LABORATORY MANUAL

SC1013 : Physics for Computing

[Location: Hardware Projects Laboratory, N4-01c-09]

Module 4 Experiment:

NFC - An Application of Electromagnetic Field

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COMPUTER ENGINEERING COURSE
COMPUTER SCIENCE COURSE

SCHOOL OF COMPUTER SCIENCE & ENGINEERING
NANYANG TECHNOLOGICAL UNIVERSITY

Near Field Communication (NFC) - An Application of Electromagnetic Field

1. OBJECTIVES

1.1 To investigate the transmission of data through electromagnetic induction between two loop antennas placed close to each other.

1.2 To investigate the effect of changing the antennas placement and shielding.

1.3 To implement a simple electronic lock using an NFC control.

2. LABORATORY

This experiment is conducted at **Hardware Projects Laboratory 1**, N4-01c-09, SCSE.

3. EQUIPMENT/COMPONENTS

1) PC installed with Arduino Desktop IDE software [1]

2) Arduino Uno Board and prototype shield.

3) MFRC-522 NFC reader and NFC card or NFC tag.

4) A piece of cardboard.

5) A piece of aluminium foil in a plastic envelope (do not remove the foil from the envelope).

4. INTRODUCTION

4.1 Near Field Communication (NFC) is a short-range, typically less than 10 cm, low data rate wireless communication system which uses electro-magnetic field induction to achieve contactless communication between two electronic devices. It uses an inductive coupling concept that is similar to the operating principle of a transformer. The magnetic field of two conductor coils, also refer to as antennas, provides the coupling effect of the polling device (reader) and the listening device (card) as illustrated in Figure 1.

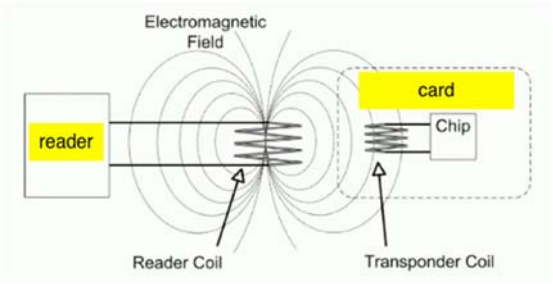


Figure 1: NFC system

Most NFC cards are passive devices which are powered by the field generated by the reader. When in close proximity, NFC establishes a communication link with identification protocols that ensure a secure data transfer. NFC enables users to perform intuitive, safe, contactless transactions, access digital content and connect electronic devices simply by touching or bringing devices into close proximity.

4.2 In this experiment, you will learn how to use Arduino Uno which is a microcontroller board, to control an NFC module and study its operation.

First you will learn how to write a simple program (a.k.a. sketch) to blink an LED on the Uno board using the Arduino Integrated Development Environment (IDE) software. Next, you will learn how to control the NFC reader using Arduino Uno and the correct approach to read the card. Finally, you will learn how to implement a simple application to emulate an electronic lock.

5. EXPERIMENT

5.1 Getting started with Arduino UNO – Blink an LED

5.1.1 Connect the Arduino Uno board to the PC's USB port with a USB printer cable and the red LED on the Uno board will light up as shown in Figure 2. The USB connection is used to program the Uno board as well as providing its power supply. Note: If the prototype shield is already stacked on the Uno board, you may leave the two boards connected.

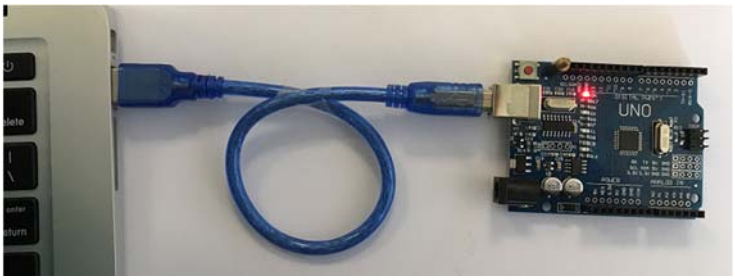


Figure 2: Uno-PC connection (without the prototype shield)

5.1.2 Run the Arduino IDE on the PC by clicking the icon . Note: the IDE window will automatically open the last sketch stored. You can ignore this sketch.

Click Tools -> Board -> Boards Manager, select the Arduino Uno board as shown in Figure 3.

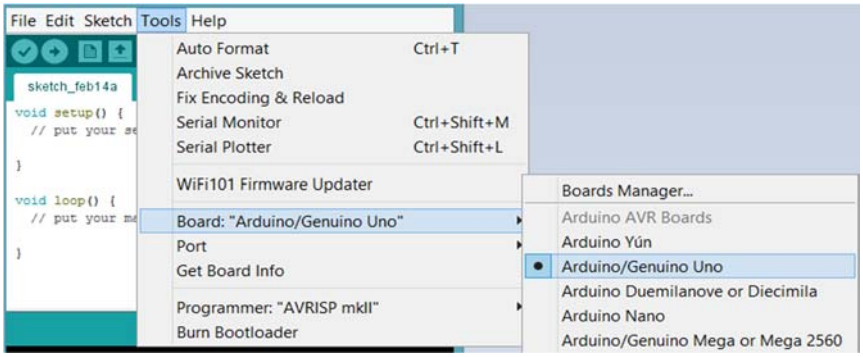


Figure 3: Select Arduino Uno

Next, select the serial device "COM10" from Tools -> Port -> Serial Ports as illustrated in Figure 4. Note: The assigned port number "COM#" may vary from PC to PC.

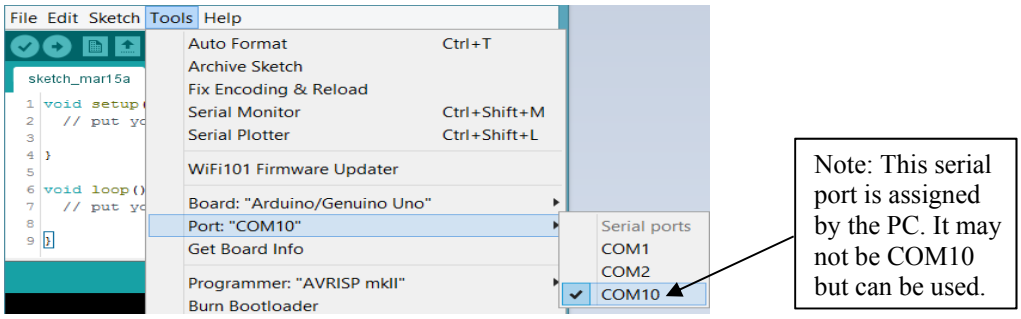


Figure 4: Select serial device

5.1.3 Type Ctrl+N or click on File -> New to create a new file. The IDE will open a new window filled with the two basic functions: setup() and loop() as shown in Figure 5. The 1st function setup() is where you put your initialization code which will run only once. The 2nd function loop() is the main program which will run repeatedly. Note: You can now close the first window with the last sketch stored that was open when you run the IDE in Step 5.1.2.

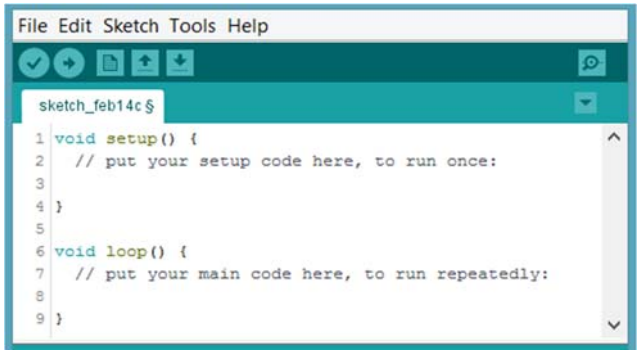


Figure 5: A new sketch

5.1.5 The Uno Board has a built-in LED connected to pin 13. Enter the codes as shown in Figure 6 into the two functions setup() and loop(). You may choose not to enter those text (i.e. comments) preceded by "//".

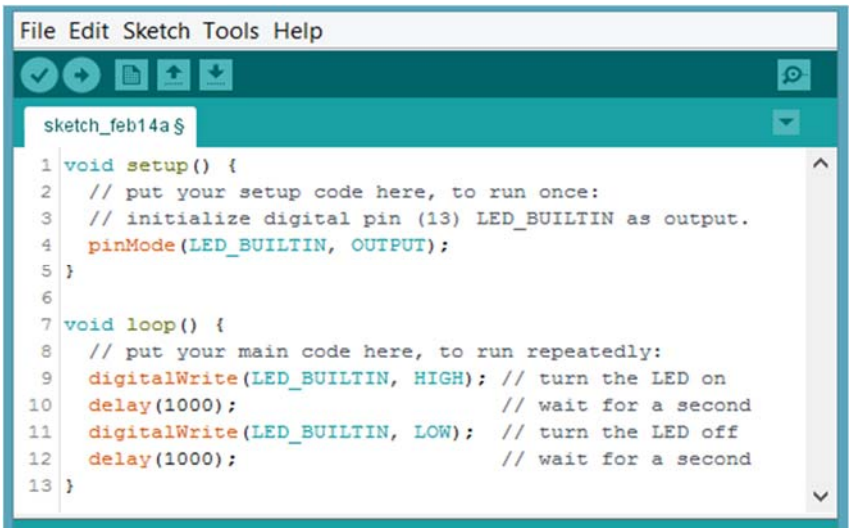


Figure 6: Blink LED program

5.1.6 Next, upload the program into the Uno board by typing Ctrl+U or click Sketch -> Upload. Upon completing the upload, the board will automatically execute the program. You will see the built-in LED blinking.

5.1.7 Change the values in the function delay() in lines 10 and 12 from 1000 to, say, both 500 or 2000 or different combinations. Recompile and upload the program by typing Ctrl-U for every change.

Comment on your observations: _____

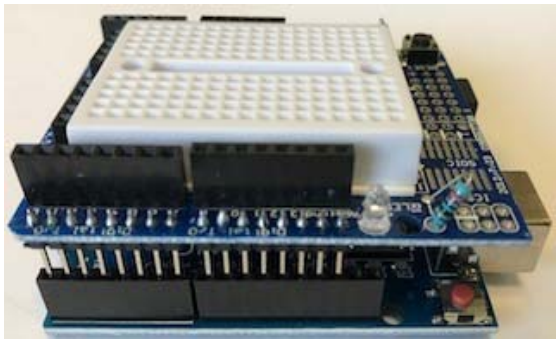
___(Record your observation on Page 8-Appendix for submission to Lab Instructor)____

_____

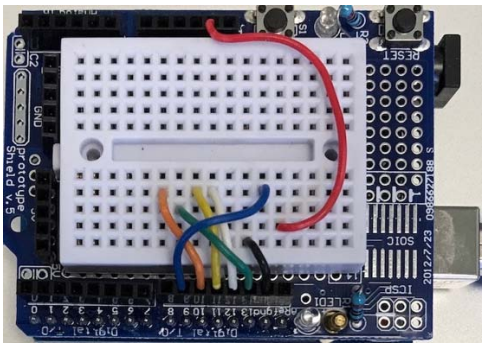
_____

5.2 Controlling the NFC module (reader)

5.2.1 First disconnect the USB cable so that the power supply to the Uno board is cut off. Next, stack the prototype board and press down firmly on the Uno board as shown in Figure 7(a). Then setup the connections on the prototype board as shown in Figure 7(b) and the table below. Note: you may use wires with colours differ from those in Figure 7(b). Ensure that the Red wire is connected to the 3v pin. Connecting it to a 5v pin may damage the NFC reader.



(a) Prototype board sits on Uno



(b) Connections

Wires:	Red	Black	Green	White	Yellow	Orange	Blue
Board pins:	3v	gnd	13	12	11	10	9

Figure 7: Connections on prototype board

Figure 8a: NFC reader connections

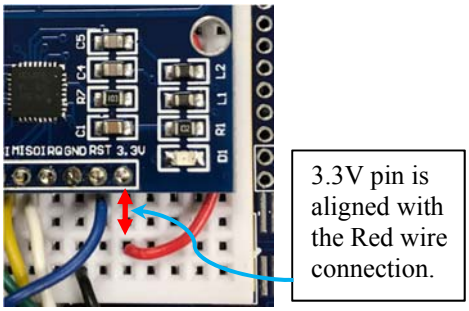


Figure 8b: 3.3V to Red wire connection

5.2.2 Insert the NFC reader as shown in Figure 8a. Ensure that its 3.3v pin is aligned with and connected to the red wire (Figure 8b) via the breadboard internal connection.

5.2.3 Ensure that the connections are correct before you reconnect the USB cable to power the Uno board. Open a new sketch by repeating Step 5.1.3.

5.2.4 Enter the codes as shown in Figure 9 into the new sketch. You may choose not to enter those comments preceded by "//".

File Edit Sketch Tools Help

Figure_9

```
#include <SPI.h>
#include <MFRC522.h>
MFRC522 mfrc522(10, 9);  // Create MFRC522 instance
byte MyID[4];            // array to store the card ID

void setup() {
  Serial.begin(9600);  // Initialize serial communications with the PC
  SPI.begin();         // Init SPI bus
  mfrc522.PCD_Init();  // Init MFRC522
  Serial.println("Ready! Present NFC card to display UID and Type ...");
}

void loop() {
  if ( ! mfrc522.PICC_IsNewCardPresent()) return;  // Look for new cards
  if ( ! mfrc522.PICC_ReadCardSerial()) return;    // Select one of the cards

// Read card ID and display it in hexadecimal numbers
  Serial.print("Card ID:");
  for (byte i=0; i<4; i++) {
    MyID[i] = mfrc522.uid.uidByte[i];
    Serial.print(MyID[i] < 0x10 ? " 0" : " ");
    Serial.print(MyID[i], HEX);
  }

// Read card type
  byte piccType = mfrc522.PICC_GetType(mfrc522.uid.sak);
  Serial.print("  Type: ");
  Serial.print(mfrc522.PICC_GetTypeName(piccType));
  Serial.println();

  mfrc522.PICC_HaltA();  // Stop reading
  }

```

Figure 9 NFC initiator program

5.2.5 Upload the codes into the Uno board by typing Ctrl+U or click Sketch -> Upload. When it is done, the board will automatically execute the program.

The IDE has a separate pop-up window called Serial Monitor that acts as a terminal communicating with the Uno board via the USB cable. Type Ctrl+Shift+M or click on Serial Monitor to activate the Serial Monitor. We will use this to monitor the output of the reader. Place the NFC card (or tag) on top of the reader and the Serial Monitor will display the card ID and the type.

Record the ID : _____ and the type : _____

5.2.6 Now lift the NFC card (or tag) to about 20cm above the reader and slowly move it closer to the reader until the monitor displays the ID and the type. See Figure 10a.

Record this distance: _____

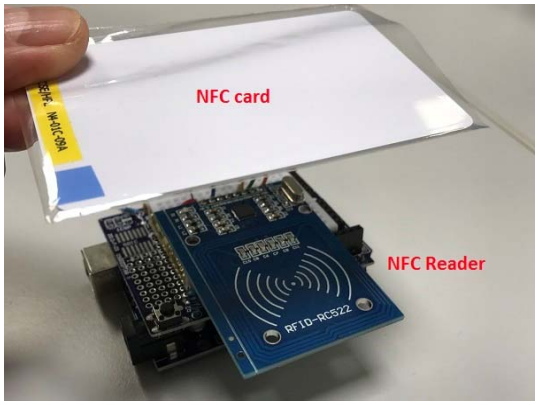


Figure 10a Illustration for Step 5.2.6.

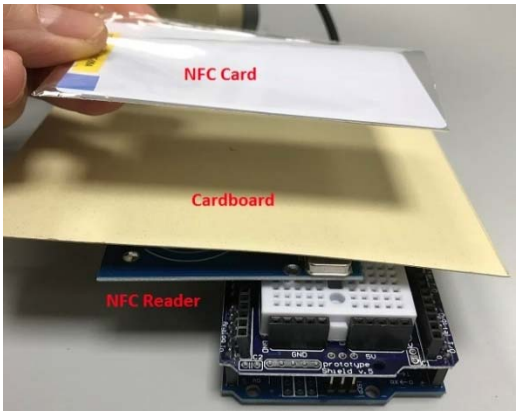


Figure 10b Illustration for Step 5.2.7.

5.2.7 Repeat Step 5.2.6 with the reader covered with a piece of cardboard. See Figure 10b.

Can the reader read the card? _____

5.2.8 Repeat Step 5.2.6 with the reader covered with the plastic envelope containing a piece of aluminium foil. The plastic envelope serves as an electrical insulation. Do not take the foil out of the plastic envelope. See Figure 11a.

Can the reader read the card? _____

Comment on your observations in Step 5.2.7 and 5.2.8 : _____

_____

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Figure 11a Illustration for Step 5.2.8.

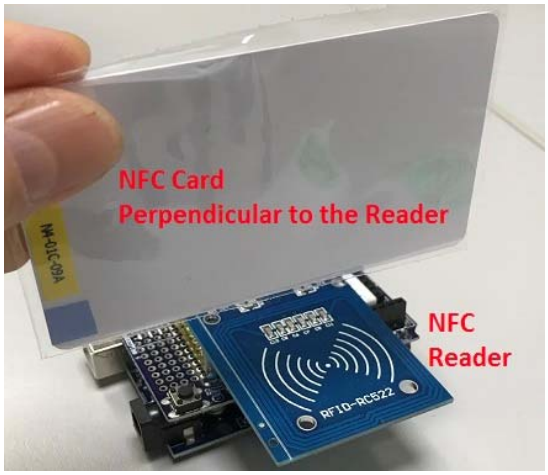

Figure 11b Illustration for Step 5.2.9.

5.2.9 Repeat Step 5.2.6 by presenting the NFC card (or tag) perpendicular to the reader. See Figure 11b.

Comment on your observations: _____

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5.3 Implementation of an electronic lock

5.3.1 A simple electronic lock can be implemented by reading the ID of a valid NFC card (or tag) and compare it with a preset value. The following code segment can be used to validate the card ID:

```
// Compare the card ID with a preset value, eg: 4D 73 0A 85
  if  ( *(uint32_t*) MyID == 0x850A734D )   // note the order of the ID data byte
  Serial.println("Correct card: Unlock");    // valid card ID
  else
  Serial.println("Unknown card: Access Denied");    // invalid card ID
```

Insert the above code segment at an appropriate location in the NFC initiator program of Figure 9. You will need to replace the preset value with your card ID as earlier recorded in Step 5.2.5. Compile and upload the program to the Uno board.

5.3.2 Present your NFC card (or tag) to the reader and record the display of the serial monitor:

_____

_____

5.3.3 Now borrow a NFC card (or tag) from someone next to you and present the card to the reader. Record the display shown on the serial monitor:

_____

_____

5.4 Disconnect all connections and remove all wires from the prototype shield.

6. REFERENCES

[1] www.arduino.cc/en/Main/Software

Appendix

Name: _____ Bench No:_____ Lab Group: _____

Record your observation and submit this page to your lab instructor at the end of the lab session.

5.1.7 Change the values in the function delay() in lines 10 and 12 from 1000 to, say, both 500 or 2000 or different combinations. Recompile and upload the program by typing Ctrl-U for every change.

Comment on your observations: _____

_____

_____

_____

5.2.5 Record the ID : _____ and the type : _____

5.2.6 Now lift the NFC card to about 20cm above the reader and slowly move it closer to the reader until the monitor displays the ID and the type.

Record this distance: _____

5.2.7 Repeat Step 5.2.6 with the reader covered with a piece of cardboard.

Can the reader read the card? _____

5.2.8 Repeat Step 5.2.6 with the reader covered with the plastic envelope containing a piece of aluminium foil.

Can the reader read the card? _____

Comment on your observations in Step 5.2.7 and 5.2.8 : _____

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5.2.9 Remove the plastic envelope containing the foil, repeat Step 5.2.6 by presenting the NFC card perpendicular to the reader.

Comment on your observations: _____

_____

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5.3.2 Present your NFC card to the reader and record the display of the serial monitor:

_____

_____

5.3.3 Now borrow a NFC card from someone next to you and present the card to the reader. Record the display shown on the serial monitor:

_____

_____