REQUEST FOR PROPOSAL (RFP) (Rev A)

Acoustic Messenger

Appendices:

A. Requirement Specification
B. Proposal template
C. Test report template

Interested suppliers are invited to provide proposals according to this request. More than one supplier will be selected.

Technical requirements are presented in **Appendix A**.

Proposals shall follow the format according to **Appendix B**.

The customer may call each company to a hearing to discuss the proposal before selection of suppliers and signing contracts.

Suppliers will be selected based on technical content of proposal and offered price. The contract price will be the same to all selected suppliers, and calculated as average of proposed prices among selected suppliers.

Latest at the delivery deadline the supplier shall submit a Test Report according to **Appendix C**, referring to the Requirement Specification, stating for each requirement if it is fulfilled or not. Deviations from the Requirement Specification should be clearly stated.

In case delivery with full compliance at the deadline is not possible, the supplier can report the actual state and negotiate a revised plan. Minor delay and minor deviations from requirements may be accepted. In such cases the price will be reduced. After the delivery the suppliers will be called to a demonstration, to demonstrate and explain the product to the customer.

In case a supplier discovers a significant deviation from the initial plan, regarding technical solution and/or execution of the development, this shall urgently be reported to the customer.

TIME SCHEDULE

See Project memo.

WARRANTY

Warranty period: 1 year. During the warranty period any discovered functional or performance deviation shall be corrected by the supplier free of charge and without any undue delay.

NOTE: *This RFP is intentionally made to resemble a real world RFP. The meaning of the following terms in the present context of an educational project is explained in the Project Memo: customer, supplier, contract, price, warranty.*

Appendix A
REQUIREMENT SPECIFICATION – Acoustic Messenger

INTRODUCTION TO THE PRODUCT TO BE DEVELOPED

The physical layer of a communication system for transmission of text messages over the acoustic channel is to be developed. The company requesting the product has developed applications to communicate between two computers with encrypted text messages. The company requires an reliable two-way *full-duplex* communication system with low transmission delay.

The requested product is a set of MATLAB functions that implement the transmitter and receiver needed in compliance with the below specifications. One of the critical constraints is the recently acquired spectrum by the company requesting this product (see the specific requirements), where the transmission has to occur through the allocated spectrum to reduce interference with users utilizing neighboring frequencies.

The hardware platform consists of two standard computers and two low-quality headsets which will be connected to the computers as shown in Fig. 1. This is a real-time link, when one computer sends an encrypted message, the receiver on the other computer has to automatically wake up and start receiving the transmitted signal. If the reception is successful the message is displayed on the receiver application.

The communication system in demand is full-duplex, it must be possible to transmit and receive message at both the computers at the same time. Two separate bands centered at two different carrier frequencies have been bought by the company for supporting full-duplex communications.

PLATFORM

- 2 Standard PCs.
- 2 Headsets each connected to a PC. Headsets may be borrowed from the customer during the execution phase. If so, they should be returned at the demonstration.
- Operating System: Windows XP/Vista/7
- Software platform for implementation: MATLAB, Version R2008b or later.

Figure 1: The hardware configuration

SPECIFIC REQUIREMENTS

- The carrier frequencies f_{c1} and f_{c2} are chosen by each team in the range 1 to 6 kHz.
- The system must be able to support half-duplex communication for **approval**. Successful demonstration of full-duplex communication without packet errors will be granted extra points (see Table 1).
- The pass-band transmitted signal must satisfy the **red mask** shown in fig. 2.

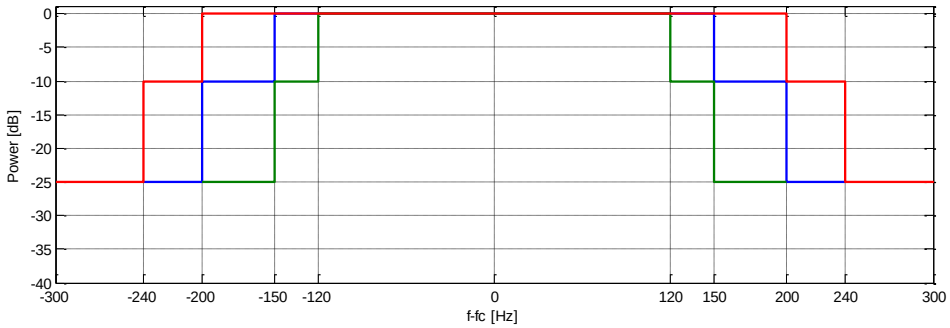

Figure 2: Spectrum masks

Extra points will be granted if the transmitted signal satisfies blue or green masks (see Table 1).

- The number of lost packets (missed or not decoded packets) must not exceed **10%** of the total number of transmissions (min. 60). Decreasing the number of lost packets will be granted extra points (see Table 1).

- The round trip time (RTT), defined as the time interval between the beginning of the transmission of a message and the end of the reception of the automatic reply from the other computer in the diagnostics mode (explained later) must be less than **6 seconds**. Decreasing the transmission time will be granted extra points (see Table 1).

Table 1. Extra points[1].

Extra Points	Mask
1	Blue
2	Green

Extra Points	RTT (sec)
1	<5
2	<4.5

Extra Points	Lost packets (%)
1	5
2	0

Extra Points	
4	Full-duplex without packet error

- A vector of **432 information bits** of data needs to be transmitted within one packet between two computers.
- Linear modulation (*M*-PAM, *M*-PSK, *M*-QAM) must be used for transmission.
- The microphone of the headsets should be kept in the position shown in Fig. 3.
- All stages of volume control, e.g., the volume control on the headsets and all internal PC software control, shall be on a maximum level.
- All software should be written in **MATLAB**.

[1] Extra points are granted only if the system satisfies the basic requirements.

Figure 3: Headsets positioning.

Modes of operation:

A. Chat Mode:

Transmitters (`Chat_PC_A_Tx` and `Chat_PC_B_Tx`)**:**

`Chat_PC_A_Tx.p` and `Chat_PC_B_Tx.p` MATLAB functions are placed in PC A and PC B respectively. These interfaces allow the users to enter the carrier frequencies of the link and the message to be sent. Message should contain a maximum of 50 ASCII characters. When the 'SEND' button is clicked, the entered text is encrypted and a 432 bit long message `X` is generated. The message X and the carrier frequency are then passed to the function `transmitter(X, fc)`.

Receivers (`Chat_PC_A_Rx` and `Chat_PC_B_Rx`)**:**

`Chat_PC_A_Rx.p` and `Chat_PC_B_Rx.p` are placed in PC A and PC B respectively. These interfaces display received messages and allow the user to enter the carrier frequencies of the link. On pressing 'Activate receiver', `receiver(fc)` function is called. The `Chat_PC_A_Rx` interface also displays the PHY layer performance measures which include power spectral density (PSD), constellation, eye-diagram.

The operation of the interfaces in Chat mode is illustrated in Figure 4.

Note: Different MATLAB sessions have to be run for transmitter and receiver on both the computers.

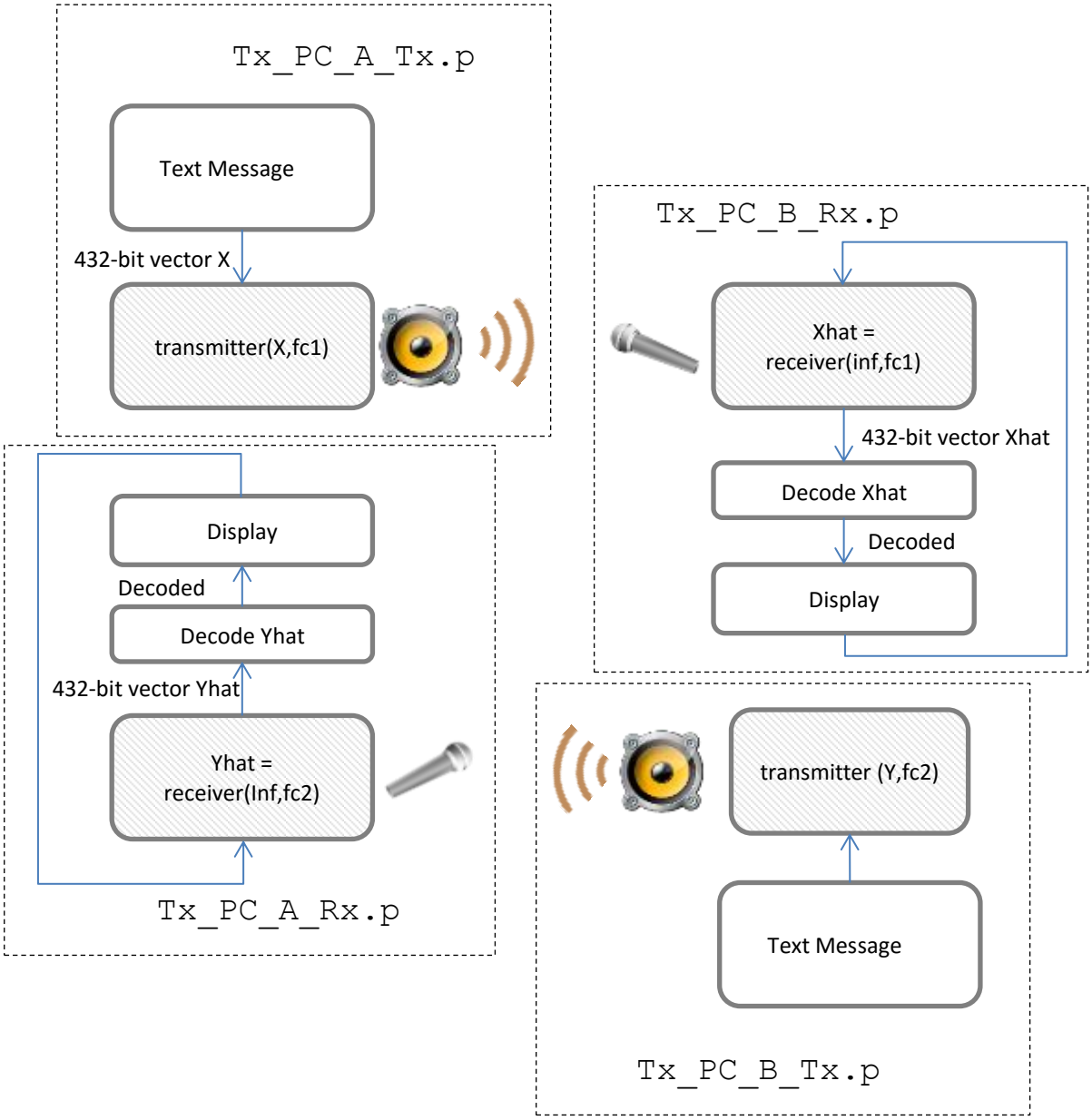

Figure 4: Chat Mode

B. Diagnostics Mode:

When the operation mode is set to 'Diagnostics mode' on the interfaces `Chat_PC_A_Rx` and `Chat_PC_B_Rx`, they work both as a transmitter and a receiver. Packet loss rate and RTT are measured in this mode.

In this mode, a text message is typed on `Chat_PC_A_Rx` and transmitted to `Chat_PC_B_Rx`. After the transmission `Chat_PC_A_Rx` waits for `6` sec for a reply from `Chat_PC_B_Rx`. `Chat_PC_B_Rx` receives the message, decodes it and transmits an automatically generated acknowledgement in reply. At `Chat_PC_A_Rx`, this acknowledgment is decoded and used for measuring packet errors and RTT.

Note: In the Diagnostics mode, `Chat_PC_A_Tx` and `Chat_PC_B_Tx` will not be used.

The operation of the interfaces in Diagnostics mode is illustrated in Figure 5.

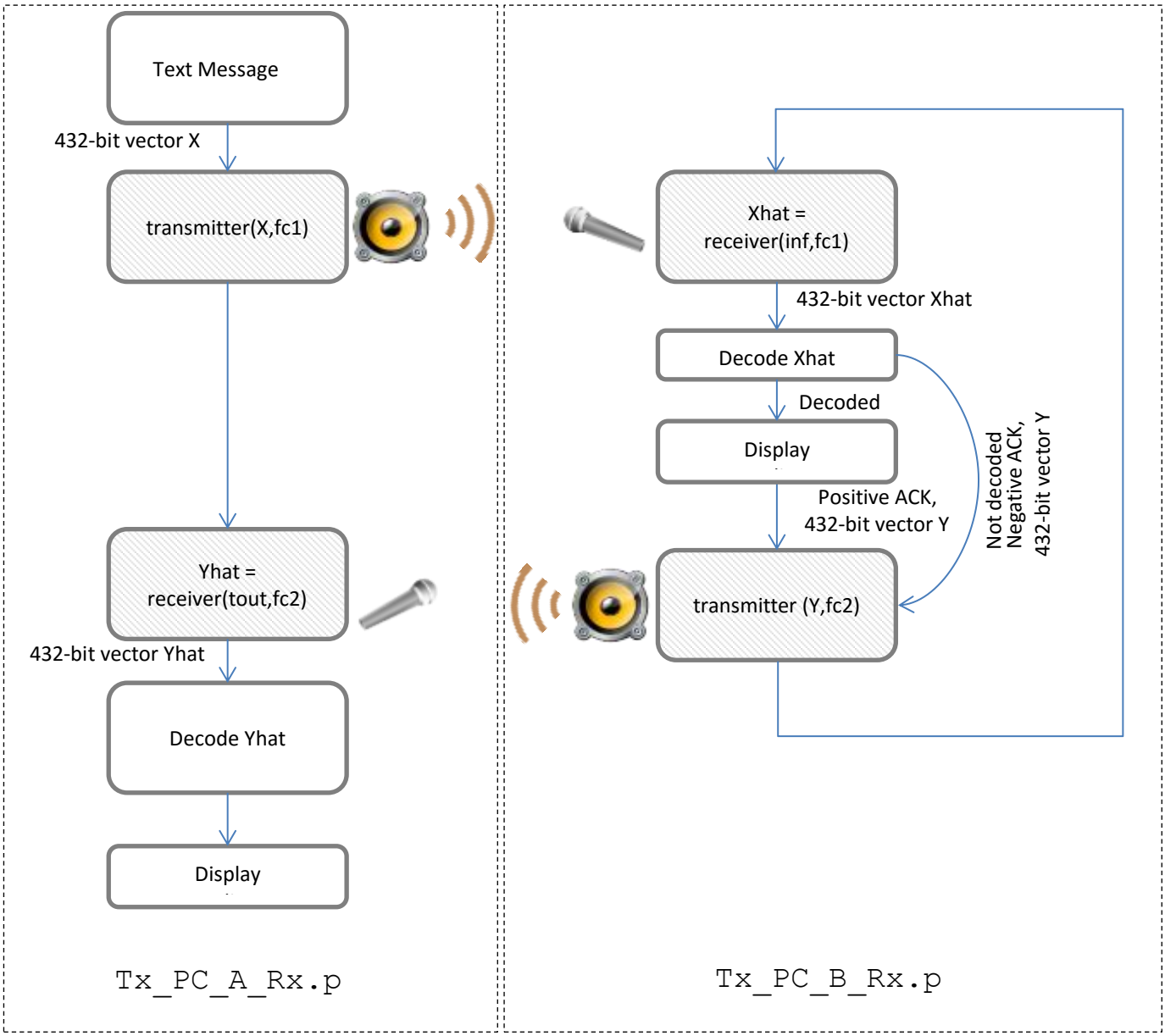

Figure 5: Diagnostics mode

INTERFACES

The MATLAB functions `Chat_PC_A_Tx`, `Chat_PC_A_Rx`, `Chat_PC_B_Tx` and `Chat_PC_B_Rx` will be provided. The MATLAB functions `receiver.m` and `transmitter.m` need to be implemented with the inputs and output described below.

function `transmitter(X,fc)`
Input argument `X` is a row-vector of 432 bits (0, 1) and `fc` is the carrier frequency of the link.

function `[rec_obj] = receiver(fc)`

Parameter `fc` is the carrier frequency of the link. The recorder object (an instance of audiorecorder()) is a structure that contains a field called UserData. This field is where the received data will be stored. The data to be stored are the power spectral density (*pwr_spect*), the constellation points (*const*), the eye diagram (*eyed*) and the decoded bits (*pack*). Note that the fields in UserData must have exactly these names. Finally, a flag to denote when a receive is finished needs to be set equal to one in the UserData, called *receive_complete*. More specifically:

When the signal is received, the output parameters are assigned as follows.

i) `pack` is a row-vector of 432 bits (0, 1) of the received information.

ii) `psd` is a structure with two fields: `psd.p` is a row-vector of the PSD of the received signal calculated after down-conversion (before matched filtering) in dB. The vector psd.p is normalized so that maximum value is 0 dB. `psd.f` is a row-vector of corresponding frequencies in Hz. (Hint: Inbuilt function pwelch can be used for generating PSD)

iii) `const` is a row-vector of complex samples after downsampling that correspond to *information part* (basically it is a constellation).

iv) `eyed` is a structure with two fields: `eyed.fsfd` is an integer and stands for a number of samples per symbol; `eyed.r` is a complex row-vector of *information part* of the received signal after matched filtering and timing synchronization (properly cut so that MATLAB `eyediagram(eyed.r, eyed.fsfd)` plots a desired eye diagram).

NOTE: functions `Chat_PC_A_Tx`, `Chat_PC_A_Rx`, `Chat_PC_B_Tx`, `Chat_PC_B_Rx` and templates `transmitter.m` and `receiver.m` can be downloaded from the course homepage. `Chat_PC_A_Tx.fig`, `Chat_PC_A_Rx.fig`, `Chat_PC_B_Tx.fig`, and `Chat_PC_B_Rx.fig` are graphical user interfaces (GUIs) and should be kept in the same folders as their .p counterparts.

NOTE: Use Ctrl+C to force MATLAB to stop the execution of a running script.

NOTE: Do not use commands `close all` and `clear all` in your functions.

TESTING PROCEDURE

The computers in room 5225 with pre-installed MATLAB will be used for testing. The configuration of these computers, i.e., sound level, headset positioning, computer speed, sound card characteristics, etc., will be the reference model. The testing procedure of the final software implementation will be carried out on these computers.

After receiving the final product, the following testing procedure will be carried out by the customer:

- Each team will set up the Acoustic Messenger, using the provided functions and the designed physical layer.
- Half-duplex communication will be verified for approval of the project.
- Full-duplex communication will be verified by transmitting from both the PCs simultaneously.
- Round trip time will be measured, to see if it complies with the time requirements.
- The number of unsuccessful transmissions which is counted in the diagnostic mode will be checked, to see if it agrees with the requirements.
- The PSD of the signal will be measured.

At the demonstration, the internal operations of the product should be visualized by the following figures:

- Spectrum of the transmitted and received signal
- Eye diagram
- Constellation plot

Note that, there will be no extra noise beyond the normal noise in the testing room.

Appendix B
PROPOSAL TEMPLATE

(Expected page count: 2-4)

Technical description
Short description of how the requested product will be implemented.

Project plan
Description of work break-down into separate activities for performing the development.
An organization plan showing how roles and responsibilities will be distributed in the team.

Test plan
Plan for step-wise testing during the development, including testing according to customer requirements before delivery.

Time schedule
A chart showing the planned execution of the activities in the work break-down, showing how the delivery time requirement will be met. Internal dead-lines and all deliveries to the customer (also status reports) shall be included.

Estimate of man-hours
Estimate of total man-hours for the project work.

Proposed price
Price proposal based on the conditions in Project Memo, Section 3.6.1.8

Appendix C

TEST REPORT TEMPLATE

(Expected page count: 1)

The test report delivered to the customer must compare the performance with each requirement in the requirement specification.

This report must contain:

- One item for each item in the requirement specification.
- State compliance or deviation (specify the deviation) and a brief description of how it has been tested.
- A very short operation manual.