Introduction to Arduino IDE and getting started with the ESP32 microcontroller

# Part 4: Receiving strings from the computer and string manipulation to extract values from the string

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# Introduction

- Receiving strings from the computer and string manipulation to extract values from the string. Walk-through example. Send the extracted values back to the PC:

1. The microcontroller receiving and sending serial data using serial communications (UART).
2. The microcontroller receiving strings.
3. The microcontroller extracting values from a string.
4. The microcontroller formatting and transmitting data.
5. Walkthrough example using the Arduino IDE Serial Monitor and then in Python.

# Receiving and transmitting a single byte (1)

- Arduino serial communication function:
  - https://www.arduino.cc/reference/en/language/functions/communication/serial/
- The microcontroller UART set-up with a Baud rate of 9600.
- The UART is checked (polled) to see if a byte has been received. If received, the byte is read and transmitted back to the computer as the value and also as the ASCII character code.
- The code is in the Arduino Sketch part_4_single_byte.
- Watch the video part_4_single_byte_video.mp4 to see the code in operation. This code also toggles the on-board LED when a byte is received (the LED code is not shown in the code to the right).

```
int incomingByte = 0;


void setup( void )
{

  Serial.begin(9600);

}


void loop( void )
{

  if ( Serial.available() > 0 )
  {
    incomingByte = Serial.read();
    Serial.print( "Byte received: " );
    Serial.println( incomingByte );
    Serial.print( "Byte received ASCII code decimal: " );
    Serial.println( incomingByte, DEC );
    Serial.print( "Byte received ASCII code hexadecimal: " )
    Serial.println( incomingByte, HEX );
  }

}
```

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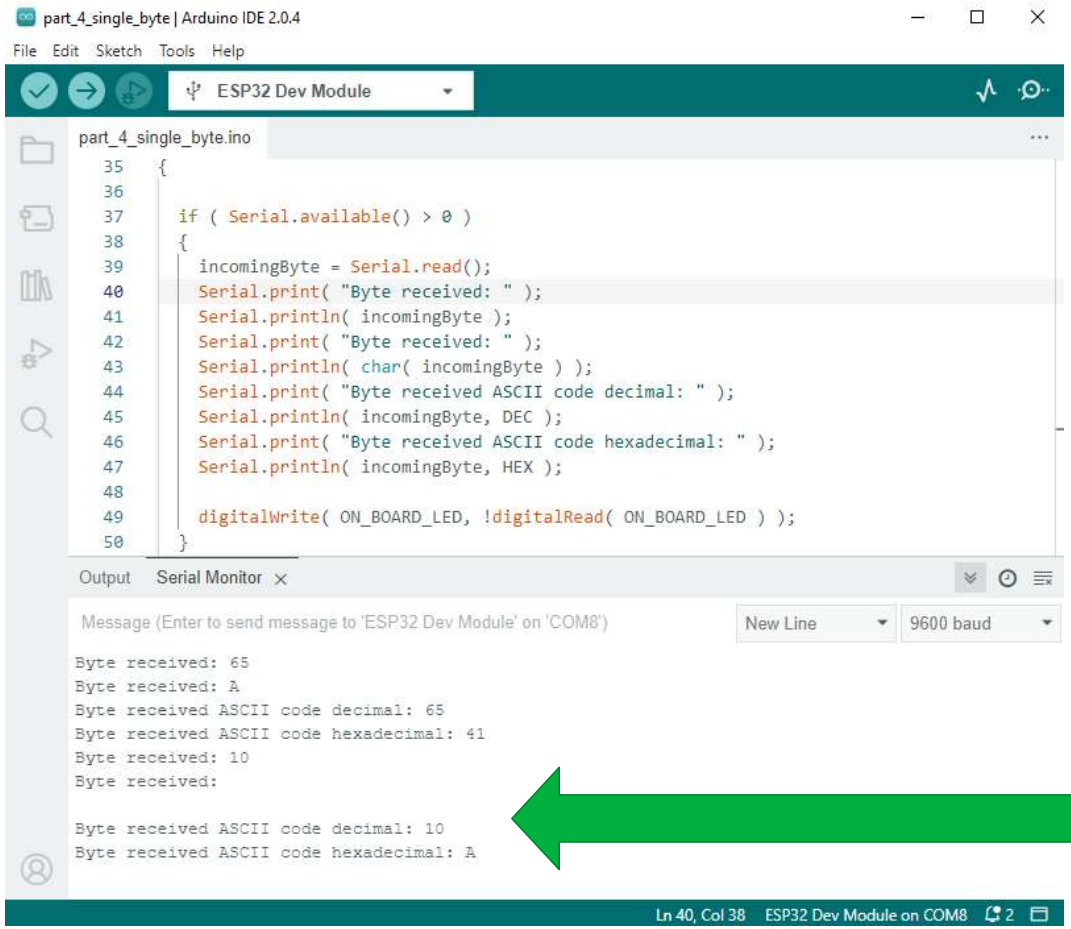
# Receiving and transmitting a single byte (2)




```
    Serial.print( "Byte received: " );
    Serial.println( incomingByte );
    Serial.print( "Byte received: " );
    Serial.println( char( incomingByte ) );
    Serial.print( "Byte received ASCII code decimal: " );
    Serial.println( incomingByte, DEC );
    Serial.print( "Byte received ASCII code hexadecimal: " );
    Serial.println( incomingByte, HEX );
```

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# ASCII code

- ASCII: American Standard Code for Information Interchange.
- ASCII is a 7-bit character set containing 128 characters.
- Extended ASCII is an 8-bit character set containing 256 characters.
- ASCII Table:
  - https://commons.wikimedia.org/wiki/File:ASCII-Table-wide.pdf

## ASCII TABLE

| Decimal | Hex | Char | Decimal | Hex | Char | Decimal | Hex | Char | Decimal | Hex | Char |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | [NULL] | 32 | 20 | [SPACE] | 64 | 40 | @ | 96 | 60 | ` |
| 1 | 1 | [START OF HEADING] | 33 | 21 | ! | 65 | 41 | A | 97 | 61 | a |
| 2 | 2 | [START OF TEXT] | 34 | 22 | " | 66 | 42 | B | 98 | 62 | b |
| 3 | 3 | [END OF TEXT] | 35 | 23 | # | 67 | 43 | C | 99 | 63 | c |
| 4 | 4 | [END OF TRANSMISSION] | 36 | 24 | $ | 68 | 44 | D | 100 | 64 | d |
| 5 | 5 | [ENQUIRY] | 37 | 25 | % | 69 | 45 | E | 101 | 65 | e |
| 6 | 6 | [ACKNOWLEDGE] | 38 | 26 | & | 70 | 46 | F | 102 | 66 | f |
| 7 | 7 | [BELL] | 39 | 27 | ' | 71 | 47 | G | 103 | 67 | g |
| 8 | 8 | [BACKSPACE] | 40 | 28 | ( | 72 | 48 | H | 104 | 68 | h |
| 9 | 9 | [HORIZONTAL TAB] | 41 | 29 | ) | 73 | 49 | I | 105 | 69 | i |
| 10 | A | [LINE FEED] | 42 | 2A | * | 74 | 4A | J | 106 | 6A | j |
| 11 | B | [VERTICAL TAB] | 43 | 2B | + | 75 | 4B | K | 107 | 6B | k |
| 12 | C | [FORM FEED] | 44 | 2C | , | 76 | 4C | L | 108 | 6C | l |
| 13 | D | [CARRIAGE RETURN] | 45 | 2D | - | 77 | 4D | M | 109 | 6D | m |
| 14 | E | [SHIFT OUT] | 46 | 2E | . | 78 | 4E | N | 110 | 6E | n |
| 15 | F | [SHIFT IN] | 47 | 2F | / | 79 | 4F | O | 111 | 6F | o |
| 16 | 10 | [DATA LINK ESCAPE] | 48 | 30 | 0 | 80 | 50 | P | 112 | 70 | p |
| 17 | 11 | [DEVICE CONTROL 1] | 49 | 31 | 1 | 81 | 51 | Q | 113 | 71 | q |
| 18 | 12 | [DEVICE CONTROL 2] | 50 | 32 | 2 | 82 | 52 | R | 114 | 72 | r |
| 19 | 13 | [DEVICE CONTROL 3] | 51 | 33 | 3 | 83 | 53 | S | 115 | 73 | s |
| 20 | 14 | [DEVICE CONTROL 4] | 52 | 34 | 4 | 84 | 54 | T | 116 | 74 | t |
| 21 | 15 | [NEGATIVE ACKNOWLEDGE] | 53 | 35 | 5 | 85 | 55 | U | 117 | 75 | u |
| 22 | 16 | [SYNCHRONOUS IDLE] | 54 | 36 | 6 | 86 | 56 | V | 118 | 76 | v |
| 23 | 17 | [ENG OF TRANS. BLOCK] | 55 | 37 | 7 | 87 | 57 | W | 119 | 77 | w |
| 24 | 18 | [CANCEL] | 56 | 38 | 8 | 88 | 58 | X | 120 | 78 | x |
| 25 | 19 | [END OF MEDIUM] | 57 | 39 | 9 | 89 | 59 | Y | 121 | 79 | y |
| 26 | 1A | [SUBSTITUTE] | 58 | 3A | : | 90 | 5A | Z | 122 | 7A | z |
| 27 | 1B | [ESCAPE] | 59 | 3B | ; | 91 | 5B | [ | 123 | 7B | { |
| 28 | 1C | [FILE SEPARATOR] | 60 | 3C | < | 92 | 5C | \ | 124 | 7C | \| |
| 29 | 1D | [GROUP SEPARATOR] | 61 | 3D | = | 93 | 5D | ] | 125 | 7D | } |
| 30 | 1E | [RECORD SEPARATOR] | 62 | 3E | > | 94 | 5E | ^ | 126 | 7E | ~ |
| 31 | 1F | [UNIT SEPARATOR] | 63 | 3F | ? | 95 | 5F | _ | 127 | 7F | [DEL] |

| Decimal | Hex | Char |
|---|---|---|
| 64 | 40 | @ |
| 65 | 41 | A |
| 66 | 42 | B |
| 67 | 43 | C |

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# Receiving multiple bytes with a termination character (1)

- Serial communications will send data one byte at a time.
- Where multiple bytes are to be received by the microcontroller in “one go”, such as in a string of text, each byte in the string would be received and put into a character array variable within the code (a String in Arduino code).
- The microcontroller needs to know when the string ends, so a termination character, such as the end of line character ( \n ) will be used to identify the end of the string. For example:

This is a string\n

- T is transmitted first and \n is transmitted last.
- The Arduino Serial Monitor can insert the \n character or the code writer can insert this with code.

# Receiving multiple bytes with a termination character (2)

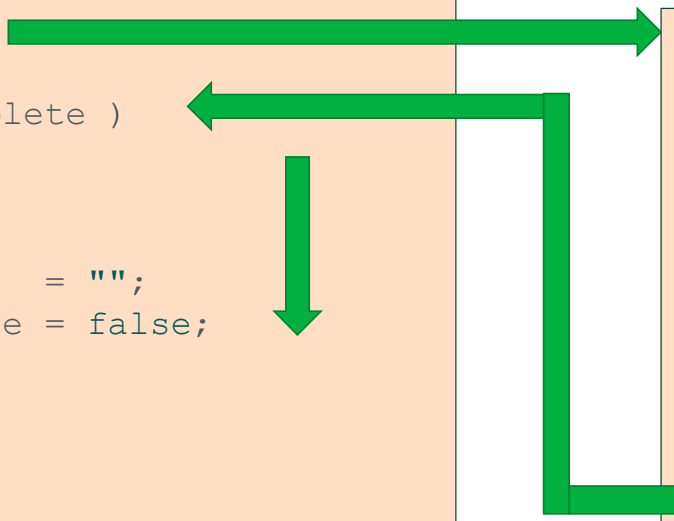
```
String  input_string     = "";
boolean string_complete  = false;
```

```
void loop( void )
{

  serial_event();

  if ( string_complete )
  {
    Serial.print( "String received: " );
    Serial.println( input_string );

    digitalWrite( ON_BOARD_LED, !digitalRead( ON_BOARD_LED ) );

    input_string    = "";
    string_complete = false;
  } else
  {
  }

}
```

# Receiving multiple bytes with a termination character (3)

```
void loop( void )
{

  serial_event();

  if ( string_complete )
  {
    …

    input_string    = "";
    string_complete = false;

  } else
  {
  }

}
```

```
void serial_event( void )
{

  while ( Serial.available() )
  {

    char in_char = ( char )Serial.read();
    input_string += in_char;

    if ( in_char == '\n' )
    {
      string_complete = true;
    }

  }

}
```



# Receiving multiple bytes with a termination character (4)

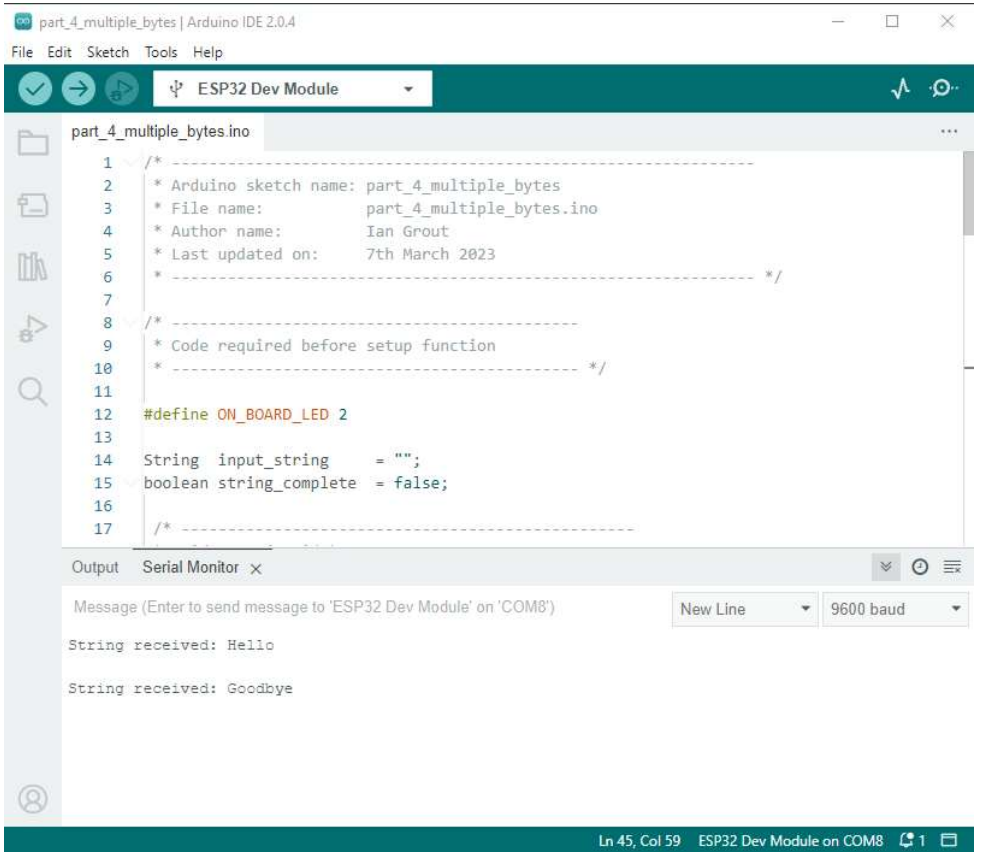
- Arduino serial communication function:
  - https://www.arduino.cc/reference/en/language/functions/communication/serial/

- The microcontroller UART set-up with a Baud rate of 9600.

- The UART is checked (polled) to see if a byte has been received. If received, the byte is read and transmitted back to the computer as the value and also as the ASCII character code.

- The code is in the Arduino Sketch part_4_multiple_bytes.

- Watch the video part_4_multiple_bytes_video.mp4 to see the code in operation. This code also toggles the on-board LED when a byte is received (the LED code is not shown in the code to the right).

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# Replacing the Arduino Serial Monitor with Python

```
import time
import serial

com_port = 'COM8'


def main():

    ser = serial.Serial(com_port, timeout=5)
    ser.baudrate = 9600
    ser.flush()
    time.sleep(5)
    print(ser.name)

    value_to_send = 'Hello\n'
    ser.write(value_to_send.encode())
    line = ser.readline().decode('latin-1')[:-1]
    print(value_to_send)
    print(line)
    line = ser.readline().decode('latin-1')[:-1]

    time.sleep(1)

    value_to_send = 'Goodbye\n'
    ser.write(value_to_send.encode())
    line = ser.readline().decode('latin-1')[:-1]
    print(value_to_send)
    print(line)
    line = ser.readline().decode('latin-1')[:-1]


if __name__ == '__main__':

    main()
```

- The Arduino IDE Serial Monitor is useful for initial prototyping and debugging the design code.
- For more advanced work, other software languages and tools can be used.
- For example, using Python to access the serial port as shown in the example to the left.
- This example uses pySerial to access the serial port. This is the same COM PORT as set in the Arduino IDE.
- In the code, COM8 is used on a Windows platform. This should be replaced with the actual COM PORT number used.

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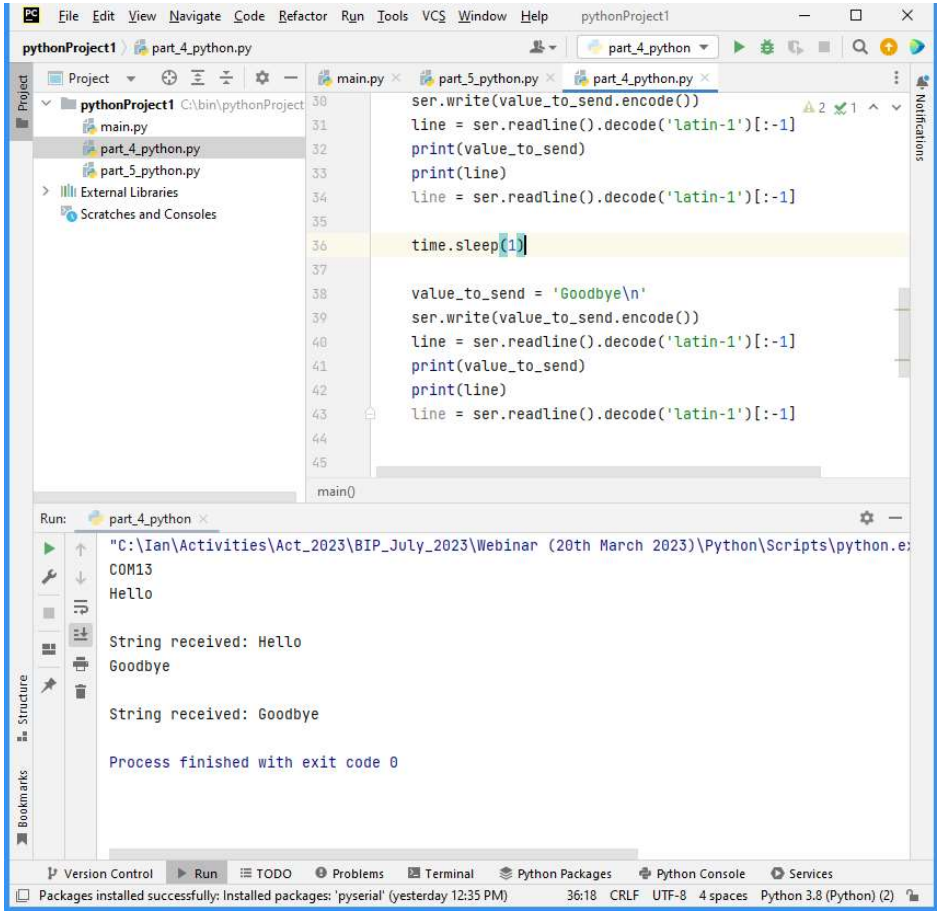
# Replacing the Arduino Serial Monitor with Python

- Python scripts can be created and run using different software tools.
- For example, the image to the right shows the Python script developed and using PyCharm Community Edition.
- The Python script is part_4_python.py .
- Watch the video part_4_python_video to see Arduino IDE and PyCharm in use.

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# Any questions?

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