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Secure Communication between Two Devices Using MATLAB with Encrypted Des Algorithm and Arduino Board

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ABSTRACT: We are living in the information age. We need to keep information about every aspect of life and that information need to be secured from attacks. To be secured information needs to be hidden from unauthorized access (confidentiality), protected from unauthorized change (integrity), and available to an authorized entity when it is needed (availability). Information is now distributed but these three requirements have not changed. Large amount of data has been vitiated in the coming years therefore data security has become the most important aspect of information sharing. More private data is stored in the cloud. Practically, the quantity of data to be transferred is not the concern. The important factor is the channel, through which the data is transferred, should be secured. Cryptography is one such technique which is can ensure for secure transmission of the data. And, using cryptographic techniques security can be provided to the information**.** Cryptography's main advantage is that the information is somehow distorted, scrambled by the sender, an encryption key is known only by the intended receiver who decrypts the message. This research work classifies the security between two devices in communication using Data Encryption Standard (DES) Algorithm with arduino. Arduino simplifies the communication between hardware and software development in order to get a system running interactively. It is a safe communication technique. DES Algorithm's main advantage is that other users will not know what type of communication is held between the 2 user and it is hard to crack .Communication in MATLAB with Arduino Hardware, we use this to communicate effectively with an Arduino board. This enables to perform tasks such as: Acquire analog and digital sensor data from Arduino board and Communicate with an Arduino board over a USB cable or wirelessly in Wi-Fi. Build customs to interface with additional hardware and softwares.MATLAB is a high level language. In this we can see results from I/O instructions immediately, without compiling. MATLAB allows matrix manipulation, Implementation of algorithm, thousands of built-in math, engineering, Plotting of function and data that use to quickly analyse and visualize data collected from Arduino, or any hardware.

KEYWORDS: SECURE COMMUNICATION, ENCRYPTION ALGORITHM, DES, COMMUNICATION THROUGH MATLAB, COMMUNICATION THROUGH ARDUINO HARDWARE, MATLAB, ARDUINO.

I. INTRODUCTION

With the emergence of large amount of data, the need of data security is become primary concern for the users. In cloud computing there are concerns with the safety and privacy of important data stored remotely, more and more private digital data has been put into the cloud and this data is accessed through many kinds of devices. The possibility of private data immingle with other organizations makes some businesses unstable or insecure. All this brings into a situation where data security plays a significant role.

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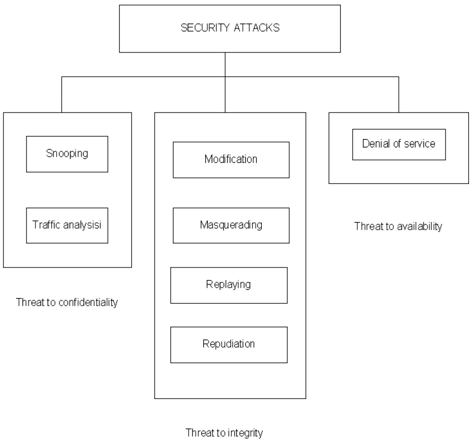

Fig 1: Taxonomy of attacks with relation to security goal

Fig 1 shows a modern block cipher encrypts an n-bit block of plaintext or decrypts an n-block of cipher text. The decryption algorithm is the inverse of encryption algorithm and both operations are use with the same secret key so that receiver retrieves the message sent by sender. The encryption or decryption algorithm uses a k-bit key in order to get secure key-exchange channel.

A. **Plain Text**: The original text or message used in communication in called as Plain text For example Hello world is an example of a simple plain text.
B. **Cipher Text**: Any un-readable message that is obtained from a plain text is a cipher text.
C. **Encryption**: Encryption is used to convert Plain text into cipher text. This un-readable message can be communicated over any communication channel without the fear of the loss of confidentiality and integrity. Encryption process is done using encryption algorithm with the help of a key.
D. **Decryption**: Decryption process is just the opposite of encryption process, i.e. cipher text is converted into plain text using a particular decryption algorithm.
E. **Key**: A key is a numeric or Alpha-numeric text. It acts on the plain text through encryption algorithm to encrypt the text and on cipher text through decryption algorithm to decipher the text. Encryption or Cryptography have some goals that needs to be fulfilled for user benefit.

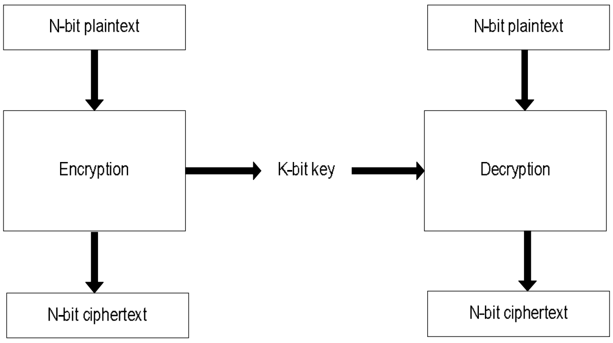

Fig 2: Encryption-decryption between two devices

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II. SCOPE OF RESEARCH

Data security is our main concern in these days. Three goals of security is –confidentiality, integrity, and availability can be threatened by security attacks which people come across in day to day life. Nowadays PM Narendra Modi encourages making INDIA a DIGITAL INDIA. For this we need to concern over the security and prevent us from attacks like identity theft, masquerading, spoofing, sabotage, software attacks and information extortion. All these attacks must be handled in an efficient way such that only intended users could access the private data and unauthorized users should be blocked from using the data.The encryption process is followed by all the algorithms which are defined under this category. In encryption techniques algorithms like Advanced Encryption Standard (AES), Data Encryption Standard (DES), Blowfish, Rivest Shamir Adlemen (RSA), DiffieHelman and attribute-based encryption algorithms have been defined. Since DES is vulnerable to brute force attacks therefore it is proven inadequate in terms of security. The DES algorithm has been modified (called M-DES) Modified- Data Encryption Standard, to improve the Bit Error Rate (BER) rate caused due to avalanche effect and is made more secure so that it can be used in wireless communication.

A. **DES ALGORITHM:** Our project is based on the Data Encryption Standard (DES) algorithm that is aSymmetric - key block cipher. DES is an implementation of a Feistel Cipher.It uses 16 round Feistel structure. The block size is 64-bit. Key length is 64-bit andDES has an Effective key length of 56 bits, since 8 of the 64 bits key are not used bythe Encryption algorithm (function as check bits only).

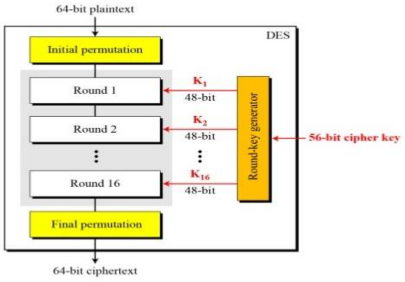

Fig 3: General structure of DES

INNER WORKING OF DES: Fig shows the element of DES cipher at the encryption site. Initial permutation takes 64-bit input and permutes them according to a predefined rule. The permutation is the inverse of the initial permutation. These two permutation cancel the effect of each other. In other words, if the rounds are eliminated from the structure, the cipher text same as the plaintext.Rounds: DES uses 16 rounds. Each rounds of DES is an invertible transformation, as shown in fig 3.2. The round takes L_{i-1} and R_{i-1} from the previous round (or the initial permutation box). Each round can have up to two cipher elements (mixer and swapper). Each of these elements is invertible because of the Xor operation. All noninvertible elements are collected inside the function$f(R_{i-1,\ K_i})$.

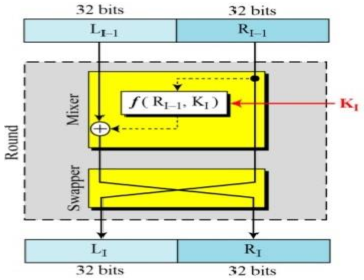

Fig 4: DES each rounds

DES Function: The heart of DES is DES function. The DES function applies a 48-bit key to the rightmost 32 bits (R_{i-1}) to produce a 32-bit output.Made up of four sections: an expansion of P-box, a whitener (that adds a key), a group of S-boxes, and a straight P-box, as shown in fig.

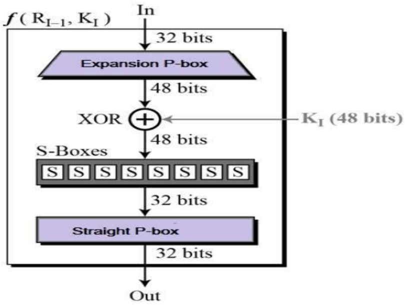

Fig 5: DES function block diag

III. PROPOSED METHODOLOGY AND DISCUSSION: HARDWARE

A. ARDUINO UNO BOARD

Introduction: Arduino is an open source microcontroller which can be easily erased, programmed and reprogrammed at any instant of time. It is introduced in 2005. The Arduino platform was found an inexpensive and easy way for students and professionals to create devices that interact with their surroundings using sensors and actuators. It is an open source computing platform that is used for constructing and programming electronic devices. It is based on simple microcontroller boards and also capable of acting as a mini computer just like other microcontrollers by taking inputs and controlling the outputs for various electronics devices.

It is also susceptible to receive and send information over the internet with the help of various Arduino shields. Arduino uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment).Arduino is Built up with the 8-bit Atmel AVR microcontroller's that are manufactured by Atmel or a 32-bit Atmel ARM, these microcontrollers can be programmed easily using the C, C++ or MATLAB language in the Arduino IDE.

The development of Arduino board now also be used to burn a new code to the board by simply using a USB cable to upload.

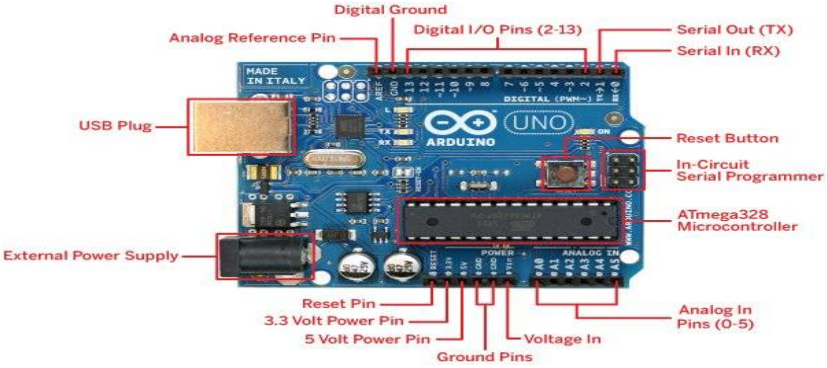

Fig 6:Pin description of an Arduino board

Arduino UNO consists of following component: we can see the reference circuit of Arduino board.

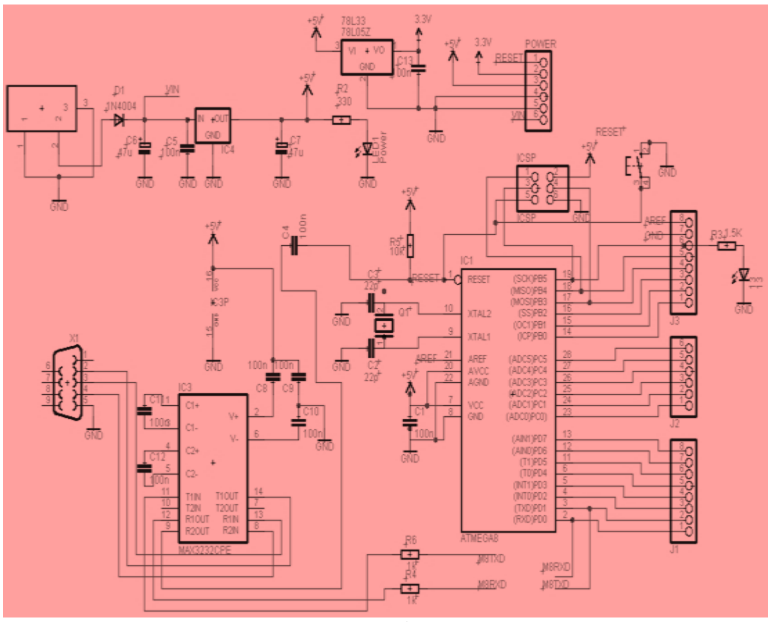

Fig 8: Arduino reference circuit

ATMEGA 328: The Atmega328 is a popular microcontroller chip produced by Atmel. It is a main is of Arduino board or we can say it is the brain of Arduino. It is an 8-bit microcontroller and has 32K of flash memory, 1K of EEPROM, and 2K of internal SRAM. Atmega328 is one of the microcontroller chips that are used with the popular Arduino boards. The Arduino board comes with any 1 or 2 microcontroller chips, the Atmega168 or the Atmega328.

The Atmega328 has 28 pins. It has 14 digital I/O pins, of which 6 is used as PWM outputs and 6 analog input pins. 2 of the pins are crystal oscillator. This is used to provide a clock pulse for the Atmega chip. There is a need of clock pulse for synchronization so that communication can occur between the Atmega chip and a device effectively that it is connected to. The chip is needed power so 2 of the pins, Vcc and GND that provide it power so that it can operate. The Atmega328 is a low-power chip, so it is only needed between 1.8-5.5V of power to operate.

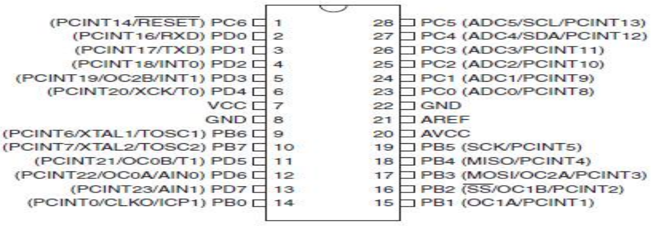

Fig 9: ATMEGA 328 pin description

Power LED Indicator: It is to the right of the word “UNO” on the Arduino circuit board, there’s a tiny LED next to the word ‘ON’. This LED is light up whenever you plug your Arduino into a power source. If this light doesn’t turn on it means there’s a chance that something is wrong.

TX-RX LED: TX is for transmit, RX is for receive. This appears a bit in electronics to indicate that these pins are responsible for serial communication. Two places on the Arduino UNO where TX and RX appear – once by digital

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pins 0 and 1, and a second time next to the TX and RX indicator LEDs. These LEDs will give us some nice visual indications when our Arduino is receiving or transmitting data.

Voltage Regulator: It is not only something you can interact with on the Arduino but also it is useful. The voltage regulator does exactly what its name says – it controls the amount of voltage i.e. let into the Arduino board. It is kind of gatekeeper that will turn away an extra voltage that might harm the circuit. Yes, it has its limits-not greater than 20v.

B. HC-05 BLUETOTH MODULE: Bluetooth is a type of wireless communication that is used to transmit voice and data at high speed using radio waves. It is used for short range radio communications between many different types of devices, including mobile phones, computers and other electronics devices. Bluetooth range is around 10 meters and data transfer rate is 3 Mbps.HC-05 is a more capable module that can be set as either Master or Slave.HC-06 is a Slave only device. It is not use as Master It looks just like the HC-05. HC-05 and HC-06 both small 3 cm long modules can run on 3.3V power with 3.3V signal levels. Two types of modes of operation is used, first is Command Mode in which we can send AT commands to it and Data Mode where we can transmits and receives data from another Bluetooth module."Breakout" Boards make these easy to use. These mount the sub-module like that shown on the right on a slightly larger board. Mostly these boards support operation at 5V power and interface with 5V Arduino signal levels. A typical "breakout" board is shown in figure: 4.5.

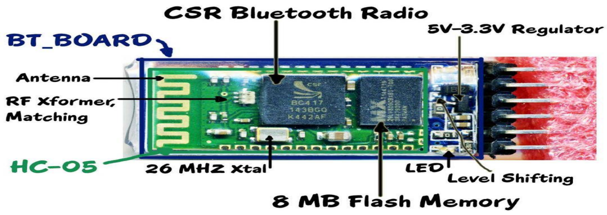

Fig 10: HC-05 Bluetooth module

C. **CONNECTING: HC-05 MODULE AND ARDUINO BOARD:**In order to do this we need to follow below steps:

Step-1: HC-05 is a serial port module that's why it is very easy to use.

- Connect VCC with 3.3V of Arduino; do not connect it with 5V because that can cook the module.
- Connect GND with any GND of Arduino
- Connect Rx pin of Bluetooth with Tx of Arduino
- Connect Tx pin of Bluetooth with Rx of Arduino
- Then power-up the Uno using USB cable, a red light LED on HC-05 will start blinking that means connections are correct.

Step-2: Connect the LED and Control It Using Arduino Serial Monitor.

Step-3: Send Serial Command to Arduino Using Monitor (or Any Terminal).

Step-4: Get HC-5 to Work With Arduino and Test the Communication.

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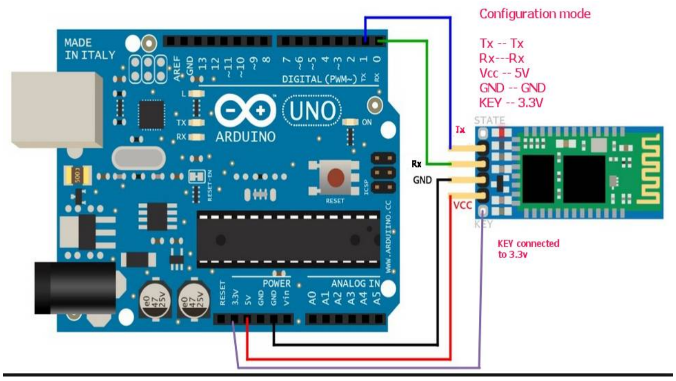


Fig 11:Connection between HC-05 Bluetooth module-Arduino

IV. PROPOSED METHODOLOGY AND DISCUUSION: SOFTWARE: MATLAB

MATLAB is a short form of MATrix LABorator. It is a programming package and makes quick and easy scientific calculations and I/O. It has hundreds of built-in functions for various computations and many toolboxes designed for specific research, including statistics, optimization, solution of partial differential equations and data analysis. For communication between two devices in matlab, you need a sound knowledge in basics of MATLAB commands and several advanced features.

SIMULATION IN MATLAB :Simulation is the initiation of the operation of real world process. Simulation modeling is applied methodology which describes the behavior of a system, conduct theories or hypotheses that account for the observed behavior and then use these theories to predict future behavior.fig 5.5 shows simulink window.

Arduino Serial Transmission Model In Simulink Matlab: In Simulink use the play button, and run another model on the Arduino using the "Tools->Run on Target Hardware->Run" option.I have included two models which perform this functionality. The transmitting model is called "SerialSend" and the receiving model is called "ArduinoReceive". The SerialSend model should be run by using the play button while the ArduinoReceive model should be run by selecting "Tools->Run on Target Hardware->Run" to push code to the Arduino. The transmitting model sends a pulse with values of 2 and 3. The pulse has a period of 4 seconds with a 50% duty cycle. In the receiving model just checks to see if the value sent is a 2 or 3 and sends a corresponding Boolean to pin 13. On the Arduino Mega 2560 and Uno this will cause the corresponding onboard LED to blink with a period of 4 seconds.

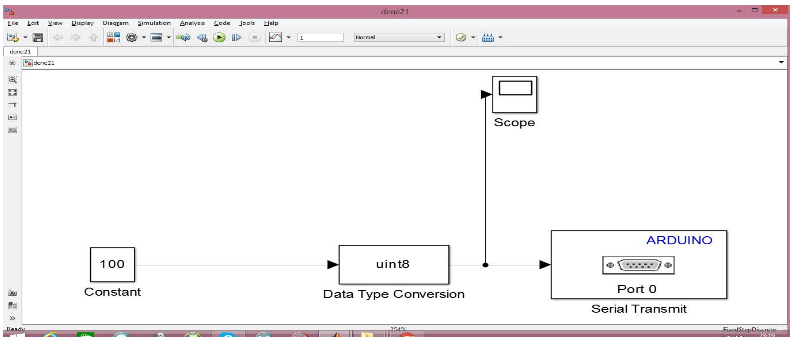


Fig 12:Arduino Serial Transmission model in Simulink

V. EXPERIMENTAL RESULTS WITH FIGURE AND CODING IN MATLAB

ARDUINO-HC05: MASTER SLAVE SET UP: In the setup- at the master, we set the LED pin as output and set it low right away, and then start the serial communication at 9600 baud rate. Similar, at the slave, we set the button pin as input and define the servo to which pin is connected and start the serial communication with the same baud rate.In the loop section, in both code, with the Serial.available() function we check whether there is available data in the serial port to be read and using the Serial.read() function we will read and store the data into the “state” variable. So if the master receive the character ‘1’ which is sent from the slave when the button state is high, or the button is pressed, the LED will be on. Else if the character is ‘0’ the LED will be off.

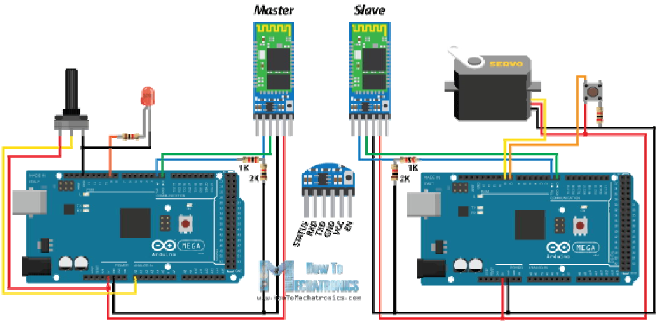


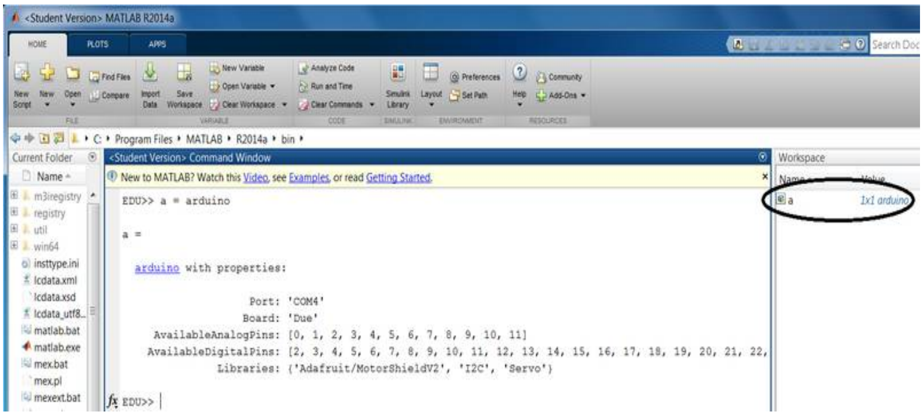
Fig 13:ARDUINO-HC05: Master-slave: Hardware set up

HOW TO CONNECT ARDUINO BOARD WITH MATLAB: Now we are going to create simple MATLAB m-files to talk to our Arduino board. lets you use MATLAB to communicate with your board through USB cable.

Step 1: Select Arduino from a list of support packages then click Next to see a list of support packages and select Arduino from the list for MATLAB Support Package and Arduino Due for the Simulink Support Package.

Step 2: Then click next and log in to Math work account then continue and complete the installation. Step 3: To (>> a = arduino on between MATLAB and Arduino boards, the following command can be used from MATLAB.

This command connects MATLAB to the first Arduino detected on the system. A MATLAB variable by the name 'a' should now appear on the workspace or an error message indicating what went wrong.



New to MATLAB? Watch this Video, see Examples, or read Getting Started.

```
EDU>> a = arduino

a =

  arduino with properties:

                   Port: 'COM4'
                  Board: 'Due'
    AvailableAnalogPins: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11]
   AvailableDigitalPins: [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22,
              Libraries: {'Adafruit/MotorShieldV2', 'I2C', 'Servo'}

fx EDU>>
```

Fig 13:MATLAB-ARDUINO Connection preparation

```
>> writeDigitalPin(a, 9, 1)
```

To switch on the LED connected to Pin 9 on the Due, execute the following command

Then we are sending a request from MATLAB to Arduino, to write on the Digital Pin 9 the value of 1. This will switch ON your LED. To blink the LED, we have to switch it ON and OFF periodically.

```
for i = 1:10
    writeDigitalPin(a, 9, 1);
    pause(0.5);
    writeDigitalPin(a, 9, 0);
    pause(0.5);
 end
```

Step4 : Now we mention the COM port at which the Due is connected to the computer.

```
>> a = arduino('COM4', 'Due')
```

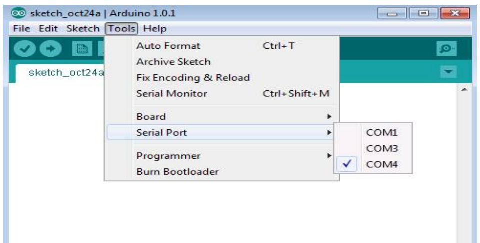


Fig 14:Tool-COM4 is selected for MATLAB-ARDUINO Connection

Step 5: Now we can ready to serial communication between MATLAB and Arduino.

VI. CONCLUSION

The thesis presents a introduction and analysis of all encryption algorithm like DES, AES, RSA and discussed about the types of cryptography. And complete analysis of DES algorithm. Then define the ARDUINO board and HC-05 Bluetooth module and make the connection between them to create master-slave circuit. In this we also talk about MATLAB and discussed the basic operation. Then finally connect the hardware to software. Establish the connection between MATLAB and Arduino-HC05 Bluetooth module then communicate between two devices using MATLAB through master and slave connection via USB cable.

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BIOGRAPHY

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