Design of an USB HID device with data-logger and pulse-oximeter.

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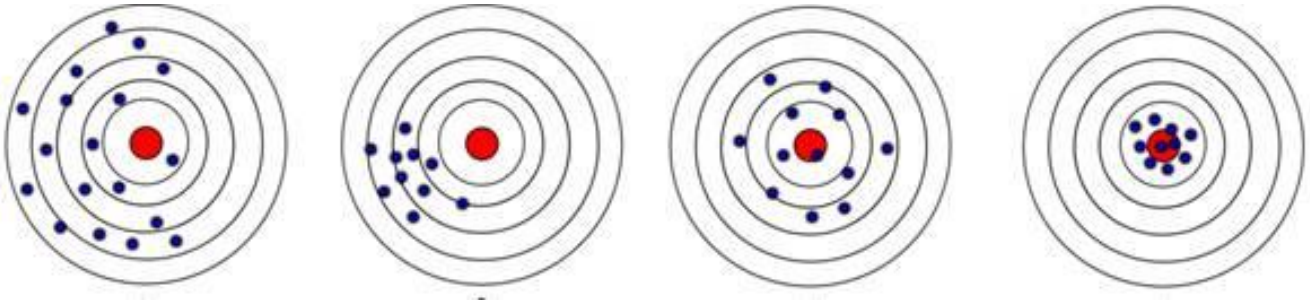
Introduction

- Device for psychological tests with computers.
  - As a method of analysis and diagnosis.
- Record the time when various events happen (Accuracy)
- Correct the delay produced by the hardware I/O (Precision)



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Objetives

- Implement USB HID keyboard.
  - With at least two programmable keys (buttons)
  - Able to record events
- Store, read and delete information events in the Flash memory (datalogger).
- Synchronize watches.
- Desig a control console serial port.
- Implement a pulsioximeter.

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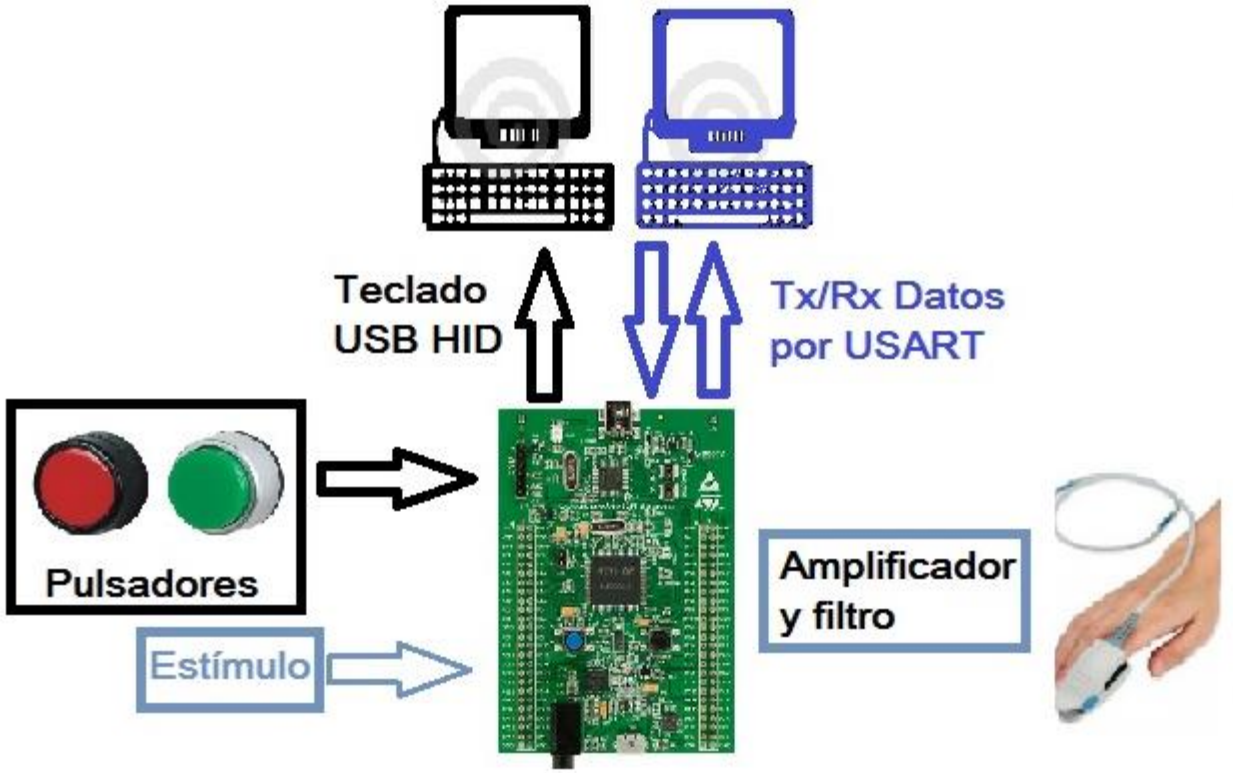
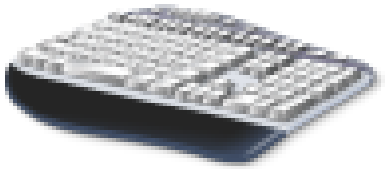
Background



USB background

- Architecture master / slave.
  - PC : as HOST
  - All communications are initiated by the HOST.
- Multiple speeds : Low=1.5Mbps, Full=12 Mbps, High=480Mbps, Super=5Gbps
- Unique identifier : *Vendor Id*, *Product Id*, *serial number*



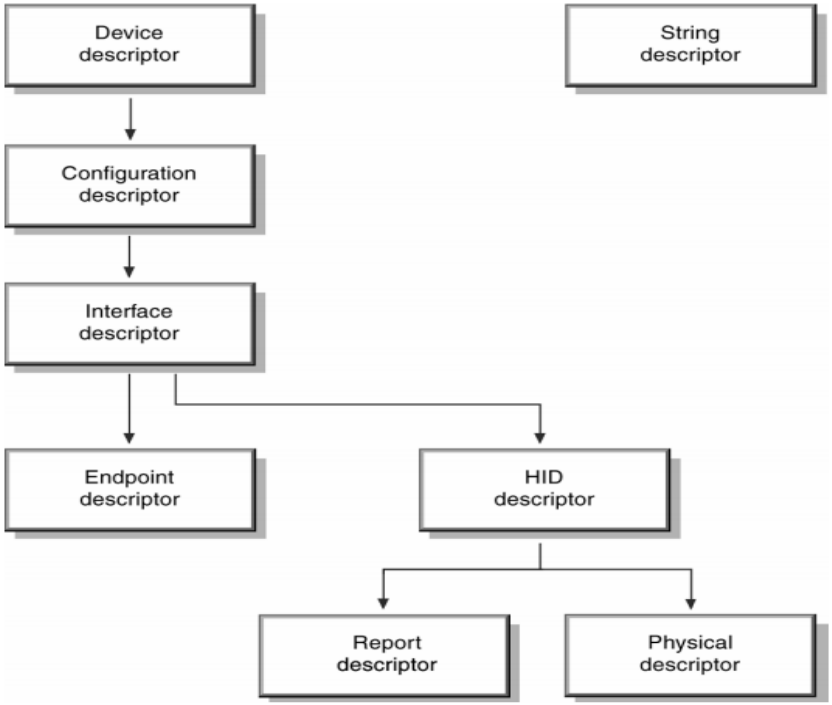
USB HID device
in FS mode

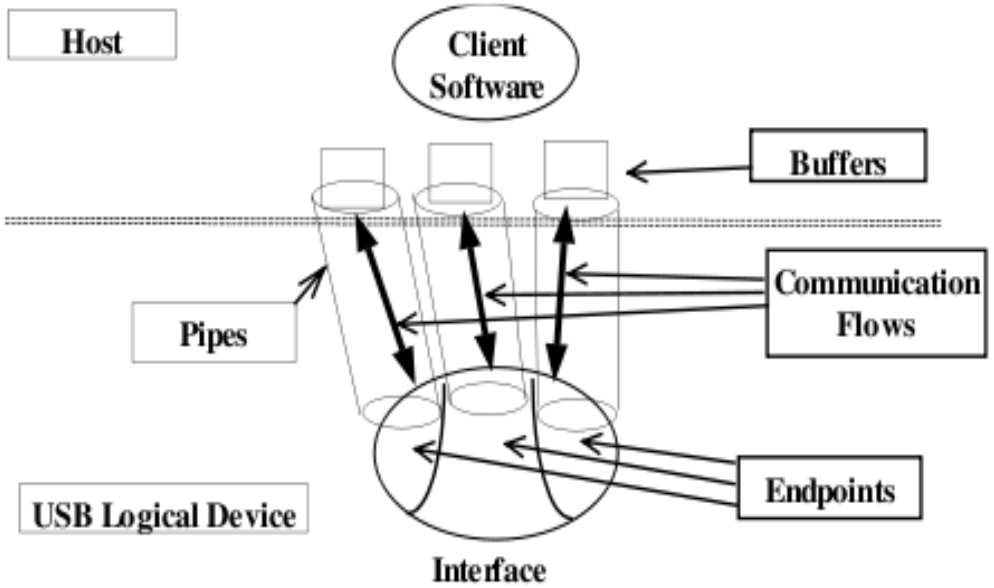
Enumeration

1. The user plugs the device into a USB port.
2. The hub detects the device.
3. The host learns of the devices presence from the hub (Get Port Status Request)
4. The hub detects whether a device is Low speed or Full Speed.
5. The hub resets the device.
6. The host learns if a full speed device supports high speed.
7. The hub establishes a signal path between the device and the bus.
8. The host sends a Get Descriptor Request to learn the maximum packet size of the default pipe.
9. **The host assigns an address (Set Address Request).**
10. **The host learn about a devices abilities (Get Descriptor Request).**
11. **The host assigns and loads a device driver.**
12. The host's device driver selects a configuration (Set Configuration Request).

USB Background

- **Endpoints**
  - The host uses this to retrieve info about the device through descriptors..
  - De control y de datos
  - Endpoint 0: bidireccional. Los de datos: Unidireccionales





- **Descriptores**
  - The host use this to take info from the device and to communicate.
  - **Interface**
  - It represents a logical USB device.

USB: Clase HID

- Device Classes: Each device class defines the common behavior and protocols for devices that serve similar functions.
- HID Class: "Human Interface Device"
  - Devices that are used by humans to control the operation of computer systems..
  - Mouse, keyboard, joystick, pads…
- Requisitos de los dispositivos de clase HID:
  - All data transferred must be formatted as reports
  - HID devices must respond to standard HID requests in addition to all standard USB requests
    - "Get Report and "Set Report" requests.

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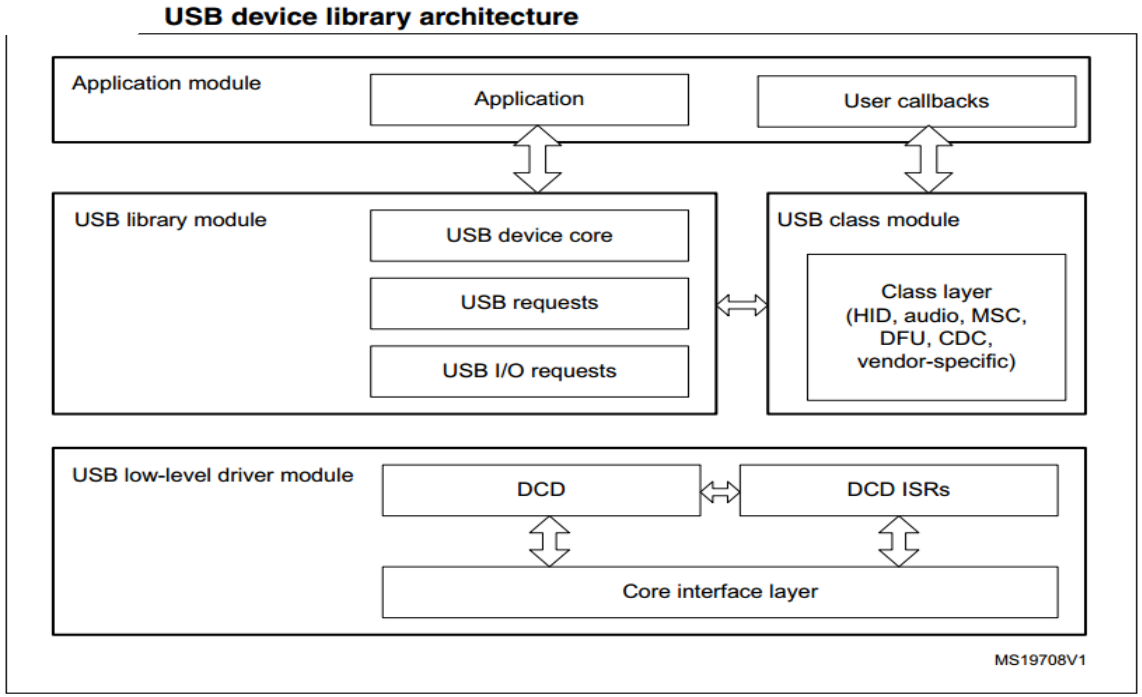
STM USB Device Libray



- Discovery STM32F407D
  - Cmsis
    - Core_cm4.h
    - Core_cm4_simd.h
    - Core_cmFunc.h
    - Core_ccmInstr.h
  - User
    - Stm32f4_usb_hid_device
    - Defines.h
    - Main.c
    - Usb_bsp.c
    - Usb_conf.h
    - Usbd_conf.h
    - Usbd_desc.c
    - Usbd_desc.h
    - Usbd_usr.c
  - Usb_Hid_Device
    - Usb_bsp.h
    - Usb_core.c
    - Usb_dcd.c
    - Usb_dcd_int.c
    - Usb_defines.h
    - Usbd_core.c
    - Usbd_ioreq.c
    - Usbd_req.c
    - Usbd_usr.h
    - Usbd_hid_core.c
    - Usbd_hid_core.h

Archivo	Descripción
usbd_core (.c, .h)	Contains the functions for handling all USB communication and state machine.
usbd_req(.c, .h)	Includes the requests implementation.
usbd_ioreq (.c, .h)	This file handles the results of the USB transactions.
usbd_conf.h	This file contains the configuration of the device: vendor ID, Product Id, Strings…etc
usbd_hid (.c, .h)	This file contains the HID class callbacks (driver) and the configuration descriptors related to this class.

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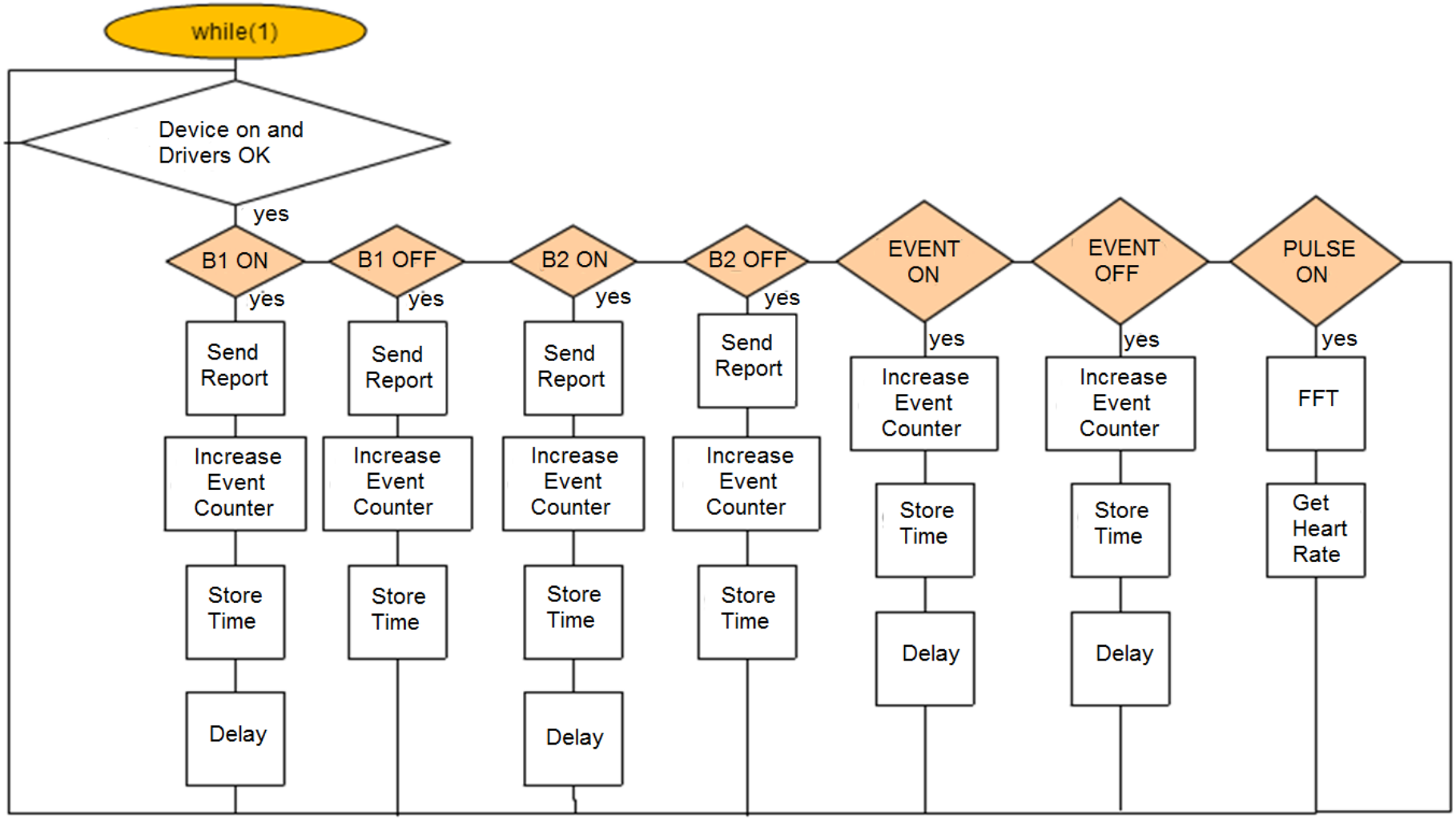
Flow Chart: Record of events



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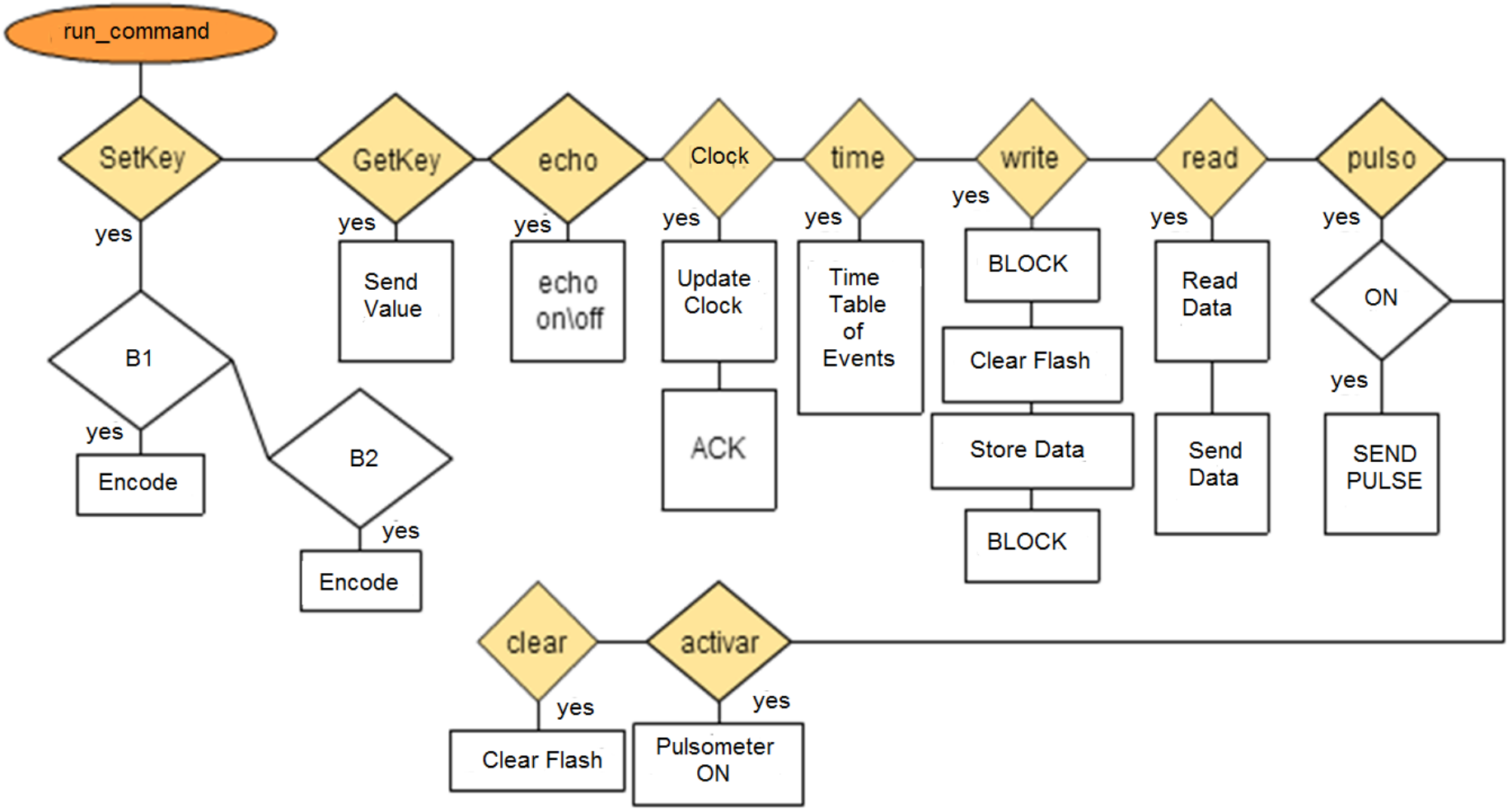
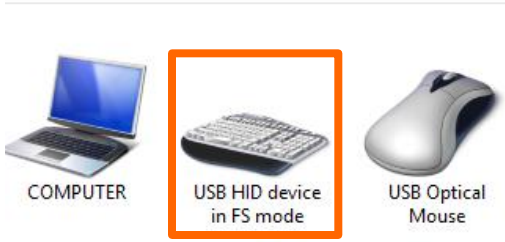
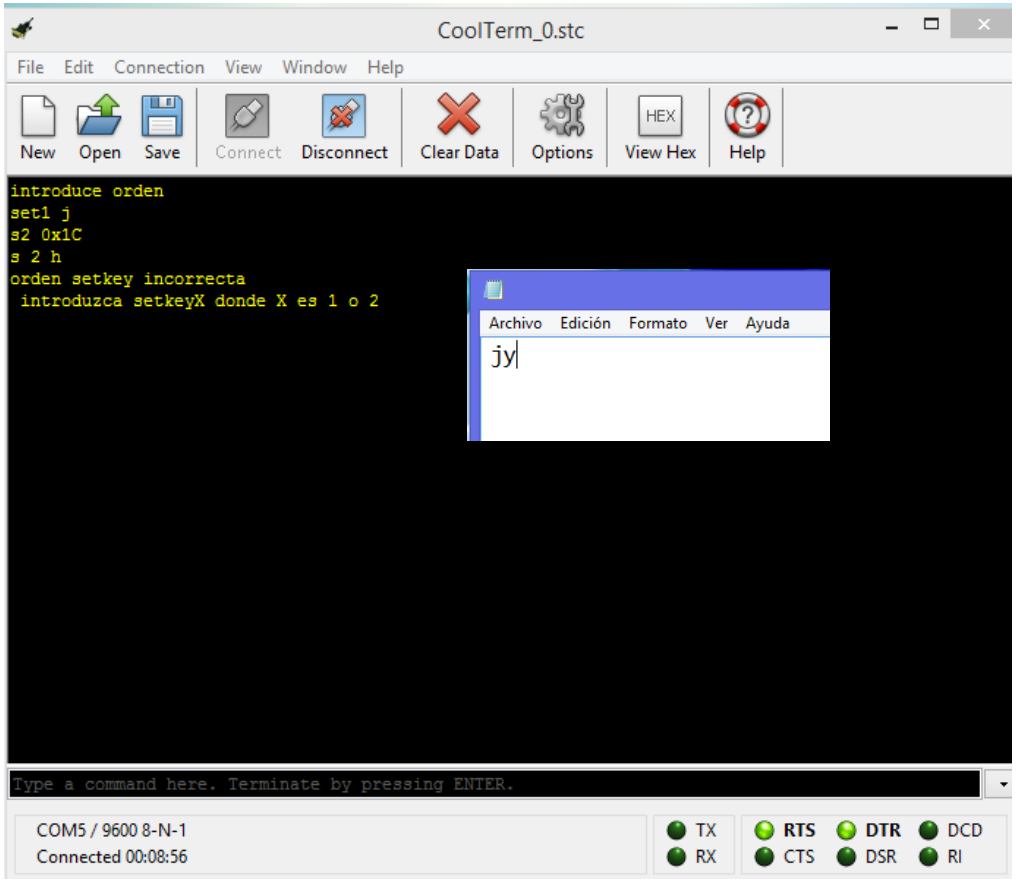
Flow Chart: Control Console in UART



USB HID Device Test

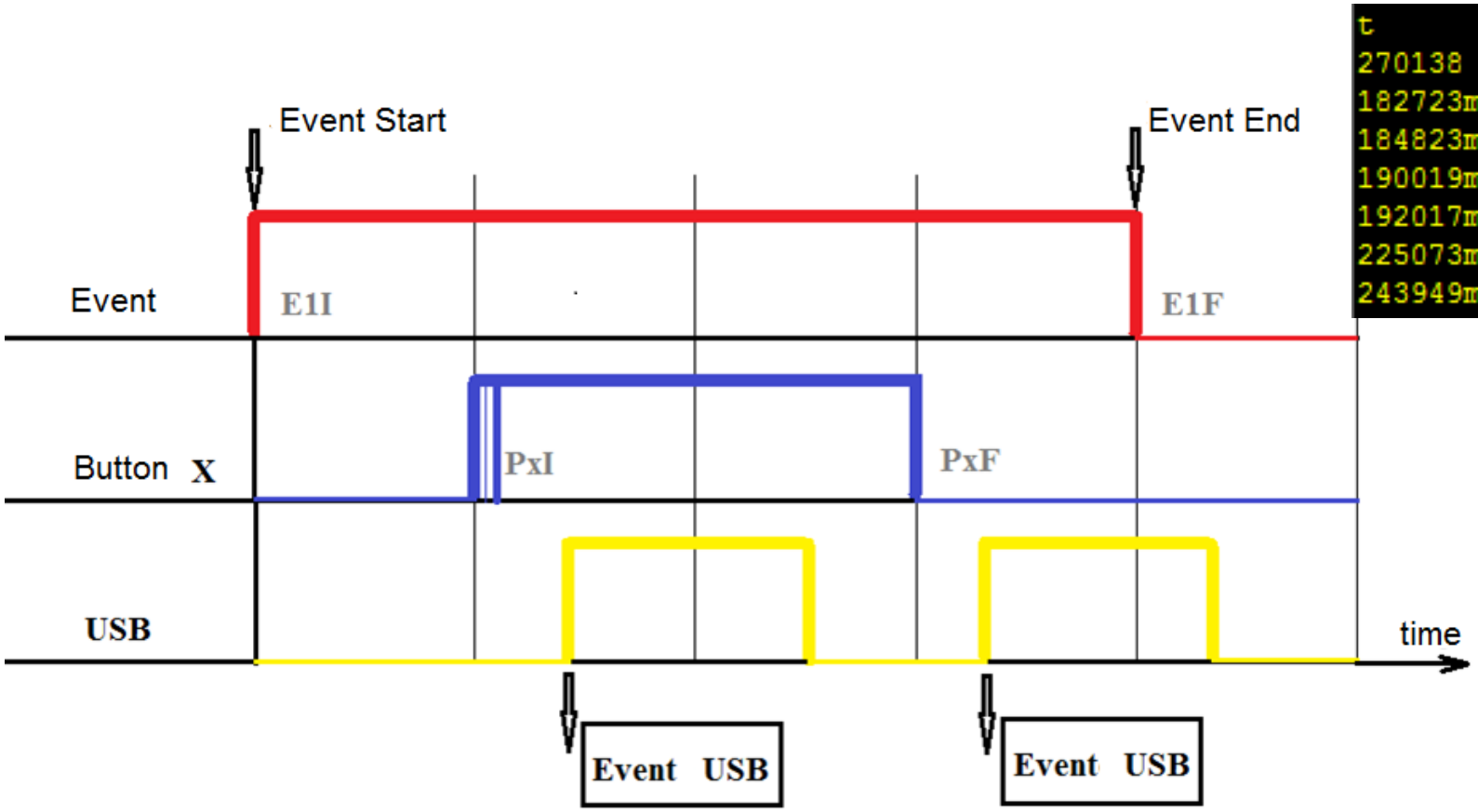


	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	Report ID = **0x01**							
Byte 1	Right GUI	Right ALT	Right SHIFT	Right CTRL	Left GUI	Left ALT	Left SHIFT	Left CTRL
Byte 2	Padding = always 0x00							
Byte 3	Key 1							
Byte 4	Key 2							
Byte 5	Key 3							
Byte 6	Key 4							
BYTE 7	Key 5							
BYTE 8	Key 6							




```
get
el valor de la tecla 1 es: j
el valor de la tecla 2 es: y
```

USB HID Device Test: command *time*




```
t
270138 ms/10
182723ms/10 -- P1I1
184823ms/10 -- P1F1
190019ms/10 -- P2I1
192017ms/10 -- P2F1
225073ms/10 -- EI1
243949ms/10 -- EF1
```

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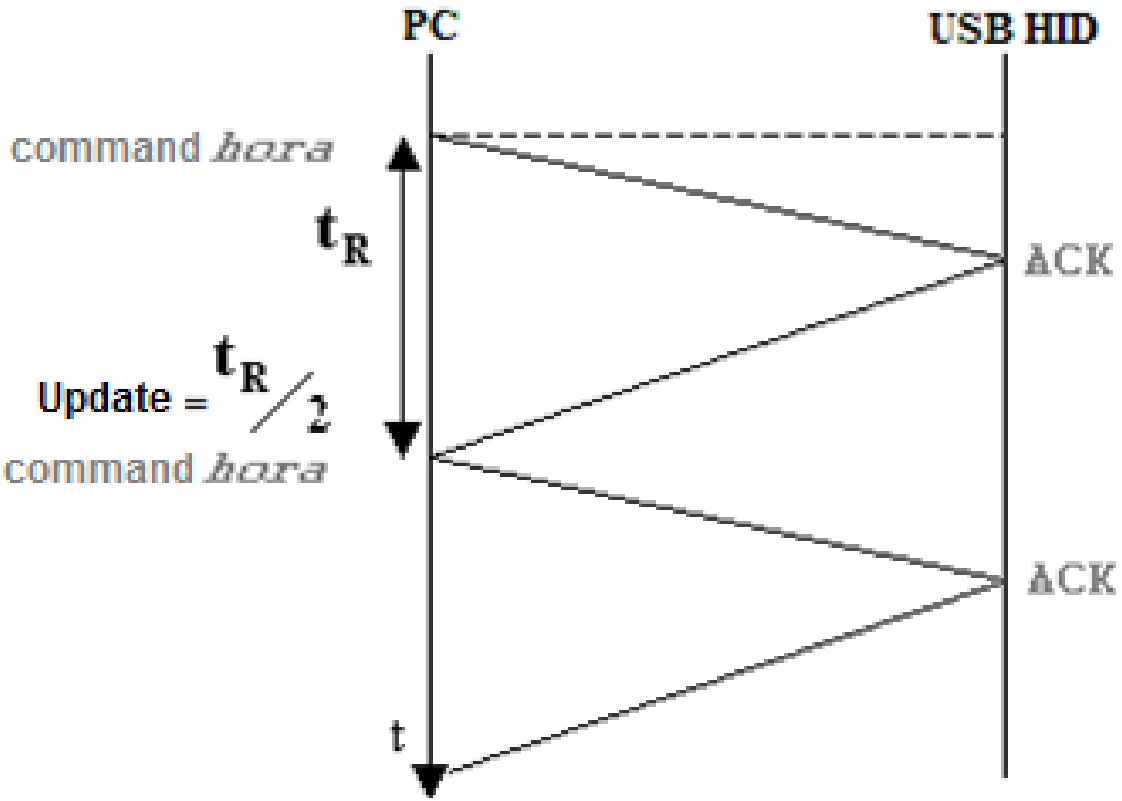
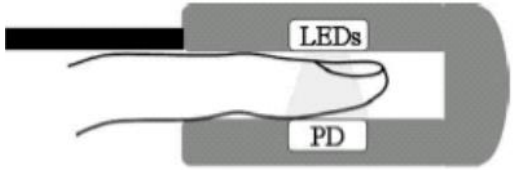
USB HID Device Test: command *hora (clock)*

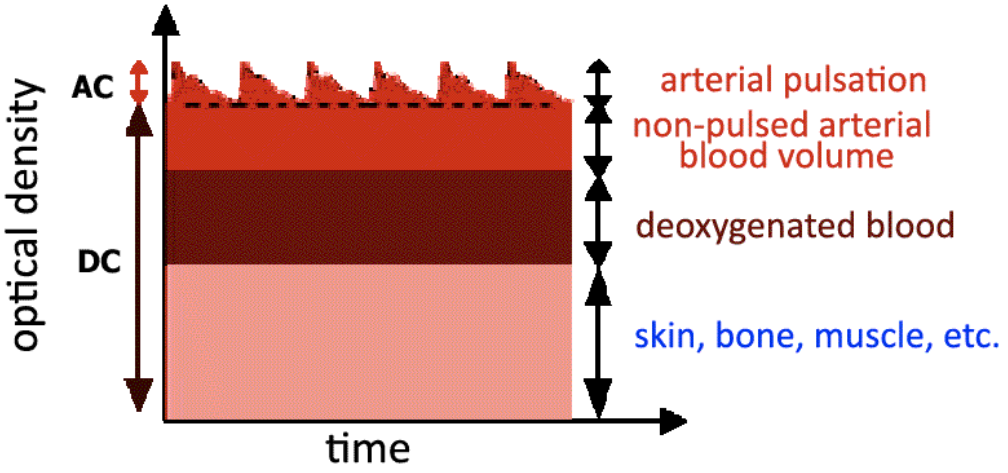
```
h 3102545
ACK
```



Pulsometer

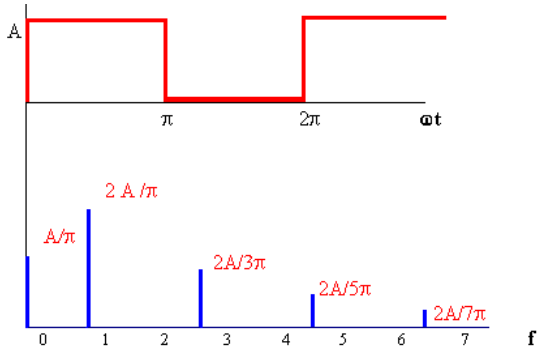
- Pletismography
  - Volume changes produced by variations in blood flow
- Fotopletismography
  - Light is emitted through the skin
  - Light is absorbed in greater or lesser amount depending blood flow amount.





Obtaining Heart Rate by FFT

- **FFT**: "*Fast Fourier Transform*"



- **Frecuencia de Nyquist**: It is the highest frequency that can be captured by the analyzer.

$$250\ \text{BPM} \rightarrow 4{,}16\text{Hz} = Fmax$$

- **Sampling Frequency**

$$Fs > 2Fmax \rightarrow Fs > 8{,}33\text{Hz}$$

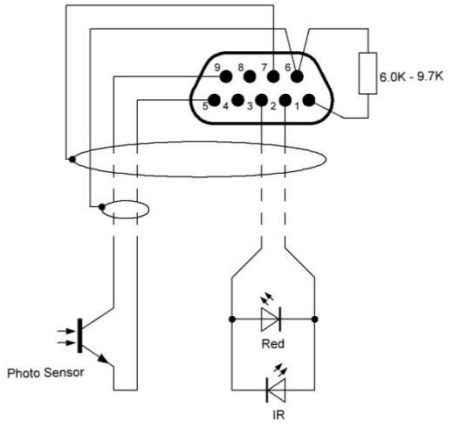
- **FFT size**

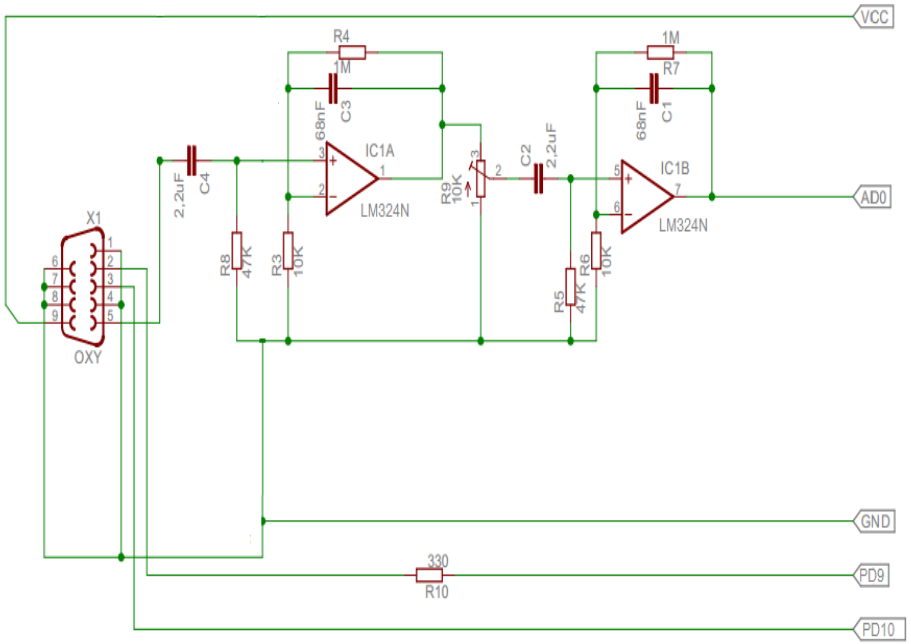
$$Fs = 100\text{Hz}$$

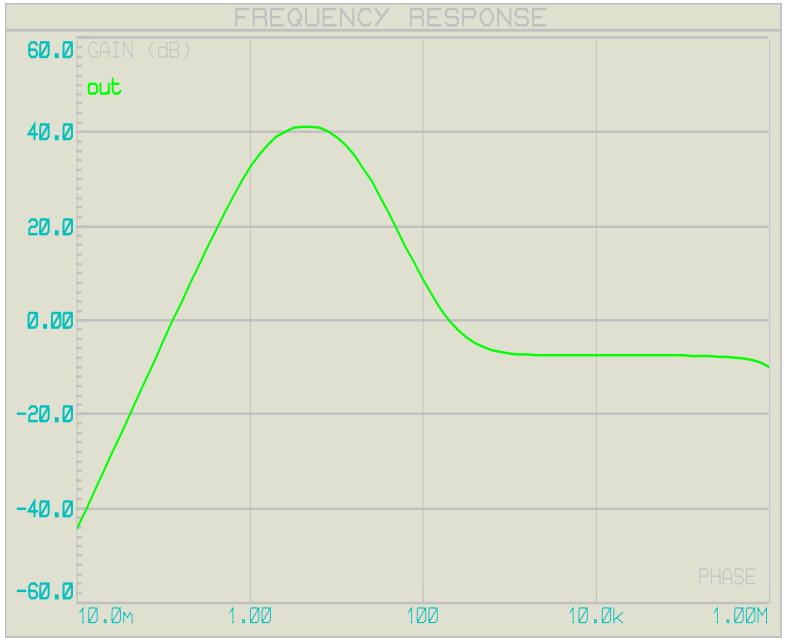
- **Frequency resolution**

$$\Delta f = \frac{\text{fs}}{\text{N}} = \frac{100}{2048} = 0.04883\ Hz$$

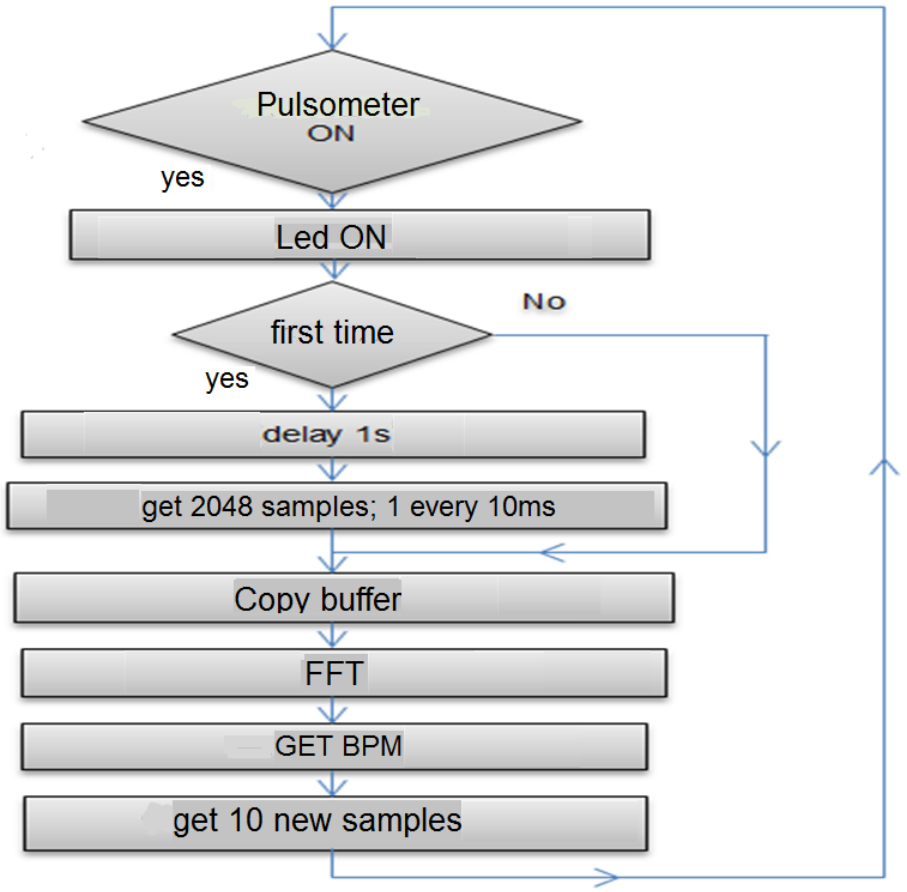
Sensor, filter and amplifier

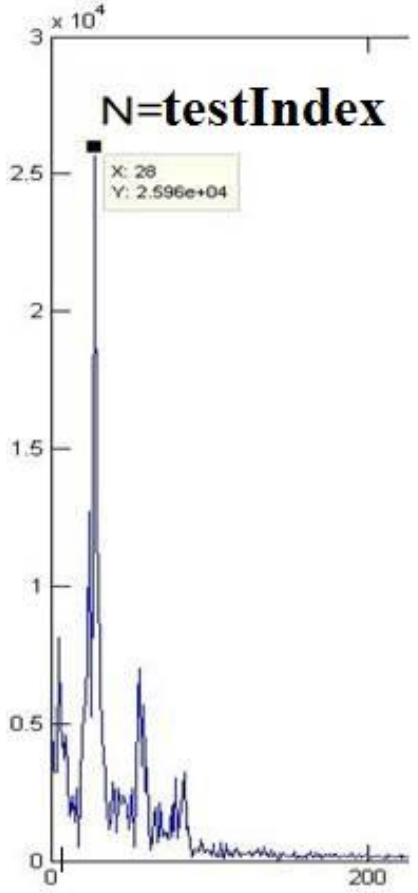






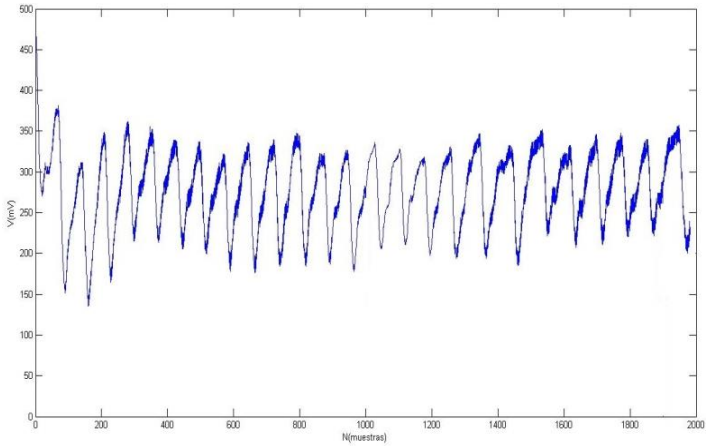
Pulsometer Implementation

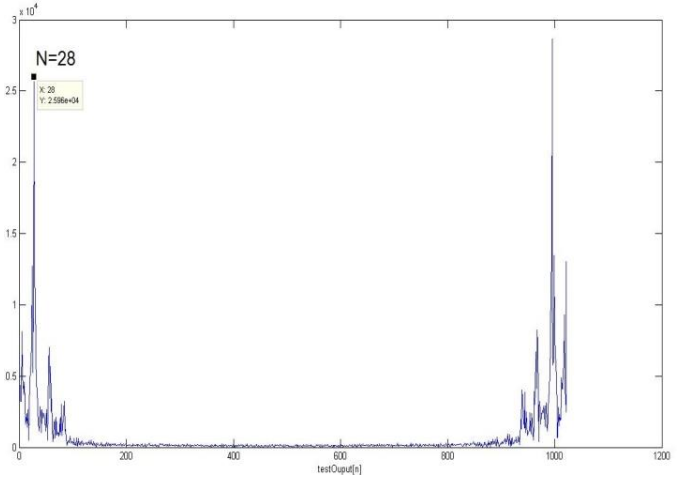




$$BPM = \Delta f \cdot testIndex \cdot 60$$

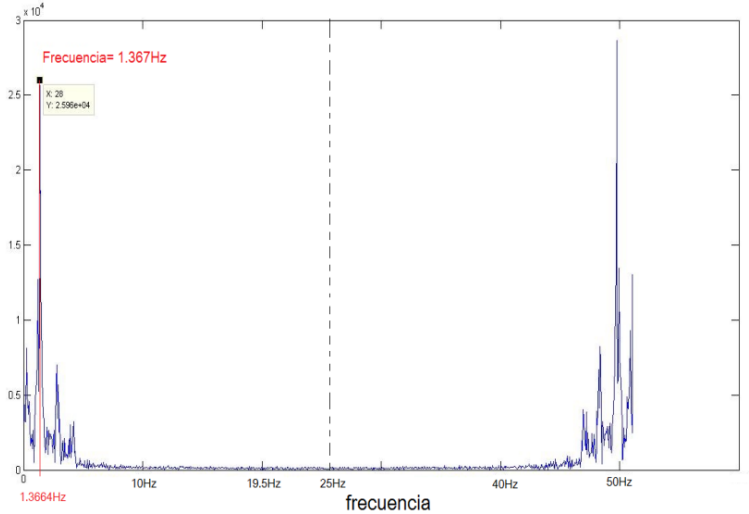
Pulsometer Test





To frequency→
$f=N*\Delta f=N*0.04883Hz$

With comercial pulsometer *Sigma 20303* :
80 BPM



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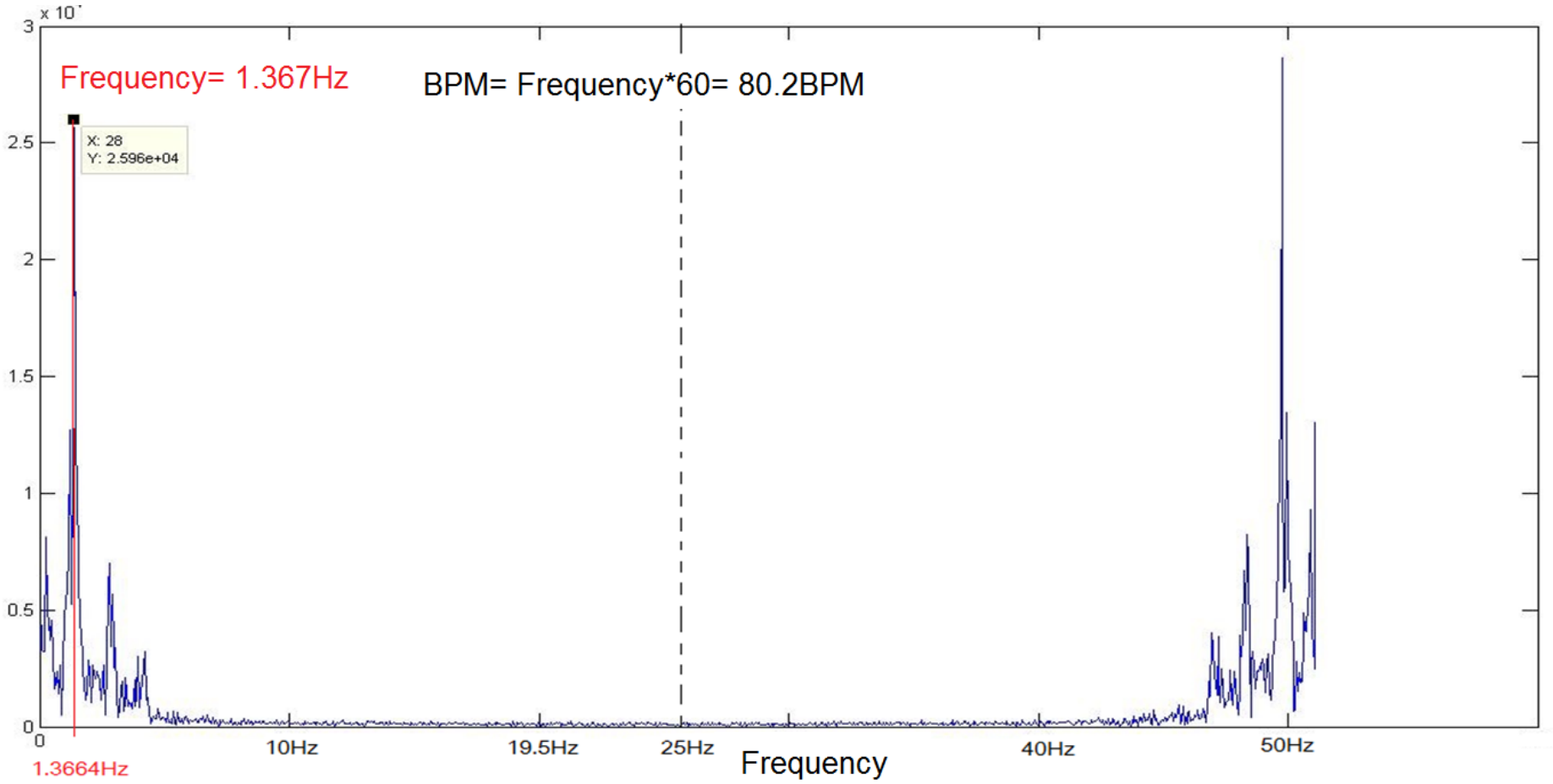
Pulsometer Test



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