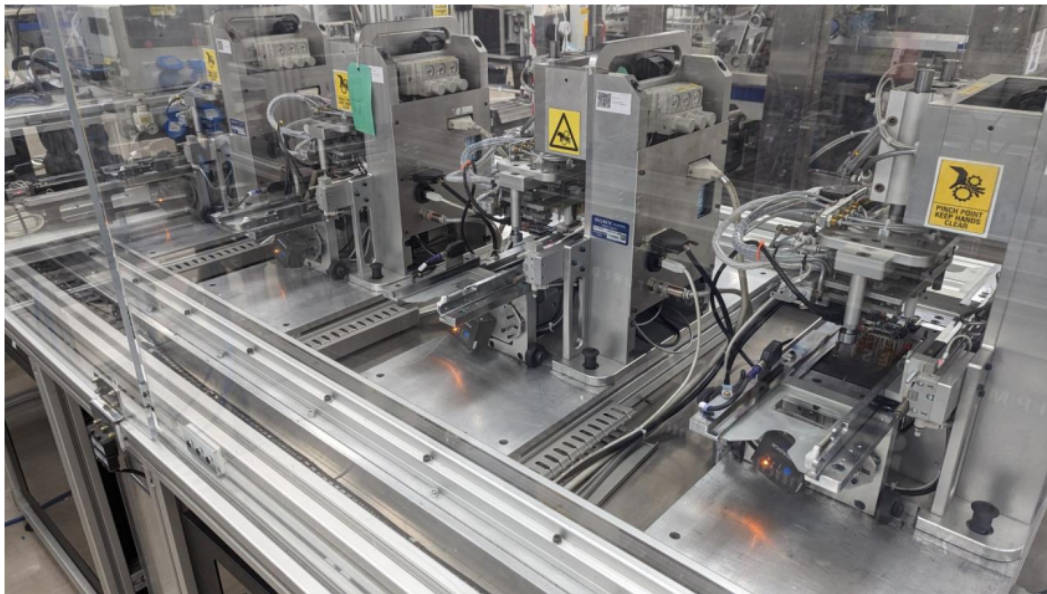


Figure 3 - Automated Test Pod

2.1.1 CURRENT TEST SETUP

In order to automatically test Raspberry Pis 7 things are inserted automatically. These can be seen in the diagram in Figure 4. The USB inserter that is relevant to this project has been highlighted in grey.

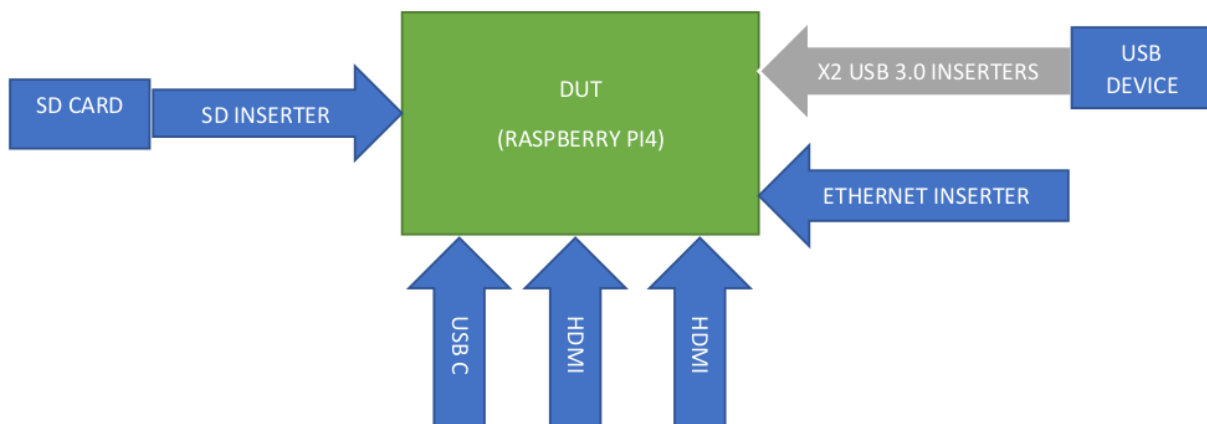


Figure 4 - Automatic Insertions at test

2.1.1.1 USB 3.0 Device

Connected to each of the USB inserters is a USB device. The circuit on this device contains both a USB 2.0 device and a USB 3.0 device and is used to verify that the USB functionality on the DUT is working



Figure 5 - USB 3.0 device

correctly. For a pass condition at test 4 devices should be connected when the USB inserters are connected. The device can be seen in Figure 5.

2.2 PROBLEM

This project is related to the USB insertion of the test. The existing hardware used has numerous issues that this project aims to address. These include:

-Reliability issue: There is a constant ~4% NFF for the USB check. A NFF refers to a test failure that is not caused by a genuine product fault. NFFs require product to be retested and this will reduce efficiency of the production line due to the additional time reprocessing these NFFs, which will itself incur additional costs. This USB check failure occurs when the devices inserted into the DUT are not detected. These devices are connected through an existing USB inserter design, so there is potential to improve first time yield of the production line with an improved USB inserter design.

-Difficulty to maintain: USB inserters require manual alignment to ensure they make good contact to the DUT inside the test jig. This can be time consuming as a good alignment can be quite difficult to achieve with the current design.

2.3 DESIGN BRIEF

The aim of this project is to design a consumable USB 3.0 inserter board that is compatible with the automated test jigs for Raspberry Pi4 and Raspberry Pi5. The consumable part must be capable of connecting to both ports of a USB stack connector at the same time. It must also be easy to align within the automated test equipment.

2.4 EVALUATION CRITERIA

This section defines the criteria that the design must be evaluated against to determine if it is a success.

2.4.1 FUNCTION

The most critical part of the design is to ensure that it works as a USB extension. The project will be a complete failure if the part does not function correctly. This will be the first thing to be tested. It must also be able to connect to both ports of the USB stack connector.

2.4.2 DAMAGE

The inserter must not damage the connector on the product as it inserts during the test. This is critical as if they do damage the product, then every unit that is tested will have a damaged USB connector, which is not an acceptable result.

2.4.3 ROBUSTNESS

The inserter must be able to last a significant time in the production environment before it needs to be replaced.

2.4.4 RELIABILITY

A study will need to be done to evaluate if the 4% NFF has been reduced with a redesigned inserter. This will require a comparison of test data before and after a new inserter has been installed.

2.4.5 MAINTAINABILITY

The design must allow the inserter to be aligned quickly to reduce downtime on production equipment. To check this, a timed alignment of both the old and new design could be undertaken and then compared.

2.5 ETHICAL CONCERNS

An ethics form was completed for this project and no concerns were identified.

3 LITERATURE REVIEW

3.1 MARKET RESEARCH

This section will evaluate established designs for USB inserters that are available on the market. The characteristics of each will be compared with the aim of identifying features that will help improve the design for this report.

3.1.1 INGUN - 51377

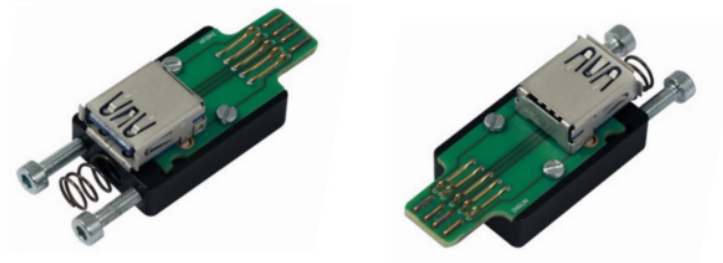


Figure 6 – Image of Ingun 51377 USB 3.0 inserter [5]

3.1.2 INGUN - 55130

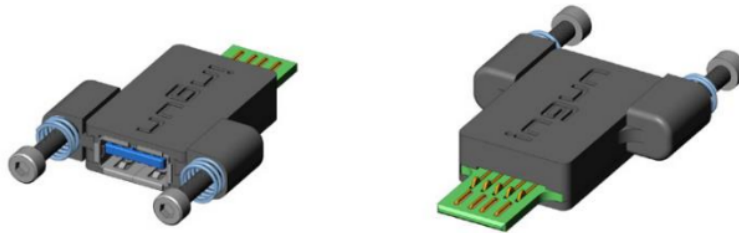


Figure 7 – Image of Ingun 55130 USB 3.0 inserter [5]

3.1.3 FEINMETALL CONTACT TECHNOLOGIES - 2112159

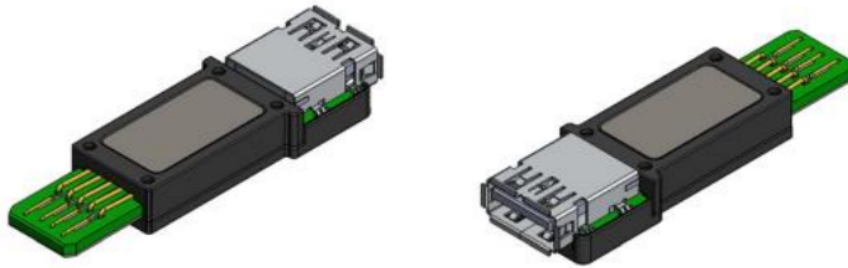


Figure 8 – Image of Feinmetall Contact Technologies 2112159 USB 3.0 inserter [6]

3.1.4 ENGMATIC - 1552-89-000

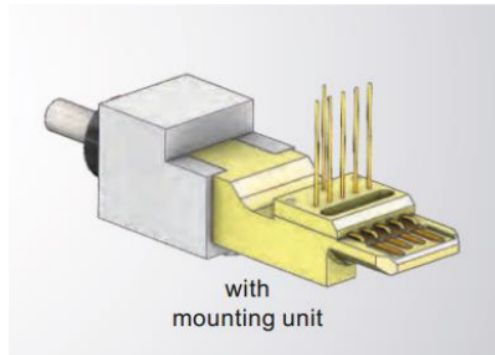


Figure 9 – Image of Engmatic 1552-89-000 USB 3.0 inserter [7]

3.1.5 EXISTING DESIGN

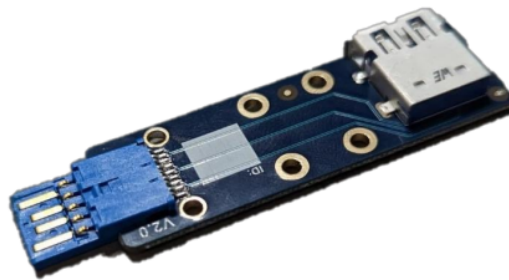


Figure 10 – Current design USB 3.0 Inserter used in Sony

3.2 COMPARISON

Part #	51377	55130	2112159	1552-89-000	EXISTING DESIGN
Manufacturer	INGUN	INGUN	FEINMETALL CONTACT TECHNOLOGIES	ENGMATIC	SONY
Cost	£174.33 (See quote in appendices)	£174.33 (See quote in appendices)	No price available	£229.38 (See quote in appendices)	£10 (Costing in appendices)
Can it connect to both ports of a USB Stack?	NO	YES	NO	NO	YES
USB 3.0 Capable	YES	YES	YES	YES	YES
Data rate	5 Gbit/s	5 Gbit/s	4 Gbit/s	Unknown	Unknown
Mating Cycle Rating	100,000	100,000	50,000	200,000	Unknown
Contact Method	Spring Contact	Spring Contact	Spring Contact	Spring Contact (copper beryllium)	Connector (Can removed)
Reference	[5]	[5]	[6]	[7]	

Table 1 – USB Inserter Comparison Table

Table 1 shows that there are many options available for automatically inserting USB 3.0 devices. Unfortunately, none other than the existing Sony inserter design is suitable for use within the Sony test equipment. The first reason for this is that only the existing design and the Ingun 55130 can insert into a USB stack. Secondly, only the Sony design fits within the mechanical constraints of the test jig in Sony.

The constraint issue can be seen in Figure 11 and shows there is no room for the USB devices if the connector is on the back of the inserter as there is a large cylinder used to press the DUT into the jig. A significant and expensive redesign would be required to incorporate any of the designs researched.

One common thing across all inserters on the market is the spring contact that is built into the units. These parts are not available to buy from standard suppliers and therefore must be sourced some other way. This is something that could be investigated for the new design.

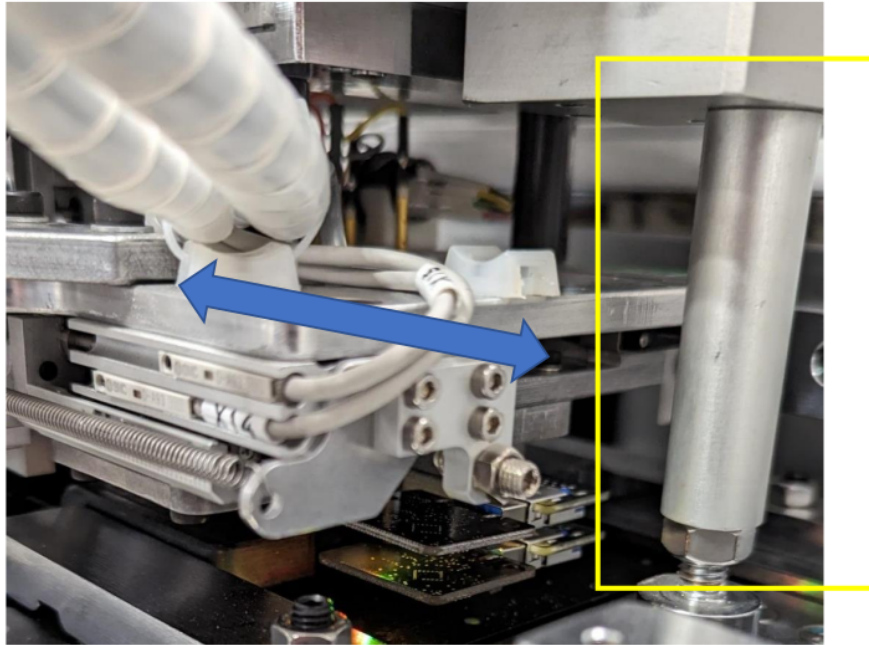


Figure 11 - Mechanical Constraint Issue Explained

One thing that can be seen from the research is that there are some gaps in the specification of the Sony designed inserters. This is something that could be defines, such as mating cycle rating and data rate.

3.3 USB DESIGN CONSIDERATIONS

Universal Serial Bus (USB) is a communication specification that is used to connect two devices together. It is often used to easily connect a slave device (e.g. mouse) to a master device (e.g. computer). There have been several revisions of the specification over the years, such as the improved 3.0 standard which included faster data transfer rates, better efficiency of power and more device compatibility.

When designing PCBs with USB interfaces, there are some methods techniques that can be implemented to ensure that a good connection is made. These techniques aim to reduce reflections in the high-speed signals which if present will reduce signal integrity [8].

The USB specification states that USB 3.2 connections required a differential impedance in the range of 72-120ohms. To achieve this on a PCB, the PCB thickness, trace width and spacing of differential pairs are adjusted to specific values [9].

The length of the traces in a differential pair must also be matched to reduce the impact of timing delays. Serpentine routing is one method that can be used to tune the length of mismatched differential traces.

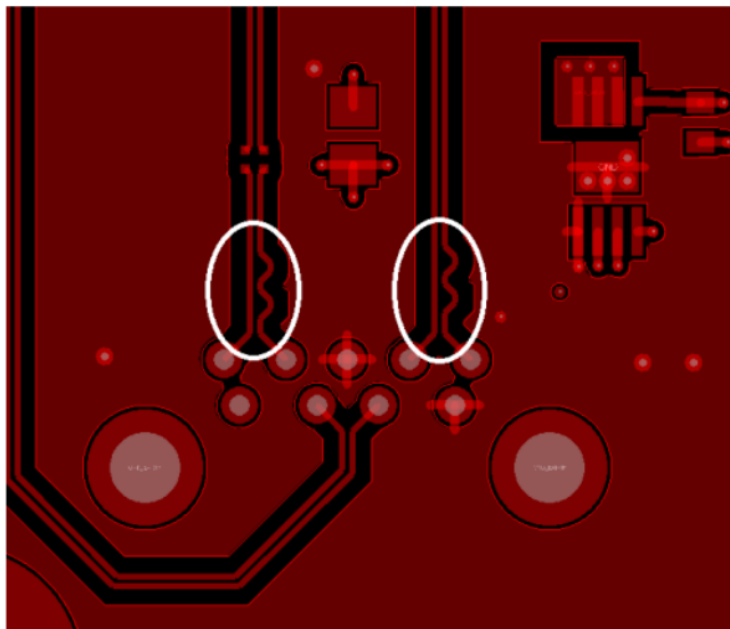


Figure 12 - Example of serpentine routing [9]

The PCB stack-up can also be used to improve signal integrity. Having a ground reference plane under USB traces can improve signal integrity. The ground plane should not be split by any signal traces to maintain a good return path [9].

4 PROJECT DESIGN

4.1 DEVELOPMENT METHOD

The waterfall design methodology will be followed for this project as it has clear stages of development. This type of methodology is often used in software development projects, however the stages of development can also be relevant to more general project developments, such as the one in this proposal.

The Waterfall Method

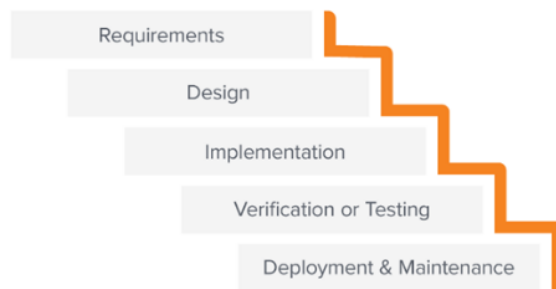


Figure 13 - Waterfall Design Methodology

The first stage is where the requirements are defined. All features and capabilities will be defined in this section as well as the time scale of the project.

Next is the design stage and the first thing which is done here is a high-level overview of the design. This may include a block diagram for example. After the high-level design is completed, the specific solutions are investigated and defined.

The implementation stage of this project will be the installation of the new design into production equipment for initial testing.

The testing phase of the project is next, and for this specific development, it will be the most key part. The criteria defined in previous sections will be evaluated in this section to determine if the project was a success or not.

The deployment for this will be a full installation into production equipment after the design has been confirmed to be ok.

The waterfall method does have some limitations. For example, it does not handle changes very well when compared to some other development models [10].

4.2 RESOURCES REQUIRED

4.2.1 PCB CAD SOFTWARE

The design of the inserter will be done in a PCB CAD software package. Altium Designer is the PCB design package that will be used for this project.

4.2.2 MECHANICAL SUPPORT

Some parts of the project will require the support of the mechanical design team within Sony.

4.2.3 PCB FABRICATION FACILITY

After the PCB design of the inserter has been finalized, it will need to be manufactured. This service is provided by a PCB fabrication facility such as JLC PCB [11].

4.2.4 DATA SOURCES

Multiple sources of data will be used for evaluating the success of the project. One source of data is the test log data for the products. This is gathered automatically as the test are run. This data will be analyzed for USB failure rates.

Some data will be manually gathered during the testing of the devices. This could include pictures/videos and manual observations or test results.

5 PLANNING

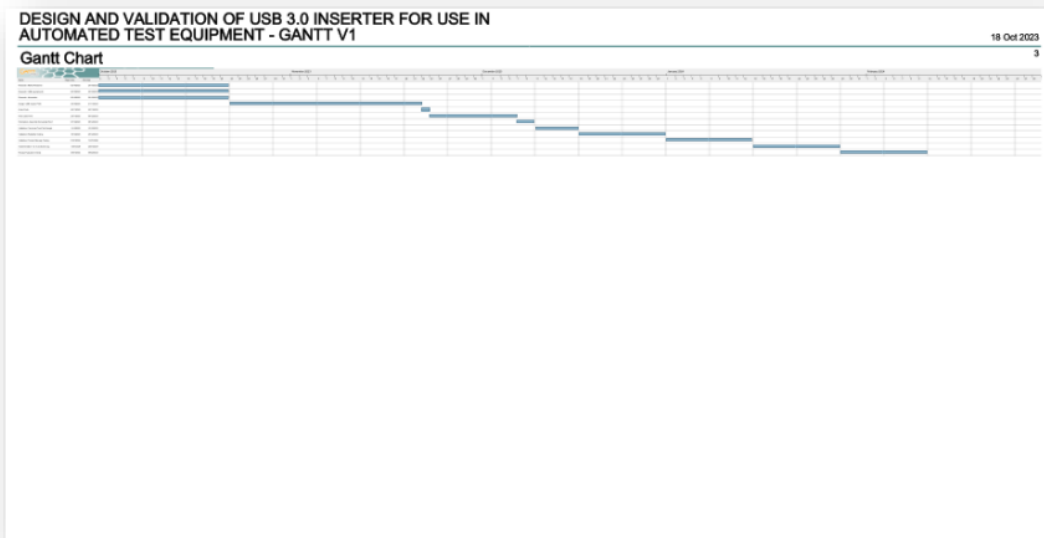
A link to the full sized Gantt chart can be found in the appendices.

5.1 DELIVERABLES



DESIGN AND VALIDATION OF USB 3.0 INSERTER FOR USE IN AUTOMATED TEST EQUIPMENT - GANTT V1			18 Oct 2023
Tasks			2
Name	Begin date	End date	
Research: Market Research	02/10/2023	20/10/2023	
Research: USB requirements	02/10/2023	20/10/2023	
Research: Automation	02/10/2023	20/10/2023	
Design: USB Inserter PCB	23/10/2023	21/11/2023	
Order Parts	22/11/2023	22/11/2023	
Parts Lead Time	23/11/2023	06/12/2023	
Fabrication: Assemble first sample Rev1	07/12/2023	08/12/2023	
Validation: Functional Test First Sample	11/12/2023	15/12/2023	
Validation: Reliability Testing	18/12/2023	29/12/2023	
Validation: Product Damage Testing	01/01/2024	12/01/2024	
Implementation: Try in production jig	15/01/2024	26/01/2024	
Review: Evaluation Criteria	29/01/2024	09/02/2024	

5.2 GANTT CHART



6 APPENDICES

6.1 QUOTATION AND PRICES

6.1.1 SONY INSERTER COSTING

PCB COST -\$6 per board. (10 per panel), see previous quote (Figure 14)

Colors Enterprises Limited

ADD: FLAT/RM B 5/F GAYLORD COMMERCIAL BUILDING 114-118 LOCKHART ROAD,HONG KONG

TEL: +86 13590104035 Email: hqewpcb4@hotmail.com

COMMERCIAL INVOICE

Bill To:	Company name: Sony Europe B.V. Accounts Payable Department UK Technology Centre Pencoed Technology Park Pencoed, Bridgend , CF35 5HZ United Kingdom	PO: INVOICE NO.C2022-562
ship to 收件地 址:	Company name: Sony Europe B.V. address: Non Production Goods Inwards Department. UK Technology Centre Pencoed Technology Park Pencoed Bridgend , CF35 5HZ United Kingdom	Date:2022-5-11
Attn:	Michael Howells	Tel: +44 1656 867 304

ITEM	DESCRIPTION	Quantity (pcs)	unit price	Amount (USD)
1	PCB SAMPLES for testing USB3_Ext_right_v2_Panel 1.6mm/blue/ENIG/impedance	5	\$60.00	\$300.00
Bank Charge				\$35.00
TOTAL		5		\$335.00

Remarks: 1. Material: FR4 2.H.S.code:85340020

PAYMENT ITEM: T/T (in advance)

NAME OF THE BANK: HSBC Hong Kong

NAME OF THE ACCOUNT: COLORS ENTERPRISES LIMITED

ACCOUNT NUMBER: 561-845462-838

SWIFT CODE:HSBCHKHHKHH

BANK ADD: 1 Queen's Road Central, Hong Kong

COMPANY ADD:FLAT/RM B 5/F GAYLORD COMMERCIAL BUILDING 114-118 LOCKHART ROAD,HONG KONG



Supplier

Colors Enterprises Limited

Figure 14 - Previous quote for manufacturing USB Inserter PCB boards

X1 692121230100



£2.50 per component

X1 692112030100



£2.56 per component

Therefore total cost of original Sony designed inserter is ~£10 per board.

6.1.2 INGUN – 51377 and INGUN – 55130 COSTING



ingun (UK) Ltd
15 Headley Road, Reading RG5 4JB

Sony Europe B.V.
Accounts Payable Department, UK Technology
Centre
Pencoed Technology Park
Pencoed
Bridgend
CF35 5HZ
GB

Sales Quotation			
Document No.	Date	valid till	Page
51003578	04/05/2023	04/06/2023	1 / 1
Customer No.			
5100357			
Contact person			
Michael Howells Michael.Howells@sony.com			
Ref.			
Quotation			
Your contact			
Tauseef Afzal			
Delivery Address			
Sony Europe B.V. UK Technology Centre, Delivery Point G Pencoed Technology Park Pencoed Bridgend CF35 5HZ GB			

We thank you for your inquiry and forward to you the following quotation in accordance to our general terms and conditions which can be downloaded from our homepage <http://www.ingun.com/downloads>

Description	Quantity	Price	Total GBP
1 51377 SSTK-USB-3-009 connector contacting Commodity Code: 85366990 Country of origin: Germany	2	174.33	348.66
2 UK_001 Freight Freight Charges Commodity Code: 85369095 Country of origin: Germany	1	10.00	10.00

DELIVERY : 2 WEEKS FROM RECEIVING AN ORDER

Subtotal	358.66
Net Amount	358.66
VAT 20.0% (O1) on 358.66	71.73
Total GBP	430.39

We hope that our quotation meets your demands and we look forward to receiving your order.

Payment Terms CUST Net 30 Days EOM Lead Time
Validity 30days
Shipment Terms

Kind regards

Please sign below to accept	
Date	Signature

[terms and conditions](#)

ingun (UK) Ltd
15 Headley Road
First Floor
Centrum House
Woodley
Reading RG5 4JB
United Kingdom

Phone: +44 0118 969 3500
Fax: +44 0118 969 3504
E-mail: probe@uk.ingun.com
VAT Number: GB578177590
EORI Number: GB578177590000

Bank Details: Barclays
Account Number: 00314692
Bank Code: 204071
Swift/BIC Code: BARCGB22
IBAN Code: GB54BARC20407100314692

Figure 15- INGUN – 51377 and INGUN – 55130 QUOTATION

6.1.3 ENGMATIC - 1552-89-000 COSTING

Quote obtained from Peak Test, which is a company that supplies this part.



Item	Part Number	Description	Qty	Unit Price	Ext. Price
1	1552-89-000	USB 3.0 Type A with shielding Delivery In stock	1	£229.38	£229.38
2	1014-43-000	Mounting shoe with rubber buffer for 4 pin test plug Delivery In stock	1	£41.48	£41.48
3	UK Shipping		1	£8.00	£8.00
Total					£278.86

This quotation is valid for 30 days.

Delivery dates stated are only valid on day of quotation and subject to sales

Price excludes VAT

Incoterms 2020: DAP

Figure 16 – PEAK TEST - 1552-89-000 QUOTATION

6.2 FULL GANTT CHART

<https://www.dropbox.com/scl/fi/qjj7lpr6hqunb8n835bak/USB-INSERTER-DESIGN-GANTT-V1-PROJECT-PROPOSAL.pdf?rlkey=mojzrdkp41h5hwh53l6zpsszm&dl=0>

7 REFERENCES

- [1] Sony, "Aobut Us - Sony Pencoed," [Online]. Available: <https://www.sonypencoed.co.uk/about-us/>. [Accessed 05 10 2023].
- [2] Raspberry Pi Ltd, "Buy a Raspberry Pi 4 Model B – Raspberry Pi," [Online]. Available: <https://www.raspberrypi.com/products/raspberry-pi-4-model-b/>. [Accessed 5 10 2023].
- [3] Raspberry Pi Ltd, "Buy a Raspberry Pi Zero 2 W – Raspberry Pi," [Online]. Available: <https://www.raspberrypi.com/products/raspberry-pi-zero-2-w/>. [Accessed 5 10 2023].
- [4] Sony, "Manufacturing-automation-600x400-c-default.png," [Online]. Available: <https://sonypencoed.co.uk/app/uploads/2023/03/Manufacturing-automation-600x400-c-default.png>. [Accessed 18 10 2023].
- [5] Ingun, "Tillbehör-ZUB_USB3.0-kontakter_EN_2.2.pdf," [Online]. Available: https://www.promoco.se/wp-content/uploads/2018/08/Tillbehör-ZUB_USB3.0-kontakter_EN_2.2.pdf. [Accessed 19 10 2023].
- [6] FEINMETALL CONTACT TECHNOLOGIES, "2112159_TC-P_198_009_USB3A_EN.pdf," [Online]. Available: https://www.heynen.com/application/files/9016/1727/0172/2112159_TC-P_198_009_USB3A_EN.pdf. [Accessed 19 10 2023].
- [7] ENGMATIC, *Product catalogue, Test plugs, for functional tests and EOL tests*.
- [8] Autodesk, "What is USB 3.0? High-Speed Routing Guidelines -," [Online]. Available: <https://www.autodesk.com/products/fusion-360/blog/what-is-usb-3-0-high-speed-routing-guidelines/>. [Accessed 19 10 2023].
- [9] Texas Instruments, "Layout Basics for Universal Serial Bus (USB) Designs," [Online]. Available: https://www.ti.com/content/dam/videos/external-videos/4/3816841626001/6087491555001.mp4/subassets/usb_layout_basics.pdf. [Accessed 19 10 2023].
- [10] K. Petersen, C. Wohlin and D. Baca, "The Waterfall Model in Large-Scale Development," in *International Conference on Product-Focused Software Process Improvement*, 2009.
- [11] JLC PCB, "aboutUs," [Online]. Available: <https://jlcpcb.com/aboutUs>. [Accessed 10 19 2023].
- [12] Adafruit, "image(1).png," [Online]. Available: [https://cdn-shop.adafruit.com/categories/105/image\(1\).png](https://cdn-shop.adafruit.com/categories/105/image(1).png). [Accessed 05 10 2023].
- [13] Adobe, "Waterfall Methodology - A Complete Guide | Adobe Workfront," Adobe, [Online]. Available: <https://www.workfront.com/en-gb/project->

management/methodologies/waterfall#:~:text=The%20Waterfall%20methodology%E2%80%94also%20known,before%20the%20next%20phase%20begins.. [Accessed 03 05 2022].

- [14] Adobe , "waterfall-method-process.png," [Online]. Available:
<https://www.workfront.com/sites/default/files/inline-images/waterfall-method-process.png>.
[Accessed 03 05 2022].

PROJECT PROPOSAL - DESIGN AND VALIDATION OF USB 3.0 INSERTER FOR USE IN AUTOMATED TEST EQUIPMENT - MICHAEL HOWELLS

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

78/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26
