Bachelor thesis

Design proposal for the FLUKE Wireless Touch Power Quality Analyzer

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Preface

Introduction to my bachelor assignment.

This report is my bachelor thesis about the project I worked on for Fluke. The project gave me the unique opportunity to work at the Product Development department at Benchmark Electronics at Almelo for five months. This means working together with well experienced both Industrial designers and Mechanical engineers. The perfect place to work for me, with my Mechanical Engineering background.

I would like to thank everyone at Benchmark Electronics for making me feel a member of the team, for involving me in their own projects and work related activities and especially for sharing their extensive knowledge and resources with me. I also wish to thank several people in particular.

Christian Suurmeijer, Benchmark's Lead Industrial Interaction Designer, for his guidance and support during the project. And of course for thrusting my capabilities. As a colleague, Christian is very enthusiastic which made me feel right at home.

Maarten van Alphen, Benchmark's Usability Engineer/researcher, for sharing his extensive knowledge about wireless possibilities for the future power quality analyzer.

All Coworkers of the Mechanical Engineering and Product Development department, for their assistance and social behaviour in the workplace.

Theo Krone, my supervisor at the Univirsity of Twente, for offering guidance and advice during the project. He also drawed attention to the importance of defining the goals of the project.

I experienced my bachelor assignment as a challenge for myself, to stay both focused and deliver a good design which is valuable for Benchmark Electronics.

Abstract

Final report for the bachelor assignment.

BACKGROUND

Fluke has the idea to use an excisting consumer tablet in their future power quality analyzer. An early study by Philip Jansen, a bachelor student at the Univirsity of Twente, shows that a touchscreen interface is a real addition to the functionality of a power quality analyzer. Philip used an iPad 2 to test the touchscreen interface he designed. The problem is that such consumer tablet is very vulnerable for the typical use of a Fluke product.

APPROACH

A design study will give insight in which way a consumer tablet could be integrated in a new design for a power quality analyzer. The goal is to create a design proposal which complies to Fluke's design standards. The design has to meet both esthetical and functional desires.

RESULTS

After a design traject, a design proposal for the next generation power quality analyzer was created. The design features several functions Fluke wanted to integrate in previous models but never succeeded for different reasons. The design also has a different design than other Fluke products which could be an inspiration for Fluke's other future designs.

CONCLUSIONS

The presented future power quality analyzer shows that integrating a consumer tablet into a Fluke product is possible. This design is different than other brand's analyzers, which makes the product unique on the market.

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Introduction

Power quality is becoming more important these days. High-end electronics and sensitive semiconductors require a stable and clean power source, which makes the power quality measurement equipment market larger and growing.

Fluke produces power quality analyzers and wants to be te biggest competitor in every segment the company is involved. Fluke has a reputation to be innovative with their products. This means that the next generation power quality analyzer needs to be an improvement to the current device and it's developed successor. Fluke does research to the integration of a consumer tablet in the future power quality analyzer, this report will be an addition to this research. The report is devided into three parts, *a reasearch phase, a conceptualisation phase and a finalisation phase*.

RESEARCH PHASE

The research phase contains a small brand and market analysis to gain knowledge about the users and excisting devices. The phase also contains research to product specific information. What is power quality and which safety standards are important for designing a professional electronic measuring tool?

CONCEPTUALISATION PHASE

The conceptualisation phase focuses on the future power quality analyzer. Is it esthetically and technically possible to include a consumer tablet into a professional electronic measuring tool? After evaluating several concepts, the esthetical foundation for furter detailed design is created.

FINALISATION PHASE

The finalisation phase contains research to the technical design of the future power quality analyzer. The last step of the process is the design verification by using the stereolithography [SLA] rapid prototyping method.

RESEARCH PHASE

01.1 Fluke logo.

01 |FLUKE Corporation

" Fluke Corporation is the world leader in the manufacture, distribution and service of electronic test tools and software."

INTRODUCING FLUKE

The Fluke corporation aims to be the world's leader in the manufacture, distribution and service of electronic measurement test tools and software.[07] Fluke was founded in 1948 by John Fluke sr, friend and room mate of David Packard, co founder of Packard Bell. In the past years, Fluke has been a noticable player in the test- and measuring equipment market and helped to define the standard in this market. Every new manufacturing plant, office, hospital or facility built today, represents another potential customer for Fluke products.

Fluke is a subsidiary of the Danaher Corporation since June 1998, which makes Fluke a multinational corporation with a headquarter in Everett, Washington, USA. Manufacturing centers are located in the USA; the UK; Asia and The Netherlands. Sales and service subsidiaries are located all over the world: Europe; North America; South America; Asia and Australia. Fluke has 2,400 employees worldwide.

A notable detail is the acquisition of Tektronix by the Danaher Corporation in 2007 because Textronix was one of Fluke's competitors. Since Tektronix and Fluke are now part of the same holding, Tektronix and Fluke operate on the same market but focus on an other segment. Fluke focuses on the so called 'blue collar' worker that uses handheld instruments, where Tektronix focuses on the 'white collar' worker that uses portable; bench; and handheld products. Blue collar stands for 'on the site use' and white collar stands for 'laboratorium use'.

THE ALMELO PLANT

Fluke has a manufacturing center in Almelo, The Netherlands. This plant is a design and production plant that has been a division of Benchmark Electronics that operated under the banner of Fluke from 1993 until 1999. The plant was called the Almelo Industrial Center [AIC] and formed the basis of Fluke's Diagnostic Tools Division that focuses on portable oscilloscopes and other graphical diagnostic tools like power quality analyzers.

When the AIC was sold to Pemstar, it's relationship with Fluke endured, because it became an electronics manufacturing service provider [EMS]. Fluke's test and measurement tools were still developed at the Almelo plant and it operated like an integral part of Fluke's manufacturing operations. At this moment, Fluke oscilloscopes and power quality analyzers are developed and produced in Almelo, using Benchmark Electronics' facilities.

01.2 Current Fluke products.

PRODUCTS

Fluke produces a wide variety of products which can be categorized as following: electrical and temperature; indoor air quality; calibration and biomedical. Fluke products are portable, easy to use and built rugged to function like a tool, also in extreme conditions. Fluke products comply to the latest safety and measuring IEEE and IEC standards and have mostly a CAT III and CAT IV rating, which will be explained later. Fluke has archieved a number one or number two position in every market in which the company competes. Fluke products are famous for their accuracy, reliability, toughness, safety and usability.

Image 01.2 shows different Fluke products.

01 Fluke 233 Remote True-RMS Display Multimeter
The Fluke 233 remote display digital multimeter is a high quality multimeter with a wireless display, that makes it possible for the user to be 30 ft away from the measurement point.

02 Fluke Ti25 Thermal Imager, Radiometric Camera
This thermal imager captures images of infrared energy or temperature. Thermal imaging or thermography, detects heat patterns or temperature changes in objects. These changes allow the user to discover problems very quick.

03 Fluke Scopemeter 190 Series II
This is the newest Fluke scopemeter which offers a bigger display, less weight and better accurancy. This scopemeter is the perfect tool for troubleshooting capabilities by visually inspecting signals amplitude, time, shape and disturbance or distortion characteristics.

04 Fluke 337 Clamp Meter
This clamp meter is an electrical tester that combines a voltmeter with a clamp type current meter. Today's clamp meters have most of the basic functions of a Digital Multimeter [DM].

05 Fluke 810 Hand Held Vibration Tester
This vibration tester locates and diagnoses common mechanical problems and prioritize repair actions with no prior machine history. The device offers a database, which allows the vibration tester to come up with an acurate diagnosis of the problem.

06 Fluke Ti40 FlexCam Thermal imager
This thermal imager is a bigger version of the Ti25 with more functions. The shape has a lot in common with a underwater consumer camera and it offers a big five inch display.

07 Fluke 1653B Multifunction Installation Tester
The 1653B Installation Tester verifies the safety of electrical installations in domestic, commercial and industrial applications. It can ensure that fixed wiring is safe and correctly installed.

01.3 Typical use of a Fluke product.[35]

TARGET GROUP

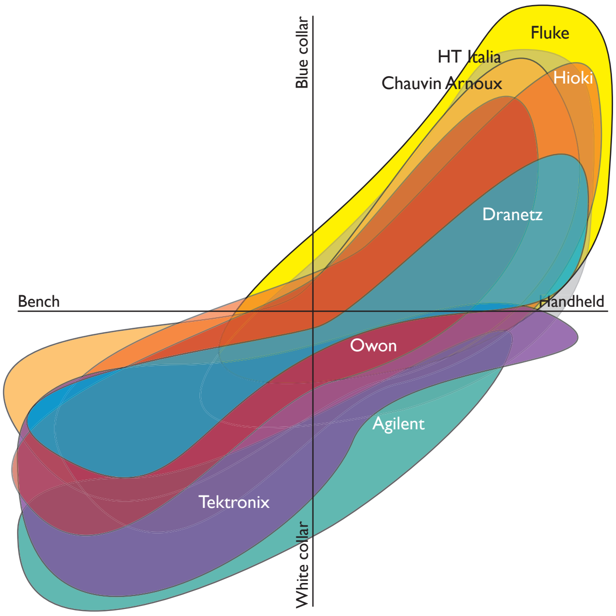
Fluke focuses on the typical blue collar worker[07] *(figure 01.3 and 01.6)* that uses handheld instruments under extreme conditions. The blue collar worker is a member of the working class, performs skilled or unskilled labour and does not want to deal with bad functioning tools. The worker also operates in dangerous, dirty and hot environments. This worker needs portable, reliable, acurate and easy to use instruments that can withstand a drop on the floor. Fluke products comply to these requirements with their tools by providing tools that are made of high quality components packed in a rugged enclosure that complies to the rigid safety standards.

The blue collar worker has a long term relationship with his tool, since these professional tools are very expensive. So, the worker and the worker's employer don't buy a new upgraded tool when the advantages are minor. A new feature has to be innovative and very improving for the product's function.

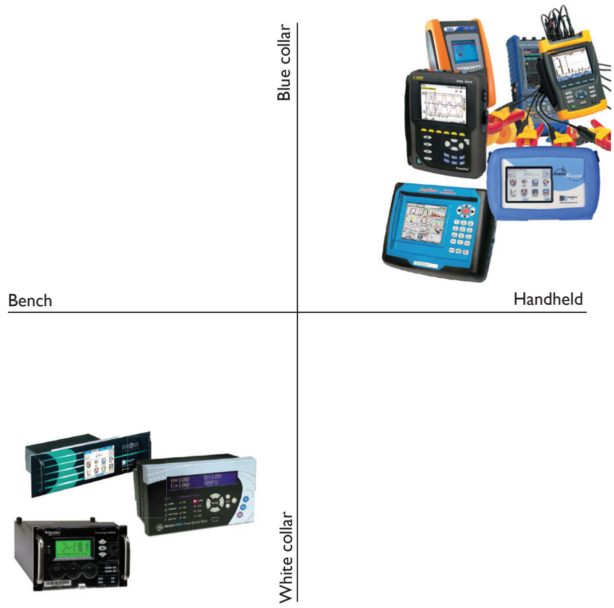
The electronic measurement market is a market with a wide variety of completely different products which all have different users. The market can be categorized by the location where the product will be used, called blue and white collar. The market can also be categorized in the product's portability. Both relations arvisualized in figure 01.4 and 01.5.

FLUKEVERSUS OTHER BRANDS

As said, Fluke products are portable and rugged. Other competitors produce completely different tools. It's interesting to analyze the complete market to define Fluke's image and position. Important competitors of Fluke are *Dranetz; Agilent; Hioki; Chauvin Arnoux, HT Italia and Owon*. Tektronix is not mentioned because it also is a Danaher Corporation brand. Fluke's direct electronic measurement tools competitors are *Dranetz; Chauvin Arnoux; Hioki, HT Italia and Owon* where *Dranetz; Chauvin Arnoux, HT Italia and Hioki* also produce a power quality analyzer.

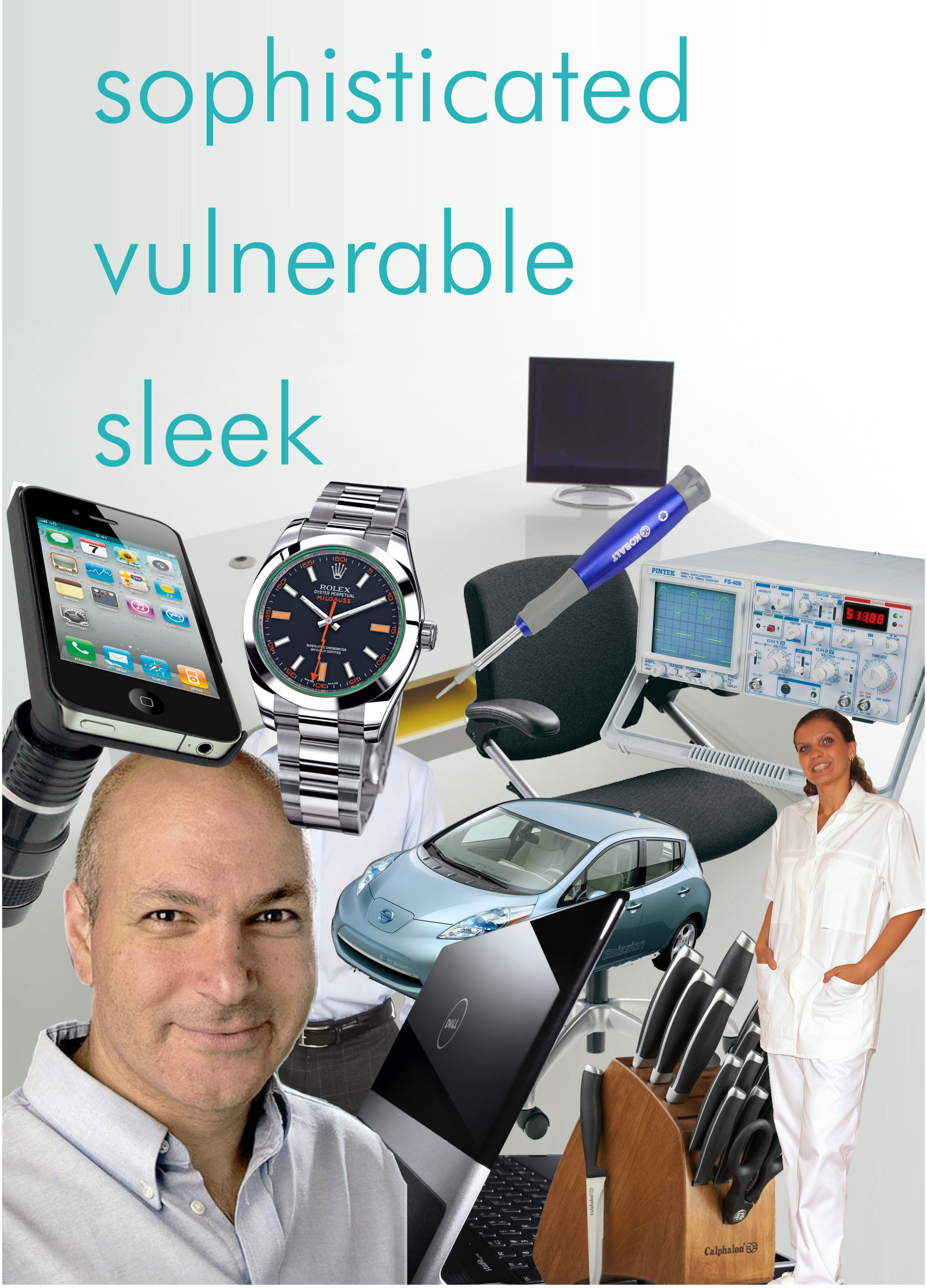


01.4 The electronic measurement market



01.5 The power quality analyzer market

01.6 Blue collar collage: the typical FLUKE user



01.7 White collar collage: the typical Tektronix user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	Fluke 434/435	**C.A Qualistar 8335**	**Dranetz PX5-400**	**Hioki 3197**	**HT Italia PQA823**
Scope waveform and phasor	Yes	Yes	Yes	Yes	*Yes*
Volts/Amps/Herz	Yes/Yes/50/60hz	Yes/Yes/50/60hz	Yes/Yes/ 50/60/400Hz	Yes/Yes/50/60hz	Yes/Yes/50hz
Dips and swells	Yes	Yes	Yes	Yes	*Yes*
Harmonics	Yes	Yes	Yes	Yes	*Yes*
Power and Energy	Yes	Yes	Yes	Yes	*Yes*
Flicker	Yes	Yes	Yes	No	*Yes*
Unbalance	Yes	Yes	Yes	Yes	*Yes*
Transcients	Yes	Yes	Yes	Yes	*Yes*
Inrush Currents	Yes	Yes	Yes	Yes	*Yes*
Logger/recording	Yes	Yes	Yes	Yes	*Yes*
PQ monitoring	Yes	Yes	Yes	Yes	*Yes*
Safety	1000V CAT III, 600V CAT IV	1000V CAT III, 600V CAT IV	600V CAT III	600V CAT III, 300V CAT IV	1000V CAT III, *CAT IV 600V*
Standards	IEC61000-4-30 class A, EN50160, IEC 61000-4-15, IEC 61000-4-7, IEC/EN61010-1-2001	IEC 61000-4-3, IEC 61000-4-4, IEC 61000-4-8, IEC 61000-4-11, IEC 61010-1, NF EN 60529 A1, IEC 61000-4-11	IEC 61000-4-30 Class A , IEEE 1159, IEEE 1459, EN50160	EN61326 Class A, EN61010, EN61000-3-2, EN61000-3-3	*IEC / EN50160, IEC / EN61000-4-30 class B, IEC / EN61000-4-15, IEC / EN50160, EC / EN61000-4-7, IEC / EN50160*
Connectivity	Optical USB	Optical USB	USB 2.0, Ethernet	USB 2.0	USB 2.0 (Host and slave) Flashdrive
Touchscreen	*No*	*No*	*Yes*	*No*	*Yes*
Battery	NiMh	NiMh	NiMh	NiMh	*Li-ION*
Weight	2,0 kg	2,1 kg	1,9 kg	1,2 kg	*1,0 kg*

01.8 Features and specifications of different Power quality analyzers. [02,03,04,05,06]

Fluke's and competitors' power quality analyzers

The described brands which produce power quality analyzers are discussed below.

Fluke 434/435 Power Quality Analyzer [04]

The Fluke 434 and 435 power quality analyzers are professional accurate devices for power quality measurements. The 434 and 435 differ in the way that the 435 also features a logger function. The 434 and 435 comply to rigid safety standards and have proven reliable. The devices do not offer a touchscreen which makes is possible to use the device while wearing gloves.

Chauvin Arnaux QUALISTAR 8334, 8334B, 8335 [02,08,37]

The Qualistar is a professional three phase power quality analyzer with color display. The display doesn't use a touch interface, but the buttons below the screen match the correspondating active funtions on the display. The Qualistar provides the same measuring modes as the Fluke device but the Qualistar offers less accurance and quality.

Dranetz PX5-400 [03,09]

The Dranetz PX5-400 is a professional three phase power quality analyzer with color touch display. The body is made of a soft blue plastic (propably TPU), the display lays deep in the body to be prevented from damage. The PX5-400 has different modes to measure power quality: waveform and phase mode, harmonics mode; recording and long term monitoring. The PX5 also features 400Hz measurements and a libary with Power Quality answers on the field. The PX5 has no CAT IV rating.

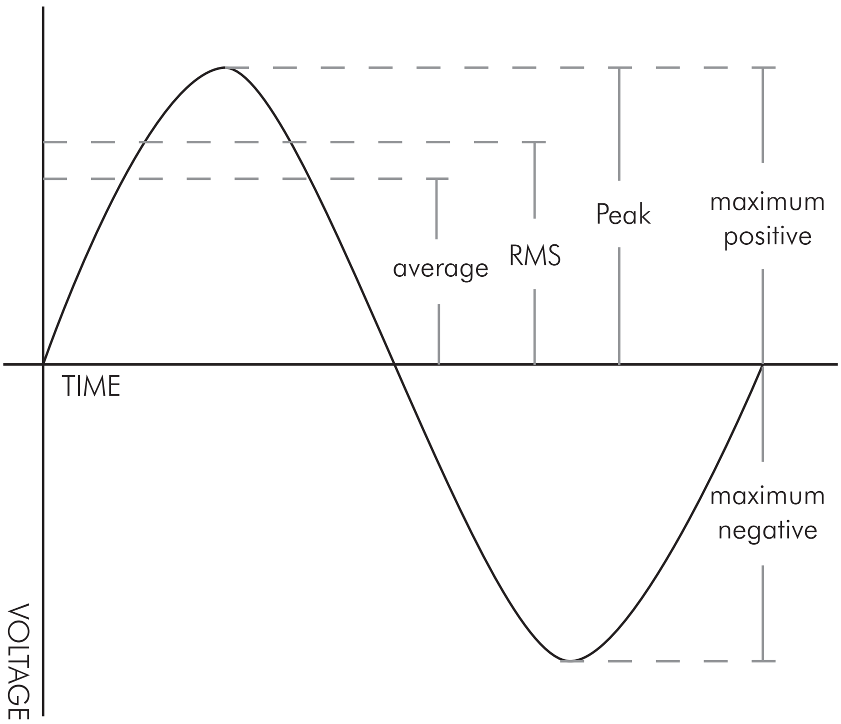
Hioki power quality analyzer 3197 [05,10]

The Hioki 3197 is a small power quality analyzer with a color display and a hardware interface. The analyzer features different measure modes: waveform and phase; harmonics; inrush; dip/swell and a record function.

HT Italia PQA823 [06,11]

The HT Italia PQA823 is a power quality analyzer with severeal connection possibilities. It features connections for USB flash drives and compact flash cards. It also features a touchscreen. The device lags 60Hz measurements.

All analyzer's specifications are shown in figure 01.8. [02,03,04,05,06]



02.2 Peak and RMS voltage [16]

02.3 Fluke 435 Power Quality Analyzer [34]

02.4 Fluke 1740 Power Quality Logger

02 | The Power Quality Analyzer

Fluke currently produces the Power Quality Analyzer 434 and 435 and 1740 Power Quality logger. The 434/435 successor is being developed.

PORTABLE POWER QUALITY ANALYZERS

Fluke produces a family of three-phase portable power quality analyzers which are capable to measure and log different electrical parameters that indicates the power quality. These measuring tools are used by electrical technicians, scientists and engineers to troubleshoot power problems in power systems at different locations. The current models are the Fluke 434 and 435 *(figure 02.3)*. Fluke also produces the 1740 power quality logger *(figure 02.4)*. The Fluke power quality analyzer will be discussed in depth later.

POWER QUALITY EXPLAINED

First there has to be noticed that no real-life power source is ideal.[17] This is why the source's quality has to be descibed by a set of parameters, which is called the power quality. This term describes how well an electric load performs with the electric power source provided. Power quality doesn't describe the power's quality as the term suggests, but the voltage's quality. The power is simply the flow of energy which is related to the electric current and voltage by the multiplication of both.

Ideally, the voltage supplied by an utility changes polarity in a specified time which gives the voltage an alternating character. The voltage alternates by a sinusoidal shape with an amplitude and frequency given by national standards or system specifications. The voltage-shape becomes non-ideal due to the used equipment in a system like switching power supplies (high frequency currents) difficult to handle loads (low resistance) and other appliances that contaminate the power system.

This is where power quality becomes important because the non-ideal power source's quality can be rated by a set of parameters which are: *peak and RMS voltage; crest factor; nominal voltage; frequency; harmonics and impedance.*

Peak and RMS voltage[17,18]

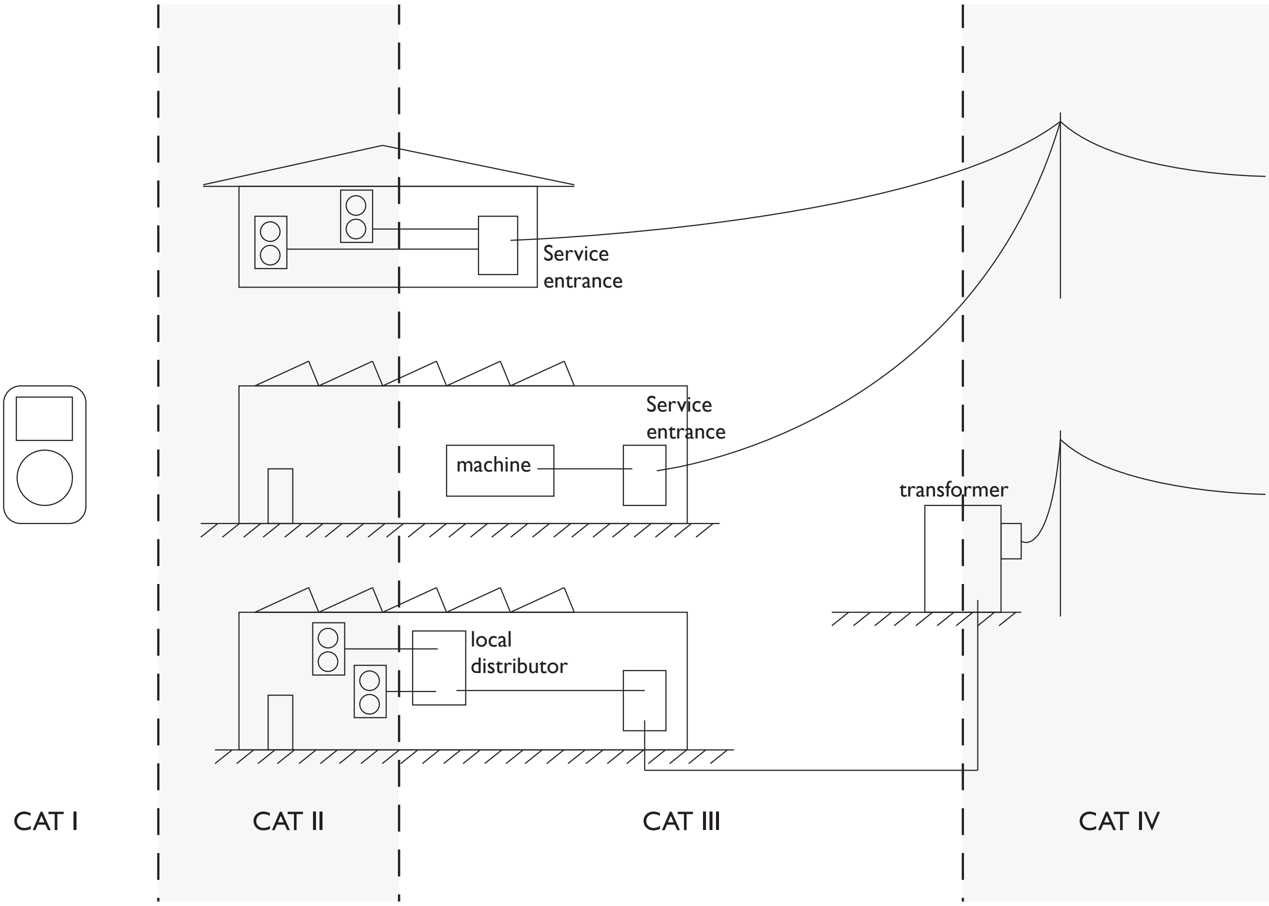
Peak and RMS voltage are both different variables but have a relation to each other. This relation is shown in figure 02.2. [18] For a sine wave, the RMS voltage is the peak voltage devided to the square root of two, where RMS stands for "root mean square" [18]. The RMS voltage is a value for the effective voltage, where the peak voltage is the maximum voltage. There are different scenarios or events that can occur to the peak and RMS voltage.

When the RMS voltage exceeds the nominal voltage by 10 to 80 percent for half a cycle to 1 minute, the event is called a 'swell'. When the RMS voltage is below the nominal voltage by 10 to 90 percent for half a cycle to 1 minute, it is called a 'dip', which is the opposite situation.

Random or repetitive variations in the RMS voltage between 90 and 110 percent of the nominal voltage can produce a phenomenon known as 'flicker' in lighting equipment. Abrupt increases in voltage, called 'spikes' are generally caused by large inductive loads being turned off.

Crest factor [15,17]

The crest factor is a dimensionless quantity that is a measurement of a waveform, calculated from



Rated Voltage	*IEC 61010-1 2nd edition*		
	CAT IV	**CAT III**	**CAT II**
150V	4000V	2500V	1500V
300V	6000V	4000V	2500V
600V	8000V	6000V	4000V
1000V	12000V	8000V	6000V
Resistance	2 Ohms	2 Ohms	12 Ohms

02.5 Electric categories visualized (up) and IEC 61010-1 specified (down) [19,20] the peak amplitude of the waveform divided by the RMS value of the waveform. The Crest Factor is a quick and useful calculation that gives the analyst an idea of how much impacting is occurring in a time waveform.

Nominal voltage [17]

The nominal voltage for a sine wave is descibed by the peak voltage multiplied by 2 and derived by Pi. The nominal voltage can change in time which results in undervoltage or overvoltage. Undervoltage and overvoltage occur when the nominal voltage drops repectively below 90 percent and voltage rises above 110 percent of the specified nominal voltage for more than 1 minute.

Frequency [17]

The alternating voltage has a specified frequency which can change in time. Changes in frequency are undesireble and result in a lower power quality.

Harmonics [16,17]

All variations in wave shape are called harmonics. A harmonic is a component frequency of the signal that is an integer multiple of the fundamental frequency. But variations in wave shape also occur when a different signal disturbs the original signal, which is not called a harmonic.

Harmonic distortion or THD [17,19]

Total harmonic distortion, is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. Lesser THD means that the output signal is a better representation of the original signal.

SAFETY STANDARDS

Electrical equipment has to comply with different safety standards [20,21] and specified standards for measuring. The 434 and 435 comply to the IEC 61010-1 safety standard, which is the standard for electrical measurement-, control-, and laboratory equipment. The analyzer also complies to specific power quality analyzing standards, described in both IEC 61000-4-30 class A and EN50160 standards.

Categories

IEC 61010-1 describes four categories which specifies where a device may be used. These categories are shown in figure and table 02.5.

CAT I

This category limits the device to measure only electrical cirquits which are not directly connected to the mains, but powered by batteries.

CAT II

This category pertains the device to measurements to electrical circuits that are connected to the mains. The maximum available continuous power must be limited to not more than 22000 VA. For example, a device connected to a mains socket with a fuse.

CAT III

This category pertains the device to measurements in building installations or local power destributors. The energy is limited by circuit breakers to less than 110000 VA with the current not exceeding 11000 Ampere.

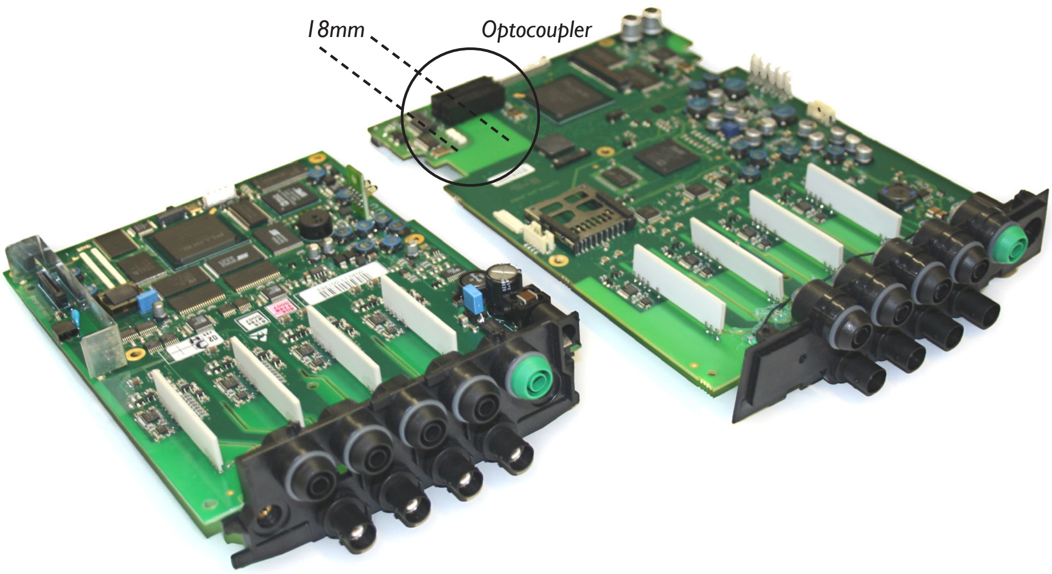
CAT IV

This final category pertains the device to measurements at circuits which are connected directly to the source of power for a given building. The level of available energy is so high that arc flashes can occur.

Voltage rating [20,21]

The category is also indicated with a voltage rating, for example 1000V CAT III or 600V CAT IV. This rating gives a limit for the maximum impulse voltage

03.6 Housing parts of Donar.



03.7 Thor's (left) and Donar's (right) electronics. The optocoupler is well visible.

the device can withstand. A 1000V CAT III and 600V CAT IV rated device can withstand a 8000 Volt impulse voltage.

Thor is 1000V CAT III and 600V CAT IV rated which means serious design considerations so that the risk of an arc flash is reduced. By placing the connectors deep enough into the housing, the Thor housing gets a CAT IV rating. For example, the DC connector to charge the built-in battery is placed about twenty millimeters into the enclosure to minimalize the risk of an arc flash. For the same reason, the USB connection is made using an optical USB connection.

THOR'S HOUSING

Thor's housing has, when not evaluating the buttons, two brand specific colors.[01]

Grey 8 - Munsell 7.1B 3.51/0.3 : this color is used for the main housing. The disdplay surround is also gray 8 with an other finish.

Fluke Yellow - Munsell 9YR 7.36/14.6 : the recognizable Fluke color. This color is applied to the shock absorbing holsters.

UL94 V0 fire rating [04,22]

The housing consists of heavy duty plastics and a solid construction. The grey colored casing is a combination of the elastomers acrylonitril-butadiene-styrene [ABS] and polycarbonate [PC]. The material has a UL94 V0 fire rating which means that burning stops within 10 seconds on a vertical specimen. Drips of particles are allowed as long as they are not inflamed.

The yellow holster parts are also based on the elastomers ABS and PC with a thermoplastic polyurethane [TPU] overmould. TPU is flexible, ultraviolet [UV] - and oil resistance. The yellow parts are higher than the grey part to prevent the grey part from being scratched when it lays on a rough surface.

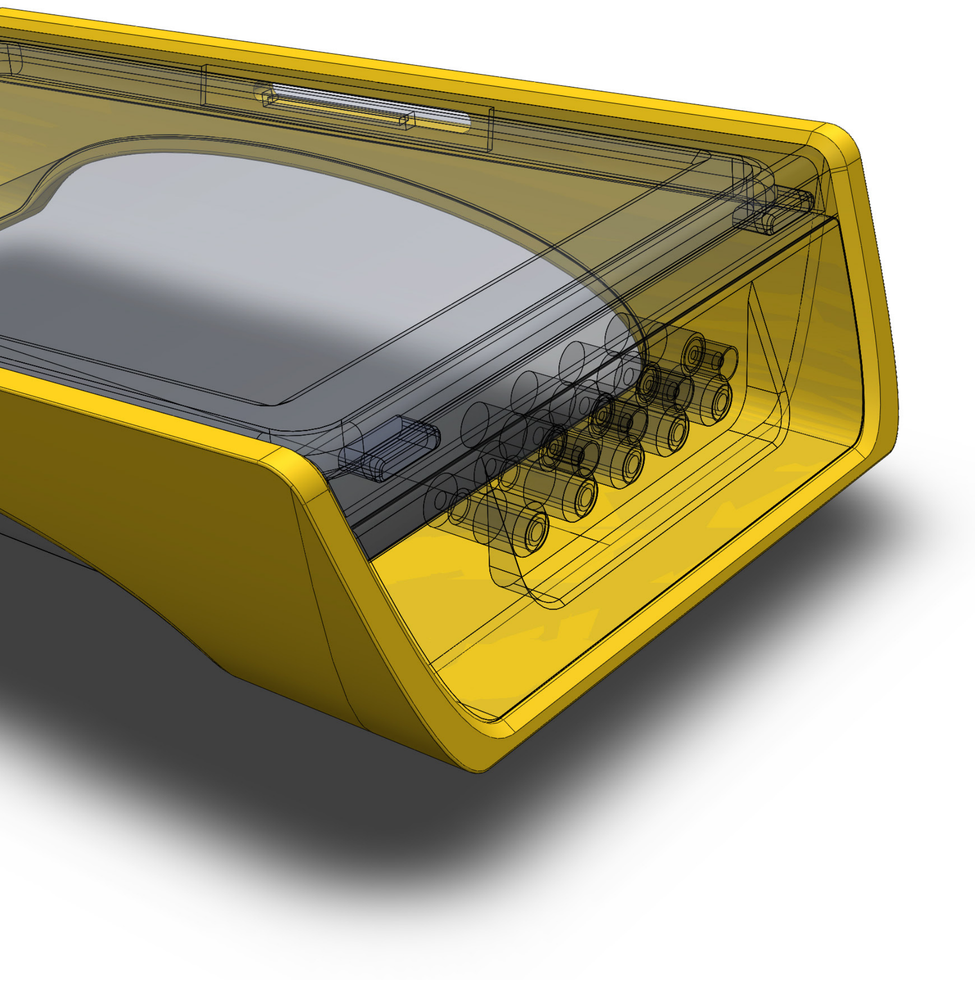
Other safety requirements

The use of visible screws has been minimalized to create a clean and safe look which also results in less collecting of dirt. These and other safety requirements like button size, text size and other standardisations are stated in IEC/EN61010-1-2001. The complete device is shock and vibration proof *(complying to MIL-PRF-28800F Class 2)* which means that the device can withstand a 30g shock and 3g sinusiod vibration.

THOR'S SUCCESSOR

Thor's succesor is called Donar which provides a bigger screen, SD card storage, other shaped buttons and a non-optical USB connector on the outside. This outside USB connector made the inner USB electronics more complicated. [38] To ensure galvanic isolation between the USB port and input clams, the USB electronics and the device electronics are connected with an eighteen millimeter optocoupler. At this moment, the Donar enclosure is available for the Fluke scopemeter and in progress for the power quality analyzer *(figure 02.6)*.

CONCEPTUALISATION PHASE



03.1 Transparent view of concept two.

03 | Future model

The next generation Fluke power quality analyzer has to be a improvement compared to the current model.

Not because this model lags performance, but Fluke wants to provide a state of the art measurement tool with new functionalities. While researching the market, it became clear that the current Fluke appliance has good specifications and performance, but two competitors provide a touch screen. Since there are not a lot of touch screen power quality analyzers on the market, being one of the first brands providing a well integrated touch screen could be a major advantage.

An early study done in 2011 by Philip Jansen, a bachelor student at the University of Twente, shows a design proposal for a power quality analyzer with a touch interface *(figure D.01 - D.04 in appendix D)*. This study gives a good indication about how the power quality analyzer's specific touch screen interface could be designed. It also shows new functionalities due the use of a big touch screen.

TOUCH SCREENS

Touch screens appear more and more in several electronic equipment. Touch screens are, when used with a proper interface, easy to use and have a wide application range. The idea to use a touch screen in electronic measurement tools has inspired Fluke for some years [38], but a touch screen brings a lot of disadvantages, when it comes to ease to use with gloves or serious damage to the tool.

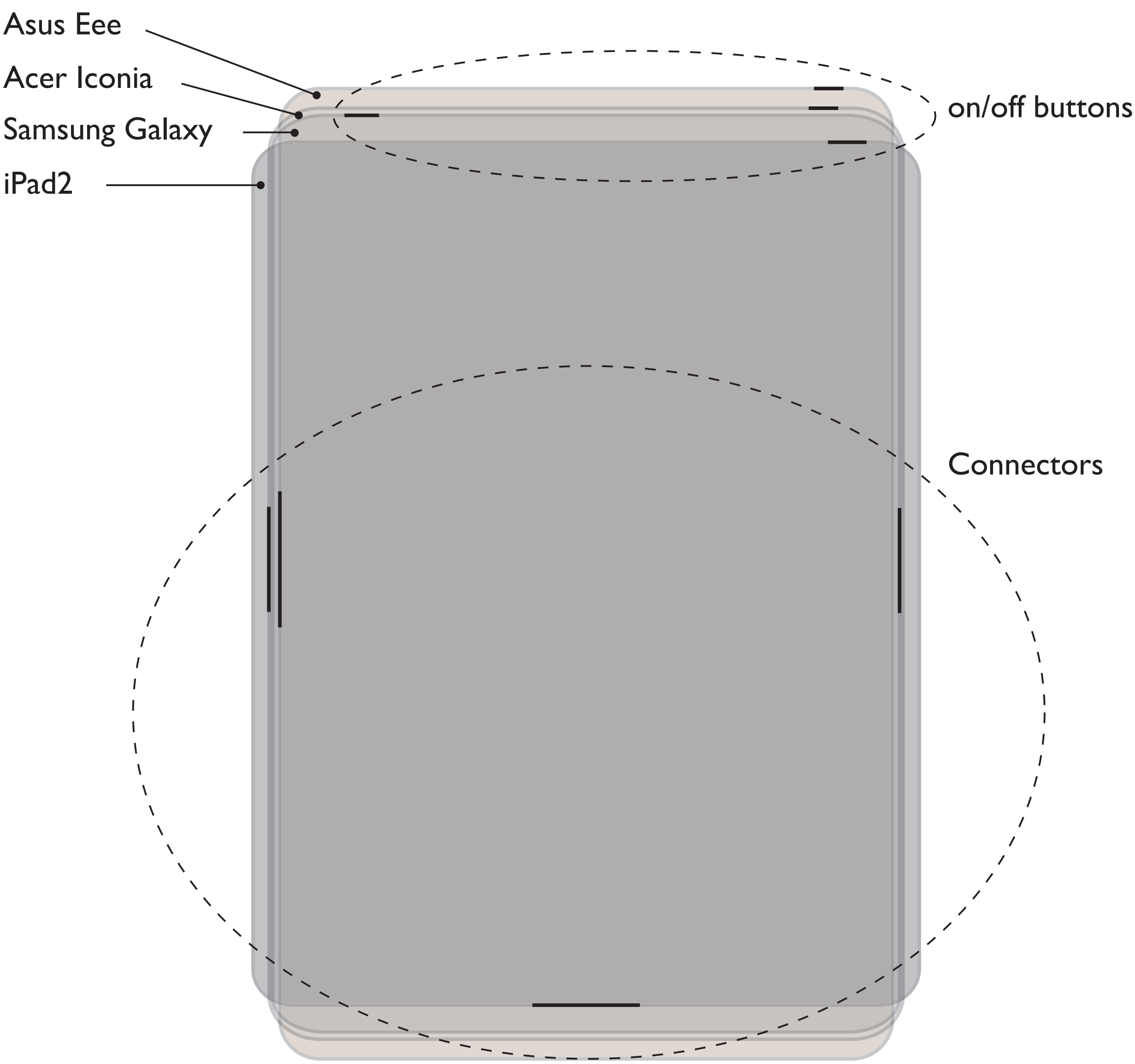
The Dranetz PX5-400 offers a touch screen, but the PX5-400 doesn't comply to the CAT IV rating,[03] propably because the use of gloves is mandatory for CAT IV and the tool does not function while wearing gloves.[23] There are different touch screen technologies which are described in Appendix A. These touch screen technologies all function with an other principle. Some touchscreen technologies are: *restitive touschscreen; capacitive touchscreen; dispersive signal technology and acoustic pulse recognition,* where the capacitive touchscreen is used a lot in consumer electronics these days.

TOUCH SCREEN INTEGRATION

The touch screen interface by Philip Jansen offers a display which has more than ten times the current power quality analyzer display's resolution and it uses pop-up screens to display temporary functions. This means that the hardware to control the display has to be more powerful. The interface also describes a on-screen keyboard so the display controler has to be very acurate.

All hardware has to be more powerful [38] so it is necessary to design complete new electronics. An other Fluke devision, Fluke networks, offers different touch devices so it could be possible to use these in-house technology. But all these touch devices have heat dessipation holes which is not allowed for the specific Fluke electrical measuring equipment. The less expensive way to us state of the art touchscreen technology is to use a touchscreen device that is already on the market and produced by an other brand.

This is where the domestic consumer tablet gets involved. The domestic tablet market is a big market which boosts the mobile computer technology and makes these tablets relatively



Brand and model	*Operating system*	*Size*	*Screen size*	*Docking mode*
iPad 2:	iOS	241x186x8,6mm	*9.7 inch*	Portrait
Asus eee tablet TF101	Android	271x171x12.98 mm	*10.1 inch*	Landscape
Samsung Galaxy tab 10.1	Android	256,7x175,3x8,6 mm	*10.1 inch*	Landscape
Acer Iconia A500	Windows Mobile 7	260x177x13 mm	*10.1 inch*	Landscape

03.2 Various sizes of iOS, Windows and Android consumer tablets, shown graphical and as a table inexpensive. These tablets offer a good touch screen with controller, central processing unit [CPU] power and graphic capabilities. The tablets also offer wireless connectivities and an operating system that supports several connectivity standards. All current A-brand tablets use a capacitive touch screen.[26,27,28,29]

DOMESTIC TABLET PCS

There excist plenty of domestic tablet PCs with different operating systems. The two most common operating systems used for domestic tablet PC's are Apple's iOS and Google's Android. Both systems are able to run third party software where software for iOS is written in objective C and software for Andriod is written in Java. Both operating systems feature several connectivity standards [26,27,28,29] such as USB 2.0 (or USB 3.0), Bluetooth and a WiFi standard. At this moment, there are some tablet PCs which are interesting for integrating in the analyzer: *iPad2; Asus Eee Pad; Acer Iconia A500 and the Samsung Galaxy 10.1 Tab.* The sizes and operating systems for these tablets are shown in figure 03.2.

Connectivity

All tablets use a connector for charging and several other connectivities. [26,27,28,29] The connector is placed on the bottom or on the side, depending on the way the tablet will be used in a docking station. Some tablet PCs use the Portable Digital Media Interface [PDMI] standard [12] for the connectivity, however the layout may have slightly changes to make a connector brand specific. Apple iPad connectors look the same as PDMI, but the inner side is inverted, propably because the Apple pinout is different than the PDMI standard.[14] The Samsung Galaxy 10.1 Tab uses an other connector standard[13] and the discontinued Dell Streak uses the same PDMI housing, but the connector's inside is different. The ASUS Eee Pad uses a 40 pin connector instead of the 30 pin PDMI connector.[28] Choosing a connector type for the power quality analyzer makes the power quality analyzer 'pad-brand' specific so the power quality analyzer needs an adaptive connector. But all tablets feature wireless connectivities, why not use these connectivities for all data exchange?

WIRELESS COMMUNICATION

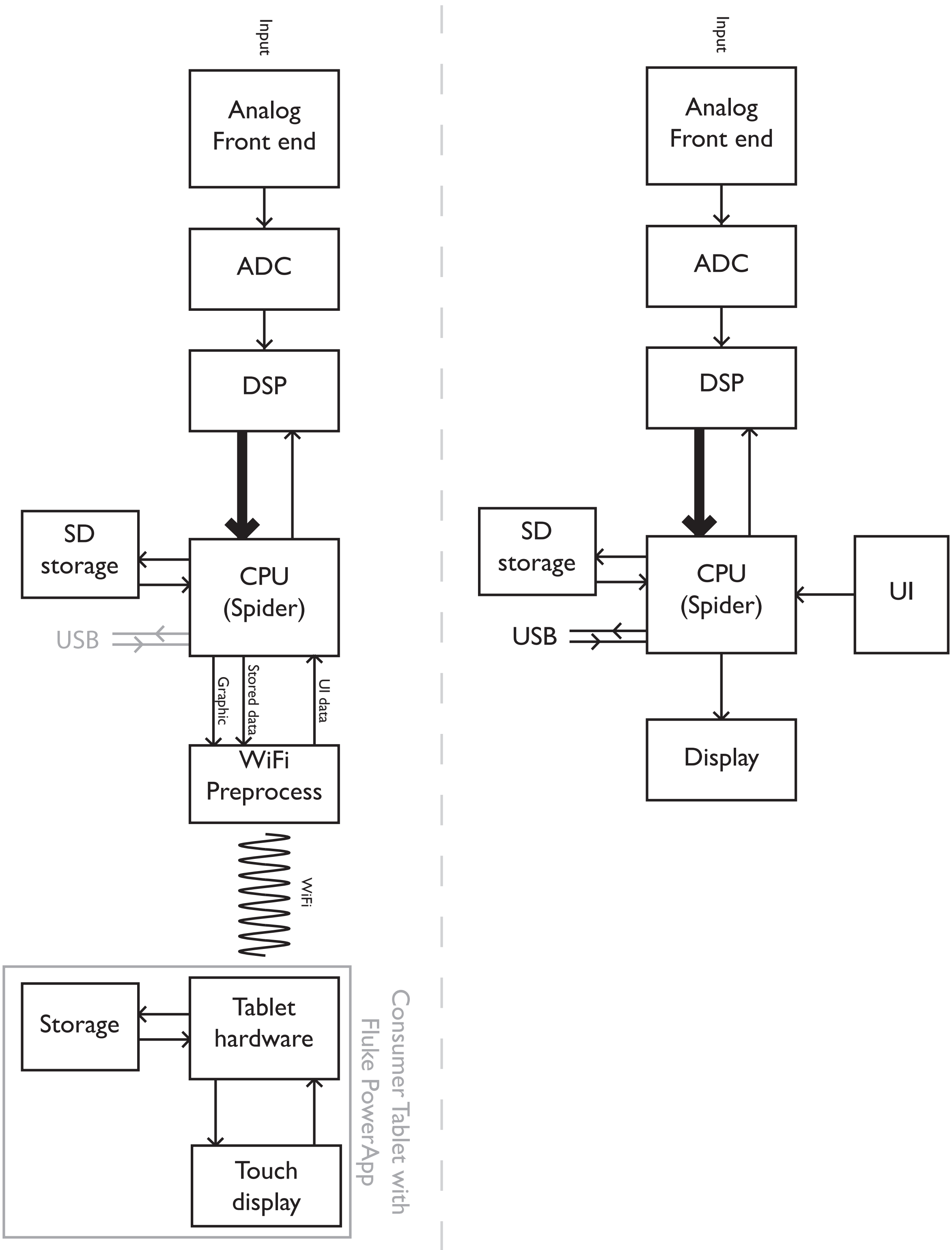
An earlier study in 2010 by Mark Grob, a bachelor student at the University of Twente, shows a new Fluke scopemeter with wireless capabilities. The main idea was making the scopemeter able to measure on a distance. The advantage is that the operator can measure systems that only operate with a closed door by placing a transmitter and receive the measured data via a wireless connection. According to Mark Grob's study, wireless measuring is only possible when the receiver receives one transmitter's data because of the data rate and communication lag on a distance.

Data rate

Wireless data transfer is possible for the power quality analyzer. [38] The minimal necessary data rate depends on the display data.[38] Since the power quality analyzer features eight channels, it needs to display eight traces on a 800 pixels width display (Samsung Galaxy 10.1 tab) with 16 bit depth (the current analog digital converter [ADC] resolution) and for example a 10 frames per second frame rate. A typical margin is a 10/8 multiplier since one byte of data often has a start and stop bit. [38] This makes 800 x 16 x 10 x 8 x 1,25 = 1280 kBit/s = 1,28 MBit/s which is a lot less than the slowest IEEE 802.11a Wifi standard.[24]

Splitting

The wireless power quality analyzer will be splitted into a tablet module and an analyzing module, communicating using a WiFi connection.
This WiFi connection has to transmit display, user



03.3 Current and future simplified block scheme [38] interface and storage data. For Fluke, it is desirable to keep Donar's excisting electronics[38] due to development costs and for the fact the current electronics have been proven reliable.

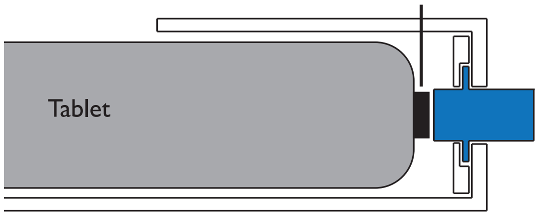
Editing the current system
Since the Thor and Donar power quality analyzers are both modular built,[38] it is relatively easy possible to locate the user interface, display and some storage to a tablet by adding a WiFi connection to the excisting system.[38] There needs to be added a type of WiFi preprocessing after the processed analyzed data before transmiting it to the tablet.[38] The tablet will be able to display current data, control the analyzing module on a distance and download stored data. The analyzing module will be able to operate stand alone for logging purposes. The simplified block diagrams shown in figure 03.3 shows the current power quality analyzer (right) and the future analyzer with WiFi integration (left).

OTHER DESIGN ISSUES

To use a domestic tablet for industrial purposes, the tablet has to be covered to protect it. Most tablets turn of when the screen has not been touched for a while. Since the screen is turned on by using a button on the tablet's top or side, the tablet's enclosure has to provide acces to such button. A mock up for this issue is shown in figure 03.4. [37] The tablet's enclosure also has to provide acces to the tablets brand specific connector for charging, to avoid different expensive adaptive connectors.

Fluke already has analyzing software, called iFluke, The tablet's application could be based on this software which makes using a customer tablet more realistic. The Analyzer module is required to use Donar's excisting electronics.

When the transmitter operates as a data logger, the stored data can be downloaded to the tablet since the datalogger has it's own data storage capabilities using an SD card.



03.4 Mock up for reaching the buttons on a tablet.

04| Design requirements

The next generation Fluke power quality analyzer will have the following requirements.[37]

General

- Weight less than 2.5 kg;
- Maximum product size 350x250x80mm;
- Solid Fluke look and feel;
- Complying to Fluke material and color guidelines;
- Shock (30g) proof;
- Vibration (3g sinusoidal) proof (MIL-PRF-28800F Class 2);
- Both parts act like one appliance;
- Water proof;
- Android or Windows based;

Tab module

- Screen protection for transport;
- Battery charging capability;
- USB connectivity;
- Suitable for different tablet PCs (about 10 inch);
- Tablet in portrait orientation;

Analyzer module

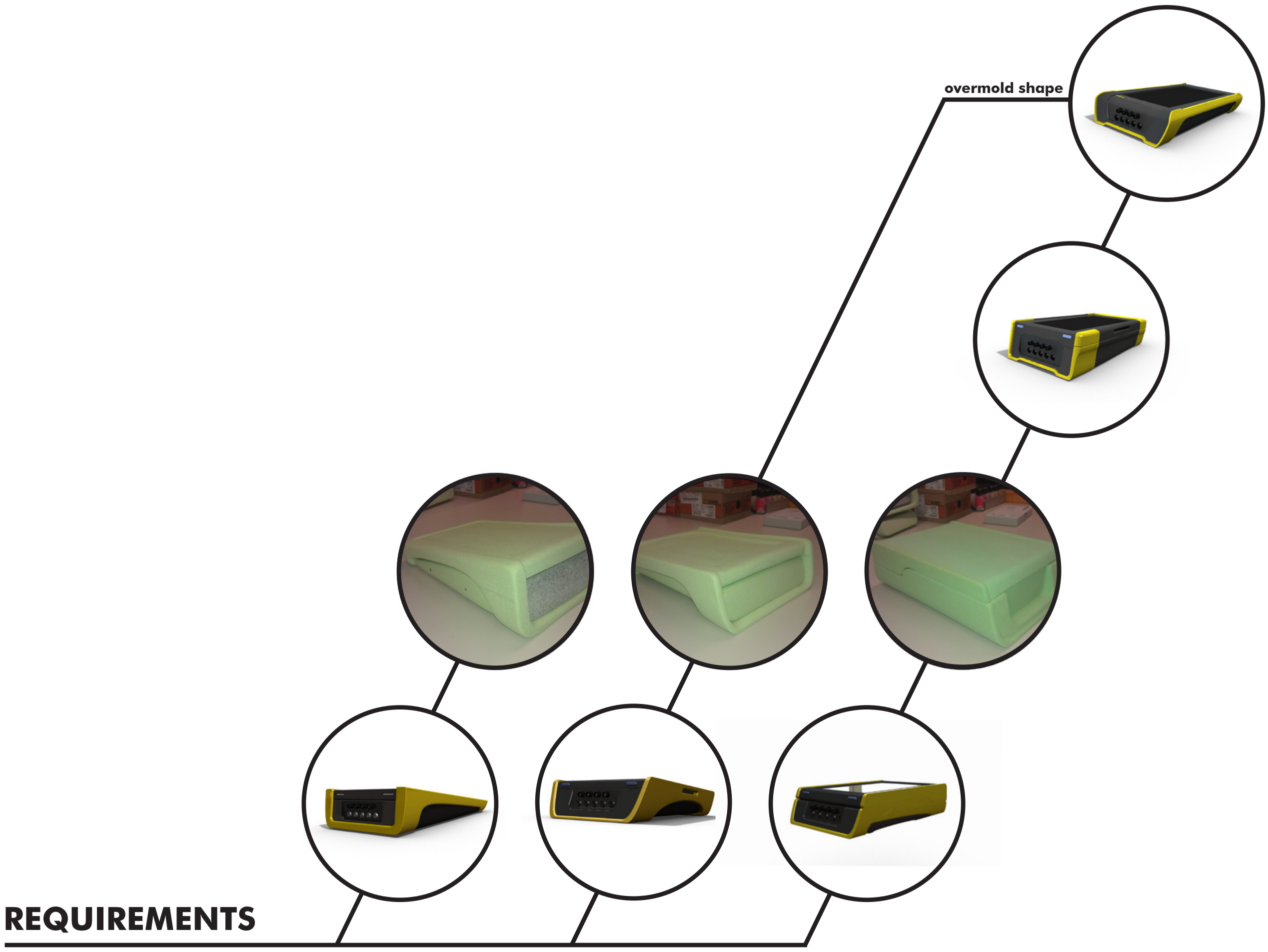
- Minimal size 250x180x40mm to enclose Donar electronics;
- Space for Rechargeable NiMH BP190 battery;
- Maximum 80x30mm black/white display;
- Wireless transmitter;
- Logging capabilities;
- Data storage;
- Simple user interface (current buttons are between 50 mm^2 and 200 mm^2);
- Oparating indicator;
- Start/stop logging button;
- Power source for 75 days logging with 1 hour resolution;
- Battery charging connector;
- Electric shock proof (1000 V CAT III and 600V IV certification) ;
- Dust proof (IEC60529);
- BNC connector (for i400s and i430flex clamps);
- Insulated Banana connector (such as TL222 connector);

Materials

- TPU overmold for shock resistance;
- PC/ABS/V0 for the housing;
- Silicon buttons;

Colors

- Munsell 2.4B 4.49/0.18 for grip area;
- Munsell 2.49B 2.62/0.23 for the general housing;
- Munsell 9YR 7.36/14.6 for the holster;
- Texture matte or semi matte;



05.1 Schematic view of the concept generation process.

05 | Concept generation

The design requirements and the research phase both give a clear basis for the concept generation. The concepts have to solute the tablet integration issue while using the excisting Donar electronics.

The concept generation focusses on a housing that includes tablet integration and a seperate analyzing- and tab module. This feature gives users the possibility to share the expensive analyzing modules when these are not needed for a task. The design's focus point will be splitting and merging the tab- and analyzing module easily while both parts look like a well designed stand alone device.

To comply to the design requirements, the consumer tablet has to be protected by a shock absorbing holster. This holster needs adjustable inner sides to use the holster with different tablet sizes. The Windows and Android tablet sizes don't differ significant because all tablets use the same 10.1 inch display which is an advantage. [26,28,29] An overview with the different tablet sizes is shown on page 20.

Since Fluke products all use a yellow holster, the design requirement to use a holster completely complies to Fluke's design standards. The tablet module will be a non-electronical functional module that offers a housing for the tablet and splitting and merging system.

TAB MODULE

The wireless power quality analyzer will use a consumer tablet which doesn't comply to several savety standards. But since there is no galvanic connection between the tablet and analyzing electronics, the consumer tablet doesn't have to comply to these rigid savety standards.[38]
This doesn't make the device an unsafe device, moreover the device could be safer than excisting appliances because there is absolute no chance of any electrical connection between the analyzing electronics and the userinterface.

The tablet housing may not restrict the tablet's functionality such as connectivity and the use of special buttons. To provide good connectivity, the housing will get an open slot on the left and right side to provide acces to the tablet's connector. The housing also gets buttons to make the user able to press the tablet's buttons by pressing the button on the housing.[37]

LISTED FEATURES

The features that every concept needs to have are listed as following.[37]

- Open sides to provide acces to the tablet's connector;
- Buttons to control the tablet's top buttons;
- Rugged holster to protect the tablet;
- Dust and water proof housing for analyzing electronics;
- Physical connection between tab- and analyzing module.
- Battery acces to analyzing module;
- SD card acces to analyzing module;
- On/off button on analyzing module;
- Simple user interface for analyzing module;
- Operating indication for analyzing module;
- Rugged overmold;
- Stand for both modules;

	01	02	03	04	05	06	07
Module coupling	Slide in	Fit in	Slide on	Click on			
Cable storage	None X			In a case			
Grip and holding							
Battery pack	Bottom insert	Body part	Slide in				
Carrying/Protection	In a case	Display cover					
Standing/hanging			Standard magnetic strap				
SD card	Under battery	Bottom SD card slot	Front SD card slot	Side SD card slot			
Measure module Recharging	Connector	Inductive	Shaking				
Measure module interface	Small touchscreen	Small screen with buttons	Status digits and buttons	Status leds and buttons			

05.2 Morphological overview.

The different design functions can easily be displayed in a morphological scheme. All concepts will not have the functionality to wrap cables, since the power quality analyzer uses too much cables (nine cables).

SHAPE AND SIZES

The design's sizes and shape will be determined by excisting parts such as the consumer tablet and the current Donar electronics. It is desirable to make the design as small as possible, so the way these products will be integrated is the first step for the concept generation.

Landscape or portait

The consumer tablet can be used in portrait and landscape mode. The early study by Philip Jansen shows a portrait oriented touchscreen user interface. Since the screen uses fixed buttons above and under the displayed information, it is desirable to use the tablet in portrait mode, otherwise, too much screen size would be used for the interface instead of the displayed information.

Size

All suitable Android based tablets for the power quality analyzer use a 10.1 inch display which results in little variety in size. The widest and thickest tablet is the Acer Iconia A500 tab [26] and the longest tablet is the Asus EEE tablet. [28] Those width, length and thickness will be the reference sizes for the device and are respectively 177,0 mm, 271,0 mm and 13,0 mm. The current Donar electronics footprint is smaller than the tablet's reference size, so the height of the electronics will determine the design's shape the most. Since the electronics footprint is smaller than than the tablet reference size, it will be able to give the design a trapezoid shape.

Position and orientation

The design will use the same orientation and features as the original power quality analyzer. The connectors will be placed on the device's front and the display will be placed on the top. An adjustable stand will be placed at the bottom. The battery and SD card storage are located into the analyzing module and reachable by unscrewing a plastic cover so the device's electronics are not reachable accidentally while using the device.

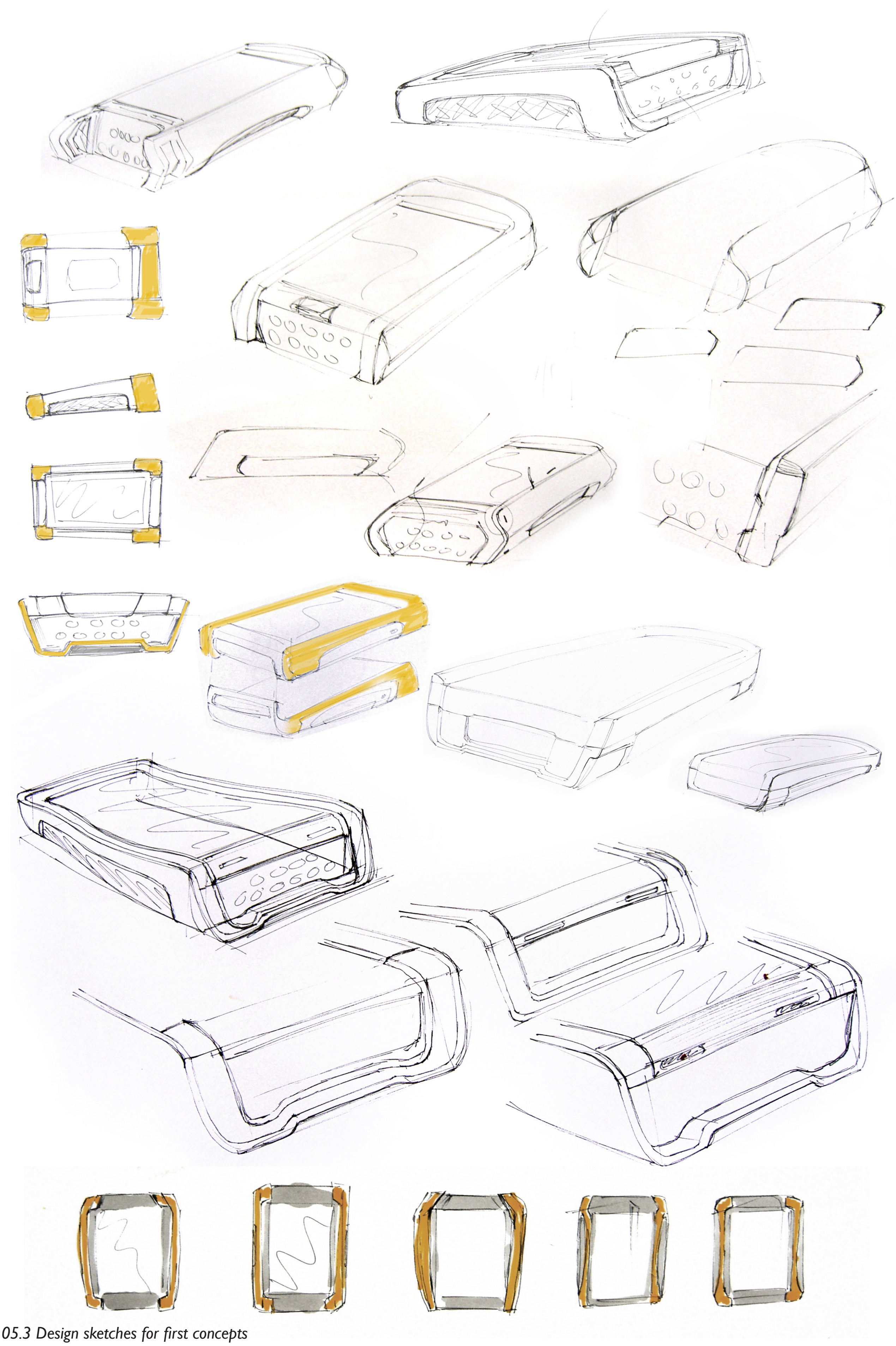
Merging and splitting

The way both parts will be merged and splitted will be a challenge. As said, both modules have to look like a seperate device and look like one device while merged. There won't be a galvanic connection between both parts which makes the physical connection more simple.[37]

It is desirable to merge and split the devices whitin a simple movement that could not occur accidentally. Merging and splitting has to be done by a coupled task, like pressing a knob and pulling the device simultaniously.

Carrying and protection

The device has to be carried in a simple way. The current Power Quality Analyzer has a strap on the size to grab the device easily.
The design has to feature a hook, strap or edge to grab the device. Protection will be supplied by the typical yellow Fluke overmold. A morphological scheme is shown in figure 05.2.



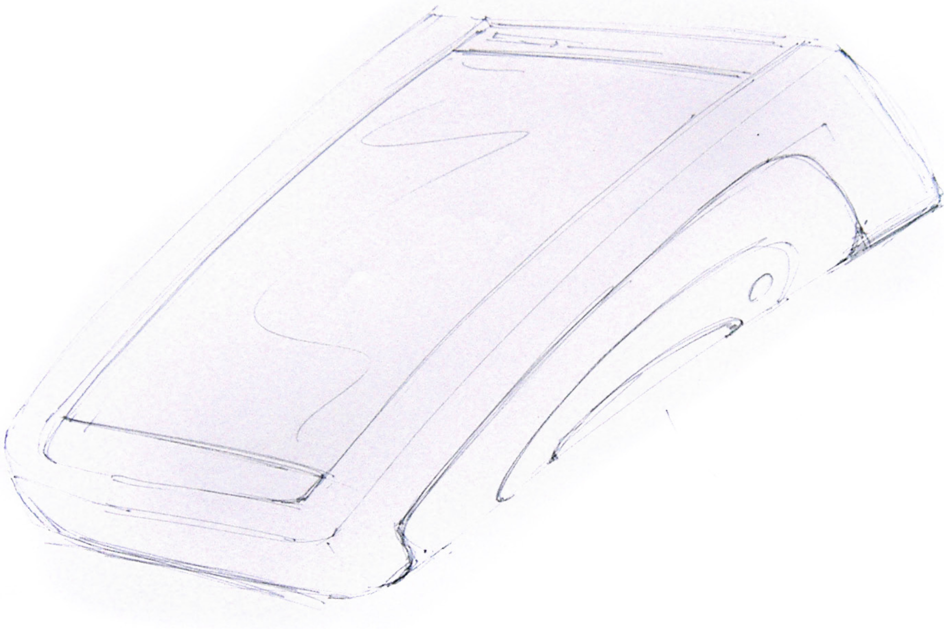
05.3 Design sketches for first concepts

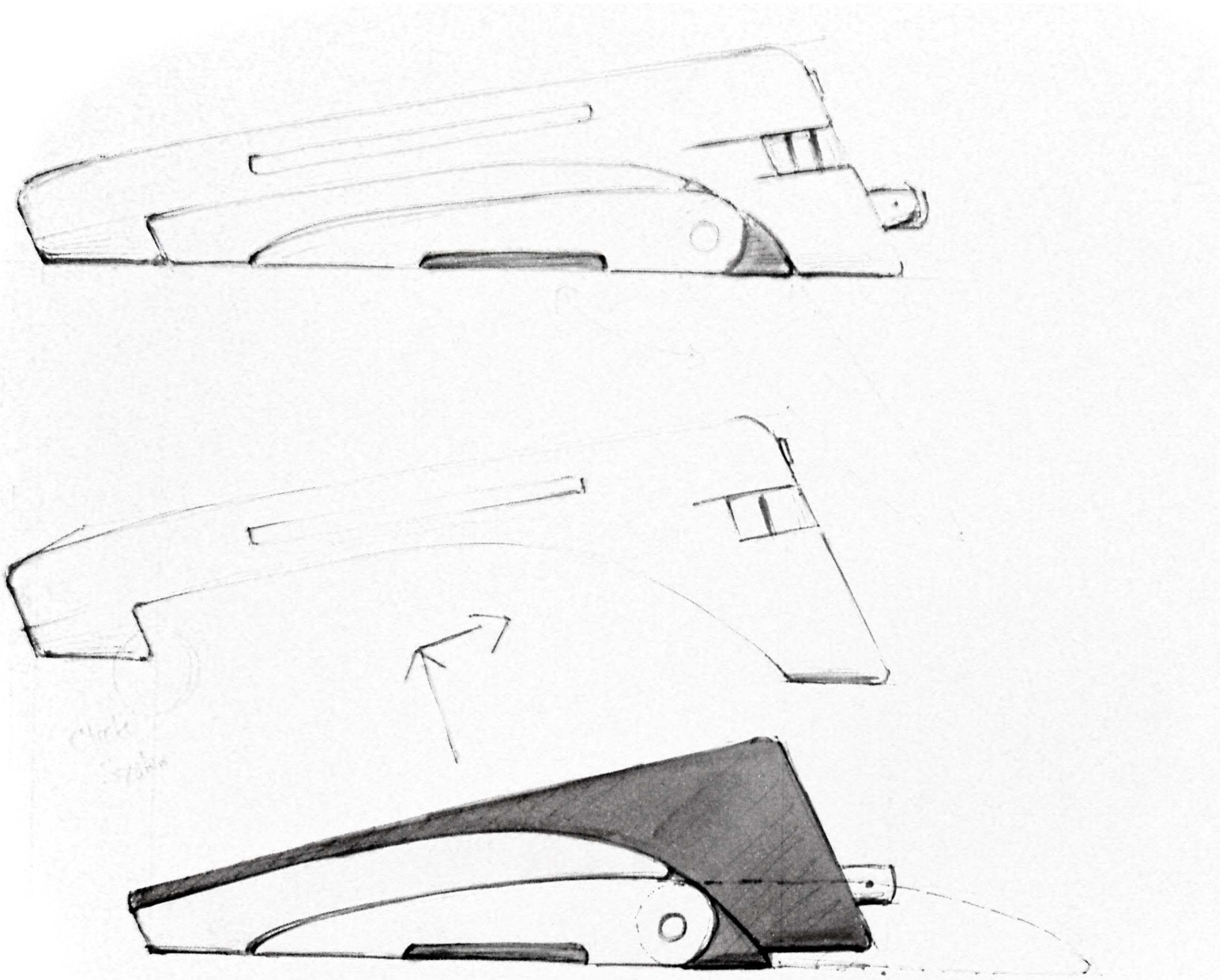
ESTHETICS AND HOUSING'S DESIGN

All Fluke products have a typical design, defined by the company's design requirements. Most current Fluke products look heavy and robust, it would be challenging to design a more elegant still robust device, which correspondents with the wireless technology and consumer tablet used in the future power quality analyzer.

To obtain design inspiration, watching other elegant and robust products with inspirating shapes, like fast and strong cars, watches and tools, would be useful. Especially for the main shape and the way the overmold could be used. The typical yellow overmold has much effect on the device's design, so the way overmold is being used is very important. Yellow overmold has to be applied on the device's corners for shock absorbance, but also provide grip when the device is placed on a slant surface. Figure 05.4 shows a small shapstudy used for inspiration. First design sketches are displayed in figure 05.3. The main design focus was the use of overmold, the basic shape and the connector and display orientation.

05.4 Small shape study.





05.5 Design sketches of concept 1.

Concept 1
PowerWedge

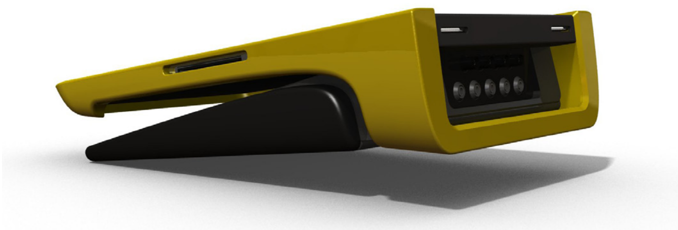
The first concept, shown in *figure 05.5 - 05.9*, the PowerWedge, features a yellow holster to protect the tablet, which can be opened to place the tablet, which has te be done once. The concept's size is about 200x300x80 mm, providing enough space for a tablet, electronics and battery.

The yellow holster protects the tablet against shocks and features a handle to transport the tablet while wearing gloves. The handle can also be used as a stand when the tablet is used on a table or knees. Fluke's standard magnetic strap can be attached to this handle to hang up the tab module.

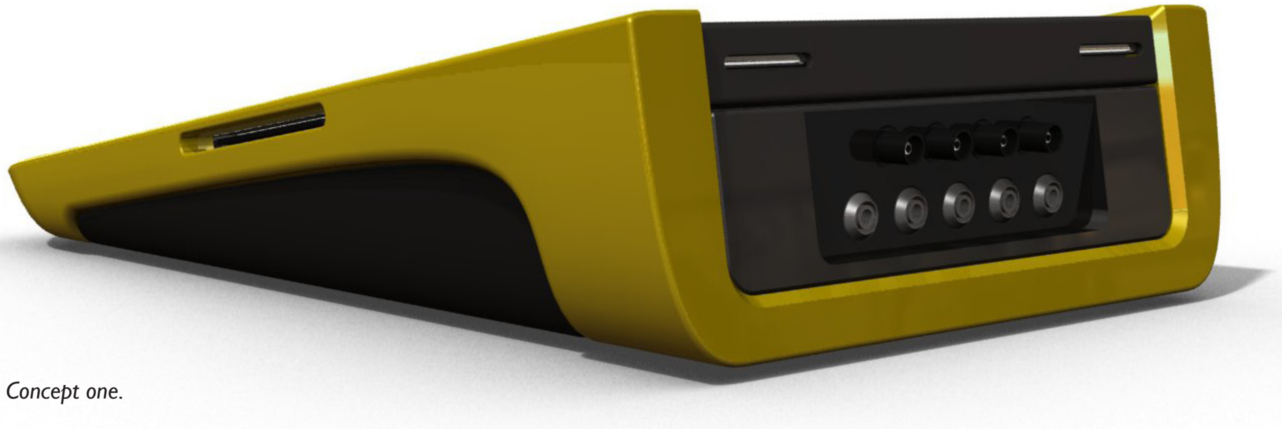
The analyzing module slides with it's top in the handle and falls into the opposite shape. When fully slided into the handle, the analyzing module's back clicks into the tab module. The shape looks solid and rugged and the color use complies to the Fluke standards.

05.8 Concept one's top.

05.9Concept one's bottom.



05.6 Concept one's merging procedure.



05.7 Concept one.

05.10 Concept two's top.

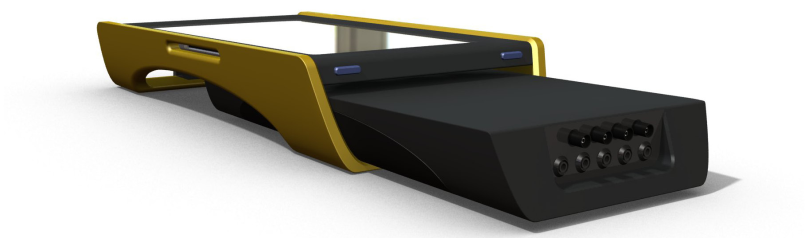
05.11 Concept two's bottom.

Concept 2
Powerslide

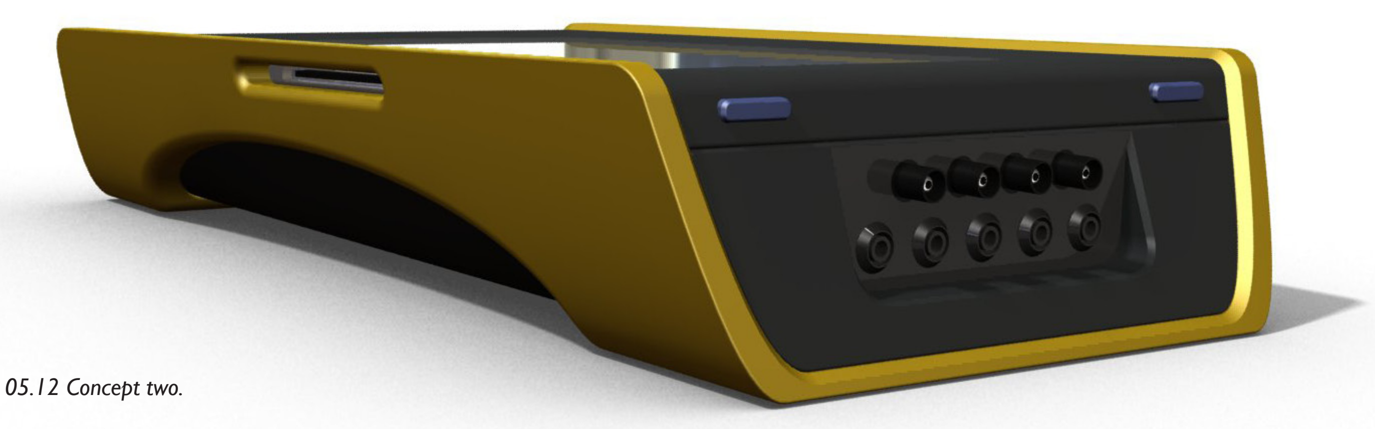
The second concept, shown in *figure 05.10 - 05.13*, the Powerslide, has a yellow holster that is not able to be parted. The gray top will be able to open which makes is possible to place a tablet. The concept's size is also about 200x300x80mm,

The yellow holster provides a rugged surround on the tablet which holds the analyzing module and a click system to hold the analyzing module in place. The holster provides a stand while the tablet is used on a table or knees and two handles. The tab module has two holes to connect a standard tablet connector and two buttons to control the tablet's top buttons.

The shape looks solid and rugged and the color use complies to the Fluke standards. The overmold's shape is different from current Fluke products.



05.13 Concept two's merging procedure.



05.12 Concept two.

Concept 3

Powerslide Two

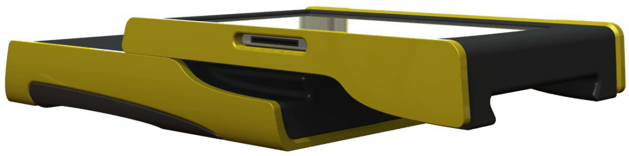
The third concept, shown in *figure 05.14 - 05.17*, the Powerslide Two, looks a lot like the Powerslide but the sliding feature has been designed different. The tab module slides on the analyzing module instead of sliding the analyzing module into the tab module, using a trapezoid and cone-shaped body The concept's footprint size is also about 200x300mm but the height is 90mm for the fact that te tab module's height must be 20mm at least for providing a good grip.

This makes the tab module smaller but doesn't feature a handle for the tablet. The analyzing module has a usefull stand like the current power quality analyzer. Such stand could be applied to the PowerWedge and Powerslide as well.

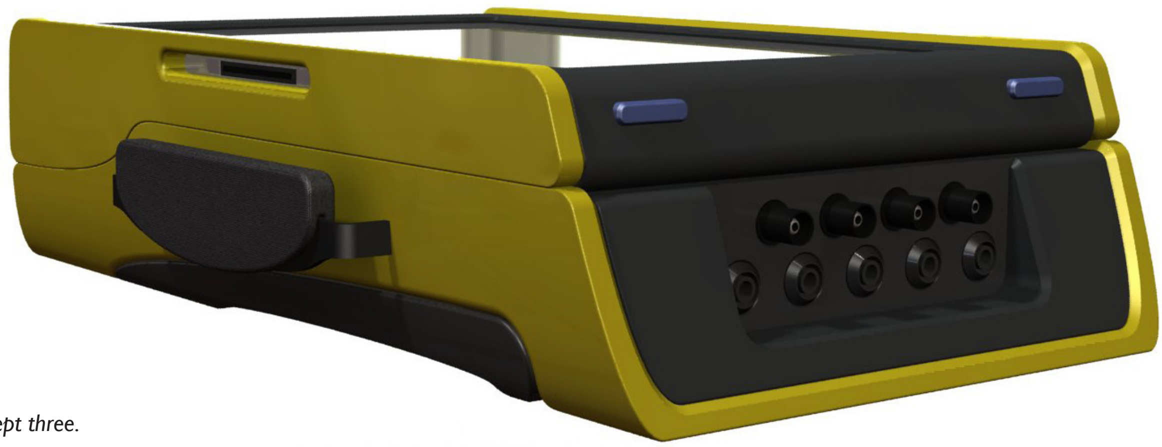
The Powerslide Two will propably slide the most intuitive and fool proof but looks less sleek than both other two concepts.

05.16 Concept three's top.

05.17 Concept three's bottom.

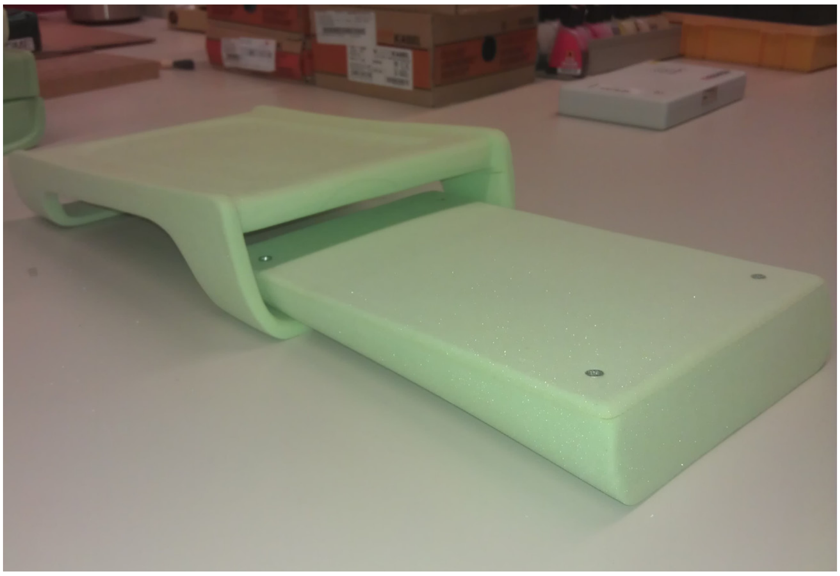


05.14 Concept three's sliding procedure.



05.15 Concept three.

05.18 Concept 1 foam model.



05.19 Concept 2 foam model.

05.20 Concept 3 foam model.

Testing and redesigning

To test the models' shapes, all three concepts were made of foam *(figure 05.18 - 05.20)* to see and feel the shape and interaction between the two modules. All models were tested by a technical male student, a non technical female student and two Benchmark employees working at the product development department. [39] The users were asked to fit both parts together without giving them extra information.

SLIDING TEST

The three concepts differ in the way both parts slide together. All three sliding methods work the way they were designed. [39] But the margins and softness of the foam model make the sliding less realistic. However, the foam models give a good interpretation of how users understand the sliding method.

Concept one: PowerWedge
Concept one's sliding method is not just sliding but fitting the analyzing module's shape into the tab module's contra-shape. The movement is a combination of rotating and sliding and it works intuitive since the analyzing module can not be fit different into the tab module. A disadvantage is the fact that fitting the analyzing module into the tab module is a coupled movement which the user has to understand without seeing the movement. It would be more logical to flip the parts, which results in fitting the tablet module into the analyzing module, so the user can see the movement.

Concept two: Powerslide
Concept two's sliding works, but it is not completele clear how the analyzing module fits into the tab module. There are too many options and the movement is a blind operation, the user can not see what is happening. There is also too less guidance for sliding the analyzing module into the tab module.

Concept three: Powerslide Two
Concept three's sliding works, but it would be more logical to slide the tab module from the top to the bottom. The concept's sliding misses some guidance and clue to let the user understand how the sliding works. The analyzing module needs an edge to provide the tab module more guidance.

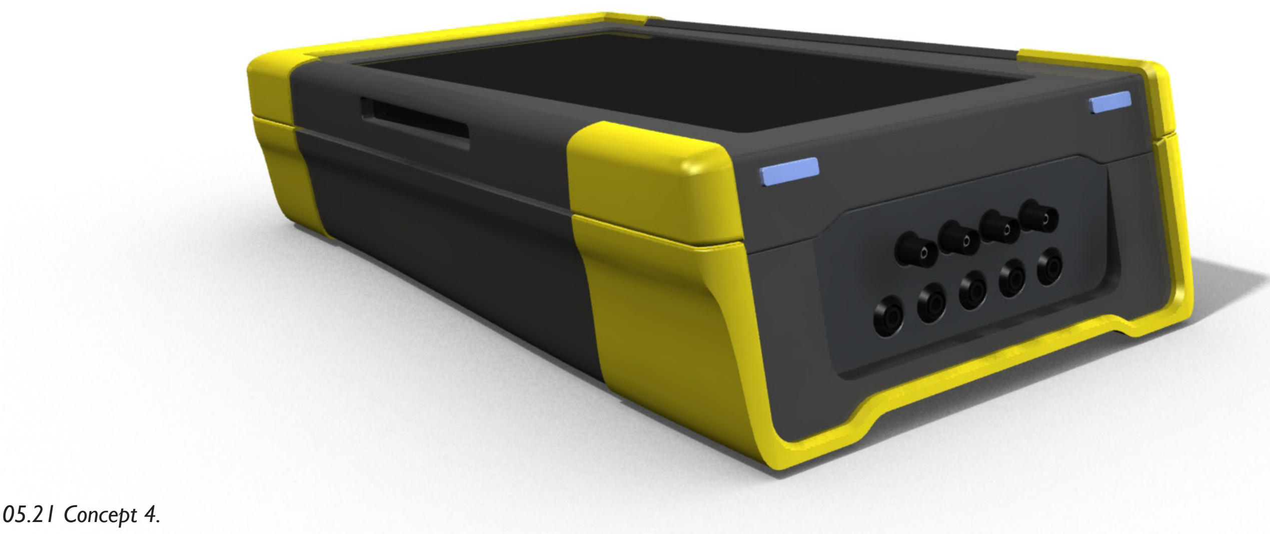
CONCLUSION

The conclusion is that all concepts look well, for a concept, but the sliding needs a lot of improvement. There is no feedback during sliding. [39] The user can't see what happens because of the fact that the analyzing module slides into the tab module or the tab module covers the analyzing module.

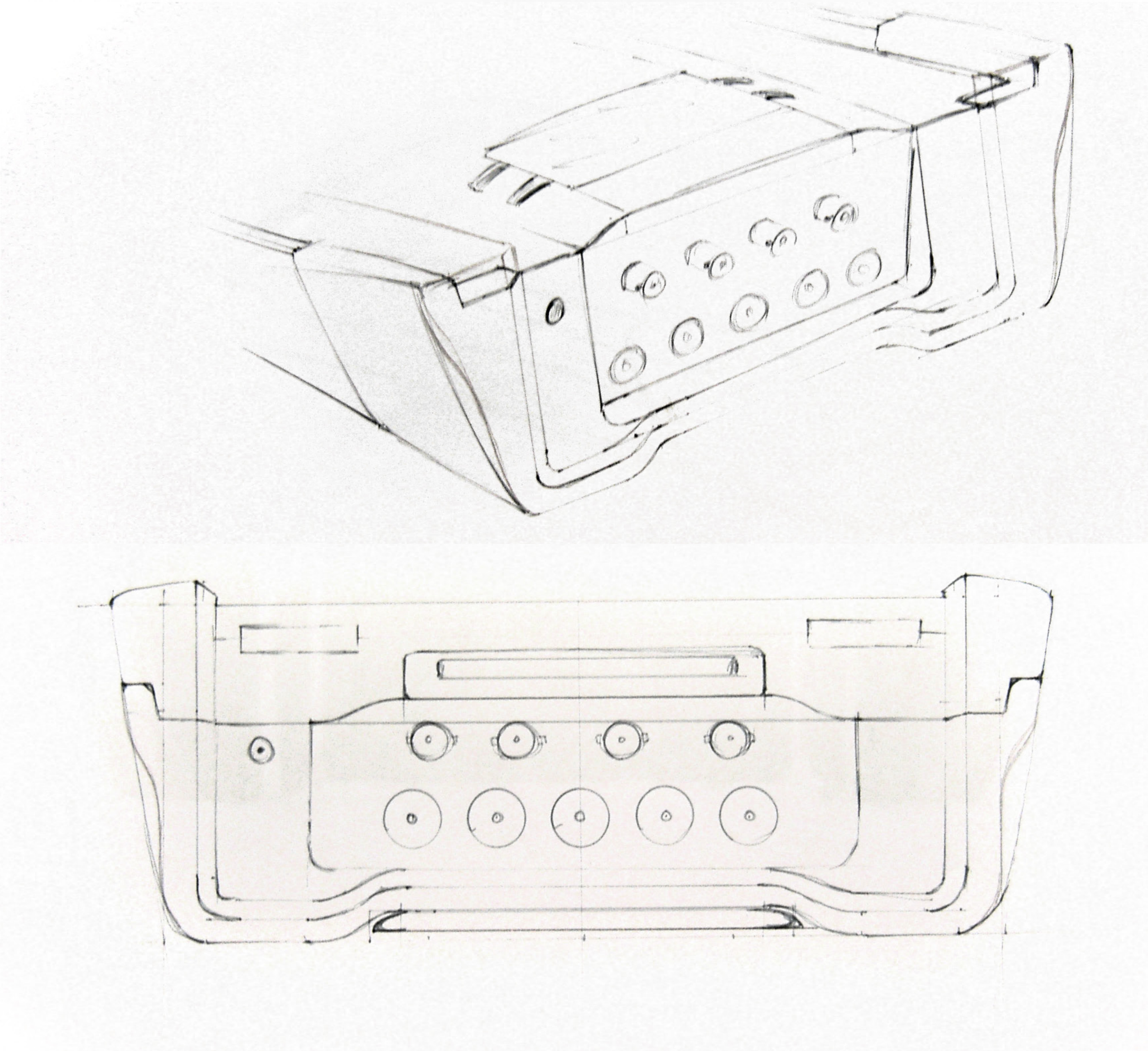
The PowerWedge (Concept 1) has the best intuitive sliding concept, due to both part's shapes.[39] The Powerslide Two (Concept 3) is good for the fact that the tab module slides on the analyzing module, but it is more logical to slide the tab module in the opposite direction.[39] The Powerslide (Concept 2) looks good and should be very intuitive, but the user test concludes that there are too many options to slide the analyzing module into the tab module.[39]

Since all sliding methods need improvement and the fact that Concept one and two's tablet modules are too big, a complete new concept has to be designed with the following improvements:

- The tab module needs to slide <u>on</u> the analyzing module.
- Sliding is done by moving the tab module to the analyzer module's bottom.
- Sliding needs more guidance.



05.21 Concept 4.



05.22 Sketches of Concept 4.

Concept 4

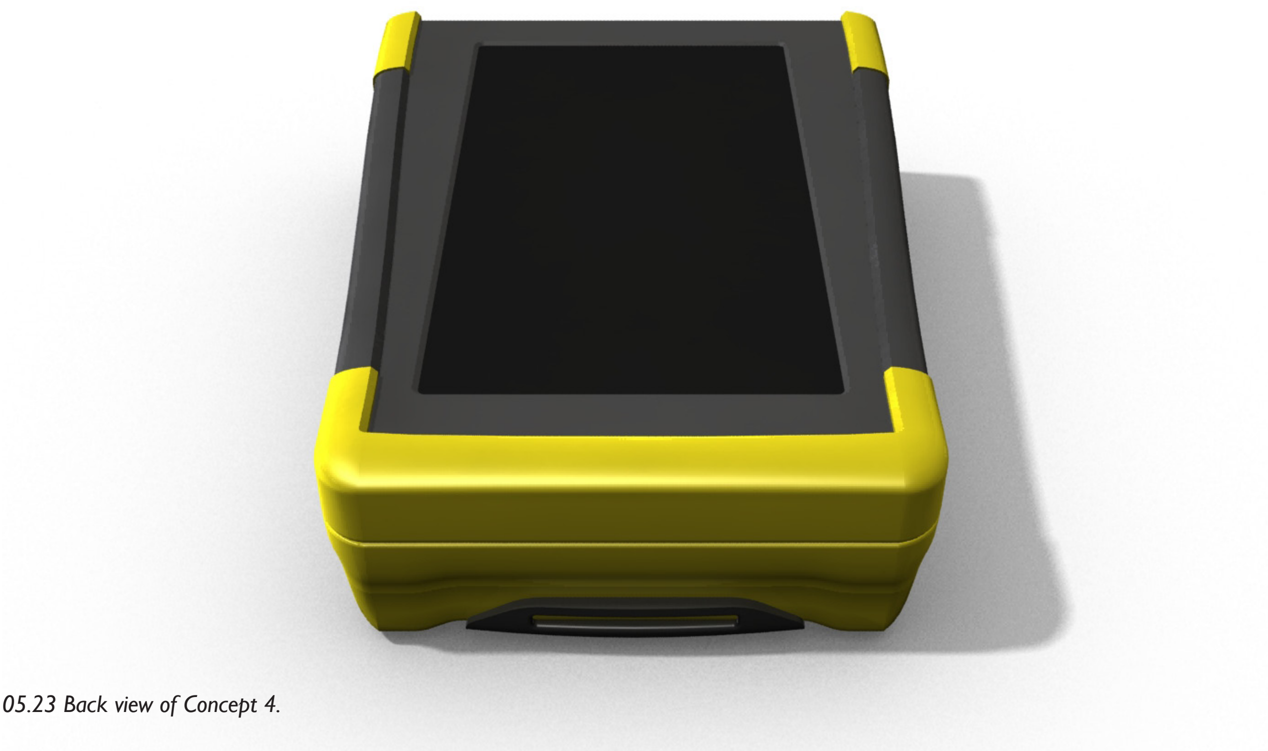
Sliding Donar

Concept 4, shown in *figure 05.21 - 05.24,* called Sliding Donar looks a lot like the current new power quality analyzer with the Donar casing. The concept has the opposite sliding method used in Concept 3.

The concept features an adjustable stand which lays into the body to provide a flat bottom. The tablet module slides intuitive from the top to the bottom and has a leading on the sides and in the middle *(figure 05.22)*. The concept features knobs and holes to provide acces to the consumer tablet.

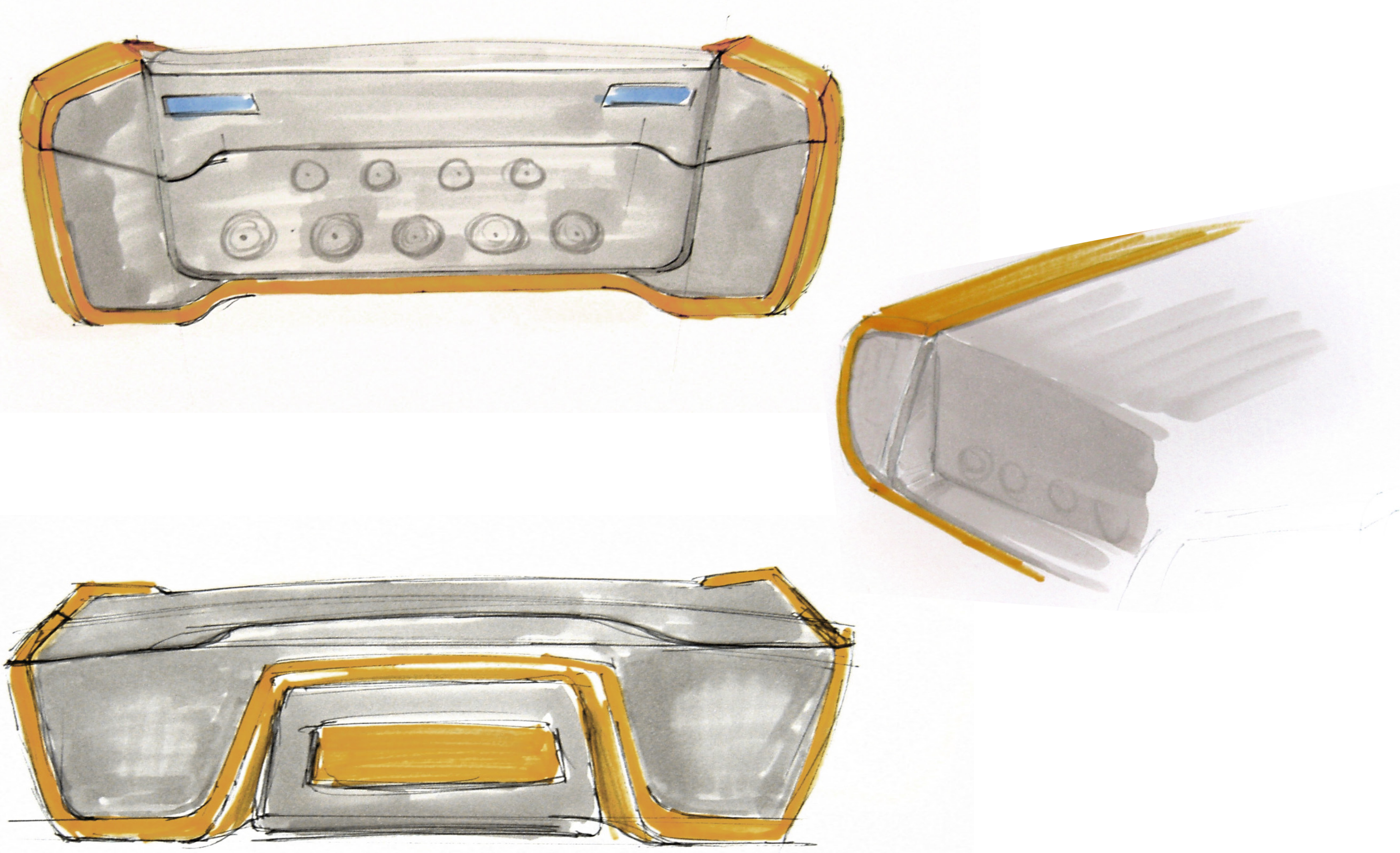
Since the concept's shape looks a lot like the Donar body, the concept would be a good current Fluke product but a bad future model, even though the model contains all features. [40]
The model's shape has to be more like concept one or two. [40]

05.24 bottom view of Concept 4.



05.23 Back view of Concept 4.

05.25 Concept 5.



05.26 Sketches made during designing Concept 5.

Concept 5

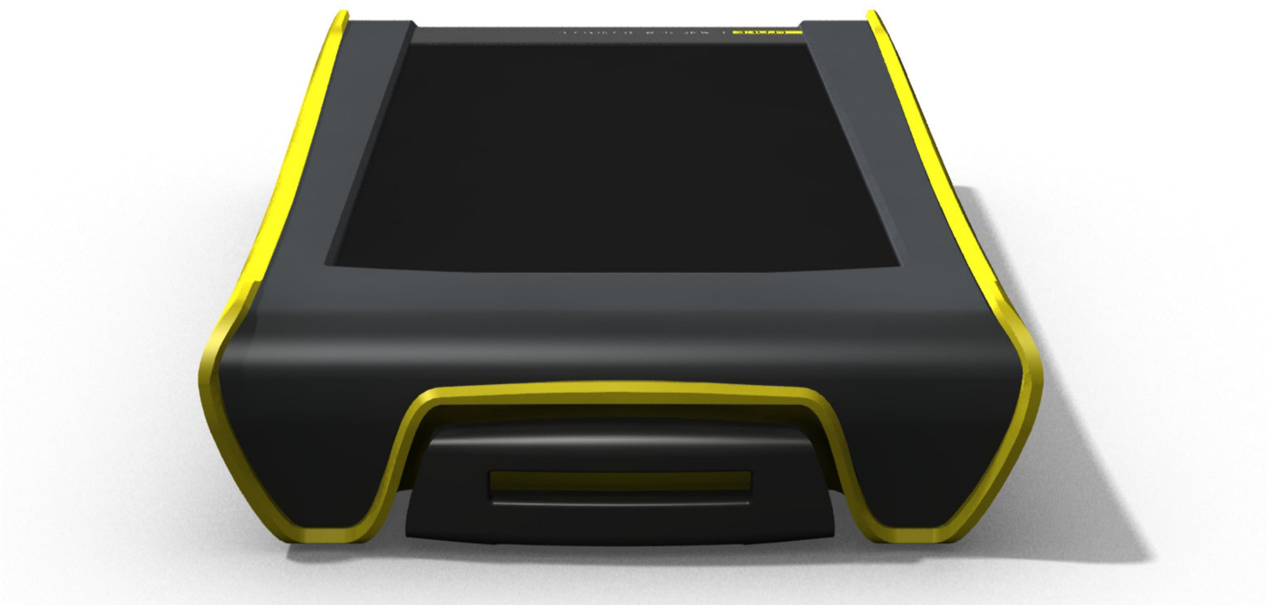
Streamline

Concept 5, shown in *figure 05.25 - 05.28,* has different shapes than Concept 4 and all other current Fluke products. The concept not only shows a functional solution fot using a consumer tablet, but also a new design, inspired again by the shown shapestudy on page 31.

Even though the model is a solid shape, the yellow overmold, diffuser shaped bottom and the shadow under the model make the model look less heavy. The concept features an adjustable stand that lays into the bottom to provide a flat bottom. The concept also features a big hook to hang up the device, a feature that Fluke wanted to add to previous power quality analyzers but didn't pass esthetical requirements.

The model has Concept four's functionality and Concept two's use of yellow overmold. This concept is a starting point for a more detailed rebuild version that encloses the current Donar electronics.[41]

05.28 Bottom of Concept 5.



05.27 back of Concept 5.

FINALISATION PHASE

06.1 Bottom and back view of the SLA model.

06 | Concept modeling

The final concept is a detailed version of Concept five, consisting of custom and original equipment manufacturer [OEM] parts. The current Donar electronics fit in the housing and there is a high level of detail.

The final concept features all requirements stated in the design phase.[43]

SIZE AND MATERIALS

The concept's size follows by measuring the Acer Iconia A500 tablet, which is the widest reference Android or Windows based tablet[26], the battery and the current Donar electonics.

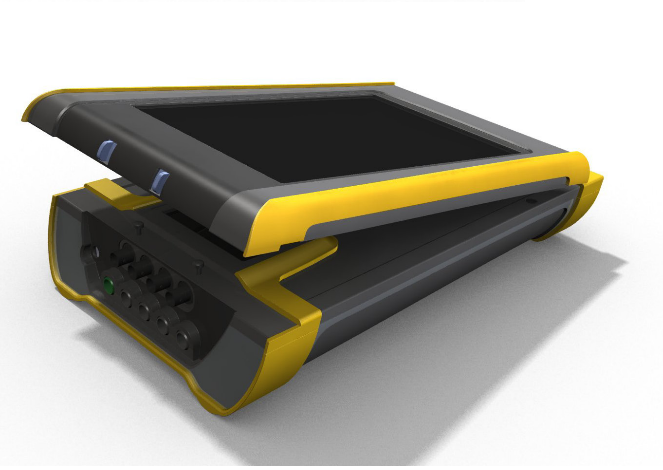
Making the analyzing module as thin as possible, the battery and electronics have to be placed in a line instead of one above the other, which defines the total inside length en height necessary. The Acer tablet defines the necessary width inside the tab module.

All plasic parts will be made of PC/ABS/V0 which is also used in the current power quality analyzer.[38] For the model, all wall thicknesses are set to 1,5 millimetres with some exceptions. Some reinforcing ribs will be two millimetres thick and the screw fixing buses have a wall thickness of two millimetres. The battery holder's wall thickness is one millimetres and the stand has a three millimetres wall thickness.

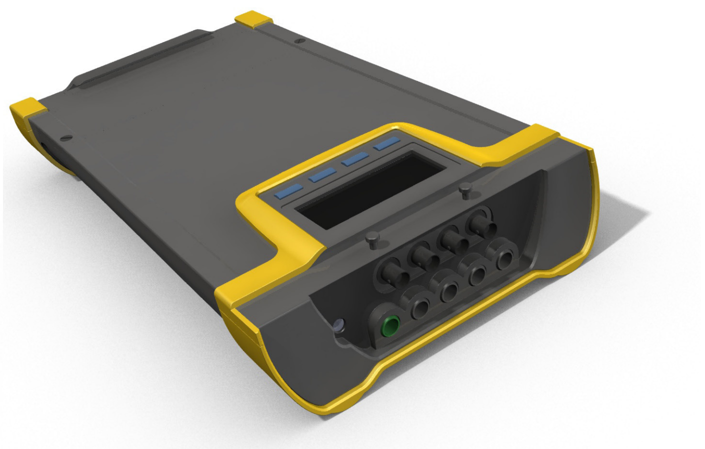
The chosen thicknesses are copied from the current power quality analyzer, which hass wall thickesses between 1 and 2 mm and similar screw fixing buses. The reinforcement ribs on the stand draw inspiration of the Fluke 123 scopemeter's stand and an other stand shown in figure 06.2. All yellow parts are made of TPU overmold and will be added on the gray parts during the production process. The overmold's thickness is three millimetres.

06.2 Various parts of Fluke products for inspiration.

06.3 Render of the Fluke wireless touch power quality analyzer.



06.4 Render of splitting both modules.



06.5 Render of the analyzing module.

CONCEPT FOR THE FLUKE WIRELESS TOUCH POWER QUALITY ANALYZER

The wireless touch power quality analyzer, shown in *figure 06.3 - 06.9,* consists of two parts that look like one device while physically connected, and two devices while seperated. Seeing both parts gives the impression that these parts could be connected, but seeing both parts stand alone doesn't look wrong in the way that both parts are missing something.

The yellow overmold on the top of the analyzing module is completely covered by the tab module to create a solid overmold while both parts are connected. The blue tabs and edge between the tab- and analyzing module give the impression that the tab module could be seperated.

The yellow overmold at the analyzing module's back is visible while connecting both parts, for several esthetic design purposes. There would be too less overmold on the top of the analyzing module when the overmold was only placed on the sides. Creating a shape that covers the appearance of this overmold would result in a strange shape.

The stand perfectly fits the yellow overmold's shape while folded in and provides a hook to hang up the device. The stand can be rotated almost 180 degrees and while folded in, the bottom remains completely flat. The yellow overmold provides an edge to maintain the stand's position.

The seperate assemblies will be discussed on the next pages. All details are designed to show that the current and future electronics will fit the housing. Reinforcement ribs are made since these ribs have a certain function (rigidness for the buttons, rigidness for the stand and guiding the blue sliders). Detailed renders are displayed in appendix B.

06.6 Front view.

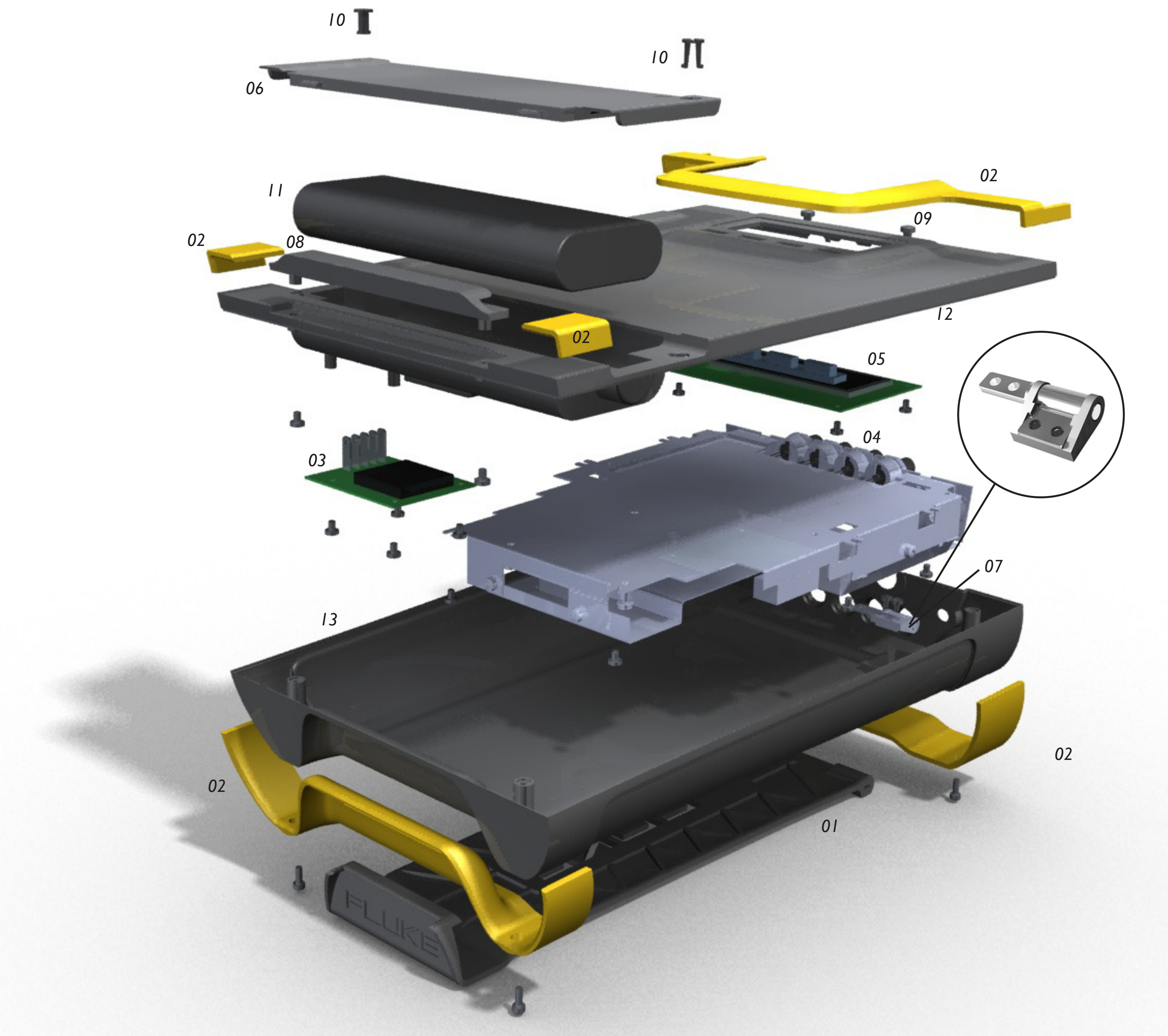
06.7 Top view.

06.8 Bottom view

06.9 Back view.

legenda

01 Stand
02 Overmold
03 Battery connector and SD card print
04 Donar Electronics
05 Secondary display on print with buttons
06 Battery cover
07 Friction hinge
08 Wide hook for sliding
09 Mushroom shaped tabs
10 Batterycover fixation
11 Battery
12 Top
13 bottom



06.10 Exploded view of the analyzing module

ANALYZING MODULE

Figure 06.10 shows all parts used for the analyzing module's assembly. The way the parts were designed will be discussed more in depth below.

Design details

The design details for several parts will be shown more in depth on this page.

Partitioning

The way the different parts are devided depends on the fact that the parts have to be released while molding. The wall of the bottom *(13)* and the top *(12)* are designed perpendicular to the ground on the area where both parts are devided. This also determines the splitting of the overmold, since the overmold will be added on the top and bottom during the future production process.

The hook for the sliding system *(08)* is designed loose as a part since the wall thickness is different and the hook would result in an extra insert during the molding process.

The bottom will have to be designed in two parts to make the shape releasing during the molding process. The front with the connector holes, containing the yellow overmold, should be a seperate part. This is not designed for this model, since this issue would be too detailed for a first model.

Sliding and fixing

One of the concept's core features is the way both parts are connected physically. The connection consists of two subconnections which define the six degrees of freedom [DOF] together.

The bottom of the tab module slides into the wide hook *(08)* at the analyzing module's bottom and the 'mushroom shaped tabs' *(09)* provide a connection to define position of the tablet module. The bottom of the tab module fits over the secondary display which provides an edge to guide the tab module. The analyzing module has both esthetic and functional edges on the sides to provide more guidance for the tab module.

Stand

The stand *(01)* consists of two OEM parts and the custom plastic stand. The OEM parts are two 1,01 Newtonmeter friction hinges produced by Hanaya inc.*(07)* [25] The friction hinges are placed into a small container which makes it able to seal the containers against moisture, since the friction hinger are placed into the main housing. The stand itself has enough firmness to support the device and features an improved version of the hook to hang up the device, used in Concept five.

Battery placement and SD storage

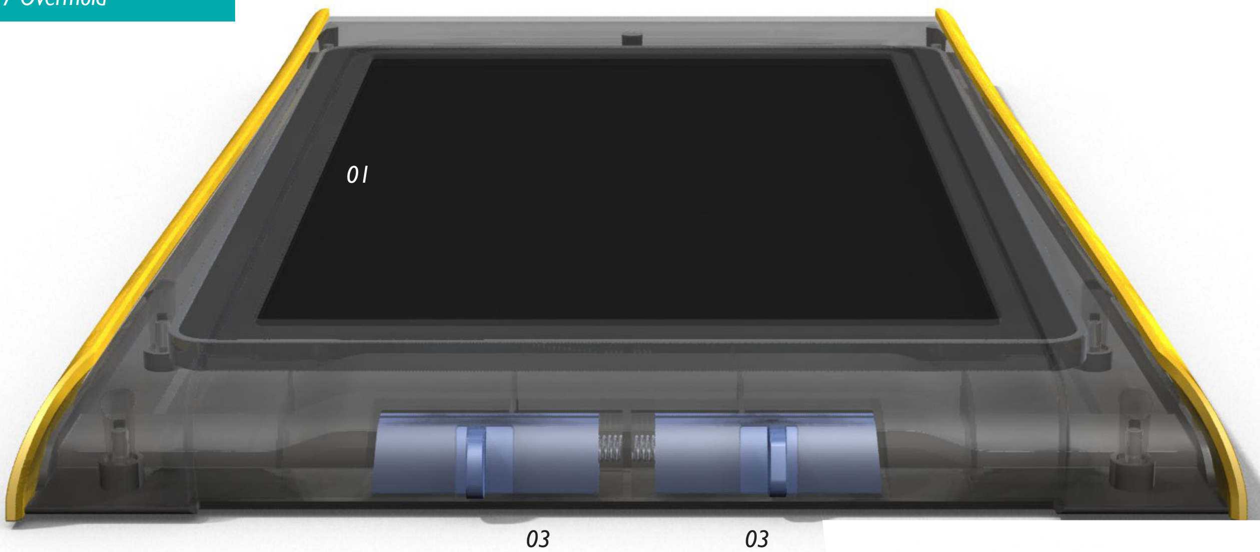
Just like the Donar model, the power quality analyzer features SD card storage. To avoid two seperate openings for the battery and the SD card, the SD card is placed under the battery, both accesible via one cover *(06)*. Since the battery fits slightly into the batteryholder, two cutouts are made to get grip on the battery. The cover is supported by two small tabs and two self-tightening rotating buses *(10)*. Current Fluke batteries will fit the battery storage location.

Secondary display

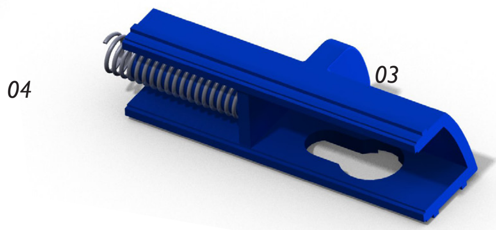
The analyzing module has to be usable without the tab module. To meet this requirement, the analyzing module has an own display. The display is placed on the analyzing module which adds a guidance for the tab module and a design element. The display is an example stated in the design requirements and could be bigger or smaller. The four buttons under the screen are function buttons which function depends on the displayed information.

legenda

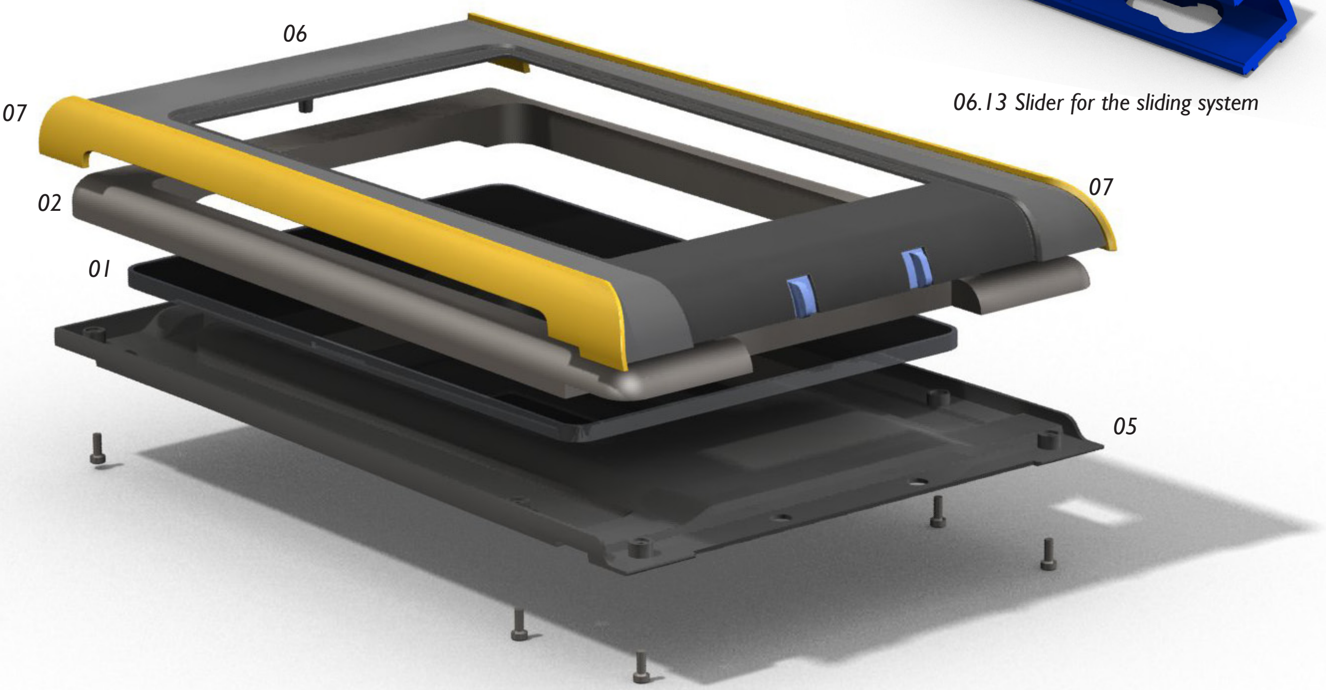
01 Samsung galaxy tablet
02 Foam
03 Blue sliding tab
04 Metal spring
05 Bottom plate
06 Top cover
07 Overmold



06.11 Transparent view of the tab module



06.13 Slider for the sliding system



06.12 Exploded view of the tab module

Assembling
All the parts of the model are provided with the basic techniques of assembling a device. All plastic components have screw buses and contra-buses to define a component's position and attach the parts together. The main housing's components also feature a small lip and groove to archieve a smooth edge between both parts.

All screws will be screwed into the plastic buses which is more desirable than using a metal nut insert, since the device doesn't have to be often disassembled and assembled. [43] The friction hinges will be attached on a metal insert since a metal nut insert offers a more solid mounting.[43]

TAB MODULE

The tab module, shown in *figure 06.11 - 06.13,* consists of two parts to enclose a consumer tablet. The tab module is like a holster for a tablet and provides the mechanical connection between the consumer tablet and the analyzing module. This connection has only two moving parts, well placed into the tab module consisting of two sliding plastic parts and springs *(figure 06.13).*

The analyzing module's secondary display fits into the cutout made in the bottom of the tab module. This cutout provides leading for sliding the tab module on the analyzing module.

Design details
The design details for several parts will be shown more in depth on this page.

Partitioning
The tab module is parted to make fitting a tablet possible easily. This is why the yellow overmold will be added on the top *(06),* covering the sides of the bottom part *(05)*. It makes is possible to unscrew the bottom as a lid and place a consumer tablet without unscrew more parts. This is also why the blue sliders *(03)* are positioned into the top part. The bottom and top are also splitted to make releasing during the molding process possible. As a reccomendation, the bottom needs to have perpendicular inner sides for releasing.

Sliding system
The mushroom shaped tabs on the analyzing module fit into the blue sliders displayed on the left shown figures. The blue sliders are guided by the ribs placed on the tab module's upper part and gain their position by a metal spring *(04)*.

Tablet positioning
The tab module is bigger than the consumer tablet. To provide a good fit for all different tablets, the tab module has a soft inner foam *(02)* which has to be availlable for different tablets.

Tablet connection and buttons
The module has to be assembled together by the user once since the consumer tablet's knobs and connectors will be accessible while the tablet is placed into the tab module. Due to the limited time for the project, the knobs and connector hole are not designed in the final concept but recommended in the recommendations section.

07.1 SLA model standing

07.4 Bottom view of the SLA model

07.2 SLA model of the analyzing module

07.5 Secondary display detail on SLA model

07.3 The complete SLA model with the user interface by Philip Jansen

07 | Concept verification

To verify how the design would perform, the design was build using the Stereolithography, called SLA, rapid prototyping technology.

The SLA technology is able to create a model with a lot of detail and good surface finish after sandblasting and sanding. The material is less rigid than plastic but it gives a good interpretation of the model's appearance and functions. The SLA model is shown in figure 07.1 - 07.7.

Since the SLA material is less rigid than plastic, the friction hinge's specifications didn't match the model's firmness. The torque to rotate the hinges had to be decreased to make a functional prototype.

ASSEMBLING

While assembling the parts, it became clear that all parts were well designed. [44] All parts had a fixed position and all screw buses matched position and height. Placing the friction hinges may be a little difficult, since the space is too small to push the friction hinges into the stand. The friction hinges have to be placed by a coupled translating movement. See figure C.04 in Appendix C for how the hinge is placed.

The worst task during assembling is cutting the black foil in shape, during a production process this problem won't be an issue since the foil is pre-shaped.

VERIFICATION

The sliding feature works intuitive and very well, it needs minor improvements, since the mushroom shaped tabs do not perform as expected. The stand works perfect. The model is able to stand alone on a table or hanged up.[44]

The model needs improvements to make the device more rigid, the model misses some reinforcement ribs and the wall thickness of the body is too thin. Overall does the model feature all requirements.

07.6 Holding the SLA model

07.7 The SLA model hanging

08 | Recommendations

The recommendations regarding to the final design.

This section will offer reflection on the final design, but also on related issues and opportunities. Overall the design seems to fit well in Fluke's future product range[44] and features almost al requirements. However, the design is a concept model that needs improvement.

MODEL RECOMMENDATIONS

The SLA model looks very well and all components fit the housing. The OEM friction hinges and the current Donar electronics fit perfectly in the housing.

Analyzer module's housing

But the model does not have the typical firmness that Fluke products offer. Especially the analyzing module's housing needs improvement. The wall thickness has to be increased to at least two millimetres and reinforcement ribs have to be added.

The connection between the analyzing module 's bottom and the top consists of four screwbuses that support both parts. It misses firmness in the middle of the assembly, so two extra screws or an other connection have to be added. The analyzer module's top needs small ribs that will prevent pushing the bottom's wall to the inside.

Sliding system

The current connection between the analyzer module's bottom and top is not water resistant, a small maze has to be added to ensure water resistance.

The connection between the analyzer and tab module works fine, but the mushroom shaped tabs have the wrong shape. When the parts are connected, there is space on the tab's left and right which makes it possible to rotate the tab module two millimetres to the left and right. The problem can be solved by make the mushroom shaped tabs a three millimetres T-shaped extrusion.

Batterycover

The batterycover also has to be improved, adding extra edges and a rubber seal will make the cover water resistant.

The small self tightening batterycover fixation was designed too small and has to be redesigned. It is recommended to implement a more standard fixation system with OEM parts.

Tablet connectivity

The concept model doesn't feature any tablet connection possibilities as mentioned earlier. The tablet module needs a connection to make it possible to reach the tablet's connector for data transfer and battery charging purposes. This connection can be made by design two slots on both sides of the tab module since the connector's position is different for various tablets.
It is also possible to feature the tab module with an adjustable inside connector to hardwire the data and battery charging connection to a well positioned connector in the tab module's housing. This solution will provide both better esthetics and usability. The tablet's buttons on the top can

be controlled by using plastic tabs that hit the tablet button by pushing these plastic tabs. Since all consumer tablets have a different size, some adapters to adjust the plastic tab's length have to be designed for every supported consumer tablet.

INTERFACE RECOMMENDATIONS

The analyzing module has a small display with four buttons. This display is a placeholder for a future display to show that it is possible to fit a small display with buttons into the device.

WIRELESS COMMUNICATION RECOMMENDATIONS

The future Power Quality Analyzer will use a WiFi connection for data transfer. There has to be tested in which way the electromagnetic field of such connection will affect power quality measurements. Or in which way a high voltage environment influences the electromagnetic field of the WiFi technique. The performance of a very short distance connection also needs to be tested since WiFi connections often perform only about 20 percent of their maximum rated data transfer speed.[38]

09 | Evaluation

An evaluation of the project and its progression.

At the beginning of the project, it was very clear for me what the project's goals were. The project is related to an earlier study which focussed on a touchscreen interface. The main goal was to find a solution for merging and splitting a basestation and a tablet module.

For me, it was a challenge to use my skills I gained during my bachelor Industrial Design and my discontinued bachelor Mechanical Engineering. Personally, I found it important to show my supervisors that I'm able to design a device that is well looking and complies to the stated requirements as well. I also wanted to add a specific level of detail since esthetics have to meet technical specifications.

When I started at the beginning of January, my supervisors and I knew that the project's duration would be more than three months. This is because I'm one of the four partners of an own design company and I wanted to work one day a week at this company. I also made an agreement to myself that I would only stop when a good result was a fact. This agreement is a little risky for a person that has the property to be a perfectionist, but this agreement fits the professional and personal challenge.

The first phase of the project went very well, the productivity was very high and I had no problems with being focussed. Only usefull research to gain more knowledge about Fluke products and additional information was done. The first problems occured while designing the first three concepts. I found it difficult to design three different concepts. But bigger problems occured later, when I was not satisfied with these first three concepts.

During three weeks, I made different semi-finished designs and I liked none of them. Concept four emerged by using the current Fluke design shapes which is good for a current model variation, but not for a future product. I started again with gaining inspiration and after two weeks of sketching and working in Solidworks, concept five was a fact. The finalisation phase took more effort than expected, I had problems to create a specific shape in Solidworks, since the chamfer feature did not fit on the designed shape. But I did not reach the planned six weeks, which is a positive fact.

It took some time to order the SLA model because of the price was too high. I made a presentation for the Fluke staff and they approved to order the SLA model. Finishing the SLA model was a nice job, the only problem that occured was the fact that the two-component glue I used is very solid, which results in small gaps.

Working at Benchmark was a great experience for me. It was always possible to ask colleagues for help or a professional oppinion, which makes it possible to make decisions very fast. I also liked the fact that colleagues asked me for small tasks and a personal or professional oppinion. For example, I helped the department manager with developing a concept for Philips. Together with other employees, we discussed that concept's features and design issues and I translated it to a CAD model. The CAD model's renders were used

later that week to show the concept to Philips.
I also helped my supervisor with different small internal projects and a small project he does for IBM.
Overall I'm very satisfied with the result of the project. I managed it to maintain the project's focus and respected the earlier choices I made. The final design is not a revolutionary looking design, but it perfectly matches Fluke's expectations and it is realistic for the target market.

Being a Industrial designer is more than only being creative, a designer needs to make choices and focus on the project's goal. I think I succeeded both parts of this description.

Benchmark gave me the perfect experience of being an internship student. I felt like being a part of the team and all colleagues respected my personal and professional oppinion. The experience I have gained at Benchmark is priceless, I wish to thank my supervisor and all other involved people for this amazing opportunity.

Glossary

ADC :Analog Digital converter.

Analyzing module: Name for the basestation used in the concepts. The analyzing module encloses the electronics to perform measurements.

Android: is a Linux-based operating system for mobile devices such as smartphones and tablet computers. It is developed by the Open Handset Alliance led by Google.

BNC connector: (Bayonet Neill–Concelman) a common type of Radio Frequency connector usually applied for frequencies below 3 GHz and used for several equipment such as a power quality analyzer or scopemeter.

Donar : The project name for the new Fluke scopemeter and power quality analyzer.

Galvanic isolation: A principle of isolating functional sections of electrical systems and necessary to comply to several industry standards.

IEC: International Electrotechnical Commission is a non-profit, non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies

IEEE: Institute of Electrical and Electronics Engineers. IEEE is one of the leading standards-making organizations in the world.

iOS: iPhone OS, Apple Inc.'s mobile operating system, derived from Mac OS X, which is therefore a Unix-like operating system.

Java: An object oriented programming language which language derives a lot of the C and C++ syntax.

Munsell: A color system that specifies colors based on three color dimensions: hue, value (lightness), and chroma (color purity). The Munsell color system was created by Albert Munsell in 1898.

NiMh: Nickel-metal Hydride, a type of rechargeable battery.

Objective C: A reflective, object-oriented programming language used for Apple applications.

Optocoupler: Also called opto-isolator is an electronic device designed to transfer electrical signals by utilizing light waves to provide coupling with electrical isolation between its input and output.

PCB: A printed circuit board, or PCB, is used to mechanically support and electrically connect electronic components using conductive pathways, tracks or signal traces etched from copper sheets laminated onto a non-conductive substrate.

PDMI: A connector standard for consumer media appliances (http://en.wikipedia.org/wiki/PDMI)

RMS: In mathematics, the root mean square, also known as the quadratic mean, is a statistical measure of the magnitude of a varying quantity.

Tab module: Name for the holster that encloses the consumer tablet.

Tablet: A typical small portable computer with a touch screen, also called a pad named to the most famous tablet, the Apple iPad. Tablets are more and more used these days.

Thor: The project name for the old Fluke equipment.

Transient: A signal measured by an oscilloscope that only occurs once.

VA: volt-ampere (VA) is the unit used for the apparent power in an electrical circuit, equal to the product of root-mean-square [RMS] voltage and RMS current.

WiFi: Alsp spelled as Wi-Fi is a popular technology that allows an electronic device to exchange data wirelessly (using radio waves) over a computer network, including high-speed Internet connections.

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APPENDICES

Appendix A - Touch screen technologies

This appendix article shows the different touch screen technologies[21] which are interesting for industrial use.

Resistive touschscreen
The restitive touchscreen is made of multiple layers. The most important layers are two thin electrically-resistive layers which are facing each other with a thin gap between.

When an object presses down on the outer surface, the two layers touch to become connected at that point. Then the panel behaves as a pair of voltage dividers. For a short time, the associated electronics applies a voltage to the opposite sides of one layer, while the other layer senses the proportion of voltage at the contact point.

This technology provides a horizontal x and vertical y position. Resistive touchscreens are used for electronics that become wet, greasy or dirty. The main disadvantage is that the top layer is very thin because of the need to push it down which makes it very sensitive for scratches and other damage.

Capacitive touchscreen
A capacitive touchscreen panel consists of an insulator, mostly glass, coated with a transparent conductor. As the human body is also an electrical conductor, touching the surface of the screen results in a distortion of the screen's electrostatic field, measurable as a change in capacitance.

There are different technologies to determine the touch's location. Most capacitive touchscreens can not be used with insulating materials like a stylus or gloves, but some rugged industrial screens have the ability to function while the user wears gloves.

Dispersive signal technology
This technology uses sensors to detect piezoelectricity which occurs in the glas while touching the glass. The signal processing is very complex, but the system claims to be unaffected by dust and scratches. A disadvantage is that a motionless finger can not be detected.

Acoustic pulse recognition
The acoustic pulse recognition works with the principle that every touch on the glass generates a different unique sound. The sound is picked up by four tiny transducers on the edges of the glass. The sound is then digitized by the controller and compared to a list of prerecorded sounds for every position on the glass.

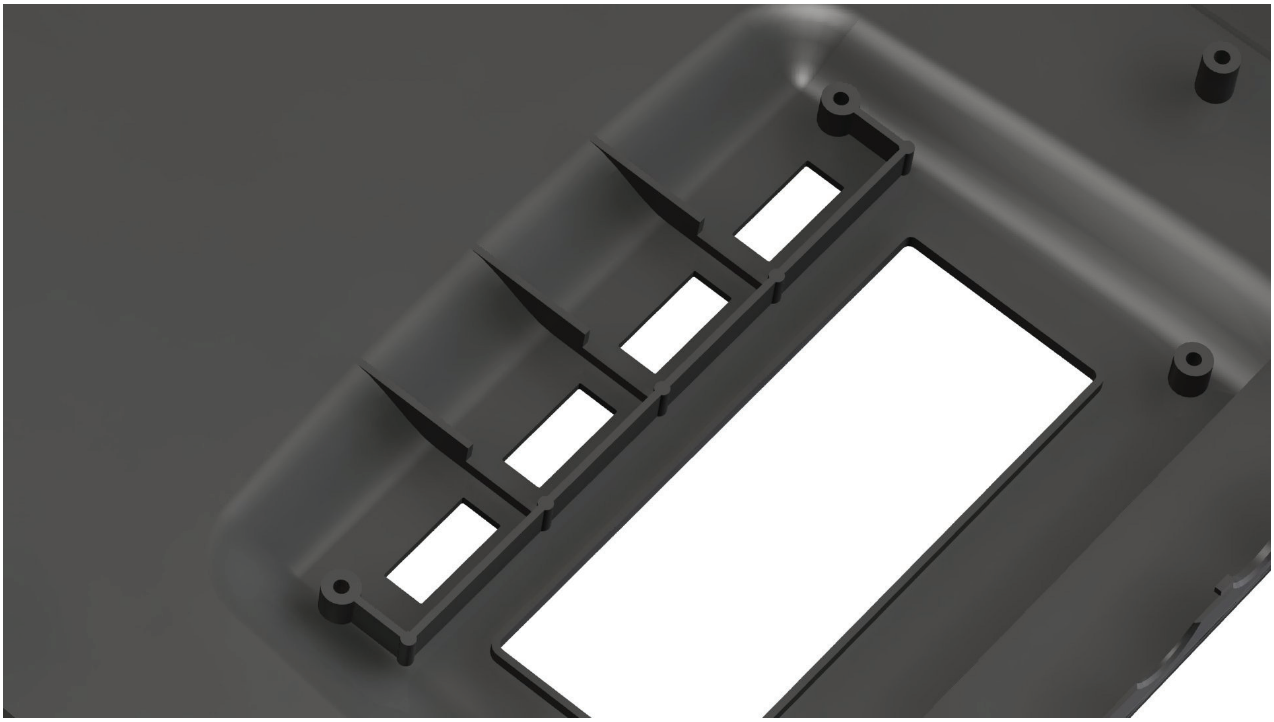
Since the display is made of ordinary glass, the technology is unaffected by scratches or heavy damages. Motionless fingers can also not be detected.

Appendix B - Detailed renders

B.01 reinforcement ribs of the stand in detail

B.02 Bottom of the tab module

B.03 Stand folded out to hang up the device

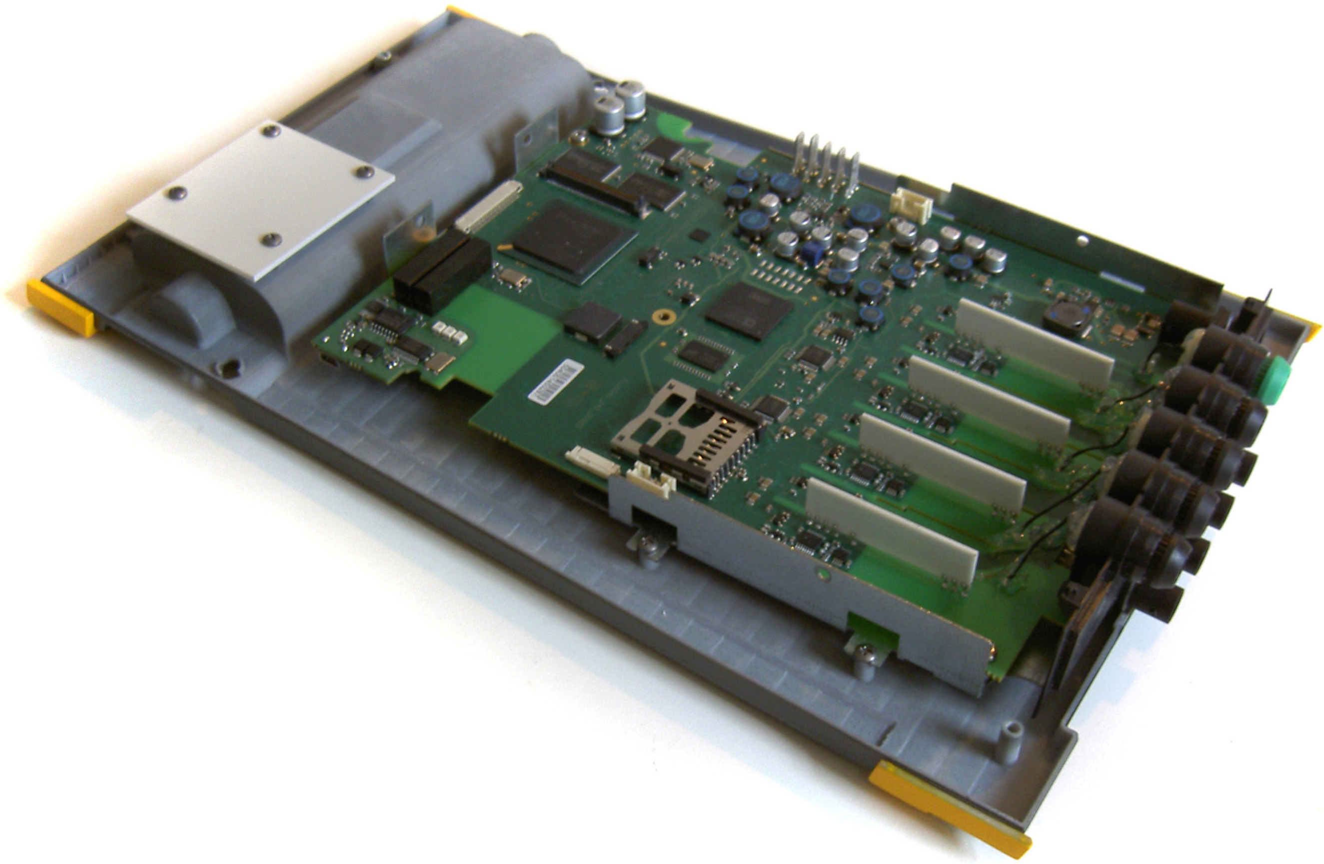


B.04 Detail of the ribs for reinforcing the knob interface. The ribs also feature the screwbusses for holding the PCB. An edge for fitting the display is also featured.

B.05 Details of the battery and SD card container. Buses for assembling the extra PCB with SD card connection and batteryconnection are also featured. The outer edge has a inner lip for a smoothe connection.

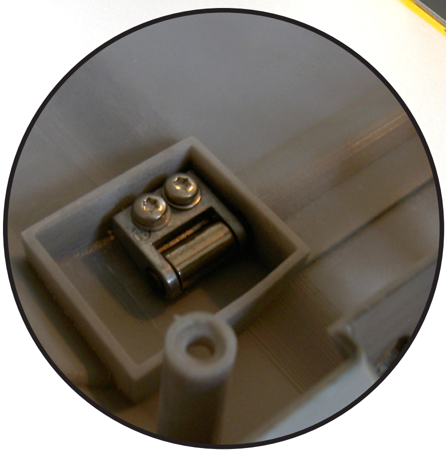
Appendix C - Detailed pictures

C.01 All unfinished parts



C.02 Electronics and placeholders for electronics attached to the top of the analyzing module

C.03 Picking up the battery



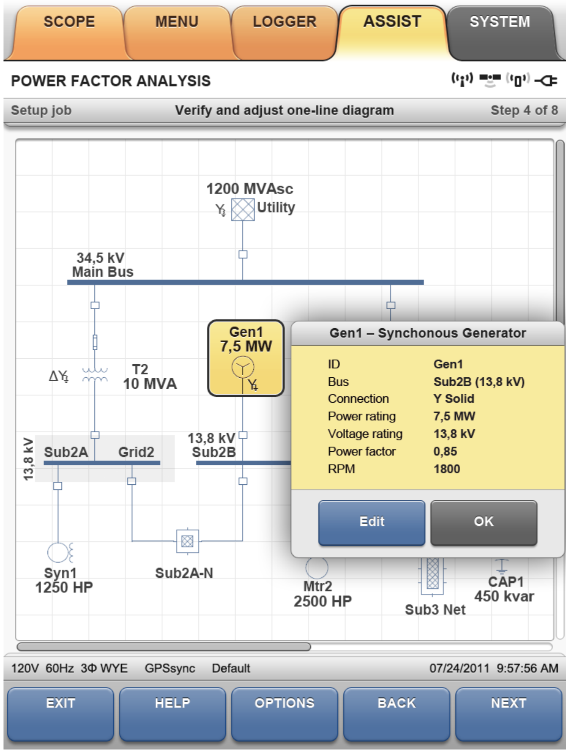
C.04 Detail of the friction hinge

C.05 The front of the Analyzing module

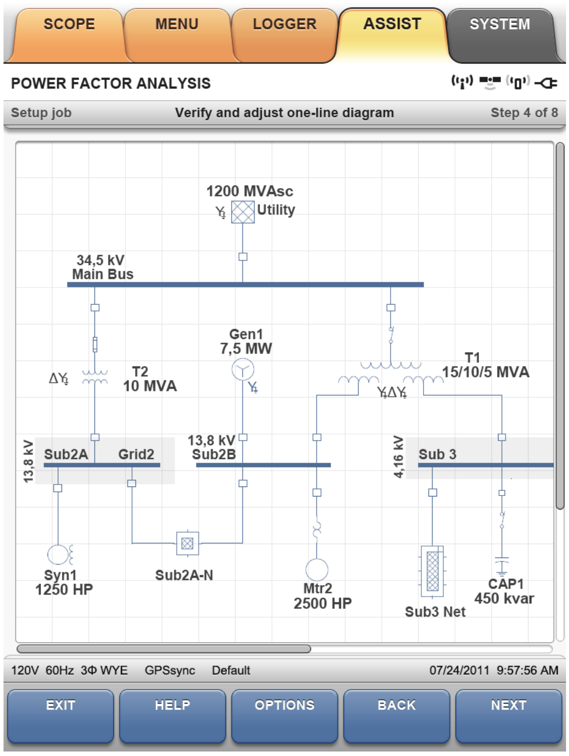
Appendix D - Touchscreen interfaces by Philip jansen [36]

This appendix shows some interface screens Philip Jansen made for a future touch power quality analyzer. The study of Philip Jansen concentrated on how a tablet size touch screen could be integrated in the Power Quality Analyzer.

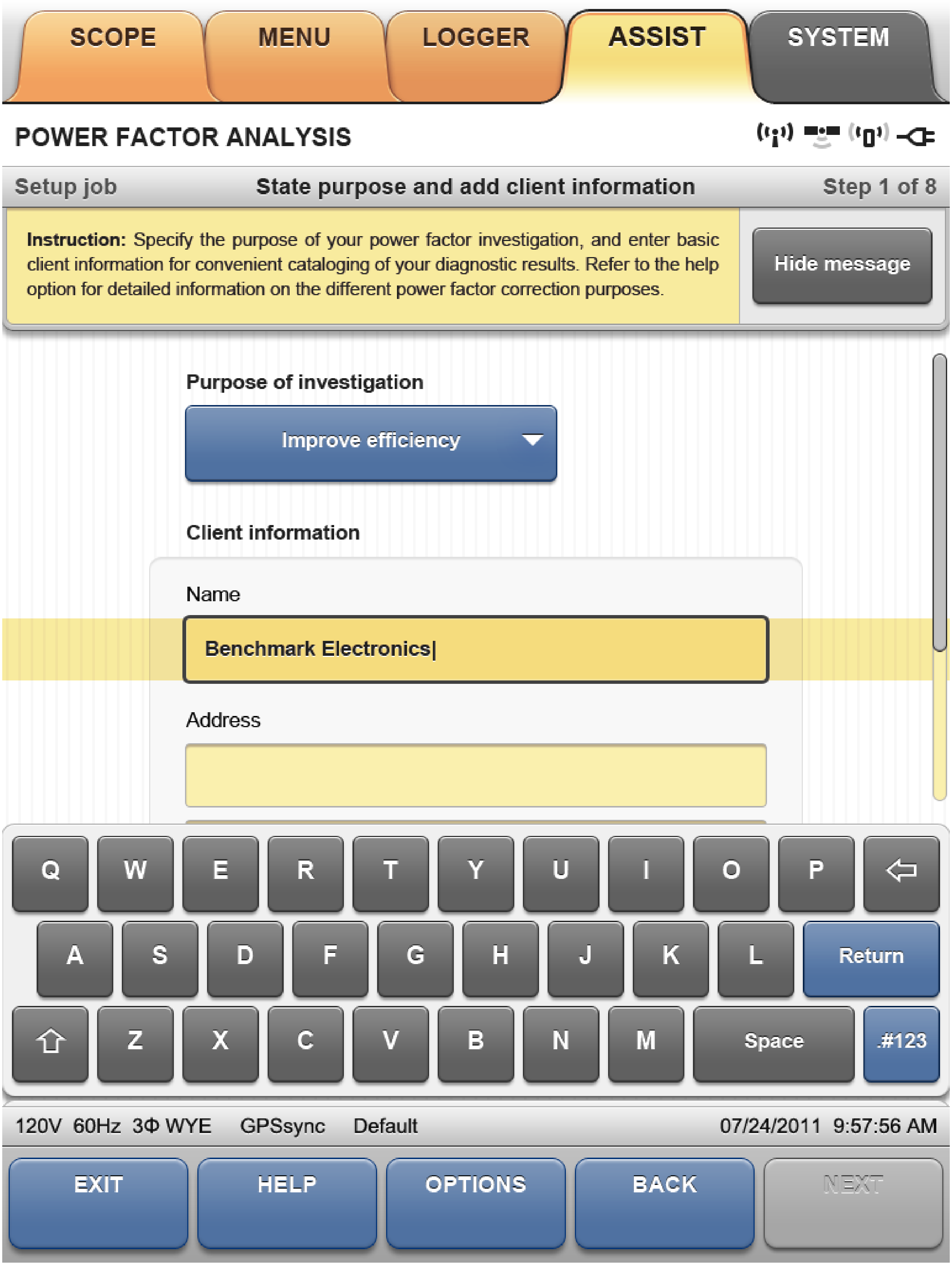
The main goal was to research in what way a this size of touch screen gives the device more functionality. The reasearch concluded that a Power Quality Analyzer could perform very well with the use of such display. This conclusion made Fluke decide to do more research for the implementatuion of a consumer tablet.



D.01



D.02


SCOPE
MENU
LOGGER
ASSIST
SYSTEM
POWER FACTOR ANALYSIS
Setup job
State purpose and add client information
Step 1 of 8
Instruction: Specify the purpose of your power factor investigation, and enter basic client information for convenient cataloging of your diagnostic results. Refer to the help option for detailed information on the different power factor correction purposes.
Hide message
Purpose of investigation
Improve efficiency
Client information
Name
Benchmark Electronics|
Address
Q W E R T Y U I O P
A S D F G H J K L
Return
Z X C V B N M
Space
.#123
120V 60Hz 3Φ WYE
GPSsync
Default
07/24/2011 9:57:56 AM
EXIT
HELP
OPTIONS
BACK
NEXT

D.03