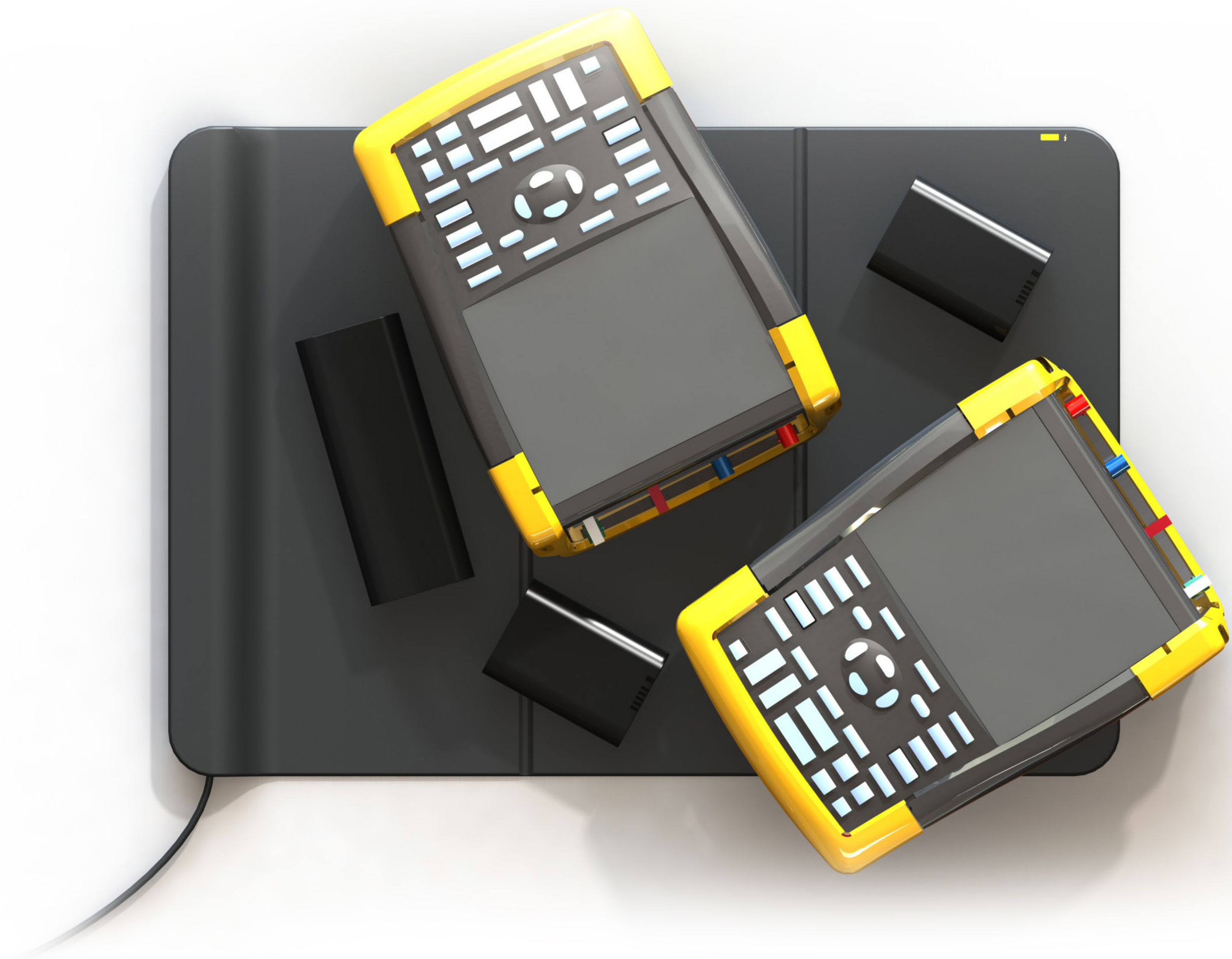
# Developing a better way to charge FLUKE ScopeMeters

by W.M. Bos



UNIVERSITY OF TWENTE.

▶ Benchmark

# TITLE PAGE
Final report on the bachelor's assignment

## Research and design of an effortless way to charge Fluke Scopemeters for instant use.

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# PREFACE
## An introduction to my bachelor's assignment

For this project I have been given the great opportunity of working alongside the experienced designers at Benchmark Electronics in Almelo for four months. My gratitude goes out to everyone at Benchmark for making me feel at home and involving me in all of their work challenges, allowing me to look over their shoulders, and of course for giving me this interesting assignment.

I would like to offer my heartfelt thanks to the following people, for investing their time in me and helping me with the minor speed bumps.

Firstly, **Christian Suurmeijer**, Benchmark's lead designer, for coaching me during the project. His experienced look at things and his kind tips helped me through the most difficult decisions.

**Theo Krone**, for his understanding during the more difficult times, his advice and guidance, and his outside look on things to help me put it all in perspective.

**Mark Grob** and **Frank Egbers**, for giving me all kinds of helpful tips during my time at Benchmark, and allowing me to bounce ideas off' them. And of course all the coffee breaks.

All **coworkers** and **fellow students** of the mechanical engineering & product development departments, for their help with finding resources and for being good company.

All in all, this was an amazing learning opportunity for me. I hope that during this project I have shown my skills as an Industrial Designer and have contributed something of value to Benchmark Electronics.

# ABSTRACT

“Fluke. Keeping your world up and running”.®




**Background**

Despite the effort Fluke and Benchmark put in developing the Scopemeters, end users are often inconvenienced when their Scopemeters are not charged when they need them. This problem can be tackled by designing a product that requires a minimum amount of human involvement. Ease of use is paramount here. Therefore, Benchmark has been tasked with developing and designing an effortless method for charging Fluke Scopemeters.

**Approach**

The requirements for the new product were easy to convert into concrete criteria. These criteria are met by several possible solutions. The analysis of the outcomes is illustrated in a Goeller Scorecard, a method used to find the best possible solution. Besides, former research on the Voice-of-the-Customer, an analysis of the current way of dealing with the problem by end users, and an analysis of the preferences of the target group offer more insights in the daily use of Scopemeters in practice.

**Results**

An innovative solution was found that satisfies the demands and wishes of the client in the most complete way and takes full advantage of the in-house expertise Benchmark has at its disposal. It consists of a concept for a smart, efficient, and low cost product, that minimizes the involvement of end users. The outcome is an induction platform that can be integrated smoothly into the workflow of end users. Benchmark will be able to pitch this concept to Fluke Corporation.

**Conclusions**

By combining an upcoming technology with the use of the Scopemeter in practice, the induction platform meets all criteria for the demands and wishes of both the involved companies and the end users, thus creating a high quality product that eases the effort for all users.

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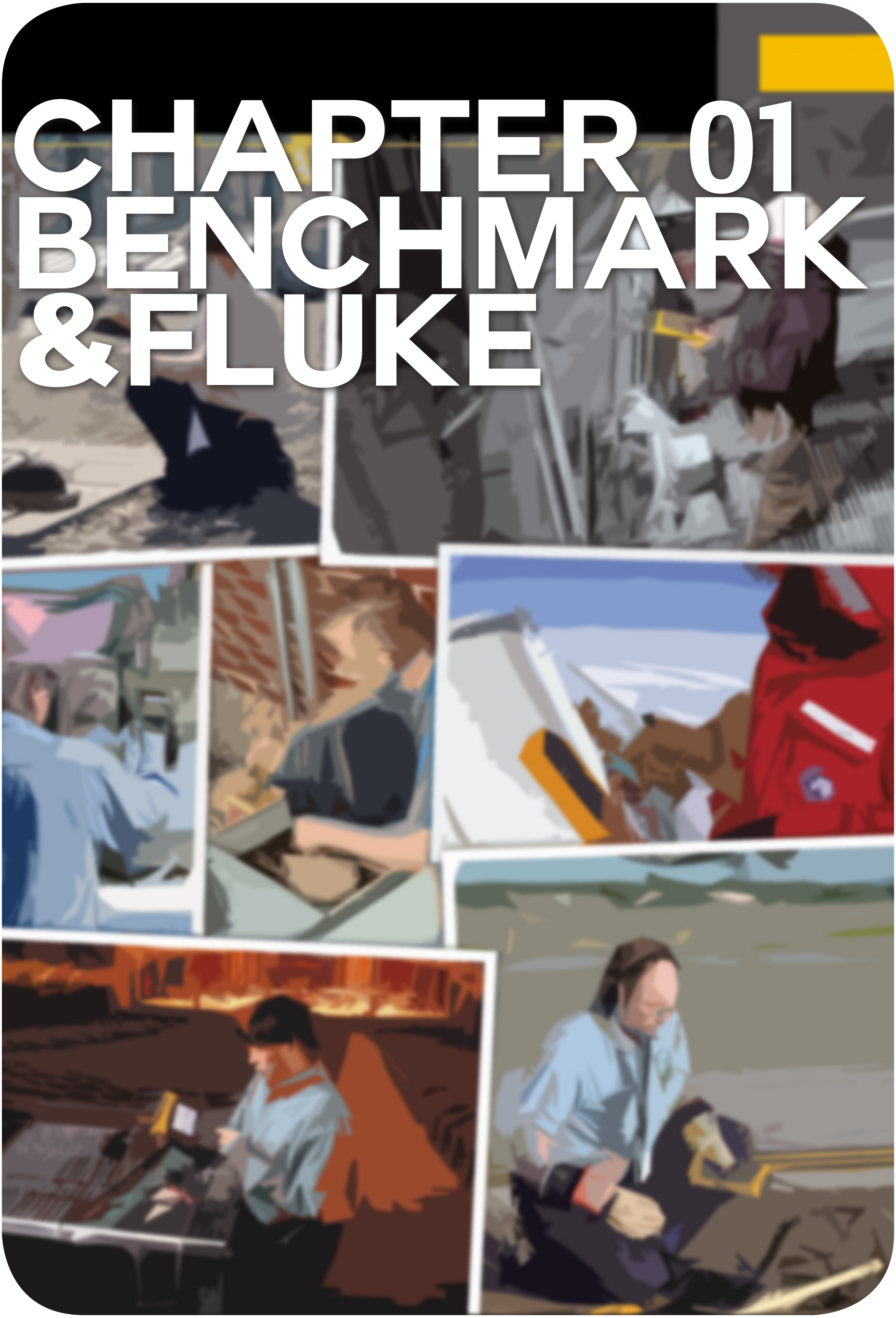


CHAPTER 01

# BENCHMARK ELECTRONICS & FLUKE
## An introduction

### BENCHMARK ELECTRONICS

Since its founding in 1986, Benchmark Electronics has been developing a broad range of products. As an American producer for Original Equipment Manufacturers (OEMs), they have become very successful. Their global success has led to production bases and facilities all over the world. Approximately 10.000 employees work for Benchmark at facilities ranging from the corporate headquarters in Angleton, Texas to Europe (the Netherlands) and Asia (Singapore).

Benchmark Electronics is considered a global leader in the supply of integrated design and manufacturing solutions to many customers. Their Design Engineering Centers can be found in all three regions, one of which is located in Almelo, the Netherlands. Besides that, they possess ''Precision Technologies manufacturing capabilities'' in both Asia and The Americas.

Each region is equipped with an integrated system of people, technology and innovation, enabling Benchmark to offer the full extend of its capabilities to all its customers. The production process largely takes place in the Asian region, in low-cost countries, enabling Benchmark to offer a competitive price for a high quality service. Thus customers enjoy a high quality but cost effective manufacturing solution.

The focus of Benchmark Electronics concerns the ''products it makes, the customers it serves, its employees, and suppliers. It all boils down to people'' 01. Because Benchmark is known for delivering satisfying products to both customers and end-users, the care for products is very important. In order to live up to the expectations, Benchmark pays the utmost attention to correctly designing and building their products. Next to a focus on delivering high quality services, Benchmark highly values its relationships with customers. Their ''win-win strategy'' typifies the importance of satisfaction for both parties.

Something that should not be forgotten, is the high quality of the work force, the power that drives the creation. Employees are very much respected and appreciated, since their knowledge, capabilities, and contributions are what enables Benchmark to offer such high quality. ''We know that a company is nothing more or less than the synergistic sum of all the people comprising it''. [01]


[fig 01] Product Life Cycle [01]

Last but not least, are the suppliers of everything Benchmark needs in order to design and manufacture new products. It is very important to work with reliable and trustworthy suppliers since they too contribute to the process of transforming each new idea into an actual product.

The broad range of products Benchmark produces, is something that really makes them stand out. This is mainly due to the ''full range of services'' they offer and supply. They have developed a Product Life Cycle, which is illustrated in the figure above. [fig 01]
It all starts with a concept, leading to a design and a prototype, which has to be verified and pre-produced before it can be qualified, to eventually become an actual product.

Benchmark's full range of services leads to big advantages as opposed to a production process where parts of the product are developed separately. The advantages are: a focus on Core Technologies and a reduced Time-to-Market and Revenue and flexibility in line with changing market demands. The development process leads to a final product that is ready to be manufactured.

All steps are converted into phases that are represented by the abbreviations in the inner circle of the figure. The first phase is the Product Development Phase (PD), which is composed of Concept and Design. Next up are NPI and NPL, which are the New Product Introduction and the New Product Launch.

These phases include the process from the development of the prototype to the qualification of the final concept. EOL stands for End of Life, this means that the final two steps represent the end of the production process at Benchmark. [02]

The Design Engineering Centers mentioned before, are places where ideas flourish in an innovative atmosphere. Benchmark's DEC in Almelo offers a full range of specialties from programming to electrical engineering, industrial design, and assembly, making the development of new products quick, due to the integrated production process.

Benchmark Electronics offers and supplies complete production processes to many big companies; varying from the design of new products to the marketing and maintenance of the final products.

Custom Printed Circuit Boards (PCBs) and electronic devices like Fluke's analyzers are the most important products that Benchmark manufactures. Benchmark Electronics closely cooperates with Fluke Corporation and fully participates in the design and development process of new products for Fluke.

## FLUKE CORPORATION

Fluke Corporation was founded in 1948 by John Fluke, Sr. Its headquarters can be found in Everett, Washington USA. Currently, approximately 2.400 employees work for Fluke worldwide, in one of the 100 countries where it is represented. The production centers are located in the USA, Asia, the United Kingdom and the Netherlands. Besides, Fluke operates in and distributes from almost every continent on Earth.

Fluke also owns several companies that are specialized in certain areas. Comark, Datapaq, Fluke Biomedical, Fluke Calibration, Fluke Networks, Ircon and Raytek are all part of the huge corporative network that Fluke represents.

Since its founding, Fluke has managed to become a global market leader in ''the manufacture, distribution and service of electronic test tools and software''. Its contribution to the development of technology over the past decades has led to an impressive network in both production and service branches. Fluke's influence is noticeable worldwide. Numerous companies, buildings and industries are kept ''up and running'' thanks to the wide variety of high quality electronic devices that Fluke produces at a global level. [03]

Nowadays, the world market depends on companies like Fluke, since many branches cannot even function nor execute their jobs without the required equipment. The high quality and safety standards that Fluke is known for, have led it to become the market leader or runner-up in every branch.

Fluke offers its services to basically every branch that uses electronics. Technology has grown rapidly and electricity has become indispensable in this globalized society, which means that Fluke can help people all over the world by providing whatever electronic device they need for whatever purpose. The most important market segments are: Industrial/ Electronic Service Installation and Maintenance, Electrical and Temperature, Indoor Air Quality, Calibration and Biomedical.[04]

Each segment has special types of tools that support the end-users while doing their jobs. One of Fluke's flagship products is the Tetra ScopeMeter from the 190 Series II. It is the only CAT IV safety rated ScopeMeter in existence. Fluke emphasizes the unique combination of impressive performance and the highest safety ratings in this field. [05]

It is no surprise that electricians and mechanics all over the world trust Fluke with their lives, considering the dangerous and risky circumstances they sometimes have to work under. The ScopeMeter is designed to function under the most troublesome circumstances and yet to deliver optimal results.[14]

FLUK

# CHAPTER 02
# SCOPE METERS

# SCOPE METERS
## Different types of portable oscilloscopes

The combination of the oscilloscope and the portable Digital Multimeter, an invention by Fluke, has led to the creation of the Scopemeter in 1991. This device is designed to overcome the difficulties that other devices couldn't thus far. Considering the harsh, hazardous and dirty circumstances under which the Scopemeter has to perform, its capabilities are quite impressive.

Its basic features can be described as follows: it is a portable, though heavy, device that can be used in the smallest places, because it does not require an external power source. It completely runs on power coming from an internal battery. The Scopemeter is usually transported in a custom made soft or hard case, also designed by Fluke.

After the first Scopemeter was launched on the market, the product has extended to a wide range of different types of Scopemeter test tools. Currently, there are several series of Scopemeters, each including special features. Some are developed for a specific branch, the Scopemeters from the 190 medical series, for example, are used primarily to do measurements for medical purposes. Each series will be discussed briefly.

*Fluke 120 series*

The 120 series of Scopemeters have basic features like a dual input and DMM, which are designed to be used for industrial electrical or electro-mechanical applications. The Scopemeters have varying bandwidths of either 20 or 40 MHz.

120 series

*Fluke 190 series (II)*

The recently upgraded 190 series II includes unprecedented new features. The Scopemeters are the first to have two and four channels and to be CAT III 1000V / CAT IV 600V safety rated portable oscilloscopes. Besides being a reliable test tool, the Scopemeter is designed to exercise troubleshooting tasks that usually require several tests and measurements before one can find a problem in industrial electrical or electronics systems.

190 series

The 190 series Scopemeters have bandwidths of 60, 100, 200 or 500 MHz.

*Fluke 190 medical series*

The 190 medical series Scopemeters has been designed specifically for medical equipment applications and video display systems.
It complements the original 190 series I with a type that has capabilities useful for the medical branch, but that are usually not included in an oscilloscope. The series are quite similar concerning their basic features, despite the medical extension.

190 medical series

| Model: | 190-502 | 190-204 | 190-202 | 190-104 | 190-102 | 190-062 | 225C/S | 125 | 124 | 123 |
|---|---|---|---|---|---|---|---|---|---|---|
| Oscilloscope Specifications | | | | | | | | | | |
| Bandwidth | 500 MHz | 200 MHz | | 100 MHz | | 60 MHz | 200 MHz | 40 MHz | | 20 MHz |
| Max. real time sample rate | 5 GS/s | 2.5 GS/s | | 1.25 GS/s | | 625 MS/s | 2.5 GS/s | 25 MS/s | | |
| Input sensitivity | 2 mV/div. | | | | | | | 5 mV/div. | | |
| Max. timebase speed | 1 ns/div. | 2 ns/div. | | 4 ns/div. | | 10 ns/div. | 5 ns/div. | 10 ns/div. | | 20 ns/div. |
| Inputs and digitizers | 2 + Ext.Tr. | 4 | 2 + Ext.Tr. | 4 | 2 + Ext.Tr. | 2 + Ext.Tr. | 2 + Ext.Tr. | 2 (+ Ext.Trig. Optional) | | |
| Independently floating isolated inputs | 600 V CAT III | 1000 V CAT III, 600 V CAT IV | | | | | 600 V CAT III | - | | |
| Max.record length<br>.... In Scope mode<br>.... In ScopeRecord mode | 10 000 samples per trace<br>30 000 min/max pairs | | | | | | 3000<br>27500 | 512 min/max pairs per input | | |
| Glitch capture | 8 ns peak detect at full timebase range | | | | | | 50 ns | 40 ns | | |
| True RMS multimeter built-in (5000 counts) | yes | - | yes | - | yes | | | dual 5000 counts DMM | | |
| Dedicated test capabilities | V/Hz ratio | - | V/Hz ratio | - | V/Hz ratio | | Bus health test | | - | |
| General Specifications | | | | | | | | | | |
| Mains adapter/battery charger incl. (type) | BC 190 | | | | | | | PM8907 | | |
| Battery installed | BP291 | BP291 | BP290 | BP291 | BP290 | BP290 | BP190 | BP120MH | | |
| Size | 265 x 190 x70 mm | | | | | | ** | 232 x 115 x 50 mm | | |
| Weight | 2.1 kg | 2.2 kg | 2.1 kg | 2.2 kg | 2.1 kg | | 2 kg | 1.2 kg | | |
| Safety certified | 1000 V CAT III / 600 V CAT IV | | | | | | 600 V CAT III | | | |

[fig 02] An overview of all scopes Art1

*Fluke 125 series*

The 125 series of Scopemeters is quite similar to the 120 series and includes dual input and DMM. The bandwidths vary between 20 or 40 MHz too. The big difference, though, is that the 125 series devices includes additional industrial network physical layer test capability.

125 series

*Fluke 225/215 series*

The 225 (200 MHz) and 215 (100 MHz) series is quite similar to the other series, but these Scopemeters include an Industrial Bus health Test mode, that automatically analyses electrical signals and validates these.
Besides that, it also includes an industrial network physical layer test capability, similar to the 125 series described above. Though, overall, the 225/215 series are a bit better than the 125 series Scopemeters.

225/215 series

## TECHNICAL SPECIFICATIONS

On page 8 an overview is shown of all Scopemeters and their capabilities. [fig 02]

# CHAPTER 03 ASSIGNMENT

CHAPTER 03

# ASSIGNMENT
Fluke charging softcase

## FLUKE CHARGING SOFTCASE

Benchmark Electronics produces several types of Scopemeters for Fluke Corporation. These devices cost about 900 to 5.000 Euros and are crucial for mechanics when carrying out their tasks. Unfortunately, a well-known problem is that these devices often run out of power by the end of the day and that their users forget to recharge them, leading to inconvenience the next day when the mechanic arrives at a client.

The Scopemeter has to be charged on the spot, which results in delay and causes annoyances for both the mechanic and the client. During previous Voice-of-the-Customer research done by Fluke, this has been mentioned as a problem users would like to see a simple and effective solution for.[14]

Therefore, it is necessary to find a solution that ensures a charged Scopemeter without too much involvement of the mechanics. If this leads to a distinct, clear and directly applicable product, it could be pitched to Fluke.

Such a solution could improve and extent the cooperation with Fluke, leading to the launch of a new product when responded to positively. The idea for such a product is not new, though it has never been elaborated in practice.

Since the devices are usually kept in soft/hard-cases, it might be possible to integrate a charging application into the case, so that the case charges the Scopemeter automatically.


A hardcase

## FINDING A SOLUTION

Obviously, this requires a well-elaborated concept for the product. It will henceforth be called a ‘’charging soft/hard-case’’.

The most important factors for a solution to the aforementioned problem are:
- Ease of use
- Low cost profile
- Integration in current products
- Efficiency

All demands and wishes are described in the Design Brief on page 12


A softcase

C195 Softcase

C345 Softcase

C125 Softcase

C116 Softcase

C12A Softcase

C75 Softcase

C789 Softcase

C100 Hardcase

C290 Hardcase

C120 Hardcase

C20 Hardcase

C101 Hardcase

C435 Hardcase

As shown on the left, a wide variety of soft- and hardcases are currently in Fluke's assortment. Users from all over the world use these cases for their Scopemeters and other products from Fluke.

It is important to take note of the fact that a solution to the posed problem has to be able to scale easily with this variety of cases.

After deliberation with Christian Suurmeijer, a decision was made to explore the design options for the most important cases used by customers. These cases are the C195 Softcase and the C290 Hardcase, both shown on the left.

The C195 Softcase is used for several types of Scopes, including but not limited to the 120, 125 and 190 series. The C290 Hardcase is generally shipped with an inlay for the 190 series Scope.

## DESIGN BRIEF

Taking recent Voice-of-the-Customer research into consideration, the following Demands and Wishes were selected as the most important in designing a solution to the stated problem.

**Demands**

1. Easy to use
2. Low-cost profile
3. Improve the current methods of charging, either in efficiency, ease-of-use, or both
4. Easy integration into current cases
5. Unified style language for all fluke products
6. Low weight solution to reduce strain during carrying
7. The shape and look must fit the Fluke brand identity
8. Charge the Scopemeter with a speed that fits the workflow of users

**Wishes**

1. Modularity in design (e.g. stackable)
2. Integration into the current workflow
3. Low-effort to use
4. Highly innovative charging methods (e.g. induction, wireless)
5. Scalability for multiple Scopemeters
6. Add value to the Fluke brand

# CHAPTER 04 MARKET RESEARCH

CHAPTER 04

# MARKET RESEARCH
## Current technologies

### CHARGING METHODS

Several methods for charging already exist at the moment, but the way these methods work varies greatly. In order to make a clear decision based on a solid argumentation, the following main methods of charging were identified:

1. Solar Charging
2. Induction Charging
3. Car Battery Charging
4. Internal Battery pack Charging
5. In-Storage Charging
6. Hub Charging
7. Integrated Charging

Before deciding on a certain charging method, each method will be explained shortly.

**Solar Charging**
With the great leaps made in solar panel efficiency over the last years, increasingly smaller solar panels are becoming more useful for low-voltage applications. One could think of trickle-charging cell phones or power provision for small radios and other low-power devices. Applications have been found in phone-cases, laptop-bags and other cases for mp3-players and similar objects.

A great deal of these cases and/or bags doesn't supply enough power to charge a significant amount of power in a relatively short time though, so it might be a challenge to find a system that can satisfy the design brief.

**Induction Charging**
The technology behind Induction Charging has quickly evolved into a feasible method of charging over the last few years. Currently, induction coils as small as a fingernail are already available for integration with AA-batteries. This could leave larger applications like the battery pack for a Scope open for even greater efficiency.
With the increase of efficiency, an increase of the acceptable distance between induction coils has also been realized. To maintain a 90% input/output-ratio, coils cannot be apart further than half the diameter of the largest one, e.g. a 10 cm diameter coil can at most be 5 cm apart from the other one. This varies greatly with different sizes, and better set-ups can be found with a variety of sizes. This technology will be further explained on pages 30-31.

**Car Battery Charging**
Using the power supplied by the dynamo of a car has quickly become one of the classic ways of charging devices. Users attach a standard plug to the lighter inlet of the car, and a 12V transformer delivers the power to the desired device. Because of the strength of the car battery, a sufficient wattage can be delivered for normal charging.

**Internal Battery pack Charging**
Several brands of backpacks, bags and cases have recently developed versions with an auxiliary battery pack built into the product to allow users to charge their devices in the bag themselves. These products come at a hefty premium compared to non-charging versions, and have drawbacks like the inability to wash the product or short-circuiting in case of a spill.


**Integrated Charging**
When the power source is completely integrated into a product that often accompanies the electronic device, it can be seen as an integrated charging method. Almost like an extra battery, this product delivers extra power to the device whenever it is needed without having to plug anything in or adding any hardware. An example is the ZoPro, a phone case with integrated battery pack to charge a smartphone.

**In-Storage Charging**
Charging a device while in storage is the standard way most electronic devices are charged. During the rise of mobile devices like laptops, smartphones and more recently, tablets, new products for storing and charging these devices have been developed.

**Hub Charging**
When several small devices are all connected to a single carrying product, this product can be considered a hub for all the devices. In the example above 10+ smartphones are being charge by a single drawer.

## EXISTING CASES

On the right in [fig 02b] is a selection of cases -mostly for tablets and smartphones- which I found that gave me the inspiration for the definition of these different types of charging.

They serve to illustrate more clearly the different ways of implementing several of these types of charging than just the description and a single image.

All images used page 14 - 15 various internet sources [14]




[fig 02b] Different types of existing cases [15]

## SCORING CHARGING METHODS

| Solution Type | Eco Friendly | Inexpensive | Low maintenance | Efficient | Protected Connections | Durability | Wireless | Independent | Low Weight | Ease-of-use | Results |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight | 7.5% | 7.5% | 7.5% | 10.0% | 5.0% | 15.0% | 7.5% | 5.0% | 20.0% | 15.0% | 100% |
| Solar Charging | 1 | 1/2 | 1 | 0 | 0 | 1/2 | 0 | 1 | 1/2 | 1 | 5.63 |
| Induction Charging (wireless) | 1/2 | 0 | 1 | 1/2 | 1 | 1 | 1 | 0 | 1 | 1 | 7.88 |
| Car battery Charging | 1/2 | 1 | 1/2 | 1/2 | 0 | 1 | 0 | 1/2 | 1 | 1 | 7.25 |
| Internal Battery pack | 0 | 1/2 | 1 | 1/2 | 0 | 1/2 | 1/2 | 1 | 0 | 1 | 4.75 |
| Storage Charging | 0 | 1 | 1 | 1 | 1/2 | 1/2 | 1/2 | 0 | 1 | 1 | 7.38 |
| - In a closet/cabinet | 0 | 1 | 1/2 | 1 | 1/2 | 1/2 | 1/2 | 0 | 1 | 1 | 7.00 |
| - In the car/in the back | 1/2 | 1 | 1/2 | 1 | 1/2 | 1/2 | 1/2 | 0 | 1 | 1 | 7.38 |
| - On a table/workplace | 0 | 1 | 1 | 1 | 1/2 | 1/2 | 1/2 | 0 | 1 | 1 | 7.38 |
| Hub Charging | 1/2 | 1/2 | 1 | 1 | 1/2 | 1/2 | 0 | 1/2 | 1/2 | 1/2 | 5.50 |
| - Stacked Cases | 1/2 | 1/2 | 1 | 1 | 1/2 | 1/2 | 0 | 1/2 | 1/2 | 1 | 6.25 |
| - Central Powercase | 1/2 | 1/2 | 1 | 1 | 1/2 | 1/2 | 0 | 1/2 | 0 | 1/2 | 4.50 |
| - Grouped Cases | 1/2 | 1/2 | 1 | 1 | 1/2 | 1/2 | 0 | 1/2 | 0 | 1/2 | 4.50 |
| Integrated Charging | 0 | 1/2 | 1 | 1/2 | 0 | 1/2 | 0 | 0 | 1 | 1 | 5.88 |
| - Smartphone included | 0 | 1/2 | 1 | 1/2 | 0 | 1/2 | 0 | 0 | 1 | 1 | 5.88 |
| - Detachable Probes | 0 | 1/2 | 1 | 1/2 | 0 | 1/2 | 0 | 0 | 1 | 1 | 5.88 |
| - Detachable screen/tablet | 0 | 1/2 | 1 | 1/2 | 0 | 1/2 | 0 | 0 | 1 | 1 | 5.88 |

[fig 03] Scoring charging methods for the Scopemeter

## SCORES

The earlier described methods of charging all have their own merits. To judge them in a comparative and quantified way, a goeller-scorecard was made with weighted importances of all merits the different types have.

The following qualities were identified as the major influences in finding a solution fitting the design brief:

- Eco-friendliness
- Inexpensiveness
- Low maintenance
- Efficiency of charging
- Protected electrical connections
- Durability of the system
- Optional wirelessness
- Independency of the system
- Low weight for carrying
- Ease of use

These factors were then given a weight in percentages of the total 100%, so as to not give too much weight to rather insignificant qualities.

Due to the difficult nature of scoring methods like this, several basic rules were established. Every quallity receives 10% importance from the start, after which the following deliberations changed them up or downward.

Because of the relatively heavy weight of the Scopemeters, a significant percentage was given to the Low Weight category, as it is paramount that the end-users don't get unduly strained.

Durability and Ease of use were also given larger percentages because of the fact that FLUKE products have a reputation of ruggedness to maintain which is essential to their users. Ease of use was given the larger percentage because of the fact that the whole purpose of the assignment is to make it easier for users to charge their devices and not make it more of a hassle.

All other categories were average or below, thus receiving less percentages.

To make the scoring easy for the types of solutions, 0, 1/2 or 1 point can be awarded, which have the following meaning:
0 : This feature is completely absent or not effctive for the proposed use.
1/2 : This feature is present, but not very efficient or really important for this solution.
1 : This feature works the way is needed for the proposed use or is completely the same.

From this scorecard, the following best fit candidates emerge. Induction charging leads the way with a 7.88 score. Second comes Storage charging with a 7.38 score for both on a table/in the workplace and in a car, and third comes Car battery charging with a 7.25.

These three options were chosen for exploration in the conceptualization phase.

# CHAPTER 05
# DESIGNING CONCEPTS

CHAPTER 05

# DESIGING CONCEPTS
Exploring the options

## DIFFERENT SCENARIOS

The following four scenarios were made to illustrate the current way end users charge their Scopemeter, and how this would work given the adjustments made possible by either of the three selected solution types.

These scenarios are merged together into a flowchart of scenarios, showing the different ways the situations can go. Page 21 and 22 show this flowchart in its entirety.

All four scenarios are described in the text below for completeness.

**Scenario 1: Current situation.** (1) After a workday, electrical engineers and/or electricians come back from a day's work. (2) His tools are usually stored in his vehicle, so he retrieves them. (3) He enters his house,

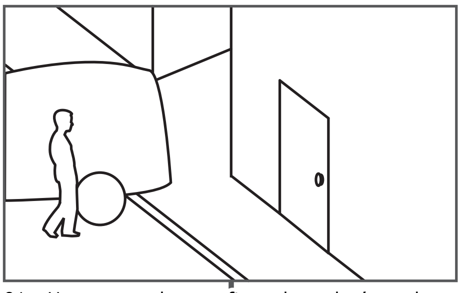
a) (4a) and drops his carrying case in the hall. (6) He has dinner and a relaxing evening, and completely forgets about his tools. (7) The following day when he has to go to work again, he grabs his tools, but these are not charged. (8a) This results in a Scopemeter that loses power during the day or the next. This is one of the core problems that created the need for a solution.

b) (4b) and walks to the shed/workshop to place hisScopemeter on the workbench (5) to plug in the charger. (6) After the charger is plugged in, he has dinner and a relaxing evening.
(7)The following day he retrieves the charged Scopemeter and/or tools, (8b) and he is ready to face the day again.

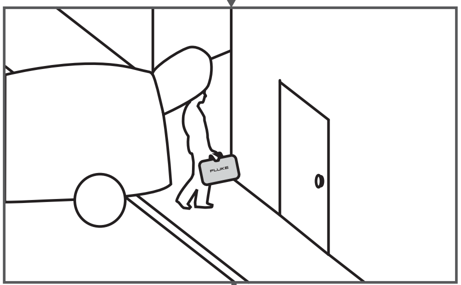
**Scenario 2: Induction charging.**
(1)(2)(3)(4c) and places his suitcase with Scopemeter on the induction charging pad he set up there . (6)(7)(8b)

**Scenario 3: Storage charging.** (1)(2)(3)(4d) and places his case into the storage charger on the shelf in his workshop. (6)(7)(8b)

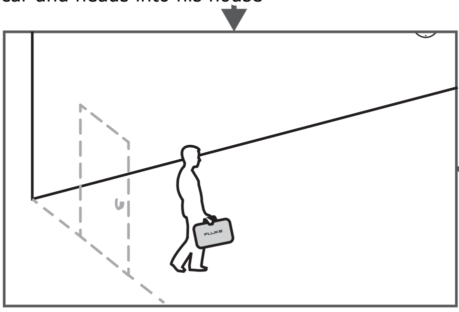
**Scenario 4: Car battery charging.** (1) A technician uses his Scopemeter for checking a faulty cable (2) When he's done, he places the Scopemeter in his car alongside him (3) He plugs in the charger and his Scopemeter starts getting charged (4) During his travel to the next location that requires his assistance, the Scopemeter is charged (5) Once he arrives at the new jobsite, the Scopemeter has a charge and is ready to go again



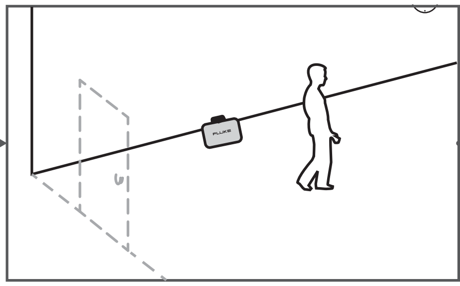
01 - User comes home after a long day’s work.



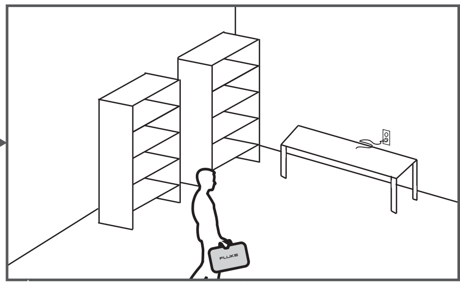
02 - He grabs his toolbox from the back of the car and heads into his house



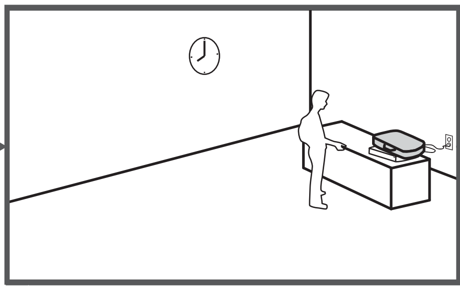
03 - He enters his house



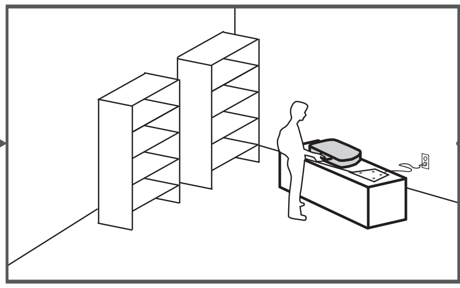
04a - He drops his suitcase in the hallway



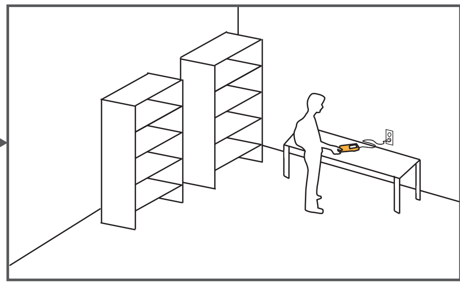
04b - He goes to his shed/workshop to charge his scope



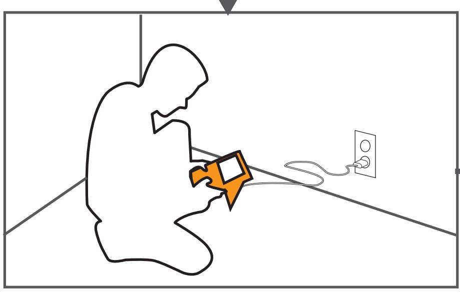
04c - He places his suitcase on the induction charging pad



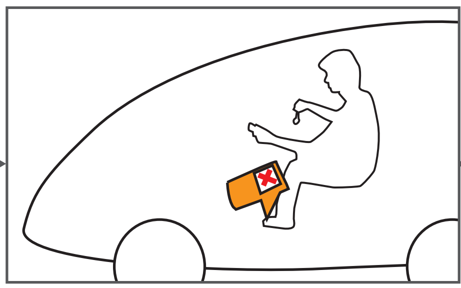
04d - He plugs his case into the storage charger on the shelf in his workshop



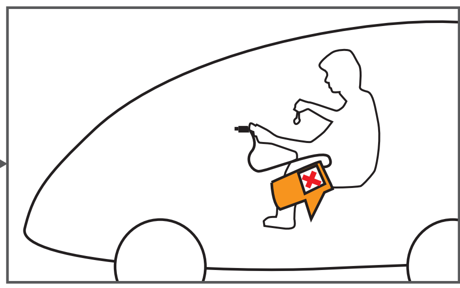
05 - He places the scope on the workbench and plugs in the charger



01 - A technician uses his Scopemeter for



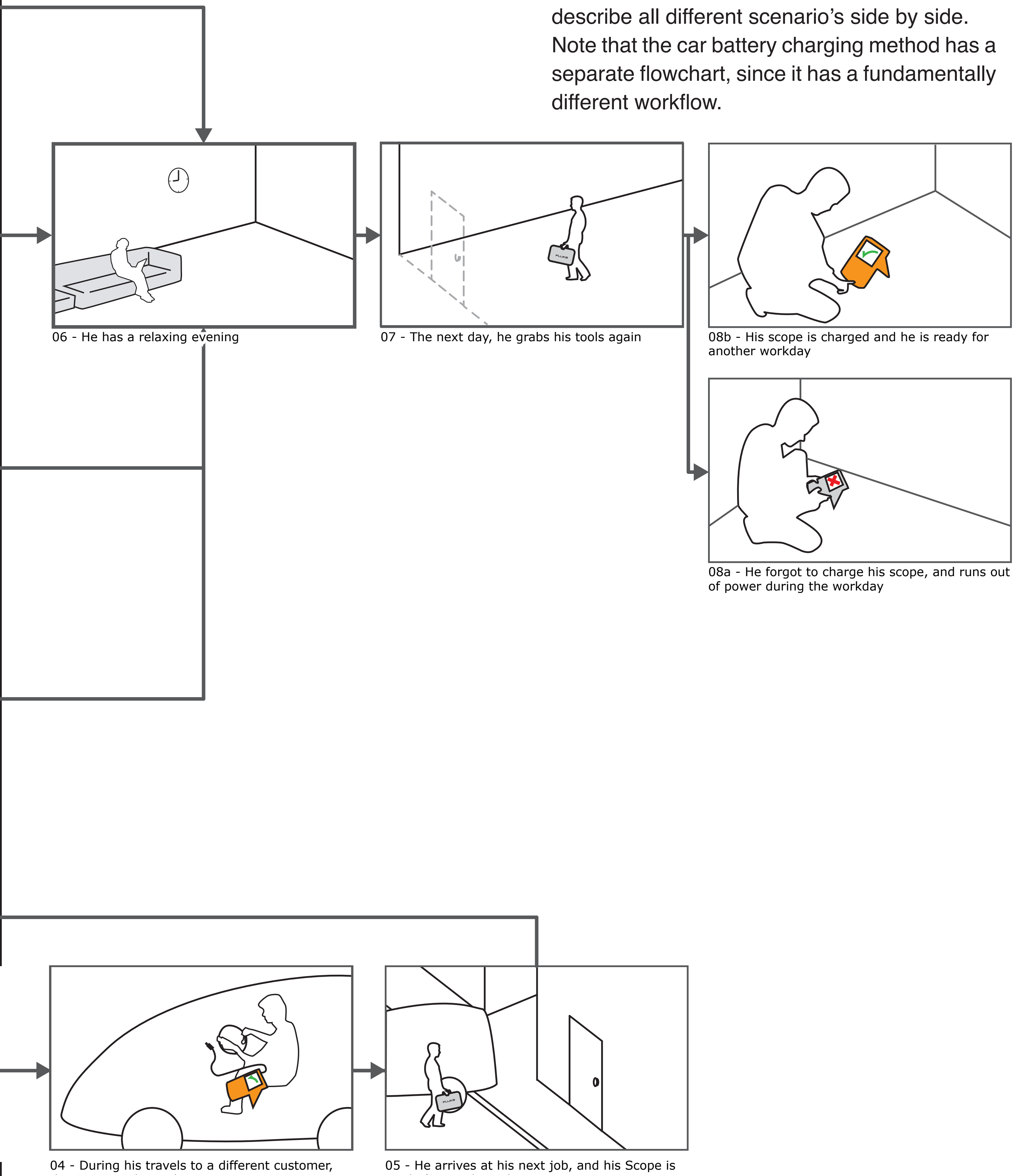
02 - When he’s done, he places the scope in his



03 - He plugs in the car charger and his Scope

## CLARIFICATION

To minimize the amount of pages filled with scenarios, a flowchart-scenario was made to describe all different scenario’s side by side. Note that the car battery charging method has a separate flowchart, since it has a fundamentally different workflow.




[fig 03b] Scenario flowchart for ScopeMeters

## BUILDING THE CONCEPTS

To make sure the right choice is made from the possible solutions, a concept elaboration was made for all three solution types.

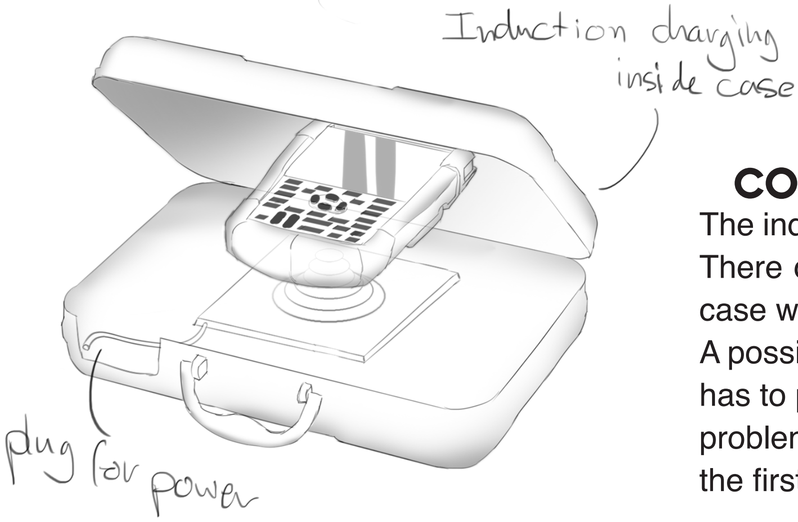
A larger collection of sketches was made for all types of solutions, so as to develop a good sense of all the different ways a Scopemeter can be charged before, during and after its use.

To keep everything organized, a selection of these sketches has been re-done digitally. These sketches were then enhanced to give them a presentable look and feel for the report. The large collection can be found in the Appendix [B].

The bigger theme that emerged during these sketches is that it is quite difficult to remove one or more steps from the current way users charge their scopes. If a user does not take the Scopemeter out of the case, there has to be a way to connect it to the power without adding a different -extra- step.

From the start, the Induction concept showed a lot of promise, because it removes the “plug in” task from the workflow. It was uncertain however if it could become a good candidate, because the induction receiver has to be built into the device somehow, raising the costs and thus lowering the attractiveness of the option.

These considerations will be revisited later on in the report. [page 36]

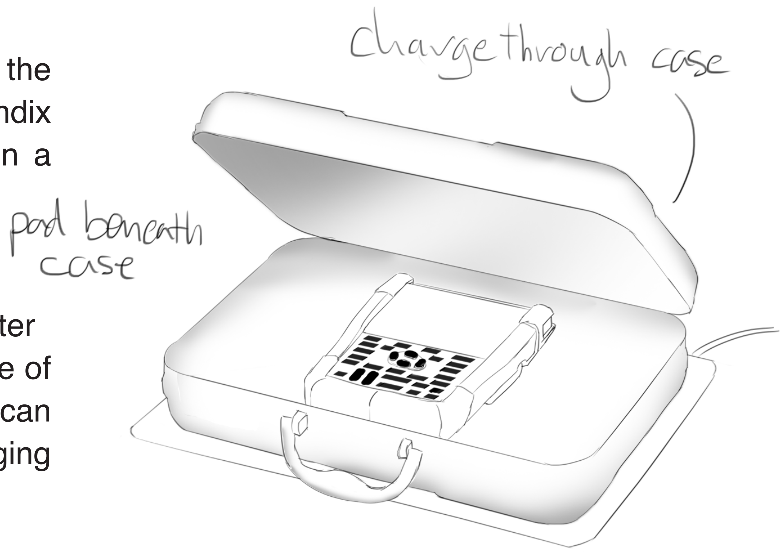


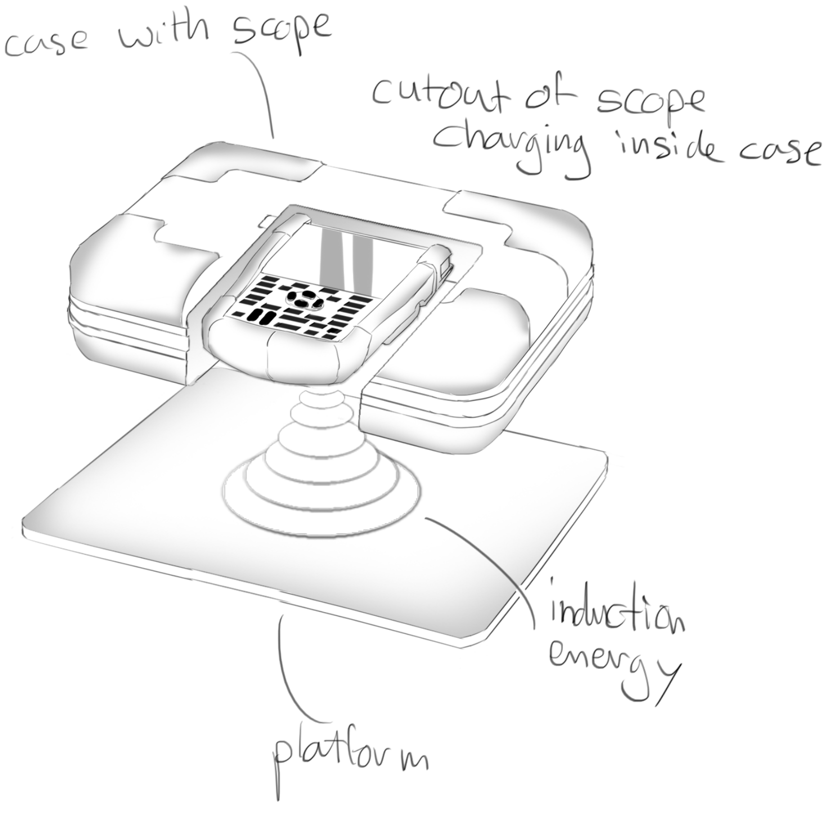

## CONCEPT 1: INDUCTION PAD

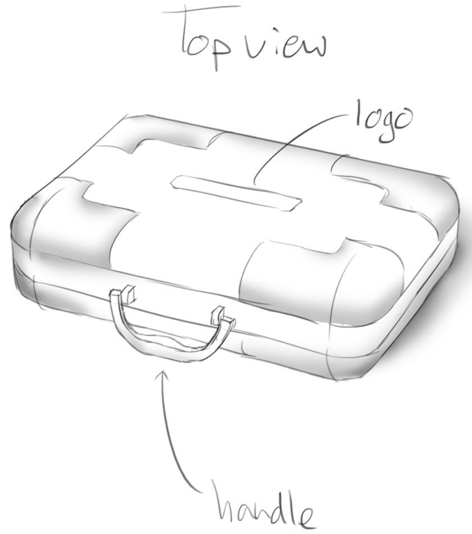
The induction pad concept has several options. There could be an induction system inside the case which receives power from a mains plug. A possible problem with this is that the user still has to plug in the case, returning to the original problem of forgetting to plug in the charger in the first place.

Since the case has a fixed position for the Scopemeter on the inside as shown in Appendix [A] with an inlay, if we place the case on a certain spot, we will know where the Scope is aswell.

This means we can charge the Scopemeter without taking it out of the Case. Since ease of use is of importance to this assignment, this can alleviate a lot of work for the users. Charging while in the case is demonstrated below.



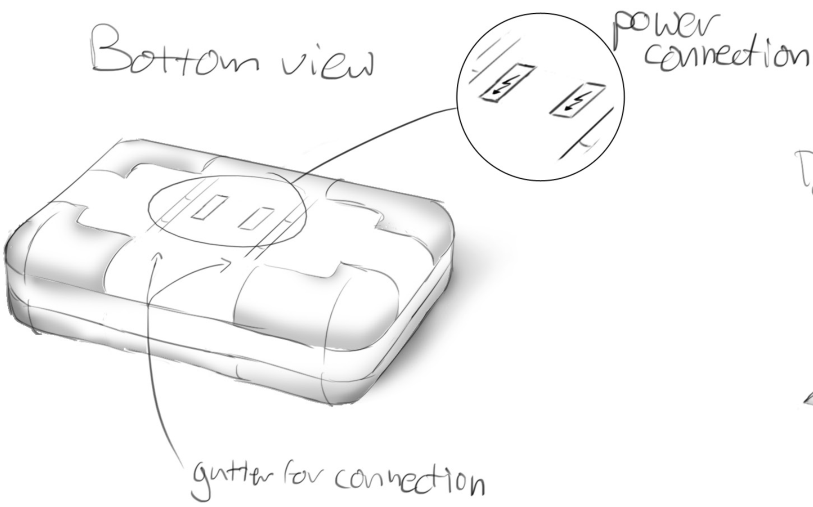



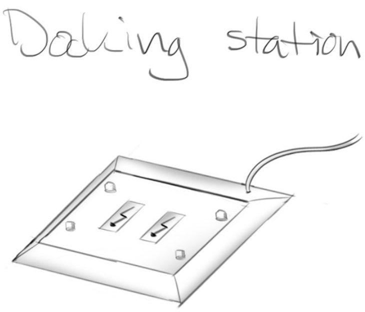



## CONCEPT 2: STORAGE SYSTEM

A storage system could have a similar functionality as docking stations for laptops for example. All that’s needed is for the case to be slid onto the station and connect with the power through there.

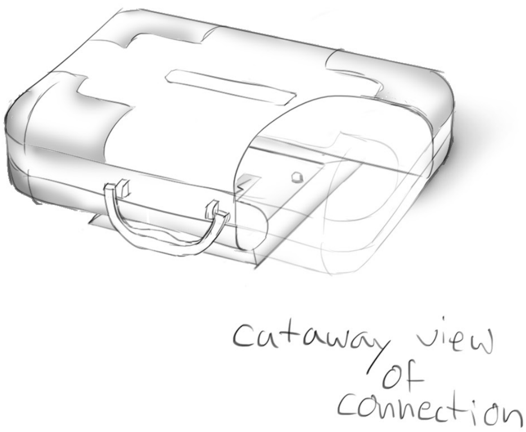
This sliding mechanism needs two grooves on the bottom of the Case so that it slides into the right position. The two electrical points can then make a connection and start charging.

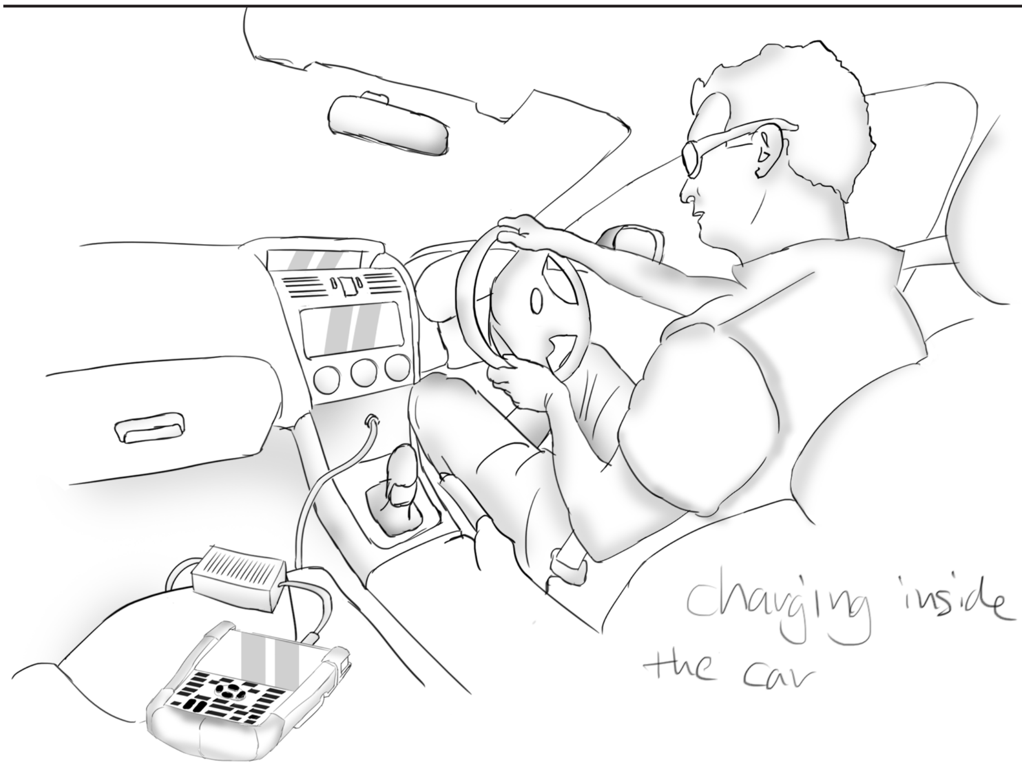



The docking station can be plugged into the main power in the house, whether this is in the workshop, in a locker, on a bench or on a shelf.

This is a big advantage of the storage dock system, because it can be used on several locations and in different ways.





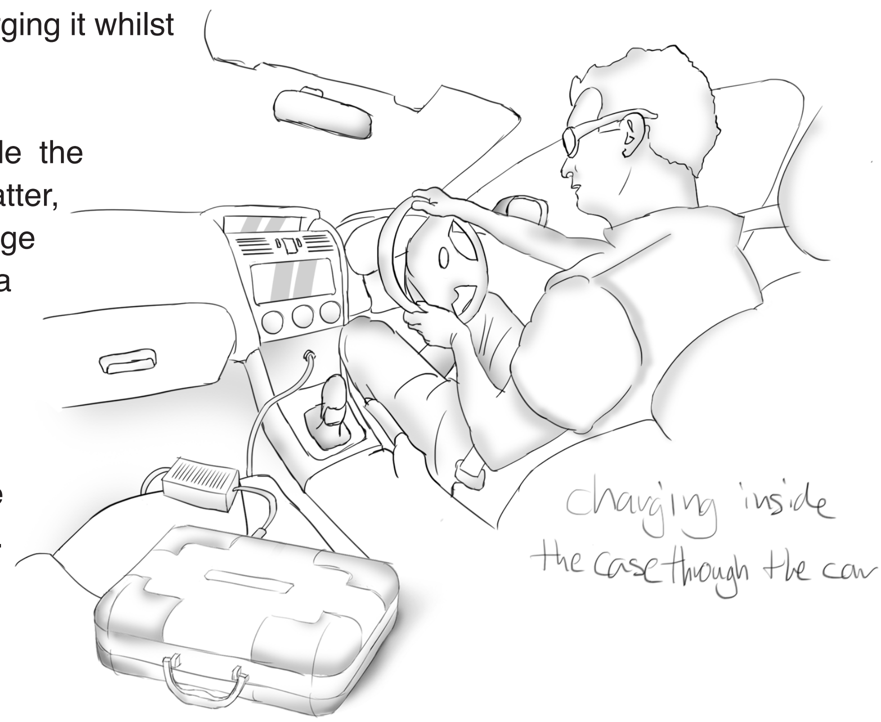

## CONCEPT 3: IN-CAR SYSTEM

Plugging in your Scopemeter with the car power system is very efficient. Once driving around, a car's dynamo produces more power than needed, and thus this power is utilized instead of wasted.

A user can plug in the car charging system to his Scopemeter, and thus charging it whilst driving to a location.

This can either be done outside the case, or on the inside. In the latter, situation just as with the Storage system, there needs to be a connection inside the case between the outside plug and the Scopemeter itself.

This makes this solution more problematic than foreseen earlier.



# CHAPTER 06
# CONCEPT CHOICE

CHAPTER 06

# CONCEPT CHOICE

## Finding the right fit

### FURTHER DEVELOPMENT

During the conceptualization phase, the following considerations were made.

To integrate the Car charging and the storage charging, an internal connection between the outside plug and the scopemeter has to be established.

This can be done in several ways, a simple plug inside the case which connects the Scopemeter to the power source. The internal induction pad could also be combined with the car or storage charging scenario.

Because of the versatility of the induction system, this can also replace both other concepts in their function. Instead of a docking station, the Induction pad could function as a non-connecting docking station.

During a meeting with Christian Suurmeijer, it was decided that because of these factors, and the overall higher upside to the Induction Pad concept, this concept should be further developed.

### PROS AND CONS

To make an educated decision about which concept fits the initial Design Brief best, a short list of all positive and negative elements of the proposed concepts was made:

**In-Car System:**

+ Very usable during the workday
+ Relatively simple technology
+ Eco friendly for using otherwise wasted energy
+ - Average durability
- Not independent
- Not very innovative
- Current cases need to be modified
- Non-scalable (one per device)

**Storage System:**

+ Easy to use
+ Relatively simple technology
+ Very efficient (because of 220V)
+ - Average durability, possible breakage
- Not independent
- Not very innovative
- Relatively expensive
- - Current cases need to be modified heavily
- - Non-scalable (one per device & expensive)

**Induction pad:**

+ Really low effort (no plugs)
+ Innovative technology with extra options
+ Multiple devices possible
+ High durability because of zero wear&tear
+ Compatibility with other devices possible
- Extra costs for adding induction coils
- Not independent
- Not very efficient

# CHAPTER 07 DEVELOPING CONCEPT

# DEVELOPING CONCEPT
Further development of the chosen concept

## INDUCTION CHARGING

Induction charging is a futuristic technology first attempted as "Wireless Power" by Nikola Tesla in the late 19th century.[12]

The basic workings of Induction are as follows;

1. Send a current through a coil [D] made of copper wire (any electrical wire is fine).
2. This creates a magnetic field [B] around the coil, shown in green on [fig 04][07] on the right.
3. This magnetic field then induces an electrical current in the coupled coil [$D_2$] above the bottom coil.
4. This electrical current is then used to provide power to the device which has the coil built into it.
5. In this case, this current will be used to charge the battery of the Scopemeter.

This technology needs to be applied to the Scopemeter and a base "pad" which is to be set beneath the the Scopemeter and its case, allowing the system to charge without having to plug in any cables. The base pad would only have to be plugged in the first time it is installed, and afterward have no more actions apart from charging the Scope.

As shown on the right, [fig 05] shows how a proposed system like this should work.

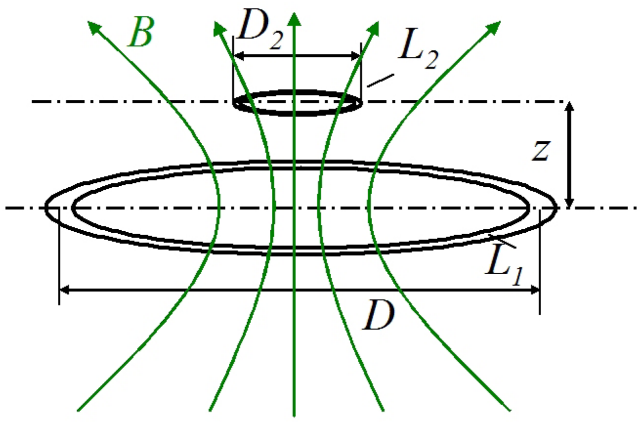
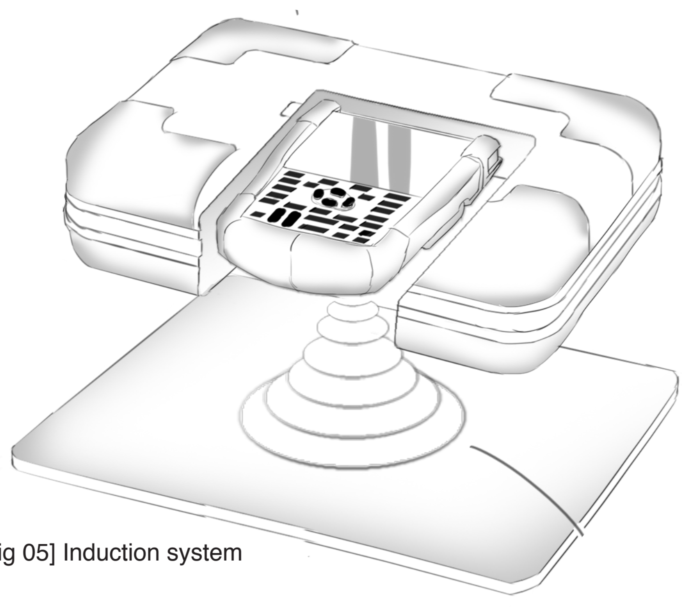



*Figure 1 Typical arrangement of an inductively coupled power transfer system*

[fig 04] Induction coils within a magnetic field

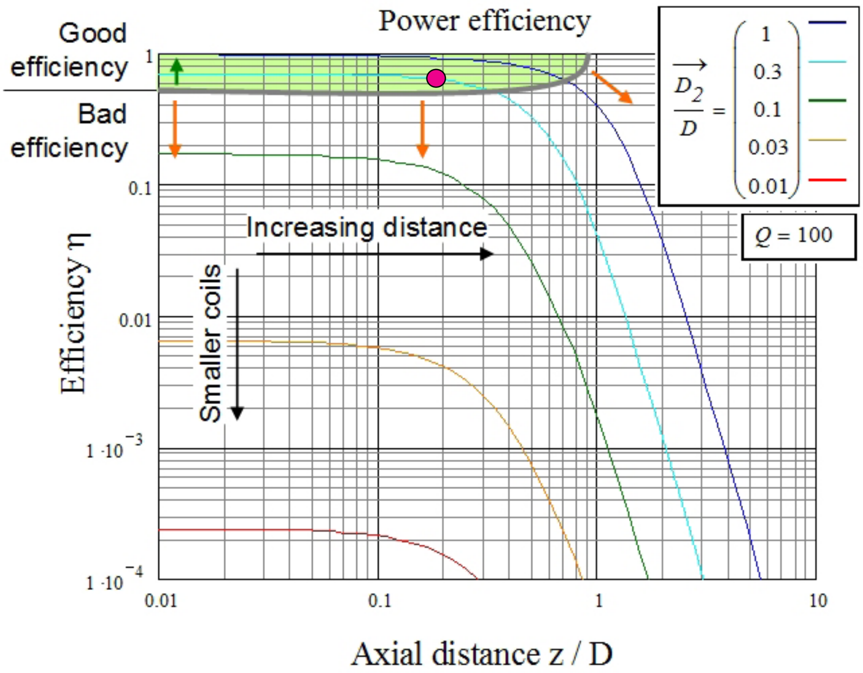


[fig 05] Induction system

## EFFICIENCY

Firstly, efficiency in the general sense of the word needs to be addressed. With Induction this has been an important and frequent topic of discussion because of the quick loss of power when the distance increases.

As shown in [fig 06][08], the efficiency of an induction setup decreases exponentially as the distance between coils [z] is increased beyond half the diameter of the base coil [D].

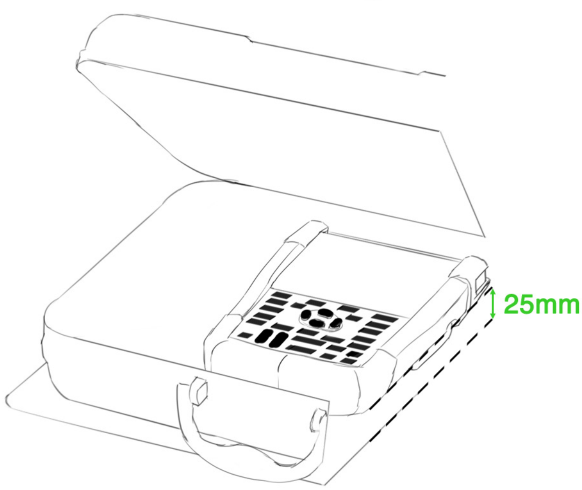



[fig 06] Efficiency plotted vs Axial distance

This may become a problem for our design, and therefore a series of calculations was done to make sure this would not become an issue.

$$D = 12.8\ cm$$
$$D_2 = 5\ cm$$
$$\frac{D_2}{D} = 0.3125$$
$$\frac{Z}{D} = 0.1953$$
$$Z = 3.5\ cm$$
$$n = 0.65\ (65\%)$$

As shown in [fig 07], the distance between the induction pad and the bottom of the Scopemeter is 25mm. To create a safe margin, 10mm has been added to this distance.




[fig 07] Estimated distance between pad and Scopemeter

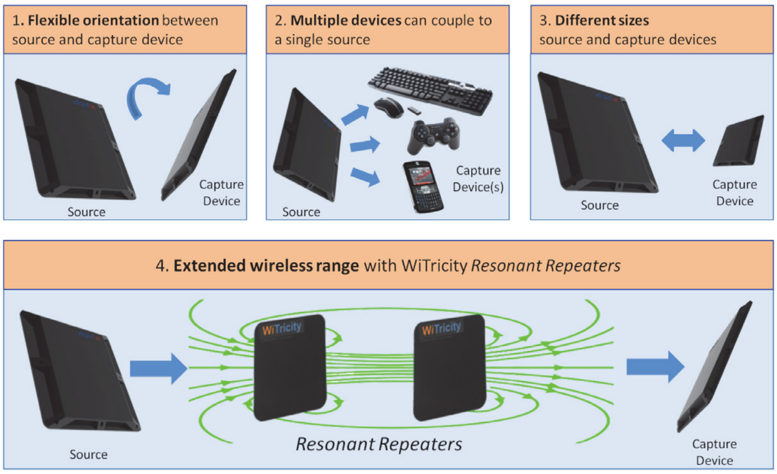
With a battery of 2.4 Ah [Ampere-hour] and 10.8V [Volt], the Scopemeter has a capacity of 25.92 Wh [Watt-hour].

The QI standards for safe charging with Induction state that a maximum energy throughput of 5 Watts should be entirely safe. Since the battery has a capacity of 25.92 Wh, we can calculate the time it takes to charge the battery via induction.

$$\frac{25.92\ Wh}{5\ W} = 5.184h = 5\ hours\ and\ 12\ minutes$$

Looking to 2015, the QI consortium has stated a desire to upgrade the standard to 10 Watts, which would halve the charging time or increase the distance.[09] When this standard is applied to the Induction Pad, charging times would range from 3 to 6 hours for a Scopemeter battery.

These earlier calculations presumed an efficiency of 100% however, and this is highly unlikely to be achieved. Taking a minimum of approximately 65% efficiency as the lower limit, calculated on the left, we however reach 4.5 to 9.5 hours of charging time. These charging cycles would take place in between working hours and during the night however, so this is not a problem at all.




[fig 09] Charging multiple objects at once and other examples [art03]

## POSSIBLE IMPROVEMENTS

There is a lot of room for Improvement compared to the distances and amounts of power described on the previous page.

A team of MIT students and professors have developed and commercialized a way to wirelessly charge any kind of device at any amount of Watts over large distances and with high efficiencies.[13]

The so-called WiTricity© relies on a slightly different version of Induction, namely Resonant Inductive Coupling. This way, larger distances can be bridged with very small losses in efficiency compared to normal Induction.

In 2007, the WiTricity team demonstrated powering a 60 Watt lightbulb over two meters away from the base coil with an efficiency of 45%. since then, a lot of improvements have been made.[10] More recently, an efficiency of 90% was achieved over a distance of one meter.

As shown in [fig 08], large distances and higher amounts of power are achievable.

Apart from the higher distances and more power, [fig 09] shows other implementations of WiTricity;

- Charging devices which are not on the same angle as the base station
- Charging multiple devices at the same time from the same source
- Large varieties in size from source to device
- Extreme distances with repeater devices

These examples could all be made possible by implementing the WiTricity technology in the Induction Pad.

***Figure 3: Photographs of highly resonant wireless power transfer systems used to wirelessly power and operate an LCD TV (~250 W supplied wirelessly) (left) and to wirelessly charge a battery in a smart phone (~5 W supplied wirelessly) (right).***

[fig 08] High and low power delivery over large distances [art03]

# CHAPTER 08 IMPLEMENTING INDUCTION

CHAPTER 08

# IMPLEMENTING INDUCTION
## Making the induction pad work

### SYSTEM DESIGN

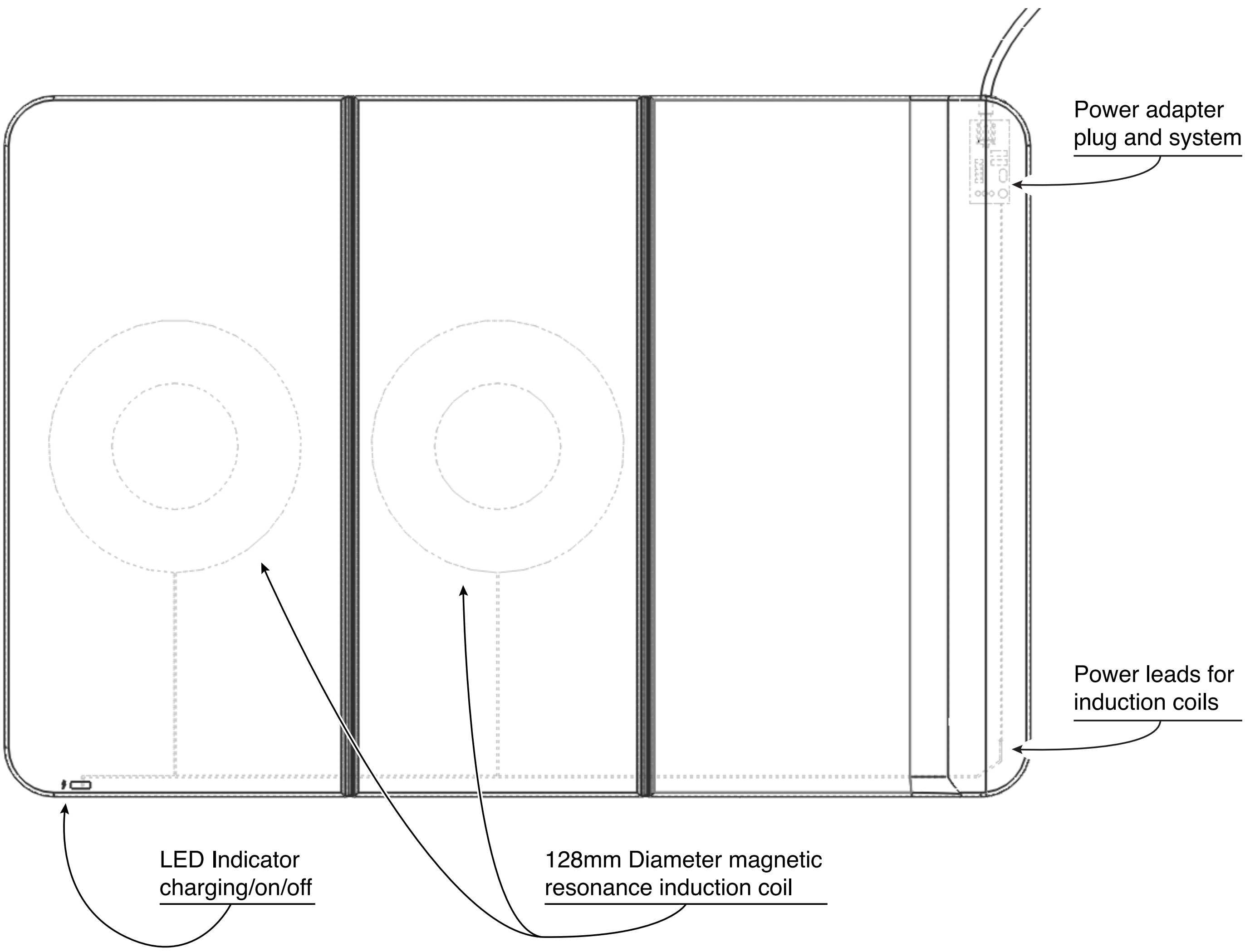
The current adapter delivered with the Scopemeter can be used to plug in the Induction pad. This way, users don't have to purchase another adapter, lowering the costs.

[fig 10] below displays the proposed layout of the electrical components. The current printed circuit board design from the EBC290 [fig 11] can almost entirely be reused for the induction pad.

The LED indicator on the bottom left shows the charging status. These are consistent throughout all FLUKE products, so it follows this guideline. The guidelines are as follows:


[fig 11] FLUKE EBC290 battery pack charger

- Slow flashing indicates that the battery is charging.
- Continuously on indicates that the battery is fully charged.
- Fast flashing indicates a battery error.



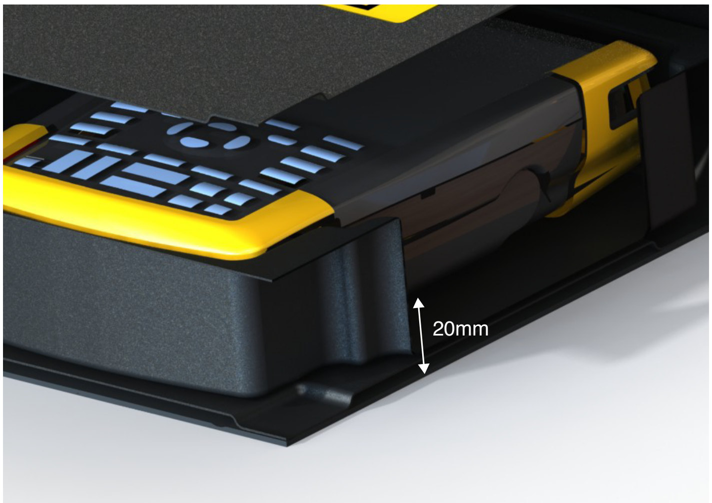

[fig 10] Electrical system design and layout of components

The standard way of using the Induction pad will be by placing the Hardcase on the pad without removing the Scopemeter from its Case.

To ensure that the maximum distance of 35mm between coils is not exceeded, a cutout of the design was made to evaluate the distance between coils. As shown in [fig 13], the distance is 20mm, way below the maximum distance.

This ensures that the extra effort of removing it from its case is completely eliminated from the earlier demonstrated scenario.

This setup is shown in [fig 12] below. This way, the base coil in the Induction Pad and the coil inside the battery [fig 14] are aligned in a way that enables the Inductive charging to work.



[fig 13] Cutout of the ScopeMeter inside the Case, with 20mm clearance between coils

Since the hardcase is bigger than the softcase, the dimensions for the Induction Pad have been chosen so both fit onto it.

Due to the fact that the softcases are significantly smaller than the hardcase, two softcases can fit on one Induction Pad.

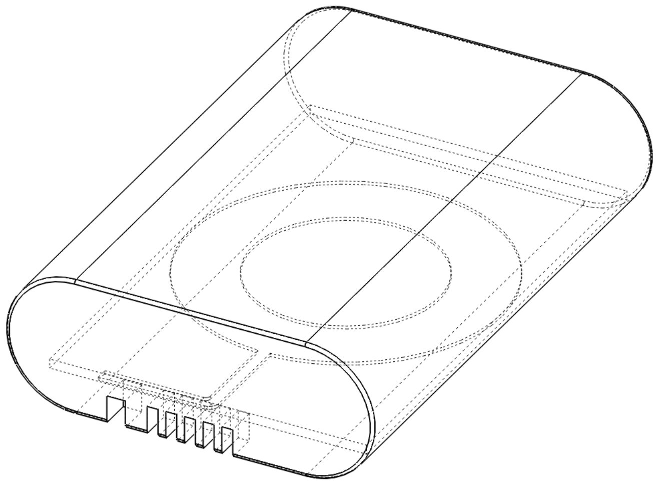
[fig 12] Charging the Scopemeter inside its Case

## BATTERY

As mentioned before, to add a system of Induction Coils inside a Scopemeter is a problem. This is way too expensive, because all Scopemeters would have to be redesigned and no user would ever spend another several thousand dollar just to get this upgrade of product.

To combat this problem, a simple yet elegant solution has been found. By integrating the Induction Coil receiver inside the Battery Pack of the Scopemeter instead of the Scopemeter itself, a lot of costs can be saved. This is a solution that already exists in some products, as shown by Power by Proxi, a different company working with Magnetic Resonance as well.[10b]

A new Battery Pack is always useful, and is relatively cheap. The Induction pad can be sold with a Battery Pack with integrated Inductive charging capabilities alongside it. To make this even more attractive, all other batteries (for multimeters, power quality analyzers, etc.) can also be fitted out with an induction coil, and through that coil also be used with the Induction Pad.

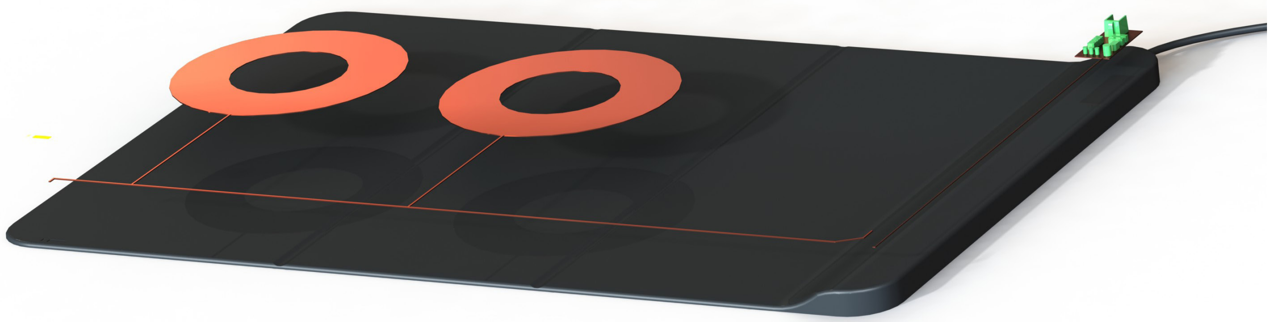


[fig 14] BP290 Battery with integrated magnetic resonance receiver coil[16]

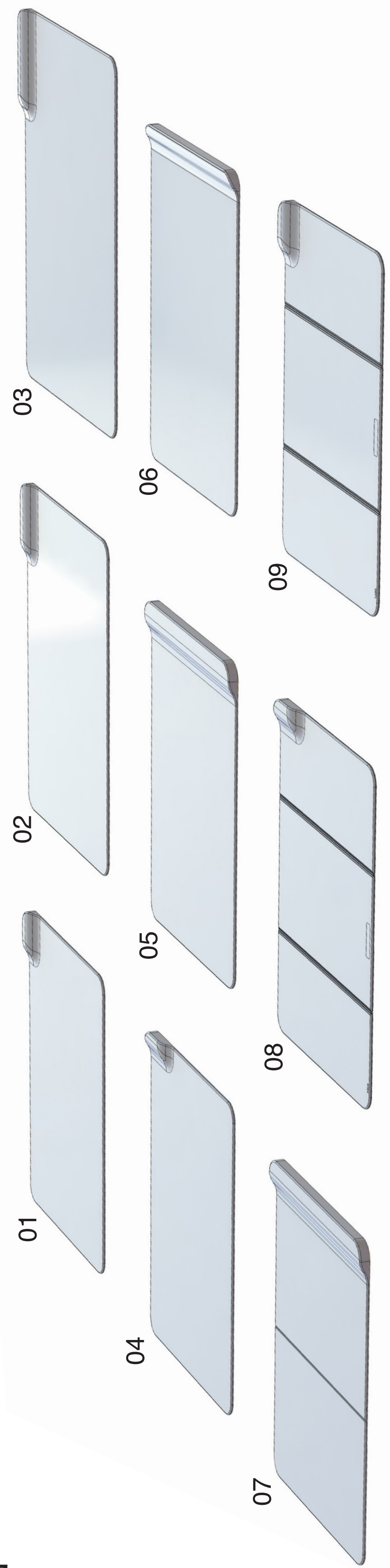
This solution makes a purchase of the induction pad a lot more attractive for users. They can buy a set of extra batteries for their other tools, and enjoy the benefits of charging all of their devices with a single Induction pad.

## EXPLODED VIEW

Below, in [fig 15], an exploded view of the components of the induction pad is shown. The goal was to keep a minimal design as per FLUKE’s design guidelines, yet give it as much flexibility as possible.



[fig 15] Exploded view of the induction coil and electrical components outside the pad




# SHAPE STUDY

01 - The first version of the induction pad design. The electronics for the induction coil are located in the bump on the top right, allowing just enough space for the adapter to plug into the side.

02 - A slightly expanded version 01, with a longer electronics space. It turned out that the small recluse wasn't large enough for the electrics that had to be implemented into the induction pad.

03 - The exaggerated version 02, with more space and more width/height. This way more devices can be placed on the induction pad while maintaining the same shape.

04 - Basically version 01, but with the electronics space on a vertical line instead of horizontal. This design led to more versions, 05 and 06.

05 - Once we changed the electronics space to a vertical one, the step to a line along the whole of the pad was quickly made. To accommodate possibly larger electronics, this strip was made wider as well.

06 - The larger electronics space might not be needed if the circuit board were to be redesigned. To find out how this would look, a much slimmer strip was designed to get a feel for the design.

07 - After deliberation, it turned out that if the induction pad could be folded, the induction pad might prove useful for charging through a soft case, since the Scopes are sideways inside a soft case. With this design, the half of the pad can be lifted up to 90 degrees to make a vertical induction pad.

08 - Two folds turned out to be better than one, so that the angle remains manageable and the induction pad could be placed inside a storage shelf into which the soft/hardcase could be placed.

09 - The inevitable horizontal design with the double fold, for comparison.

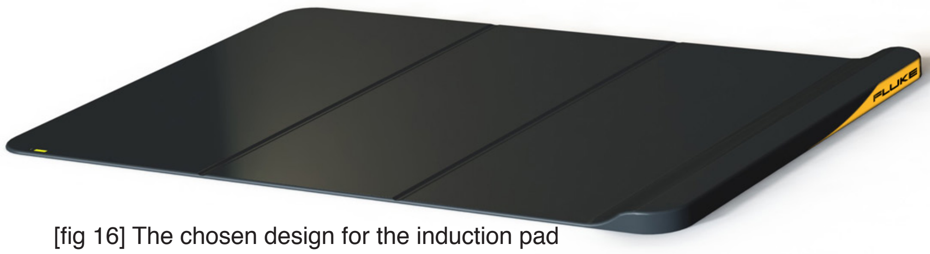
## SHAPE CHOICE

After deliberation with Christian Suurmeijer, a combination of shape 08 and shape 05 was chosen as the final design.

The continuous strip on the right side gives the product a more continuous look compared to the single blob on the top of the pad.

This also gives a more solid edge to rest the bottom of the Case against, immediately making it line out with the coil inside the pad.

A yellow strip along the right side was chosen to give the design a more interesting look, ofcourse remaining within the design guidelines for Fluke products.[15]

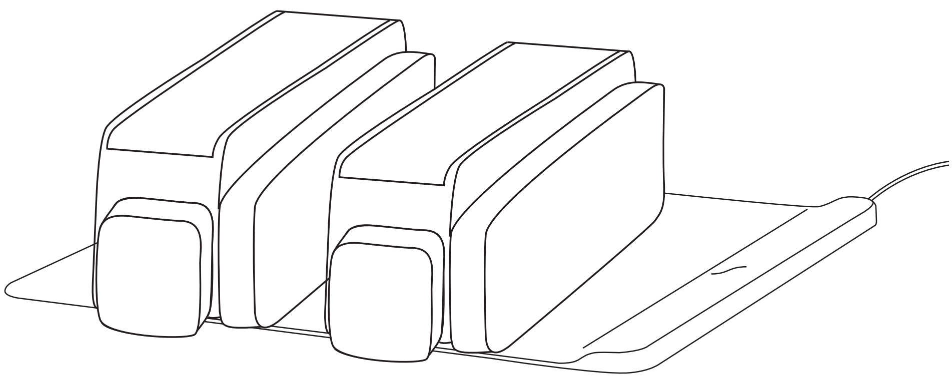



[fig 16] The chosen design for the induction pad

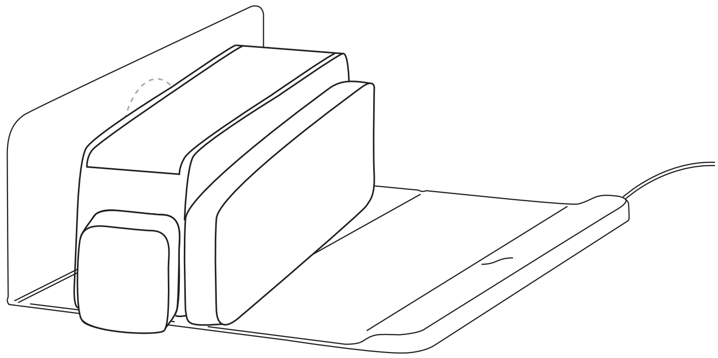
## USAGE SCENARIO

The induction pad has three sections, with the middle one being the smallest. This enables the left section to be bent on the grooves designed purposefully for this ability.

Since the Scopemeter is on it's side inside a Softcase, this way the Induction Coil and the receiver in the Battery Pack are aligned with eachother and they can be charged. [fig 17]



[fig 18] Two softcases on the same pad, both using a coil



[fig 17] Left panel folded to accomodate softcase

As shown in [fig 18], if the WiTricity improvements are made, multiple softcases could lie side by side on the pad, charging their devices at the same time. The versatility of the proposed improvements is very big, as shown on page 32 [fig 09]. Several devices can be charged at the same time without a problem.

As shown in [fig 17], if the shelf isn't big enough to fit the whole induction pad, you can fold up the left part making it smaller so it does fit.

Multiple induction pads can also be purchased to place on multiple shelves for a larger company for example. This way, at the end of each workday the electricians can place their Scopemeters on the shelf, charging them automatically. The following day when they come to work, all devices are charged and ready to go.

# CHAPTER 09 PRODUCTION DESIGN

CHAPTER 09

# PRODUCTION DESIGN
Exploring everything for implementation

## TECHNICAL SPECIFICATIONS

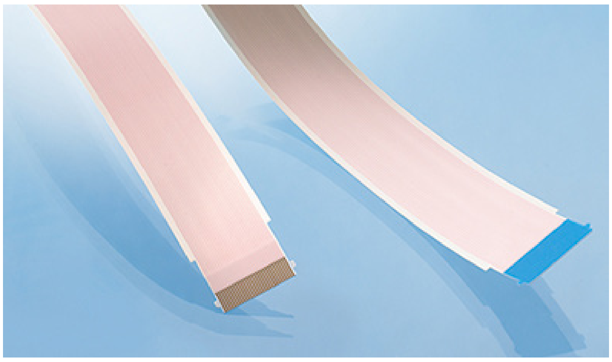
To make sure the design is a feasible one, several considerations were done regarding power draw, charging times, electric design and others. A short summary of this is below.

**Power**
There is a limited maximum power transfer described by the QI Wireless Power Consortium (5 Watts, possibly 10 Watts in the future).[07]
This raises the charging time for the batteries, yet opens up a different possibility, using the adapter delivered with the Scopemeter for plugging in the Wireless Charging Pad. This way it can deliver up to 15W, so several devices can be powered at the same time.[16b]

**Electric Design**
Due to the foldable nature of the Wireless Charging Pad, connections that can be folded are also needed.

Flat Flexible Cables are proposed as a solution to this issue. These type of cables can take an incredible amount of folding, twisting and repetetiveness. With only a 10mm bend radius, these cables can be folded up to 70.000.000 times without breakage.[10c]

An example of these cables is shown in [fig 18b] below.



[fig 18b] Flat Flexible Cables [10c]

**Material**
A material for production was also chosen during the design process. A double layer of Neoprene Polychloroprene will be used for manufacturing the outside of the Wireless Charging Pad. This is flexible and strong, completly electrically isolating and can withstand temperatures up to 120 °C.[10d]

**Manufacturing**
This material will be heat pressed around the electrical components, creating a watertight seal and isolating all electrical parts.

The electrical system from the normal battery charger from Fluke [fig 11] can be almost entirely re-used for this system, all that is need is a connection to the Induction Coils instead of a connection to the battery pins. This will be enclosed in a Polypropylene enclosure.

The induction coils will be made from standard copper, wound as tightly as possible to create a stable and strong magnetic field.

Due to the relatively simple nature of the end product, not a lot of manufacturing processes will be needed.

## MARKETING PITCH

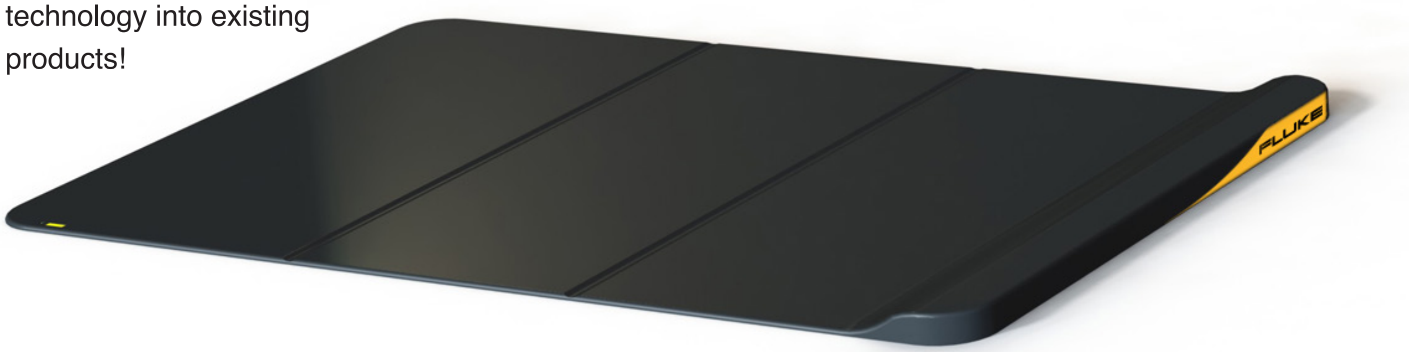

**Charging your devices has never been this easy! By combining Fluke’s High-Tech knowhow with upcoming technologies, Fluke is proud to present the Fluke Wireless Charger.®**

Every time you run out of power on the job, you remember you should have charged your Scopemeter the day before. Alas, not to worry, this is going to become a problem of the past!

With the Fluke Wireless Charger® you can charge your Multimeters, Scopemeters, Power Quality Analyzers, and spare batteries at the same time! This is an incredible integration of this new technology into existing products!

Find your Wireless Charging Pad in the Fluke 2015 - 2016 Test Tools Catalog in back at Accessories.

This amazing technology can be yours tomorrow!



# CHAPTER 10
# THE FINAL PRODUCT

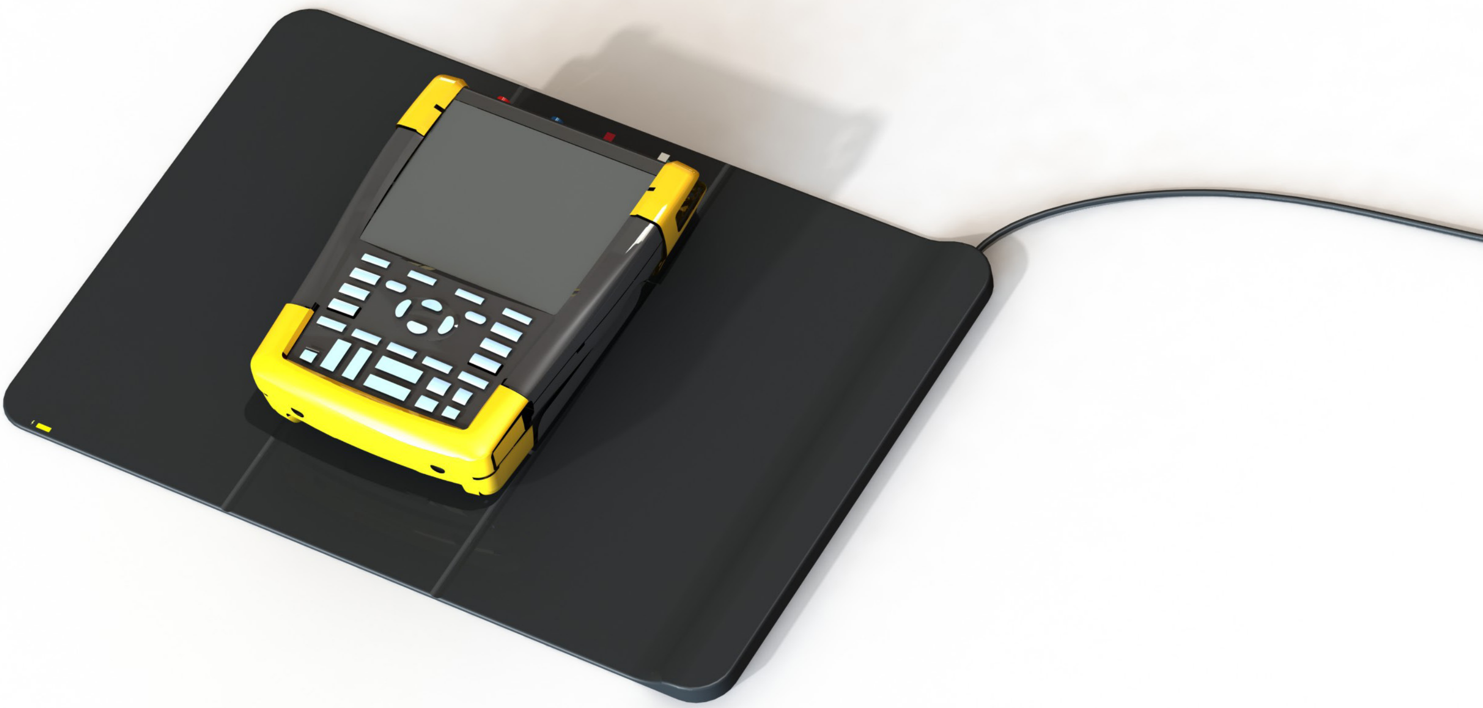
CHAPTER 10

# THE FINAL PRODUCT
## Concept design & 3D renders of usage

### FINAL PRODUCT
Below, the final product alongside the multiple products possible to use with it is shown. Note that in several of these usage scenarios the assumption is made that the WiTricity technology will be implemented into the Induction Pad. Otherwise, situations with up to 5 devices being charged simultaneously would not be possible.


[fig 19] Multiple scopes and batteries charging on the Induction pad simultaneously

[fig 20] Charge your Scopemeter by itself on the Wireless charging pad




[fig 21] Classic induction charging the Scopemeter while inside the Case

Charging multiple batteries and scopes with batteries inside at the same time can become a possibility if the WiTricity technology is used.

[fig 22] Solo Scopemeter on the Pad

This enables users to purchase battery packs with integrated induction coils for alll their other products as well. Multimeters, Power Quality Analyzers, Scopemeters, Thermal imaging cameras, basicallly every device with a battery can be upgraded to work with the Wireless Charging Pad.


[fig 23] Multiple scopes and batteries charging on top of the induction pad

# CHAPTER 11
# EVALUATION

CHAPTER 11

# CONCLUSIONS & RECOMMENDATIONS

Looking at now, then and the future

## CONCLUSIONS

An innovative solution to the problem stated by Benchmark has been found, and with the current technological advancements in wireless charging, will give Fluke a great boost to their innovativity.

The proposed Induction Pad integrates flawlessly with the workflow of users, and adds value by reducing the work for users, adding another high end accessory to the inventory and enhancing Fluke's image.

Benchmark now has a new project idea that they can pitch to Fluke, enhancing their bond even further. Important to note is that the original reason of the assignment was the "Charging Softcase".This idea by Benchmark had as its function to solve a problem. This problem was identified, and a better solution than a Charging Softcase was found, which is more universal and can be integrated in every product made by Fluke.

Due to the changed nature of the result, the original plan of making a Proof of Concept was changed into a pitch of a product concept for Fluke with 3D renders. All in all I look back with a positive feeling on this bachelor's assignment.

## RECOMMENDATIONS

Efficiency and power usage were problems in the past with Induction, but with the current state the trade-off is acceptable. With optional improvements via a WiTricity license, these issues can be resolved completely.

An OEM license for the technology is currently $1000,- and could give Fluke the ability to be at the forefront of the implementation of new technology.

Due to the limited nature of a Bachelor's assignment, I did not have the time to go into this implementation, yet the possibilities have been explored and its benefits outlined.

## PITFALLS

During the course of the assignment I learned several valuable lessons. I have experienced first-hand how a big disappointment can throw you off your balance.

Halfway through the project I was turned down at the last hurdle for a job I had been working to obtain for the past year.

This caused me to have difficulty finding motivation and finishing the project. Luckily I had already finished the bigger part of the project.

I managed to pull through, and must say I am very happy I did. I regret delaying  off till the last moment, and truly bellieve I will not make a mistake like this again.

As said in the beginning, I would like to offer my gratitude to Christian and Theo for helping me through the hardest parts and kickstarting me into action when I didn't have enough finished.

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## Images

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A list of all sources used during the assignment


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17. Images on pages 14 - 15:
*http://www.tylt.com/energi-backpack/*
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*http://www.hertzfurniture.com/i/640x480x1/SLP-37C.jpg*
*http://www.pc-security.com/products_solutions/iPod/images/IPT-4.jpg*
*http://s3images.coroflot.com/user_files/individual_files/346724_cyecmrxwdr5mxsuxg_rfmfi7k.jpg*
*http://www.inglue.com/wp-content/uploads/2009/06/solar-power-mobile-phone-charger-asm17.jpg*

18. Collage on page 16:
*http://ww.dealwinwin.com/wwwimages/product/l2/2013-05-08-23545912671.jpg*
*http://www.voltaicsystems.com/img/products/spark-s.jpg*
*http://images.gizmag.com/hero/juicetank-iphone-charger.jpg*
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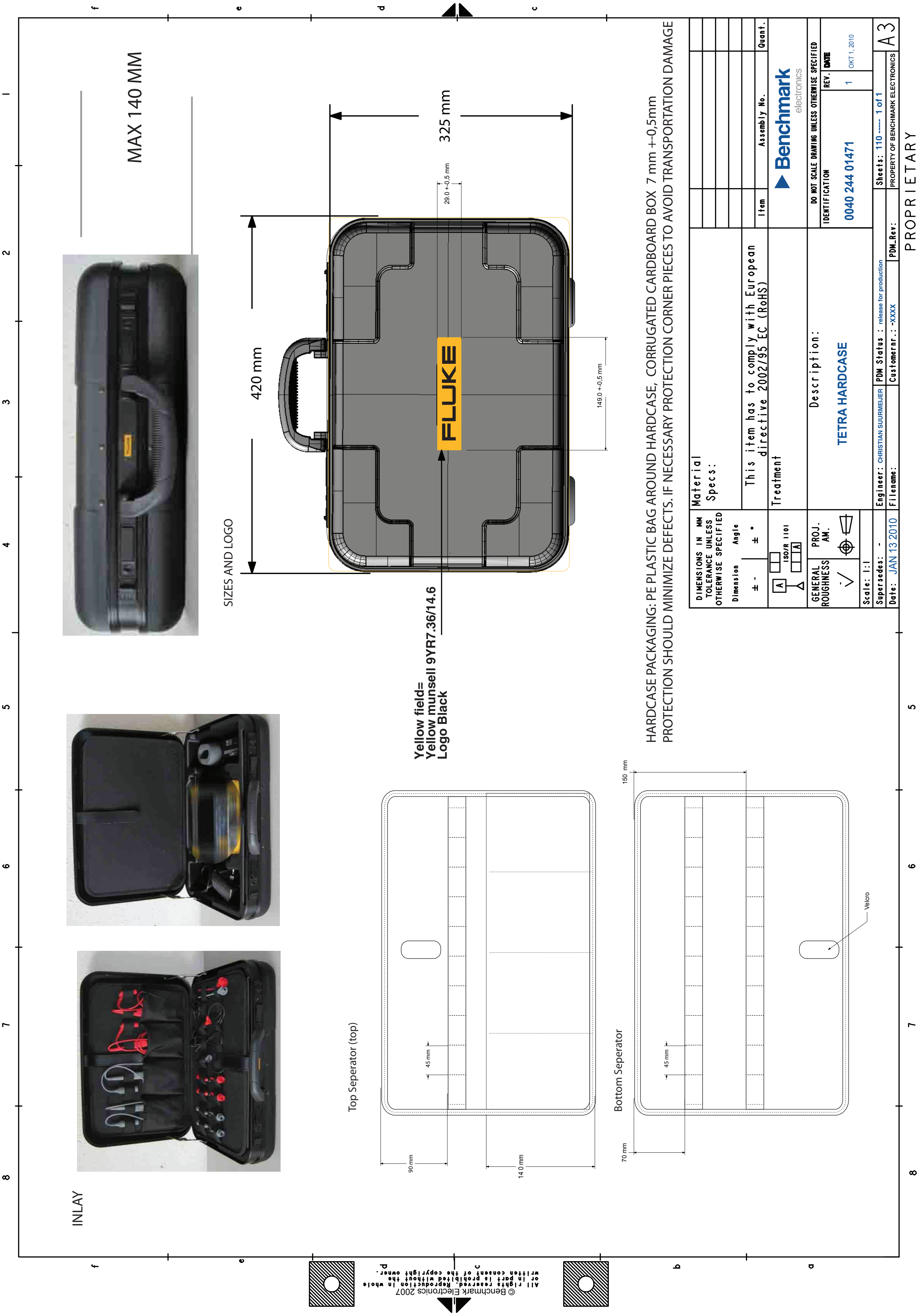
*http://digital.hammacher.com/Items/81332/81332_1000x1000.jpg*
*http://ww.dealwinwin.com/wwwimages/product/l2/2013-05-09-00062515133.jpg*
*http://www.envirogadget.com/wp-content/uploads/2010/01/China-Gadget-Solar-Battery-Bag.jpg*
*https://encrypted-tbn0.gstatic.com/shopping?q=tbn:ANd9GcTinFZWiRnzS2ouqPiaDW29HjbUq5qJ9POn-BlJIkgAA8W gwQdikJgfaQoeFT9Wbu2kA8XF6HPQ&usqp=CAY*
*http://totally-av.co.uk/image/cache/data/Cabinets/paraproject-case-i16-ipad-charging-station-51-500x500.jpg*
*http://parotec-it.co.uk/uploads/images/insyncslideshow1.jpg*
*http://www.datalinksales.com/uploads/DS-IP-TC10C.jpg*
*http://www.casecruzer.com/ipad-charging-station/gallery-ipad-charging-station/mobile-ipad-charging-station-lg.jpg*

19. Collage on page xx:
http://www.infraredtraining.com.au/wp-content/uploads/electrical-safety-training-course-image-1.jpg
http://2.bp.blogspot.com/_ld4qZws9ApM/TSKrc-MaiUI/AAAAAAAAAH0/mo1ytw-0iMc/s1600/scope%2B190%2Bseries%2B%25282%2529.jpg
http://i.ytimg.com/vi/2W5wGZwSvRQ/maxresdefault.jpg
https://my.cqu.edu.au/documents/5445674/0/Scopemeters+handover/345c419e-f4f4-4d81-9f5f-7df24b3901b4

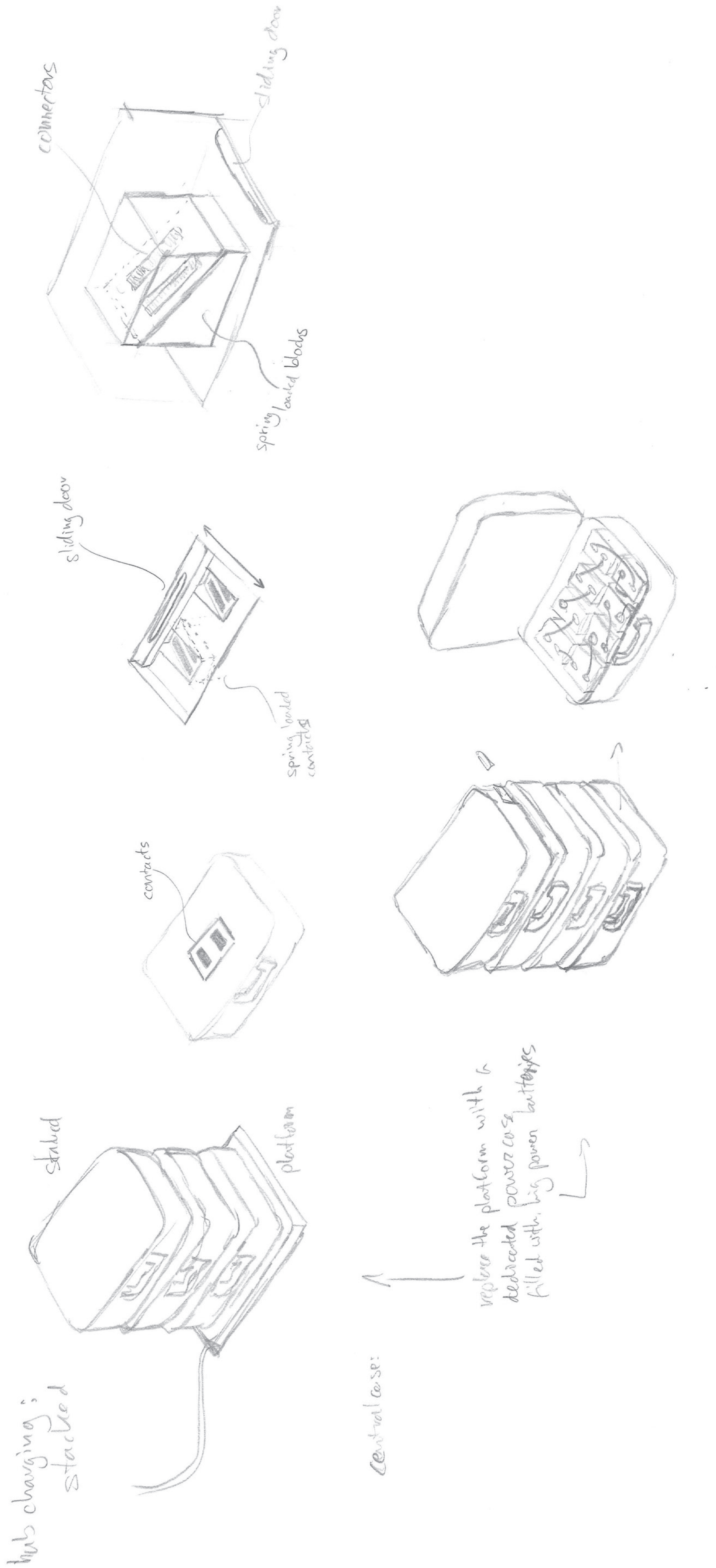
20. All FLUKE images copyright FLUKE Corporation

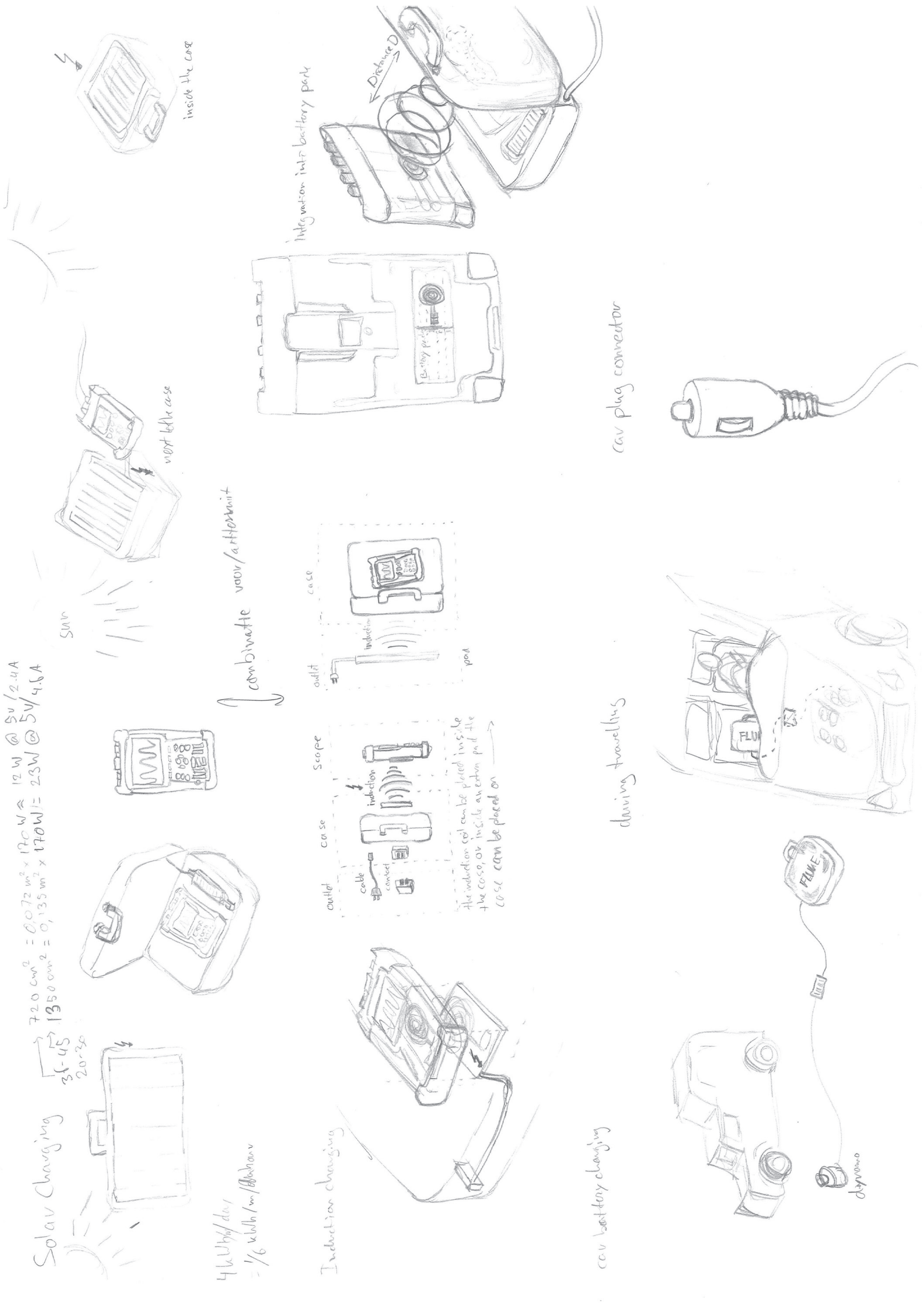
# APPENDIX

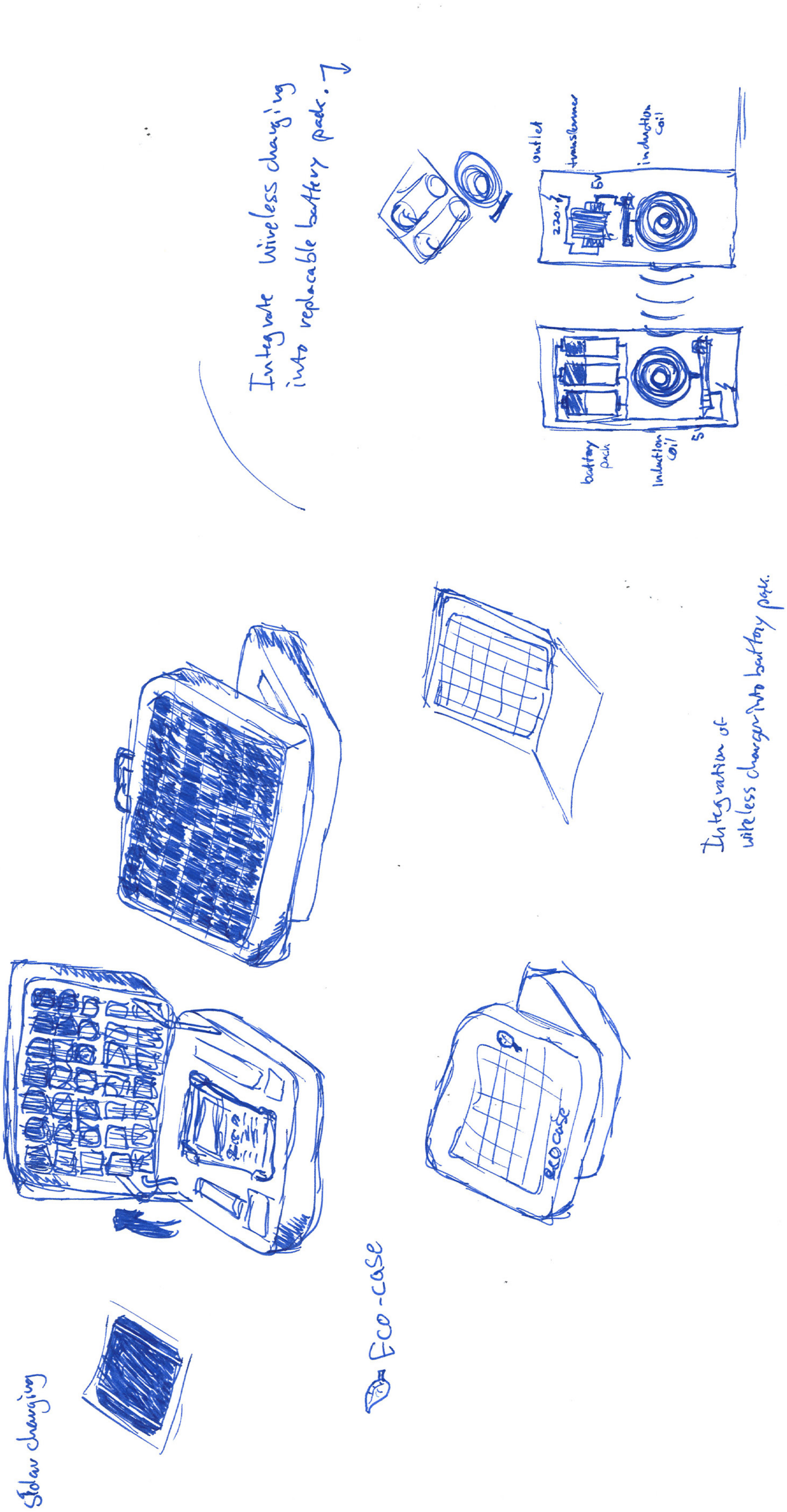
# APPENDIX A - HARDCASE

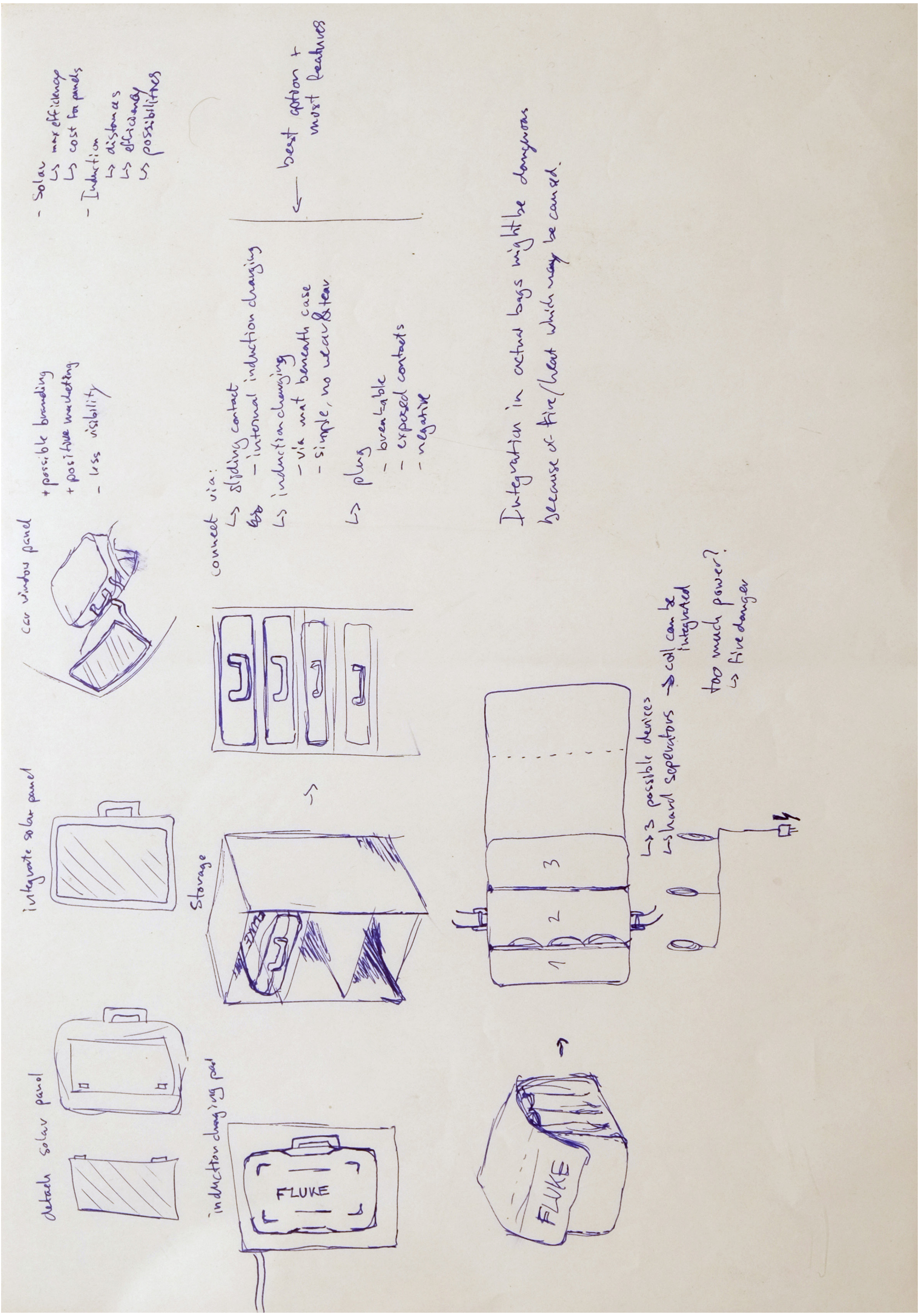


# APPENDIX B - SKETCHES



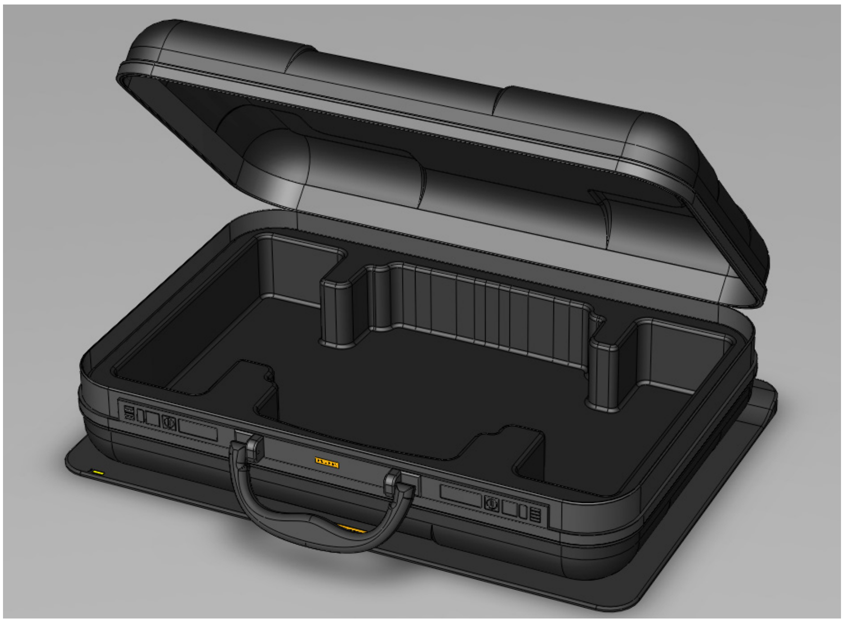

Solar Charging
720 cm² = 0,072 m² x 170 W ≈ 12 W @ 5V/2.4A
1350 cm² = 0,135 m² x 170W = 23W @ 5V/4.6A
3f-45
20-30
4 kWh/m²/day
= 1/6 kWh/m²/hour
sun
next to the case
inside the case
combinatie voor/achterunit
Induction charging
outlet
case
scope
cable
contact
induction
the induction coil can be placed inside the case, or inside an extra pad the case can be placed on
pad
Integration into battery pack
Battery pack
Distance D
car battery charging
dynamo
FLUKE
during travelling
car plug connector


Integrate wireless charging into replacable battery pack.
outlet
transformer
220v
5V
induction coil
battery pack
induction coil
5V
Integration of wireless charger into battery pack.
Eco-case
ECO case
Solar charging



detach solar panel
integrate solar panel
car window panel
+ possible branding
+ positive marketing
- less visibility
- Solar
↳ max efficiency
↳ cost for panels
- Induction
↳ distances
↳ efficiency
↳ possibilities
induction charging pad
FLUKE
Storage
connect via:
↳ sliding contact
- internal induction charging
↳ induction charging
- via mat beneath case
- simple, no wear & tear
↳ plug
- breakable
- exposed contacts
- negative
best option + most features
FLUKE
1
2
3
Integration in actual bags might be dangerous because of fire/heat which may be caused.
↳ 3 possible devices
↳ hard seperators
coil can be integrated
too much power?
↳ fire danger

# APPENDIX C - ORIGINAL CONCEPT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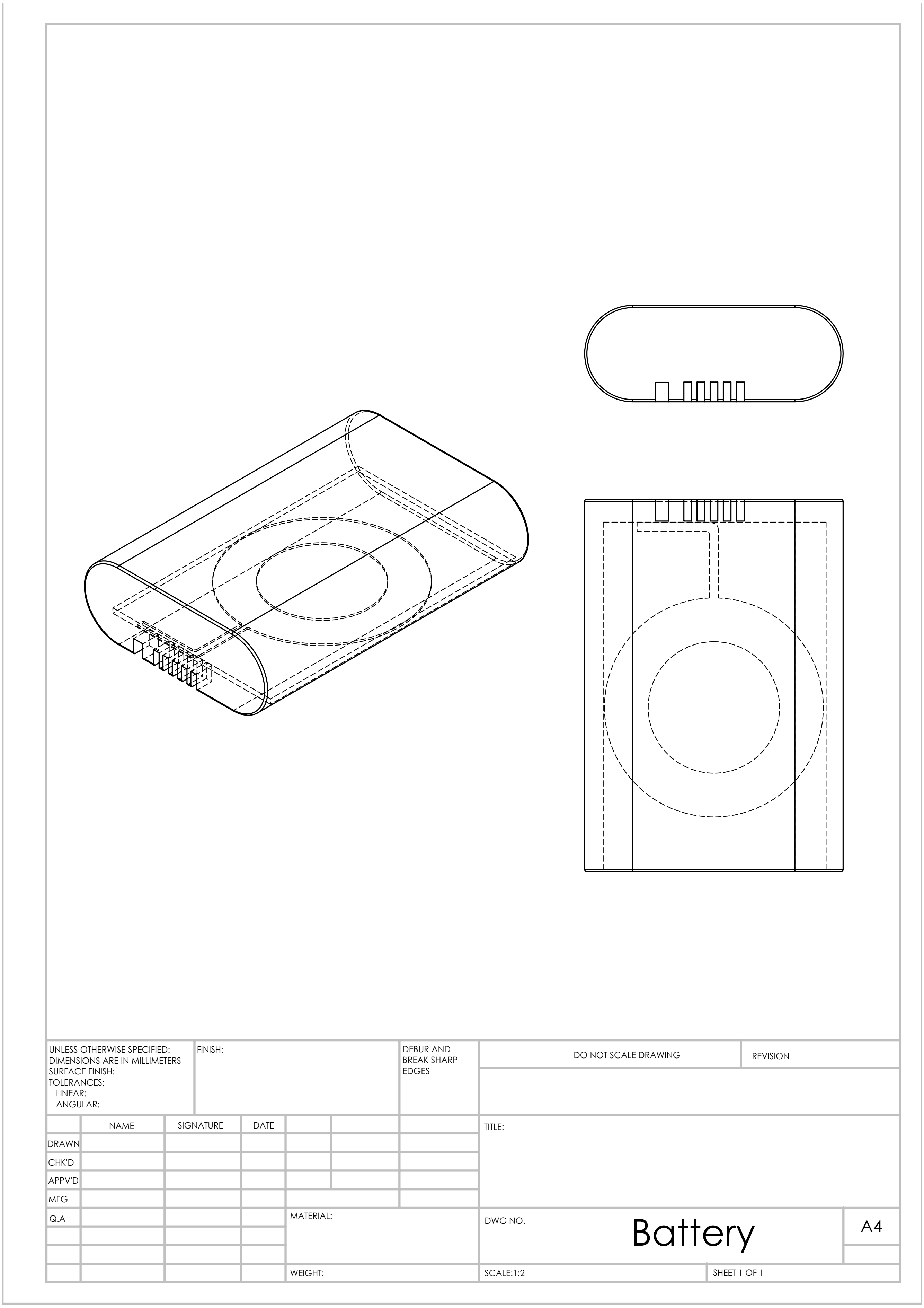
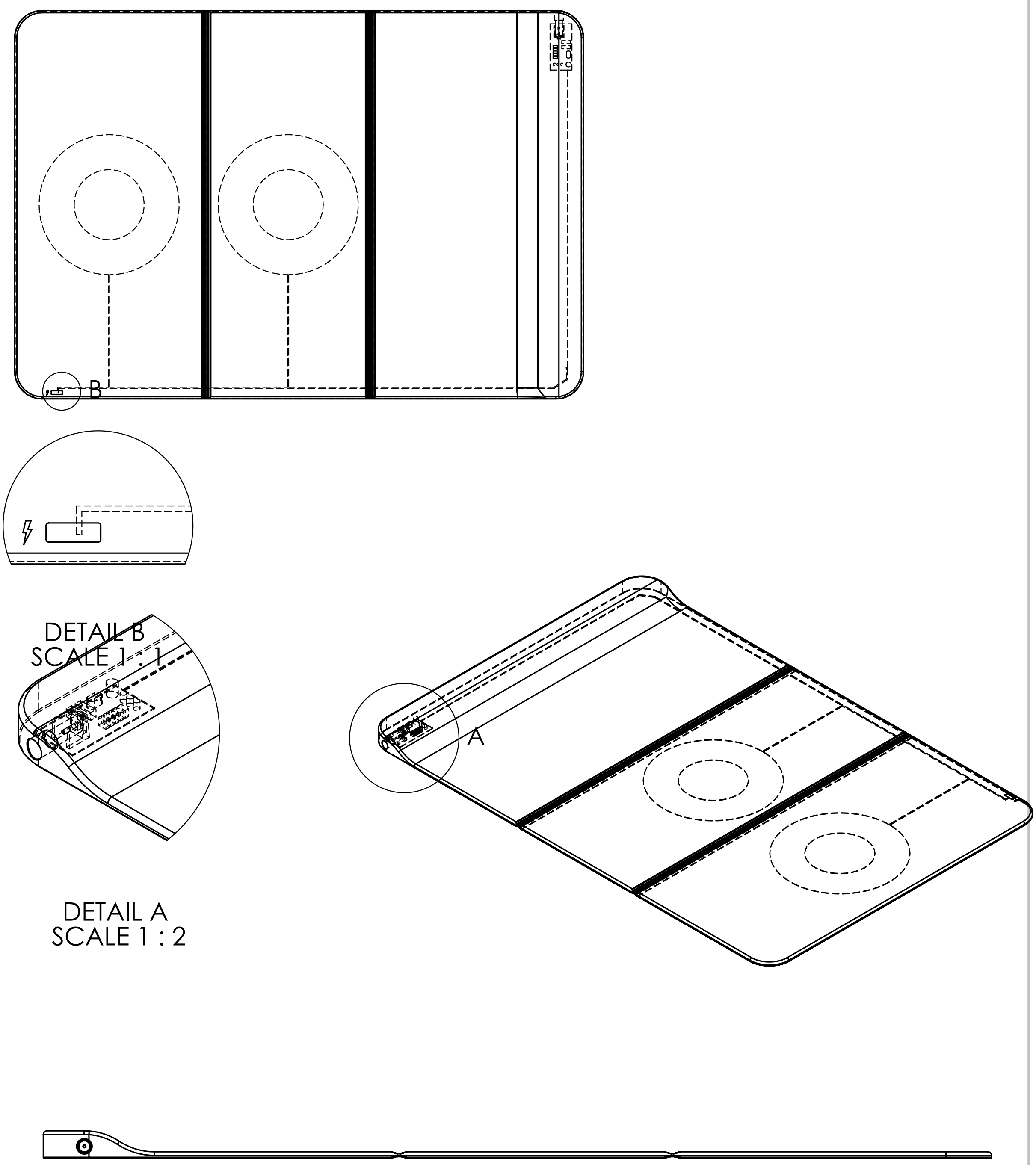
# APPENDIX D - TECHNICAL DRAWINGS






| | | | | | | |
|---|---|---|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS SURFACE FINISH: TOLERANCES: LINEAR: ANGULAR: | FINISH: | | DEBUR AND BREAK SHARP EDGES | | DO NOT SCALE DRAWING | REVISION |
| | NAME | SIGNATURE | DATE | | TITLE: Induction pad design | |
| DRAWN | | | | | | |
| CHK'D | | | | | | |
| APPV'D | | | | | | |
| MFG | | | | | | |
| Q.A | | | | MATERIAL: | DWG NO. Induction Pad | A4 |
| | | | | WEIGHT: | SCALE:1:20 | SHEET 1 OF 1 |