



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. Walkthrough 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 );
    }
}
```

Receiving and transmitting a single byte (2)

```
part_4_single_byte | Arduino IDE 2.0.4
File Edit Sketch Tools Help
ESP32 Dev Module
part_4_single_byte.ino
35 {
36
37 if ( Serial.available() > 0 )
38 {
39   incomingByte = Serial.read();
40   Serial.print( "Byte received: " );
41   Serial.println( incomingByte );
42   Serial.print( "Byte received: " );
43   Serial.println( char( incomingByte ) );
44   Serial.print( "Byte received ASCII code decimal: " );
45   Serial.println( incomingByte, DEC );
46   Serial.print( "Byte received ASCII code hexadecimal: " );
47   Serial.println( incomingByte, HEX );
48
49   digitalWrite( ON_BOARD_LED, !digitalRead( ON_BOARD_LED ) );
50 }
Output Serial Monitor x
Message (Enter to send message to 'ESP32 Dev Module' on 'COM8') New Line 9600 baud
Byte received: 65
Byte received: A
Byte received ASCII code decimal: 65
Byte received ASCII code hexadecimal: 41
Byte received: 10
Byte received:
Byte received ASCII code decimal: 10
Byte received ASCII code hexadecimal: A
Ln 40, Col 38 ESP32 Dev Module on COM8 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 );
```

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



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 )
    {
        ...

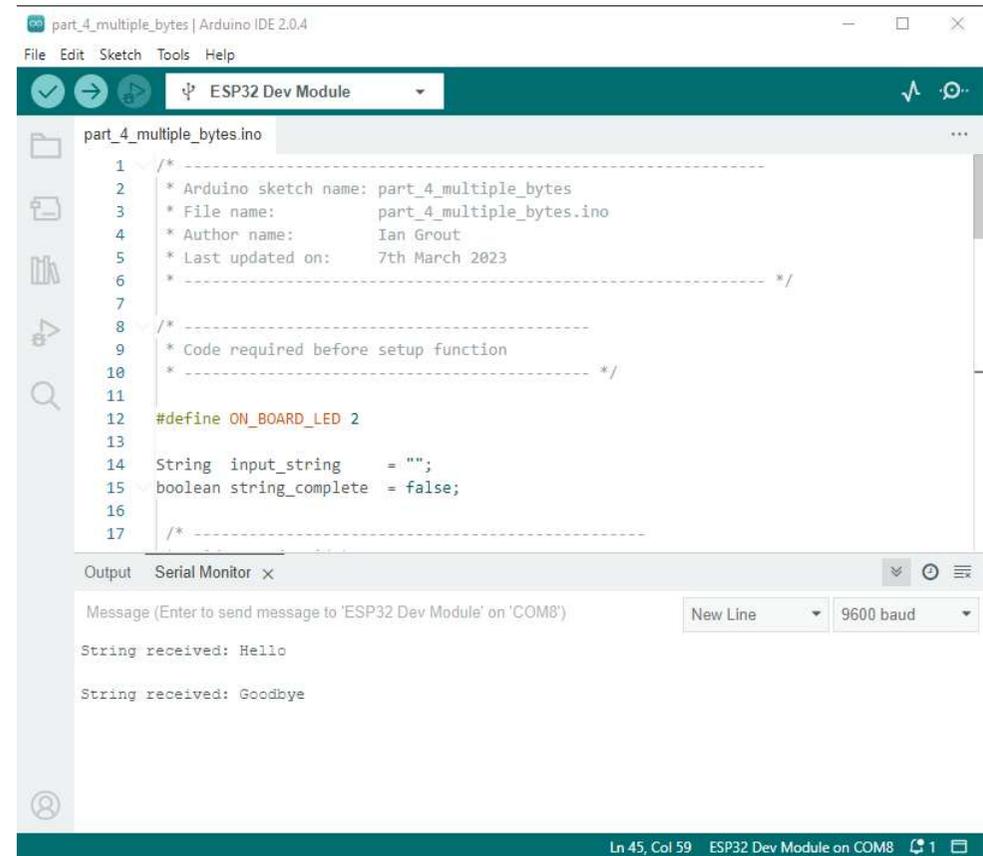
        input_string      = "";
        string_complete = false;
    } else
    {
    }
}
```

```
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).



```
part_4_multiple_bytes.ino
1  /*
2  * Arduino sketch name: part_4_multiple_bytes
3  * File name:      part_4_multiple_bytes.ino
4  * Author name:   Ian Grout
5  * Last updated on: 7th March 2023
6  */
7
8  /*
9  * Code required before setup function
10 */
11
12 #define ON_BOARD_LED 2
13
14 String input_string = "";
15 boolean string_complete = false;
16
17
```

Output Serial Monitor

Message (Enter to send message to 'ESP32 Dev Module' on 'COM8') New Line 9600 baud

String received: Hello

String received: Goodbye

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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]

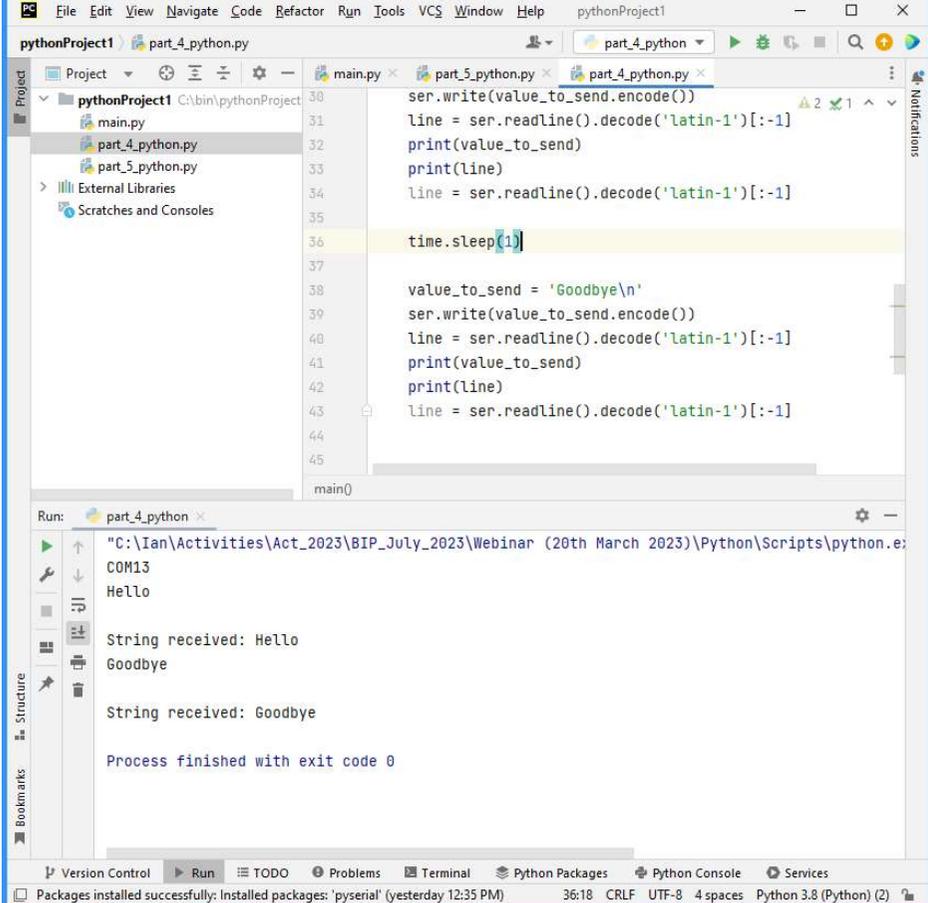
if __name__ == '__main__':

    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.

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.



The screenshot displays the PyCharm IDE interface. The main editor window shows a Python script named `part_4_python.py` with the following code:

```
30 ser.write(value_to_send.encode())
31 line = ser.readline().decode('latin-1')[:-1]
32 print(value_to_send)
33 print(line)
34 line = ser.readline().decode('latin-1')[:-1]
35
36 time.sleep(1)
37
38 value_to_send = 'Goodbye\n'
39 ser.write(value_to_send.encode())
40 line = ser.readline().decode('latin-1')[:-1]
41 print(value_to_send)
42 print(line)
43 line = ser.readline().decode('latin-1')[:-1]
44
45
```

The Run window at the bottom shows the output of the script:

```
Run: part_4_python
"C:\Iain\Activities\Act_2023\BIP_July_2023\Webinar (20th March 2023)\Python\Scripts\python.exe:
COM13
Hello
String received: Hello
Goodbye
String received: Goodbye
Process finished with exit code 0
```

The status bar at the bottom indicates that the packages installed successfully, including 'pyserial' (yesterday 12:35 PM), and shows the current Python version as 3.8 (Python) (2).

Any questions?



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