UNIVERSITÉ CÔTE D'AZUR

POLYTECH NICE SOPHIA

UNIVERSITÉ CÔTE D'AZUR

Part 4
Inputs/Outputs

Fabrice MULLER

Fabrice.Muller@univ-cotedazur.fr

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Part 4 – Inputs/Outputs

3h30

Lesson : 30mn

Lab 1 : DAC / ADC / Timer

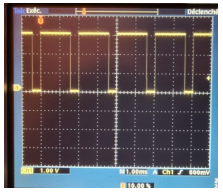
1h

- Digital to Analog Converter
- Analog to Digital Converter

Lab 2 : PWM

1h

- LEDC
- APP: light intensity of LED with PWM



Lab 3 : UART Communication

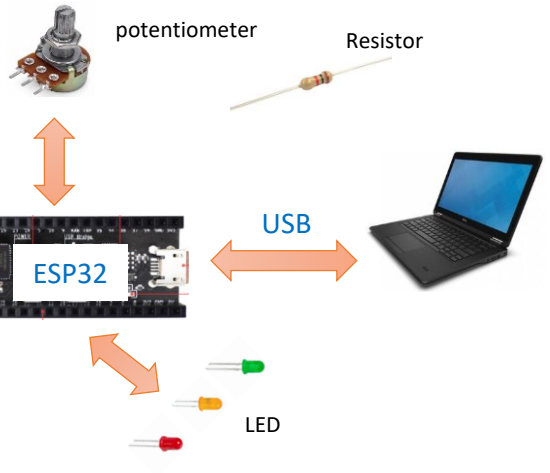
1h

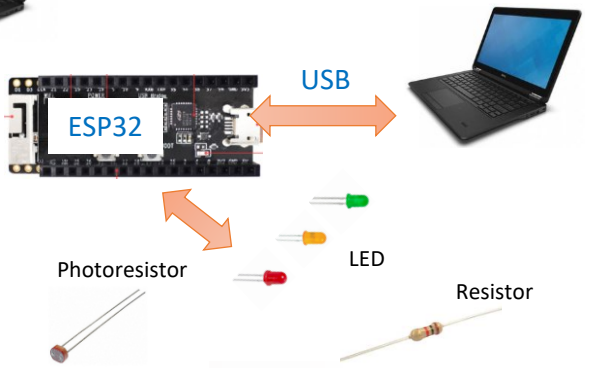
- Echo example
- Communication with a computer

Lab 4 : Application

1h

- Sensors/actuators interaction with Node-RED



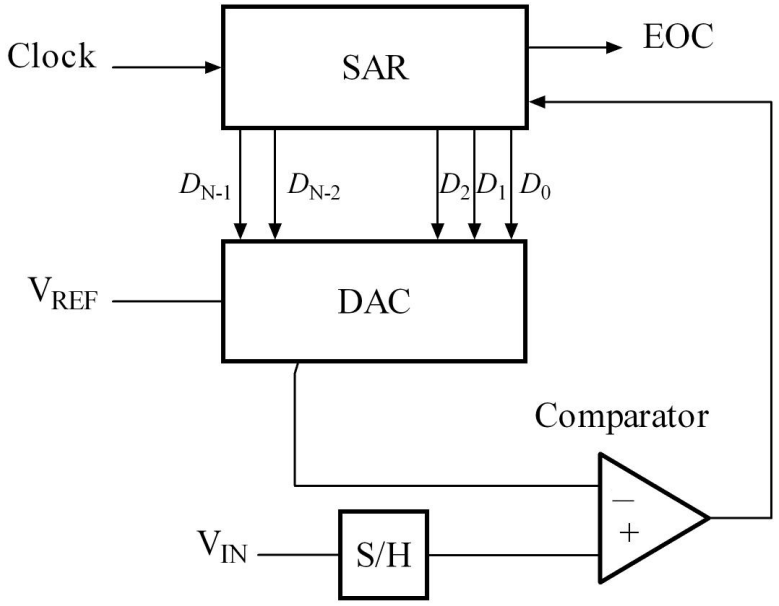


Digital to Analog Converter (DAC)

- Two 8-bit DAC
- GPIO25 (Channel 1) and GPIO26 (Channel 2)
- DAC driver
  - dac_output_enable(), dac_output_voltage()
  - Cosine wave generator function (130 ~ 55000 Hz)
  - Inter-IC Sound (I2S), example: to play audio file

Analog to Digital Converter (ADC) Introduction

- Successive Approximation Register (SAR)
- Two 12-bit SAR ADCs
  - ADC1: 8 channels (GPIO32 - GPIO39)
  - ADC2: 10 channels
- ADC2 module is also used by the Wi-Fi
- 2 Modes
  - ADC single read mode
  - ADC continuous (DMA) mode

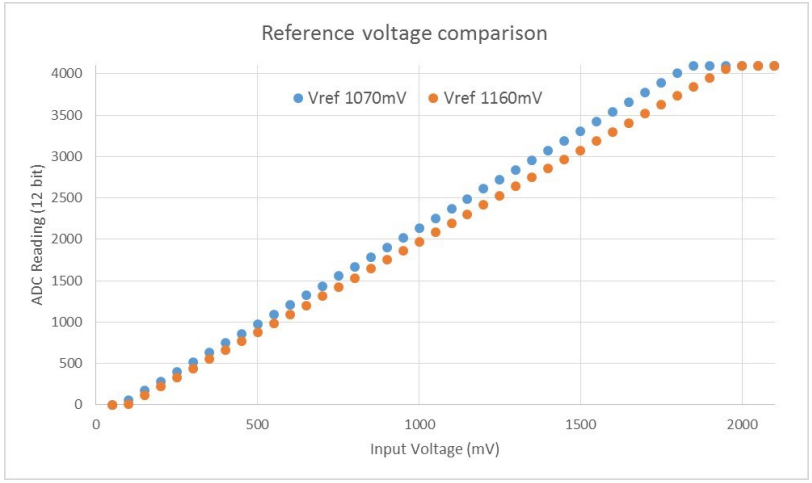


DAC = digital-to-analog converter
EOC = end of conversion
SAR = successive approximation register
S/H = sample and hold circuit
V_{IN} = input voltage
V_{REF} = reference voltage

https://en.wikipedia.org/wiki/Successive-approximation_ADC

Analog to Digital Converter (ADC) Calibration

- Correct for differences in measured voltages caused by variation of ADC reference voltages (Vref) between chips
- Range from 1000 mV to 1200 mV



Specific eFuse Vref value programmed :

espefuse.py --port /dev/ttyUSB0 adc_info

ADC VRef calibration: 1093 mV

Analog to Digital Converter (ADC) Precision and Attenuation

- Attenuation
  - 0DB (800 mV)
  - 2.5DB (1100 mV)
  - 6DB (1350 mV)
  - 11DB (2600 mV)
- Precision
  - From 9 bits to 12 bits

Configure ADC

```
adc1_config_width(width);
adc1_config_channel_atten(channel, attenuation);
```

Characterize the ADC at a particular attenuation and generate the ADC-Voltage curve in the form of [y = coeff_a * x + coeff_b].

```
esp_adc_cal_characterize(…)
```

Read from a single channel

```
val = adc1_get_raw(channel);
```

Convert the ADC reading to a voltage in mV based on the ADC's characteristics.

```
realVal = esp_adc_cal_raw_to_voltage(v, adc_chars);
```

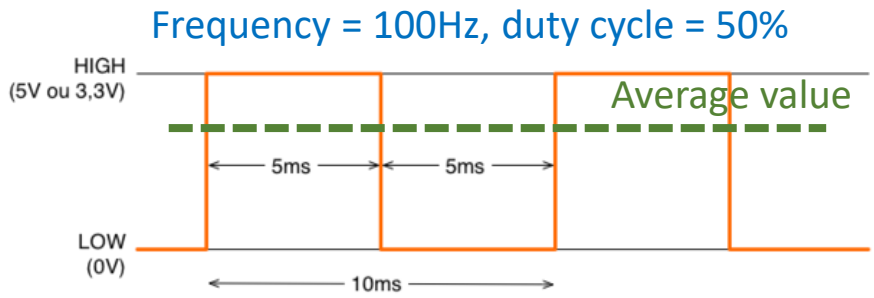
Timer

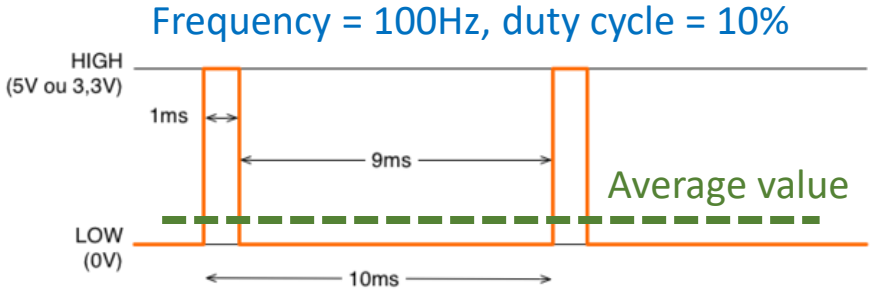
- High Resolution Timer
- 64-bit hardware timer (in µs)
  - esp_timer_get_time()
- Timer callbacks are dispatched from a high-priority *esp_timer* task.
- Can be run periodically or just once
  - esp_timer_start_periodic()
  - esp_timer_start_once()

https://docs.espressif.com/projects/esp-idf/en/latest/esp32/api-reference/system/esp_timer.html

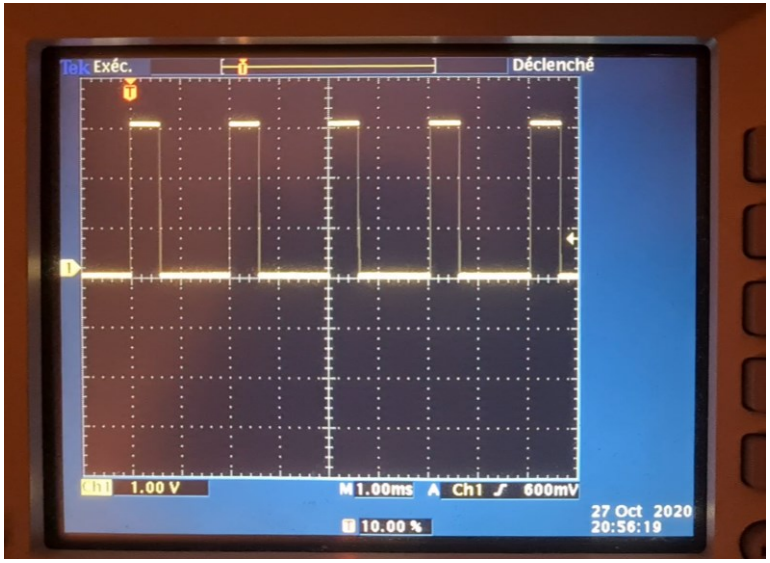
Pulse Width Modulation – PWM Principle

- Output signal whose duty cycle varies
- Average value of a rectangular signal
- Applications
  - Motor speed controllers
  - Converters: AC/DC, DC/AC …
  - Signal generator, Modulators
  - Power control
  - And so on …

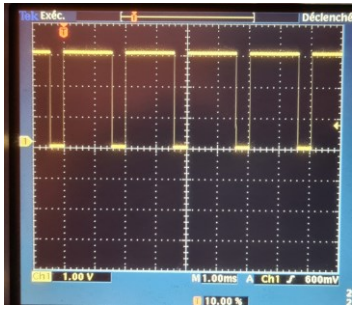




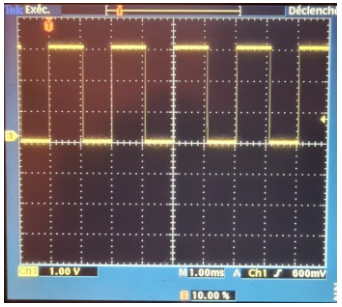
Pulse Width Modulation – PWM Examples



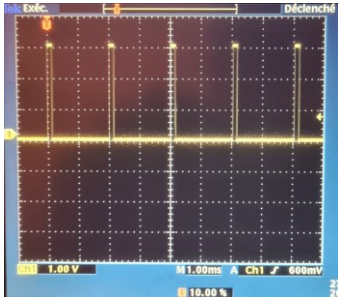
Duty cycle ~ 80%



Duty cycle ~ 50%

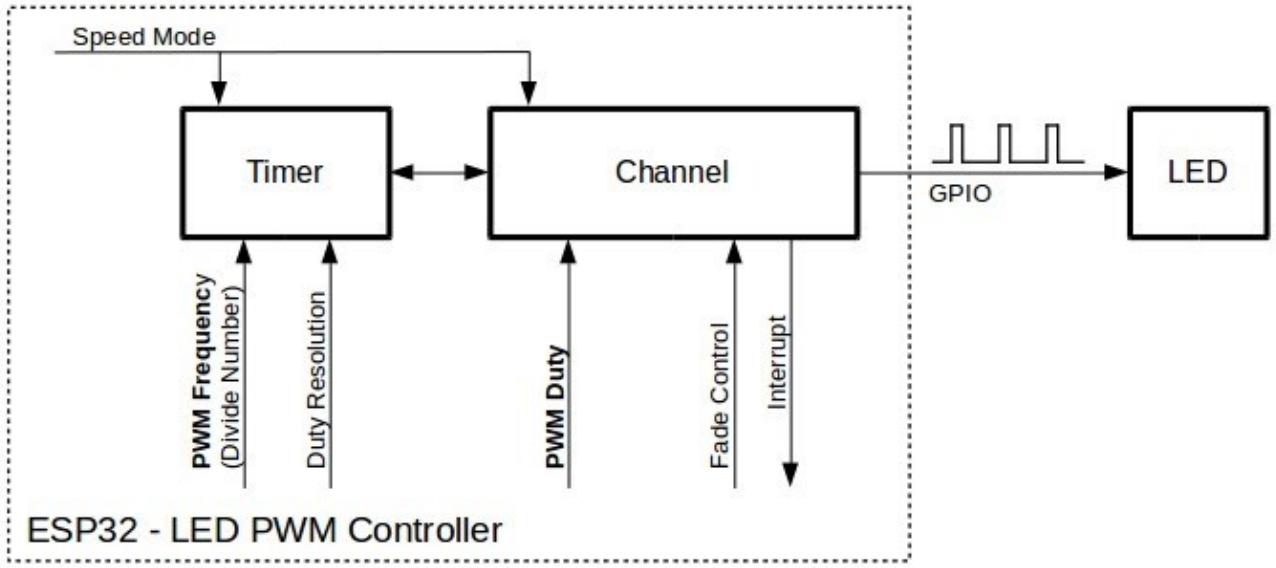


Duty cycle ~ 10%



Pulse Width Modulation – PWM ESP32

- PWM configuration
  - Timer (Résolution, Frequency …)
  - Channel (pin, duty cycle …)
  - Fade driver (change to current duty cycle to target duty cycle)

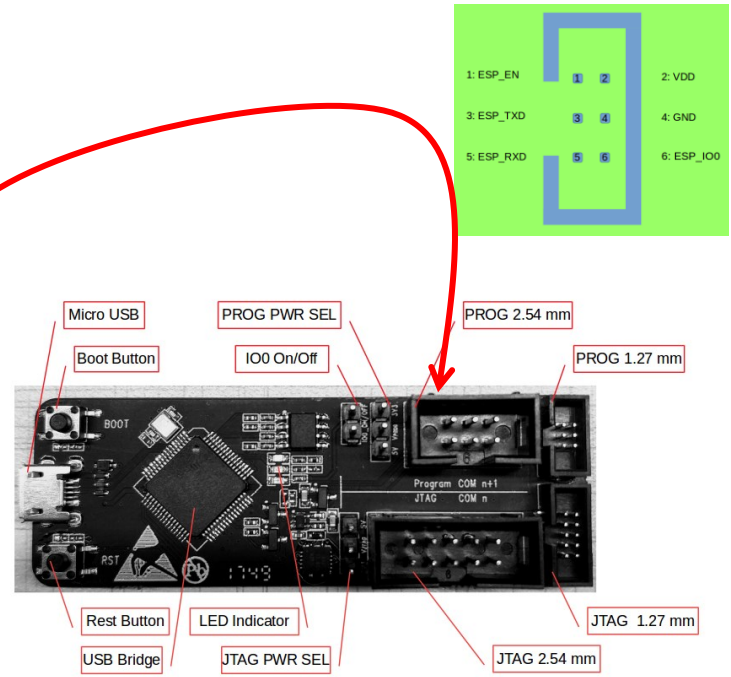


https://docs.espressif.com/projects/esp-idf/en/latest/esp32/api-reference/peripherals/ledc.html

UART Communication

- UART = Universal Asynchronous Receiver Transmitter
- RS-232, the most widely used communication standard on the planet
- TXD, RXD pin (do not forget the GND pin)

Circuit		
Name	Typical purpose	Abbreviation
Data Terminal Ready	DTE is ready to receive, initiate, or continue a call.	DTR
Data Carrier Detect	DCE is receiving a carrier from a remote DCE.	DCD
Data Set Ready	DCE is ready to receive and send data.	DSR
Ring Indicator	DCE has detected an incoming ring signal on the telephone line.	RI
Request To Send	DTE requests the DCE prepare to transmit data.	RTS
Ready To Receive	DTE is ready to receive data from DCE. If in use, RTS is assumed to be always asserted.	RTR
Clear To Send	DCE is ready to accept data from the DTE.	CTS
Transmitted Data	Carries data from DTE to DCE.	TxD
Received Data	Carries data from DCE to DTE.	RxD
Common Ground	Zero voltage reference for all of the above.	GND
Protective Ground	Connected to chassis ground.	PG



https://en.wikipedia.org/wiki/RS-232

UART Communication Protocol

- Example
  - Value = $69 (01101001 en binaire)
  - 115200 baud
  - 8 bits
  - even parity (choose between ODD/EVEN parity)
  - 1 stop bit
  - No control flow