



Kodular: A Tool For Teaching Programming And Microcontrollers

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Abstract

This document presents the design and implementation of a digital DC voltmeter with three scales (500mv, 5v and 50v) connected via Bluetooth with a smartphone using a PSoC5LP. This device has several functionalities of scale selection and voltage display, which can be used from a mobile application developed on the Kodular platform of great utility for teaching basic programming and microcontrollers.

Keywords: Bluetooth; Kodular; microcontroller; PSoC5LP; UART

1. Introduction

As the years go by, electronic devices become more complex, to such an extent that they can communicate with each other employing different technologies such as Wi-Fi or Bluetooth, depending on the use. This communication is vital because different devices have specific tasks for obtaining, displaying and processing signals or data.

Kodular (<https://www.kodular.io>) is a platform designed by a group of university students from different countries based on the free and open-source MIT App Inventor platform of the Massachusetts Institute of Technology, whose headquarters are located in the Netherlands. It is an accessible online and closed-source service (Kodular, 2022).

Its operation is straightforward to create applications and only requires dragging "components" (the essential visual elements of any application, the interface) to a smartphone with a blank screen. These components can be text boxes or side or floating menu buttons, among others (Genbeta, 2021).

The applications designed in Kodular have a nice look because the components have the style of the Material Design guidelines. Some of these components are visible and allow interaction, while others, the non-visible ones, are in charge of getting data from the devices, notifying changes, etc.

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The second part and the one that gives meaning to these components are the "blocks", that is, the elements in charge of communicating to the components how to respond to stimuli and actions and events.

The example given in Kodular describes it well: What should the application do when the user clicks on a button? What data should it have access to? That's all taken care of by the blocks (Miftahatuljannah, Sukarmin, Wahyuningsih, 2022), (Nugraheny, Sukarmin, Wahyuningsih, 2022), (Syarlisjiswan, Sukarmin, & Wahyuningsih, 2021).

In summary, Kodular is a tool to develop, in a straightforward way, mobile applications on Android platforms.

2. Formulation of the Problem

Design and implement with the ADC (Analog to Digital Converter) of the PSoC5LP, a three-scale DC digital voltmeter (500mv, 5v and 50v) with voice functions (Arora, Gagandeep, Rawat, Srinivasan & Puri, 2014), (Hui-feng, Wang & Liu, 2013) (Nue, Lwin, & Tun, 2015), (Oluwaseuna, Onib, Olabisi, Adewumid, Ogunbodee, Ajadi, & Adebayog, 2021).

The implemented digital voltmeter (Camargo, Perdomo & Bermudez, 2019) will have the following features:

- Employing a Bluetooth module connected to the PSoC5LP through the asynchronous serial port (UART) and a smartphone, all the voltmeter operation and display functions will be controlled; in the smartphone, an application in Kodular will be implemented.
- Selection of three different DC voltage scales: 500mv, 5v and 50v. This selection will be made by making use of a smartphone employing buttons implemented in the application with Kodular, or through voice messages that the application in Kodular must recognize (for example, "switch to five-volt scale"), the value that will be sent to the PSoC5LP to adjust the scale. In addition, it should play on the smartphone a message indicating the selected scale (e.g., "five-volt scale selected").
- After the selection of the scale (the scale may be changed at any time), the voltage measurement will be performed every 5 seconds, and the measured value will be sent to the smartphone displayed numerically, employing widgets (either with bars, donuts or similar) and utilizing a Voltage vs. Time graph. In addition, a voice message shall be played indicating the measured value (e.g., three-point forty-five volts).
- If the measured voltage is out of range, this event shall be indicated on the smartphone and by a voice message.

3. Design and Solution Model

The following PSoC5LP resources are used to solve the problem: a timer with the interrupt module activated, an ADC block (Camargo & Perdomo, 2016), ((Infineon Technologies AG, 2015), a Bluetooth HC-05 module, two UART (Infineon Technologies AG, 2018) blocks, one for connecting the design to a PC and the other for connecting to the Bluetooth HC-05 module (Camargo, Perdomo & Bermudez, 2019).

Figure 1 shows the resources used in the design.

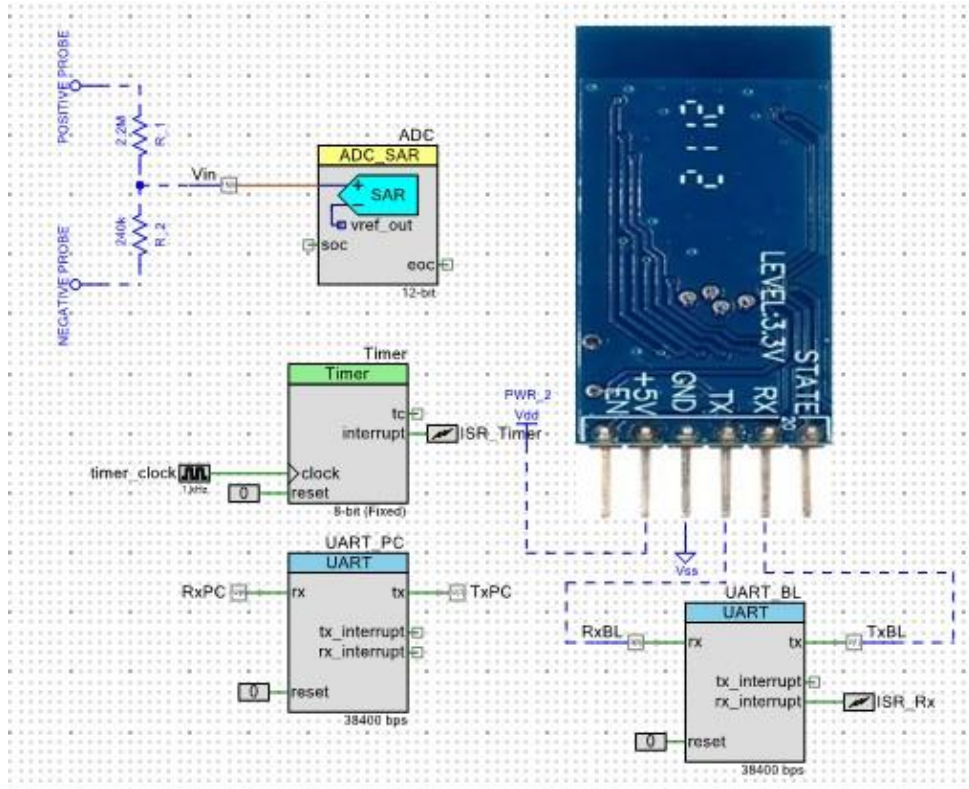


Figure 1. Connection diagram

To introduce the voltage to the implemented multimeter, a DC source that allows a maximum of 32V is used; since the PSoC5LP does not support more than 5V in its input-output pins (GPIO), a voltage divider is made, with a pair of resistors of 2.2 MΩ and 240 KΩ so that the measurement can be performed in the 50 V scale without any problem. This voltage divider is located on the ADC pin. The ADC block configuration is shown in Figure 2.

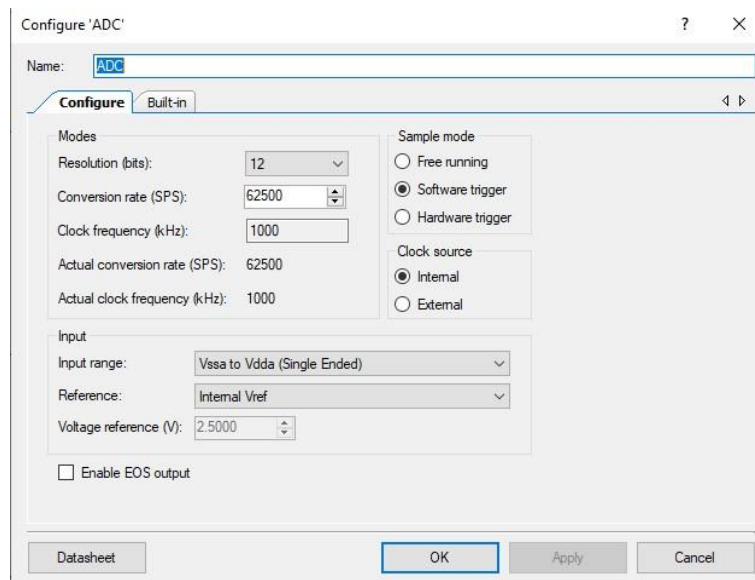


Figure 2. PSoC5LP ADC block configuration

The Timer block (Infineon Technologies AG, 2017) uses a 1 kHz clock signal with a resolution of 8 bits, generating a period of 25 ms; it also uses interrupts, as shown in Figure 3.

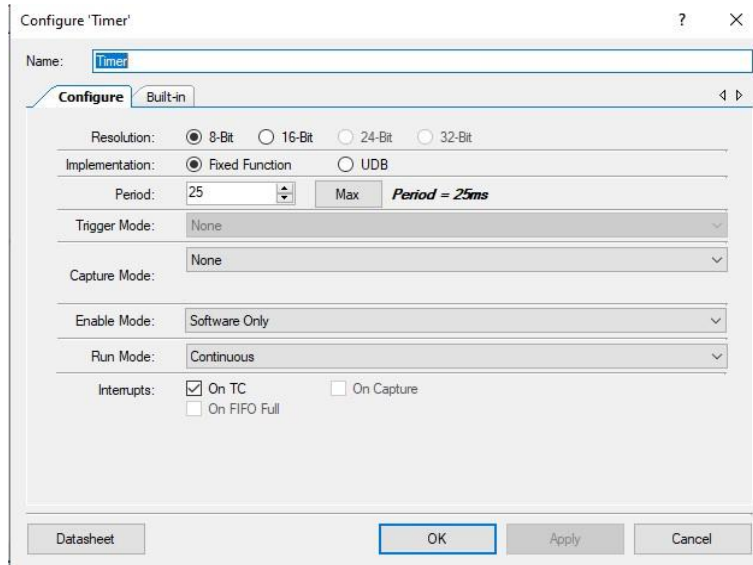


Figure 3. Timer block configuration

For the communication between the implemented device and the PC and the Bluetooth module, two UART modules are used for asynchronous serial communication; both operate at 38400bps (bit per second); their configuration is shown in Figure 4.

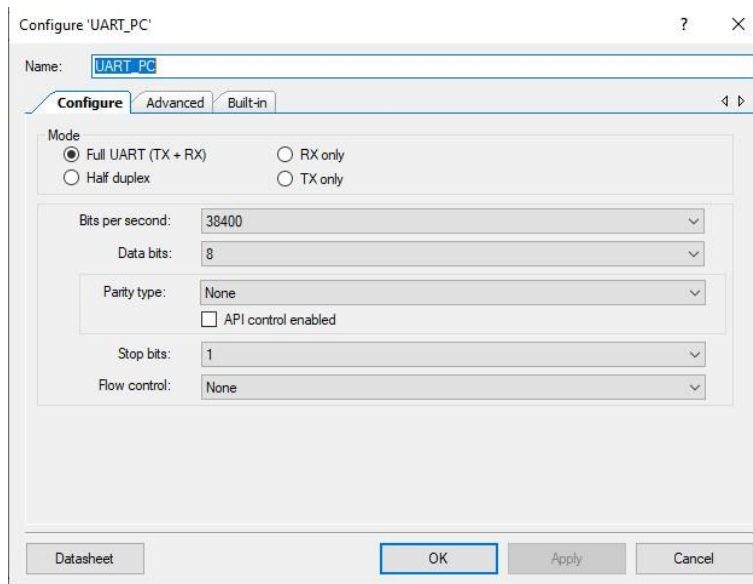


Figure 4. Configuration of the UART PC and BL blocks on the PSoC5LP

Figure 5 shows a segment of the interrupt code of the Timer block.

```

CY_ISR(Int_Timer){
char Mensaje[13]="";
uint8 size,i;

Timer_Stop();
size=UART_BL_GetRxBufferSize();
if(size>=10&&size<=13){
for(i=0;i<size-2;i++){
Mensaje[i]=UART_BL_GetChar();
UART_PC_PutChar(Mensaje[i]);
}
UART_PC_PutString("\r\n");
}else{
for(i=0;i<size;i++){
UART_PC_PutChar(UART_BL_GetChar());
}
}
UART_BL_ClearRxBuffer();
Timer_ReadStatusRegister();
}

```

Figure 5. Timer block interrupt code

The following code segment (Figure 6) is used to obtain 50 samples to make an average later displayed in the mobile application; in the code, it can also be detailed that two decimal places are assigned to the 500 mV scale.

```

for(uint8 i=0;i<50;i++){
ADC_StartConvert();
ADC_IsEndConversion(ADC_WAIT_FOR_RESULT);
volt=volt+ADC_GetResult16();
}
volt=volt/50;
volt=ADC_CountsTo_uVolts(volt);

```

Figure 6. Code to obtain 50 voltage samples

For the creation of the application in Kodular, the following functionalities were used: "Speech recognition", "Text to speech", "Bluetooth client", "Clock timer" and "Notifier". Figure 7 shows the overall design created as a user interface.

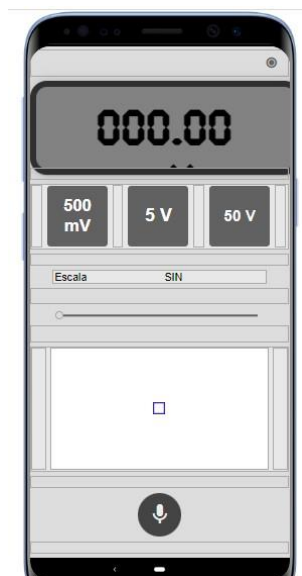


Figure 7. Design created in Kodular

The application allows the numerical display of the voltage and also performs a graph that is updated every 5 seconds; this is done by plotting points on a canvas; also, you can see the size used in the scale, i.e., the space that has been used and how much is left for the scale to be filled, if the scale exceeds this value, throws a message that is out of scale and stop plotting.

Figure 8 shows the process performed when initializing the application in Kodular.

```

when Screen1 Initialize
do
  set Speech_Recognizer1 . Language to "es-MX"
  call Notifier1 . Show Text Dialog
  message "Antes de iniciar, seleccione el dispositivo blue..."
  title "VOLTIMETRO BLUETOOTH"
  cancelable false
  set Canvas1 . Font Size to 10
  call Canvas1 . Draw Text
  text "500 mV"
  x 18
  y 8
  call Canvas1 . Draw Text
  text "0 V"
  x 12
  y Canvas1 . Height
  
```

Figure 8. Code for initialization of the smartphone screen

Subsequently, a list selector is used to choose the Bluetooth device that sends the voltage data. A list fill is performed before making the selection and then, after selecting, the connection indicator is updated and connected to the module with the specified address (Figure 9).

```

when List_Picker1 Before Picking
do
  set List_Picker1 . Elements to Bluetooth_Client1 . Addresses And Names
  if Bluetooth_Client1 . Enabled = false
  then call Notifier1 . Show Alert
  notice "Debe activar el bluetooth primero"

when List_Picker1 After Picking
selection
do
  if call Bluetooth_Client1 . Connect
  address get selection
  then set List_Picker1 . Text Color to make color
  make a list 20 120 20
  else set List_Picker1 . Text Color to make color
  make a list 170 0 0
  if call Bluetooth_Client1 . Bytes Available To Receive > 0
  then set global Voltaje to 0
  
```

Figure 9. Bluetooth device selection code

For voice recognition (Figure 10), a button activates the action, and then the graphical configurations are made to observe the scale and voltage changes.

Figure 10. Code implemented for speech recognition

To constantly update the parameters displayed on the smartphone screen, a clock with a time delay of 1s was used, checking the data to be received and thus correcting the readings (Figure 11).

Figure 11. Code implemented in Kodular to control the Clock Timer

For all the scale changes with buttons, the same logic was used, assigning the scale to the generated variable, displaying the limits of the graph and calling the voltage sampling process, as seen in Figure 12.

```

when Btn500mV Click
do
  set global Escala to "500mV"
  set global posX to 0
  set global posXprev to 0
  set global posY to 0
  set global posYprev to 0
  call Canvas1 .Clear
  call Canvas1 .Draw Text
  text "500 mV"
  x 18
  y 8
  call Canvas1 .Draw Text
  text "0 V"
  x 12
  y Canvas1 .Height
  call MostrarVoltaje
  call Text_To_Speech1 .Speak
  message get global EscalaLeer
  call Bluetooth_Client1 .Send Text
  text get global EscalaEnviar
  
```

Figure 12. Code implemented in Kodular for button control

The process responsible for displaying the voltage read by the PSoC5LP and sent by the Bluetooth module is shown in Figure 13.

```

to MostrarVoltaje
do
  set ScaleLi .Text to get global Escala
  if get global Escala = "500mV"
  then
    set global EscalaEnviar to "Scale 500mV/n"
    set global EscalaLeer to "Escala de 500 milivolts seleccionada"
    set Btn500mV .Background Color to make color make a list 50 50 50
    set Btn5V .Background Color to make color make a list 97 97 97
    set Btn50V .Background Color to make color make a list 97 97 97
  else if get global Escala = "5V"
  then
    set global EscalaEnviar to "Scale 5V/n"
    set global EscalaLeer to "Escala de 5 voltios seleccionada"
    set Btn500mV .Background Color to make color make a list 97 97 97
    set Btn5V .Background Color to make color make a list 50 50 50
    set Btn50V .Background Color to make color make a list 97 97 97
  else if get global Escala = "50V"
  then
    set global EscalaEnviar to "Scale 50V/n"
    set global EscalaLeer to "Escala de 50 voltios seleccionada"
    set Btn500mV .Background Color to make color make a list 97 97 97
    set Btn5V .Background Color to make color make a list 97 97 97
    set Btn50V .Background Color to make color make a list 50 50 50
  
```

Figure 13. Voltage display process

Finally, the process responsible for displaying the voltage in Kodular in a progress bar is shown in Figure 14.

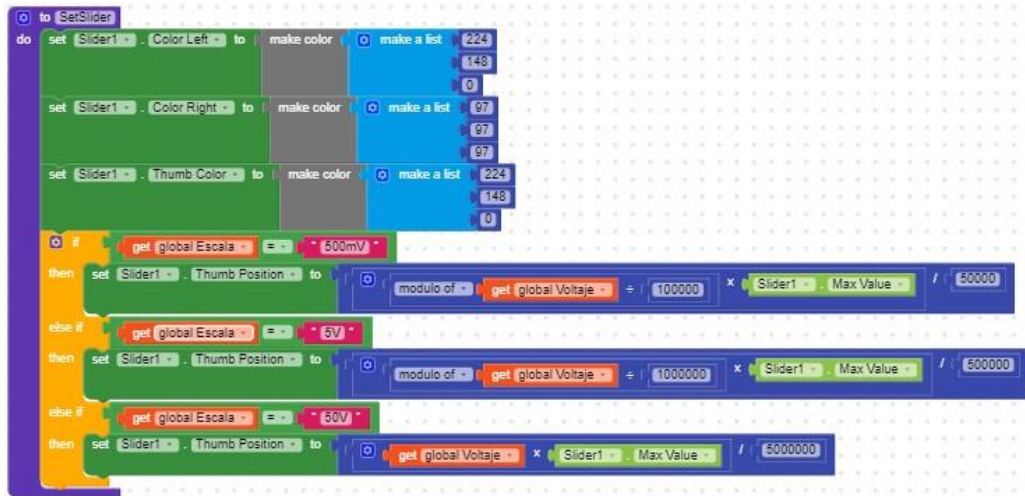


Figure 14. Code implemented to generate the progress bar

4. Results

Different measurements were made by modifying the input voltage to the circuit; in all cases, a PeakTech digital multimeter, reference P2025A, was used to compare it with the measurements made by the implemented circuit.

Table 1 shows the results obtained from the measurements of various voltage levels, the values selected for the tests allow us to check the multiple scales of the implemented voltmeter.

Table 1. Voltage measurement results

Scale	Voltmeter measurement (V)	Measurement with circuit (V)	Error (%)
500mV	0,025	0,093	272
	0,100	0,195	95
	0,25	0,231	-7,6
	0,4	0,45	12,5
	0,5	Out of range	-
5V	0,5	0,52	4
	0,8	0,83	3,75
	1	1,06	6
	2,5	2,48	-0,8
	3	3,04	1,33
	4	4,09	2,25
	4,5	4,56	1,33
50V	5	4,95	-1
	7	7,08	1,14
	9,5	9,45	-0,52
	10	10,1	1
	15,5	15,661	1,03
	18	18,1	0,55
	20	20,15	0,75
	25	25,1	0,4
30	30,09	0,3	
	32	32,1	0,31

As can be seen, the system's accuracy improves notably as the measurement scale increases, going from substantial errors (272%) too much more minor errors of about 0.7%. In Figure 15, you can see some measurements displayed on the smartphone, along with the corresponding voltage vs. time graph.

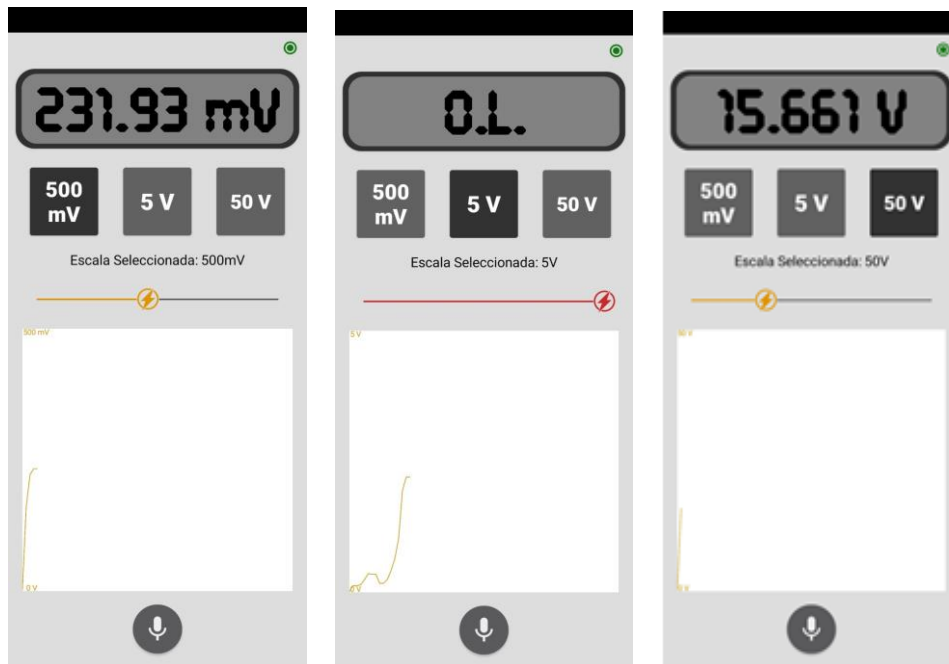


Figure 15. Operating result

5. Conclusions

By using the analog-to-digital SAR converter module of PSoC5LP, it is possible to obtain high accuracy when converting values to microvolts. However, since this value is minimal, interference may occur, causing erroneous readings of values in millivolt units.

It is necessary to add a delay time between each ADC reading since, if this were done constantly, the values could not be displayed due to the speed with which the readings change.

For serial communication, it is vital that at the time of its configuration, all the blocks and devices have the same value of bits per second (bps) because if any has a different value, the communication is not performed satisfactorily and there may be problems when transmitting data.

It should be noted that for this project, the code used in PSoC Creator was not extensive because much of the work was done in the Kodular tool, where it was possible to detail that you can interact between various types of software without any problem, interacting with communication devices, to have; as a result a better quality device.

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