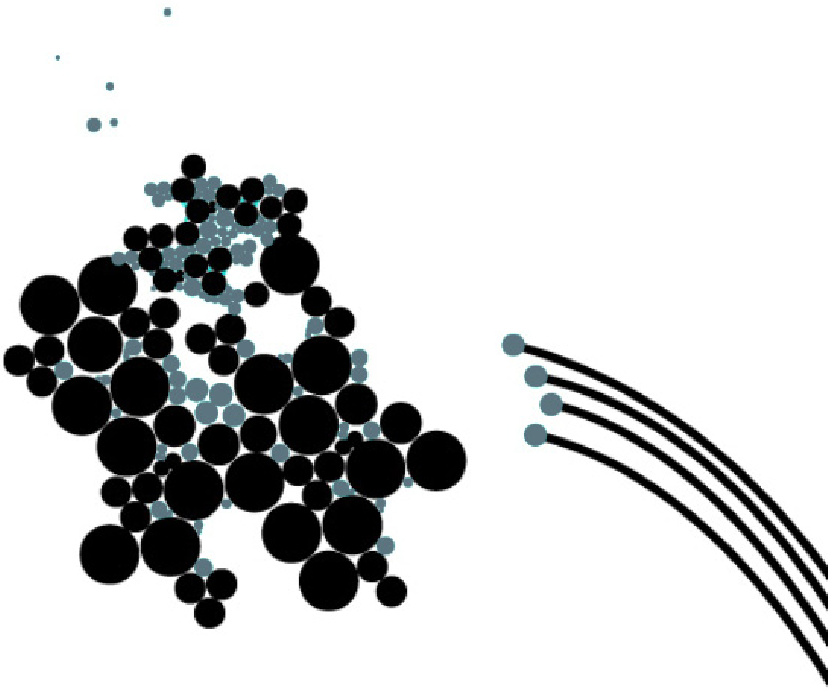
▶ future concepts for the FLUKE ScopeMeter

by M.B.C. Grob

20th of April 2011

UNIVERSITY OF TWENTE.
INDUSTRIAL DESIGN ENGINEERING



Title page

Final report for the bachelor assignment

Future concepts for the Fluke ScopeMeter

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Preface

An introduction to my bachelor assignment

For this project I have been given the unique opportunity to work alongside experienced designers at Benchmark Electronics at Almelo for four months. I would like to thank everyone at Benchmark Electronics for making me feel welcome, for involving me in all of their work related activies, for granting me access to their extensive resources, and of course for trusting me with such an awesome assignment.

I would like to express my thanks to several people in particular, for allocating their valuable time to take an interest in me:

Benchmark's lead designer **Christian Suurmeijer**, for his kind guidance and support throughout the project, even through the most difficult of times. His enthusiasm and optimism makes you feel right at home.

Maarten van Alphen, for sharing his extensive experience and knowledge, and for always being available for professional feedback and casual banter.

All **coworkers** of the mechanical engineering & product development departments, for their assistance and sociability in the workplace.

Wouter Eggink, for offering guidance and advice from the university's perspective, and for offering that fresh outsider look on matters that we sometimes need to keep perspective.

All in all it was an amazing experience that has taught me a lot. I hope that throughout this project I have managed to display my prowess as a designer and proved to be of value to Benchmark Electronics.

Abstract

Final report for the bachelor assignment

Background

Fluke is searching for future concepts for their leading product the ScopeMeter. Improvements can be made with regard to signal detection, portability, and remote control. Currently the product is portable, but not altogether hand-held.

Approach

Through extensive brand analysis, as well as market and user research, supported by a technological assessment of (future) possibilities, a promising direction of product development is identified for Fluke on the electronic test tools market.

Results

A timeline of future developments is created, with small incremental development steps towards an ideal situation and assured position of market leader for Fluke. Of this timeline, a few products have been highlighted to illustrate the possibilities of the presented direction of product development, resulting in one complete product design within the current technological limits, and a visualisation of the aspired ideal future situation.

Conclusions

The presented changes should consolidate Fluke's position as market leader of electronic test tools, supported by Tektronix under Danaher's supervision, along with accentuating the brand values and thus distinguishing the brand from the generic overflow on the market. Small incremental steps should keep development costs to a minimum, while keeping the future electronic test tool market, and position on said market, in mind.

Research phase .I

Table of contents

An overview of the content found in this report

The appendix is included separately.

Introduction

The inception to the project

“Measure what is measurable, and make measurable what is not so“, Gallileo Gallilei (1564-1642)

To understand the world around us, to know what is going on, one needs to start by measuring the events that happen around us. Fluke Corporation creates electronic test tools and software that allow their customers to understand the ever more ubiquitous electrical systems around us.

As market leader, Fluke seeks to maintain their position and wishes to do so by offering innovative products to the user. In particular, Fluke seeks for future concepts for the Fluke ScopeMeter, one of their most successful products.

The report is divided into three phases: a research phase, a conceptualisation phase and a finalisation phase.

- **The research phase**

The research phase includes a brand and market analysis, which quickly uncovered an overlap in interest between Fluke and Tektronix; both part of Danaher’s holding, an overview of the oscilloscope’s development, functionality and history, and of course a breakdown of Fluke’s ScopeMeter.

The results have been used in preparation for user research with a Fluke customer, and eventually to establish a promising basis for concept development.

- **The conceptualisation phase**

Based on results from the research phase, ideas have been generated. Subsequently the area of interest was selected, namely the scope module concept, and a timeline with incremental product development steps was created.

For the purpose of this project and within the time restraints put on the project, the focus of product development has been put on creating a successor for the Fluke ScopeMeter 120 series, though several related fields and products are touched on.

- **The finalisation phase**

The presented results in this report include a detailed product design of a successor for the Fluke ScopeMeter 120 series, though production methods and component details are kept at a superficial general level. The report also includes visualisations of the culmination of the selected product direction for Fluke and ties in the overall product development with Tektronix’ interests.

chapter 01

FLUKE CORP.

01 | Fluke Corporation

The corporate profile of Fluke

Fluke Corporation is the world leader in the manufacture, distribution and service of electronic test tools and software. The Fluke brand has a reputation for portability, ruggedness, safety, ease of use and rigid standards of quality.

Introducing Fluke

Fluke Corporation[12] aims to be the world leader in the manufacture, distribution and service of electronic test tools and software; a concise mission statement introduced in 1991. Since Fluke's founding in 1948 by John Fluke Sr.[13], a former friend and roommate of David Packard, co-founder of Packard Bell, Fluke has helped define the unique market of electronic test tools.

From industrial electronic installation, maintenance and service, to precision measurement and quality control, Fluke provides the technology market with testing and troubleshooting capabilities that keep business and industry up and running.

Fluke is a multi-national corporation headquartered in Everett, Washington, USA. Fluke has manufacturing centres in the USA, the UK, Asia and The Netherlands. Fluke Corporation has authorised distributor and manufacturer representative channels in more than 100 countries and employs approximately 2,400. All of Fluke's sales are catalogue based. Fluke is made up of number of divisions, such as Fluke Industrial, Networks and Biomedical, but also of acquisitions such as Hart Scientific, Raytek, DH Instruments and Amprobe.

Fluke as subsidiary of the Danaher Corporation

Since June 1998, Fluke is a subsidiary of the Danaher Corporation[14]. Operating from their headquarters in Washington D.C., this large global company's business activities encompass four reporting segments: professional instrumentation, medical technologies, industrial technologies, and tools & components. The Danaher Corporation continues to incorporate companies that fit in these segments and strengthen the position of the corporation.

While effects of the merger between Fluke and Danaher were invisible to the market and thus the end user, the merger has had a direct effect on the operations of Fluke. Prior to the merger Fluke invested a lot of time and money in user research; research that occasionally lead to actual product development. Danaher however did not deem the expenses sufficiently profitable and put all but a stop to this investment.

A notable detail is the acquisition of Tektronix by Danaher Corporation in 2007[15]. Formally one of Fluke's competitors but now part of the same holding, the acquisition of Tektronix significantly increases Danaher's market share of electronic test tools (refer to appendix B for more information).

This acquisition has created opportunities for Benchmark as well; Danaher would benefit from shared investments and shared knowledge to further consolidate their business activities in the electronic test tool segment, and Benchmark could offer such services due to their unique outside position as developer for Fluke - the Ruby project is a prime example hereof. However, one does need to be aware of the possible conflict of interest and cater to it accordingly.

FLUKE.

Type	Corporation
Industry	Industrial Test Products
Founded	Everett, Washington, USA, 1948
Founder	John Fluke Sr.
Headquarters	Everett, Washington, USA
Key people	Barbara Hulit President, Fluke Corporation Roderick Jones President, Fluke Biomedical Ken Konopa President, Fluke Industrial Group
Employees	2,400
Parent	Danaher Corporation
Website	*fluke.com*

DANAHER

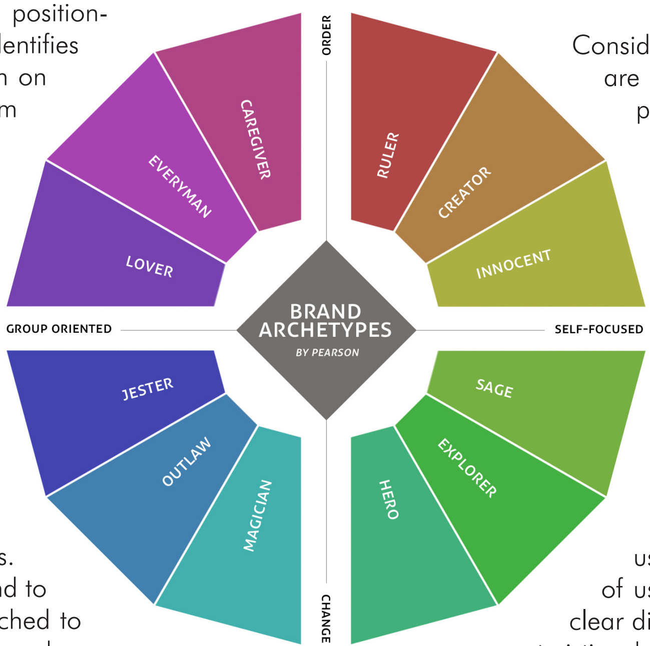
Type	Public
Industry	Manufacturing
Founded	1969
Headquarters	Washington, D.C., USA
Key people	Steven M. Rales Chairman of the Board H. Lawrence Culp, Jr. President, CEO & Director
Revenue	$11.184 billion
Operating income	$1.542 billion
Net income	$1.151 billion
Total assets	$19.595 billion
Employees	46,600
Website	*danaher.com*

Company overview: details

Brand management

The brand Fluke stands for portability, ruggedness, safety, ease of use and rigid standards of quality. The products must adhere to these characteristics and convey them to the user through their design, in particular through the use of a recognisable colour scheme, the form, and the user interface. Most noticeably perhaps is the use of the typical Fluke yellow for its products, which in combination with the grey tones give Fluke's products their distinct blue collar appearance, fit for their target group.

Pearson's Archetypes[01] can be utilised to acquire a better insight into a brand's positioning on the market. Pearson identifies 12 categories and places them on a Cartesian graph, ranging from change to order, from group oriented to self-focused, as displayed on the right. These categories aim to describe characteristics of the type of brand and its direction.



Amongst others, Fluke is a *ruler*: they exert control and take on the role of leader in the categories they operate in. Rulers are often market leaders, offering a sense of security and stability amidst chaos. Brands in this category also tend to have high status products attached to them that are used by people to enhance their power and abilities. Rulers see themselves as knowing what is good for people and wish to set a standard; they dominate and represent the established ways.

Fluke also exhibits characteristics of the *sage*, whom is driven by a desire to understand and know the world around them. They represent wisdom and wish to enlighten the consumer. Sages often express a high need for autonomy and provide their customers with expertise and information.

Lastly, Fluke shows signs of the *hero* archetype. Fluke is at the height of its powers and represents active success with its strong brand characteristics. They started out as a challenger brand and are now a market leader through their innovations and courage to be different and inspirational. It is paramount Fluke does not lose sight of this innovative nature in order to remain a hero.

These archetypes can help Fluke understand their position on the market and thus better aim and manage their products and design thereof.

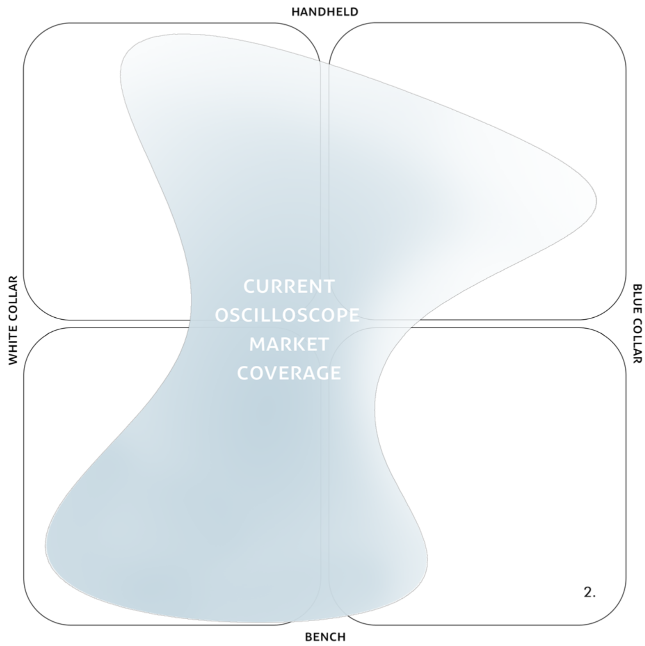
Fluke vs. Tektronix

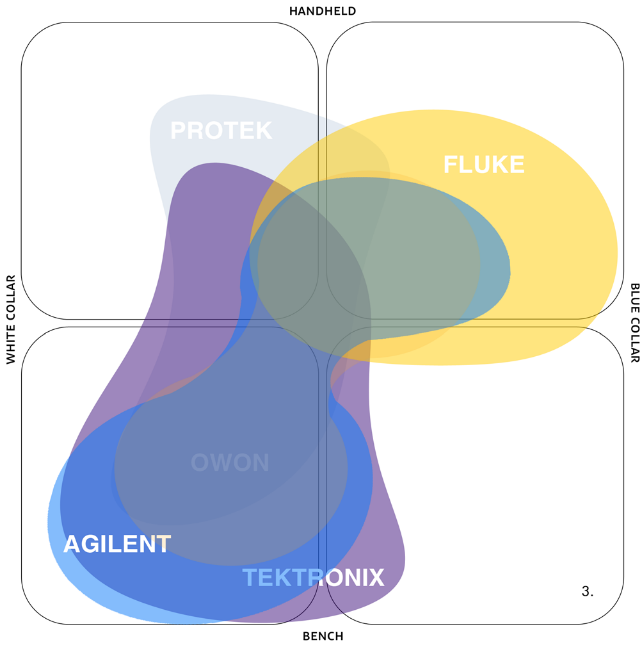
Considering that Fluke and Tektronix are both part of the Danaher Corporation, it is paramount to focus on the brand values as to keep the brands and products unique.

The brand Tektronix stands for high performance, quality and stability. Their products cater to the user who desires these characteristics; this is mainly the white collar worker doing office work. Concretely, it is reflected in colour scheme use, display quality, high degree of user control, and interface. The clear difference in values and characteristics should provide sufficient distance between Fluke and Tektronix in exterior appearance.

Tektronix, with their wide product range, seems to aim at a much larger target group compared to Fluke. Tektronix also aims to enter the lower performance sector, as is clear with the Ruby project - an adapted version of Fluke's 190 series scopemeter. It is illustrative of the possibilities offered by shared investments and knowledge between Tektronix and Fluke, in particular with regards to technological developments.


HANDHELD
WHITE COLLAR
BLUE COLLAR
BENCH
1.


HANDHELD
WHITE COLLAR
BLUE COLLAR
CURRENT OSCILLOSCOPE MARKET COVERAGE
BENCH
2.


HANDHELD
WHITE COLLAR
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PROTEK
FLUKE
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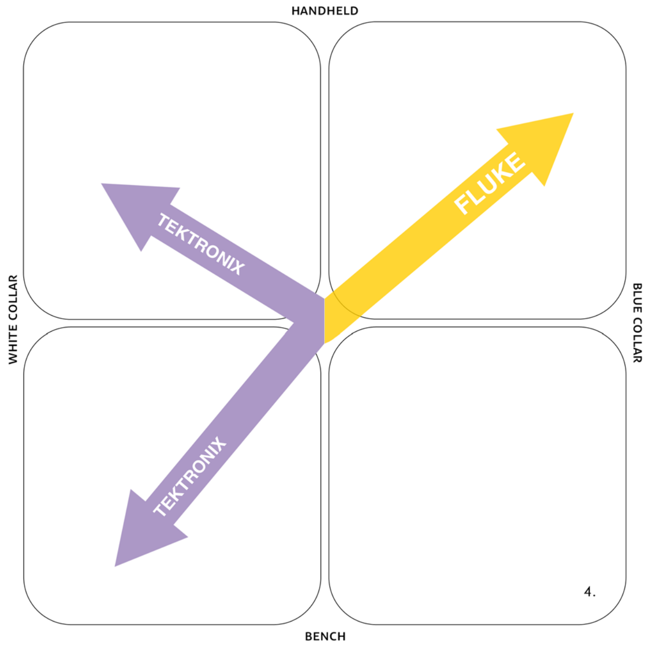
3.


HANDHELD
WHITE COLLAR
BLUE COLLAR
TEKTRONIX
FLUKE
TEKTRONIX
BENCH
4.

Market research

Market research provides important information to identify and analyse the market need, market size and competition. It offers a macro view of the complete oscilloscope product range.

There is a wide range of electronic equipment brands that manufacture oscilloscopes[02]. A comparison is made of the main brands along with some of the smaller brands to ensure no oversight is made. The comparison is made regarding the following aspects: target group, main form factors of oscilloscopes, and lastly performance.

It becomes clear that Fluke holds quite a unique position amongst other oscilloscope brands. While the performance of their product is average compared to the competition, their focus on the blue collar market and original take on the product to address said market are unparalleled.

Most competitors produce (portable) bench oscilloscopes. These products have a very similar interface, form factor, and even colour scheme. Also, they are nearly all aimed at the white collar market where performance is the main drive. Tektronix for example operates on that relatively more saturated side of the market as well.

Fluke's main competition is found in Agilent with its wide range of products and in the Chinese brands that produce cheap versions of the scopemeter. Agilent's products are more centrally located compared to Fluke's and Tektronix' positioning and as such seems to form more of a threat to the latter than to Fluke. Chinese brands such as Owon and Hantek, whose product range is comprised of a wide variety of oscilloscopes of which the design features vary highly and are often copied from the high quality brands, manage to produce scopemeters relatively cheap using off-the-shelf components, forming a threat to Fluke.

Fluke's strengths here are quality, their safety rating, and their innovative origin. These strengths need to be exploited to further consolidate Fluke's market position. Of course, Fluke does have to keep up with the developments in performance; they do not have to be ahead but they cannot afford to lag behind either.

Finally, the USB oscilloscope market is an interesting one; one can acquire high performance at a relatively low price, due to not having to incorporate the necessary processing power in the product. Form giving is very basic in this section of the market and seems to have only recently started to change. Some opportunities lay here, though mostly for Tektronix rather than Fluke.

Brands	Design			Type					Performance
	White collar	*Intermediate*	*Blue collar*	*Bench*	*Portable bench*	*Portable*	*Handheld*	*USB*	
Fluke			•			•	•		20 MHz - 200 MHz
Tektronix	•			•	•	•		•	40 MHz - 80 GHz
Agilent (HP)	•	•	•	•	•	•	•	•	20 MHz - 32 GHz
BK Precision	•	•		•	•				20 MHz - 3.5 GHz
LeCroy	•			•					40 MHz - 45 GHz
Owon	•	•	•		•	•	•		20 MHz - 200 MHz
Protek	•	•	•		•	•	•	•	20 MHz - 200 MHz
Metrix	•			•	•				20 MHz - 60 MHz
Extech			•			•	•		5 MHz - 60 MHz
Sencore	•	•		•	•	•	•		80 MHz - 150 MHz
Velleman	•	•				•	•	•	2 MHz - 60 MHz
Voltcraft	•	•	•	•	•	•	•	•	10 MHz - 200 MHz
Instek	•	•		•	•	•	•		5 MHz - 350 MHz
Hitachi	•	•		•	•				7 MHz - 150 MHz
Yokogawa	•			•					200 MHz - 1.5 GHz
Pico	•	•						•	5 MHz - 12 GHz
Hantek	•	•	•		•	•	•	•	25 MHz - 200 MHz
TPI		•	•			•	•		1 MHz - 60 MHz


01
02
03
04
05
06
07
08

Product range

Fluke manufactures electronic test tools including accessories, software and services[12]. The products all have a similar graphic design and are recognisable as Fluke products. The most interesting products will be highlighted and their intriguing features will be described, whether it is a technical, shape or design feature.

Accessories	Digital multimeters	Laser distance meters
Bench instruments	Earth ground testing	Portable oscilloscopes
Biomedical	Electrical testers	Power quality tools
Cable testers	Energy kits	Process calibration tools
Calibration instruments	HVAQ-IAQ tools	Thermal imaging
Clamp meters	Insulation testers	Thermometers
Data acquisition	IR windows	Vibration

01. The *Fluke 233 Remote Display Multimeter* is an interesting product in the sense that Fluke has played around with the area of perception. For the first time it is possible to separate the display from the product and read out values measured by the device from a safe distance. This development comes across as a jump rather than a step, quite unlike Fluke's current development pattern.

02. The *Fluke 810 Handheld Vibration Tester* is the perfect example of a product that fits Fluke's brand values and caters to their target group in a well thought-out manner. The vibration tester does not just provide the user with data; it gives a diagnosis as well. For this to function, Fluke used an extensive database for comparison, which allows the vibration tester to come up with an accurate diagnosis of the problem. This is a precursor of the future of other Fluke products; the ScopeMeter would be a perfect candidate for such a database, though it would be a far more elaborate project and one would have to choose the desired areas of application well.

03. The *Fluke 287 true RMS multimeter* has some interesting design features, such as the clearance/seeping[24] solution in the casing. Fluke products standard have an indented ridge on the casing to create a maze that adheres to both clearance and seeping requirements, but this does not work for the display. Hence the display normally requires an overlap with the casing that adheres to clearance and seeping in combination with special glue. However, the 287 employs a clear plastic inner casing with an overmould where the casing needs to be non transparent. By doing so, the display is no longer a weak spot in the design, though overall one does need more material for the casing.

Another interesting feature of the 287 is the use of an electrically conductive plastic instead of metal sheets to act as shielding material for the circuit board. This conductive plastic cannot function as a heat sink for the processor however, which is necessary for the ScopeMeter.

04. The *Fluke FlexCam TiR4FT Thermal Imager* utilises a very versatile shape. The display and the camera can rotate independently of each other, always allowing the user an optimal view of the display. The shape has one downside: it is not an ambidextrous shape; the user is forced to hold the product with their right hand and operate the buttons with their left hand.

05-07. These Fluke products have been selected due to their interesting form factor, displaying handheld features. The shapes are very straightforward and incorporate a small display for analysing purposes. The *Fluke T+ Electrical Tester* features a probing design to test for electrical parametric data; a design that could be used for signal detection as well. The *Fluke 1LAC-II VoltAlert* uses a conventional pen shape and basic functionality to check for voltage. The *Fluke TI Thermal Imager* series use a handle and a small display to establish an unambiguous design.

08. The *Fluke 1653B Multifunction Tester* builds on a conventional easy-to-hold binoculars shape that can be worn around the neck using a neck strap. The use of such conventions in Fluke products guarantee that the target group will instantly understand how to hold and use the product.

Target group

Fluke self distinguishes three types of customer personalities:

- The artisan;
- The trustee;
- The scientist.

The artisan is a non-communicative type, hands-on, and deals in action. Pride and self-esteem are linked to their mastery of tools.

The trustee is more patient and has a keen eye for detail. The trustee is persevering, serious and patient in their work, but a quiet person who keeps to themselves.

The scientist is creative and self confident; an introspective worker. The scientist is typically more flexible and open to conceptual viewpoints than the artisan.

The blue collar worker

Fluke's product characteristics are clearly mainly aimed at the blue collar worker (the artisan) rather than the white collar worker (the scientist).

The blue collar worker is the industrial and manual worker, who has to perform in dirty, dangerous environments, exposing themselves and their equipment to the harsh circumstances. Fluke's products cater to those circumstances with their rigid safety standards, their colour scheme, easy-to-use interface, materials, portability and ruggedness.

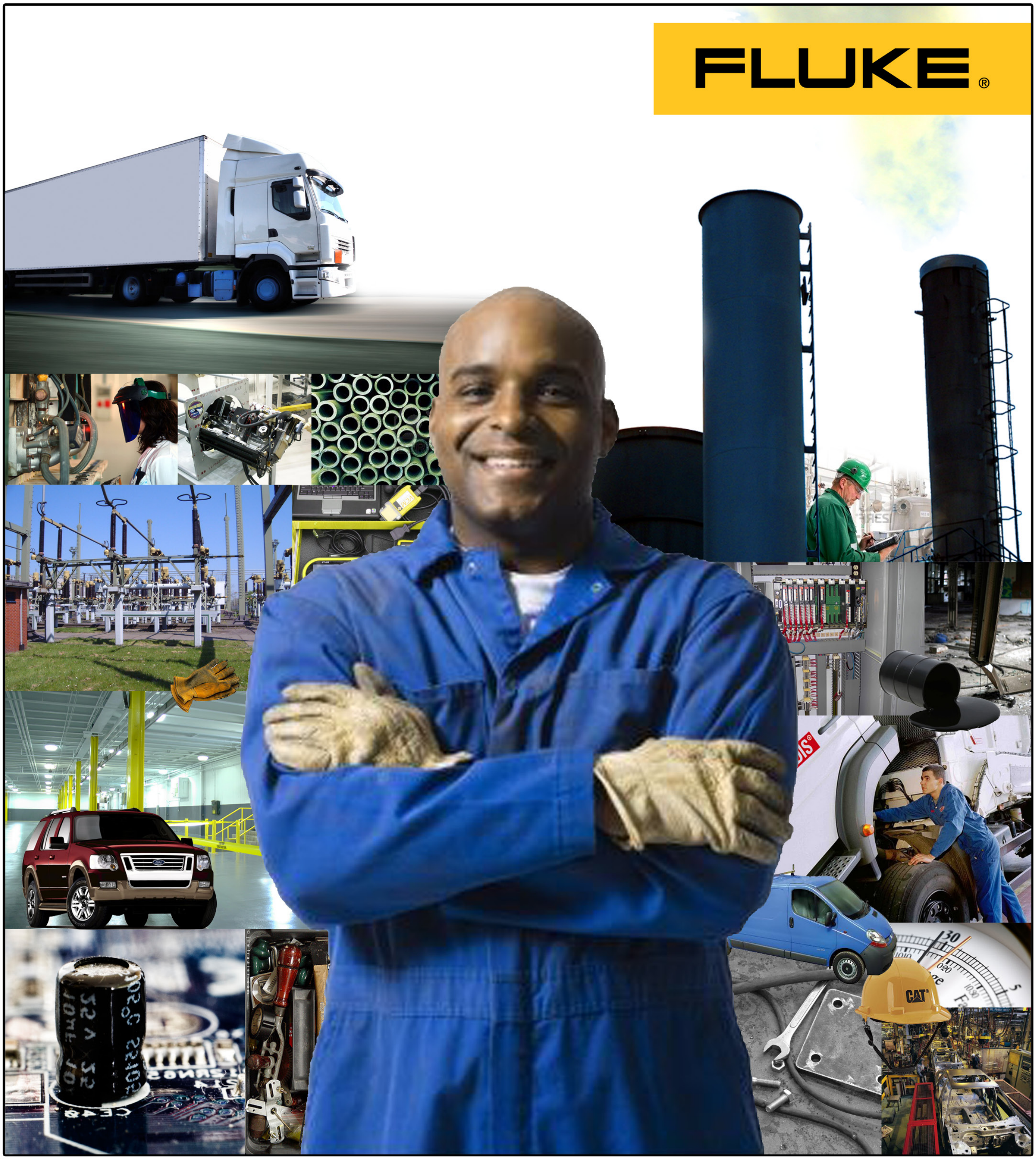
The blue collar worker is a member of the working class, performs manual skilled and unskilled labour, and does not tend to deal with qualms experienced in the white collar business, such as customer interaction. The blue collar worker wears durable clothing that can withstand the dirty environments they are exposed to. Blue collar job positions are mainly male dominated, ranging from age 16 – 65. Refer to appendix E for anthropometric data concerning this target group.

Fluke vs. Tektronix

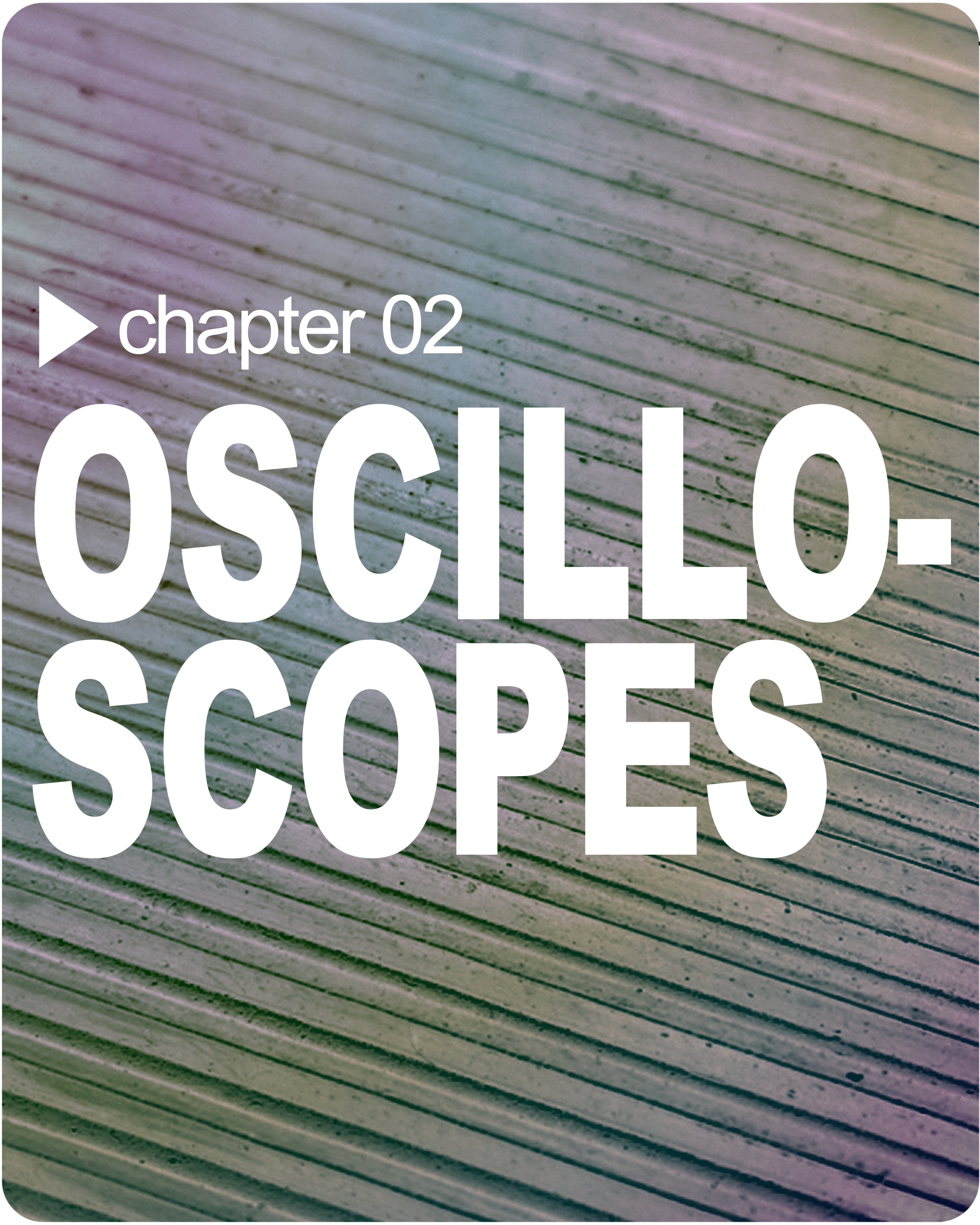
Tektronix is on the opposite side of the scale, catering to the white collar worker, doing office work behind a desk. On the next two pages, visualisations of both brands and their target groups are featured, to act as guideline for the product design. Below, a succinct overview of the differences between Fluke and Tektronix can be located.

	Fluke	**Tektronix**
Design	Rugged Safety	Scientific Performance
Colour scheme	Yellow & grey	White & blue
Purpose	Portable/handheld	Bench/portable
Environment	Industrial Dirty	Office Clean
Target group	Blue collar	White collar
Features	Ease-of-use High CAT IP rating	Performance

White Collar



Blue Collar



chapter 02

OSCILLO-SCOPES

02 | Oscilloscopes

An explanation of the oscilloscope's functionality and origin

Oscilloscope, *[uh-sil-uh-skohp]* *-noun Electricity*

A device that uses a cathode-ray tube or similar instrument to depict on a screen periodic changes in an electric quantity, as voltage or current.

Introduction

Nature around us moves in the form of a sine wave; be it sound, an ocean wave, or the natural frequency of a body in motion. Invisible to the naked eye, these phenomena can be converted into electrical signals by transducers in order to be observed and studied with an oscilloscope. In effect, oscilloscopes enable scientists, engineers, technicians and others to see events and patterns that change over time.

An oscilloscope is an indispensable diagnostic tool for anyone designing, manufacturing or repairing electronic equipment[03,31]. Oscilloscopes have a wide range of users, from a medical researcher using an oscilloscope to measure brainwaves to an automotive engineer using an oscilloscope to measure engine vibrations – the applications are far and wide[02].

In our contemporary, largely digital world, designers still need to step into the analogue domain in order to solve signal integrity problems due to the fact that digital errors often have their roots in analogue signal integrity problems. In such cases an oscilloscope is required to uncover how the digital and analogue signals interact. The oscilloscope can display waveform details, edges and noise, can detect and display transients, and can help precisely measure timing relationships such as setup and hold times.

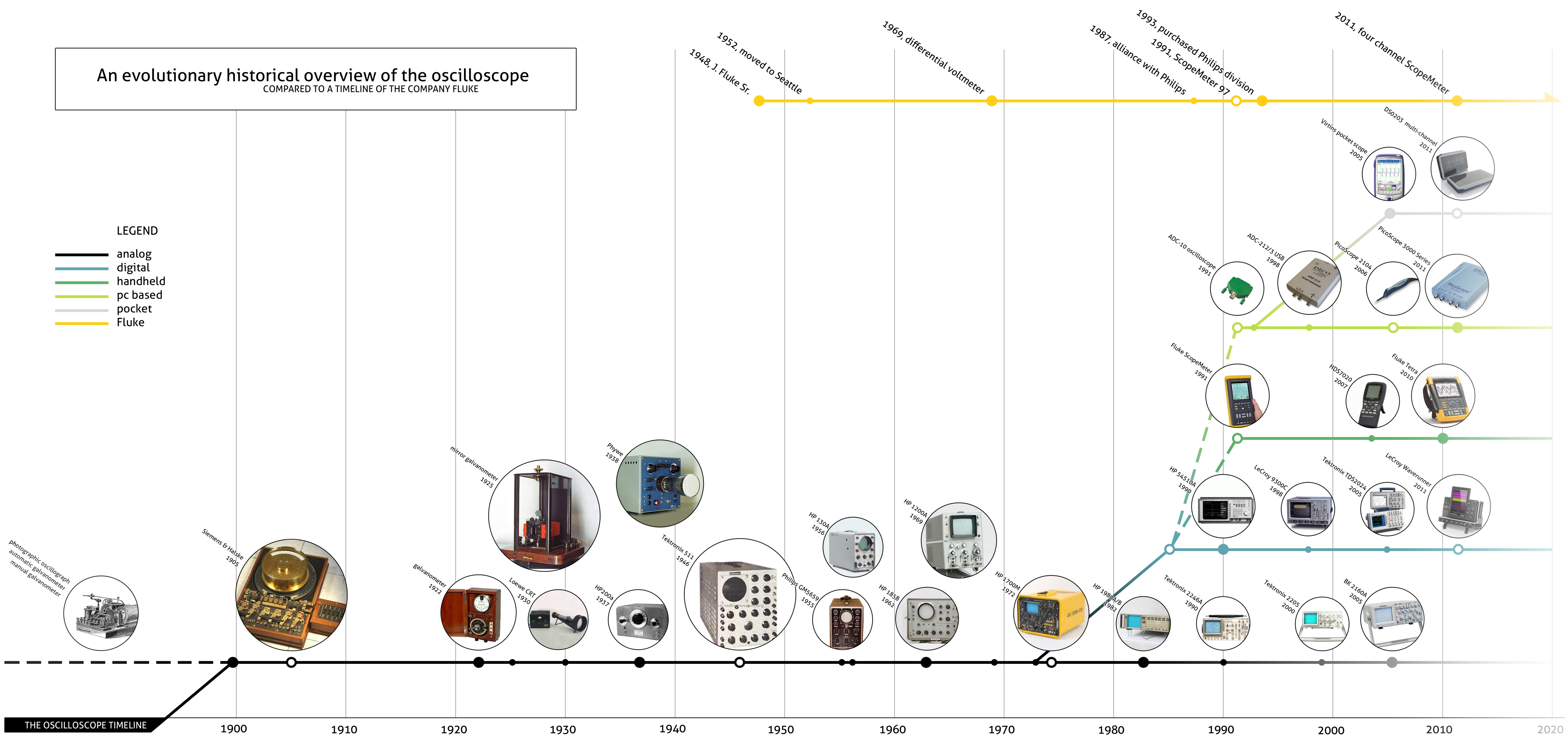
Oscilloscope vs. multimeter

A multimeter tends to be a handheld device that measures features such as voltage, current and resistance. The data gathered is parametric of nature and its relation to time is of a relatively large scale, such as seconds or larger. The data presented by the device is quite straightforward and requires proportionately little understanding.

An oscilloscope measures varying signal voltages; electrical potential differences are plotted over time, on a time scale that is a lot smaller compared to that of a multimeter, think of microseconds or nanoseconds.

To correctly interpret data presented by an oscilloscope, one requires knowledge and training[35]. For example, one has to understand how to manipulate the signal and understand the meaning of the displayed waveforms. Coincidentally, Fluke tries to lower this threshold for the user to make oscilloscope troubleshooting more accessible.

Refer to appendix B for more information regarding oscilloscope and probe functionality.


An evolutionary historical overview of the oscilloscope
COMPARED TO A TIMELINE OF THE COMPANY FLUKE
LEGEND
analog
digital
handheld
pc based
pocket
Fluke
1948, J. Fluke Sr.
1952, moved to Seattle
1969, differential voltmeter
1987, alliance with Philips
1991, ScopeMeter 97
1993, purchased Philips division
2011, four channel ScopeMeter
photographic oscillograph
automatic galvanometer
manual galvanometer
Siemens & Halske
1905
galvanometer
1922
mirror galvanometer
1925
Loewe CRT
1930
HP200a
1937
Phywe
1938
Tektronix 511
1946
Philips GM5659
1955
HP 130A
1956
HP 185B
1962
HP 1200A
1969
HP 1700M
1972
Tektronix 2246A
1990
HP 54510A
1990
LeCroy 9300C
1998
Tektronix 2205
2000
Tektronix TDS2024
2005
BK 2160A
2005
LeCroy Waverunner
2011
Fluke ScopeMeter
1991
HDS7020
2007
Fluke Tetra
2010
ADC-10 oscilloscope
1991
ADC-212/3 USB
1998
PicoScope 2104
2006
PicoScope 3000 Series
2011
Virtins pocket scope
2005
DSO203 multi-channel
2011
THE OSCILLOSCOPE TIMELINE
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

History

Hand drawn oscillograms based on galvanometer readings were the earliest method for representing electrical waveforms. Thereafter methods of (partially) automating this process would appear, such as Jules François Joubert's point-to-point stroboscopic contact method in 1880, or the 1903 Hospitalier Ondograph.

Karl Ferdinand Braun was the first to create a cathode-ray tube (CRT) oscilloscope in 1897, primarily as part of his physics research. It took time before the CRT was commercially viable and as such it was not until the 1920s that CRT oscilloscopes became practical to use[16].

The first dual beam oscilloscope became available in 1937. It was developed by the British company A.C. Cossor Ltd., later acquired by Raytheon. Oscilloscopes saw a lot of development during the Second World War due to their role in RADAR systems, and in 1946 Howard C. Vollum and Jack Murdock invented the triggered oscilloscope. They went on to found Tektronix and became the first manufacturer of calibrated oscilloscopes[19,20].

By the late 1970s transistor components replaced the traditional vacuum tubes, allowing signals to be processed faster, in a larger quantity and at a higher accuracy.

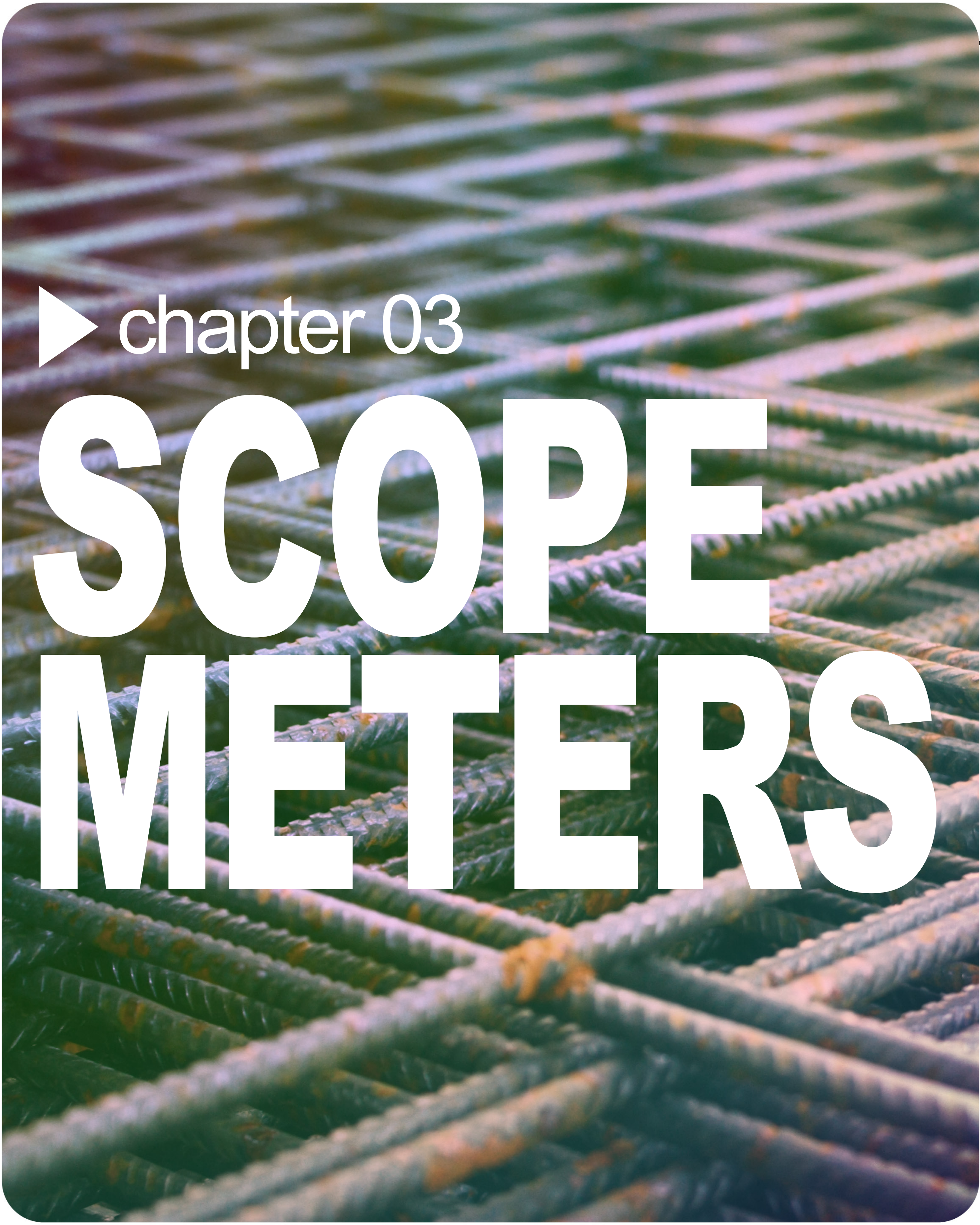
In 1985, the transition was made from analogue to digital when the LeCroy Corporation introduced the first digital oscilloscope. This first digital storage oscilloscope (DSO) was invented by Walter LeCroy, founder of the LeCroy Corporation, after producing high-speed digitisers for the research centre CERN in Switzerland. Digital oscilloscopes soon became prevalent over its analogue predecessor and since 2004 barely any analogue oscilloscopes are still being produced, if any at all.

Fluke's creation, dubbed the ScopeMeter, first saw the light of day in 1991; it was the first of its kind of portable oscilloscopes, a development made possible thanks to advances in display technology.

The year 1991 also saw the release of the first USB oscilloscope by Pico. USB oscilloscopes were able to reduce the price by making use of the processing power of the computer it is connected to. Since 2002, due to the price factor of USB oscilloscopes and its compatibility with standard (household) computers, the USB oscilloscope has become very popular amongst hobbyists and education facilities.

In 1998 Tektronix had a scoop with the introduction of the first digital phosphor oscilloscope (DPO); a digital oscilloscope that effectively emulates the persistence of analogue phosphor traces. The DPO is the latest in line of developments with regards to digital oscilloscopes.

The adjacent page features a timeline of the oscilloscope's development, set off against Fluke's main corporate developments. Refer to appendix B for a product phase analysis[04].



chapter 03

SCOPE METERS

03 | Scopemeters

Specifics about portable oscilloscopes

ScopeMeter test tools combine the high performance of a bench oscilloscope with the rugged portability of a Fluke Digital Multimeter to take you into territory other scopes cannot go - where it is harsh, hazardous and dirty.

120 series

190 series

225/215 series

125 series

190 medical series

199 x-ray series

Scopemeters

Scopemeters are essentially portable oscilloscopes that include multimeter functions and usually also a recording feature[22]. Their development has been stimulated through the combination of technological advances of displays and the need of the user to have access to a portable oscilloscope for troubleshooting the ever expanding and more complex electrical networks[05].

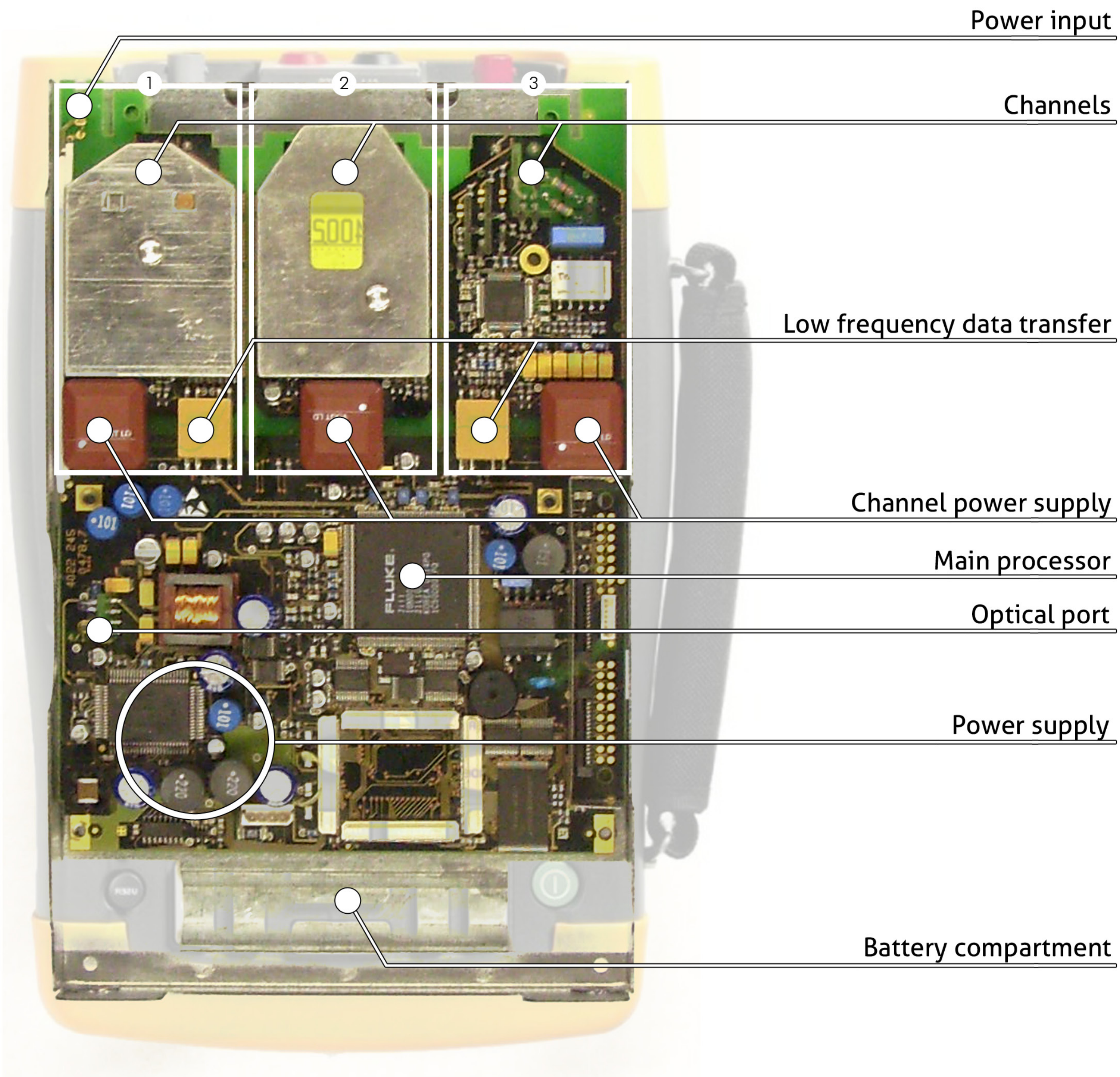
Portable does not necessarily mean handheld; the weight of the device puts quite a strain on the user. However, as opposed to bench oscilloscopes that require an external power source, the scopemeter runs on battery power, allowing the user to carry the scopemeter on their service route and use it in small spaces.

Since the development of their first scopemeter in 1991, Fluke now features a variety of scopemeters in their product range (refer to appendix B for Fluke ScopeMeter designs throughout the years). An overview of Fluke's current assortment of scopemeters:

- Fluke 120 Series Oscilloscope
  - *Industrial electro-mechanical and electrical systems troubleshooting.*
- Fluke 190 Series Oscilloscope
  - *Wide bandwidth oscilloscope for industrial or electronic equipment field service and maintenance.*
- Fluke 225/215 Series Oscilloscope
  - *Industrial network physical layer signal integrity test.*
- Fluke 125 Series Industrial Oscilloscope
  - *Industrial network physical layer signal integrity test.*
- Fluke 190 Medical Series Oscilloscope
  - *Medical imaging systems installation and troubleshooting.*

Fluke targets many different markets and tries to enter new ones where they see fit; the network division is a prime example thereof. The X-ray medical series is an interesting one; Fluke has changed their recognisable Fluke colours for the 199 X-ray series to better fit the Fluke Medical branch, though the shape is clearly still unique for a Fluke product - in particular the indentation at the top.

Currently the components of both the 120 series and the 190 series are becoming obsolete and require replacement; Fluke invests cash in this development. As such these two series will be the focus of attention during the project.



Power input
Channels
1
2
3
Low frequency data transfer
Channel power supply
Main processor
Optical port
Power supply
Battery compartment

Fluke ScopeMeter design specifics

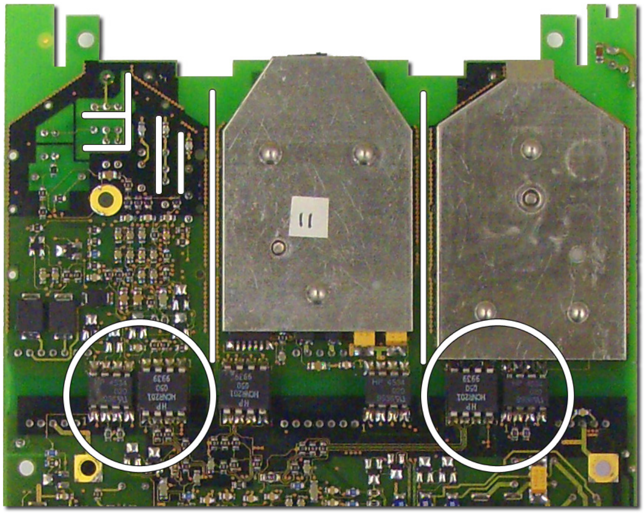
After establishing the development of the market and general functionality of the product it is time to take a closer look at Fluke's scopemeters; the ScopeMeter 196B will be scrutinised in particular (see the bottom image[42]). With the scopemeter 196B's relatively large size of 256 x 169 x 64 mm and weight of two kilograms, the product is portable but not easily handheld. For comparison: the ScopeMeter 123 comes in at 232 x 115 x 50 mm and weighs 1.2 kgs.

The functionality, interface, materials, colour application, and safety standards will be reviewed in this section.

Functionality

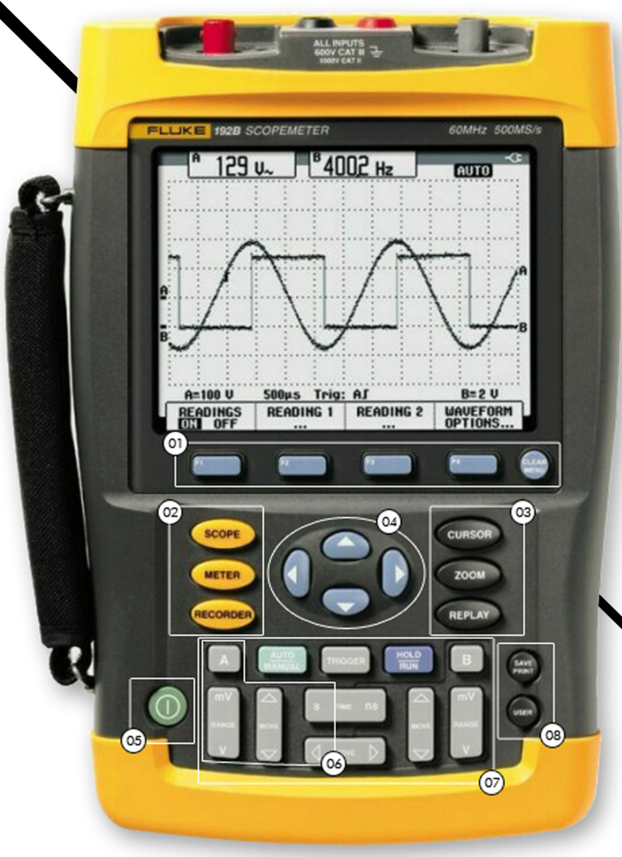
The circuit board of a digital scopemeter shows a clear separation between the main processor and the channel inputs. The inputs are listed as numbers one to three in the image on the adjacent page, taken of the bottom side of the ScopeMeter 196B's circuit board. Numbers one and three are oscilloscope inputs, number two is the multimeter input.

The input of each channel is shielded with an aluminium casing and there is a physical so-called galvanic isolation in the form of a straight narrow cut in the circuit board between each channel as well (see the top right image). Each channel is connected to the rest of the



circuit board via a power supply and a signal converter; the low and high frequency signals need to be relayed to the rest of the circuit board and of course the probes require power to operate. The opto-couplers, the components that take care of high frequency data transfer within the galvanic isolation, are located on the top side of the circuit board (these are circled in the image above). In its entirety, this particular isolation offers opportunities for new concepts[38].

The battery in the ScopeMeter 196B is a 7.2 volts 3,600 mAh 450 grams nickel-metal hydride battery (NiMH), creating an effective battery life of four hours in this product. For reference: the battery in the ScopeMeter 123 is a 4.8 volts 2,000 mAh 250 grams nickel-metal hydride battery, creating an effective battery life of seven hours. The choice in rechargeable battery packs for electrical testing equipment is between NiMH and lithium-ion, considering that NiCd is no longer allowed for use in any product besides electric drills. Lithium-ion has a higher energy density and a lower self-discharge rate than NiMH. The higher self-discharge rate of NiMH batteries is not really a problem for heavy-duty use, but the user may perceive the faster discharge as a disadvantage, especially considering the fact the scopemeter is not a frequently used product and the user may not check battery power that often.


FLUKE 192B SCOPEMETER
60MHz 500MS/s
READINGS ON OFF
READING 1
READING 2
WAVEFORM OPTIONS...
SCOPE
METER
RECORDER
CURSOR
ZOOM
REPLAY
HOLD RUN
TRIGGER
01
02
03
04
05
06
07
08


FLUKE 123 INDUSTRIAL SCOPEMETER
20 MHz
A COM B
227,3
AUTO
HOLD RUN
SCOPE MENU
AUTO
USER OPTIONS
SAVE PRINT
01
06
05

Interface[06,30]

The buttons on the ScopeMeter are fairly large, as are all its features: this is to accommodate to users wearing work gloves on top of electrical safety gloves while operating the ScopeMeter (see images below). The colour palette for the buttons is a soft one, as to not distract the user too much during use.

Buttons

The button interface (see the image on the adjacent page) relies on Gestalt principles for interface design[23]. For instance, it is clear that most sections are grouped by proximity, as is the case with no. 01, 02, 07 and 08. In case of no. 04 the addition of common fate implies a movement in a certain direction that will be translated onto the display; this is further amplified by the extruded mid-section on the casing. The particular use of colour and button shape suggests similarity and aids the proximity principle. The use of symmetry in the design makes it appealing and clear to look at, but also aids in separating functions.

In case of no. 06 and 07, one can see grouping by proximity, but the figure-ground plays a role in separating the two groups into input A and input B. As can be seen, this effect is achieved by slightly indenting the surface of the casing as well as changing the texture of said surface to suggest similarity.

Another specific feature can be seen with no. 05: the power button. This button has been placed so its surface is level with the surface of the casing, prohibiting the user from accidentally pressing the button and turning off the device. This is a feature that is often seen in remotes and game controllers.

Overall, the buttons do not protrude outside of the protective outline of the casing; this shields the buttons from damage and prevents buttons from unintentionally being pressed.

Display

All input from the buttons is displayed on a 144 mm full-colour LCD screen with backlight. Most of the principles seen in the button layout are also reflected in the display, though there seem to be some inconsistencies with translating the actions of the user onto the display.

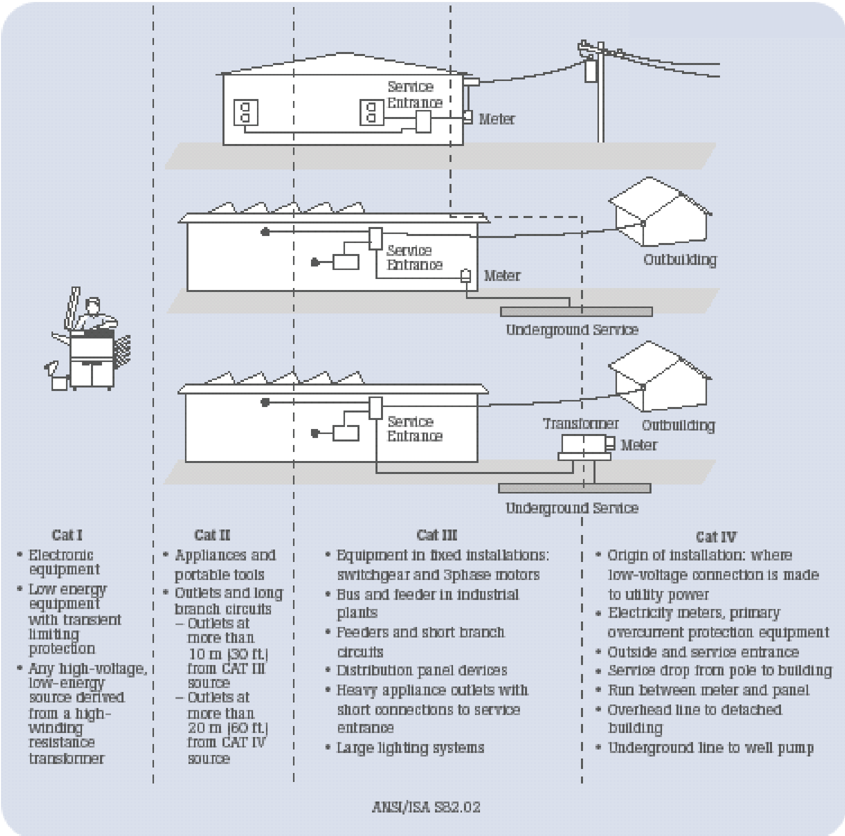
One issue with the interface is that the point of perception and manipulation do not overlap; the user needs to divide their attention between the probes on the electrical circuit and the display. The ScopeMeter does have a strap that can be fitted on either side of the product to allow the user to hold the product in their hand to perform quick measurements and keep the point of perception and manipulation as close as possible, but this is far from an ideal solution.

Materials

The colours that make up the Fluke appearance have been well established in the company's graphic design guidelines. The Fluke yellow Munsell 9YR 7.36/14.6 for its rubber overmoulds are well recognised by its user group. In some cases Fluke deviates from this standard, as is the case with some biomedical products such as the 199XRay Medical Scopemeter, where the typical yellow overmould is replaced by a white one.

The material of the casing is made up of the combination of the elastomer ABS (acrylonitrile butadiene styrene) and polycarbonate (PC) with a V0 fire rating, as indicated by the PC/ABS/V0 marker. It is a very strong material and fire retardant as well, suitable for extreme use. The material has a textured finish and is coloured grey, most likely to appeal to the rugged character of the brand.

The material of the overmould is thermoplastic polyurethane (TPU) with a matte finish. This material is flexible, can withstand wear and tear, has an excellent UV resistance and can withstand exposure to oil based products: all



CAT safety rating overview[43]

vital for use in a harsh industrial environment.

Another interesting design feature to mention is the minimisation of usage of screws on the exterior of the product. This is to lessen chances of getting snagged on wires or other protruding items, it reduces buildup of dirt, and it creates a cleaner look.

Safety standards

Electrical equipment for measurement, control and laboratory use have to adhere to safety requirements as described in the IEC 61010-1 Safety Standard[24,25]. One specific point in the Standard states that:

"Multimeters and similar devices may not be the source of any danger whatsoever, regardless of the utilized combination of specified input voltages, function settings and range selections. The term danger includes electrical shock, fire, sparking and explosion. Conformity is substantiated by means of the following test: The highest specified, rated voltage for any of the device's functions is applied to each pair of terminals, one after the other, in every possible function and range combination. ... No danger may occur either during or after the test."

The following four categories have been established in accordance with the IEC 61010-1 Safety Standard, see the image on the adjacent page[43] for its contextual application.

- CAT I
  Category one pertains to measurements in electrical circuits which are not directly connected to the mains, but rather to batteries and the likes.

- CAT II
  The second category pertains to measurements in electrical circuits which are directly connected to the low-voltage mains via plug, such as in household, office and laboratory applications.

- CAT III
  Category three pertains to measurements in building installations: stationary consumers, distributor terminals, and devices connected permanently to the distributor.

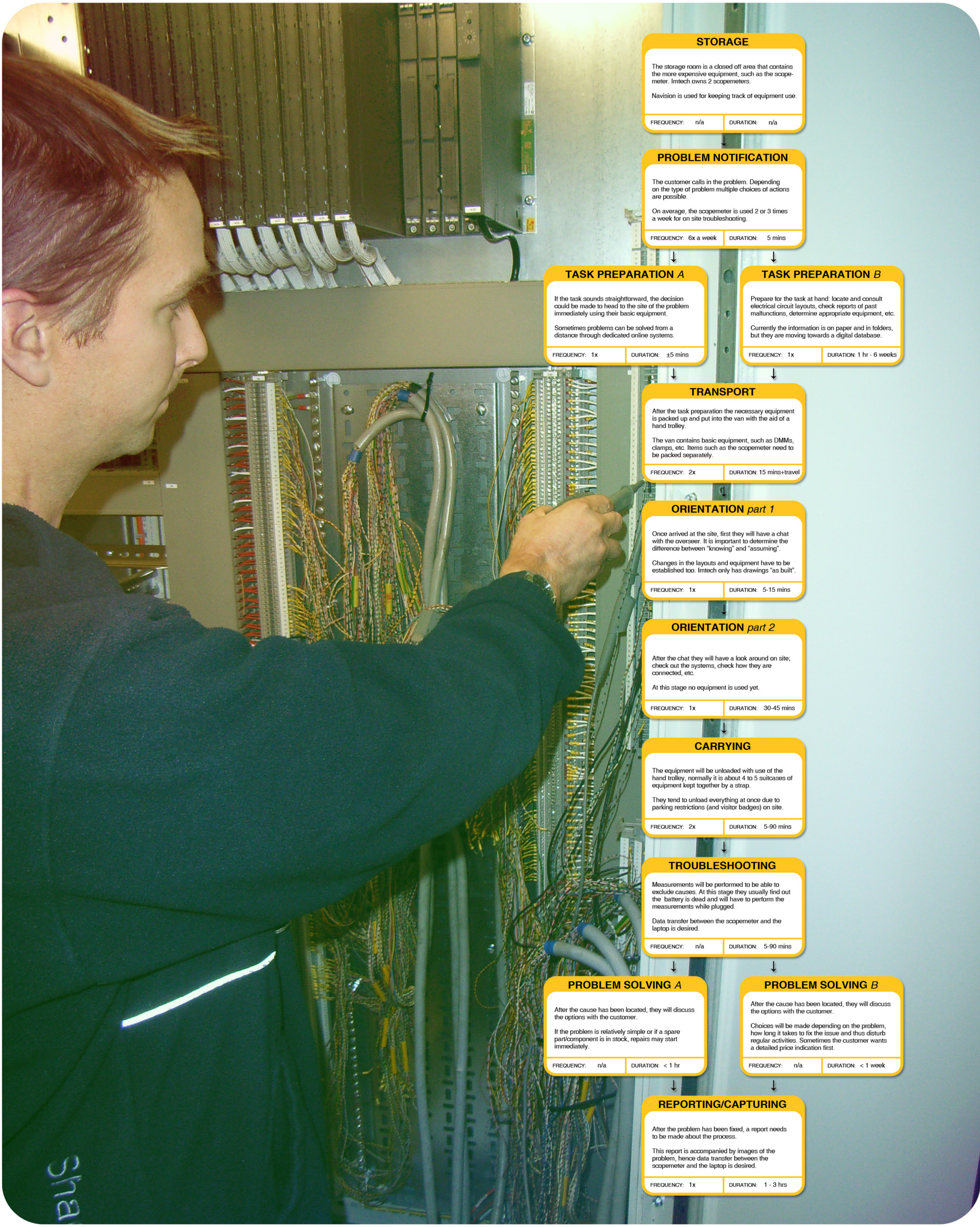
- CAT IV
  The final category, category four, pertains to measurements at power sources for low-voltage installations: meters, mains terminals, and primary over-current protection devices.

These safety categories translate into design features for the product, for instance CAT III dictates a clearance and seeping distance of at least 8 mm and CAT IV dictates a clearance and seeping distance of at least 16 mm.

On top of the above safety categories, it is common for professional electrical equipment to contain an IP rating. This International Protection Rating consists of the letters IP followed by two digits and an optional letter. As described in the international standard IEC 60529, this rating classifies the degree of protection provided against the intrusion of solid objects, dust, accidental contact and water.

In case of the ScopeMeter's IP55, the first digit indicates that the product is dust protected and the second digit indicates that the product is protected against water jets from intruding the interior.

Fluke distinguishes itself from other brands through its rigorous safety ratings, no other brands live up to the high standards Fluke has set for its products. Safety is an important selling point for Fluke products; the next step would be to enhance the perception of safety by displaying this characteristic more explicitly in the design. Considering Fluke's sales are catalogue based, this would be a beneficial move.



STORAGE

The storage room is a closed off area that contains the more expensive equipment, such as the scope-meter. Imtech owns 2 scopemeters.

Navision is used for keeping track of equipment use.

FREQUENCY: n/a | DURATION: n/a

PROBLEM NOTIFICATION

The customer calls in the problem. Depending on the type of problem multiple choices of actions are possible.

On average, the scopemeter is used 2 or 3 times a week for on site troubleshooting.

FREQUENCY: 6x a week | DURATION: 5 mins

TASK PREPARATION *A*

If the task sounds straightforward, the decision could be made to head to the site of the problem immediately using their basic equipment.

Sometimes problems can be solved from a distance through dedicated online systems.

FREQUENCY: 1x | DURATION: ±5 mins

TASK PREPARATION *B*

Prepare for the task at hand: locate and consult electrical circuit layouts, check reports of past malfunctions, determine appropriate equipment, etc.

Currently the information is on paper and in folders, but they are moving towards a digital database.

FREQUENCY: 1x | DURATION: 1 hr - 6 weeks

TRANSPORT

After the task preparation the necessary equipment is packed up and put into the van with the aid of a hand trolley.

The van contains basic equipment, such as DMMs, clamps, etc. Items such as the scopemeter need to be packed separately.

FREQUENCY: 2x | DURATION: 15 mins+travel

ORIENTATION *part 1*

Once arrived at the site, first they will have a chat with the overseer. It is important to determine the difference between "knowing" and "assuming".

Changes in the layouts and equipment have to be established too. Imtech only has drawings "as built".

FREQUENCY: 1x | DURATION: 5-15 mins

ORIENTATION *part 2*

After the chat they will have a look around on site; check out the systems, check how they are connected, etc.

At this stage no equipment is used yet.

FREQUENCY: 1x | DURATION: 30-45 mins

CARRYING

The equipment will be unloaded with use of the hand trolley, normally it is about 4 to 5 suitcases of equipment kept together by a strap.

They tend to unload everything at once due to parking restrictions (and visitor badges) on site.

FREQUENCY: 2x | DURATION: 5-90 mins

TROUBLESHOOTING

Measurements will be performed to be able to exclude causes. At this stage they usually find out the battery is dead and will have to perform the measurements while plugged.

Data transfer between the scopemeter and the laptop is desired.

FREQUENCY: n/a | DURATION: 5-90 mins

PROBLEM SOLVING *A*

After the cause has been located, they will discuss the options with the customer.

If the problem is relatively simple or if a spare part/component is in stock, repairs may start immediately.

FREQUENCY: n/a | DURATION: < 1 hr

PROBLEM SOLVING *B*

After the cause has been located, they will discuss the options with the customer.

Choices will be made depending on the problem, how long it takes to fix the issue and thus disturb regular activities. Sometimes the customer wants a detailed price indication first.

FREQUENCY: n/a | DURATION: < 1 week

REPORTING/CAPTURING

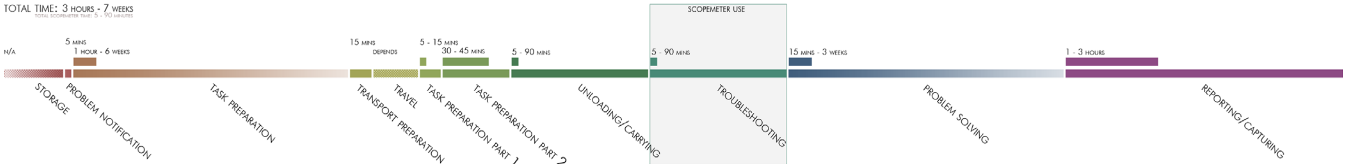
After the problem has been fixed, a report needs to be made about the process.

This report is accompanied by images of the problem, hence data transfer between the scopemeter and the laptop is desired.

FREQUENCY: 1x | DURATION: 1 - 3 hrs

04 | User research

Acquire insight into the user experience and product use



User research

To acquire a better insight into the use of the scopemeter and the process surrounding its use[33,34], user research was conducted with an employee of Imtech Vonk at Coevorden.

Imtech Vonk[26] is an engineering and contracting company specialised in the oil and gas industries as well as other high grade industries, with the main focus on electrical, control, automation and power electronics. Imtech Vonk is a prime example of a Fluke customer.

The meeting was structured using the following main steps:

01. Explain the purpose of the visit;
02. Map the current procedures with the aid of CUTA cards[07];
03. Discuss opportunities, ideas and problems;
04. Use endowed props to explore concept directions and acquire feedback[08].

A complete report of the visit can be located in appendix A[37]. The key points will be reiterated here.

CUTA session

The CUTA session helped identify all stages surrounding the task of troubleshooting. The result can be seen on the adjacent page.

One thing that stands out after mapping the sequence of events is the very narrow window in the troubleshooting process during which the scopemeter is actually used. This is expected, since the scopemeter is merely a tool, but its high price and effects thereof should not be overlooked.

As displayed at the top of this page, the troubleshooting process takes between 5 and 90 minutes, out of a process that can take anywhere between 3 hours and 7 weeks.

This leaves a lot of opportunities to better integrate the scopemeter into the process of troubleshooting, which suits Fluke's blue collar target group perfectly. One could think about aiding in the reporting process by facilitating communication between Fluke products and peripheral devices or by creating an augmented reality application that aids in pinpointing possible issues, to just name a few.

Parametric vs. signal

As expected, signal analysis plays but a small role in the entire troubleshooting process. Multimeters are the first piece of electrical testing equipment used. Scopemeters come into play with electrical power systems, such as electrical motors and generators. In practice the scopemeter is used about two or three times a week.

The scopemeter is too expensive to be part of the basic equipment of Imtech employees, such as multimeters or clamps. As a result, the scopemeter is shared amongst multiple users, leading to issues with settings and recharging the battery.

Safety issues

Due to issues with recharging, the scopemeter is often plugged in while performing the measurements. This negates the safety aspect of the scopemeter.

Most of the electrical systems they work with have failsafes; the electronics are embedded in metal housings and refuse to turn on as long as the door or hatch is opened. Employees tend to circumvent this by forcing open the door, by guiding the wires through vents or by taping off the fail safe. It would be preferable to perform the measurements from the safety of an operator room without having to circumvent safety measures.

Storage
01. Arriving on location
02. Assessing the situation
03. Unpack required equipment
04. Start measuring
05. Connect probes
06. Monitor from operator room
Storage

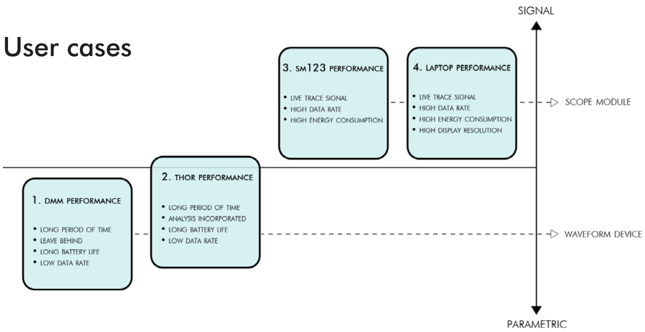
Scenario

A succinct use scenario was created as a derivative of the user research conducted at Imtech. The use scenario focuses purely on use of the product, to act as a reference during the idea generation phase.

Use of the product has been condensed into six consecutive steps, refer to the adjacent page for a visualisation:

01. Arrive at the location;
02. Assess the situation - at this stage no equipment is utilised;
03. Unpack the required equipment, this is determined by the location, the nature of the error, and the person's expertise;
04. Start measuring to exclude problems - first with a DMM, then if required: with a scopemeter;
05. Place the probes in such a way that measurements can be performed from a safe location and without tripping the fail safe (e.g. through the vents, or by forcing open the door);
06. Perform measurements from the safety of the operator room and be able to make changes to the system.

User cases



Based on the research four different user cases can be identified. User cases one and two revolve around the employee who is performing maintenance in the factory. On his rounds he will check varied equipment repetitively and regularly. User cases three and four revolve around more specialised electrical troubleshooting, requiring more expertise for accurate signal interpreting.

01. DMM performance:

- *The product should remain functional for months, only operating for brief moments at a time;*
- *As a result a long battery life is desired;*
- *The user is presented with raw data;*
- *The data is parametric, thus the data rate is very low;*
- *The product should be cheap so it can be left behind.*

02. Thor performance:

- *The product should remain functional for months, only operating for brief moments at a time;*
- *As a result a long battery life is desired;*
- *The user is presented with processed data; the product does part of the signal interpreting, making it easier for the user to comprehend;*
- *The data is mostly parametric, except for the occasional triggered snapshot, thus the data rate can be relatively low;*
- *The product should be cheap so it can be left behind.*

03. SM123 performance:

- *A live trace signal needs to be displayed;*
- *As a result the data rate is very high;*
- *The power requirements are a lot higher as well;*
- *The price will be rather high.*

04. Laptop performance:

- *A live trace signal needs to be displayed;*
- *As a result the data rate is very high;*
- *The power requirements are a lot higher as well;*
- *The price will be rather high;*
- *The high resolution screen requires more data points, be it in the form of more data or of clever processing.*

Conclusions

Forming the basis for the idea generation phase

The analysis puts forth key points, opportunities and issues that need to be kept into account or otherwise addressed; a comprehensive list will follow.

General:

- The point of perception and manipulation are separated (probes and display), ideally they should be in the same area of attention[09] (refer to appendix B for more information);
- The majority of problems encountered are related to the life span and durability of electrical components and thus can be predicted;
- On site, the most common space available to place electrical equipment is on or around the metal doors and structure. Thus the most versatile method of holding or placing a piece of electrical equipment is by use of a (permanent) magnet;
- The scopemeter is used in an extensive process of troubleshooting, which from beginning to end could take anywhere between 3 hours and 7 weeks, of which the scopemeter is employed between 5 and 90 minutes. There are a lot of opportunities to better integrate the scopemeter in this entire process;
- The ability of Fluke products to communicate with peripheral devices such as laptops is rather poor and needs improvement;
- There could be a demand for a cheap scopemeter or an integrated scope feature on a multimeter (< €800.-), although this needs to be researched more carefully.

Power:

- Continued battery power after not using the product for a period of time is an issue;
- The scopemeter is an expensive piece of equipment, often shared amongst employees. As such the responsibility of charging is often passed on to others resulting in a flat battery;
- It could be possible to power the scopemeter using the DUT.

Display:

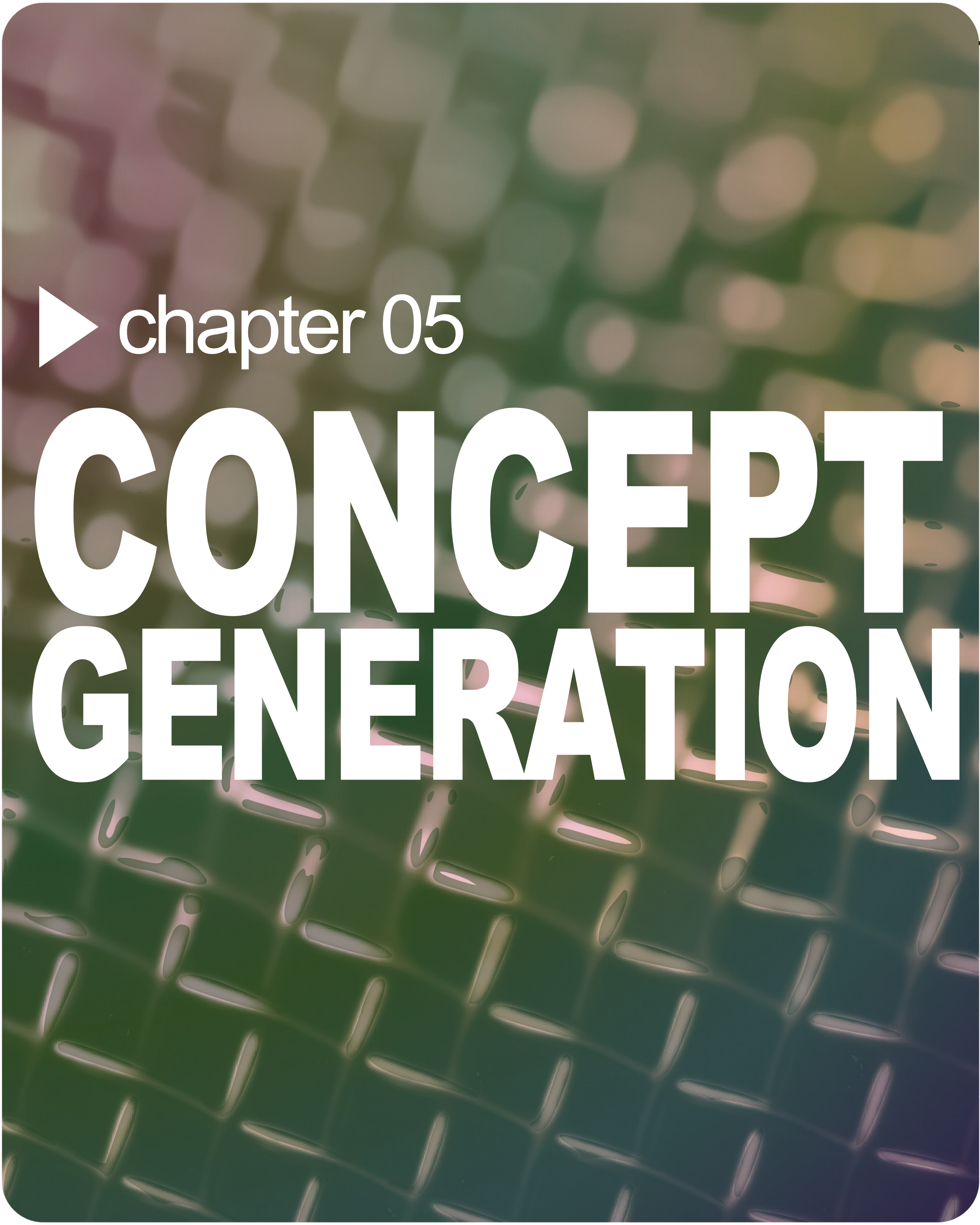
- The size of the screen suffices for the task, zooming however demands a fair share of the user's time and could use improvement;
- Cutting down costs is always desirable; one could achieve this by allowing the product to adapt more readily to changes on the market (particularly the display).

Wireless:

- The majority of electrical housing contains a fail safe that shuts down the system when the doors are open(ed). However, for access to the system this needs to be circumvented. All electrical housing has vents that allow wires to be put through them or a transmitter to be placed behind them.

Brand/product direction:

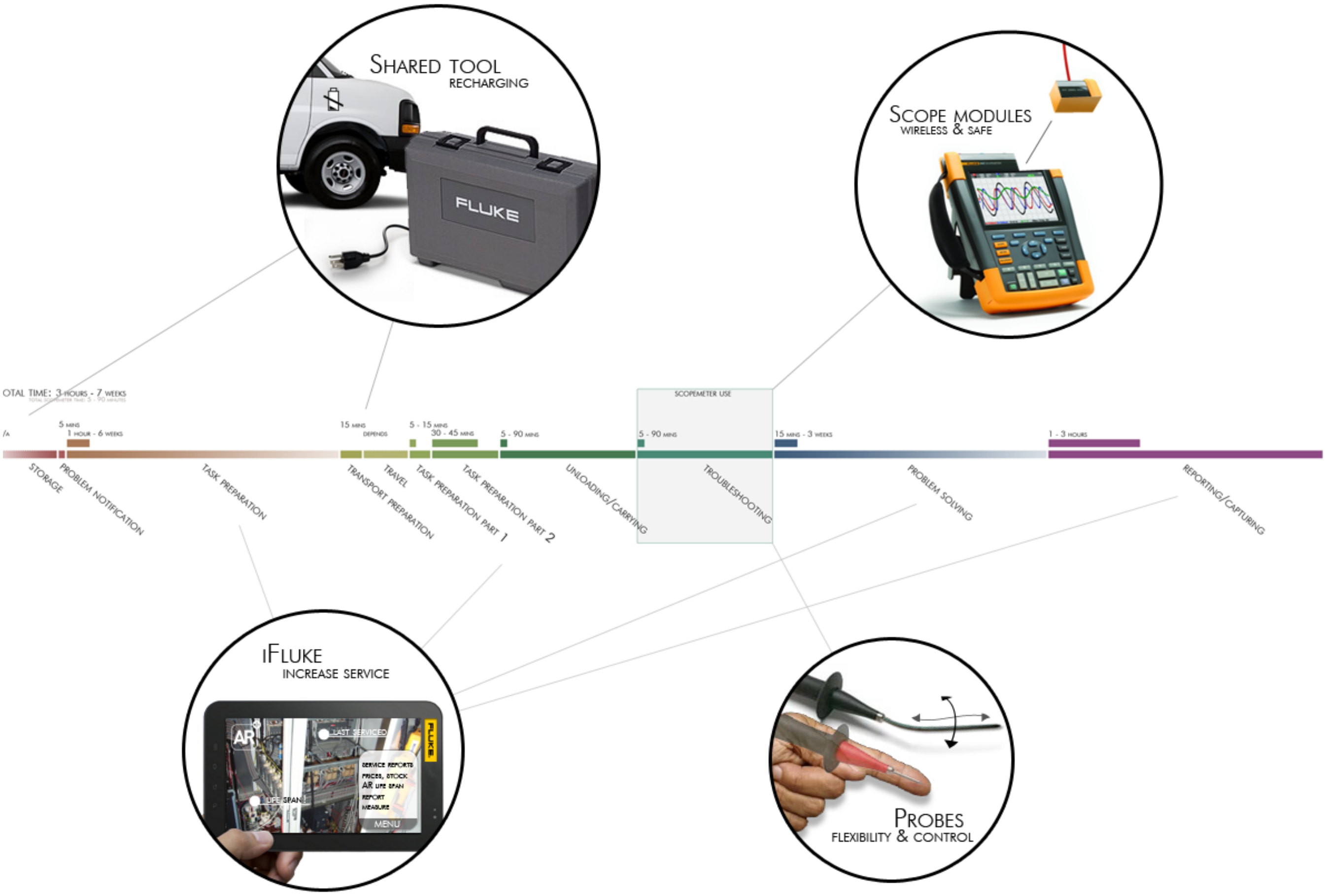
- While the product is portable, its handheld aspect requires improvement;
- The blue collar experience of the target group and Fluke as a brand need to be held into account, one could consider simplifying the diagnostic purposes or catering to problem solving in specific niches;
- Safety is one of Fluke's key brand values and selling points, by making this aspect explicit in the design Fluke could create a lot of goodwill and distinguish from other brands;
- Fluke's willingness towards radical changes is relatively low, so it would be wise to lay out a path of small incremental changes or to appeal to Danaher instead;
- Steering towards a shared investment dedicated scope module between Tektronix and Fluke would be ideal considering the shared development and production costs;
- Modularity in the product would enhance the profit margin, considering the specific nature of the product and thus relatively low sales figures;
- Creating a cheap model aimed at educational purposes could help establish customer loyalty;
- Danaher holds a large portion of the electrical measurement market: they could push for new standards and protocols.



chapter 05
CONCEPT GENERATION

05 | Concept generation

Conception of ideas based on research



Concept generation

The conclusions that followed the conducted research form the basis for the concept generation phase. The user research in particular forms a good starting point for a general assessment of the opportunities.

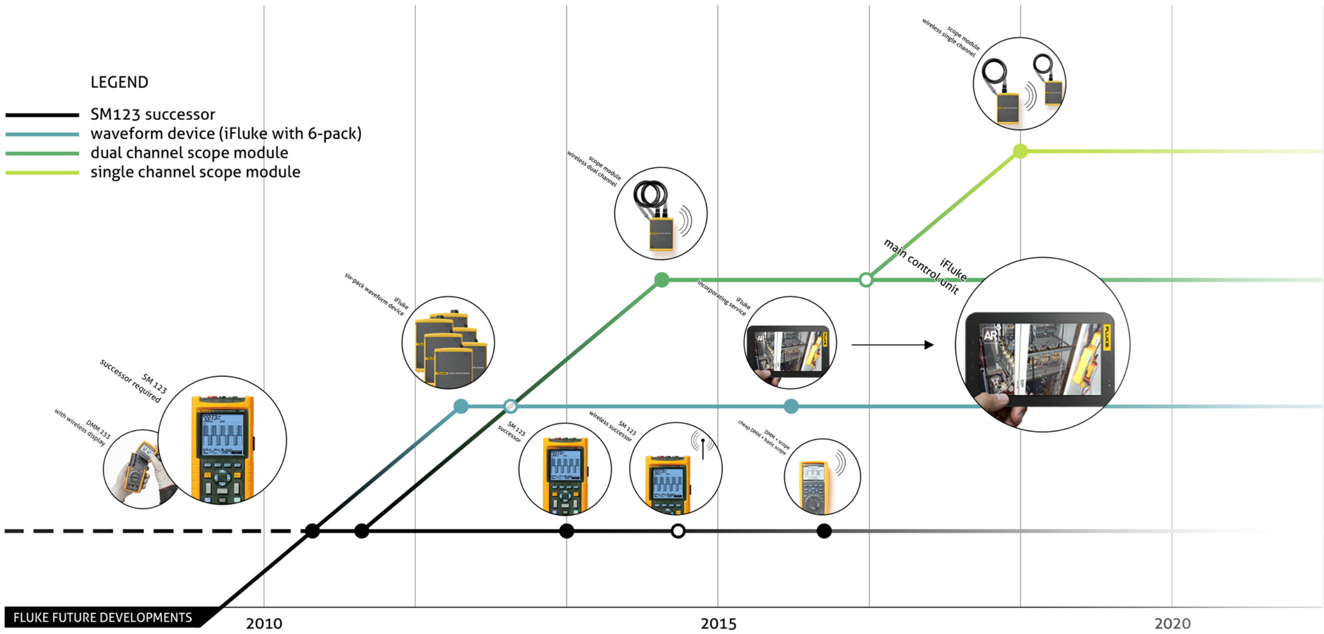
A timeline of the complete process of troubleshooting has been created; the shaded area is the actual use of the scopemeter. It is clear the scopemeter is indeed nothing more than an expensive tool, which leaves opportunities to better integrate the scopemeter in the process.

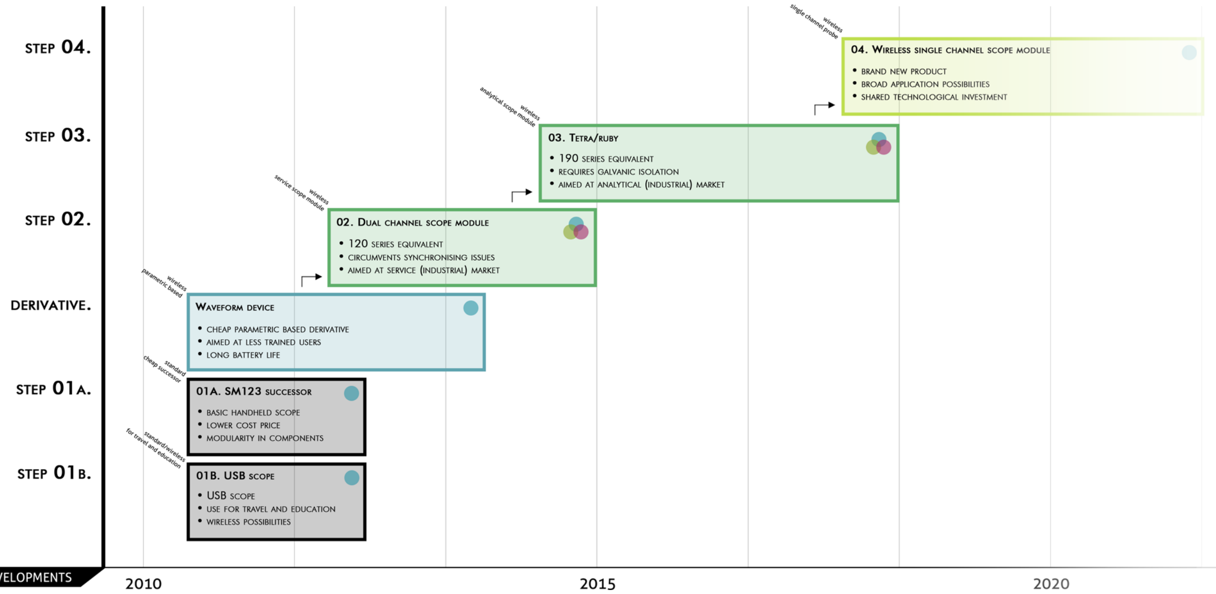
For instance, due to its price the scopemeter is often shared amongst employees, creating problems with recharging. This could be addressed by incorporating the charger into its carrying case for example.

The wireless scope module is a direction with a broad spectrum of possibilities and a lot of opportunities regarding shape and control that need to be explored. This direction ties in with probe form factor opportunities.

Of course, the bulk of the opportunities lie in the area of service; assisting the user in every stage of the process and making the product more accessible is the next major step to take for Fluke. Refer to appendix B for a visualisation of the ideal situation.

An overview of potential future developments for Fluke





Scope module and waveform device

The wireless scope module direction knows two distinctly different tracks; a (mainly) parametric based one, from now on referred to as 'waveform device', and a signal based one, from now on referred to as 'scope module', as displayed on the adjacent page. The waveform device is in line with the previously determined first two user cases, while the scope module is in line with the previously determined last two user cases.

The direction that will be pursued within the confines of this project is the wireless scope module (refer to appendix C for product architecture ideas). The ultimate goal is to create a single channel wireless scope module, though such a feat would require a substantial amount of research, in particular with regards to syncing the wireless signals.

As an intermediate step, one could circumvent the synchronisation issue by creating a scope module that houses multiple channels, synchronising them internally in the same fashion as the current scopemeter 120 series does. A dual channel module seems the most likely option (or perhaps even a triple channel module). One does have to keep in mind that multiple of these modules still cannot sync up with each other wirelessly, and thus it should be avoided to display them on screen at the same time.

However, one could choose to connect them to each other via a wire to allow them to synchronise. A major downside of this however is that all the channels that are linked will share the same ground, which can turn a simple measuring error in a costly mistake.

Progression

Small incremental steps that lay the foundation for a solid product family are most appealing to Fluke. To this end the scope module's progression needs to be scrutinised. At the bottom of this page a visualisation hereof can be found[40].

The steps ensure that investments can be spread out over a long period of time at a smaller risk, because each step can be evaluated on the market and the decision to pursue the next step and the speed to pursue it at can be decided there and then.

The visualisation tries to place these steps on a timeline in terms Fluke can relate to. The steps will be explained briefly below:

- **Step 1a.**

The components of the Fluke ScopeMeter 123 are close to becoming obsolete, hence a successor is required. The aim is to create a successor at a reduced cost price. This step aims to create a design that keeps future developments in mind; i.e. keep future functionality into account.

- **Step 1b.**

The same technology used for the successor of the ScopeMeter 123 can be used to create an USB version, assuming modularity is built-in.

- **Step 2.**

The next step is to leverage the modular technology from the previous step to incorporate wireless communication, creating a wireless scope aimed at the industrial service market. This opens up opportunities, as indicated by the three circles, namely: it can be an accessory, integrated in the design, or it can be a detachable component.

- **Step 3.**

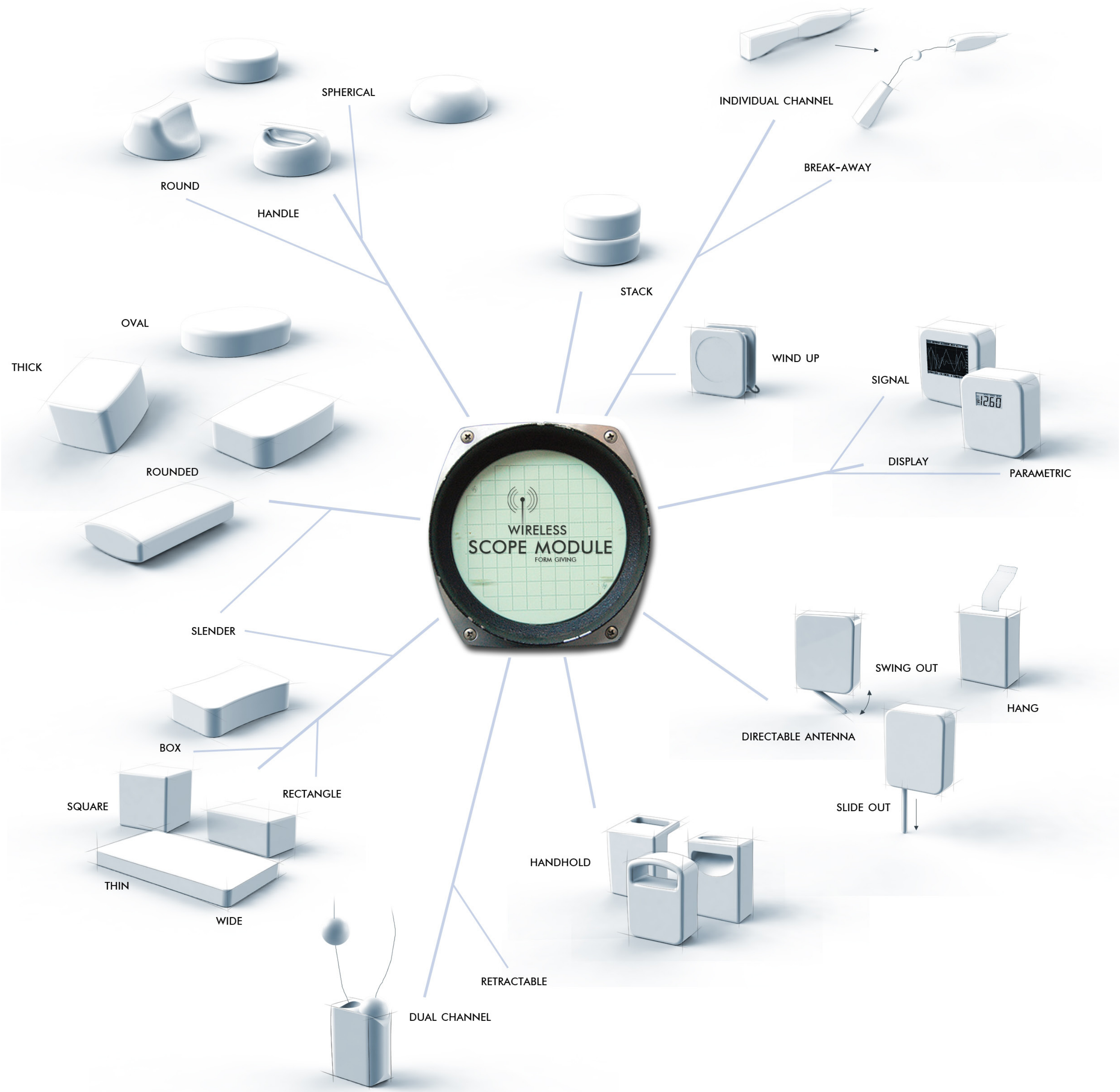
The next step is to further increase performance of the technology used in step 2, with the aim to cater to the needs of the industrial analytical market.

- **Step 4.**

Step four is the ultimate goal: a single channel wireless scope probe. This would eliminate all current issues experienced with scopemeters and would cater to both Tektronix' as Fluke's target groups.

- **Derivative step.**

The derivative step entails a waveform device aimed at the lesser trained employee. With mostly parametric functionality this direction deviates from the more demanding requirements of a wireless scope module[39].


WIRELESS
SCOPE MODULE
FORM GIVING
SPHERICAL
ROUND
HANDLE
INDIVIDUAL CHANNEL
BREAK-AWAY
STACK
OVAL
THICK
ROUNDED
WIND UP
SIGNAL
DISPLAY
PARAMETRIC
SLENDER
SWING OUT
HANG
DIRECTABLE ANTENNA
BOX
SQUARE
RECTANGLE
SLIDE OUT
HANDHOLD
THIN
WIDE
RETRACTABLE
DUAL CHANNEL

Within the confines of the project and allocated time, the choice was made to create a complete product design for step 2 and create visuals for step 4. Refer to appendix D for some preliminary designs thereof.

Specialising functionality

With external wireless modules, the functionality of the components changes; it specialises (refer to appendix B for gathered user feedback on Fluke's wireless DMM). Rather than have one component that needs to fulfil all needs and functions, such as display, control, ergonomics, etcetera, the future form factor consists of multiple separate components. These components can be optimised for their purpose; this purpose needs to be defined in detail for each component.

Base station and scope module

For the future form factor of the product, one can identify two main components: the base station and the scope module. Each component needs to cater to different needs.

The base station consists of the following components:

- Display
- Controls
- Back-end processor
- Wireless transmitter
- Battery (main)

The base station forms the channel of communication between the user and the measurements; it features a display and offers controls for the measurements. The base station needs to be easy to carry around and needs to be able to be placed on a desk. Translated into design features, one thinks of a form factor that is optimised for display and control, transport, and placement.

For future developments, one could consider expanding the functionality of this base station. Fluke could create one fully fledged universal dedicated work station capable of communicating with many wireless Fluke products and assisting the Fluke user throughout the complete troubleshooting process, from the moment the problem is called in to the point where it is fixed.

The scope module consists of the following components:

- Probes
- Front end processor
- Wireless transmitter
- Battery (secondary)

The scope module is responsible for the measurements, processing the gathered data, and sending it to the base station. The scope module needs to enable the user to probe, it needs to be placed near the DUT and enable a wireless connection with the base station. Perhaps it could even act as storage space for the probes. Translated into design features, one considers a small form factor that allows easy handling and a smart wireless connection in an environment with a lot of electromagnetic interference.

The form factor for the scope module purpose does not dictate a direction in and of itself, hence one has the choice between unidirectional and omnidirectional. Each choice has its merits and weaknesses, a comprehensive list will follow below. Refer to appendix D for a more detailed account of the scope module.

Unidirectional:

- Facilitates coupling with the base station;
- Dictates placement during wireless use (could be an advantage in case of antenna positioning).

Omnidirectional:

- Facilitates winding up the probe cable;
- Restricts coupling with the base station to rotational or clamping gestures;
- Restricts the coupling location of the scope module;
- Leaves placement during wireless use up to the user (could be a disadvantage in case of antenna positioning).

List of requirements

The list of requirements is based on current Fluke product details and Fluke corporate standards. To cover all bases the list of requirements keeps multiple categories into account, from all stages of the product lifecycle[10].

- General
  - o Minimum product display features (72x72mm, 240x240 px)
  - o Maximum component size (256x169x64mm)
  - o Weight (<1kg per component)
  - o Exterior has to express Fluke's characteristics: robust, ruggedness, quality, compactness
  - o Exterior has to adhere to Fluke's design and colour guidelines
  - o Product must be suitable for production of at least 10,000 per year

- Power source
  - o Battery operating time (currently ±4 hours)
  - o Battery (re)charging time (currently ±4 hours)
  - o Must be rechargeable
  - o Interchangeable battery (with the need of additional tools)

- Colours[29]
  - o Fluke yellow (Munsell 9YR 7.36/14.6) for the overmoulded holsters
  - o Fluke handheld grey for the casing (grey 8; Munsell 7.1B 3.51/0.3)
  - o Grey 7 (Munsell 2.4B 4.49/0.18 CIE 48.69,-0.48,-0/14) or grey 9 (Munsell 2.49B 2.62/0.23) for emphasis, such as soft material in grip area
  - o The Fluke logo should be black (Munsell N 0.5/) and surrounded by yellow (Munsell 9YR 7.36/14.6)

- Product text[29]
  - o Must display the Fluke logo
  - o Product number (10 pt. Helvetica Bold Oblique)
  - o Product descriptor (7.5 pt. Helvetica Regular Oblique, all caps)

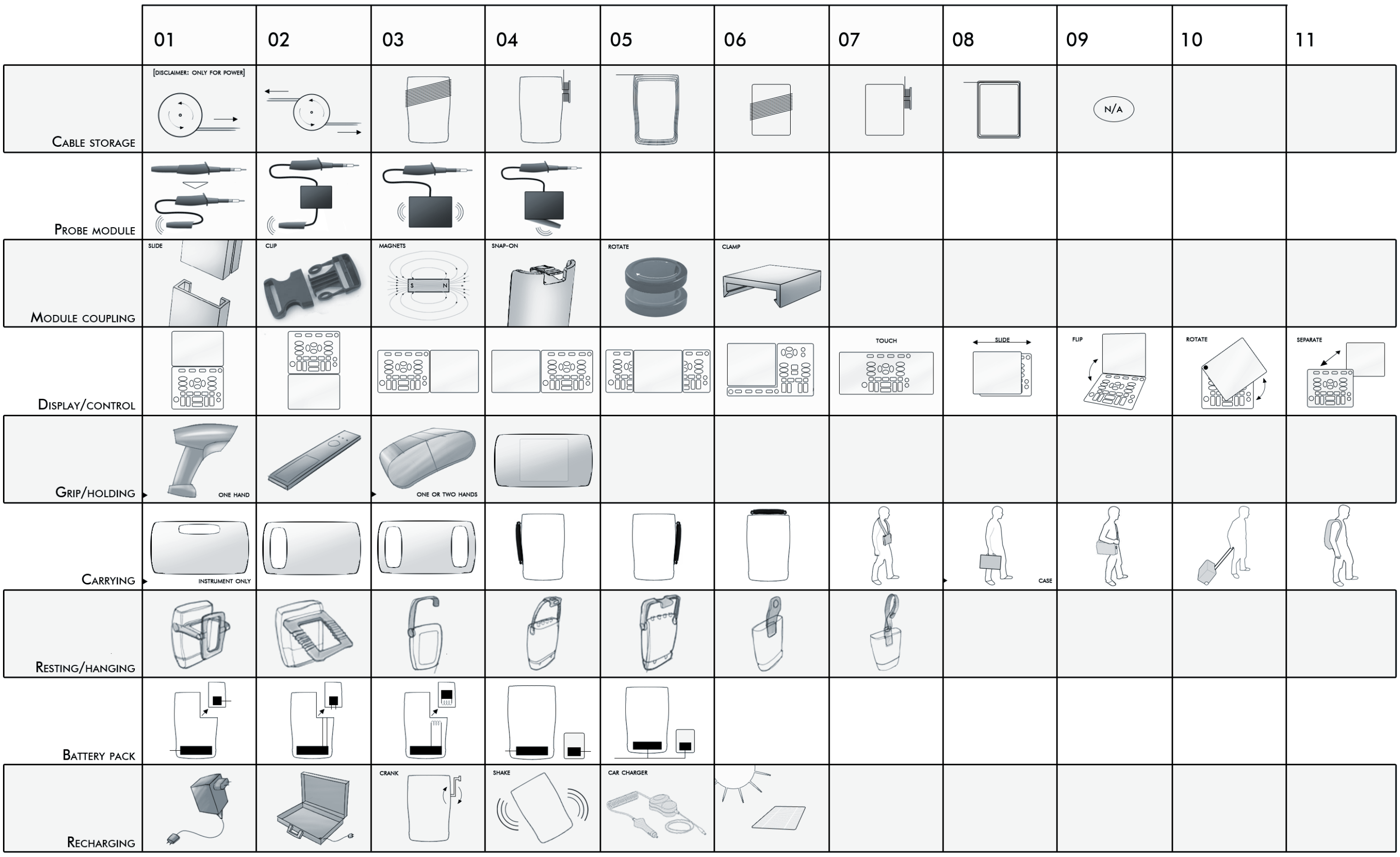
- Materials
  - o Silicon pads for the buttons
  - o PC/ABS/V0 for casing
  - o TPU for overmoulded holsters

- Circumstances of use[32]
  - o Temperature
    - Operating temperature: 0 °C to +50 °C
    - Storage temperature: -20 °C to +60 °C
  - o Vibration (sinusoidal) 3g according to MIL-PRF-28800F Class 2
  - o Shock (30g)
  - o Brightness of display (80 Cd/m^2)
  - o Moist (protected against water jets, current IP rating; IP51 according to IEC529)
  - o Dust protected (current IP rating; IP51 according to IEC529)
  - o Impact height (for a Fluke product between 0 – 6.8 kgs the survivable impact height is 91.44 cms)
  - o Electric shock (core needs to be well isolated; CAT III: distance of 8 mm from between circuit board and casing)
  - o Must function in an electromagnetically 'dirty' environment

- Probes
  - o The product should feature either BNC or ScopeMeter 123 connectors

- User interface
  - o Size of buttons (currently between 50 mm^2 and 200 mm^2)
  - o Force required to press (currently ±2500 mN)
  - o Shape (if possible, use Fluke conventions)
  - o Texture (matte finish)
  - o Colour (Fluke conventions, refer to Fluke's graphic manual[29])
  - o Function related to sensitivity (e.g. power button placed level with casing surface)
  - o Actions should have feedback (sound, light, motion, display)[11]

Morphological overview



Morphological overview

A morphological overview, as featured on the adjacent page, aids in the creative process of constructing valid concepts. Refer to appendix D for a larger version of the morphological overview. The overview covers the following areas:

- Probe cables storage;
- Probe handling;
- Coupling scope module and base station;
- Display and control arrangement;
- Grip and holding;
- Battery pack;
- Recharging;
- Carrying;
- Resting.

A solution to cable storage will reduce wire clutter, making the work area and the connections easier to oversee, thus resulting in a safer work environment. If one chooses cable storage however, there has to be a way of replacing the wire in case of damage as well as a method of attaching different probe heads.

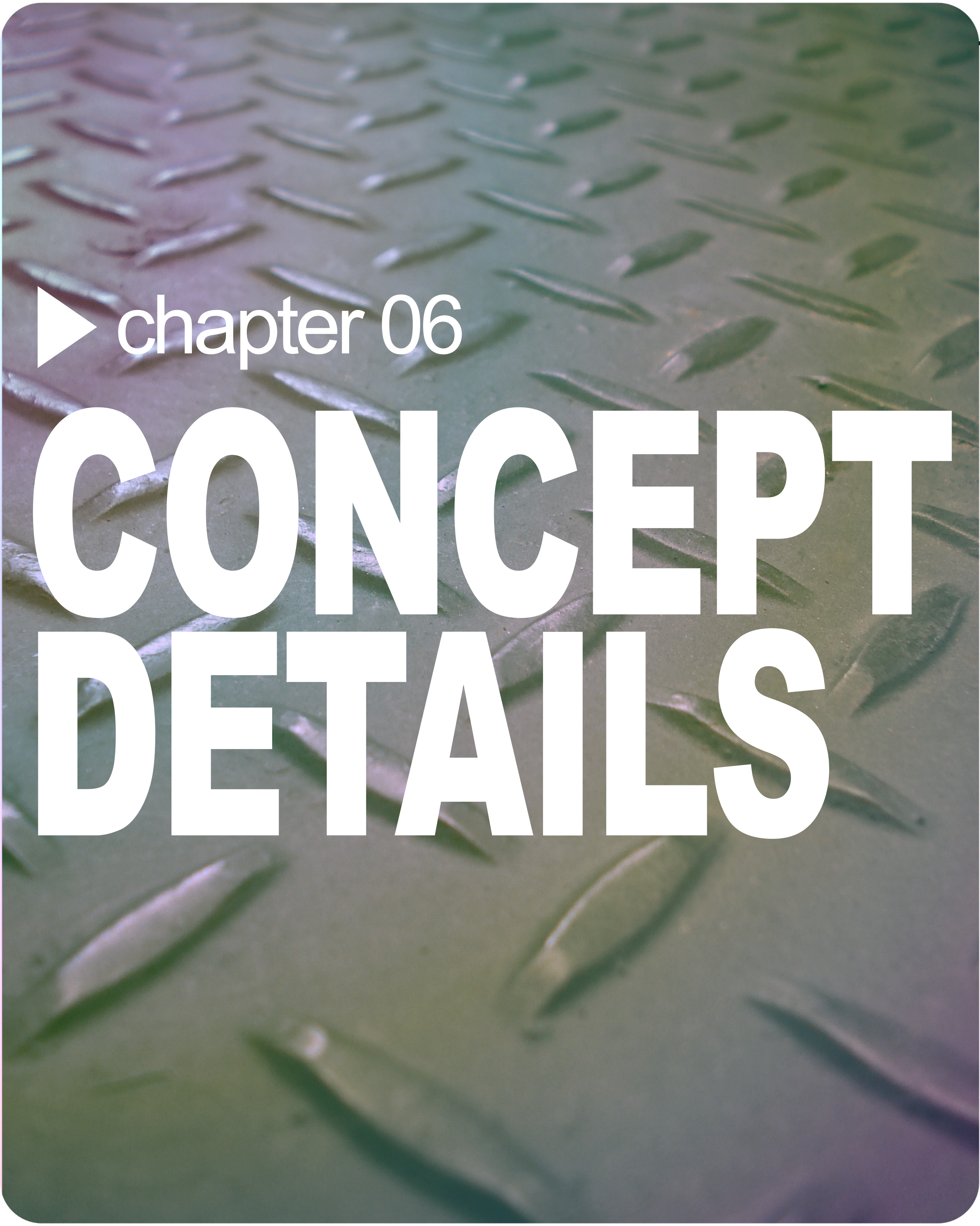
The coupling mechanism is paramount to the wireless scope module system; a collection of loose components will not be favoured by the user. The most interesting coupling feature here is the magnet; it is the best option for the work place considering the metal housings of the electrical equipment. With the magnet one could attach the display to the housing for easy readouts at eye level and one could also use it to attach the scope module near the vent to be able to establish a wireless connection. If a power connection with the base station is required, an additional sliding mechanism may be required.

The display and control arrangement is intertwined with the form factor of the device; one could choose for a one-handed solution or a two-handed variant. It would be optimal to select a form that allows ambidextrous use, rather than limiting the user in their choice. Also, one needs to keep into account the future direction of the product and the brand; a versatile base station that allows for future expansion would be the best option.

The scope module and the base station both have their separate battery packs to be able to operate. It is also a given that the scope module will utilise a wireless connection. The question here however is: when do these need to interact? For example, it is possible to not allow the products to interact beyond what is necessary and recharge both components separately while keeping all communication wireless. But it is also possible to have the scope module use the base station's battery pack and communicate via wire as long as it is attached to the base station. Or the scope module's battery pack could recharge using the base station's battery pack. One could even turn it around: it would also be possible for the scope module's battery pack to function as an extra battery pack for the base station.

The recharging feature is something that followed directly out of the user research; the rather expensive scopemeter is shared amongst employees, so it would be beneficial to accomodate to this shared usage. For instance, one could incorporate the charger in the hard case, or in the car.

The product must also be easy to transport and carry around. For transport, a hard case or soft case is almost a given, even if it just to emphasise on the quality of the product - after all the artisan takes pride in their mastery of their tools.

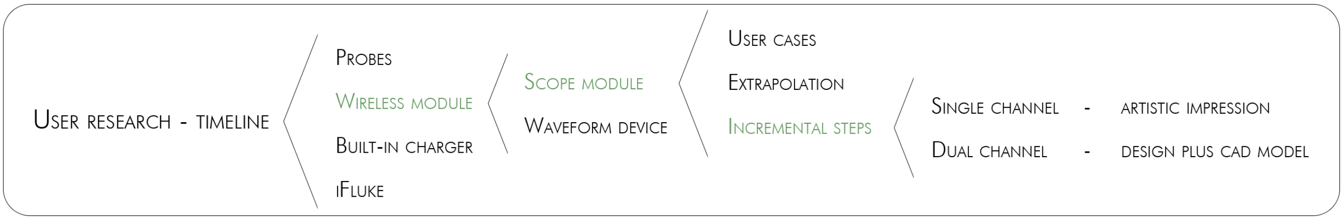


chapter 06

CONCEPT DETAILS

06 | Concept details

Taking a closer look at the technical and aesthetic principles



After having gone through the process of determining the most promising areas of focus and doing inventory of the possibilities and (sub)solutions, it is time to commit and establish specifics.

As the saying goes; ´the devil is in the details´. Details and clever design can aid Fluke in convincing the consumer, especially considering Fluke's catalogue based pull-strategy. In the catalogue it needs to be clear in an instant what the benefit is of Fluke's products. These benefits need to be clear aesthetically. The details to Fluke need to be in the technical aspects and in the costs.

Ultimately, this will lead to a final design of aforementioned step two. The final pages of this chapter are dedicated to visuals of aforementioned step four, including a brief description.

Technical details

The scope module requires a fair amount of research with regards to the technical details, of which the wireless connection, the display, and the battery pack form the main areas of attention.

A succinct point-by-point list will be given below, for a detailed discription refer to the pages following this one:

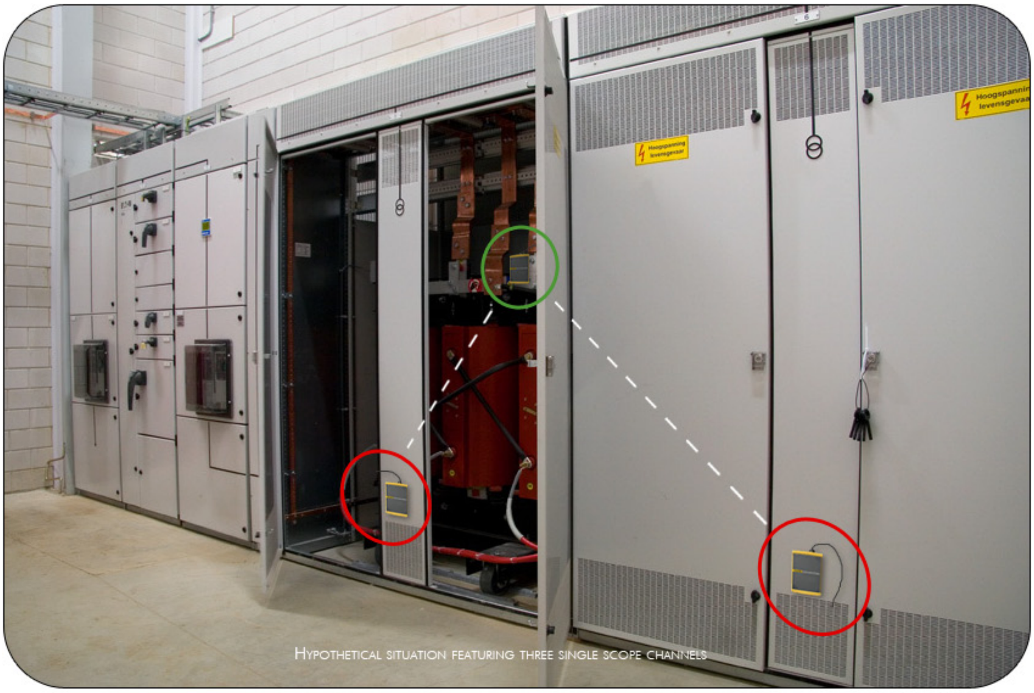
- Wireless connection
  - Technologies & protocols
  - Synchronisation
- Scope module
  - Position
  - Cable storage
- Battery pack
  - Battery types
  - Switch to li-ion
  - Recharging
- Display
  - Display types
  - Button layout
- Specific design features

Form factor

The form factor is based on past Fluke products, while keeping an eye on the future. The slender shape of the overmould of the DMM 287 is an example of the new Fluke shape direction and has been applied to the design featured in this report. Refer to appendix D for various shapes leading up to the final design.

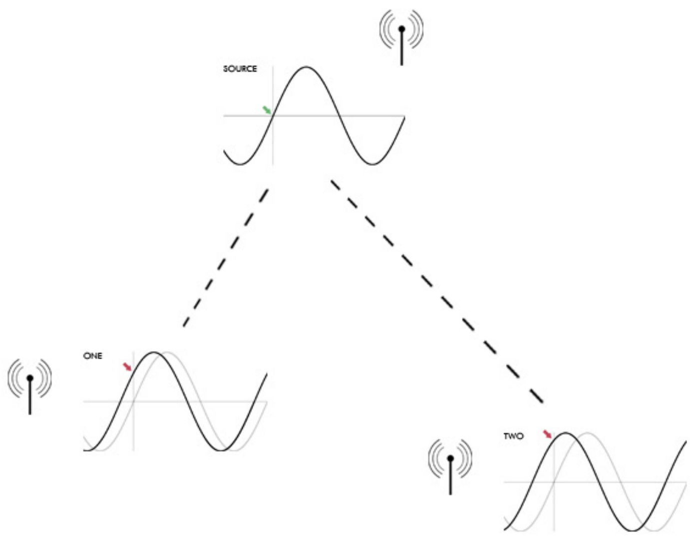
Ergonomics of the base station have been the main influence for its shape. The scope module has been tailored to facilitate secondary issues such as cable storage while keeping its main functionality at heart.

One pitfall was to not create a product that is too small and may convey a 'gadget-ish' image. After all, Fluke sells high-end tools for the industrial market.



Hypothetical situation featuring three single scope channels

Simplified situation - trigger issue due to a delay in synchronisation

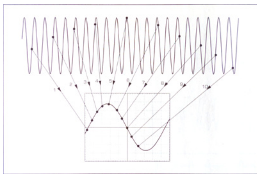


Wireless data transfer

Sending a scope signal wirelessly would be quite demanding with regards to data rate. However, one does not have to send all the data of the trace, one merely has to send the data that has to be displayed on the screen; i.e. the data points of the trace (see the image below).

An example of the requirements such a data transfer would impose on the wireless technology can be illustrated with a simple calculation. In case of a replacement of the 120 series, one requires a two channel module, capable of sending its data to the base station. So a realistic estimate would be:

- 2 traces
- 640 points/trace
- 8 bits/point
- 10 updates/second



The above would result in a data rate of 102.4kbit/sec, which is a data rate that can easily be achieved with a wireless technology such as ZigBee[27]. Refer to appendix E for a complete overview of wireless technologies[28].

Synchronisation

A much bigger issue than data rate and power consumption is synchronisation. When measuring multiple channels, one needs to know the time relation between those two channels in order to be able to trigger them properly. Without a highly accurate time relation the displayed waveform will be meaningless. One can imagine that with a signal of 200 MHz even a difference of just a nanosecond would result in a deviation of 0.2 cycles, which is entirely unacceptable for a live trace.

The issue

If one deals with a separate module per channel, each module will rely on its own crystal. These crystals do not run at exactly the same speed, there will be a small standard deviation between each crystal; some will run slightly faster than average, some slightly slower. This will cause the separate signals to go out of sync, simply because the time stamps are different between modules.

On the adjacent page, an impression is shown of a problem one would encounter with single channel scope modules that rely on wireless communication. In this impression, three separate single channel scope modules are shown. The one circled in green determines the time relation and signals the trigger to the other scope modules.

Due to a delay in wireless communication, that trigger will be too late for scope modules “one” and “two”. As a result, they will not catch the signal at the same time as the source. Instead, a slightly shifted signal will be recorded. The further away from the source, the larger the delay and the more distorted the signal.

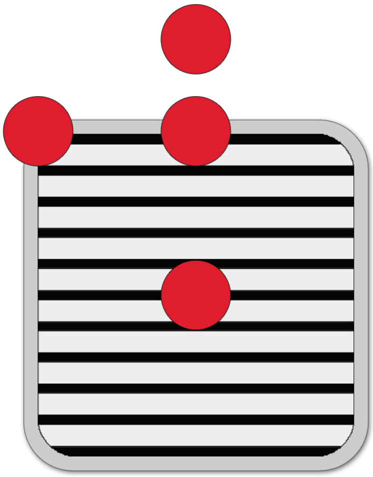
In the current scopemeter, the distance is merely a short one on the circuit board and is thus determined by the speed of the electrons - not a problem. However, when latency comes into play, as is the case with wireless communication, the situation becomes more complex.

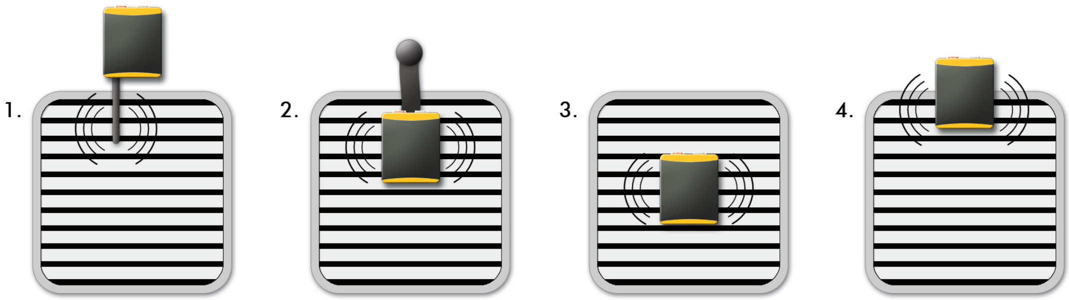
Another problem is having the separate scope modules operate on the same range of frequencies. This could make it difficult to recognise each separate module, unless it is clearly identified by the system. It is also a possibility to change the sequence of data slightly, to distinguish data of the separate modules that way.

Solutions

Highly accurate synchronisation systems do exist in our everyday life, think of synchronisation between satellites and GPS systems where a few seconds mean a large discrepancy in distance, or in IT networks where a lot of communication data needs to be synchronised and work alongside each other in order to be able to operate.

To address the issue, one could think of synchronising the separate modules from a base station. Once you know how much the crystals deviate, you can compensate for the deviation for a limited amount of time at least.




1.
2.
3.
4.

Scope module

The features of the scope module will be described in this section. These features include position, components and additional functionality such as cable storage.

Scope module position

In order for the scope module to be able to send its data to the base station from within the confines of the DUT's casing in an electromagnetically 'dirty' environment, the scope module needs to be placed in the most ideal position possible.

In case of the industrial service segment, this often means in front of, or through, the vent. The area around the vent is of a ferro alloy and thus magnetic, the vent itself is made of plastic in most cases. As a result, though this does require further testing, one can infer that the scope module's antenna needs to be placed on the vent in order to successfully transmit data. To do this, one has multiple options, as demonstrated in the image on the adjacent page. These options are:

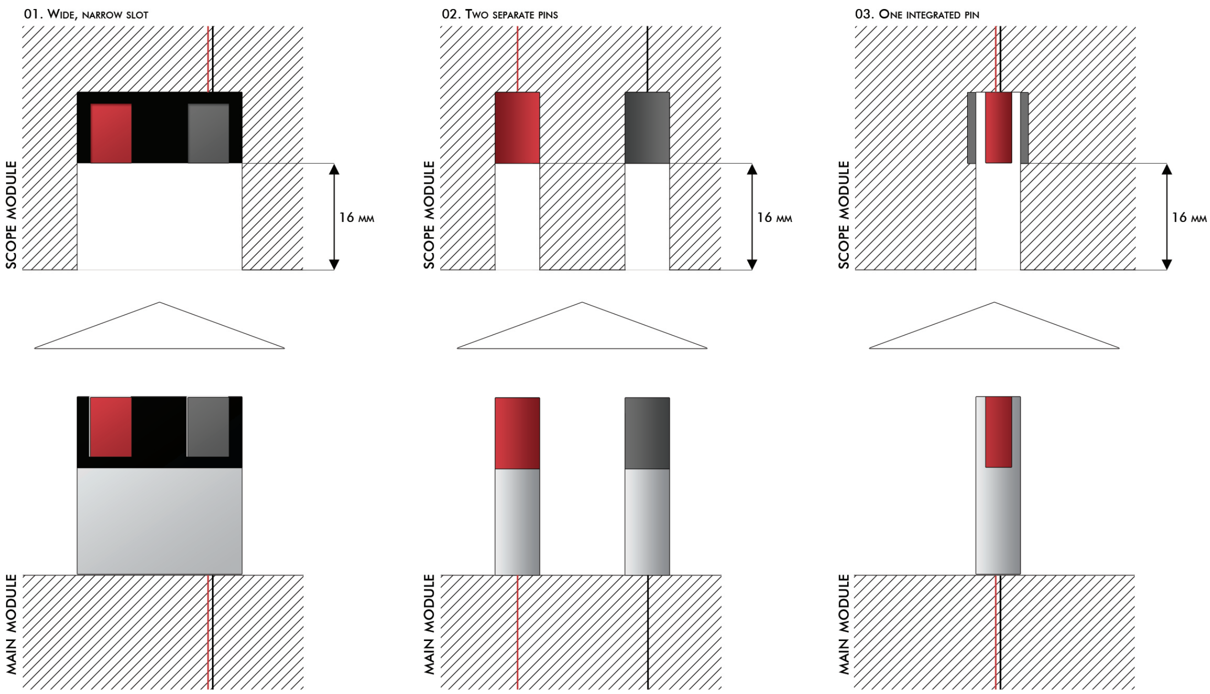
- Next to the vent (above, below, left, or right);
- On the edge of the vent;
- Anywhere on the vent;
- On a corner of the vent.

All options have their own implications. In case a Wi-Fi network is used, one has a small integrated antenna on the circuit board. If the module is placed next to the vent, the antenna needs to reach out over the vent, which requires a separate external antenna, incurring additional costs. To circumvent the issue of needing an additional antenna, one can invert the problem and place the module on top of the vent, hanging it from a magnet placed above the vent. Or one could find a universal method of attaching the module to the vent itself of course, or to the edge of the vent (e.g. by clamping or by exploiting the lever effect). These two options are not ideal however, due to extensive differences in design of the various vents.

Something else that needs to be kept in mind is the appearance to the customer; the product needs to look robust and of high quality.

Cable storage

Due to the separation of functionality in a base station and a scope module, room was created for additional features such as cable storage. For the final design the choice was made to keep it simple and offer the user a place to wind up their probe cables, incorporated in the exterior design of the scope module. For a complete overview of possibilities with regards to cable storage, refer to appendix D.


01. Wide, narrow slot
02. Two separate pins
03. One integrated pin
SCOPE MODULE
16 mm
MAIN MODULE

Battery pack

Fluke has always relied on rechargeable NiCd and NiMH battery packs, though nowadays lithium-ion batteries have the highest energy density and thus offer the smallest form factor. The development of lithium-ion batteries has been highly stimulated due to their application in consumer products such as mobile phones and laptops; products which have a relatively short life span and as a result evolve relatively quickly.

Fluke can tag along with this development to be able to offer the longest battery life span in the smallest package.

	NiMH	NiCd	Li-ion
Specific energy (Wh/kg)	30 - 100	40 - 60	100 - 250
Energy density (Wh/L)	140 - 285	50 - 150	250 - 620
Specific power (W/kg)	150 - 300	150	250 - 340
Charge/discharge efficiency	66	70 - 90	80 - 99.9
Self-discharge rate (%/month)	30	10	8
Cycle durability (cycles)	500 - 1500	2000	400 - 1200
Nominal cell voltage (volts)	1.2	1.2	3.6 - 3.7
Energy/consumer-price (Wh/€)	4	1	4

Fluke's current battery for the ScopeMeter 196B is a 7.2 Volts 3,600 mAh NiMH battery weighing 450 grams. A li-ion battery with the same specifications weighs 250 grams. This is a significant difference that will reduce weight, and thus strain on the user, greatly as well.

Position of the plug

A power connection between the base station and the scope module is desired. Considering that the scope module could be under high voltage when connected to the DUT, the scope module needs to adhere to all the CAT safety rating standards. The base station however only needs to adhere to all CAT safety ratings as long as the scope module is physically attached. If the scope module is detached, the base station can no longer be under high voltage at any point.

As a result, one can infer that the power contact points on the base station only need to be out of reach when it is connected to the scope module; when the scope module is not attached the power contact points are allowed to be exposed.

The power contact points on the scope module however need to be out of reach at any given point during its use; in case of a CAT IV rating this would mean a safe clearance of 16 mm in its design. Such a feat can be achieved in three different ways, as displayed in the image on the adjacent page:

01. Wide, narrow slot;
02. Two separate pins;
03. One integrated pin.

Options one or three are preferred due to their simplicity and sturdiness. Of these two the wide narrow slot design could reduce the required depth slightly for the CAT safety rating, compared to the integrated pin. This is due to the form factor; one measures the required distance for the CAT safety rating from the fingertip to the contact inside the scopemeter, not from the surface of the hole to the contact inside the scopemeter. A necessary requirement because the skin of a finger enters the hole ever so slightly, up to 4 mm, which could be reduced by creating a form factor that is incompatible with a finger, hence why a narrow slot design would outperform a round hole in this aspect.

Extrapolation

Considering the fact that Fluke already uses a custom power plug for the charger, namely an elongated generic barrel shaped stereo jack style pin, one could push this development even further with the introduction of a slot shaped connector. Fluke has to change its chargers anyway due to a transition to lithium-ion based battery technology, making previous chargers incompatible with the new technology, and vice versa. As such, changing the connector design would not only result in a slight decrease in required hole depth, it would also prohibit the user from connecting the wrong charger.


227,3 rms V~
+003,1 V=
AUTO
A=100 V/
10ms/
Trig:A/
A MOVE
B MOVE
TRIGGER SLOPE
CONTRAST
F1
F2
F3
F4
mV
V
A
B
switch
s
ns
menu
hold
auto

Display and button layout

The future development timeline indicates that oscilloscope technology is headed towards landscape style media, such as laptop screens, tablets and touchscreens.

As example: the Fluke ScopeMeter 123's screen is entirely square, resulting in the Fluke ScopeMeter 123's portrait oriented shape. To follow the development of commercially available displays, Fluke needs to keep the future landscape orientation in mind.

Display

The display is currently a component that is subject to several issues; the desired life span for an industrial display is a long one, while the more commonly available commercial displays for mobile phones and the likes have a rather short life span. Also, the displays used for Fluke's scopemeters are custom made displays, unnecessarily increasing costs. If one could manage to tag along with commercial developments, one could reduce the price of the display significantly.

As mentioned before, the available displays will be mostly landscape oriented, as coincidentally also feels most natural to the user. To move towards a completely landscape based product, such as a tablet for instance, one needs something in between to bridge the gap and set a new standard in user interface. Refer to appendix B for more information regarding various shapes and their (dis)advantages.

Button layout

A more unilateral shape allows for key mapping; keys can be placed in a location that corresponds with their function. The function keys are a prime example hereof, but it can also be applied to the vertical and horizontal operators. It is a vital step towards implementation and acceptance of touch screens.

One could also place buttons elsewhere on the product. For instance, the user has indicated that zooming takes up a fair amount of time, one could offer solutions for that issue. One example would be to create a dial that allows for quick zooming in or out. One could place this dial on top, but also in the overmould, in the sides, or even on the back. The unilateral shape allows for such 'gamepad like' features to be implemented. User acceptance hereof however would require more research.

Ultimately, the choice was made to only place the power button on a different surface, namely on the top surface. Additionally, based on past research conducted by Benchmark, the dial is left out as well.

Redundancy in the form of multiple range buttons is also addressed; one range button suffices. However, one does need to supply the user with more feedback with regards to which channel they are manipulating. This can be done in the same fashion as is done with Tetra: semi-transparant keys with LEDs placed under them. Such a feature can be applied with the channel buttons for instance: the selected channel will be highlighted so the user is aware which channel he/she is manipulating.


STRAP WITH MAGNET
POWER SOCKET
POWER BUTTON
CURVED LENS
KEY MAPPING
CABLE STORAGE
USB SOCKET
TETRA-ISH FLOW
TERTIARY BUTTONS
ERGONOMIC GRIP
LOCAL/REMOTE BUTTON
FLUKE 123 REMOTE SCOPEMETER
F1
F2
F3
F4
A
B
HOLD RUN
SCOPE MENU
MANUAL AUTO


BATTERY INDICATOR
CONNECTOR SOCKET
STAND UP

Specific design features

In this section the design features of the final design will be highlighted.

Base station

The top side of the overmould flows over the edge, conform other Fluke products such as Tetra.

The lens takes up a relatively large portion of the model and follows the fillet at the top, this enhances the perception of the user with regards to screen size, which is in line with the general development of handheld oscilloscopes.

The stand up is multifunctional: it can act as stand up but it can also act as a handle. When used as a handle, the space between the base station and the handle is large enough for a convenient hold (appendix E). It is possible to move the stand up from either extreme position while the scope module is attached.

A playful design feature has been integrated in the stand up as well: when looked at from the top one sees a sine shape; very fitting for an oscilloscope.

An indentation on the back of the base station offers good grip for the user, keeping their use of thick safety gloves in mind. Other ridges have been created for this purpose as well, such as the ridges of the overmould and the ridges on the bottom side of the scope module.

The USB socket has been placed on the top right side of the base station. The USB socket needs to be galvanically isolated from the rest of the circuit board, hence it cannot be placed next to the power connector socket for instance. Placing it top right will create sufficient space for such a galvanic isolation.

When the product is placed on a surface, it is always easy to pick up; in case the scope module is attached, all sides are off the surface allowing for an easy pick up. If the scope module is not attached, the indentation at the bottom of the base station allows for an easy pick up.

Buttons

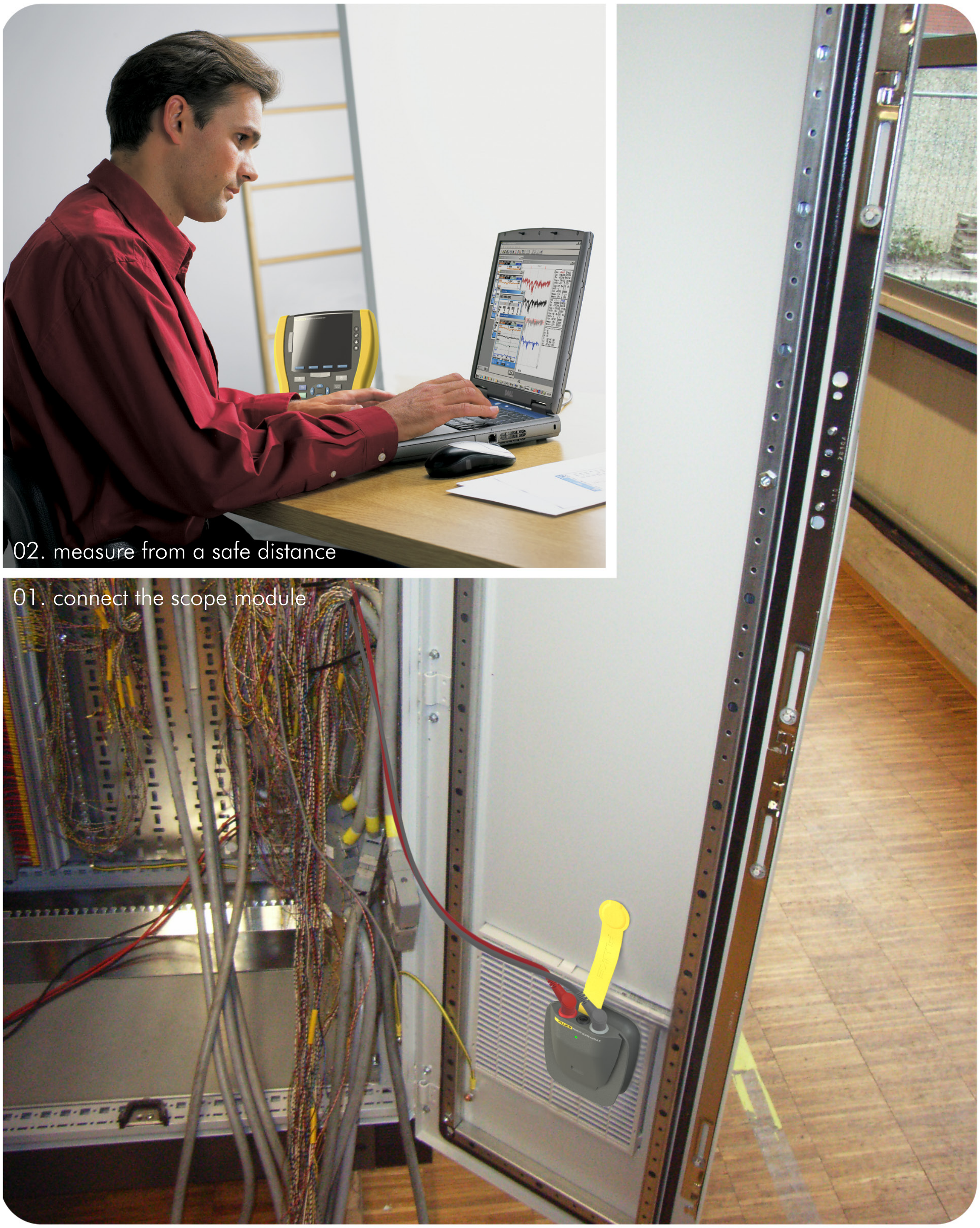
The buttons have been mapped to suit their function to their respective location, this is particularly the case with the buttons that manipulate range and time. The function keys have also been mapped and are integrated with the lens to augment their purpose.

The buttons that manipulate range and time are also slightly indented in the middle, creating a shape that describes a catenary, augmenting the function of the key.

The power button has been placed on top and is level with the surface of the casing, this is to prevent it from being pressed accidentally. A chamfer on the edge of the casing surrounding the power button facilitates pressing the button when the user intends to. The socket for the power connector has been placed next to the power button and they are linked via a shallow indentation in the surface of the casing to imply a link between the two.

Tertiary functions such as brightness, settings, and saving, have been placed top right next to the lens. These buttons are used less frequently, hence are not grouped with the main buttons. Additionally, the buttons are level with the surface to prevent them from being pressed accidentally. A chamfer on the surface facilitates them being pressed.

A button has been added to allow the user to switch between a local scope module and a remote scope module. Communication between the modules is always done wirelessly, the base station can differentiate between the two states by using the battery connection as discriminat-



02. measure from a safe distance

01. connect the scope module

ing factor.

The local/remote button exists for a few reasons: it is a means for the user to get familiar with the wireless scope feature, which is important for a catalogue based sales method, and it also prevents issues with displaying signals that do not share the same time synchronised basis. As clarification: signals from two separate scope modules could not be displayed in the same screen due to not sharing the same time basis, so one wants to prevent this problem by disallowing the user to display both at once.

A few buttons are semi-transparant with LEDs placed underneath them, as is already done with Tetra. They will highlight when pressed, offering feedback to the user. The channel selectors and the new local/remote button are amongst those to have this feature.

Scope module

The overall shape of the scope module is kept basic in order to facilitate production and also to facilitate implementation of the technological components in a product family. The shape of the sliding mechanism is V-shaped in order to imply directionality required for sliding the scope module into the base station.

The indentation on the side of the scope module offers room for the cable to be wound up. The fillets are sufficiently large to prevent damage to the scope cable. The space available should be sufficient for a total of 4 metres of cable (it has been tested experimentally); in practice this will be 2 cables, each 2 metres long.

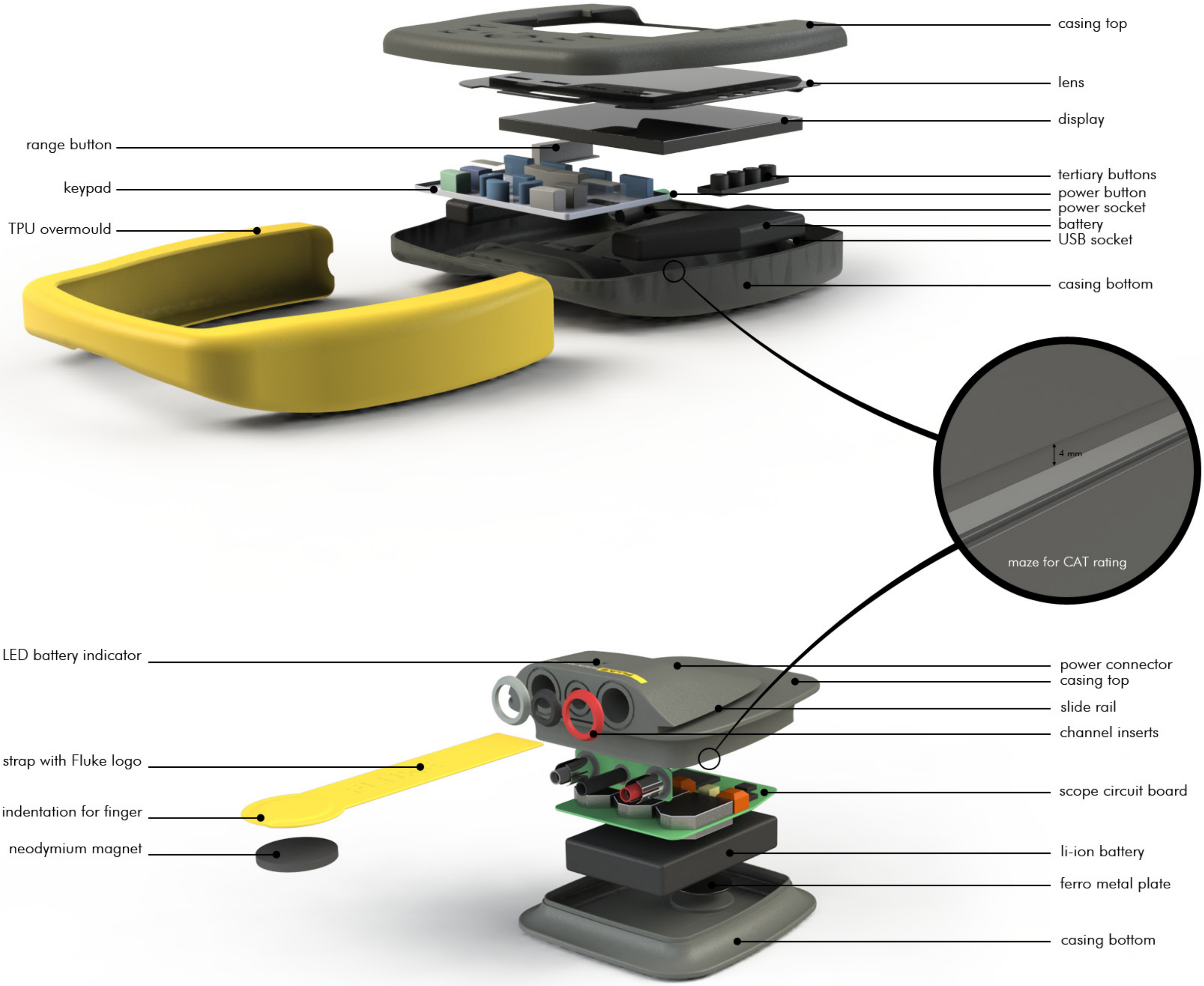
A multi-coloured LED on top of the scope module indicates remaining battery power. A straightforward system of red meaning empty battery, yellow meaning half full, and green meaning full, should suffice. An alternate system would be a series of LEDs in one line. User tests would be required to determine the method that is perceived as most convenient.

The strap of the scope module contains a magnet, which can be used to place the scope module above a vent inside the casing of the DUT. This strap has a dual functionality: it also keeps the wires in place that are wound around the scope module. A permanent magnet does not interfere with the measurements, an electromagnet would.

The strap has a slight indentation near the magnet to facilitate pulling the strap.

The power connector is thin and wide to save on depth required to adhere to the CAT safety rating. The scope module recharges off the battery of the base station while it is connected, putting priority on the battery level of the scope module. After all, once detached, if necessary, the base station can be safely plugged in if measurements are performed at a safe distance.

Refer to appendix E for technical drawings of the base station and the scope module.


casing top
lens
display
range button
keypad
TPU overmould
tertiary buttons
power button
power socket
battery
USB socket
casing bottom
4 mm
maze for CAT rating
LED battery indicator
strap with Fluke logo
indentation for finger
neodymium magnet
power connector
casing top
slide rail
channel inserts
scope circuit board
li-ion battery
ferro metal plate
casing bottom

Component indication

In this section a short indication with regards to assembly and available space for components will be given.

Battery

The base station has a volume of 90 cm^3 available for the battery, and the scope module has a volume of 75 cm^3 available for the battery. For a rough comparison: a 7.4 volts 5,200 mAh li-ion battery is available in size 72 x 20 x 70 mm (100 cm^3) and weighs 190 grams.

Interpolated, one could infer that both the base station and scope module could each contain a battery with a power capacity higher than that of the ScopeMeter 123, at the same total weight.

Casing

The casing has a maze around the edge to adhere to the CAT safety rating (see circled image).

The TPU overmould stretches and can be fit around the scope module after assembly. Any screws needed for assembling the casing should be placed around the edges, so they can be covered with the overmould. Such a feature increases safety and allows the design to adhere to the strict IP rating.

Lens

The lens is not glued in on top of the casing, as is the case with the current ScopeMeters. Instead, the lens flares out at the bottom, making it possible to place the lens in the inside of the top casing. The overlap of the lens with the casing acts as maze required for the CAT safety rating.

Wireless scope module

The size and volume of the circuit board for the wireless scope module is based on necessary components and an extrapolation of additional components. For example, the front end of each channel input cannot be further integrated and thus cannot be further downsized; the front end is limited by its components and the CAT rating. The manner it is processed however can be downsized. In this model, a fair amount of space is reserved for the processing part, keeping in mind the cheapest development path.

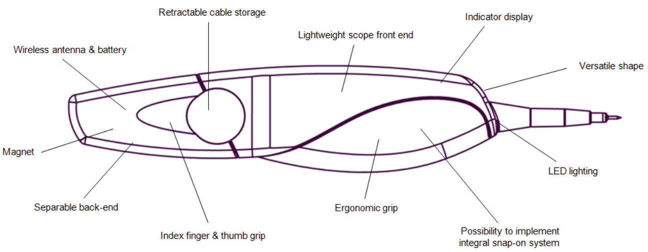
Depending on development choices, there are two possibilities:

- Highly integrated processor; expensive to develop and manufacture, but it occupies a very small volume. It will be hard to copy by competitors;
- Off-the-shelf components; cheap to develop and manufacture, but it occupies a relatively large volume. It will be easier to copy by competitors.

Fluke wireless scope probe with dedicated work station

Wireless scope probe

In the final section of this chapter the visuals for step four will be presented, accompanied by a short explanation.



The single channel scope probe's design is based on a few solid premises:

- User feedback has indicated the probe needs to remain small, much like its current form factor;
- The current form factor is very versatile and forms a good basis for a redesign;
- Its functionality addresses the same issues as the design of the wireless successor of the ScopeMeter 123;
- Modularity ensures a joint investment to cut costs and increase efficiency.

An overview of the components of the designed scope probe can be seen above. Its size should have sufficient volume for all the components, considering the timeline of the product and the development of battery technology.

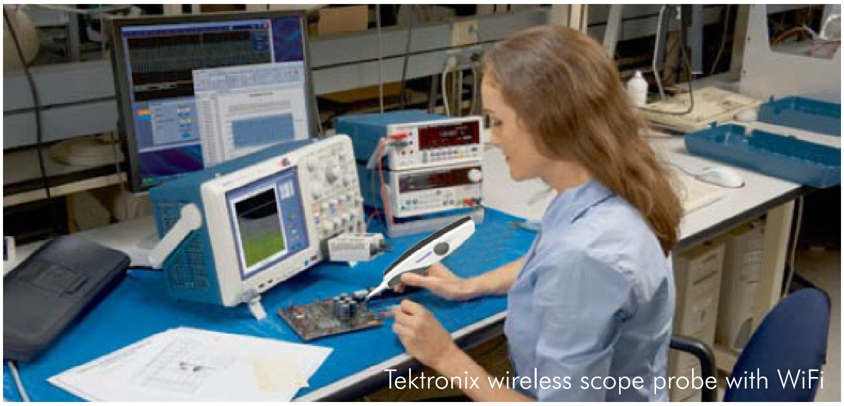
The scope probe has some added functionality due to its integral design, such as the ability to place LEDs in the front now there is a power supply near the probe tip. It is also possible to integrate a small display, which will most likely be used to display parametric data during the process of probing for a signal. This feature would finally take care of the issue with the lack of overlap for the point of manipulation and the point of perception.

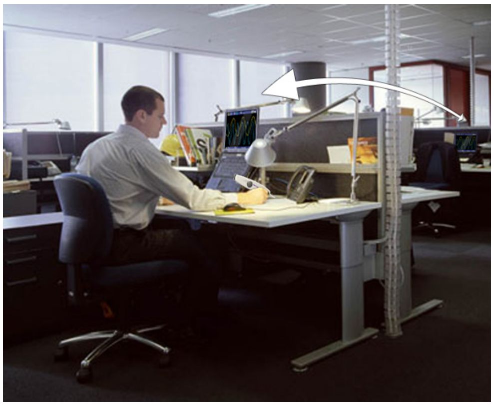
For Fluke purposes, a removeable back-end in combination with a retractable cable storage (e.g. as we know it from a travel mouse for a laptop) ensures a proper functioning product in the electromagnetically 'dirty' environments they have to operate in.

For Fluke, the wireless scope probe could use a secure protocol to communicate with a dedicated base station. Amongst the added values for Fluke are: measurements can be performed safely and the amount of channels measured is only limited by the amount of scope probes the user possesses.

For Tektronix, a more common technology such as Wi-Fi would be recommended in order to ensure compatibility with peripherals such as laptops and iPads. Amongst the added values for Tektronix are: information becomes very easy to share with colleagues, there is no more tangled wire mess, measurements can be done safely (which is a bonus for the education market Tektronix tries to reach).

Refer to appendix E for the final presentation that contains more visuals of the scope probe's design[41].


Tektronix wireless scope probe with WiFi



chapter 07

CONCEPT REVIEW

07 | Concept review

Reviewing the concept with an SLS model

"When the product is right, you don't have to be a great marketer", Lido Anthony Iacocca, (1924-current)

The final design needs to be evaluated, which can be done in multiple ways:

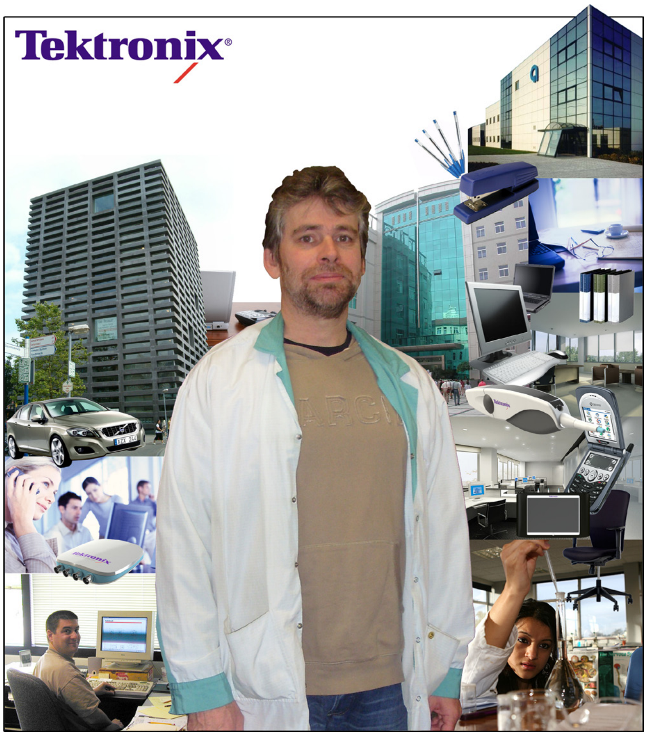
- Checking the list of requirements;
- Placing it in the target group collage;
- Placing it on the timeline;
- Create a visual model;
- Verify the model with aid of a user.

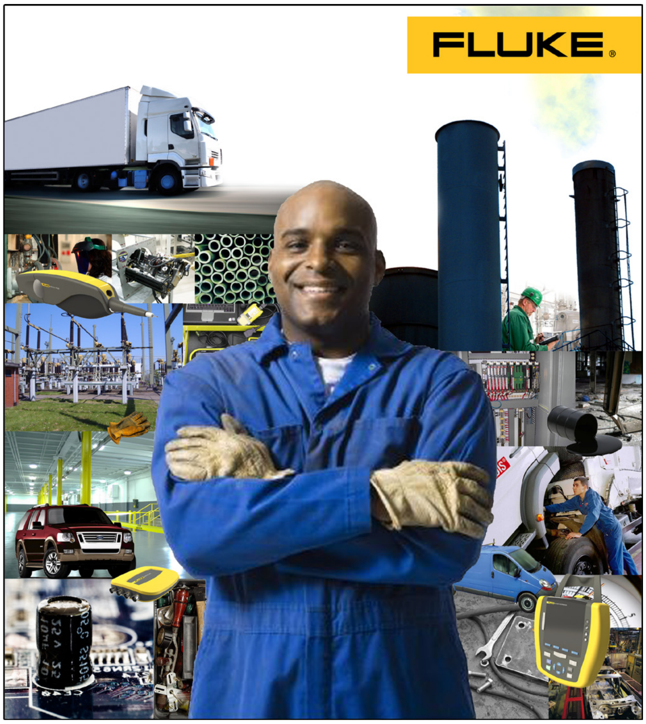
All but the last one can be managed within the limitations of the project. An addendum will follow once the design is cleared by Fluke and a user is available for concept verification.

See below for impressions of the products within their respective target group collages.

Refer to appendix E for a complete cross-reference of the final concept with the list of requirements.

The following pages will feature the rapid prototyped visual model and recommendations regarding the design and derivative paths. The model has been used and its ease of use and aesthetics have been tested. However, as mentioned, the model and its intended functionality still need to be tested and verified with aid of a Fluke user.






SLS MODEL
design verification

Recommendations

Recommendations regarding the final design and outcome of the project

This section will offer reflection on the final design, but also on related (future) issues and opportunities uncovered during the project. The latter can be located under “derivative recommendations”.

Overall, the design seems to fit well within Fluke’s product range and its also leads to a promising future outlook for Fluke as a brand. There are always points that need to be improved however, these points will be listed below.

Technological recommendations

Determine the exact power requirements of the separate components to optimise the battery pack for each component.

Synchronisation is the main issue for the single channel scope module. It will require research to overcome this issue; it is recommended to start pursuing this as soon as possible as it is the future of scope technology.

Tests need to be performed with wireless connections in an environment with a lot of electromagnetic interference. On top of that, tests need to be performed with wireless connections near the DUT; to be more specific inside the metal casing of the DUT and near the vent.

Indicators with regards to battery power and wireless connectivity need to be followed up on: a visit to a user should clear up the need for such a feature. The base station offers room under the sloped part of the lens for this feature, the scope module offers room on top for this feature (refer to the multi-coloured LED on top).

Model recommendations

The SLS model has put forth an issue with the scope module; to be specific the method of sliding the scope module in the base station seems to cause confusion. This needs to be looked at: perhaps it can be addressed by enhancing the directionality with decals, if not: the sliding method might need to be reviewed completely.

The connector that acts as power connection between the base station and the scope module does not always slide in that easily. This could be fixed by guiding the movement, for example by throwing a 5 mm fillet on the sides of the connector socket in the scope module. Refer to the technical drawing of the scope module in appendix E for details of this solution.

The stand up does not adhere to Fluke’s rigid standards; hence the stand up needs to be reviewed and adapted accordingly.

The sides of the base station could be a bit more rounded off for a better ergonomic hold and a smoother appearance. The curvature at the bottom of the base station looked at from the side also needs a review, even though it fits within Fluke’s product as it is.

Currently there is no room to create easy access to the battery. This should not pose a problem, however, Fluke may desire it regardless.

Derivative recommendations

For the waveform device it needs to be determined which purpose(s) it needs to fulfil exactly; user research is required to determine this purpose.

User research has put forth a user sharing issue, due to the relatively high price for a measurement tool. This leads to problems with recharging and user settings. Suggestions to solve these issues have been put forward in this report, however they require more follow up.

The application of touch screens in oscilloscopes needs to be researched. For instance, how does one operate the scope functions using gestures and multi-touch? Functionality also needs to be tested in the blue collar target group’s relatively harsh and dirty environments.

Probe shapes still requires a lot of research; user research conducted during this project has scratched on the surface of some of the user’s needs for more control and flexibility.

Evaluation

An evaluation of the project and its progression

At the start of the project I underestimated the amount of research already conducted by Benchmark and the time I would require to familiarise myself with the product.

It was also a challenge to try and contribute to a company as large and experienced as Benchmark; it took a fair amount of research and effort to try and find an approach that was valuable and fresh to Benchmark. As a result, a wide approach from a macro view was taken to try and filter out as many opportunities as possible that could have been overlooked by the company.

Some of the bottlenecks identified in the draft of the assignment did indeed turn out to be problematic during the project; a prime example hereof was arranging vital user research. The reason for this however was not as predicted: the product has a relatively small target group and caters to a very specialised market. It turned out to be quite difficult to get through to companies and reach the intended employees.

In retrospect, I could have been more proactive about highlighting this issue with the lead designer at Benchmark. The lack of input from user research kept my project development relatively abstract up to that point, since prior to that point the development from my perspective was mainly based on research papers and staged product videos. A more assertive approach on my part would have tackled this issue earlier on during the project, most likely resulting in a higher overall productivity.

A general issue I have experienced is that I seem to be too ambitious in my goals and do not always manage to take that into account with my planning. Exploring derivative paths is one of the things I enjoy doing, but do not always have sufficient time to do so. I have learnt I have to incorporate the occasional small buffer to ensure I am able to reach my intended goals.

When one constantly works on one single project, one risks the possibility of losing perspective on the project. Especially during such a relatively long project, this issue becomes apparent. Sometimes I found that I had to change my activies completely in order to maintain that fresh view on the matter; for example what helped for me was switching between research and rough modelling for instance.

Due to working on a project close to the ones assessing the project, decision moments are abundant and frequent. As a result of these brief consultations, the product direction is gradually and gently steered towards its final destination, rather than sparsely and with greater momentum as is usually the case with projects at university. I believe this is clearly reflected in the report as well.

An insight into the production process offered by colleagues on the work floor has taught me a lot about margins in the design and methods one can use to enhance the aesthetic qualities of the product during production. Unfortunately, I have not been able to apply that to the project due to it still being in the development stage. I did have my own personal experience with it however, in the form of the SLS-ed (selective laser sintering) visual model. My margins in the printed design were off and as a result the components did not fit as intended. A fair amount of time spent sanding down the material ensured it was a lesson one does not forget.

Overall I am quite satisfied with the result of the project. I hope I have managed to display my skills as a designer in this project and have proved to be of value to Benchmark. The experience I have gained there really is priceless and I wish to thank them again for the amazing opportunity.

Attenuation

The decrease in signal amplitude during its transmission between two points.

BNC connector

The BNC (Bayonet Neill-Concelman) connector is a common type of coaxial RF connector used for electrical equipment, such as the scopemeter. The connector is typically applied for frequencies below 3 GHz.

CIE lab system

Uniform colour-space system originated in 1976, by Commission Internationale de l'Eclairage (CIE). It makes use of a colour cube modified according to a psychometric colour diagram.

(Circuit) loading

An unintentional side effect of the interaction of the probe and oscilloscope with the DUT, resulting in interference and distortion of the signal.

CRT

Acronym for cathode-ray tube; it consists of a vacuum tube containing an electron gun. A CRT works by sweeping an electron beam back and forth on the fluorescent screen, illuminating phosphor dots and thus creating an image in the form of light.

DMM

Acronym for digital multimeter.

Donar

The project name for the successor of Thor. Refer to *Thor* for more information.

DUT

Acronym for device-under-test; the device and its systems subject to tests, in this case with the scopemeter.

Eddie

The project name for the Fluke 120 series ScopeMeter.

Galvanic isolation

The principle of isolating functional sections of electrical systems, preventing the direct flow of electric current from one section to the next. However, energy or information can still be exchanged between the sections by other means, e.g. by induction or optical means. Galvanic isolation is used in situations where multiple electric circuits must communicate, but where their grounds may be at different potentials.

Graticule

The grid lines on the screen of an oscilloscope, vital for measuring oscilloscope traces. Graticules usually have 8 vertical and 10 horizontal 1 cm squares called divisions.

Intensity grading

Information regarding a signal's frequency-of-occurrence, typically required for a better understanding of the waveform; only applies to (digital) phosphor traces. Refer to *z-axis* for more information.

Loki

The preliminary project name given to the design featured in this report: the wireless successor of the Fluke 120 series ScopeMeter. Its design is meant to push forward in a steady pace aiming for a new standard in scopemeters, shaking up competition.

Munsell

The Munsell colour system, created by Albert Munsell in 1898, uses the Munsell Colour Sphere. The three dimensions of colour are Hue, Value and Chroma.

Glossary

A comprehensive list of the nomenclature relevant to the topic

Rita

The project name for a past Fluke project; it combined digital multimeter functionality and basic oscilloscope functionality. The product was rather bulky and not a success.

Ruby

The project name for the adaptation of Tetra for Tektronix. Refer to *Tetra* for more information.

ScopeMeter

A product introduced in 1991 by Fluke, offering oscilloscope and multimeter functionality, hence its name ScopeMeter.

Signal integrity

The ability to accurately reconstruct a waveform is referred to as the signal integrity of the oscilloscope.

Tetra

The project name for the new Fluke 190 series II four channel ScopeMeter. Quattro is its dedicated processor. Its predecessor is called *Winnie*.

Thor

The project name for the Fluke 430 Series Power Quality Analyser. The product uses mostly parametric functions and presents processed data to the user. Its form factor is similar to that of the 190 series ScopeMeter. Its successor is called *Donar*.

Trace

The waveforms drawn by a CRT by the movement of its electron beam.

Transducer

A device that receives a signal in the form of one type of energy and converts it to a signal in another form, in case of the oscilloscope: it converts physical quantities such as sound, pressure, strain, or light intensity into an electrical signal.

Transient

A signal measured by an oscilloscope that only occurs once. It is also sometimes referred to as a single–shot event.

Trigger

The system on the circuit board that references a horizontal sweep on an oscilloscope, by adjusting the time scale.

Winnie

The project name for the Fluke 190 series two channel ScopeMeter. Its successor is called *Tetra*.

Z-axis

The display attribute on an oscilloscope that shows brightness variations as the trace is formed; only applies to (digital) phosphor traces. Refer to *intensity grading* for more information.

Zenith

The preliminary project name given to the wireless single channel probe design featured in this report, combined with either a dedicated work station or a common processor such as a tablet or a laptop. The wireless single channel probe is the culmination of the (research) timeline and the final goal in oscilloscope design.

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