



Joni Närhi

TEST ENVIRONMENT FOR WIRELESS POWER TRANSFER

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Joni Närhi
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Työn ohjaaja(t): Jarmo Vesterinen, Esko Kurttila, ST-Ericsson Oy

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Tämän insinöörityön tavoitteena oli toteuttaa testausympäristö langattomalle tehonsiirrolle. Idea tälle työlle tuli ST-Ericsson Oy:n Oulun toimipisteen karakterisointi tiimitä, joka työskenteli yrityksen langatonta latausta tukevan integroidun piirin parissa. Testausympäristö oli tarkoitus rakentaa olemassa olevan testausympäristön päälle lisäämällä siihen uusia ominaisuuksia, kuten langattoman tehonsiirron mittaamiseen tarkoitettu laturi ja lämpökamera. Vaatimuksena testausympäristölle oli, että sillä pystyttäisiin mittaamaan oikean mobiililaitteen akun latauskäyrä kokonaisuutena ja mitata langattoman latauspiirin lämpökäyttäytymistä latauksen aikana. Jotta testausympäristöstä saatiin kokonaisuutena toimiva, täytyi lisätyille ominaisuuksille tehdä graafiset käyttöliittymät ja sisällyttää ne olemassa olevan ympäristön käyttöliittymään.

Työssä toteutettiin käyttöliittymät Avid Technologies Ltd:n tekemälle langattomalle laturille ja FLIR System Ltd:n valmistamalle infrapuna kameralle. Käyttöliittymät toteutettiin LabVIEW:llä, joka on National Instrumentsin kehittämä graafinen ohjelmointikieli ja -ympäristö. Käyttöliittymistä toteutettiin sekä itsenäiset versiot että aikaisempaan käyttöliittymään sisällytetyt versiot. Työssä perehdyttiin langattoman latauksen toimintaperiaatteisiin ja Wireless Power Consortiumin (WPC) julkaisemaan Qi-standardiin. Lisäksi työssä käytetyn infrapunakameran toimintaperiaate ja pinnan heijastavuuden vaikutus mittauksissa tuli tutuksi käytännön havaintojen kautta.

Työn tuloksena saatiin testausympäristö, jossa langattoman tehonsiirron ja langattoman latauspiirin ominaisuuksia pystyttiin mittaamaan monipuolisesti ja mittaustulokset pystyttiin esittämään helposti ymmärrettävässä muodossa. Myös vaatimuksena ollut latauskäyrän mittaaminen onnistui järjestelmällä erinomaisesti. Lisäksi langattomalle laturille toteutettua käyttöliittymää jaettiin insinöörityön aikana maailmanlaajuisesti yhtiön sisällä. Toteutettua ympäristöä voidaan tulevaisuudessa käyttää esimerkiksi asiakasdemoissa ja langattoman latauspiirin lopullisten käyttökohteiden simuloimisessa. Myös lämpökameran käyttöä testaamisessa voitaisiin tulevaisuudessa tehostaa esimerkiksi lisäämällä lämpökuvan nauhoitusmahdollisuus, jolloin voidaan tarkasti analysoida kohteessa tapahtuvat lämpökäyttäytymiset.

Asiasanat: Langaton lataus, Induktio, Lämpökamera

ABSTRACT

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Author(s): Joni Närhi

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The idea for this Bachelor's thesis came from Characterization-team of ST-Ericsson Ltd, which works with a new IC chip for wireless charging. The main objective of this thesis was to create a test environment for wireless power transfer. The environment was supposed to be versatile and practical where the functionality of the wireless charging IC can be measured and the results can be exported as an easily understandable form. Requirements for the environment were that a battery charging cycle with a real battery could be measured and the temperature of wireless charging integrated circuit (IC) could be measured during the charging cycle.

Graphical user interfaces (GUI) for the wireless power transmitter developed by Avid Technology Ltd and for the FLIR infrared radiation (IR) camera were created and added to the existing GUI for a functional entity. The user interfaces were created by using LabVIEW which is a graphical development language and environment developed by National Instruments. In addition, theory of wireless charging and Qi standard for wireless power transfer by Wireless Power Consortium were studied in this thesis. Also, the infrared camera and emissivity of the surface became familiar through practice.

As a result of this thesis an environment where the wireless power transfer and functionalities of the wireless charging IC measured successfully was achieved. Also, measuring the whole charging cycle with a real battery was a great success. In addition, the created user interface of Avid transmitter was shared globally inside the company. In the future, the created environment can be used for example for user case simulation and for customer support. The environment could be improved by adding e.g. ability to record image stream of IR camera.

Keywords: Wireless charging, Induction, IR Camera

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March 2013, Oulu.

Joni Närhi

TABLE OF CONTENTS

TIIVISTELMÄ	3
ABSTRACT	4
ACKNOWLEDGEMENTS	5
TABLE OF CONTENTS	6
LIST OF ABBREVIATIONS	9
1 INTRODUCTION	10
1.1 Background of thesis	10
1.2 Purpose and objectives of thesis	10
1.3 Structure of thesis	11
2 WIRELESS POWER TRANSFER	12
2.1 Electromagnetic induction	12
2.1.1 Laws of electromagnetic induction	12
2.1.2 Induction between two coils	13
2.2 Wireless charging	14
2.3 Li-ion battery charging	15
3 STANDARD FOR WIRELESS POWER TRANSFER	17
3.1 Wireless Power Consortium	17
3.2 Qi standard	17
3.2.1 Power transmitter	18
3.2.2 Power receiver	20
3.2.3 Communications interface and system control	22
3.2.4 Foreign object detection	22
4 IR THERMOGRAPHY	24
4.1 IR Thermography cameras	24
4.2 Emissivity	25
5 DEVICES AND APPLICATIONS	26
5.1 Application environment	27
5.1.1 Application motherboard	28
5.1.2 Application chip board	29

5.1.3 uPSD microcontroller board	30
5.1.4 Secondary coil	31
5.1.5 Battery module	32
5.1.6 Characterization chip board	33
5.1.7 Application GUI	33
5.2 Avid FOD reference transmitter	34
5.3 FLIR infrared camera	37
5.3.1 GigE Vision	38
5.3.2 FLIR ThermoVision LabVIEW Toolkit	38
6 HARDWARE	39
6.1 Application environment	39
6.2 Adding characterization chip board	39
6.3 Final environment	40
7 SOFTWARE	42
7.1 Avid FOD reference transmitter GUI	42
7.1.1 Graphical serial interface	42
7.1.2 Executable avid software	46
7.1.3 Adding Avid software to Application GUI	46
7.2 Infrared Camera Software	48
7.2.1 Development SubVIs for FLIR A325sc infrared camera	49
7.2.2 Graphical interface to select and calibrate measurable area	52
7.2.3 Adding camera software to Application GUI	55
8 MEASUREMENTS	57
8.1 Emissivity test	57
8.2 Wireless charging IC test	59
8.2.1 Output current versus temperature	60
8.2.2 Overall efficiency test	62
8.2.3 Battery charging cycle test	63
9 CONCLUSION	66
LIST OF REFERENCES	68

APPENDIXES

Appendix 1 Avid Graphical Serial Interface User Guide

Appendix 2 Requirements of the thesis

LIST OF ABBREVIATIONS

AC	Alternating Current
ADC	Analog-to-Digital Converter
ATE	Automated Testing Environment
CCCV	Constant Current-Constant Voltage
DC	Direct Current
EMF	Electromagnetic Field
FOD	Foreign Object Detection
GUI	Graphical User Interface
IC	Integrated Circuit
IR	Infrared Radiation
IEEE-ISTO	IEEE Industry Standards and Technology Organization
LabVIEW	NI's Visual Programming Language and Environment
NI	National Instruments
PCB	Printed Circuit Board
Qi	Global standard for wireless charging
ROI	Region of Interest
SubVI	LabVIEW Subroutine Virtual Instrument
uPSD	Micro Programmable System Device
WPC	Wireless Power Consortium

1 INTRODUCTION

Mobility plays an increasingly important role in the development of handheld consumer electronics. Nowadays, almost all of the interfaces of electronic device are implemented by using wireless technology such as Bluetooth, Wi-Fi, near field communication (NFC), and global positioning systems (GPS). However, the power cord has been the last wire until these days, but now the wireless charging is becoming more common. The wireless charging technology has made a huge step toward becoming the most widely used charging method. This thesis was made to support the spread of the wireless charging.

1.1 Background of thesis

The subscriber of this Bachelor's thesis was ST-Ericsson Oy, which is part of a global Company of ST-Ericsson. The company is a global wireless platform and semiconductor supplier to top mobile device manufacturers and it was established as a 50/50 joint venture by STMicroelectronics and Ericsson in February 2009. ST-Ericsson is a fabless semiconductor company, meaning that the company outsources semiconductor manufacturing with STMicroelectronics and external foundries. (12.)

The idea of this thesis came from ST-Ericsson's Characterization team that was working with a new IC (Integrated Circuit) chip for Qi standard compliance wireless charging. There was a clear need to speed up the product characterization and to be able to demonstrate that the product is compliant with the latest Qi standard of WPC.

1.2 Purpose and objectives of thesis

The purpose of the thesis was to create an environment where a battery charging cycle with a real battery could be measured and temperature of the IC chip could be measured simultaneously during the charging cycle. In future the system can be used for application and validation testing, technical marketing for customers and testing foreign object detection (FOD) performance of Qi standard. An already available mother board, two different chip boards and graphical user interface (GUI) were used as the

basis of the environment. The main objectives were to develop software for the Avid wireless power transmitter and for the IR (Infrared Radiation) camera and add them into the existing GUI for a functional entity.

1.3 Structure of thesis

The theory of this thesis focuses on wireless power transfer for low power devices such as mobile phones, tablets and other handheld consumer electronics. Measured IC is based on Qi standard. This thesis presents Qi standard and its low power specification which defines interface for contactless power transfer between a power transmitter and a power receiver, based on near field magnetic induction between coils. Other Qi's test specifications which define performance requirements and compliance test procedure of wireless charging are for WPC members only and therefore are not examined in this thesis. (19.)

2 WIRELESS POWER TRANSFER

Although wireless charging is already available for mobile phones and other low power devices, it might sound like case of science fiction for most people even though technology and theory behind wireless power transfer have been around for a long time. It was originally invented by Nikola Tesla, who demonstrated the principle of wireless charging in the late 1800's. The technology is also closer to people than people may think. The technology is also already a reality in such devices as electric toothbrushes and surgically implanted devices, like artificial hearts. (17.)

2.1 Electromagnetic induction

The electromagnetic induction is one section of electromagnetism and electromagnetism is the study of interaction between electric current and magnetic field, and forces produced thereof. The scientists in early nineteenth century discovered that there is magnetic field around a current-carrying conductor and they also discovered that the magnetism could be created by electric current. A few years later Michael Faraday discovered that a magnetic field can create an electric current in a conductor or a coil. When there is a change in flux linkage in a coil, EMF (Electromagnetic Field) is induced in it. This phenomenon is credited to Faraday who established famous laws of electromagnetic induction. (4, s. 16-17.)

2.1.1 Laws of electromagnetic induction

Faraday's laws of electromagnetic induction are stated to first and second law. In the first law the EMF is induced in a coil whenever magnetic field linking that coil is changed. In the second law the magnetism of the induced EMF is proportional to the rate of change of flux linkage. The rate of change of flux linkage is derivative of magnetic flux multiplied by numbers of turns of the coil linking the flux. Thus, the induced EMF is expressed as

$$e = -N \frac{d}{dt} \phi$$

EQUATION 2

where,

e = induced EMF

N = numbers of turns in the coil

ϕ = magnetic flux in Webers

t = time in seconds.

The minus sign is introduced in accordance with Lenz's law. The law of Lenz states that the induced EMF, due to change of flux linkage by a coil, will produce a current in the coil in such a direction that it will produce a magnetic field which will oppose the cause, that is the change in flux linkage. (4, s. 21-22.)

2.1.2 Induction between two coils

When EMF is induced in a stationary coil by changing its flux linkage due to change in current flow through the coil, such EMF is called statically induced EMF. When a second coil is brought near a coil producing changing flux, EMF will be induced in the second coil due to a change in current in the first coil. This is called mutually induced EMF (FIGURE 1). The magnitude of the mutually induced EMF will depend upon the rate of change of flux linkage and the number of turns of the individual coil. The change of flux linkage in the second coil generates current to the terminals of coil. (4, s. 24-25.)

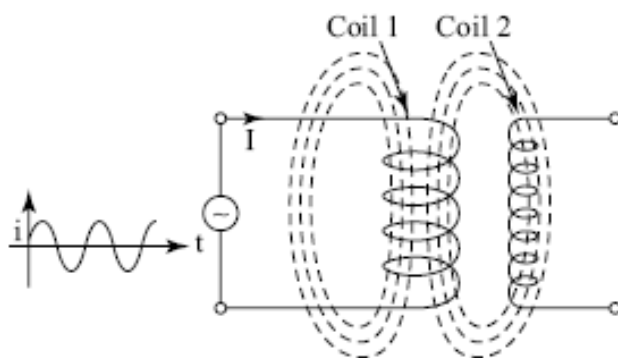


FIGURE 1. Mutually induced EMF (4, s. 25).

2.2 Wireless charging

The wireless charging, also known as inductive charging is based on a few simple principles. The technology requires two coils: a transmitter and a receiver. An alternating current is passed through the transmitter coil, generating a magnetic field. This in turn induces a voltage in the receiver coil; this can be used to power a mobile device or charge a battery. (17.)

There are two kinds of devices in basic wireless charging system. Devices that provide wireless power, referred to as base stations and devices that consume wireless power, referred to as mobile devices. The base station contains a subsystem, referred to as a power transmitter that comprises a primary coil and the mobile device contains a subsystem, referred to as a power receiver that comprises a secondary coil. FIGURE 2 illustrates the basic system overview. The subsystems are examined more specifically in section 3.2. (20, s. 7.)

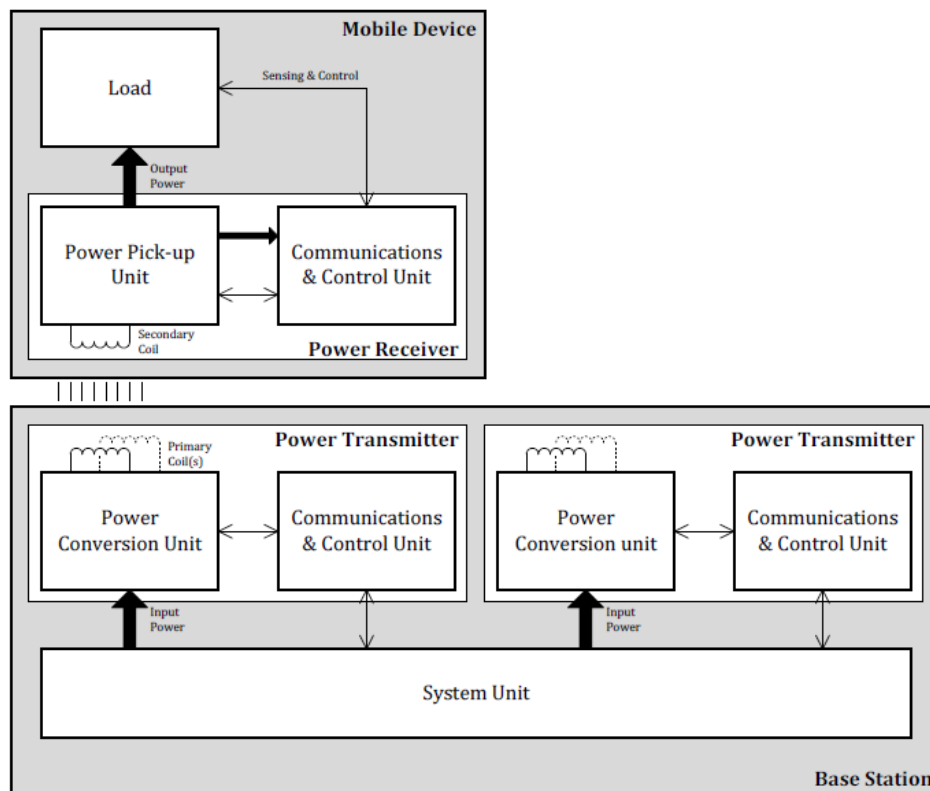


FIGURE 2. The basic wireless charging system overview (20, s. 8).

2.3 Li-ion battery charging

Nowadays most of mobile device batteries are based on li-ion cells. Thus, it is important to understand how to charge and discharge batteries in right way. The rate of charge or discharge is often expressed in relation to the capacity of the battery. This rate is known as the C-rate and equates to a charge or discharge current and is defined as equation 1. (5, s. 40.)

$$I = M * C_n$$

EQUATION 1

where,

I = charge or discharge current[A]

M = multiple or fraction of *C*

C = numerical value of rated capacity [Ah]

n = the time in hours which *C* is declared.

Typically, manufacturers specify the capacity of battery at a 5-hr rate, where n=5. For example, if rated capacity is 1000 mAh, a discharge rate of 1 C corresponds to a discharge current of 200 mA. (5, s. 40.)

The preferred charge algorithm for Li-ion battery chemistries is a constant current-constant voltage (CCCV) algorithm. The charge cycle can be broken up into four stages; trickle charge also known as pre charge, constant current charge, constant voltage charge and charge termination (FIGURE 2FIGURE 3). (5, s. 40.)

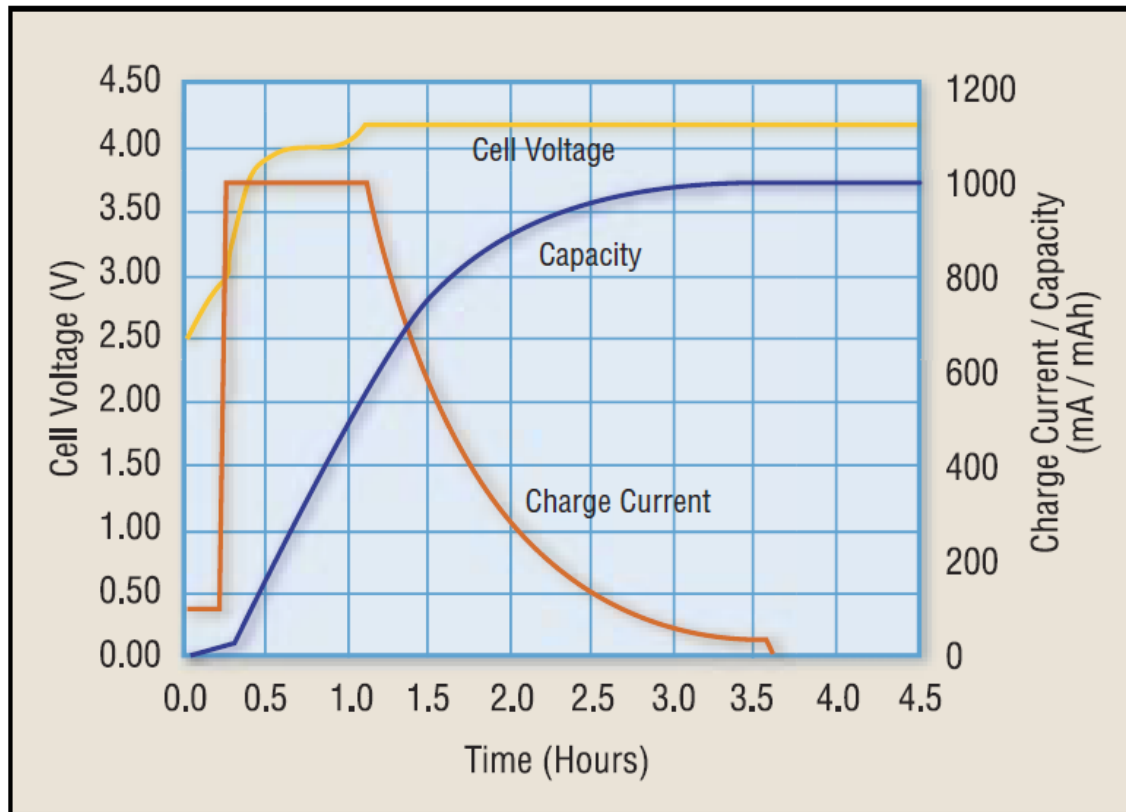


FIGURE 3. The charge algorithm for Li-ion batteries (5, s. 40).

In stage one, a trickle charge is employed to restore charge to deeply depleted cells. During this stage, the cell is charged with a constant current of 0.1 C maximum. After the cell voltage has risen above the trickle charge threshold, the charge current is raised to perform constant current charging (stage two). The constant current should be in the 0.2 C to 1 C range. Charging at constant current rates above 1 C does not reduce the overall charge cycle time and should be avoided. The constant current charge ends when the cell voltage reaches 4.2 V. At that point, the third stage of charging, the constant voltage stage, begins. In the fourth and final stage, the constant voltage charging is terminated. (5, s. 40-41.)

3 STANDARD FOR WIRELESS POWER TRANSFER

The wireless power transfer needs global standard to be more common and compatible charging technology. Over 100 companies from the fields of consumer electronics, wireless power technology, operators and more have been joined to the Wireless Power Consortium (WPC) and are working together to make wireless charging universal. The WPC created and maintains Qi, the global standard for compatible wireless charging. (18.)

3.1 Wireless Power Consortium

The Wireless Power Consortium is an open-membership organization and it promotes the adoption of a global standard for wireless charging. The WPC have 138 members and it provides to members to certify their Qi-compatible products at one of test labs of the consortium. The members can use the Qi logo on their device after certifying. (15.)

The WPC is headed by management team which is called a Steering Group. Each regular member of the WPC have one seat in the Steering groups. The WPC have also Working Groups that are chaired by individuals from a variety of member companies and the Working Groups report to the Steering Group. IEEE-ISTO (IEEE Industry Standards and Technology Organization) is contracted to provide administration for the WPC. (16.)

3.2 Qi standard

The Qi standard guarantees that any device carrying the Qi logo will work with any charging surfaces that carry the Qi logo, regardless of manufacturer and brand (16). The low power specification is available as free public download and a test specifications as performance requirements specification and compliance test specification are for WPC members only (19.)

Version 1.1.1 is the latest version of the Qi specification. The Qi low power specification defines the interface for contactless power transfer between a power transmitter

and power receiver, based on near field magnetic induction between coils. The low power specification defines only transfers of around 5 W of power, using an appropriate secondary coil having a typical outer dimension of around 40 mm. The devices which compliances the low power specification operates at frequencies in the 100 to 205 kHz range. In addition, the specification supports two methods of placing the mobile device on the surface of the transmitter. Those methods are a guided positioning and a free positioning. A simple communication protocol and very low stand-by power are also included in the main features of the specification. (20, s. 1.)

3.2.1 Power transmitter

In the low power specification the power transmitters are grouped in two basic types which are type A and type B. Type A power transmitter has a single primary coil and type B power transmitter has an array of the primary coils. FIGURE 4 illustrates a functional bloc diagram of type A power transmitter. The type A transmitters consist of a power conversion unit and a control and communication unit. The power conversion unit is the functional part of transmitter that converts electrical energy to a power signal. The communication and control unit are functional parts that control the power transfer. The type B transmitters have additionally a detection unit that detects the presence of a power receiver on the surface of the transmitter. (20, s. 4, 11.)

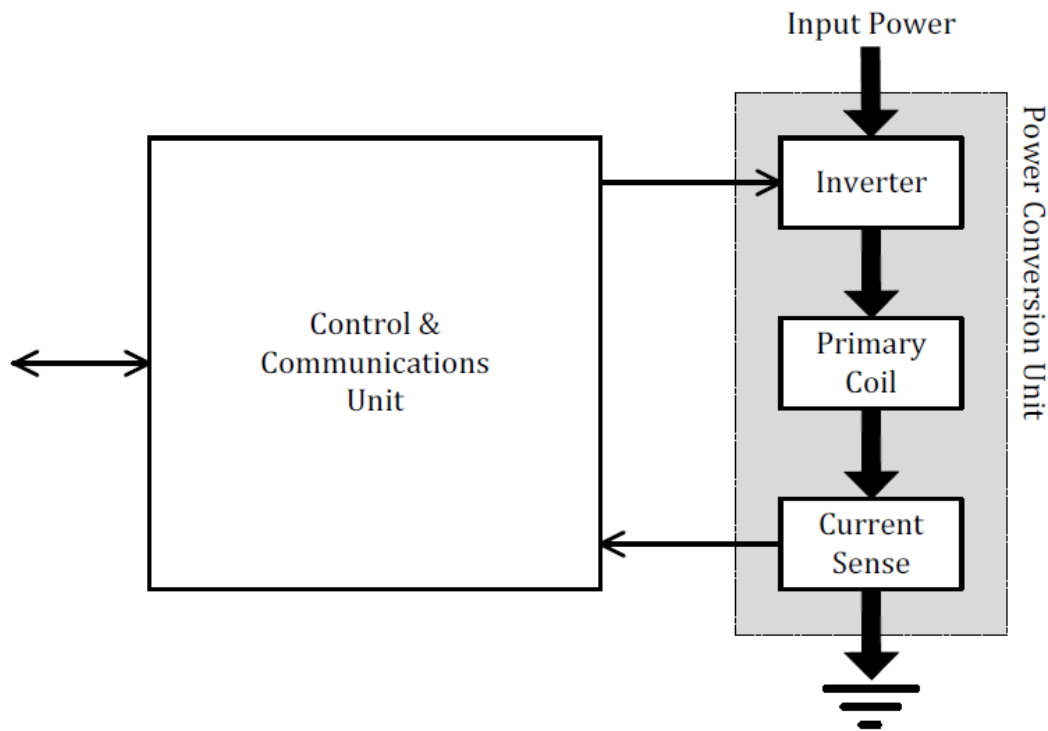


FIGURE 4. Functional block diagram of type A power transmitter (20, s. 11).

Type A power transmitters enable either guided positioning or free positioning, depending on proper alignment of the primary and secondary coil. All Type B power transmitters enable free positioning. (20, s. 11.)

The guided positioning means that the user must actively align the secondary coil to the primary coil, by placing the device on the appropriate location of the transmitter. For this purpose, the device provides an alignment aid that is appropriate to its size, shape and function. Thus, the power transmitter should simply execute a digital ping to locate power receiver. If the power transmitter receives a signal strength packet or an end power transfer packet, it has discovered and located a power receiver. Otherwise, the object is not a power receiver. The communication methods are examined more specifically in chapter 3.2.3. (20, s. 103.)

In turn, the free positioning method does not require the active participation in alignment of the primary and secondary coil and user can place the device to anywhere on

the transmitter surface. The implementation of the free positioning is more complicated than guided positioning. One implementation of the free positioning makes use of an array of primary coils to generate a magnetic field at the location of the secondary coil only. Another implementation uses mechanical means to move a single primary coil underneath the secondary coil. In the case of the free positioning, discovery and localization of the power receiver is less straightforward than guided positioning. (20, s. 103.)

3.2.2 Power receiver

The power receiver consists of a power pick-up unit and the communication and control unit. The power pick-up unit is the functional part of power receiver that converts the power signal to electrical energy. FIGURE 5 illustrates an example block diagram of the power receiver. (20, s. 4-5, 63.)

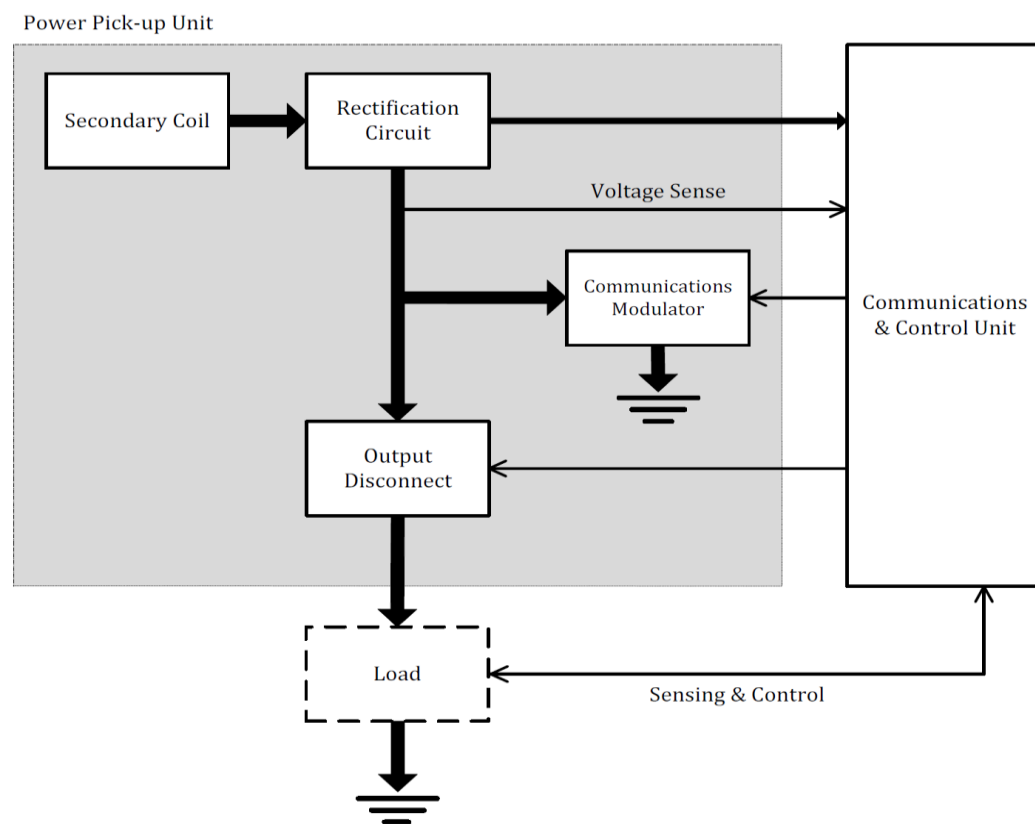


FIGURE 5. Functional block diagram of the power receiver (20, s. 63).

The power pick-up unit comprises the analog components of the receiver. Those components are a dual resonant circuit, a rectification circuit, communication modulator and an output disconnect switch. The dual resonant circuit consists of a secondary coil plus series and parallel capacitances to enhance the power transfer efficiency and enable a resonant detection method. The rectification circuit provides full-wave rectification to convert AC (Alternating Current) waveform to a DC power level. The communication modulator provides that the power receiver have the means to modulate the primary coil current and voltage and there are several methods to implement it. The communication methods are examined in section 3.2.3. The output disconnect switch enables the receiver to disconnect its output from the subsystems connected thereto. When the receiver has disconnected its output, it shall ensure that it still draws a sufficient amount of power that the communication requires to remain. (20, s. 63-64.)

The low power specification also defines mechanical design requirements for the receiver as interface distances, alignment aid and shielding. For example, the distance from the secondary coil to the receiver surface of the mobile device shall not exceed $d_z = 2,5 \text{ mm}$, across the bottom face of the secondary coil. See FIGURE 6. (20, s. 64-65.)

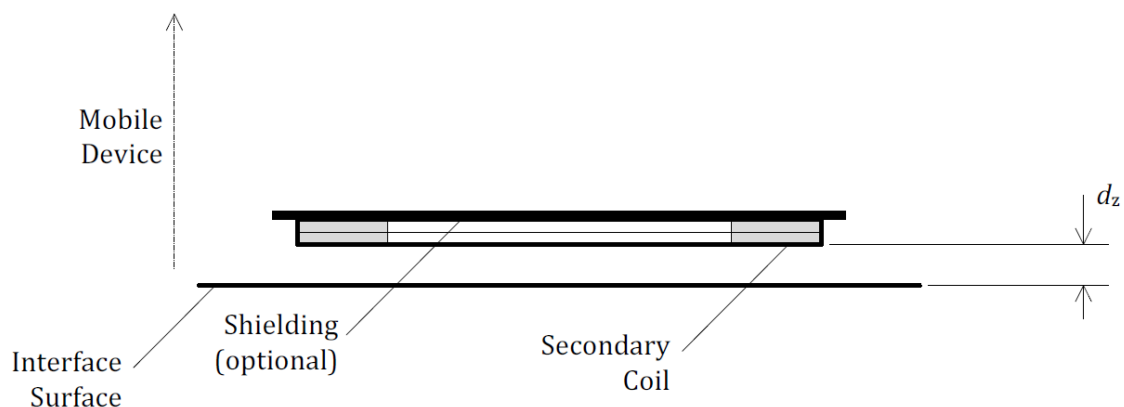


FIGURE 6. Secondary coil assembly (20, s. 64).

3.2.3 Communications interface and system control

The power receiver communicates to the power transmitter using backscatter modulation. For this purpose, the power receiver modulates the amount of power, which it draws from the power signal. The power transmitter detects this as a modulation of the current through and voltage across the primary coil or set of coils. In other words, the power receiver and power transmitter use an amplitude modulated power signal to provide a communications channel. (20, s. 85.)

The system control is divided into four phases, namely *selection*, *ping*, *identification and configuration*, and *power transfer*. In the *selection* phase the power transmitter monitors the surface of transmitter for the placement and removal of objects. When the power transmitter is detected and located (only in case of the free positioning) the power receiver proceeds to the *ping* phase and eventually to the *power transfer* phase. In the *ping* phase the power transmitter executes a ping which is called the digital ping, and listens for a response. If the power transmitter discovers the power receiver, the system will proceed to the *identification and configuration* phase. Furthermore, if the power transmitter does not extend the digital ping, the system shall revert to the *selection* phase. In the *power transfer* phase, the power transmitter continues to provide power to the power receiver and monitors parameters that characterize the power transfer from a power transmitter to a power receiver. A violation of any of the stated limits on any of those parameters causes the power transmitter to abort the power transfer and returning the system to the *selection* phase. (20, s. 69-70.)

3.2.4 Foreign object detection

The version 1.1.1 of the QI specification defines the foreign object detection. The foreign object detection is defined to enable the power transmitter to monitor the power loss across the interface. It is the one of the possible methods to limit the temperature rise of objects that is positioned on the surface of the transmitter but is not part of a power receiver device. FOD is a security feature for the user safety. In order to enable monitoring the power receiver shall report its received power to the power transmitter. (20, s. 107.)

The received power P_{PR} indicates the total amount of power that is dissipated within the device due to the magnetic field produced by the power transmitter. The received power equals the power that is available from the output of the power receiver plus any power that is lost in producing that output power. (20, s. 107.)

4 IR THERMOGRAPHY

Temperatures of an electrical device or an integrated circuit are measured to ensure safety and prevent the overheating of the device. The thermal properties can be enhanced by taking conduction, convection, and radiation of heat into account. Infrared cameras can detect only the radiation of heat. Therefore, the radiation is only examined in this thesis.

Although infrared radiation (IR) is not detectable by the human eye, an IR camera can convert it to visual image. Infrared radiation covers a portion of the electromagnetic spectrum from approximately 900 to 14 000 nanometers. IR is emitted by all objects at temperatures above absolute zero, and the amount of radiation increases with temperature. (6, s. 1.)

4.1 IR Thermography cameras

Thermography is a type of imaging that is accomplished with an IR camera calibrated to display temperature values across object or scene. Therefore, thermography allows one to make non-contact temperature measurements. (6, s. 1.)

IR camera construction is similar to a digital video camera. The main components are a lens that focuses IR onto a detector, plus electronics and software for processing and displaying the images. FIGURE 7 illustrates block diagram of an IR camera. The IR camera detector is a focal plane array (FPA) of micrometer size pixels made of various materials sensitive to IR wavelengths. Typically the detector is an uncooled microbolometer made of a metal or semiconductor material. (6, s. 1.)

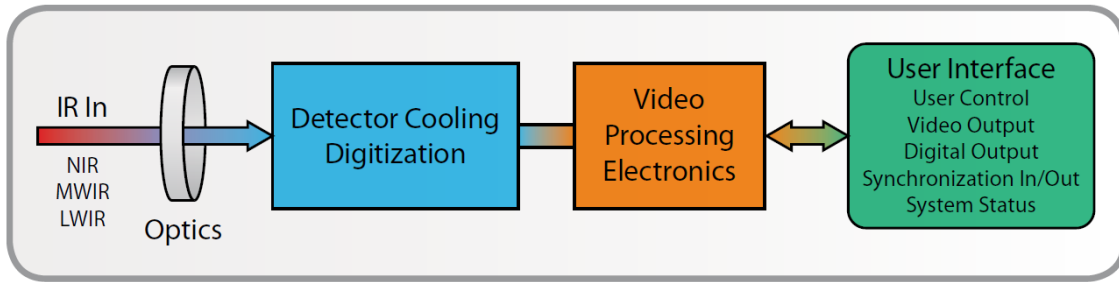


FIGURE 7. Simplified block diagram of an IR camera (6. s. 1.)

4.2 Emissivity

The radiative properties of objects are usually described in relation to a perfect blackbody (the perfect emitter). The emissivity is a number between 0 and 1. The better the radiative properties of the object, the higher is its emissivity. An object that has the same emissivity for all wavelengths is called a greybody. Consequently, for a greybody, the law of Stefan Boltzmann states that the total emissive power of a greybody is the same as that of a blackbody of the same temperature reduced in proportion to the value of emissivity for the object. Still, most bodies are neither blackbodies not greybodies. The emissivity varies with wavelength. (6, s. 4.)

The IR camera calculates a temperature based on radiance measurements and the emissivity of the object. When the emissivity value is unknown or uncertain, the emissivity can be calculated if temperature of the object is known. There are several methods to doing this. (6, s. 20.)

One of the methods is to use an area of known emissivity. The idea is to determine the temperature of the object with the camera in the usual way. The object is adjusted so that the area with unknown emissivity is very close to an area of known emissivity. The distance separating these areas must be safety assumed they have the same temperature. From this temperature measurement the unknown emissivity can be calculated. (6, s. 20.)

5 DEVICES AND APPLICATIONS

The devices and applications used and created for wireless charging measurement environment are examined in this section. As FIGURE 8 shows, the environment consists of three parts of hardware and the software can also be divided into three parts. The hardware of this environment is built on top of an existing system. In addition the created software is added inside an already available graphical user interface. Independently executed programs were also created for thermal camera and Avid wireless power transmitter. A few of the devices and applications were created only for company internal use and are only examined superficially.

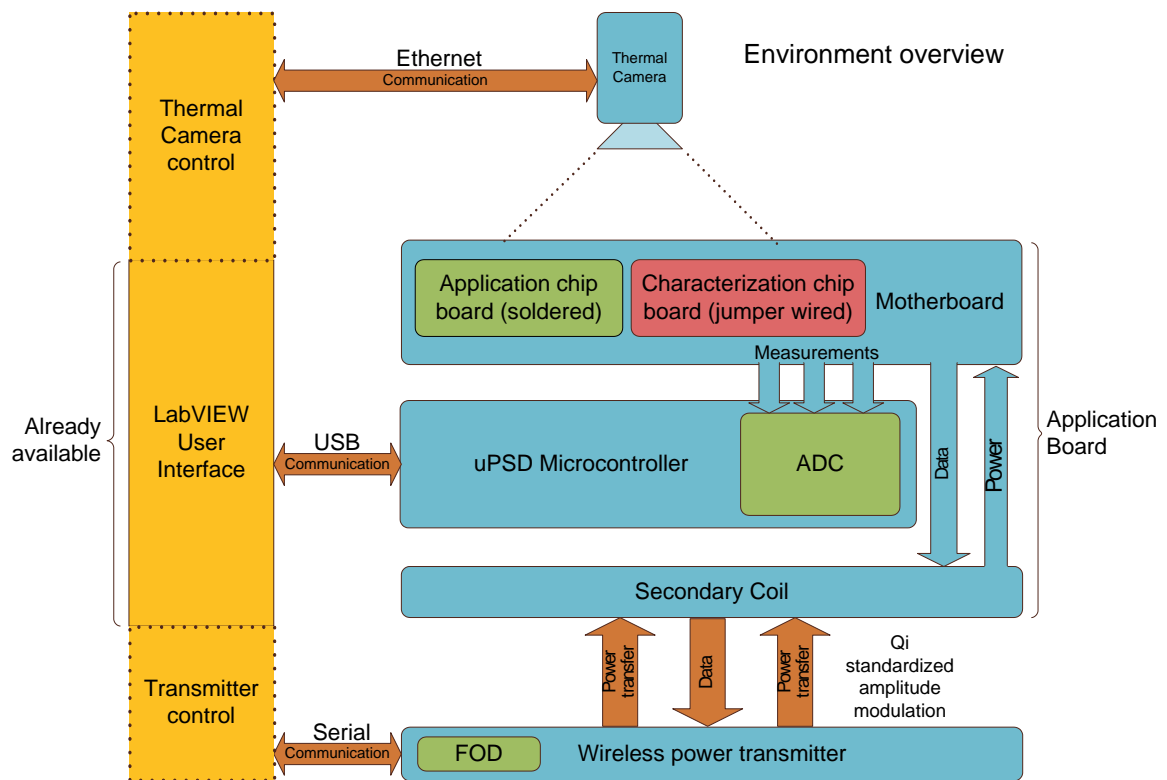


FIGURE 8. Environment overview.

5.1 Application environment

The application board is the environment where the wireless charger IC is measured for application purpose. Those purposes are for example customer demonstration, IC validation and general functionality testing. The board is composed of five different parts; motherboard, uPSD microcontroller board, application chip board module and wireless power receiver. In addition a characterization chip board was placed on top of the system. There is also a place for battery on board, but for the purpose of this thesis an external battery module was used, because the characterization chip board was placed in the place of the battery. The application board and the connected parts are presented in FIGURE 9 and FIGURE 10.

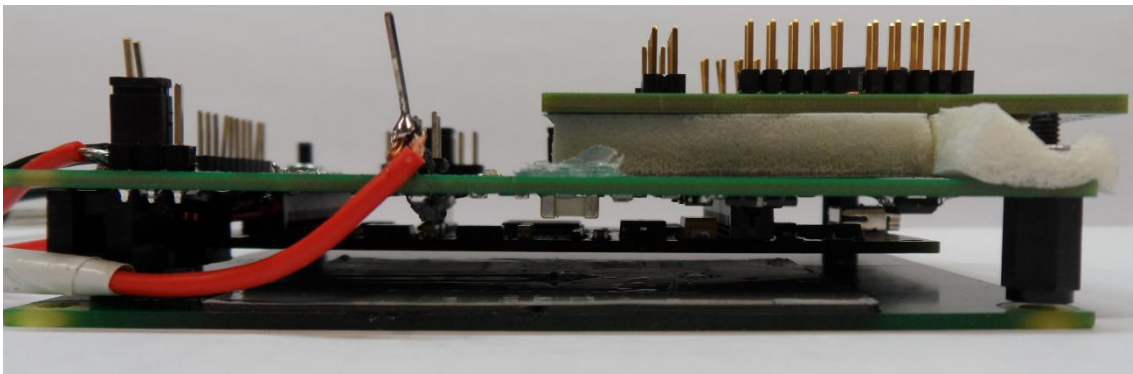


FIGURE 9. Application environment with characterization chip board.



FIGURE 10. Application environment (simplified image).

5.1.1 Application motherboard

The motherboard is used to connect all components together that a wireless charging system requires to function. Most of the components are connected through a measuring point where usually the voltage over the sense resistor is measured by ADC. The circuit diagram for current measurement is shown in FIGURE 11.

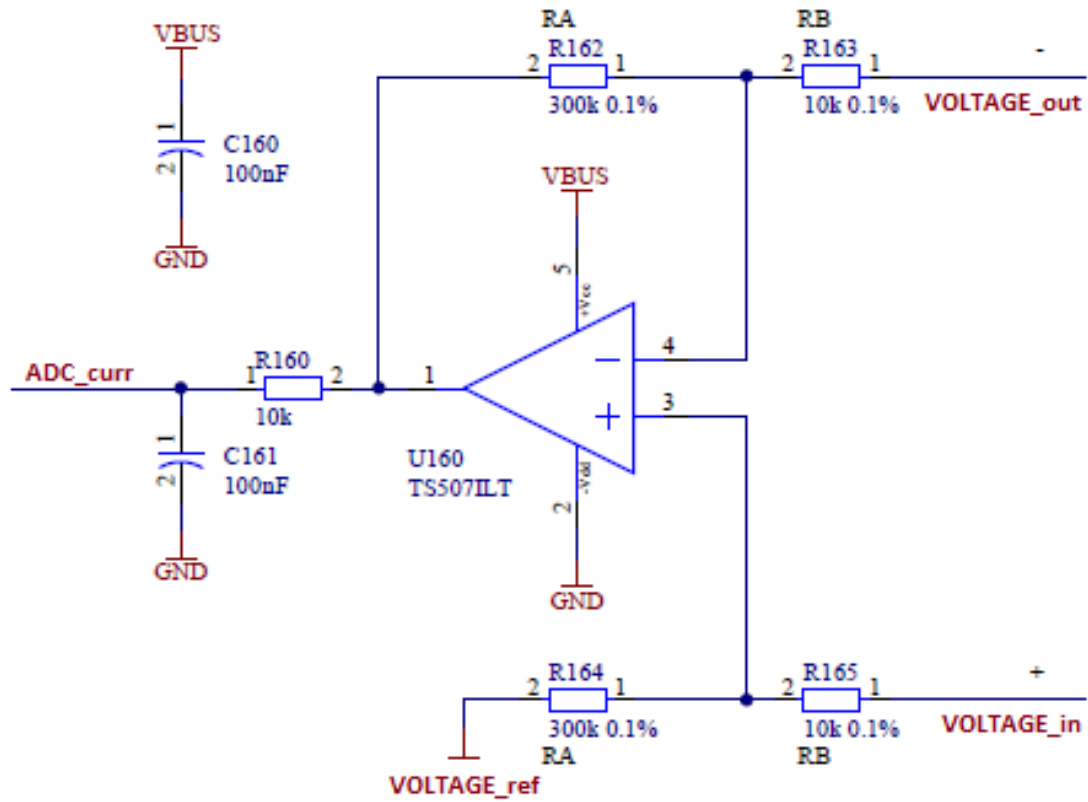


FIGURE 11. Circuit diagram of current measurements.

Current on **ADC_curr** point can be calculated by equation 3.

$$Voltage_{ADC_{curr}} = V_{ref} + \left(I * R_{sense} * \frac{RA}{RB} \right) \rightarrow$$

$$Current_{ADC_{curr}} = \frac{V_{ADC_{curr}} - V_{ref}}{R_{sense} * \frac{RA}{RB}}$$

EQUATION 3

5.1.2 Application chip board

29

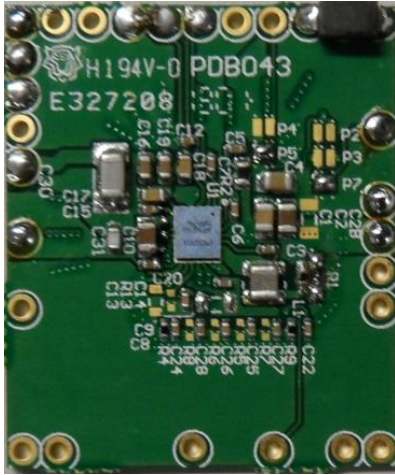


FIGURE 13. Application chip board.

5.1.3 uPSD microcontroller board

uPSD (Micro Programmable System Device) microcontroller board (FIGURE 14) is interfaced to control IC chip and measures the needed electrical parameters. The model of the microcontroller is uPSD 3434EV and it is manufactured by ST-Microelectronic. Registers of the IC chip can be read and written by microcontroller. It also includes an ADC (Analog-to-Digital Converter) with eight channel and 10-bit resolution (14). The ADC is used to measure electrical parameters.



FIGURE 14. uPSD microcontroller.

5.1.4 Secondary coil

The secondary coil (FIGURE 15) receives power from the primary coil of transmitter. The coil is connected to the bottom of the application motherboard as FIGURE 12 shows. In this thesis the external secondary coil was used also because of its usability. Using the external secondary coil enabled us to keep the motherboard in place while the thermal camera was measuring. The external secondary coil is shown in FIGURE 16.

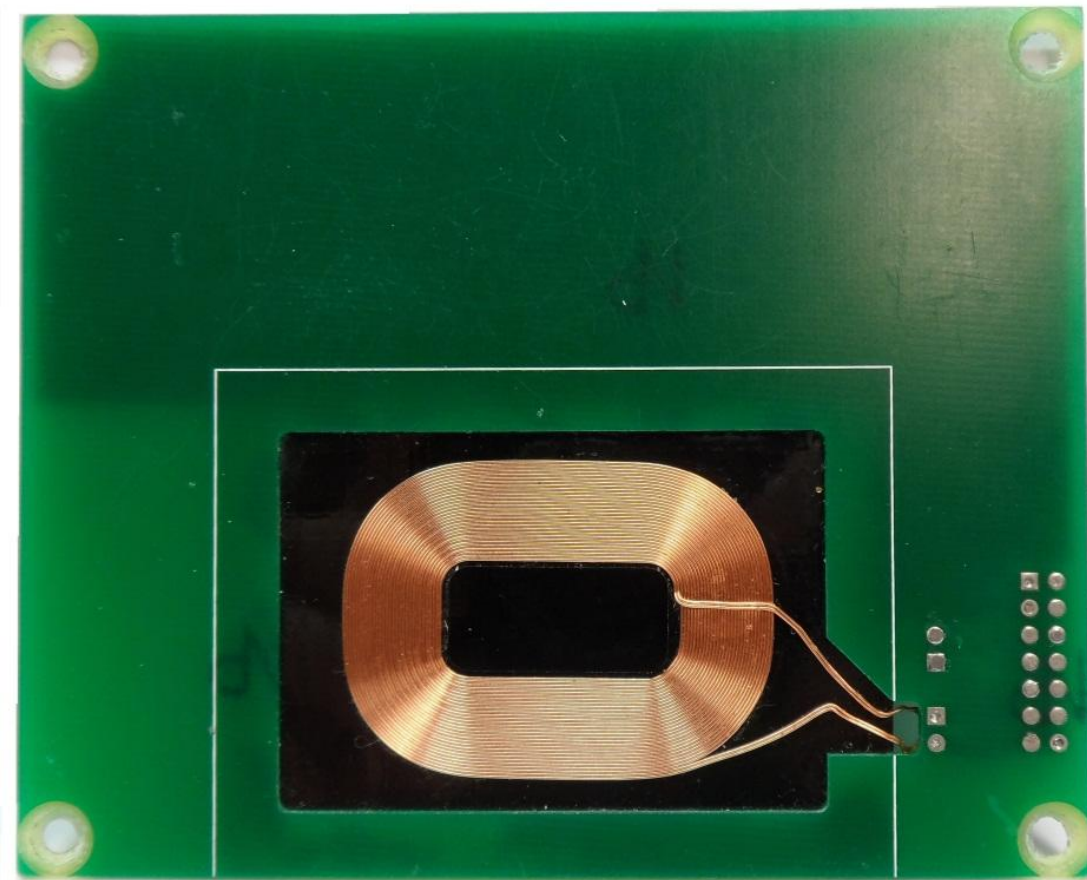


FIGURE 15. Secondary coil.

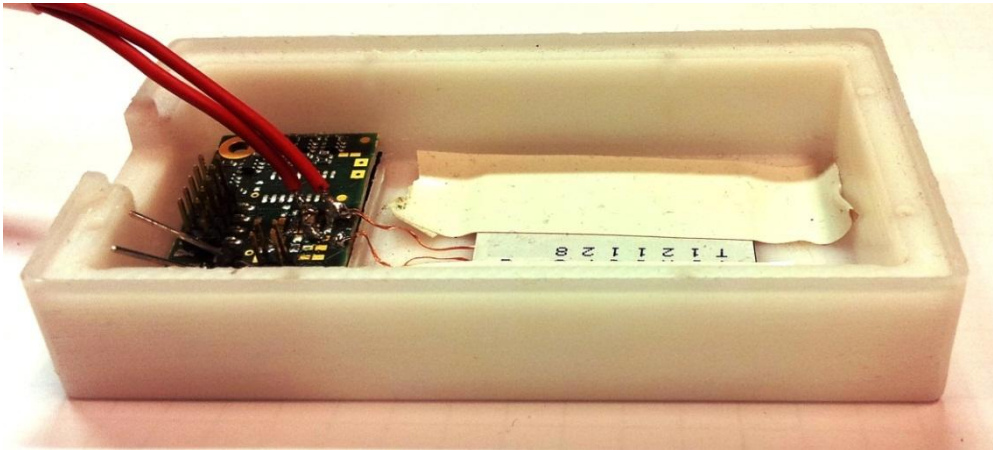


FIGURE 16. External secondary coil.

5.1.5 Battery module

The battery module is a very simple PCB where there is a place for battery and connectors for wires. The battery module was used to measure the full charging cycle of battery. In addition, the module was used for discharging battery. The battery module is presented in FIGURE 17.

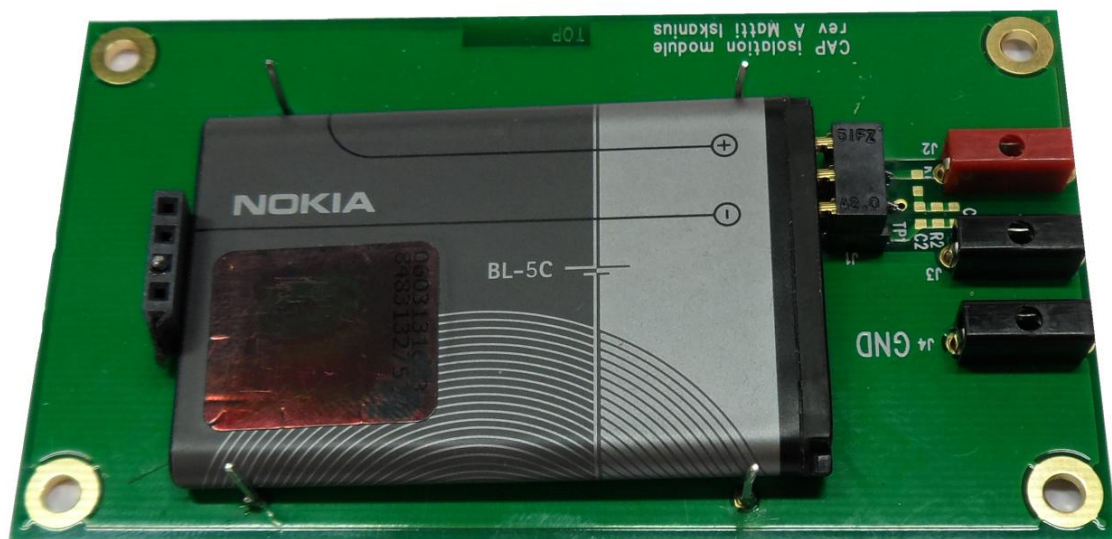


FIGURE 17. The battery module.

5.1.6 Characterization chip board

The characterization chip board (FIGURE 18) has originally been developed for automatic test environment (ATE) where the chip board is connected to ATE via specific motherboard. In ATE-tester the electrical parameters are measured for characterization and there is no possibility to test the functionality of the whole system. Therefore, the chip board was added to the application test environment.

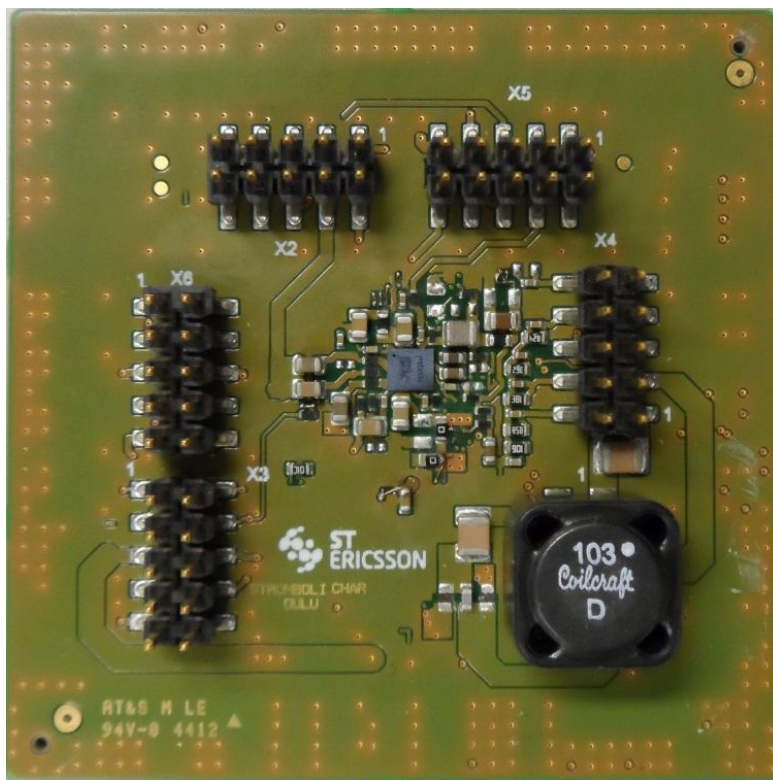


FIGURE 18. Characterization chip board.

5.1.7 Application GUI

The Application GUI (FIGURE 19) has been made by Tomas Cerny from ST-Ericsson Prague. The Application GUI is interfaced to control all the functionalities of wireless charging IC. The Application GUI is based on LabVIEW graphical programming language. It enables to read and write registers of IC, read ADC measurements and it

brings all measured data into the one graph. The GUI has own tabs for every block of wireless charging IC which makes it very practical.

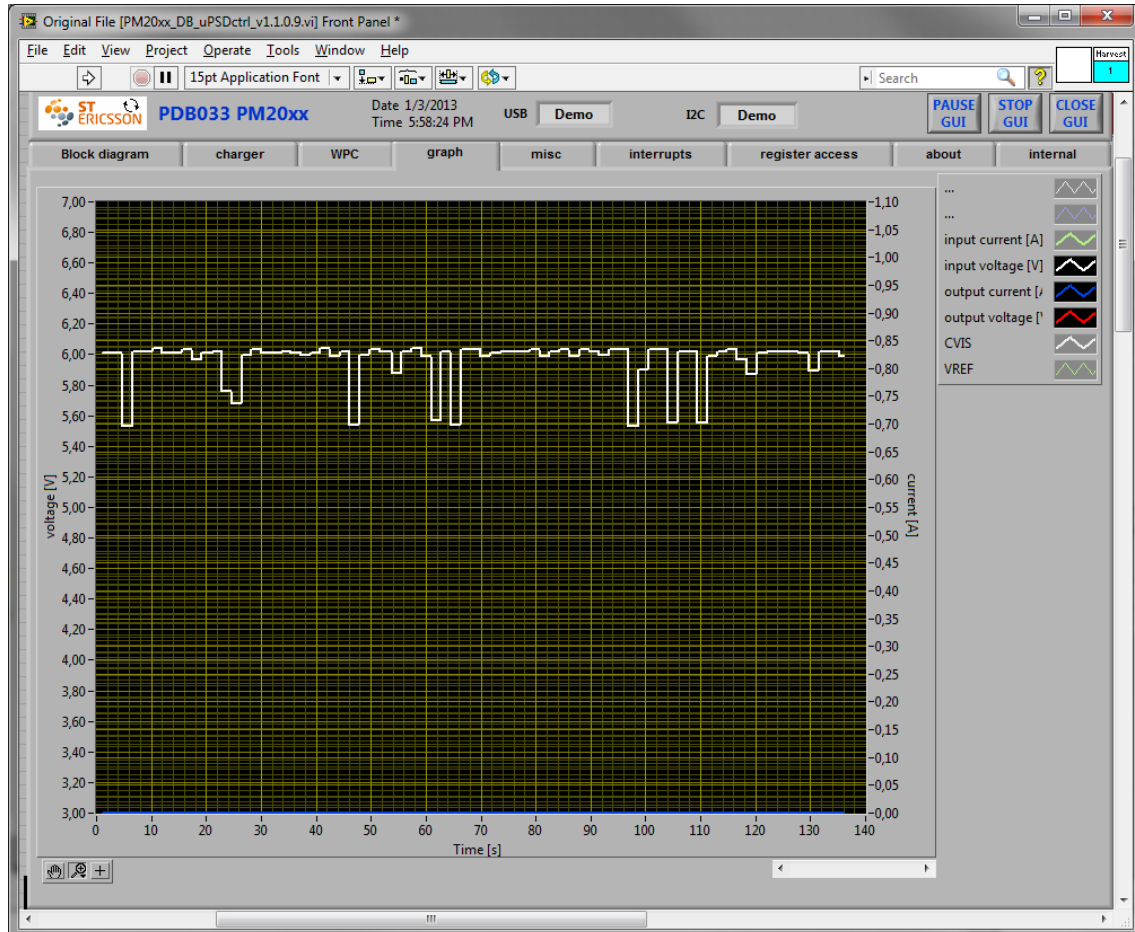


FIGURE 19. The Application GUI.

At the beginning of this thesis, the Application GUI was used for learning, controlling and measuring the wireless charging IC. Then, the GUI was used as platform for all software created in this thesis, meaning that all created programs were added to this GUI. The added software is presented in section 7.

5.2 Avid FOD reference transmitter

Avid FOD (Foreign Object Detection) reference transmitter (FIGURE 20) is a factory calibrated Qi compatible wireless transmitter to test FOD functionality of wireless

charging systems. The Avid Transmitter has USB connectivity for displaying transmitted power, received power, calculated power loss, and FOD threshold information (2). The transmitter has a single primary coil and it enables guided positioning. The guided positioning is presented in chapter 3.2.1.

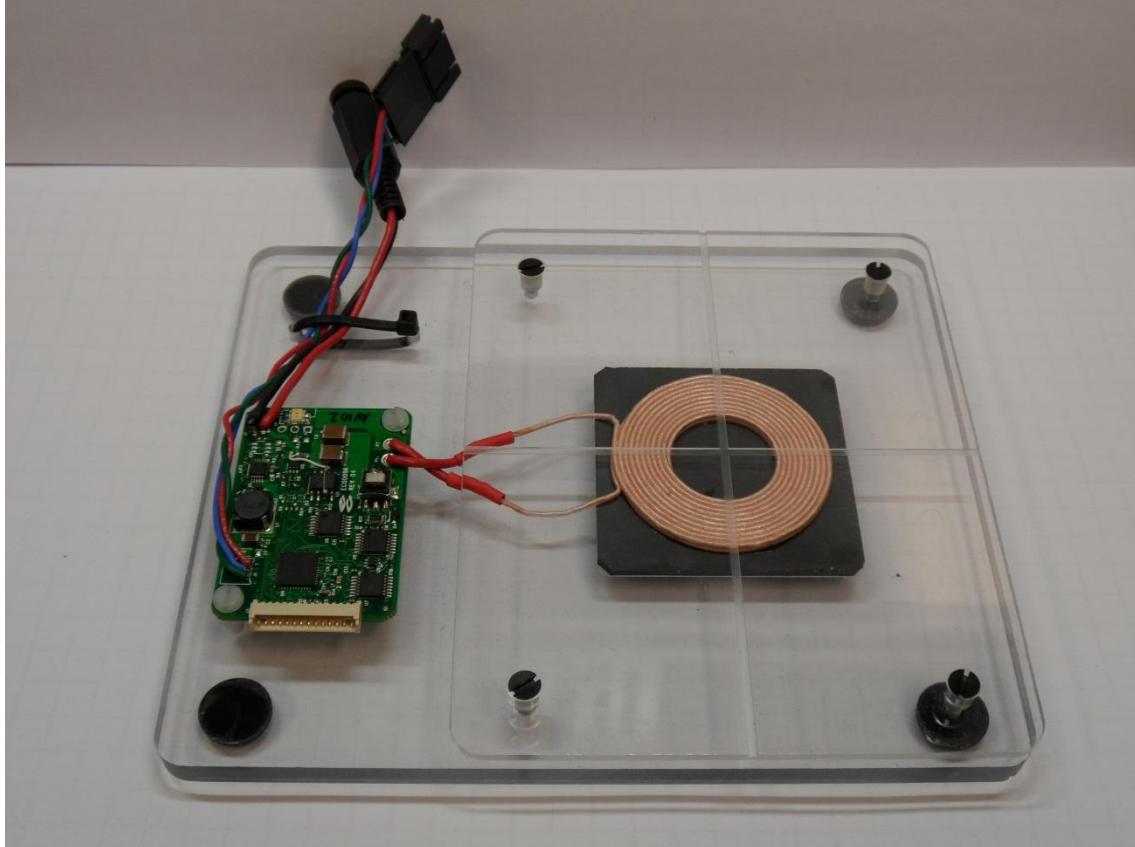
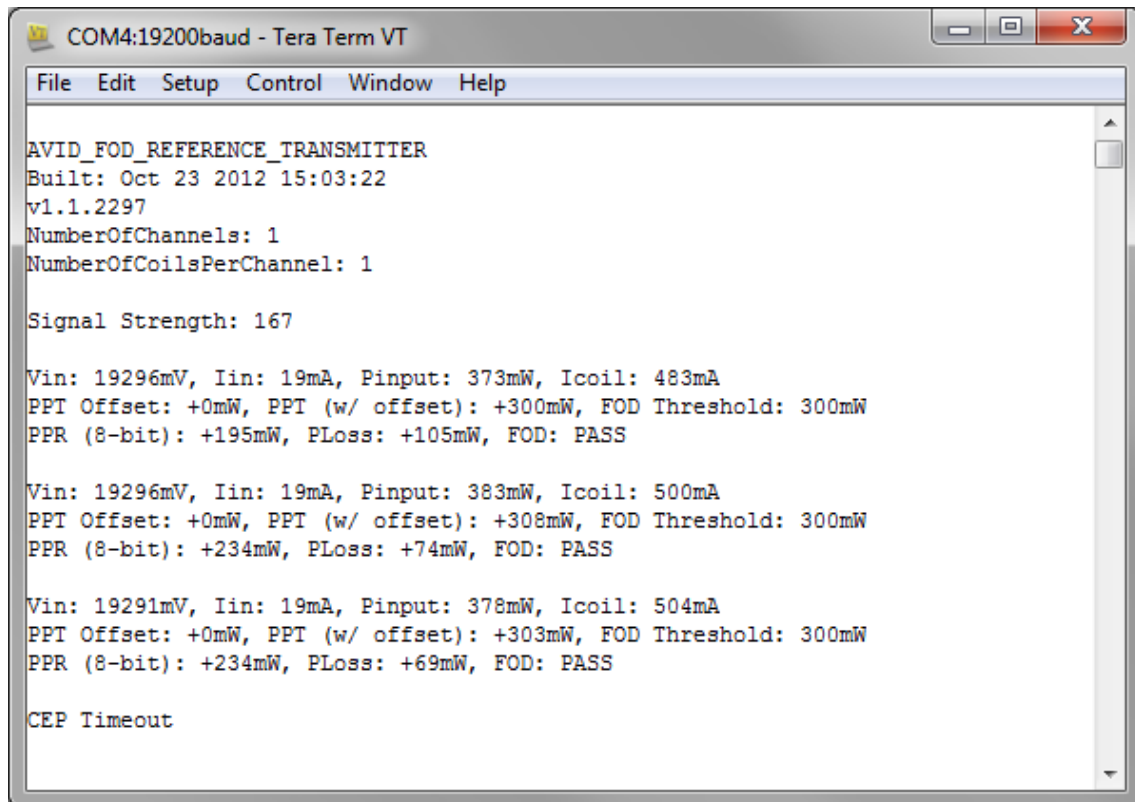


FIGURE 20. Avid FOD reference transmitter.

When first powered, the transmitter will print basic device information and will then remain in an idle state until the power receiver is detected. Once a receiver is detected, normal Qi operation between transmitter and receiver will occur. Whenever the transmitter receives the receiver power packet from the transmitter, it will calculate the amount of the power loss and print it to the serial port. The printed data of the transmitter can be read from the serial port with external serial port reader e.g. Tera Term. See FIGURE 21. (1, s. 1.)



```
COM4:19200baud - Tera Term VT
File Edit Setup Control Window Help

AVID_FOD_REFERENCE_TRANSMITTER
Built: Oct 23 2012 15:03:22
v1.1.2297
NumberOfChannels: 1
NumberOfCoilsPerChannel: 1

Signal Strength: 167

Vin: 19296mV, Iin: 19mA, Pinput: 373mW, Icoil: 483mA
PPT Offset: +0mW, PPT (w/ offset): +300mW, FOD Threshold: 300mW
PPR (8-bit): +195mW, PLoss: +105mW, FOD: PASS

Vin: 19296mV, Iin: 19mA, Pinput: 383mW, Icoil: 500mA
PPT Offset: +0mW, PPT (w/ offset): +308mW, FOD Threshold: 300mW
PPR (8-bit): +234mW, PLoss: +74mW, FOD: PASS

Vin: 19291mV, Iin: 19mA, Pinput: 378mW, Icoil: 504mA
PPT Offset: +0mW, PPT (w/ offset): +303mW, FOD Threshold: 300mW
PPR (8-bit): +234mW, PLoss: +69mW, FOD: PASS

CEP Timeout
```

FIGURE 21. Avid serial data.

If the power loss P_{Loss} exceeds a FOD threshold, the FOD Boolean will be “FAIL”. Otherwise it will be “PASS”. WPC 1.1 standard requires that received and transmitted power is inside the 250mW budged. If 250mW budged is exceeded, the foreign object between transmitter and receiver is expected and power transfer is terminated for safety reasons. But the Avid transmitter is designed to continue the power transfer even though the FOD threshold is exceeded.

In addition, the transmitter has two different operating modes. Those modes are a closed loop mode and an open loop mode. In case of the open loop mode the user can set the transmitter to run at a constant frequency. In the open loop mode there is no communication between the receiver and transmitter. (1, s. 1.)

5.3 FLIR infrared camera

FLIR A325sc infrared camera (FIGURE 22) has been chosen by the characterization team of ST-Ericsson to their laboratory for thermal testing. The camera supports 16-bit thermal image with 320 x 240 pixel resolution and built in Gigabit Ethernet connection with GigE Vision standard compatibility allows real time image streaming at 60 Hz. Therefore, FLIR A325sc infrared camera fits well to tests where changes of temperature are very fast. (7.)



FIGURE 22. FLIR A325sc infrared camera (7).

In addition, FLIR Close-up lens was used with the IR camera. The Close-up lens has 2x magnifying factor and the field of view is 16 mm x 12 mm. The working distance of the lens is 33 mm. The Close-up lens is designed for extremely small targets as PCBs. (9.)

In this thesis the camera was used to measure temperature of wireless charging IC and FLIR ThermoVidion LabVIEW Toolkit was chosen for camera controlling, because all other software was created by LabView.

5.3.1 GigE Vision

GigE Vision is a global camera interface standard and it was defined by a committee of the Automated Imaging Association (AIA). The standard has been developed using the Gigabit Ethernet communication protocol. GigE Vision allows for fast image transfer using low cost standard cables over very long lengths. Because GigE Vision is based on the Ethernet standard, it benefits from wide penetration in both the industrial and consumer markets. (3.)

5.3.2 FLIR ThermoVision LabVIEW Toolkit

FLIR ThermoVision LabVIEW Toolkit is a set of SubVIs (Subroutine Virtual Instrument) related to cameras supporting alarms, measurement functions and I/O functionality. With these VIs the communication with FLIR IR camera can be used in digital mode. In addition, the temperature images can be acquired and analyzed through LabVIEW. (8.)

6 HARDWARE

The first phase of this thesis was to set up the hardware and get familiar with the environment. In the beginning, the application chip board was used with the application motherboard to get familiar with the measurement environment and its controls. Afterwards, the application chip board was changed to characterization chip board and actual measurements were done.

6.1 Application environment

The application environment was already a functional environment where the application chip board had been tested earlier. Only a couple of modifications were made. These modifications added were pin and wires for battery voltage and added pins for output and input current measurements. Again, getting familiar with the application board took the most time of the hardware setup.

6.2 Adding characterization chip board

As mentioned in section 5.1.6 the characterization chip board is designed for automatic testing environment and it is not have been used with application chip board earlier. The first challenges were to get to know how the chip board should be connected and placed into the application board. The chip board had to be connected to the motherboard so that the chip board is easy to change and the wires are not too long. In addition the infrared camera imposes some limitation to wiring, because it had to be placed 3 cm from the chip board. Eventually, the characterization chip board was connected via jumper wire with a connector which turns away from the infrared camera. The solution is presented in FIGURE 23.

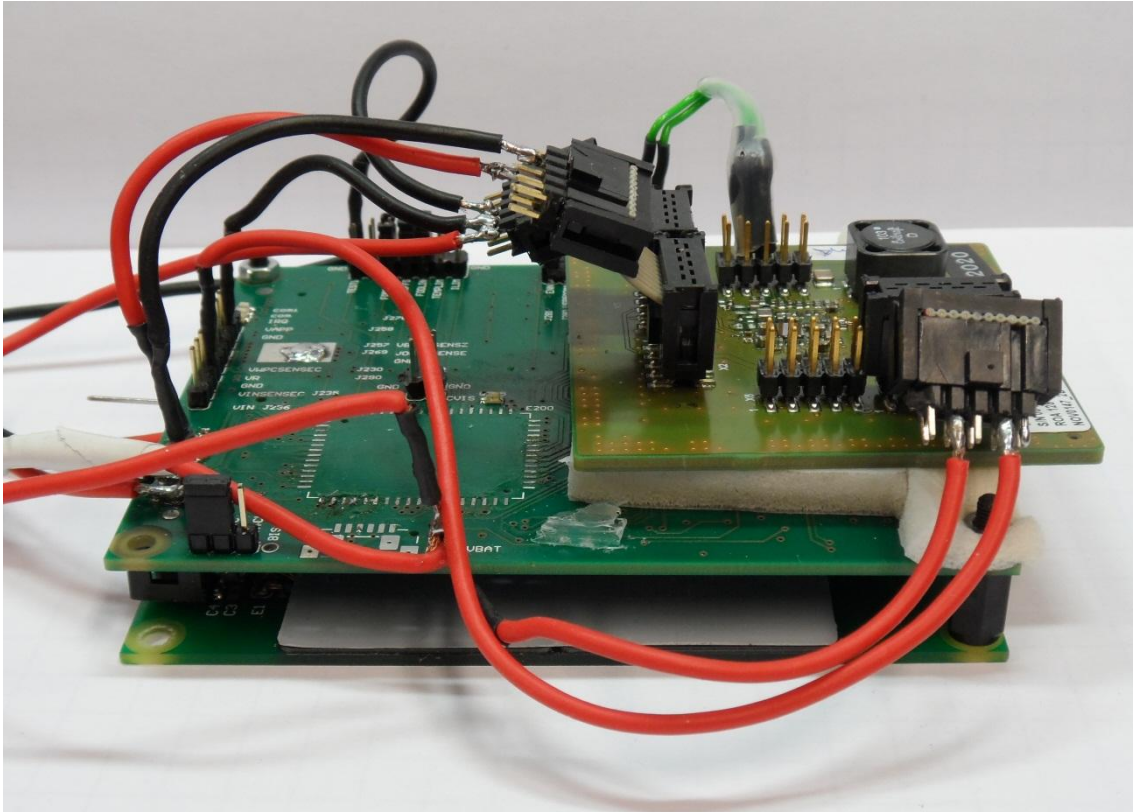


FIGURE 23. The characterization chip board wired to the application motherboard.

6.3 Final environment

The final environment, where measurements were done, consisted of the motherboard, the chip board, the battery module, the IR camera, the external secondary coil and the Avid reference transmitter. The environment and all its components are shown in FIGURE 24.

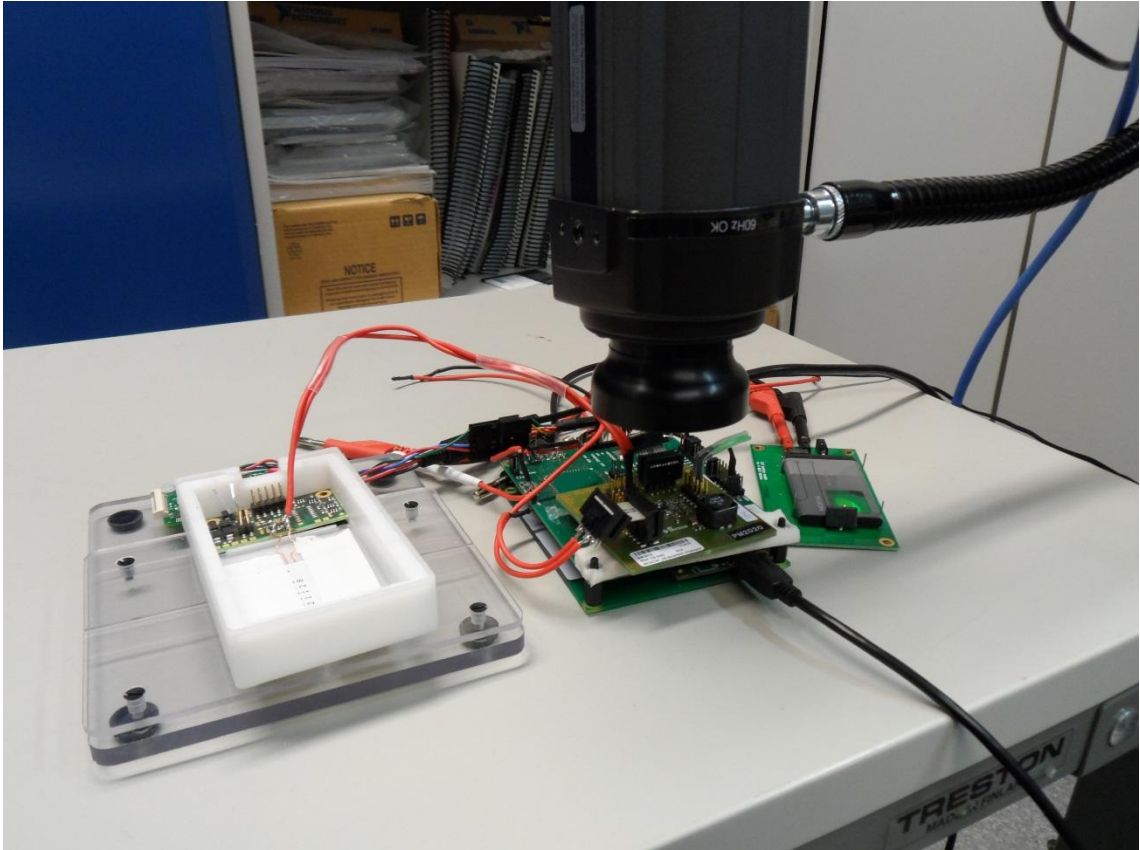


FIGURE 24. The final environment.

7 SOFTWARE

The software development of this thesis was divided in two different sections. In the first section a GUI for Avid FOD reference transmitter was created. Furthermore, when the executable GUI was ready, it was added to the Application board GUI. In the second section the software for the infrared camera was created. Also the camera software was added to the Application board GUI.

7.1 Avid FOD reference transmitter GUI

Originally, Avid transmitter sends data only in text format and needs external program for example Tera Term to plot data to screen as showed in FIGURE 21. Therefore the graphical interface was created to facilitate the measuring process. The graphical interface and communication were implemented in LabVIEW. In addition, the graphical interface was purposed to include to existing graphical user interface. The implementation of software is presented in following sections.

7.1.1 Graphical serial interface

The scope of graphical user interface was to give more illustrative and editable data for the user. Therefore the data was imported in as many formats as possible such as tables, variables, graphs and text. The user interface had to be simple and effective, and a structure of software had to be stable and fault-tolerant.

FIGURE 25 illustrates the structure of software. At first the connection and general settings are initialized and connection is checked. After that the program reads data from the serial port until a line break character is found and compares the measured string with specified string and parses the matched elements. When the program is running but no receiver is placed on top of the transmitter, it prints zeros to graph, but if the charger is active and no data is read the program prints the last measured parameters to graph. When all elements are parsed, the data is printed to a graph. Finally, if a stop signal is not received the program starts to read a new line. Otherwise, the connection is closed and the program ends.

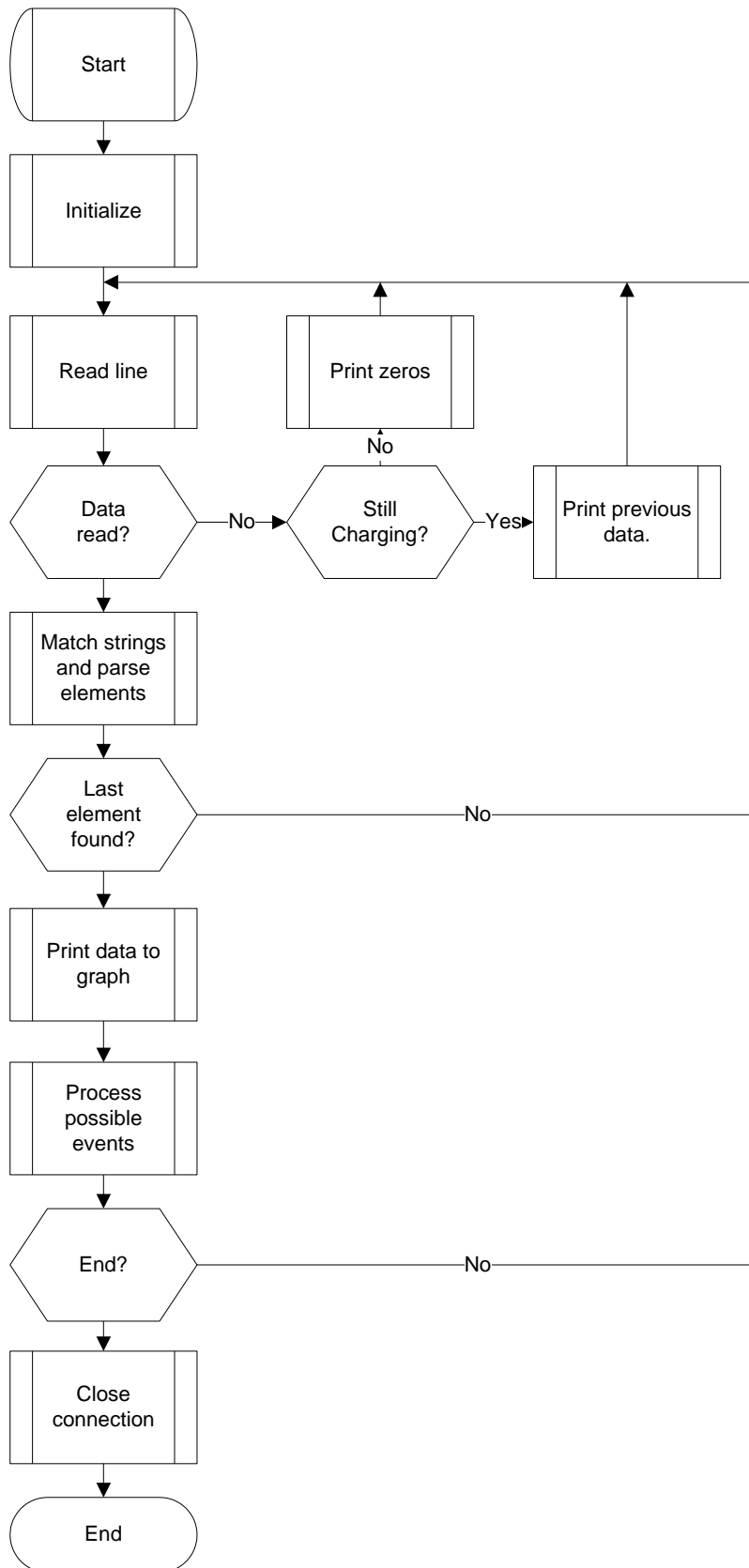


FIGURE 25. Flowchart of the Avid software.

The user interface is designed to give one kind of data for the user to see at a time. The GUI is divided into four tabs according to the type of data. These tabs are general, array, graph and about. The General tab (FIGURE 26) shows the measured data as text and allows the user to control the transmitter and set serial connection parameters. The general tab has controls for transmitted power P_{PT} offset, FOD threshold, open loop and closed loop switch and open controls. The open loop controls are visible only when the transmitter is set to open loop mode. In addition all controls can also be set as text in the command textbox.

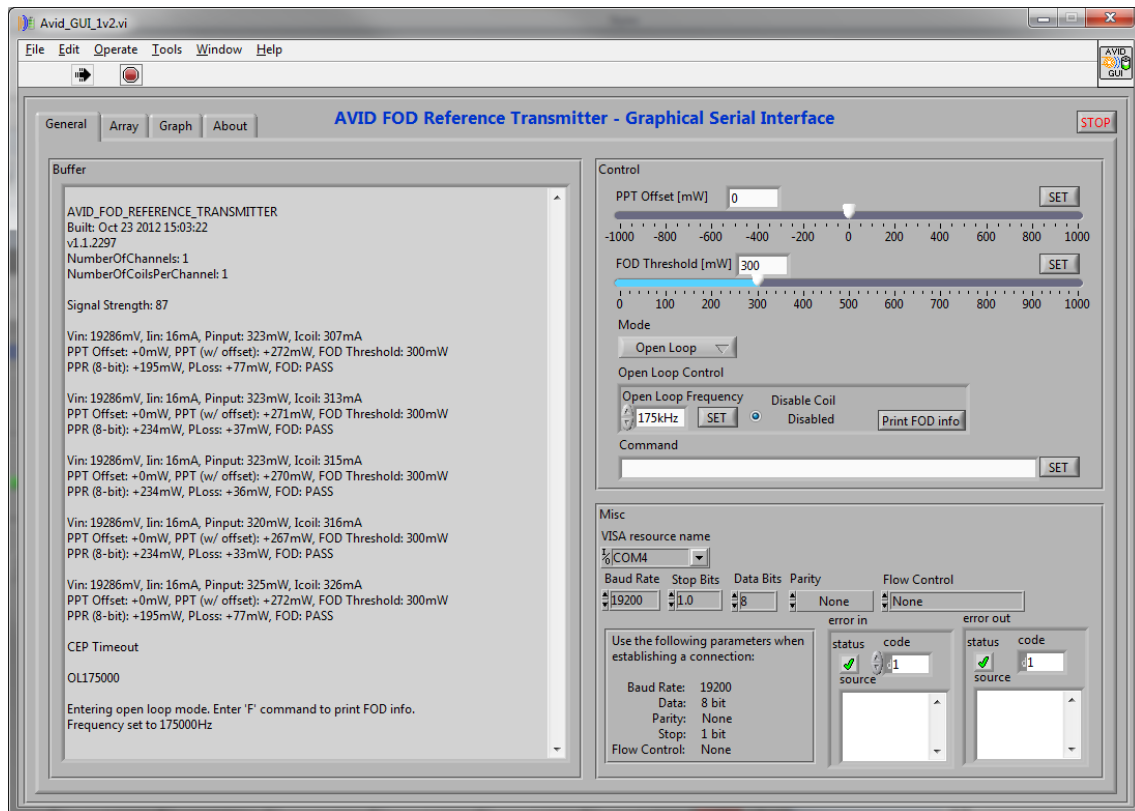


FIGURE 26. General tab with open loop controls.

In the Array tab (FIGURE 27) the user can browse the measured values in array. The array tab was created to give the user a data log where the previous measured values are logged. In addition the user can clear arrays during running the program. The cur-

rent values are used for generate XY Graph to the Graph tab and colour indicators are placed to detect the right value from the graph more easily.

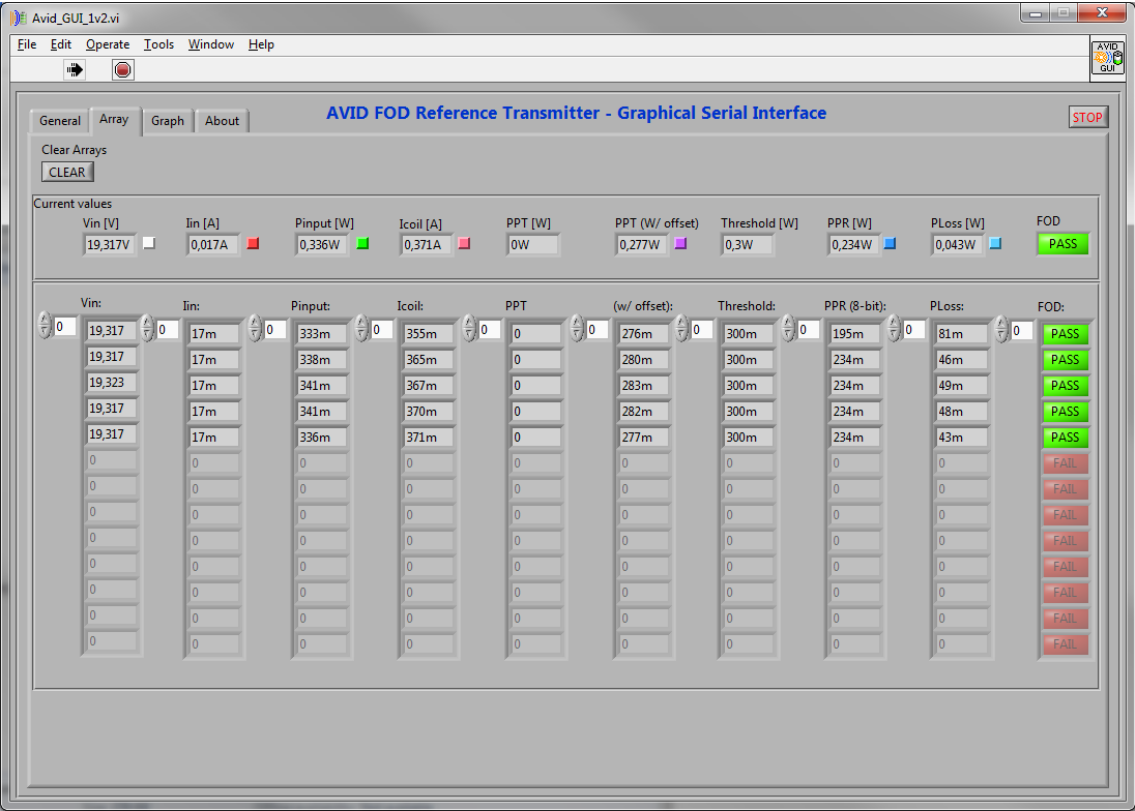


FIGURE 27. The array tab.

XY-Graph where the measured data is logged graphically is shown in the Graph tab (FIGURE 28). The XY-Graph is a very effective way to log data more demonstratively because it allows more data to be seen at one time. The user can choose which values are shown and can export data from a graph as simplified image or as Excel-table. The THRESHOLD and PPT OFFSET cursors follow the values that the user has set in the general tab.

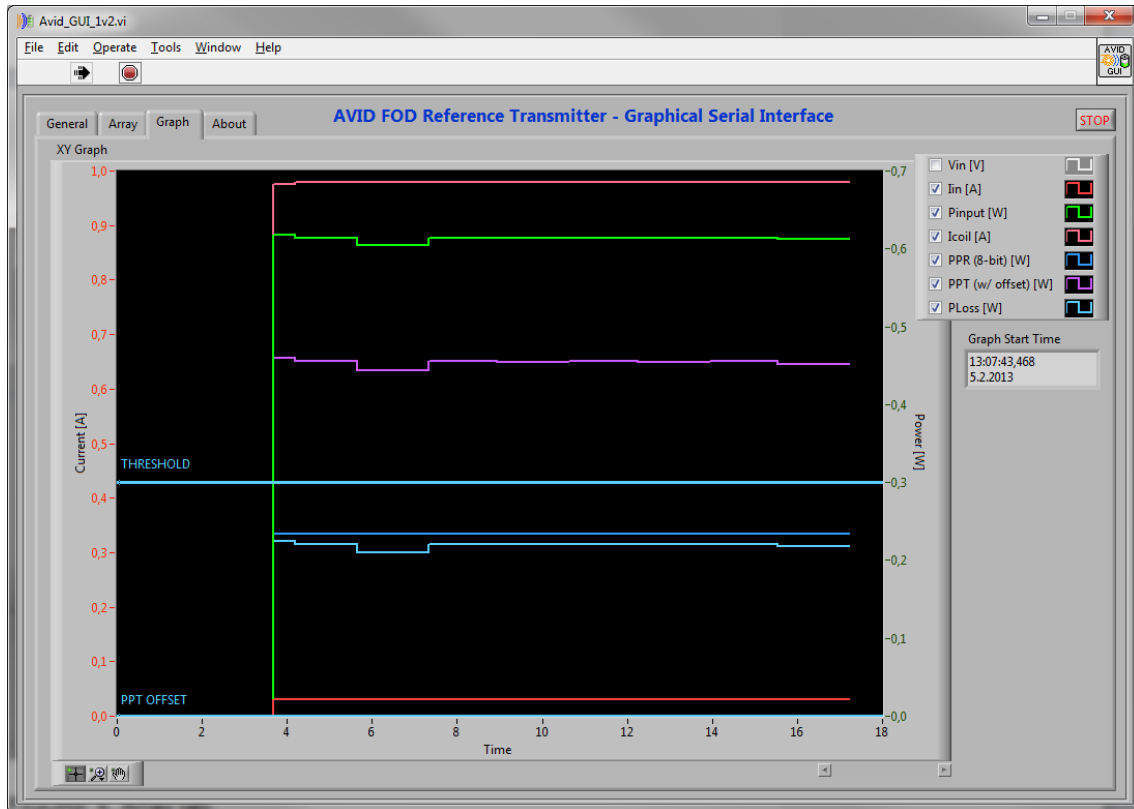


FIGURE 28. Graph tab.

7.1.2 Executable avid software

In this case, the executable software means that the software can be executed without LabVIEW. Still, the executable software needs LabVIEW runtime engine which is available for free downloading. The executable Avid software was created for computers which have no LabVIEW licence. The executable software was shared globally with employees of ST-Ericsson who use the Avid FOR reference transmitter. In addition, a user guide for this software was created and can be seen in appendix 1.

7.1.3 Adding Avid software to Application GUI

After Avid serial interface was ready, it was added to the Application GUI which is examined in section 5.1.7. The new tab for avid software was created and almost all the information of the Avid graphical serial interface was crammed into one tab. The Avid tab is shown in FIGURE 29.

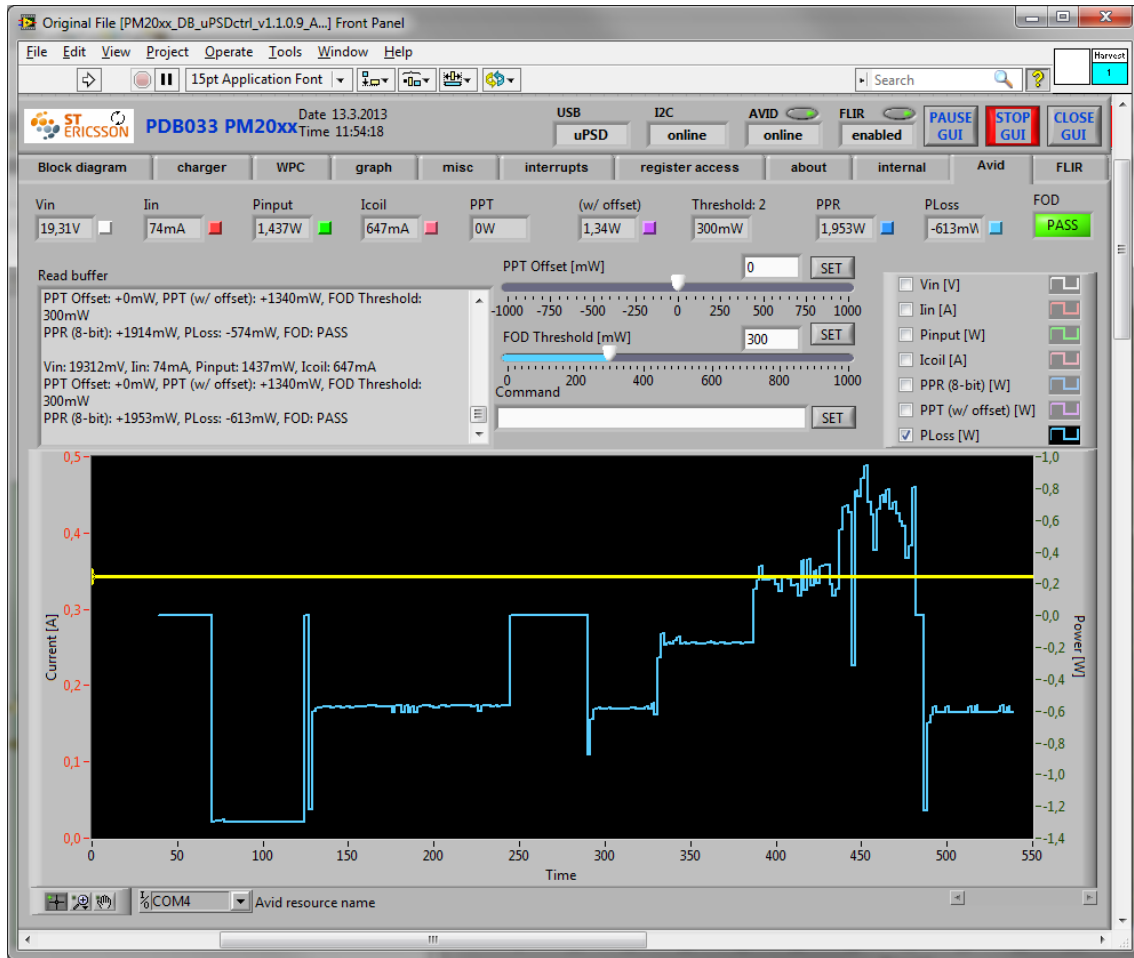


FIGURE 29. The Avid tab of Application GUI.

Adding the Avid software to the Application software was not as easy as imagined, because the Application GUI reads ADC measurements nearly a hundred times a second and the Avid transmitter sends data about every two seconds. Thus, running both of the software in the same thread was next to impossible or simply the scheduling would be difficult. Because there are no parameters that the Application GUI and the Avid software need to share, they could be run in their own thread.

FIGURE 30 illustrates the threading method that is used in this case. The threading method is based on notifications. When the software starts, it creates a new notification before threads are started. Also other initializations such as connections, graph timestamps and etc., can be initialized before the threads are started. After the threads are started they run individually until the main thread, in this case the Applica-

tion GUI thread, is closed. After that, the notification is sent and the second thread gets a stop signal. Finally, the errors of both threads are merged and for example the connections can be closed.

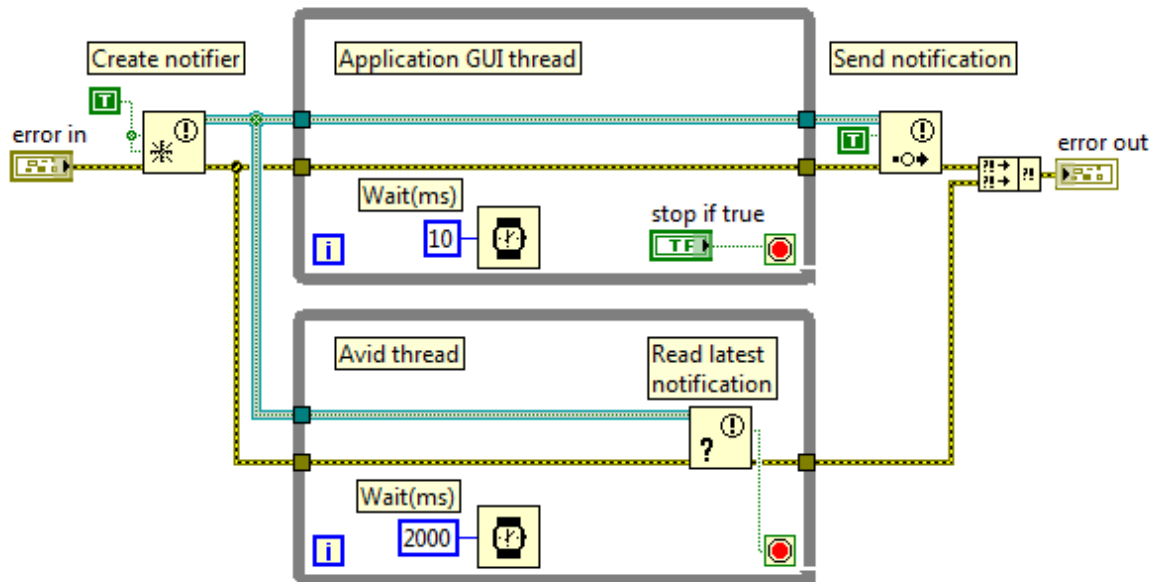


FIGURE 30. Threading example.

7.2 Infrared Camera Software

In the third phase of this thesis the software for the infrared camera was developed. The development was started by creating simplified development modules for the FLIR A325sc camera using the FLIR ThermoVision LabVIEW Toolkit SubVIs. Secondly the graphical user interface for the infrared camera was created by using simplified development modules. As the Avid software was added to the Application GUI, also the same was done for the camera software.

7.2.1 Development SubVIs for FLIR A325sc infrared camera

The development SubVIs were created to make camera software development faster and easier. Thus, the SubVIs were made simple and only the necessary controls were left visible. The SubVIs might not work with other camera models due to simplifications. In addition, modifications to the FLIR ThermoVision LabView Toolkit SubVIs were made to get full speed image grabbing. The modifications are presented later in this section. The created SubVis are listed below in table 1. These SubVIs will be also used for other test software development by the characterization team.

TABLE 1. SubVIs and descriptions.

SubVI name	Description
FLIR_A325_init.vi	Initialize infrared camera connection.
FLIR_A325_close.vi	Close the infrared camera connection.
FLIR_A325_Init_imagesize.vi	Initialize image size and remove borders.
FLIR_A325_get_image.vi	Grab thermal image from camera in RAW and image format.
FLIR_A325_autofocus.vi	Focus camera automatically.
FLIR_A325_calibrate.vi	Compares and calculates emissivity of given area.
FLIR_A325_set_framerate.vi	Set image grabbing speed and read camera parameters.
FLIR_A325_ROI_to_minmax_temp.vi	Converts selected ROI to minimal and maximal temperature.
FLIR_A325_Selection_to_minmax_temp.vi	Converts selected area to minimal and maximal temperature.

The initializing SubVIs needs to be run every time when the camera connection is started. Otherwise, the close SubVI is needed to close connections. The image size initializing is also included to the initializing SubVI, because the image size is also set only once. The inputs and outputs of the initializing and closing are presented in FIGURE 31.

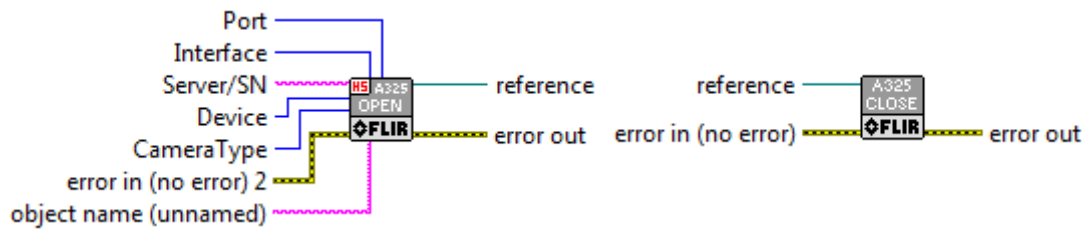


FIGURE 31. FLIR A325 initializing and closing SubVI.

The image grabbing SubVI (FIGURE 32) is designed to read images from the camera one by one. It also supports to open images to external windows for example to check the alignment of the camera. Because the infrared camera supports 60 Hz image grabbing, the SubVI of the FLIR ThermoVision LabView Toolkit has been optimized for high speed image grabbing. The problem was that the SubVI of the FLIR Toolkit used one module of National Instruments (NI) Vision Development Module which is used to remove the borders of image. The NI Vision Development Module is an expensive software and would not have been used any more than this one image border size SubVI. Therefore, the solution to avoid this expensive module was that the new copy of the FLIR Toolkit image grabber SubVI was created and the expensive module was disabled. After that, the image borders were removed in initializing SubVI while the size of the image is defined. The image initializing SubVI is illustrated in FIGURE 33.

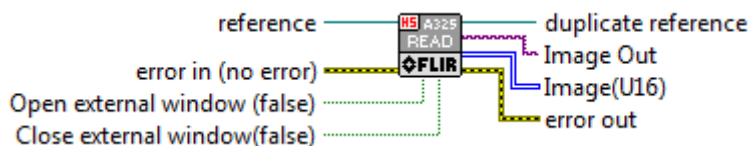


FIGURE 32. FLIR A325 image grabbing SubVI.

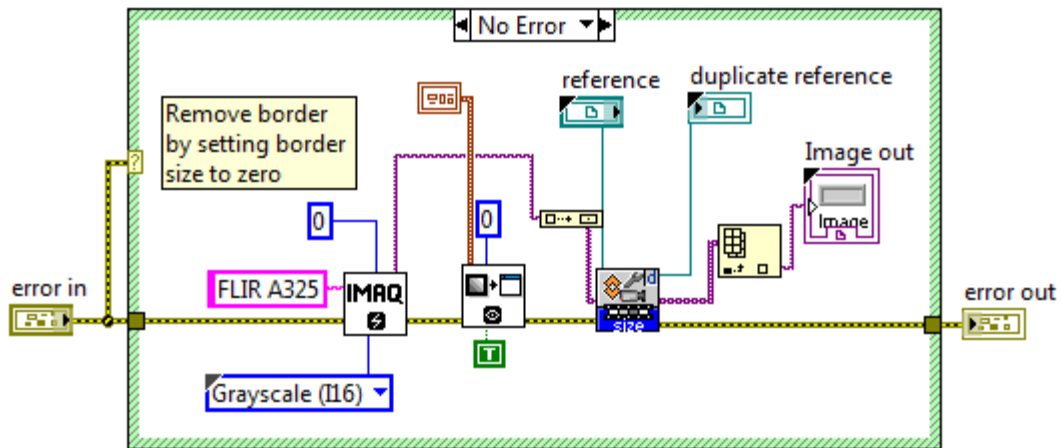


FIGURE 33. FLIR A325 Initialize image size SubVI.

When the raw data of the image is got, it could be converted to temperature by one pixel at a time. In this case, because the target of the measurement is not one pixel but a larger area, the selection to temperature SubVI was created. The module converts the selected area to minimum and maximum temperature in Celsius. The region of interest (ROI) to temperature SubVI makes also the same conversion but in a slightly different format. The methods how to select areas or ROIs are examined in section 7.2.2. The conversion modules are seen in FIGURE 34

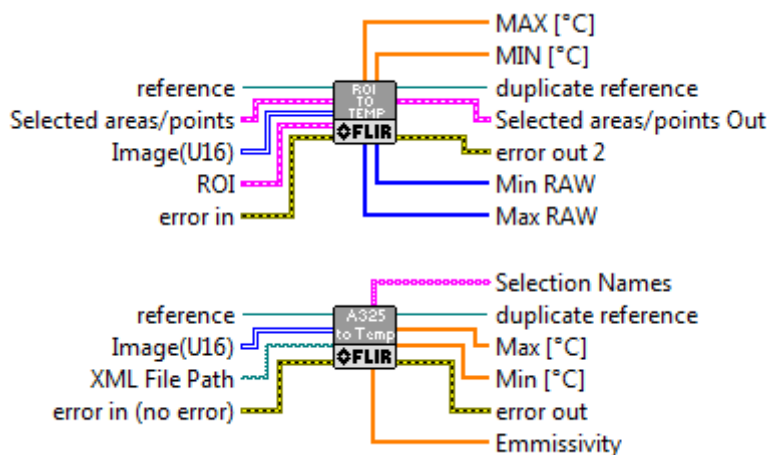


FIGURE 34. Temperature conversion SubVIs.

The selection to temperature SubVI was designed for situations where the measurable area is selected once before the test and the ROI to temperature SubVI was designed for situations where it is needed to change the measurable area while the program is running e.g. GUI. Both of those SubVIs can convert multiple areas at a time. FIGURE 35 illustrates an example of how these modules can be used in test software.

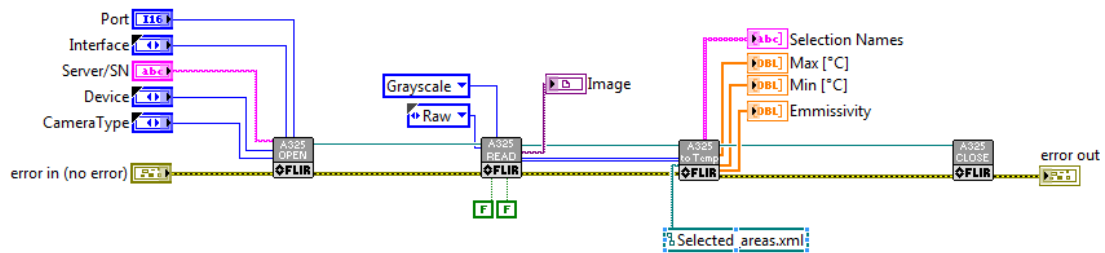


FIGURE 35. Use case example of the development modules.

7.2.2 Graphical interface to select and calibrate measurable area

The graphical user interface for a camera was created to select measurable areas, focus the camera before testing and calibrate the emissivity of measurable area. Selecting the area is implemented by using image processing tools of National Instruments image acquisition (IMAQ) module. The IMAQ allows drawing and selecting multiple areas and points on the image. The selected areas or points are referred to region of interest (ROI). The IMAQ module gives the ROI as cluster of variables which includes all data of the selected area such as XY-coordinates and type of ROI. There are several types of ROI, but only spot and square ROIs are enabled in this GUI. The GUI is shown in FIGURE 36.

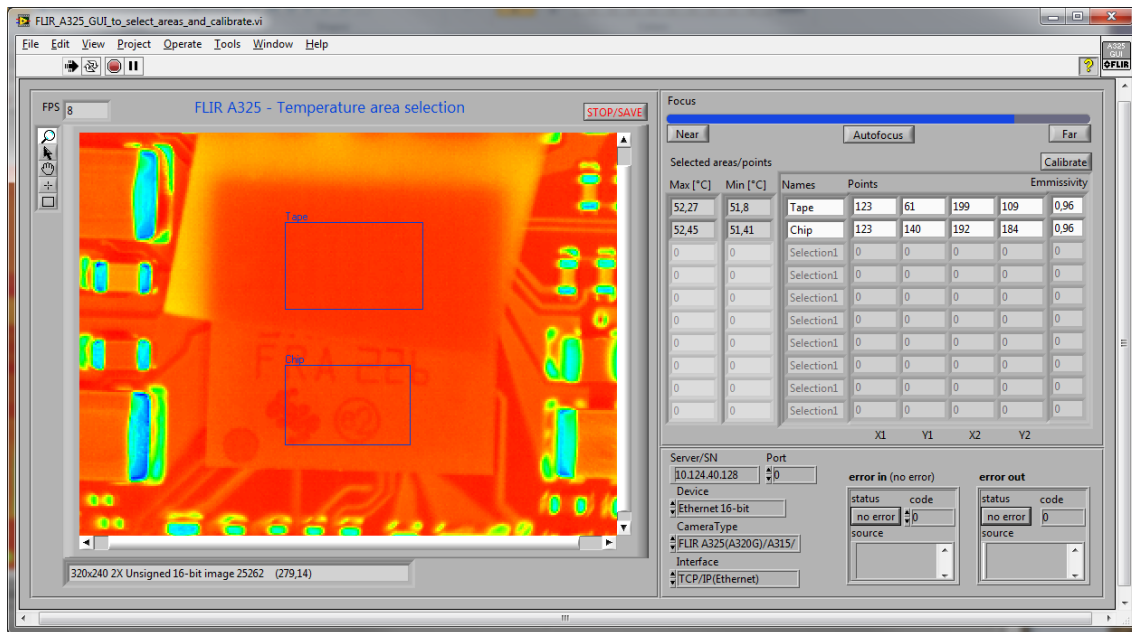


FIGURE 36. IR Camera GUI.

The structure of the IR camera GUI is illustrated in FIGURE 37. The main structure of this software is very simple; the image is read and the selected areas are converted to minimum and maximum temperature. As FIGURE 37 shows, other functionalities such as focusing and calibration are implemented by using events. At the end, when the GUI is stopped, the program asks for the path to the folder where selected areas will be saved. It saves the data of the areas to XML file. The XML file can be used for testing where the measurable area is selected once before testing as was mentioned earlier. The XML file is created programmatically and cannot be modified manually, so it has been left without analysis in this thesis.

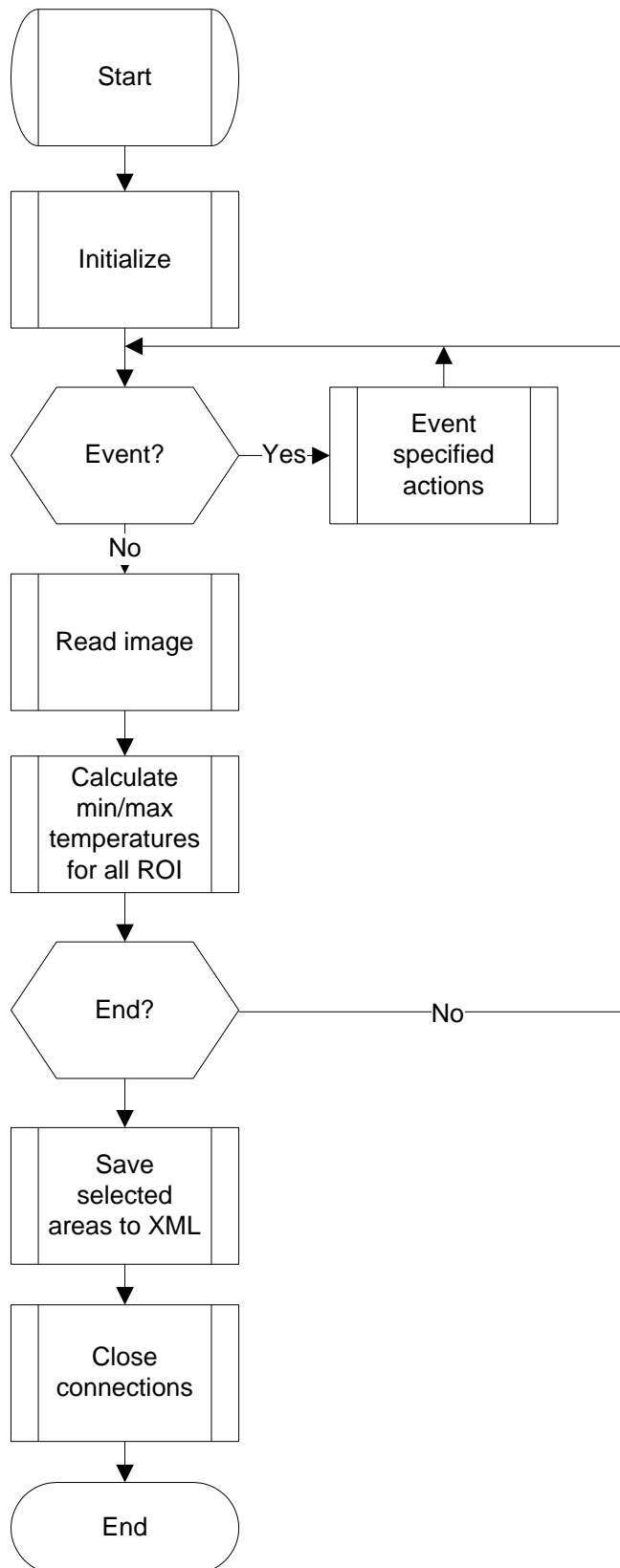


FIGURE 37. Flowchart of the camera software.

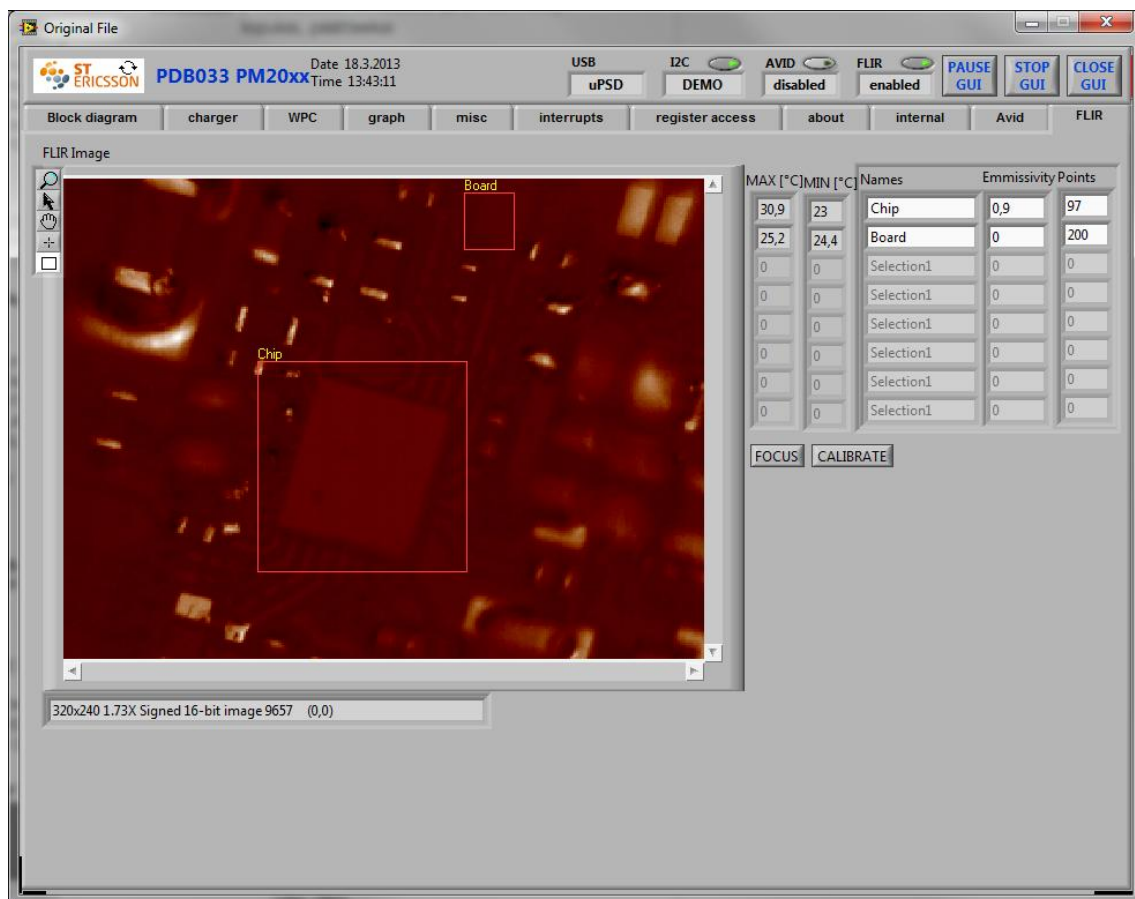


FIGURE 39. FLIR tab of the Application GUI.

8 MEASUREMENTS

The measurements of this thesis are examined in this section. The accurate results of IC measurements are not presented in this document and are not relevant for this thesis. For this reason, only what can be measured in this environment is presented and the results of IC measurements are ignored.

8.1 Emissivity test

When the IR camera was taken under investigation, the emissivity of surfaces came up very soon. The IC chip on the PCB showed much warmer than the other components. A shiny surface of the IC chip was the reason that caused distortion. Therefore, the calibration of the emissivity was needed. The methods of calibration are presented in section 4.2.

Firstly, the reference surface with a known emissivity had to be chosen. The user manual of FLIR IP Config program, that was used to configure connection parameters, contains a table of several materials with known emissivity. The electrical tape from 3M has been listed on this table. The emissivity of the type 88 3M electrical tapes is 0.96.

Secondly, the temperatures of the surfaces needed to be raised about 20 °C above the room temperature. A heating plate was created for this purpose. The heating plate was created from a piece of a stripboard by soldering strips to one long strip. The stripboard is one type of electronics prototyping board. The heating plate was used by supplying it with 6 V input voltage and input current was limited to 2 A. With these parameters the heating plate warmed up to 55 °C. The chip board was placed on top of the heating plate and the calibration could begin. The heating plate is shown in FIGURE 40.

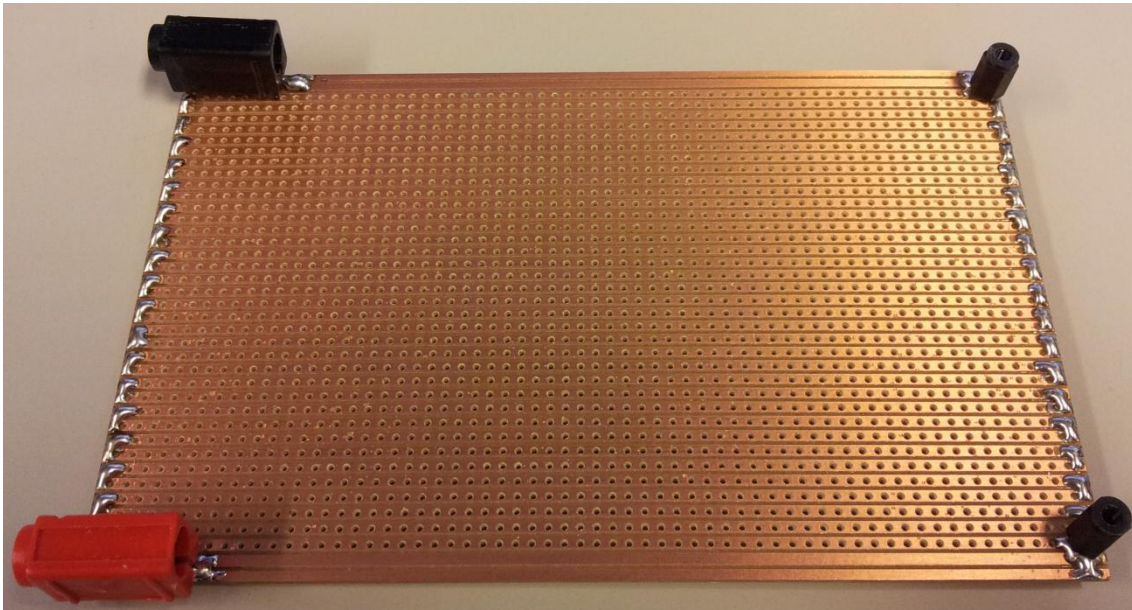


FIGURE 40. The heating plate (bottom side).

The emissivity was calibrated by placing the chip board on to the heating plate and waiting for the chip board to reach the heat of 20 °C above room temperature. A piece of electrical tape with 0,96 emissivity was placed on to the IC and the tape was used as a reference surface. One of the measurements is presented in FIGURE 41.

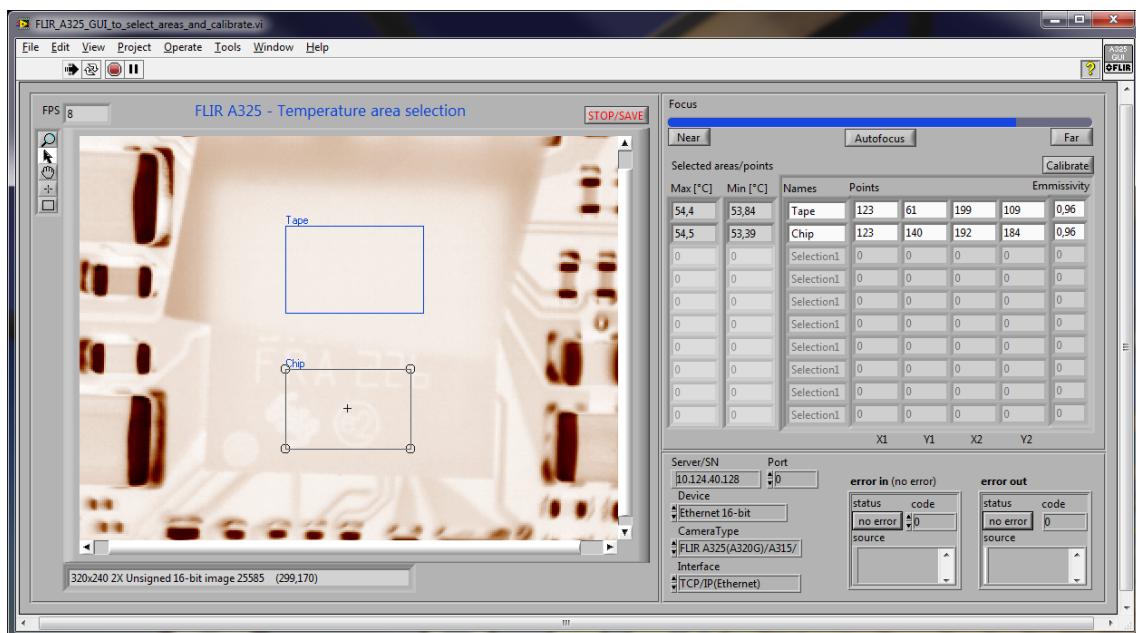


FIGURE 41. Emissivity measurement.

In case of very shiny surfaces, calibration of the emissivity is not reliable in temperatures under 100 °C (10). In those cases, the material with known emissivity should be left on the shiny surfaces. Therefore, alternative reference surfaces were tested to find a material which would have better thermal properties. Thermal grease, which is used between processor and heat sink, was found to have the same emissivity than the electrical tape. With the thermal grease the fast changes in temperature would appear better. Thus, the thermal grease would be a better selection.

8.2 Wireless charging IC test

The measurements were done with wireless charging IC of ST-Ericsson. The measurable IC was an ST-Ericsson's PowerHUB™ PM2020. The PM2020 chip is a fully integrated wireless charging solution including Wireless Power Consortium Compliant Protocol and DC/DC battery charging Function. The key features of the PM2020 are reactive and resistive modulation, it supports rectification up to 9V and includes CCCV battery charging algorithm. A block diagram of the PM2020 is illustrated in FIGURE 42. (13.)

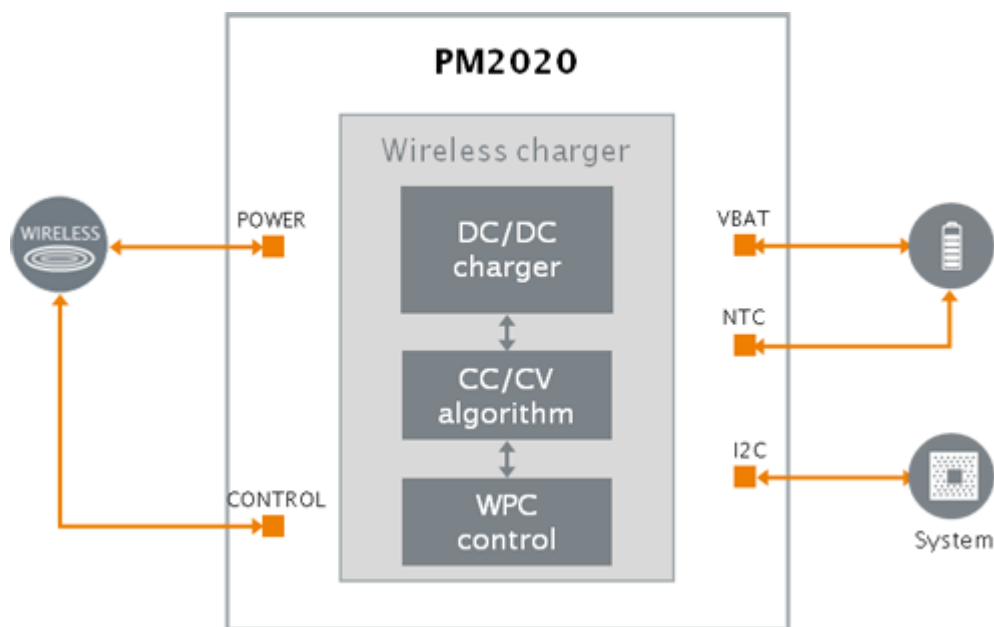


FIGURE 42. Block diagram of the PM2020 (13).

The electrical parameters that can be measured with this environment are for example, input voltage, input current, output voltage, output current, temperatures, registers of the IC and several other voltages. In addition, the environment is suitable to test general functionality and debugging. Also information from Avid transmitter makes testing more comprehensive. Several examples of the measurements are examined in the following sections.

8.2.1 Output current versus temperature

As mentioned in section 2.3 the Lithium based batteries are widely used in portable devices today. While charging these batteries, appropriate constraints must be followed to control charging current and voltage precisely. The charging voltage and current combination depend generally on battery temperature and battery voltage. The over-heating in charging IC may result in various defects such as accelerated aging of the battery or even physical damages of battery which can cause end-user injuries. Therefore, the temperature measurements are very important to ensure safe operation. (11.)

The output current is a frequently measured parameter which indicates the amount of current going to the battery. In this case, the effect between the output current and temperature of the IC was measured. In addition, the temperature between the IC chip and chip board was measured, when thermal conduction properties of the chip board could be detected. FIGURE 43 shows how the temperature raised when output current was increased. These tests were measured so that the battery was replaced by a DC-supply, when battery voltage is constant and the parameters are the same for all tests.



FIGURE 43. Output current versus temperatures.

The thermal image of the measurable IC tells invaluable information about the thermal properties of the IC and the chip board. The image shows how and where the heat conducts. See FIGURE 44.

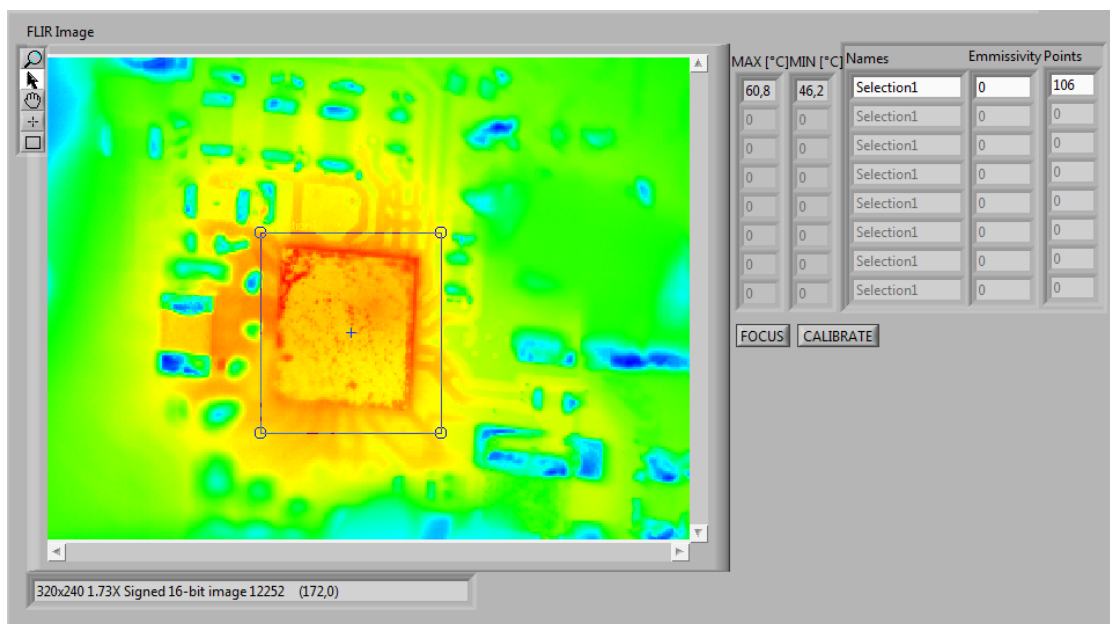


FIGURE 44. Heat conduction.

8.2.2 Overall efficiency test

The overall efficiency of the wireless power transfer was measured and calculated so that the output current was measured by supplying battery voltage constantly from DC supply. An output power was calculated from output current and output voltage which can be seen in FIGURE 45. An input power could be read from the AVID tab of the Application GUI (FIGURE 46). Thus, the overall efficiency could be calculated by using these figures. The example measurement of the overall efficiency is shown in FIGURE 45 and FIGURE 46.

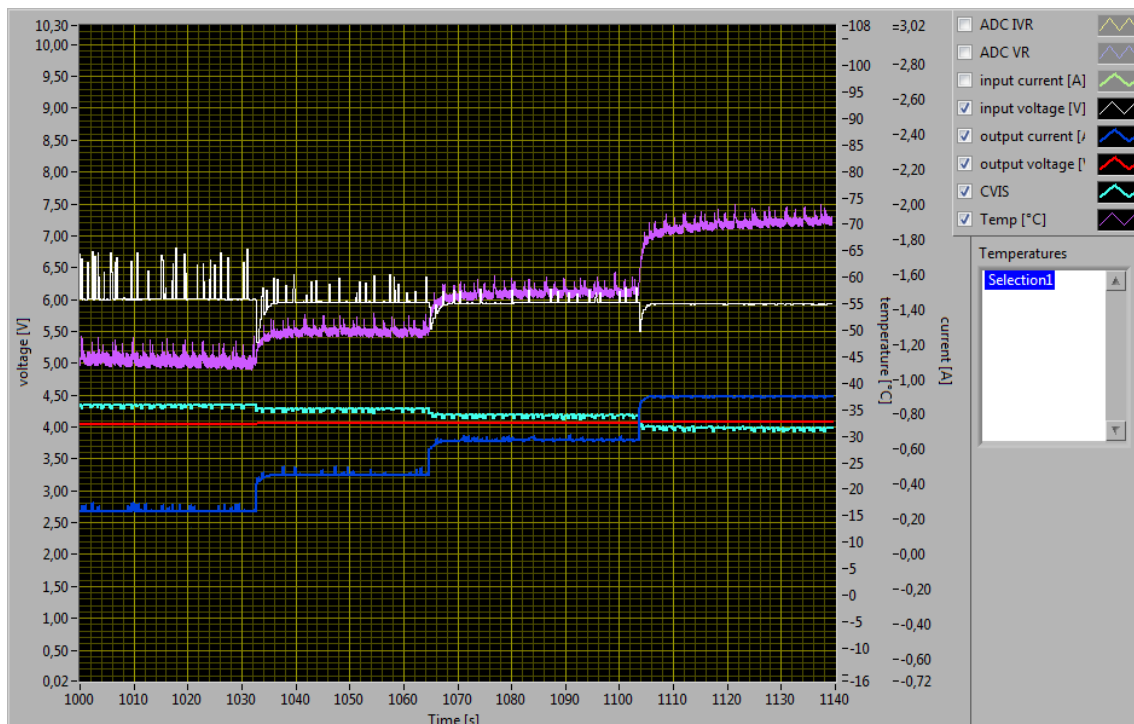


FIGURE 45. Output power of the overall efficiency test.

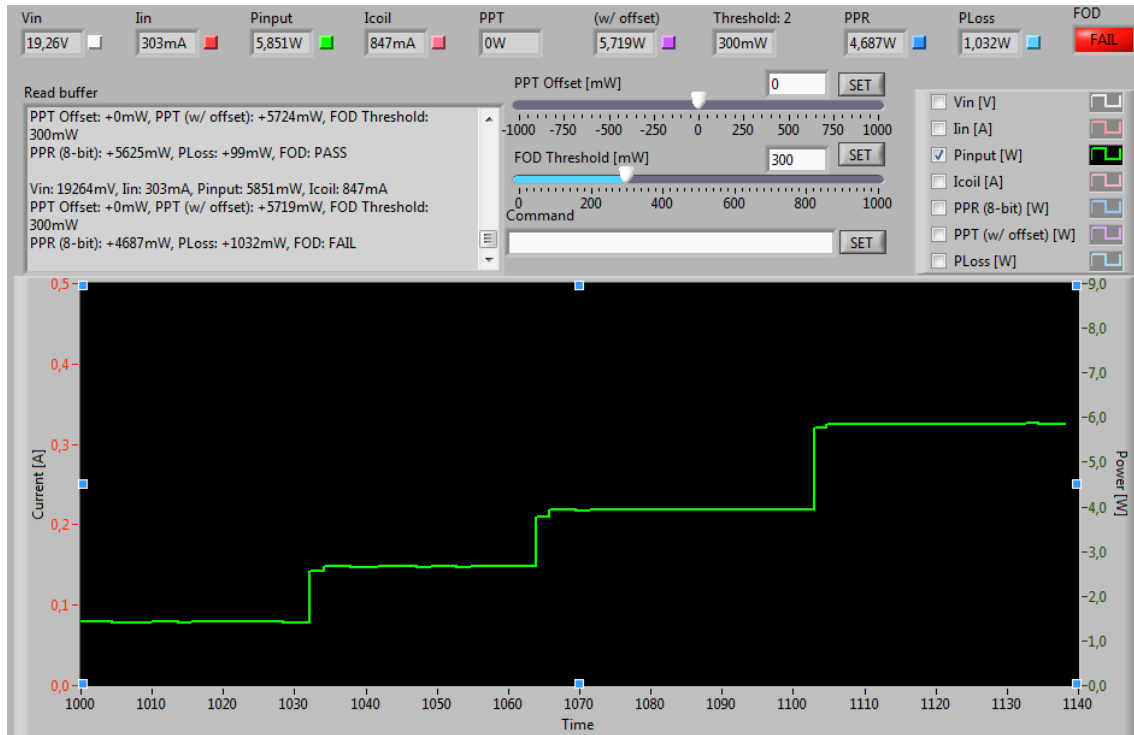


FIGURE 46. Input power of the overall efficiency test.

8.2.3 Battery charging cycle test

One of the main goals of this thesis was to be able to measure the full charging cycle with a real battery. As mentioned in section 2.3, the charge cycle can be broken up into four stages; trickle charge a.k.a pre charge, constant current charge, constant voltage charge and charge termination. The scope of the battery charging cycle test was that all of these stages can be seen in this environment.

The first problem arose when the stage of the pre charge was attempted to be measured, because the battery which was used in this test cannot be discharged under 2,3 V due to a safety switch inside the battery. The switch disconnects the poles of the battery when voltage goes under 2,3 V. Furthermore, the pre charge threshold is 2,5 V and charging between 2,3 V and 2,5 V is very short action. The pre charge was still measured and is seen in FIGURE 47.

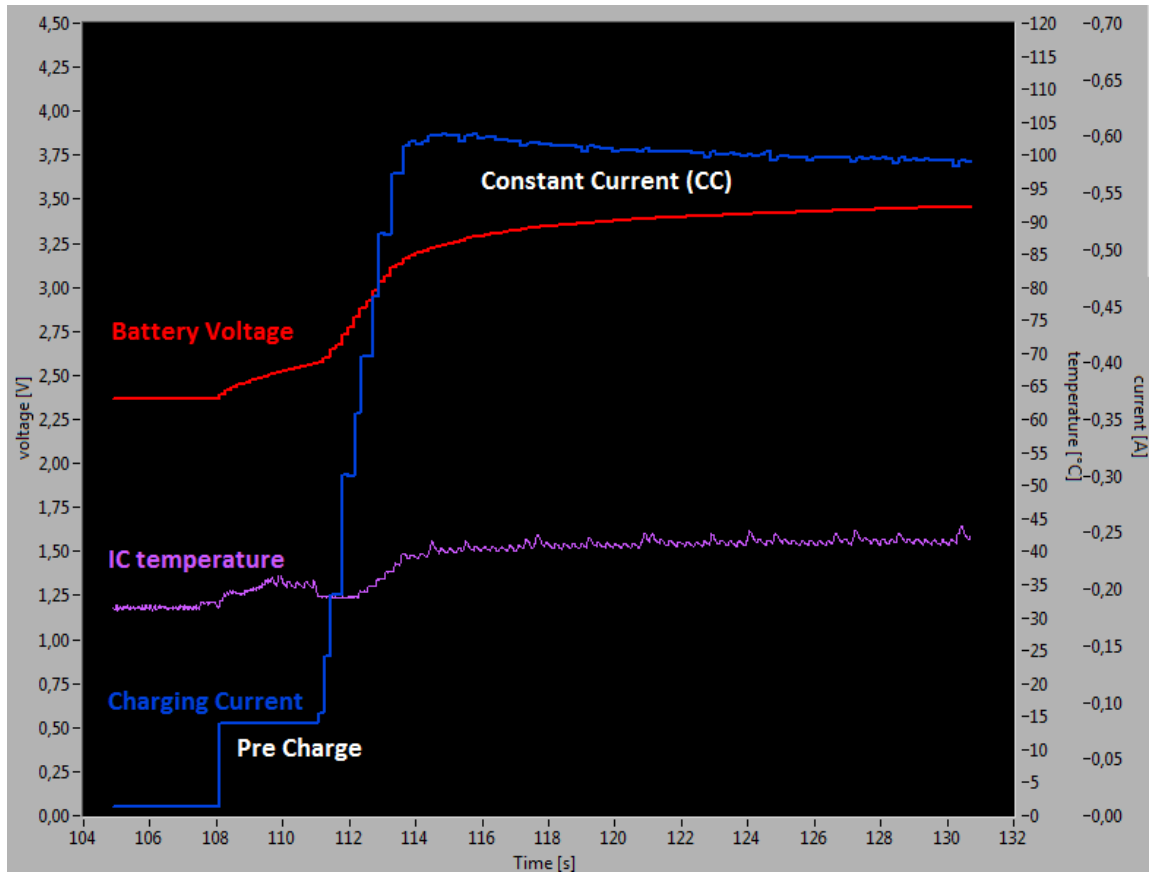


FIGURE 47. Pre charge.

The other stages of battery charging could be measured without problem. The only limiting factor was that battery charging time was a long time. Therefore a threshold, when charging is terminated, was raised from 50 mA to 250 mA. This means that charging is terminated when charging current decreases under 250 mA. Also the constant voltage of the CCCV algorithm was set to 4.0 V to make stages of charging little shorter. The full charging cycle of battery is presented in FIGURE 48.

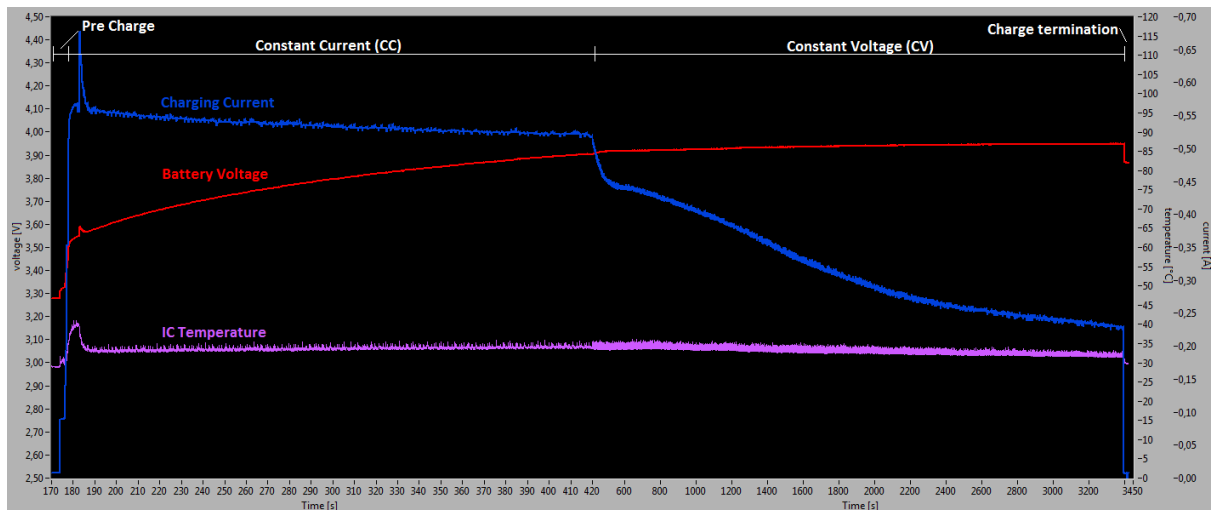


FIGURE 48. Fully charging cycle (notice fixed time scale).

9 CONCLUSION

The main objective of this thesis was to create a test environment for wireless power transfer. The environment was supposed to be versatile and practical where the functionality of the wireless charger IC can be measured and the results can be exported easily and in understandable form. The requirements, which were set at the beginning of this thesis, can be found in Appendix 2.

The results of this thesis can be divided to three parts: the Avid FOD reference transmitter GUI, the infrared camera GUI and the environment where those two GUIs have been included.

Implementation of the Avid FOD reference transmitter GUI was a great success and all the objectives which had been set were implemented on schedule. Moreover, the AVID FOD reference transmitter GUI was shared globally inside the company and so far no negative feedback has been received. Nevertheless, the Avid GUI could be improved by adding more properties to configure how the data is plotted.

The only objective that had been set for the IR camera software was that it should work with FLIR ThermoVision LabVIEW Toolkit. This objective was reached, and even exceeded. However, the time that has been spent with the camera does not correlate with the results, because the first camera which was used was broken and it took a lot of time to verify and prove the fault to the importer of the camera. After a new functional camera was received, there was not much time left. However, the IR camera GUI worked really well and had the properties for reliable temperature measurement. Still, there are a lot of features that could have been implemented to the IR camera GUI. For example, ability to record thermal image stream would be a very useful feature.

The implementation or rather integration of the whole environment was the most difficult part of this thesis. Adding the three kind of user interfaces to one, caused a lot of challenges. The worst challenge was caused by different speeds of the GUIs. As mentioned in section 7.2.3, the speed of the IR camera was selected to determine the

speed of the environment. Last, the whole environment was implemented and all the needed parameters and graphs were measured.

To conclude, this thesis gives invaluable information about the wireless power transfer, testing the wireless charging IC, standard of wireless power transfer, how to create graphical user interfaces, how the IR camera works, how the emissivity of surface effects temperature measurement and many other interesting information. For me this thesis was a great opportunity to see what the real work is and how tight the schedules are often set. This thesis gives a great starting point to adapt to working life.

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AVID FOD reference transmitter Graphical Serial Interface

Joni Närhi



AVID Graphical Serial Interface

- What does it do?
 - Gives and converts serial text data of AVID FOD reference transmitter in many format such as
 - tables
 - variables
 - Graphs
 - Logs data for more detailed examination
 - Allows user to control transmitter graphically
- Why the AVID Graphical Serial Interface was created?
 - To get more easily handle and editable data for user
 - To make working with Avid more efficient
 - To make FOD calibration and general debugging easier

Introduction

- Paths where to find AVID guides and software:
 - Software:
 -
- Driver Installation Guide:
 -
- User Guide:
 -

3

3/13/2013



SW Installation

- **NOTE! In order to be able to run LabView exe-files you need to install LabView 2011 Run-Time Engine and NI-VISA Run-Time Engine, see web pages:**
 - <http://joule.ni.com/nidu/cds/view/p/id/2534/lanq/en>
 - <http://joule.ni.com/nidu/cds/view/p/id/2662/lanq/en>

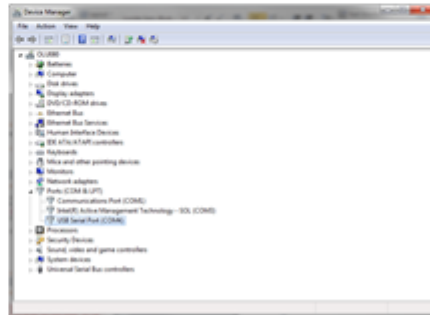
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3/13/2013



AVID FOD Reference Transmitter Setup

- Connect device to a spare USB port on your PC
- Install virtual COM-port drivers (see drivers installation guide)
- Check which COM-PORT number was selected for AVID
 - System settings (Windows+Pause) ->
 - Device Manager (Hardware tab on XP) ->
 - Ports (COM & LPT)
 - USB Serial Port (COM?)
- Run AVID_Serial_GUI_1 V?.exe
 - Stop running and select right COM-port
 - Run again



5

3/13/2013



6

3/13/2013



Avid Graphical Serial Interface

- General tab
 - Text data
 - Controls
 - Settings and errors



Hint! Press CTRL+H to show labview context help.

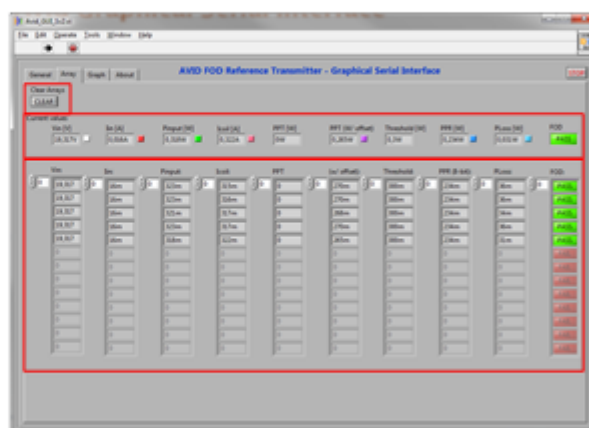
7

3/13/2013



Avid Graphical Serial Interface

- Array tab
 - Current values
 - Logged values
 - Clear Arrays



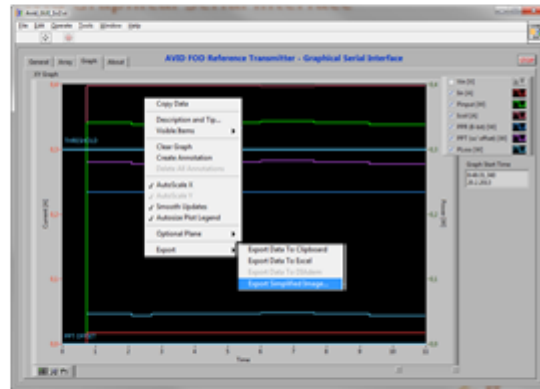
8

3/13/2013



Avid Graphical Serial Interface

- Graph tab
 - Logs data graphically
- To save graph click right mouse button on graph
 - select "Export Simplified Image..."
- Or press "Print Screen"



THANK YOU

Test Environment for Wireless Power Transfer

Joni Närhi
2013-01-04



Test Environment for Wireless Power Transfer

- Target is to join already available application board and characterization chipboard to one system for application/customer level evaluation
- The system can be used as a "turnkey solution" for application/validation purposes.
 - HW:
 - Setup Application Board which already contain Application CB, Microcontroller and RX-module.
 - Add Characterization Chipboard to Application board with "jumper wire".
 - SW:
 - Labview SW (Graphical User Interface) for controlling of Stromboli wireless charging IC and Avid wireless charging transmitter.
 - LabVIEW SW for Controlling Infrared Camera and taking measurements in sync with charging
 - Measurements
 - Measuring whole battery charging cycle automatically (including temperature).
 - FOD (Foreign Object Detection) Calibration automatically using LabVIEW or any other manufacturer supported SW

2 (3)

