



USER MANUAL

Simon Sörman

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Participants of the group

Name	Responsible	Phone	E-mail
Miguel Abadia	Software Engineer	073 723 98 37	migab416@student.liu.se
Herman Molinder	Project Manager	076 823 81 96	hermo276@student.liu.se
Simon Pålstam	Software Engineer	076 803 17 06	simpa265@student.liu.se
Thiti Sookyoi	Software Engineer	073 573 66 63	thiso311@student.liu.se
Simon Sörman	Responsible for the documentation	070 954 78 41	simso657@student.liu.se

Customer: Mikael Olofsson, mikael.olofsson@liu.se, 013 – 28 13 43

Examiner: Danyo Danev, danyo@isy.liu.se, 013 – 28 13 35

Supervisor: Antonios Pitarokoilis, antonios.pitarokoilis@isy.liu.se, 013 – 28 13 40



Contents

1	Introduction	1
2	System components.....	1
2.1	Hardware.....	1
2.2	Software	2
3	SETUP	2
3.1	Hardware	2
3.2	Software	3
4	Using the system	4
4.1	GUI.....	4
4.1.1	Encoding algorithm	6
4.1.2	Modulator type	6
4.1.3	Precoder type.....	6
4.1.4	Interleaving depth	6
4.1.5	Virtual Channel	6
4.1.6	Virtual Channel Noise Variance.....	6
4.2	Run with script.....	6
5	References.....	7



Document history

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0.2	2015-12-01	Second draft, minor fixes	SS, SP	HM
1.0	2015-12-03	Corrected typo	HM	HM



1 INTRODUCTION

This user manual describes how to use the Massive MIMO Parallel Data Transmission system. The system consists of several hardware components together with ADC/DAC cards connected to a computer with supporting software.

2 SYSTEM COMPONENTS

The hardware components are listed in section 2.1 and the software components are listed in section 2.2. A picture of all hardware components is displayed in Figure 1.

2.1 Hardware

The hardware consists of the following entities:

1. A computer with A/D converter: Contec AD12-64, D/A converter: Contec DA12-16 installed.
2. Distribution box.
3. Power supply box.
4. Eight L/M-pairs.
5. Four USB power adapters.
6. One 37-pin D-sub connector cable.
7. One 96 pin PCA connector cable.
8. Eight 9-pin D-sub connector cables.

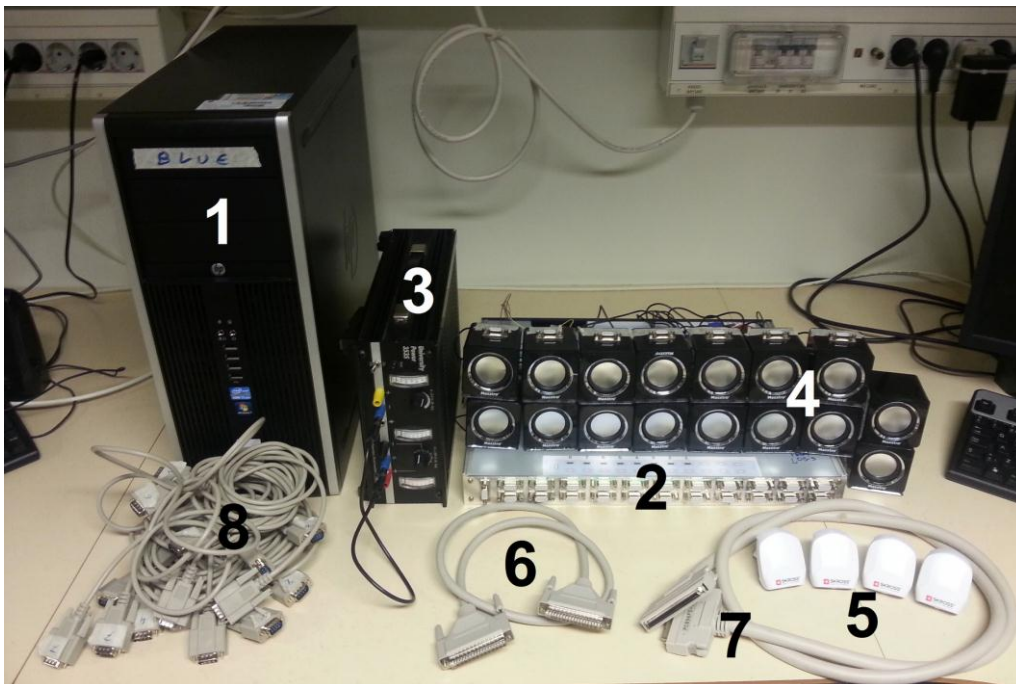


Figure 1: Hardware components (Stenmark, 2014)



2.2 Software

The software consists of the following entities:

1. Required drivers for the A/D and D/A cards.
2. Matlab installed on the computer.
3. Matlab code files.

3 SETUP

To setup the system it is needed to setup both the hardware and the software according to the steps described in the sections 3.1 and 3.2.

3.1 Hardware

The following steps must be carried out to setup the hardware for the system.

1. Place out the L/M's according to one of the recommended configurations in Figure 2, or in some other configuration that makes for an interesting test.

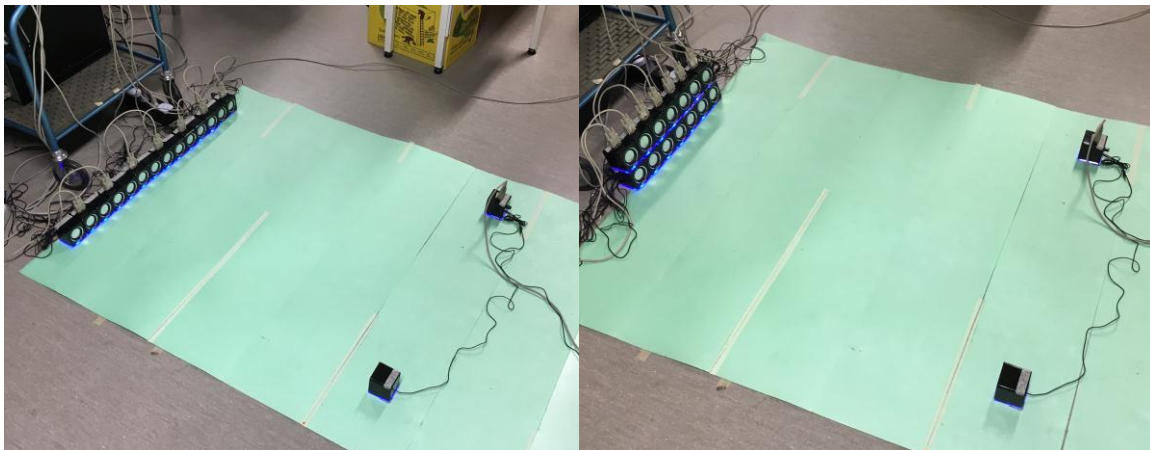


Figure 2: Recommended L/M positions

2. Connect the 96 pin PCA cable between the A/D card on the computer and the distribution box.
3. Connect the 37 pin D-Sub cable between the D/A card on the computer and the distribution box.
4. Connect each L/M-pair to the distribution box using the 9-pin D-sub cables. Make sure that each L/M-pair is connected to the corresponding connector on the distribution box to avoid any confusion while using the system.
5. Connect the power cables of the distribution box to the power supply box by first connecting the two blue ground contacts on the power supply box to each other. Then connect the black cable from the distribution box to one of these blue ground contacts. Next step is to connect the blue cable from the distribution box to the black contact on the power supply box. Lastly connect the red and the yellow cables from the distribution box to the red and yellow contacts on the power supply box. A picture of all connected cables is displayed in Figure 3.

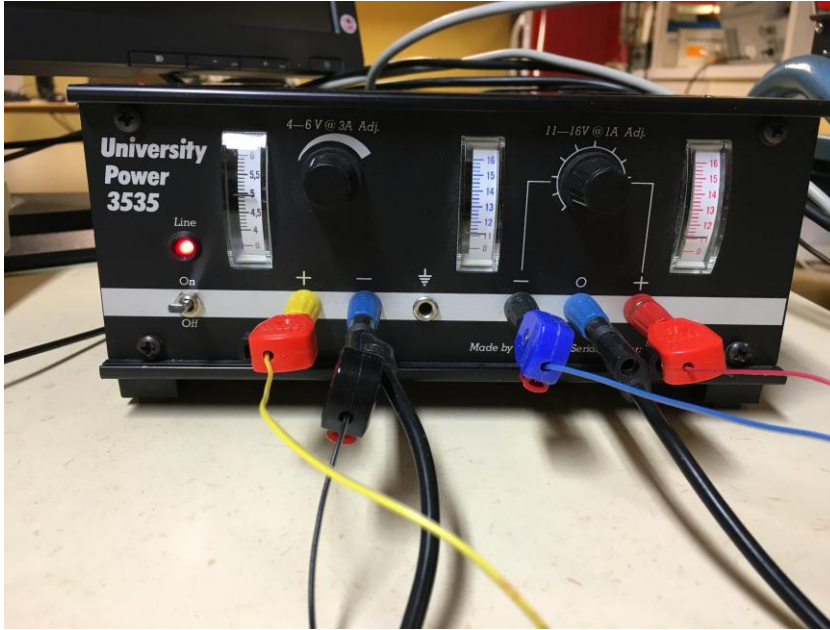


Figure 3: All cables connected to the power supply box

6. Connect the USB-cables from the L/M-pairs to the USB power adapters.
7. Power the system by connecting all USB-adapters along with the power cables for the power supply box and the computer to a regular power connection.
8. Decide which L/M-pairs will be used in the MIMO-array and which L/M-pairs will be used as terminals by turning the switches on the distribution box. If a switch is turned upwards the corresponding L/M-pair is set to be used in the MIMO-array, if a switch is turned downwards the corresponding L/M-pair is set to be used as a terminal.
9. Make sure that the voltage level to the left is set to 5 V and the voltage level to the right is set to 11 V before turning on the power for the power supply box.

3.2 Software

The following steps must be carried out to setup the software for the system.

1. Make sure that Matlab is installed on the computer.
2. Make sure that the folder PDT, containing all the Matlab files for the system, exists on the computer.
3. Start Matlab.
4. Change the Matlab directory to the PDT folder.
5. Run the command “GUI” in the command window to start the program with a graphical user interface. Or run the command “NO_GUI_transmission” to run the system immediately from the command window with default settings.



4 USING THE SYSTEM

Before using the system, make sure all hardware is connected according to section 3.1 and all software is setup as in 3.2. The system can be used either with a graphical interface or directly from the command window.

4.1 GUI

Start by writing the command “GUI” in the command window. The graphical interface should now be visible and it is possible to modify input parameters of the before starting the transmission. A picture of the GUI is shown in Figure 4.

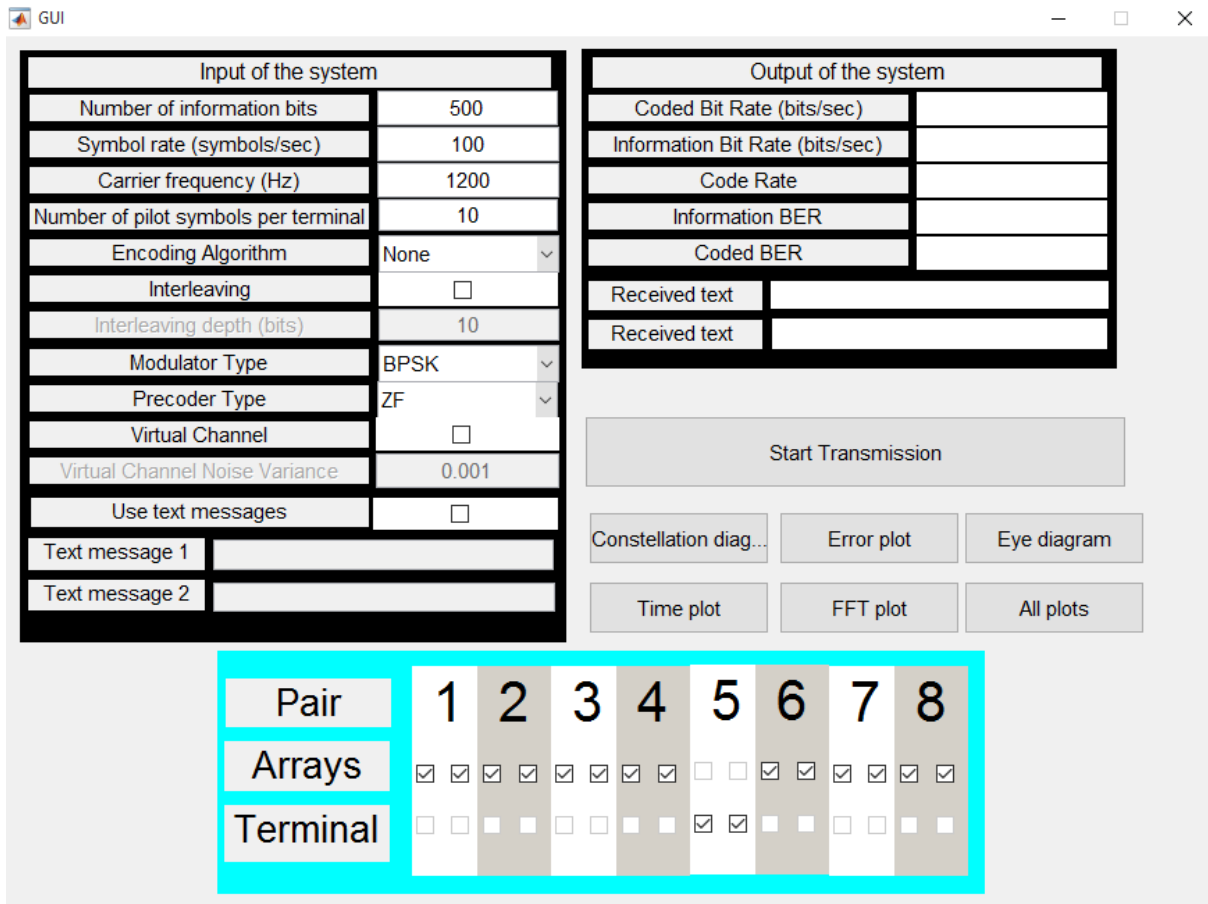


Figure 4: Picture of the GUI

The upper left box of the GUI displays the input parameters for the system, descriptions and limitations for all these input parameters are displayed in Table 1.

Table 1: Descriptions and limitations of input parameters

Input	Description	Min value	Max value
Number of information bits	Input the number of information bits (integer).	1	-
Symbol rate	Input the symbol rate in unit symbols/sec (integer).	12	3012 (fs/2)



Carrier frequency	Input the carrier frequency in unit Hz (integer).	1	3011 (fs/2-1)
Number of pilot symbols per terminal	Input the number of pilot symbols per terminal (integer).	1	2 * (Symbol rate)
Encoding Algorithm	Choose the error correcting coding algorithm from a list.	-	-
Interleaving	Choose to use interleaving.	-	-
Interleaving depth (Bits)	Input interleaving depth if interleaving is used.	-	-
Modulator Type	Choose the modulator type from a list.	-	-
Precoder Type	Choose precoder type from a list.	-	-
Virtual Channel	Choose to use a virtual channel	-	-
Virtual Channel Noise Variance	Input the variance (in Volts) of the AWGN that is applied to all simulated channels if virtual channel is used.	0	-
Use text messages	Choose to transmit text messages.	-	-
Text message 1	Input a US-ASCII text message for the first terminal. The text message must contain at least one printable US-ASCII character.	-	-
Text message 2	Input a US-ASCII text message for the second terminal. The text message must contain at least one printable US-ASCII character.	-	-

The lower box defines what L/Ms are used as terminals and what L/Ms are used in the MIMO array. The choice is done by clicking the check-box for “Arrays” or “Terminals” for each L/M. The left check-boxes in the associated pair belongs to L/M “A” and the right check-boxes belongs to L/M “B”. When choosing which L/M to use as terminals and which L/M to use in the MIMO array it is important to remember that if one L/M in a pair is used as a terminal, the other L/M can not be used in the MIMO array (and of course the other way around). Although it is possible to only use one of the L/M in a pair by just deselecting one of the speakers. In addition, due to limitations of the system, it can only select, as maximum, four L/M as terminals in every transmission. Make sure that the corresponding switches on the distribution box are set to the same group as in the GUI.

A transmission is started, after all parameters have been chosen, by clicking the button “Start Transmission”. Some statistical data will be displayed in the upper right box when the transmission is completed. Even more statistical data are displayed in the command window after each transmission. When the transmission is completed it is also possible to show the result from the transmission in different plots by clicking one of the buttons: “Constellation diagram”, “Error plot”, “Eye diagram”, “Time plot”, or “FFT plot”. It is also possible to show all plots immediately by clicking the button “All plots”.

Clicking the “X” button in the upper right corner closes the graphical interface.



In the following sections, some input parameters are explained in more detail.

4.1.1 Encoding algorithm

The encoding algorithm determines what kind of error control coding scheme will be used for the transmission. The choices available are:

- None – no channel coding
- Convolutional code with rate 1/2
- Convolutional code with rate 2/3
- (7,4) Block code
- (11,15) Block code
- Turbo code

4.1.2 Modulator type

The modulator type determines what kind of symbol constellation the bits will be mapped onto. The constellations available are:

- BPSK – Binary phase shift keying
- QPSK – Quadrature phase shift keying
- 8PSK – 8-ary phase shift keying

4.1.3 Precoder type

The precoder type determines what kind of precoding will be used. The precoding types available are:

- MRT – Maximum ratio transmission
- ZF – Zero forcing

4.1.4 Interleaving depth

This is a parameter that describes the permutation used in the interleaving. If the parameter is called d , then the permutation of the bits is done by taking each d :th bit of the block, wrapping around when reaching the end of the block. This gives a straightforward result if the block length and the interleaving depth are relatively prime. Otherwise, a small shift in this “every d :th bit”-procedure will be made to ensure that all bits are selected exactly once. I.e. the block [1, 2, 3, 4, 5, 6, 7, 8, 9, 10] would be interleaved with a parameter of 3 to [1, 4, 7, 10, 3, 6, 9, 2, 5, 8], and with a parameter of 4 to [1, 5, 9, 3, 7, 2, 6, 10, 4, 8].

4.1.5 Virtual Channel

By selecting this option, the system will be run on a simulated channel that is implemented in Matlab. This enables the user to run the system without the special hardware. Please note that the bit rates will be much higher than when using the real hardware, since Matlab processes signals much faster than it takes to physically transmit them. For more information about the simulated channel, please refer to the technical documentation.

4.1.6 Virtual Channel Noise Variance

The virtual channel noise variance determines the variance for the additive Gaussian noise added to each symbol by the virtual channel.

4.2 Run with script

The user can also run the system by running the command “NO_GUI_transmission” in the command window. The system is then running with default settings. To change these settings: open the file “NO_GUI_transmission.m” and change the parameters freely. Make sure that the choice of the parameters fulfills the limitations described in section 4.3. Statistical data are



displayed in the command window after each transmission. In this mode all the variables used in the transmission script are saved, this enables further investigations of the result from a transmission.

5 REFERENCES

Electronic references

Stenmark, F. (2014). User Manual Version 1.1 (PDF) Available:
<http://www.isy.liu.se/edu/projekt/kommunikationssystem/2014/documents/UM_1.1.pdf>