EE SENIOR DESIGN
PROJECT STATEMENT OF WORK
CLICK SENSOR HUB

TEXAS STATE UNIVERSITY
INGRAM SCHOOL OF ENGINEERING

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TEXAS STATE UNIVERSITY

The rising STAR of Texas

Revision History			
Version	**Date**	**Description**	**Author**
0.1	09/15/2018	Add section owners	Alfonso
0.2	09/15/2018	First draft of my sections filled	Alfonso
0.3	09/18/2018	Review and edit	Alfonso
0.4	09/18/2018	Completed Section 5	Dean
0.5	09/19/2018	Completed Section 2	Dean
0.6	09/19/2018	Start Section 3	Dean
0.7	09/19/2018	Continued Section 3	Alfonso
0.8	09/19/2018	Finalized Section 3	Mohamed
0.9	09/19/2018	Final review before signatures	Alfonso
0.91	09/19/2018	Edit with Sponsor suggestions	Alfonso

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1. EXECUTIVE SUMMARY

Alfonso de la Morena:

The project is to work with the FRDM-KL46Z microprocessor board by NXP, create a Printed Circuit Board (PCB) that allows simultaneous connection it to a minimum of 4 Clicks from MikroElektronika and write software that makes the board compatible with at least 10 Clicks. The purpose of the Clicks is to add functionality to Hexiwear devices by NXP by expanding their sensor capabilities. For example, one click may add a temperature sensor while another may add the capacity to detect C02 levels. The goal being that the KL46Z and similar FRDM board to have the same compatibility as the Hexiwear with the Clicks. Additionally, the data read from the FRDM-KL46Z needs to be easily usable. For this purpose, a website will be created that reads the information gathered by the clicks to creates graphs and other statistical representations. A set of instructions will be created to facilitate the open source use of the project for other individuals.

The applications of this product include giving the FRDM-KL46Z an easy to use platform for gathering data using the 10 Clicks that will be selected with the possibility of expanding it to more Clicks. One example could be to use the FRDM-KL46Z along with a Weather Click and a GPS Click to track information on a custom weather balloon. Another application could be to pair the FRDM-KL46Z with a SpeakUp Click and Bluetooth Click to operate a small robot vehicle with voice commands. Both applications might have been possible previously with a Hexiwear but the FRDM-KL46Z is a more capable and reliable device.

The first part of the project will focus on getting the sensors to operate properly on the FRDM-KL46Z. Once the minimum 4-Click PCB has been implemented and the data is successfully transferred from the Clicks to a computer via the FRDM-KL46Z, the next phase of the project will begin. In the second phase, the focus will be writing the code to translate the readings on the sensors from the Clicks to a text file that will be sent to the website. The final phase will focus on the design of the website. The website must include instructions on how to implement the Clicks with the FRDM-KL46Z, as well as display any data gathered in tables, graphs and other forms of statistical representations. Finally, once the project is concluded, detailed descriptions, reports and source code will be posted on Mbed and NXP community forums so that others may easily benefit from this project.

2. BUSINESS NEED

Dylan Dean:

Currently the Hexiware device is the IoT platform of choice for NXP student projects. The application of this product in previous student projects has been limited due to the HexiWare's lack of durability under student induced stress conditions. Also, in past projects the number of Clicks on the docking station were limited to three either for budget reasons.

The business goal is to provide FRDM-KL46Z platforms with an interface that connects a minimum of 4 Clicks simultaneously. The project aims to maintain a price point at or below the current docking station being utilized by HexiWare. Additionally, there exists an opportunity to correct pin layout issues and achieve connectivity speed and reliability on par

or above the current station is a goal. Switching to the FRDM-KL46Z platform will solve the issue of durability and expand upon current sensor number limitations.

Extending the capabilities of the Sensor Hub, a website will be created as a powerful addition to FRDM-KL46Z IoT platform. The website will provide an analysis tool to display gathered data into statistical tables and models, along with technical documentation on Sensor Hub.

3. PRODUCT SCOPE DESCRIPTION

Mohamed Sghari:

A) Interface

The Freescale Freedom KL46Z hardware, FRDM-KL46Z, is a sophisticated platformer by NXP, that can be developed to be a useful everyday application. FRDM-KL46Z is ideal for rapid prototyping of microcontroller-based applications. The main goal of the project is to provide an easy way to use interface between the FRDM-KL46Z board and a minimum of 10 Clicks by MikroElektronika. Each of the devices specific features are discussed in Sections B and C. This section focuses more on the desired integration gained from this project.

Features:

- A PCB board with connectivity to a minimum of 4 Clicks (with a stretch goal of connecting 8 Clicks)
    - In stretch goal there would be a need for separate power supply
- An Mbed library with implementation for a minimum 10 Clicks to transfer sensor information that converts to a formatted text file.
- A website that integrates the data collected by the sensors and displays them in different statistical representations (e.g. a line or bar graph)

Features	**Performance Targets**
PCB that connects FRDM-KL46Z with Clicks	Ability to connect 4 clicks simultaneously with a stretch goal of connecting 8 clicks simultaneously • Stretch goal includes an additional power supply for the PCB due to each pin on FRDM-KL46Z having a maximum current draw of 25 mA
Mbed Library	Library that implements reading from selected 10 Clicks with a stretch goal of 15 selected Clicks • One library that implements an interface for generic Click I/O to text file (meaning each Click will override the interface class)
Website	Website that receives the data gathered and displays it in an easy to read, statistical format • Use of Tableau interactive data visualization software

B) NXP FRDM-KL46Z

The FRDM-KL46Z is an ultra-low-cost development platform enabled by the Kinetis® L series KL4x MCU family built on the Arm® Cortex®-M0+ processor. An overview of the – can be seen in Figure 1.

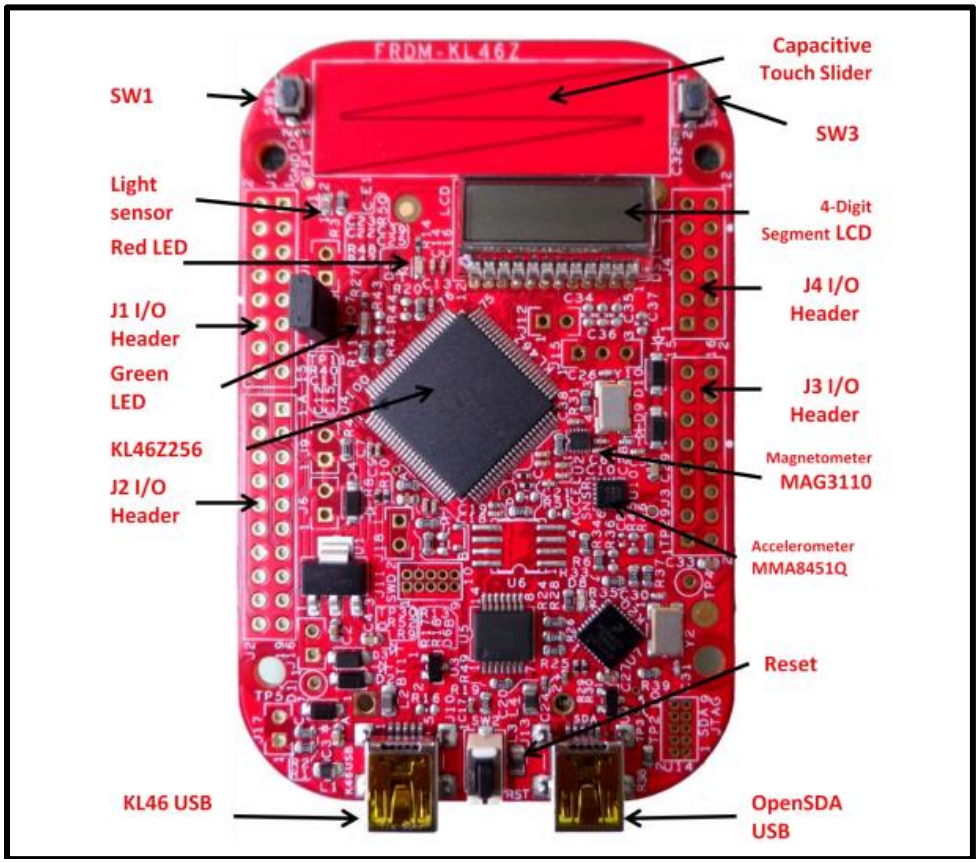

Figure 1: The FRDM-KL46Z Layout

Features	Performance Targets
Multi-Clock Operating Frequencies	For each mode: • 32-40 kHz (low freq. mode) • 3-8 MHz (high freq. mode, low range) • 8-32 MHz (high freq. mode, high range)
USB Interface	Ability to configure as a full-speed USB device. VREGIN must be powered to enable the internal circuitry of USB
Serial Port	Functional Serial Port connection for Clicks that can make use of it
Reset	Ability to use reset button to restart sensing capabilities

Debugging	Implement functional C code to troubleshoot and perform unit tests
Capacitive Touch Slider	Two Touch Sense Input (TSI) signals, TSI0 CH9/PTB16, and TSI0 CH10/PTB17 are connected to capacitive electrodes configured as a touch slider
Three-axis Accelerometer	Interfaced through an I2C bus
Three-axis Magnetometer	Interfaced through an I2C bus and one GPIO signals
LEDs	Two LED, Green LED is PWM capable
Visible light sensor	Ability to sense light levels
Multiple inputs	100-pin LQFP. Some pins are utilized in on-board circuitry, but many are directly connected to one of four I/O headers.

Reference:

- https://www.nxp.com/support/developer-resources/evaluation-and-development-boards/freedom-development-boards/mcu-boards/freedom-development-platform-for-kinetis-kl3x-and-kl4x-mcus:FRDM-KL46Z

C) MikroElektronika Clicks

Clicks by MikroElektronika are devices originally meant to amplify the sensor capabilities of devices that are compatible with the mikroBUS standard. The mikroBUS™ socket comprises a pair of 1×8 female headers with a proprietary pin configuration and silkscreen markings. The pinout (always laid out in the same order) consists of three groups of communications pins (SPI, UART and I2C), six additional pins (PWM, Interrupt, Analog input, Reset and Chip select), and two power groups (+3.3V and 5V). The layout of the mikroBUS standard chip can be seen in Figure 2.

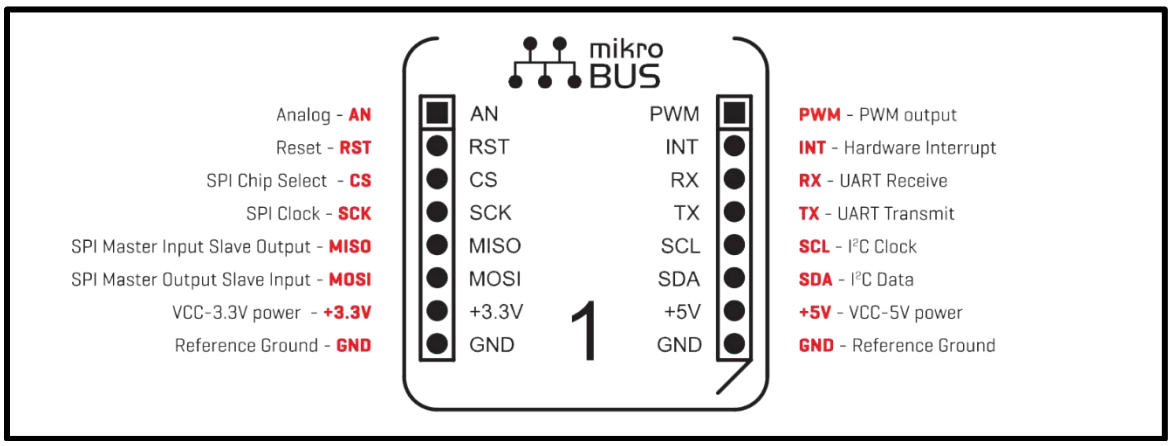

Figure 2: The mikroBUS standard layout

The following list of features provides the 10 selected Clicks that will be made compatible with the FRDM-KL46Z for the scope of the project.

Features	Performance Targets	Price
Temp&Hum 2 Click	Measures a wide range of temperature and relative humidity values with a great accuracy • 1.8 V Power supply • I2C interface	$16.00
Weather Click	Detects humidity, pressure, and temperature • 3.3V Power supply • SPI or I2C interface	$22.00
Color 5 click	Integrated color sensing device • 3.3V and 5V Power supply • I2C interface	$16.00
BarGraph 2 Click	10-segment bar graph display click, which uses a high-quality, multicolor bar graph LED display • 3.3V Power supply • PWM or SPI interface	$19.00
Accel 5 click	Triaxial accelerometer sensor • 3.3V Power supply • I2C or SPI interface	$19.00
Gaussmeter click	Gaussmeter click is a device that is used for measuring the magnetic field in X, Y and Z axes • 3.3V Power supply • I2C or SPI interface	$19.00
LightRanger 3 Click	Accurate distance measurement based on a ToF (Time of Flight) measurement principle • 3.3 V Power supply • I2C interface	$24.00
Alcohol Click	Portable alcohol detector, breathalyzer for estimating BAC • 3.3V Power supply • Analog interface	$15.00
Air Quality Click	detecting a variety of gases that impact air quality in homes and offices • 3.3V Power supply • Analog interface	$16.50
microSD click	A microSD card slot for microSD cards used as a mass storage media for portable devices • 3.3 V Power supply • SPI interface	$16.00

Reference:

- https://www.mikroe.com/click
- https://www.mikroe.com/mikrobus

4. PROJECT SCOPE DESCRIPTION

Alfonso de la Morena:

Project Schedule – Fall 2018				
Task	**DRI**	**Duration, Wks**	**Start**	**End**
Define Project Scope • Approval by Sponsor • Approval by Instructor	Alfonso	2	09/01/18	09/12/18
Research • $30 Budget for each teammate for educational tools on subject	Alfonso	36	09/01/18	05/01/18
Hardcopy Statement of Work	Alfonso	2	09/10/18	09/24/18
Hardcopy Functional Spec	Alfonso	2	10/01/18	10/15/18
Design PCB • Collaborate with Dr. Stapleton	Mohamed	2	10/01/18	10/16/18
Design for MBED Interface • High level drawings • Class, Use Case, Sequence and State Diagrams	Dylan	4	10/01/18	10/31/18
Order PCB to be printed • Order 3 anticipating hardware failures	Mohamed	2	10/16/18	11/01/18
Updated Spec	Alfonso	2	10/22/18	11/05/18
Initial Website Layout • Aesthetics (no code necessary) • Include buttons and functions	Dylan	4	11/01/18	12/01/18
Test Working PCB • In lab with different inputs using power supply • Show results to Dr. Stapleton and get functional approval	Mohamed	4	11/01/18	12/01/18
Hardcopy Labor Cost Schedule	Alfonso	2	11/05/18	11/19/18
Draft Poster for Review • Design made in with template	Alfonso	2	11/12/18	11/26/18

• Use of whitespace to save ink				
Hardcopy Test Plan	Alfonso	2	11/16/18	11/30/18
Second Design-Manufacturing Cycle for PCB • In case of errors	Alfonso	6	12/01/18	1/15/19

Project Schedule – Spring 2019				
Signal reading interface for Mbed • Define input and outputs of all selected Clicks • Create method for software to identify Click	Dylan	4	01/16/19	02/16/19
Test I/O with 10 Clicks • Testing outputs in different environments	Mohamed	4	01/16/19	02/16/19
Design Website Skeleton • HTML/CSS • Use Node JS or Bootstrap framework	Alfonso	4	01/16/19	02/16/19
Finalize MBED code • Cleanup, debug and look for power optimizations	Dylan	2	02/16/19	02/30/19
Gather sample data for Clicks • Using existing Mbed Code	Mohamed	2	02/16/19	02/30/19
Implement Website Functionality • JavaScript • Tableau for graphs and statistical data	Alfonso	4	02/16/19	03/16/19
Full PCB and Clicks functionality test • Compare with Functional Spec requirements	Mohamed	5	03/01/19	04/16/19
Full Mbed code functionality test • Compare with Functional Spec requirements	Dylan	5	03/01/19	04/16/19
Full Website code functionality test • Compare with Functional Spec requirements	Alfonso	4	03/16/19	04/16/19

Full functionality test • Last chance to make sure all parts work together • Including debugging	Alfonso	3	04/16/19	05/09/19
Final Poster Review • Review Poster to match final product	Mohamed	2	04/16/19	05/9/19
Final Presentation Preparation • PowerPoint creation • Planned rehearsals with team	Dylan	2	04/16/19	05/9/19
Present on Senior Design Day	Alfonso	1/7	05/10/19	05/10/19
Post descriptions reports and source code in Mbed and NXP community forums	Alfonso	1	05/10/19	05/17/19

5. SPONSOR SUPPORT ELEMENTS

Dylan Dean:

Sponsor Support Elements		
Element	**First Needed**	**Needed Until**
Bi-Weekly meetings	09/01/18	05/10/19
Guided Visitation of NXP in Austin	TBD	TBD
Statement of Work Review and Signature	09/19/18	09/24/18
Technical Spec Review and Signature	10/8/18	10/15/18
Feedback on Poster and Product Display	11/19/18	11/26/18
Final Work Approval	04/16/19	05/09/19

6. APPROVALS

The signatures of the people below indicate an understanding in the purpose and content of this document by those signing it. By signing this document, you indicate that you approve of the proposed project outlined in this Statement of Work and that the next steps may be taken to create a Functional Specification and proceed with the project.

Approver Name	**Title**	**Signature**	**Date**
Alfonso de la Morena	Project Manager		
Vanessa Yanez	D2 Project Manager		
Dr. Stapleton	Faculty Sponsor		
Dr. Kemp	Sponsor		
Dr. Hinkle	Instructor		

CHECKLIST for Statement of Work

The Statement of Work is graded by your Lab Section Instructor. Grades are individual and NOT team.
Use this as a checklist before submitting your SOW. Comply with each item on this list to maximize your grade.

Elements:

1. **Title Page done correctly** ☐
   - ☐ Logos properly handled
2. **All instructions (red) deleted** ☐
3. **Written contributions of each team member clearly identified** ☐
4. **Table of Contents is correct**
   - ☐ Section numbers retained
   - ☐ Page numbers correct
   - ☐ No tries other than the 6 specified
5. **Executive Summary is clear and concise**
   - ☐ 1/2 to 3/4 of a page - no more
   - ☐ Outlines what you will produce
   - ☐ All bullet items on the template are addressed
6. **Business Need is short and concise**
   - ☐ Clearly states the value of this project
   - ☐ 1/2 a page or less
7. **Product Scope describes the product** (what you'll produce)
   - ☐ **KEY:** You thoroughly researched what your project entails
   - ☐ Key features and characteristics of what you'll design are listed
   - ☐ A table or bulletized list is used to describe the features
   - ☐ The performance is described
   - ☐ How the product meets the business needs
   - ☐ The section speaks only to what you'll produce
   - ☐ Course documents are NOT listed
   - ☐ You will have worked with your D2 Team, and your Sponsor and Faculty Sponsor
8. **Project Scope describes how you will do the project** ☐
   - ☐ A table is used to describe the major tasks needed to finish the project
   - ☐ They are scheduled in a way that makes sense
   - ☐ Each task has a Duration, Start, and End Date
   - ☐ The second semester is included
   - ☐ You show when parts or software is ordered
   - ☐ You show when a prototype will be ready for testing
   - ☐ You show realization that the project must be done (ready to test) before the Characterization Report is due
   - ☐ You will have worked with your D2 Team, and your Sponsor and Faculty Sponsor
9. **Sponsor Support Elements are complete and reasonable**
   - ☐ You thought about what you'd need from the Sponsor and listed each item
   - ☐ The items were general categories
     - Need specific microprocessor board - good
     - Need 10 ohm resistor - not good, too detailed
   - ☐ It is clear to the Sponsor exactly what is expected of them
10. **All signatures were present before submitting the SOW** ☐
    - ☐ You worked with your Sponsor in a timely fashion
    - ☐ You gave them plenty of time to review the SOW
    - ☐ Signatures were written, i.e., not typed in