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1. **Standard Hardware Projects**

1.1. **Wav Player**

In this project the DE2 board will be used to play a WAV files. A WAV files will be preloaded from host PC into the boards DRAM or SRAM using RS232 interface (or any other). The DE2 will decode the WAV files and play it through the audio codec. The board’s push buttons will give basic controls over the WAV file playback (STOP, PLAY, PAUSE, NEXT). The header of the WAV file must be decoded on the DE2 board itself and not on the PC.

**Required Equipment:**
- DE2 Board
- Host PC
- RS232 Cable
- Loudspeakers or Headphones

**Project requirements:**
- WAV files is loaded to DE2 through RS232 using a terminal software
- The WAV file should be loaded using XMODEM protocol when the PC is the initiator (http://en.wikipedia.org/wiki/XMODEM)
- At least 3 files should be loaded
- WAV header is decoded on DE2
- 4 push buttons to control playback (STOP, PLAY, PAUSE, NEXT).
  - STOP stops playback and returns to file 0
  - PLAY starts the playback from current position and file
  - PAUSE stops playback, when PLAY is pressed the playback should resume from last position at last file
  - NEXT switches to next file
- An LCD screen should show the elapsed seconds, current file and WAV sample rate

1.2. **Wav Recorder**

In this project the DE2 board will be used as a sound recorder. The DE2 board will record sound from the audio codec input and store it in the DRAM or SRAM memory in a WAV format. After the recording is finished the DE2 will transfer the recorded WAV file through the RS232 interface (or any other) to the host PC were it will be saved to the disk. The board’s push buttons will give basic controls over the sound recording (RECORD, STOP). The header of the WAV file must be encoded on the DE2 board itself so the host PC will receive a full functional WAV file.

**Required Equipment:**
DE2 Board
Host PC
RS232 Cable
Microphone or any music player

Project requirements:
- WAV file is downloaded from DE2 through RS232 using a terminal software
- The WAV file should be downloaded using XMODEM protocol when the PC is the initiator ([http://en.wikipedia.org/wiki/XMODEM](http://en.wikipedia.org/wiki/XMODEM))
- WAV header is encoded on DE2
- 2 push buttons to control playback (STOP, RECORD).
- An LCD screen should show the current recorded seconds

1.3. Paintbrush

In this project the DE2 board will be used for drawing with a standard PS2 mouse on a VGA screen.
A PS2 mouse and a VGA screen will be connected to the DE2 board. The VGA screen will have a drawing color selection area.
Required Equipment:
- DE2 Board
- Host PC
- RS232 Cable
- PS2 Mouse
- VGA Screen

Project requirements
- The screen will have a drawing area and color selection area.
- There will be at least 256 colors that can be selected
- A color selection area with all the 256 colors will be displayed on right side of screen. Clicking that area will select the color that will be drawn.
- Clicking left mouse button on drawing area will draw a point with selected color
- A drawn picture should be downloaded from DE2 through RS232 using a terminal software in BMP format
- The BMP file should be downloaded using XMODEM protocol when the PC is the initiator ([http://en.wikipedia.org/wiki/XMODEM](http://en.wikipedia.org/wiki/XMODEM))
- BMP header is encoded on DE2
- Screen resolution is 640x480

1.4. Pong Game

The pong game consists of a ball bouncing on a screen. A paddle (controlled from a mouse here) enables the user to make the ball bounce back up. The screen layout is shown in the figure below.

Required Equipment:
- DE2 Board
• PS2 Mouse
• VGA Screen

Project requirements:
• A ball will move across the screen with constant speed
• In case of ball hits the wall or paddle it will bounce off
• In case the ball falls out of the bottom screen it will be re-drawn in the middle of the screen
• The paddle will be moved in horizontal direction only using mouse
• An LCD screen that shows the score
  o Score starts at 0
  o In case of ball hitting the paddle, the score increased.
  o In case of ball going out of the bottom of the screen the score decrease
  o In case of score reaches -10 or 10 , a Game Over message should be displayed on LCD and game should stop

1.5. Guitar Effect Pedal

In this project the DE2 board will simulate a guitar effect pedal. The DE2 board will make several effects on an audio signal that is sampled by an audio codec and then output the modified signal through the audio codec. The DE2 board’s push buttons will be used to select the required effect and the current effect will be displayed on the LCD screen. There will be minimum 4 effects on the system (Echo, Reverb, Channel sweep etc…)

Required Equipment:
• DE2 Board
• Sound Source (Microphone, Guitar or any music player)
• Loudspeakers or Headphones

Project requirements:
• At least 4 effects
• Audio codec samples at 44Khz constant rate
• LCD screen displays the current effects names
• Up to two effects can be chained. For example first a Reverb is applied on
input and then Echo is applied on the output of Reverb.

1.6. Disco Ball

In this project the DE2 board will be used as a music visualization effect.
A music source will be connected to the DE2 board through audio codec, the
board will process the incoming audio signal and draw a filled circle on the VGA
screen according to the input music current volume (the more is the music volume
the bigger is the circle radius). The circle color will be also according to music
volume.

Required Equipment:
• DE2 Board
• Sound Source (Microphone or any music player)
• VGA Screen

Project requirements:
• Screen resolution 1024x768
• The audio codec samples at 44Khz
• The circle radius and color should be volume dependent. As higher the
volume as larger the circle radius should be. The color should be blue
when the volume is zero and red at maximum volume. At least 256
different radiuses and colors should exist.
• The circle on the screen is updated every 20 msec
• To calculate the music volume:
  o Calculate absolute value of an input
  o Average 20msec of the calculated absolute samples

1.7. Digital Oscilloscope

In this project the DE2 board will be as a digital oscilloscope.
The DE2 board will receive in incoming signal from the audio codec and show the
received waveform on the VGA screen. The user should be able to change in
runtime Voltage/Div, Time/Div and a Trigger level. The Voltage/Div and
Time/Div should be displayed on the LCD screen and a trigger level should be
displayed on a VGA screen as a horizontal line.

Required Equipment:
• DE2 Board
---

- VGA Screen
- Signal Source (Signal generator, music player)

**Project requirements**

- Screen resolution 1024x768
- The codec samples at constant 44Khz. Subsampling should be done in FPGA
- At least 256 Voltage/Div, Time/Div steps. Time/Div steps in units of 22usec
- Number of trigger levels is the same as Voltage/Div levels
- LCD screen displays the Voltage/Div, Time/Div
- Trigger level displayed VGA screen as a horizontal line (Blue color)
- A grid should be displayed on VGA (Green color)
- A signal is displayed in Red color.
- All the points of the signal should be connected, so the waveform will be continuous.
- The waveform display should be synchronized to trigger (Rise) in Auto mode. ([http://en.wikipedia.org/wiki/Oscilloscope](http://en.wikipedia.org/wiki/Oscilloscope))

**1.8. Camera Color Detector**

In this project the DE2 board will be used as an object color detector using a CCD camera.

A CCD camera will be connected to the DE2 board, the algorithm on the board will detect specific color on the incoming video and will display an outgoing video on the VGA display in three modes selected by on-board switches:

- Original Video
- Only the detected color regions
- Overlay of detected color over the original image.

The Color that needs to be detected will be selected using a PS2 mouse

**Required Equipment:**

- DE2 Board
- VGA Screen
- CCD Camera
- Host PC
- PS2 mouse

**Project requirements**

- Three modes (Original video, detected regions, overlay)
- A mouse picks up the color that should be detected from the screen. A small cursor should be drawn on the screen that represents mouse position.
- The color should be detected using the following algorithm:
  - Calculate the normalized picked color values by
    \[ R_{nu} = R_p / (R_p + G_p + B_p), G_{nu} = G_p / (R_p + G_p + B_p), B_{nu} = B_p / (R_p + G_p + B_p) \]
  - For each pixel in the image calculate the normalized values by
---
\[ R_m = R_i / (R_i + G_i + B_i), G_m = G_i / (R_i + G_i + B_i), B_m = G_i / (R_i + G_i + B_i) \]

- Calculate the squared vector difference by:
  \[ D = (R_m - R_{m_{pn}})^2 + (G_m - G_{m_{pn}})^2 + (B_m - B_{m_{pn}})^2 \]

- Compare the squared difference to a threshold, if it is smaller than threshold means that a valid color is detected

1.9. **Alarm movement sensor**

In this project the DE2 board will be used as a movement detector using a CCD camera.

A CCD camera will be connected to the DE2 board, the algorithm on the board will detect movement (difference between two frames) on the incoming video and will display an outgoing video on the VGA display in three modes selected by onboard switches:

- **Original Video**
- **Detected movement pixels**
- **Overlay of detected movement over the original image.**

The system will also detect if the amount of moved pixels is over some defined threshold and lit LEDs to indicate intruder.

**Required Equipment:**
- DE2 Board
- VGA Screen
- CCD Camera

**Project requirements**
- Three modes (Original video, detected regions, overlay)
- The image from camera should be converted to gray scale before next operations
- Movement detection:
  - The movement should be detected by subtracting pixels of the previous frame from pixels of the current frame. An absolute operator should be applied on the difference.
  - A threshold should be applied on each pixel from above stage, if value is above the threshold a movement in current pixel was detected. A resulting image is binary image. 1 indicates movement at current pixel
  - A morphological filter of 3x3 pixel kernel should be applied to the above result to filter granular noise. A filter calculates the number of ones in 3x3 image neighborhood around each pixel. If number of ones is greater than zeroes the filtered pixel will have value of 1, zero otherwise. This will be the movement pixels image
- Alarm operation:
  - A number of the total moved pixels on screen should be calculated
  - If the number of pixels is greater than threshold the LED will be lit
1.10. **Remote Controlled Karaoke Machine**

In this project the DE2 board will be used as a karaoke machine with remote control. An audio source and a microphone will be connected to the DE2 board’s audio codec input, and speakers/headphones to audio codec output. The DE2 board will be able to control the volume of each input independently with a standard TV remote control using IRDA interface. The DE2 boards LCD screen will display the current settings.

Required Equipment:
- DE2 Board
- Audio Source (CD player)
- Microphone
- TV Remote control

Project requirements
- Two audio inputs mixed to one output
- The remote control should control the volume of each input separately
- There should be a button on remote control that mutes/un-mutes each input channel
- The volume and mute of each channel should be displayed on LCD screen

2. **Advanced Hardware Projects**

The extended projects requires much more effort and much more complex than a standard projects. Students must have knowledge or experience in a specific field in order to choose that projects.

2.1. **Disco Lights**

In this project the DE2 board will be used as a music visualization effect like in Winamp using digital filters. A music source will be connected to the DE2 board through audio codec, the board will process the incoming audio signal and draw different visual patterns on the VGA screen according to the input music rhythm. The patterns will be selectable by the DE2 on-board switches. The red LEDs of the DE2 will serve as a volume ladder (the higher the current amplitude is, the more LEDs are lit).

Required Equipment:
- DE2 Board
- Sound Source (Microphone or any music player)
- VGA Screen

Project requirements
- At least 4 different video patterns
2.2. **Fourier Transform**

In this project the DE2 board will be used to perform a Fourier transform or DCT on an incoming signal.

The DE2 board will receive an input signal from an audio codec, make a Fourier transform on that signal and visualize the result using the on-board red LEDs. The visualization will be done using a PWM that will enable changing the LEDs brightness. The brighter is the led the bigger is the amplitude. The Fourier transform must cover the whole audio frequency range 50Hz to 12KHz.

Required Equipment:
- DE2 Board
- Signal Source (Signal generator, microphone or any music player)

3. **Standard Software Projects**

All the projects are implemented on a standard PC. All projects should be written in C++ language with MATLAB GUI. It's possible to create graphical user interfaces both proprietary libraries shipped with a compiler (such as MFC) or open source libraries or toolkits distributed under the GNU GPL license.

3.1. **Audio Analyzer**

One of the very important parameters in audio equipment is the THD+N (Total Harmonic Distortion + Noise) parameters. It accounts for both harmonic distortion (non-linearity) and noise distortion of signal. In this project an input audio stream is recorded either with the microphone or the internal mixer and the THD+N (parameter is estimated. The result is reported “on the fly” using a window application.

Additional equipment: microphone

3.2. **Digital Oscilloscope**

The target of this project is to display the waveform from the sound card, display it, allows various controls (X- and Y-scaling) and measurements (amplitude, frequency, period etc.) in real time with and without trigger. Inputs signal is measured by Line in L/R.

The two independent applications should be written. One signal generator which runs on one PC computer and second application is digital scope which runs on other PC.

The Signal generator features:
1) Three standard waveforms generation – sin, square and triangle/ramp. Voltage dynamic range – 0-894 mV (peak-to-peak) and frequency range – 0-20kHz. Square wave should have ability to duty cycle change – 5%-95%.
2) Sweep, with ability to define start, stop frequencies and step.
3) Arbitrary mode. The program should allow to load *.dat file created by MATLAB and to play that in loop.
4) Two analog outputs Line out L/R – ability to generate two analog signals independently.

The scope features:
1) Capturing inputs signals by Line In input.
2) Presentation of one/two signals on PC screen.
3) Ability to resolution and time scaling "on the fly".
4) Presentation of simple mathematical functions X+Y, X-Y, abs(X) and abs(Y), -X and -Y.
5) Triggering by different amplitudes by rising and by falling edge.
6) 2-3 features should be added by students and approved by supervisor.

3.3. Sound and Light Show

In this project an audio stream is recorded using Line in R/L inputs or from saved file. It through a bank of filters and converts it to a light show. The input signals could be provided by any audio player – PC, Smartphone, MP3 player or other with ability to different filtration or with embedded equalizer. The input signal should be played by line out R/L outputs and simultaneously shoved on screen. The L and R channels should be presented in different way (up to students' decision). The value of volume should be presented as background in rainbow colors – the loudest volume should be red and the most quiet – violet.

3.4. Digital Piano

The application will present an onscreen virtual piano keyboard. Pressing a key will produce a corresponding sound. The application must support scripting, that is playing a predefined sequence of notes.

Additional equipment: loudspeakers

3.5. DTMF tones generator and decoder

In project it is required to generate and decode DTMF tones used in telephony. Each digit is encoded usual a combination of two harmonic signals. It is required to build a window with a dial pad generating DTMF signals and issue commands for a real telephone system. Also the application must decode these signals and display a transmitted digit on a screen.

Additional equipment: microphone and loudspeaker.

3.6. Digital spectrum analyzer

The target of the project is to build a digital spectrum analyzer of the input signal. A spectrum analyzer (SA) measures the magnitude of an input signal versus frequency within the full frequency range of the instrument. The SA is used to measure the power of the spectrum of known and unknown signals. The input signals that a spectrum analyzer measures is spectral compositions of other signals. The two independent applications should be written. One signal generator which runs on one PC computer and second application is digital scope which runs on other PC. The Signal generator features:
5) Three standard waveforms generation – sin, square and triangle/ramp. Voltage dynamic range – 0-894 mV_{peak-to-peak} and frequency range – 0-20kHz. Square wave should have ability to duty cycle change – 5%-95%.

6) Impulse train in frequency domain. Ability to define start impulse frequency, number of impulses and step.

7) Arbitrary mode. The program should allow to load *.dat file created by MATLAB and to play that in loop.

8) Analog output Line out L.

The SA features:
1) Capturing inputs signals by Line In L input.
2) Presentation of signals on PC screen in frequency domain.
3) Ability to resolution and frequency scaling "on the fly".
4) Ability to define spectrum presentation in two modes:
   a. Frequency center and span
   b. Start and stop frequencies
5) Ability to put up to 2 markers with marker functions:
   a. Marker On
   b. Marker Off
   c. Find pick
   d. Next Left pick
   e. Next Right pick
   f. marker1-marker2

6) 2-3 features should be added by students and approved by supervisor.

Additional equipment: microphone

3.7. Morse generator and decoder

Morse code is a character encoding that transmits telegraphic information using rhythm. It is a standardized sequence of short and long elements (dots and dashes). The application will present a field to enter a short message. The must application must encoded the message and send it to the sound card. Also the application must correctly decode an encoded message captured from the sound card.

Additional equipment: microphone, loudspeakers

3.8. Movement detector

Getting images from the web camera and analyzing it to detect movement.

Additional equipment: web camera

3.9. Pitch shifter

Pitch is an intrinsic characteristic of human voice. The target of this project is to shift the pitch of incoming voice stream, play it.

Additional equipment: microphone and loudspeakers

3.10. Photoshop
This application is allow to edit images.

3.11. **High quality audio equalizer**

This application allows separating the audio channel to 7-10 subchannels and allows value change in each pass independently. The two modes for value control should be chosen – linear and logarithmic. In addition, the following four effects may be applied on each subchannel:
1) Cyclic rotation;
2) Periodic cyclic flow of value from left speaker to right speaker and vise versa;
3) Echo;
4) By your definition

The audio file in arbitrary format (one of regular audio formats) should be load to application and the new file with post processing data should be saved in same format. The interface of application should be friendly to customer.

Additional equipment: loudspeakers

3.12. **Face registrator**

This application should allow to find faces in the picture.

4. **Advanced Software Projects**

4.1. **GSM Codec**

A popular GSM voice codec represents model of human voice as a 10-th order AR filter and excitation either with a pitch or white noise. Speech is sliced into short frames 10-20 ms and filter parameters are estimated using the Levinson-Durbin recursive algorithm. The target of the project is to encoded incoming voice stream and decode (reproduce it) using the model.

Additional equipment: microphone and loudspeakers

4.2. **BMP to JPEG Converter and vice versa**

The BMP file format, sometimes called bitmap, is an image file format used to store bitmap digital images especially on Microsoft Windows operating system. It is lossless uncompress image format. The JPEG file format is an image file format widely used by digital cameras and other image capture devices. It is a lossy image format with variable level of compression. The compression technique utilizes DCT, Huffman encoding etc.

In this project the application must convert a bmp encoded image to a jpeg encoded image and show the differences (losses due to compression) in the images.

Additional equipment: none
4.3. **BMP to PNG Converter and vice versa**

The BMP file format, sometimes called bitmap, is an image file format used to store bitmap digital images especially on Microsoft Windows operating system. The PNG file format was developed as license-free format in response to enforcement of a patent pertaining to the GIF format and as an alternative to the JPG format. It utilizes various lossless compression techniques.

In this project the application must convert a bmp encoded image to a PNG image and compare them.

Additional equipment: none

4.4. **IEEE 802.11g PHY simulator (Wi-Fi)**

Modeling IEEE 802.11g PHY. IEEE 802.11g specifies an OFDM modulated signal for wireless LAN communications. The target of the project is to build models of physical layer and model it using an AWGN and fading channel models.

Additional equipment: none

5. **Standard Android Projects**

5.1. **Paint**

Create a paint application. The app should include standard paint options, e.g., add a text, draw a circle or a triangle, and write with a pen and so on. The background of the app should include a live stream video from the phone's camera with an option for a snapshot.

Additional equipment: Android smartphones (camera)

5.2. **Trivia**

Create a trivia app with a theme of your choice. The app should include at least three levels of difficulty and four options for each question. Each question is asked and the answers are spread at each side of the screen, by tilting the device an answer is chosen. An appropriate sound is played on a right or a wrong answer with additional visual effect. This app should also include a menu and a high score with an option to take a picture of each person that reached a high score.

Additional equipment: Android smartphone (speakers, motion sensors and camera)

5.3. **Tune Me Home**

Create an application that uses the build-in GPS and compass of the smartphone in order to direct you home. The app should "remember" the home coordinates and display an arrow that points to the home direction. In this app you should also display the distance to the destination.
5.4. **Media Player**

Create a media player application to play your favorite songs. This app should include options to create playlists, to shuffle, and using an accelerometer sensor to change songs. The app should also include an option to take a picture and place it as a song icon.

Additional equipment: Android smartphone (GPS and compass)

5.5. **Alarm Clock**

Create an alarm clock application with options to choose the song and the volume. The alarm should be stopped using a motion sensor, e.g., tilting the phone to the left stop the alarm and to the right "snooze". The main objective is to take a snapshot of the user upon stopping the alarm clock. The picture should be taken automatically and the app should also include a gallery.

Additional equipment: Android smartphone (speakers, motion sensors and camera)

5.6. **Equalizer**

Create an equalizer application. An equalizer is used to alter the frequency response of a particular music source. Specifically, the app should include a bar that modifies the amplitude in various frequencies. The two modes for value control should be chosen – linear and logarithmic.

Additional equipment: Android smartphone (speakers)

5.7. **Bill splitting for roommates**

Create an application that manages an expense account for roommate's apartment. The app should include an option to take a picture of each bill, e.g., water, electricity and etc. The main menu is a list with a picture of each one of the roommates and by clicking each roommate an option to add a bill is suggested (with or without a picture). Note that there might be an option that two roommates will split a bill.

Additional equipment: Android smartphone (camera)

5.8. **Cookbook**

Create a cookbook application with a database of recipes and options to search the database by products or by the recipe's name. The app should also include an option to take a picture of the final product.

Additional equipment: Android smartphone (camera)
5.9. **Grocery planner**

Create an application to manage a grocery list. This app should include an option to take a picture of the products and a build-in database of previous products. Additionally, an option to add a new product (with or without a picture) is required. At the main menu, the app should suggest previous lists that were already been used.

Additional equipment: Android smartphone (camera)

6. **Advanced Android Projects**

6.1. **Image processing**

This project includes an image processing application. The app should first take a picture and then modify the picture with an appropriate menu. Options such as, greyscale, sepia, resize, cut, clarity and sharpness should be included. Additionally, by using a RGB bar the blue, green and red values are changed by the user.

Additional equipment: Android smartphone (camera)

6.2. **Computer vision**

Android smartphones includes a powerful processor and therefore are suitable for computer vision tasks. Computer vision is a field that includes methods for acquiring, processing, analyzing and understanding images. Specifically, in this project, we focus on a numerical identification in an image. For example, a photo of an official form should include markers where ever a numerical input is identified.

Additional equipment: Android smartphone (camera)

6.3. **Wireless Ad-hoc Network**

A mobile ad-hoc network is a communication network without infrastructure. Specifically, two Android smartphones communicate with each other directly without any access point that manages the communication. In order to establish an ad-hoc network in Android smartphones the following steps should be accomplished:

- Root your Android device. In order to change your communication controller to work in ad-hoc mode a root privilege is required.
- Use the command "iwconfig" at the command line in order to modify the phone into an ad-hoc mode. Specifically, this command is a UNIX command to configure a wireless network interface. [http://linux.about.com/od/commands/l/blcmdl8_iwconfi.htm](http://linux.about.com/od/commands/l/blcmdl8_iwconfi.htm)
- Open a UDP socket (any port over 1024 is validate) and broadcast a UDP packet.

This SMS imitating app should transfer messages between the devices.

Additional equipment: Two Android smartphones
6.4. App to meet up with friends via smartphone

This app requires an ad-hoc network, therefore please read carefully the "wireless ad-hoc network" project specifications. Instead of sending a simple message, in this app, we send our coordinates (using the build-in GPS) to the other device. Then, using the build-in GPS and compass the app should direct the user to the other device.

Additional equipment: Two Android smartphones (GPS and compass)

נא לשים לב להגשת העבודות בהתאם לדרישות המפורטות לעיל

3. מחוכם

לحلول האומר ובו יכתב构件 על ניסוי זה:

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<td>דרehler מסכם</td>
<td>פרוייקט</td>
<td>הגנה</td>
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