Project Plan

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PROJECT IDENTITY

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Linköping University, Dept. of Electrical Engineering (ISY)

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Document History

Version	Date	Changes	Sign	Reviewed
0.1	2016-09-15	First draft.	LF	KG,LF
0.2	2016-09-21	Fixed CM:s comments.	LF	KG,LF
1.0	2016-09-23	Updated version and history.	LF	KG,LF

1 Customer

The customer, Mikael Olofsson has ordered a Massive Audio Beamformer (MAB). It is a product that can beamform audio using a large number of combined loudspeakers and microphones (L/M unit). Mikael has also provided the design for the hardware. The project will assemble the hardware, design and implement software to control it, test it and finally deliver it to the customer. This document describes how the project will be run by the group. As a customer Mikael can be contacted at: mikael.olofsson@liu.se.

1.1 Definitions

The abbreviations used in this document are specified in Table 1

Table 1: Abbreviations used in the document

Abbreviation	Definition
A/D	Analog to digital
API	Application programming interface
D/A	Digital to analog
GUI	Graphical user interface
L/M	Loudspeaker/microphone unit
MAB	Massive Audio Beamformer
MIMO	Multiple input multiple output

2 Overview of the Project

This chapter describes the goals, deliverables and limitations of the project.

2.1 Purpose and goal

The first part of the goals is to deliver a MAB that can demonstrate massive Multiple Input Multiple Output (MIMO). It will demonstrate massive MIMO by beamforming audio to two different locations in a room. The customer also wants a MAB that can be used in other projects for implementing different kinds of demonstrations.

A similar project was run in 2014 where a MAB with 16 L/M units was constructed from off-the-shelf loudspeakers. [2] This was used for other projects in 2015. The goal for the project this year is to create a new, bigger and better MAB.

The second part of the goals is simply to educate the project group on a few subjects such as massive MIMO, communication systems, electronics, project management, collaboration and problem solving.

2.2 Deliveries

Apart from a product that fullfills the Requirement Specification, the deliverables specified in Table 2 should be delivered to the customer. The due dates in Table 2 are described in Table 3.

Table 2: Deliverables

Name	Purpose	Due date	Due form	Approved by
Documents				
Requirement Specification	Specifies all features and interfaces	TG2	pdf	KG
System Design Sketch	Initial sketch of the system	TG2	pdf	KG
Project Plan	How the project will be executed	TG2	pdf	KG
Time Plan	Schedule of all activities	TG2	pdf	KG
Design Specification	Detailed description of the planned system	TG3	pdf	KG
Test Plan	Describes testing of product	TG3	pdf	KG
Test Protocols	Protocols for each test	TG5	pdf	KG
User Manual	Easy-to-understand description of how to use product	TG5	pdf	KG
Technical Report	Explains how product works in detail	TG6	pdf	KG
Afterstudy	Retrospective discussion about the project	TG6	pdf	KG
Poster	Presentation of project	TG6	pdf	KG
Meeting Protocols	Protocols for each executive meeting	TG6	pdf	KG
Protocols from Milestones	Protocols from meetings where milestone fullfilment is evaluated	TG6	pdf	KG
Reports				
Weekly report	Report of progress, plans and problems	Weekly, Mon.12.00	email	LF
Individual and Collective Time Reports	Weekly reports about who has spent time on what	Weekly, Mon.12.00	ods	LF
Other				
Project Web Page	Presentation of project	TG6	webpage	LF
Oral Presentation	Present to the Communication Systems Group	Project conference	orally	LF

Table 3: Description of due dates

Description	Date	Deliverables
TG2	23/9	Requirement Specification, System Design Sketch, Project Plan
TG3	10/10	Design Specification, Test Plan
TG5	12/12	Product, Test Protocols, User Manuals
TG6	15/12	Technical Report, Afterstudy, Poster, Webpage
Project Conference	20/12	Oral Presentation

3 Phase Plan

The time period that the project stretches is divided into 3 phases according to the LIPS model [1]. These periods are called: before, during and after. This chapter gives a brief description of the activities to be performed during the

different phases. Table 4 gives a rough overview of when different activities start and end. An x marks that the activity is active during that time.

Table 4: Overview of phases

Activity		TG2		TG3		TG5		TG6	
Req.spec, Des.sketch, Proj.plan	x	x							
Assembly, programming			x	x	x	x			
Des.schematic, Test Plan			x	x					
Technical Report				x	x	x			
Afterstudy, Poster, Webpage						x	x	x	
Prepare presentation								x	x

3.1 Before

This is the first phase where the group is formed, they decide how to work together and plan the project. The Requirement Specification, Design Sketch, Project Plan and Time Plan are produced here and presented at tollgate 2, which concludes the before phase.

3.2 During

In this phase, the project group carries out the project according to the Project Plan. The first step is to define the product in a Design Specification. A Test Plan is also written, describing how and when the product should be tested to achieve the requirements of the Requirement Specification. Thereafter the other activities in the Project Plan are executed according to the Time Plan. The Time Plan describes who should perform what activity and when. As the project progresses some activities might take more and some less time than anticipated, therefore the Time Plan is continuously updated. At the end of this phase the product should be completed.

3.3 After

The last phase, the after-phase, is focused on finalizing the project. The product is completed at the end of the during phase. Now the technical report should be completed, as well as the poster, web-page and afterstudy. Finally a presentation at the project conference is held. The purpose of the presentation is to describe the final product in an understandable and concise manner to the customer, supervisor and other interested potential users.

4 Organization plan

The project is organized according to figure 1, where the connections between the members represent primary paths of communication.

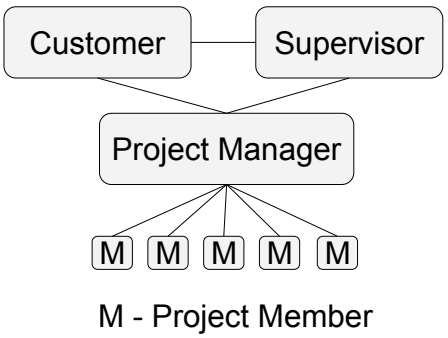

Figure 1: System overview

4.1 Definition of responsibilities

Within the group, the roles Project Manager, Chief of Design, Documentation Manager, Test Manager, Hardware Specialist and Software Specialist have been assigned. The responsibilities of all roles are defined here.

- **Project Manager:** The link between the customer and the group. Responsible for that the work is done according to the Project Plan. This means to make sure that the project members work with and finish their scheduled activities. The schedule is specified in the Time Plan and the activities in the Project Plan. The Project Manager also sends the weekly reports to the customer.
- **Chief of Design:** The expert on the overall product. Should know the design and make sure the design specification is followed, or updated if needed.
- **Documentation Manager:** The person responsible for the writing and code – that it lives up to quality expectations, that it is archived properly. Provides templates for documents.
- **Test Manager:** The person that plans the product testing and ensures that the Test Plan is followed.
- **Hardware Specialist:** Expert on hardware-part of the product. Should be able to answer most questions on hardware.
- **Software Specialist:** Expert on software-part of the product. Should be able to answer most questions on software.

4.2 Terms for cooperation within the group

A Group Contract has been written which describes the terms for cooperation.[4] The purpose of the Group Contract is to get all project members on the same page in regards to what is required from a project member. This will make it easier to discover if a project member is not doing their part and in that case expel them from the group. The Project Manager enforces the Group Contract.

5 Document plan

All documents produced in the project are described in Table 2 under the heading **Documents**. They are all reviewed by the Documentation Manager and one additional person. Thereafter they are sent to the supervisor to get additional feedback. Finally they are sent to the customer for approval. The documents are written in ShareLatex. Every version of a document sent to the supervisor or customer is also stored on the group's GitLab-repository. All documents are written in English.

6 Training

The project group has studied courses in communications but massive MIMO and beamforming is new to the group. The group will receive brief training in Massive MIMO and soldering. An introduction to the field of Massive MIMO will be given to the group by Prof. Erik G. Larsson. The hardware specialist of the group will give the rest of the group an introduction to soldering.

7 Reporting Plan

All reports produced in the project are described in Table 2 under the section **Reports**. In addition to this, all members report what they have done at the weekly meeting, see section 8.

8 Meeting Plan

The group will meet every Wednesday at 12:15-13:00 for a lunch meeting. During that meeting all members of the group will report what they have done since the last meeting and what they plan to do until the next meeting. Any problems that have arisen are also discussed. The number of reported hours are also checked for anomalies – if someone has worked unusually much or little time.

9 Resource plan

The resources for this project are described in the following subsections.

9.1 People

The project group consists of 6 persons that each will spend 240 hours on this project. This gives us a total of 1440 man-hours. The project also has access to 15 hours of supervision from the supervisor and 25 hours of expert consultancy from the customer and the PhD students at the Division of Communication Systems.

9.2 Facilities

The group has access to a room called CommSys lab with computers, all needed hardware, a workbench and tables. It can be accessed at all times.

9.3 Material

Hardware for the MAB has been purchased and partly assembled. All material in the CommSys lab is at the groups disposal. This material consists of various tools and electric components which cover most of our needs.

9.4 Economy

The money that already has been spent on the project seems to cover most of what we will need. If any more material is needed, it will be discussed with the customer.

The project has a total of 1440 man hours. We believe that this is enough to finish the project but problems we have not foreseen may arise. If so, the requirements in the Requirement Specification will be re-negotiated with the customer.

10 Milestones and Tollgates

This section describes the tollgates and milestones for the project.

10.1 Milestones

Important achievements for the project are listed in Table 5. The 1st and 2nd milestones may seem to occur late. This is because we need to assemble hardware and write code to control the hardware, preferably in parallel. In parallel since when the hardware is finished we need the controlling software in order to implement the beamforming. Both of these activities are estimated to take a long time and push the milestones forward.

Table 5: Milestones

Nr	Description	Date
1.	All L/M units are assembled	4/11
2.	All L/M units are tested	11/11
3.	The computer can communicate with the A/D and D/A cards	7/10
4.	All hardware is fully assembled and integration tested	16/11
6.	One can easily control the groups of speakers via the API	11/11
7.	The received signal is available in MatLab	16/11
8.	The system can receive and transmit sound from specified L/M units	16/11
9.	The system performs channel estimation	2/12
10.	The system performs precoding to beamform the signal	9/12
11.	One can hear one sound at one user and another sound at another user	9/12

10.2 Tollgates

Tollgates are meetings with the customer where all parties agree to move on to the next step in the project. For this project there are 4 tollgates. Their due dates and what deliverables that are due are specified in Table 2.

11 Activities

To plan the project, a number of activities have been identified. They have a number, a description, a budget and dependencies. The number is used to describe dependencies. The description describes what should be accomplished to finish the activity. Number of hours needed to accomplish the activity is estimated and specified in budget. The unit is hours. Dependencies describe what other activities must be accomplished for the given activity to start. All activities in the project are specified in Table 6. In it, DB stands for Distribution Box (which the customer will finish), Dep. for Dependencies and ss for signal splitter. The Cross Coupling Board mentioned in Table 6 is a board in the Distribution Box that handles control signals.

Table 6: Activities

Nr	Activity	Descritpion	Budget	Dep.
1	Meetings with group	Lunch meetings	90	-
2	Meetings with supervisor, customer	-	100	-
3	Design Sketch	-	20	-
4	Project Plan	-	15	-
5	Group Contract	-	8	-
6	Requirement Specification	The work to create a Requirement Specification	25	-
7	Document Handling	Creating templates, sharing documents, solving git conflicts	15	-
8	Design Specification	-	40	3
9	Test Plan	-	10	3
10	Solder L/M	Solder 38 L/M units	60	-
11	Assemble L/M	Assemble 70 L/M units	90	10
12	Assemble ss	Assemble 15 signal splitters	30	-
13	Cross Coupling Board	Wire the board	10	8
14	Driver Control	Control A/D and D/A cards through drivers	30	-
15	A/D and D/A sync.	Synchronize the A/D- and D/A-cards	30	14
16	D/A queue	Queue data from Application to D/A	40	15

17	L/M select	Program the Arduino to select which L/M units to use and how (transmit or receive)	30	13, DB
18	API	Write Matlab script that lets user decide which units to use and how (transmit or receive)	50	15,17
19	Full assembly	Assemble all hardware	30	11,12,13,DB
20	Simple System Test	Test transmitting and receiving from different L/M units.	20	18,19
21	Unit Testing	Tests for L/M units, signal splitters and cables	40	11,12
22	Integration Testing	Tests for integrating the L/M units to the central unit	20	19
23	A/D, D/A Testing	Tests for A/D- and D/A-converters	20	-
24	GUI	Implement a GUI for the Application	40	20
25	Channel measurements	Perform channel estimation using a chirp-signal to see how different frequencies in a signal affect the channel.	30	20
26	Calibration	Implement calibration of each L/M unit in Software	50	20
27	Channel estimation	Implement channel estimation in Software	60	25
28	Precoding	Implement sound precoding in Software	60	20
29	System Testing	Test the system functionality	40	24,26,27,28
30	User Manual	-	10	-
31	Technical Report	-	60	-
32	Afterstudy	-	10	-
33	Poster	-	20	-
34	Web Page	-	20	-
35	Oral Presentation	-	20	-
36	Review	Time to review documents	30	-
37	Education	MIMO lecture and soldering course	15	-
38	Reserve	Extra hours to allocate as needed	152	-

12 Time plan

All activities from Table 6 have been scheduled in a spreadsheet, see Appendix A. In the spreadsheet one can see how many hours of each activity that should be spent by the assigned group members in total each week. Each group member is described by his or her initials.

13 Quality plan

To achieve a high quality product the plan is to review all documents and test all implementations. The tollgates with the customer will also ensure that the customer gets a clear picture of the ongoing projects progress and quality. The group will keep close contact with the customer to ensure that the achieved product meet the customers expectations on quality. This will be done through discussions at tollgates and if needed, at extra meetings with the customer.

13.1 Review plan

Each document should be reviewed by the Documentation Manager and at least one more member of the group, assigned by the Documentation Manager. All members should read all documents to be aware of their contents.

13.2 Test plan

A thorough Test Plan will be constructed for tollgate 3. The Test Plan will describe how the product will be tested to ensure that work goes according to the Time Plan and to ensure that the Requirement Specification is fulfilled.

14 Priorities

The first priority of this project is to assemble a working MAB. It should also be easy to implement new signal processing for the MAB at a later time. The second priority is to implement directive sound transmission that will demonstrate the powers of Massive MIMO.

The testbed from 2014 that were used in projects during 2015 had issues with the D/A and A/D converters. Two of the issues were computer crash (error message mentioning the converters) and converter malfunctioning with the error message: "Sample Clock Error". The groups of 2015 believed them to be due to the fact that the drivers for the converters are intended for 32-bit systems while the controlling computer was a 64-bit system. According to MATLAB:s webpage on data acquisition for these converters it should work if the MATLAB version is 32-bit.[3] Therefore we hope that installing a 32-bit MATLAB version will solve these issues. The third issue was: no signal longer than 2 seconds could be sent. This was due to the converters internal queue being filled. Therefore we plan on implementing a queue to the converters from the computer. Since there have been multiple issues with the converters, a significant amount of time has been planned to establish a working communication with the converters.

To prioritize the activities in the project, their dependencies and estimated time have been drawn in Figure 2 and Figure 3.

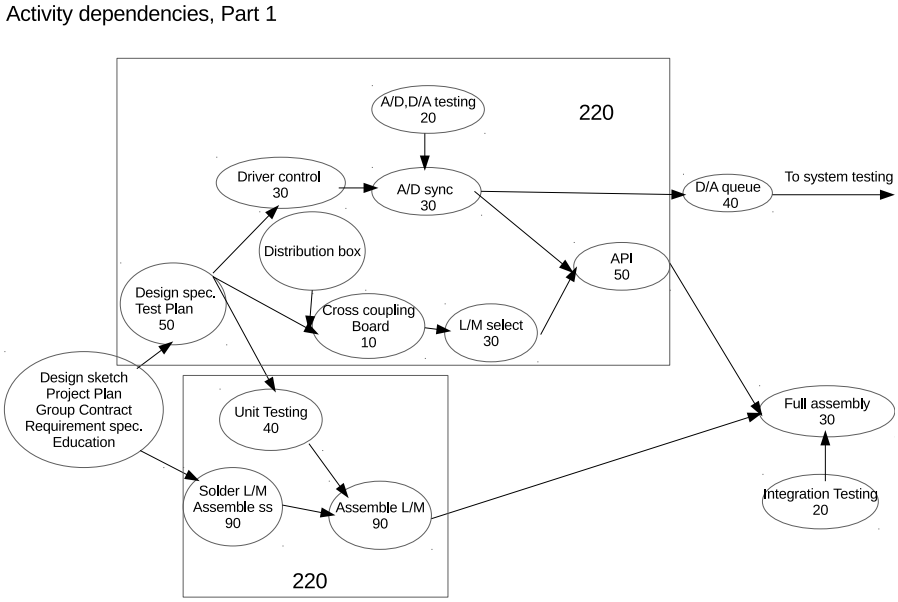

Figure 2: Dependencies for the first part of the project

Looking at Figure 2, we see that the bottom box and the top box amount to the same number of hours. Therefore the group is split in two, working on the activities in each box in parallel. This is to make sure that all activities necessary to start the full assembly are finished at roughly the same time.

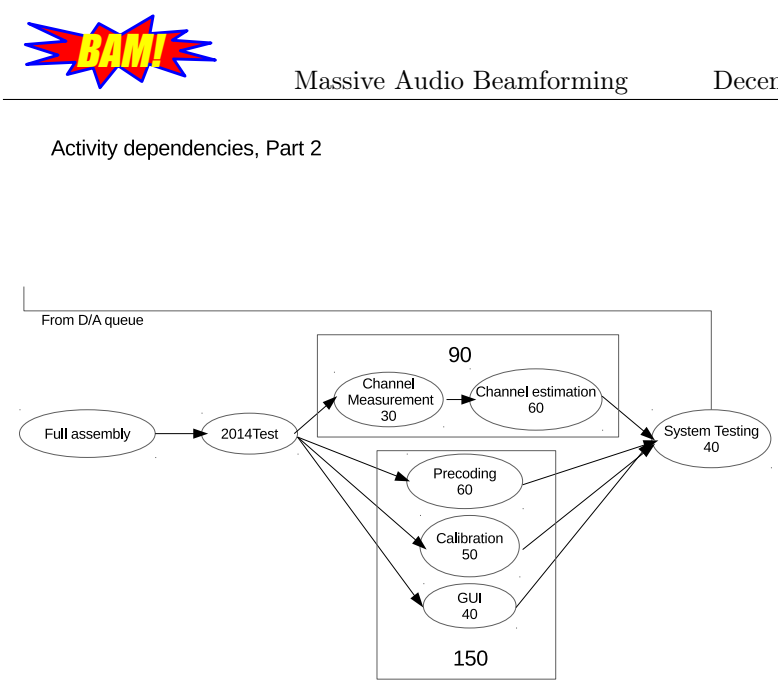

Figure 3: Dependencies for the second part of the project

The activities in the project after the activity Full assembly does not have the same number of activities to coordinate. However, we can with a similar figure see that the channel measurement and estimation activities should be prioritized while still accomplishing the other activities, see Figure 3.

15 Project termination

Upon approval of all tollgates by the customer and participation in the Project Conference the project is terminated. The group is dissolved.

A Appendix: Timeplan

Base plan																				
Project:																				
Project group:			**Date:**									**Reviewed:**								
Customer:			**Version:**																	
Course:			**Editor:**																	
ACTIVITIES		**TIME**	**WHO**	**TIMEPLAN (when), week number**																
#	Description	hours	Initials	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	
1	Meetings with group	90	All	6	6	6	6	6	6			6	6	6	9	9	6	6	6	90
2	Meetings with supervisor, sponsor	100	All	24	6	6	6	6	4			6	6	6	6	6	6	6	6	100
3	Design Sketch	20	EB, SL	7	13															20
4	Project Plan	15	LF	6	9															15
5	Group Contract	8	All	6.5	1.5															8
6	Requirement Specification	25	EJ, KG, JP	15	10															25
7	Document handling	15	All	5	3										2	3	2			15
8	Design Specification	40	EJ,LF,KG,EB		10	30														40
9	Test Plan	10	EB,LF,KG			10														10
10	Solder L/M	60	SL,JP,EJ			25	15	10				10								60
11	Assemble L/M	90	SL,JP,EJ			5	25	25	20			15								90
12	Assemble ss	30	SL,JP,EJ						10			10	10							30
13	Cross Coupling Board	10	SL,JP,EJ									10								10
14	Driver Control	30	EB,LF,KG				20	10												30
15	A/D and D/A sync.	30	EB,LF,KG				10	20												30
16	D/A queue	40	EB,LF,KG						10			10	20							40
17	L/M select	30	EB,LF,KG						10			10	10							30
18	API	50	EB,LF,KG						10			30	10							50
19	Full assembly	30	SL,JP,EJ										30							30
20	2014Test	20	EB,LF,KG										10	10						20
21	Unit Testing	40	SL,JP,EJ			5	5	5	10			5	10							40
22	Integration Testing	20	SL,JP,EJ										5	15						20
23	A/D,D/A Testing	20	EB,LF,KG				5	5	10											20
24	GUI	40	JP,KG											10	20	10				40
25	Channel measurements	30	EJ,EB,LF											30						30
26	Calibration	50	SL,JP											30	20					50
27	Channel estimation	60	EJ,EB,LF											10	30	20				60
28	Precoding	60	KG,LF,SL												20	20	20			60
29	System Testing	40	All													10	10	20		40
30	User Manual	10															5	5		10
31	Technical Report	60	All												10	20	20	10		60
32	Afterstudy	10	All															5	5	10
33	Poster	20															10	10		20
34	Web page	20	KG														10	10		20
35	Oral Presentation	20	All															20		20
36	Review	30	All		10			5								5	5	5		30

37	Education	15	All		15															15
38	Reserve	152	All		2	4	2	2	5			20	20	20	17	15	15	15	15	152
39																				0
40	Milestones																			0
41	All L/M and ss are assembled											Fri								0
42	All L/M are tested												Fri							0
43	The computer can communicate with the A/D and D/A cards							Fri												0
44	All hardware is fully assembled and integration tested													Wed						0
46	One can easily control the groups of speakers via the API												Fri							0
47	The received signal is available in MatLab													Wed						0
48	The system can receive and transmit sound from specified L/M units													Wed						0
49	The system performs channel estimation															Fri				0
50	The system performs precoding to beamform the signal																Fri			0
51	One can hear one sound at one user and another sound at another user																Fri			0
52																				0
53	Tollgates																			0
54	TG2 – Approval of Requirement specification, Design sketch and Project Plan					Fri														0
55	TG3 – Approval of Design Specification and Test Plan								Wed											0
56	TG5 – Delivery of product, test protocols and the user manual																	Mon		0
57	TG6 – Approval of technical report, afterstudy, poster and webpage																	Thu		0
58																				0
59	Project Conference																		Mo	0
60																				0
	Summa antal timmar:	1440		69.5	85.5	91	94	94	95	0	0	132	137	137	134	118	109	112	32	1440

VEM	TIDPLAN (när), veckonummer																
Initialer	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	Sum
LF	11.6	14.3	15.2	15.7	15.7	15.8	0.0	0.0	22.0	22.8	22.8	22.3	19.7	18.2	18.7	5.3	240
JJ	11.6	14.3	15.2	15.7	15.7	15.8	0.0	0.0	22.0	22.8	22.8	22.3	19.7	18.2	18.7	5.3	240
GE	11.6	14.3	15.2	15.7	15.7	15.8	0.0	0.0	22.0	22.8	22.8	22.3	19.7	18.2	18.7	5.3	240
ME	11.6	14.3	15.2	15.7	15.7	15.8	0.0	0.0	22.0	22.8	22.8	22.3	19.7	18.2	18.7	5.3	240
CB	11.6	14.3	15.2	15.7	15.7	15.8	0.0	0.0	22.0	22.8	22.8	22.3	19.7	18.2	18.7	5.3	240
OA	11.6	14.3	15.2	15.7	15.7	15.8	0.0	0.0	22.0	22.8	22.8	22.3	19.7	18.2	18.7	5.3	240
SUMMA	69.5	85.5	91	94	94	95	0	0	132	137	137	134	118	109	112	32	1440

References

[1] T.Svensson and C.Krysander, in *LIPS*, Version 1.0, Compendium, LiTH, 2002.

[2] F.Stenmark. (2016, Sep 19). *Technical Report, Version 1.1* [Online]. Available: http://www.isy.liu.se/edu/projekt/kommunikationssystem/2014/documents/TR_1.*pdf*

[3] Mathworks. (2016, Sep 19). *CONTEC Support from Data Acquisition Toolbox* [Online]. Available: http://se.mathworks.com/hardware-support/contec.html

[4] K.Gudmundsson et al. (2016). *Group Contract v.1.1*