

# Management and analysis of physics datasets, Part. 1

Sixth Laboratory

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## Laboratory Introduction

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- Discover The Arty7 FPGA Board
- build a UART transmit Unit

## a smart way to build larger simulation projects

```
student@MAPD-machine : ~$ ghdl -i heartbeat.vhd # include source file in the project
student@MAPD-machine : ~$ ghdl -i heartbeat_top.vhd # include source file in the project
student@MAPD-machine : ~$ ghdl -d # check the working directory

# Library work
# Directory :
entity heartbeat
architecture behaviour of heartbeat
entity heartbeat_top
architecture str of heartbeat_top

student@MAPD-machine : ~$ ghdl -m heartbeat_top # make the selected entity (usually the top)
analyze heartbeat_top.vhd
analyze heartbeat.vhd
elaborate heartbeat_top

student@MAPD-machine : ~$ ghdl -r heartbeat_top --wave=wave.ghw --stop-time=1us # run the simulation

./heartbeat_top : info : simulation stopped by --stop-time @1us

student@MAPD-machine : ~$ gtkwave wave.ghw #inspect the result (waveform)
```

## Arty 7 FPGA Board

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## A closer look to the Board

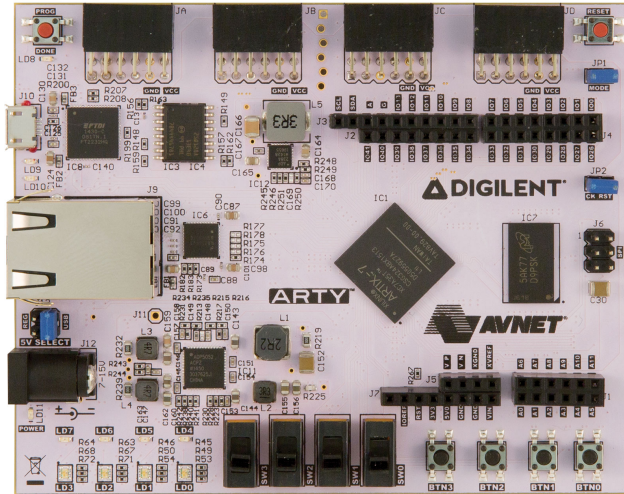


Figure 1: Arty 7 Board

## Arty7: Useful interfaces

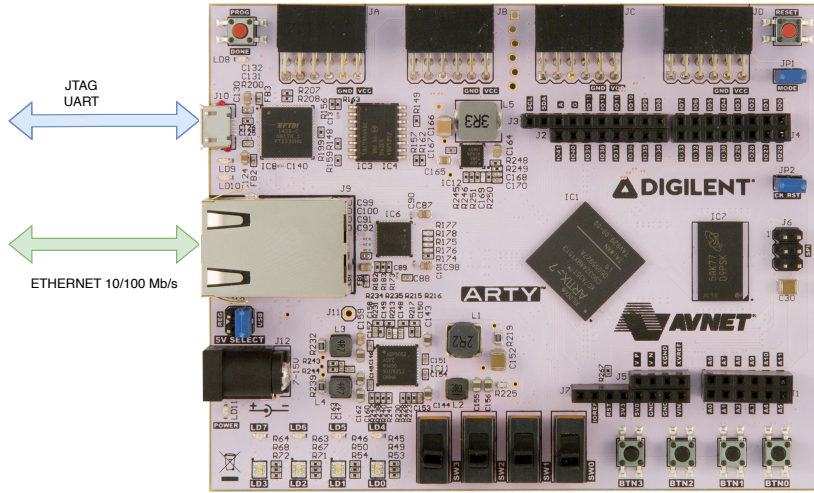


Figure 2: Arty 7 interfaces

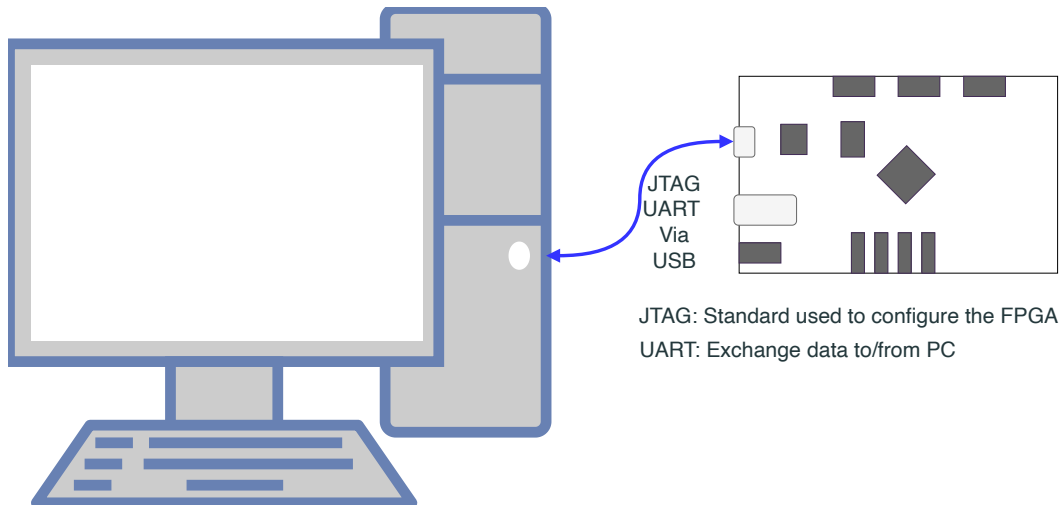


Figure 3: Arty 7 connect to a PC



- Since we need to connect our FPGA Board to a PC, we need to enable a reasonable useful interface .
- Some interfaces are available, but we need to manage them:

Interface	Speed	typical usage	Ease of use
Ethernet	100 Mbit/s	General purpose	very high
JTAG	< 10 Mbit/s	Config/Debug	moderately high
<b>UART</b>	< < 1 Mbit/s	text messages	<b>Easy</b>

Universal **A**synchronous **R**eceiver **T**ransmitter: The device

**RS-232**: the standard protocol

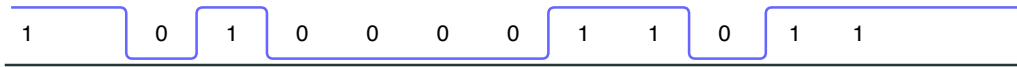
## Introducing the RS-232 standard

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## The RS-232 Data frame: an example

- **Byte oriented frame**
- Mostly used to exchange *character stream* ( ASCII code, see next slide) but also binary stream
- optional parity bit at the end of the trasmitted byte
- **start** and **stop** frame delimiter length = 1 bit ( stop-bit could be 2 in some cases)

Transmit Character 'a' ( ASCII CODE hexadecimal: 61, binary: 01100001) at 115200 Bit/second, no parity bit



$$T_{bit} = 1/115200 \text{ s} = 8,68 \text{ us}$$

# The ASCII standard

The hexadecimal set:

00 nul	01 soh	02 stx	03 etx	04 eot	05 enq	06 ack	07 bel
08 bs	09 ht	0a nl	0b vt	0c np	0d cr	0e so	0f si
10 dle	11 dc1	12 dc2	13 dc3	14 dc4	15 nak	16 syn	17 etb
18 can	19 em	1a sub	1b esc	1c fs	1d gs	1e rs	1f us
20 sp	21 !	22 "	23 #	24 \$	25 %	26 &	27 '
28 (	29 )	2a *	2b +	2c ,	2d -	2e .	2f /
30 0	31 1	32 2	33 3	34 4	35 5	36 6	37 7
38 8	39 9	3a :	3b ;	3c <	3d =	3e >	3f ?
40 @	41 A	42 B	43 C	44 D	45 E	46 F	47 G
48 H	49 I	4a J	4b K	4c L	4d M	4e N	4f O
50 P	51 Q	52 R	53 S	54 T	55 U	56 V	57 W
58 X	59 Y	5a Z	5b [	5c \	5d ]	5e ^	5f _
60 `	61 a	62 b	63 c	64 d	65 e	66 f	67 g
68 h	69 i	6a j	6b k	6c l	6d m	6e n	6f o
70 p	71 q	72 r	73 s	74 t	75 u	76 v	77 w
78 x	79 y	7a z	7b {	7c	7d }	7e ~	7f del

## The Universal Asynchronous Receiver-Transmitter

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UART communication is made on a **point-to-point** connection

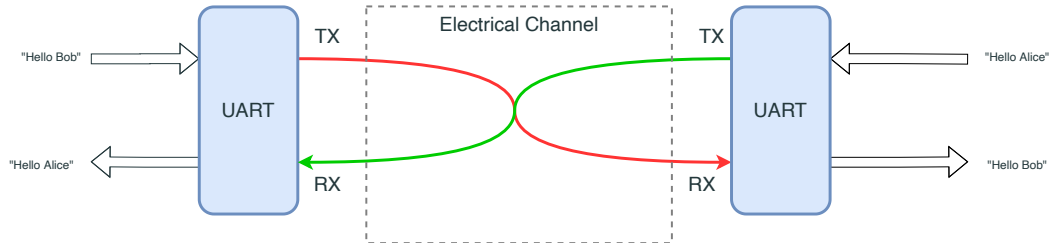


Figure 5: UART typical interconnection

## The UART subsystem in the Arty7 Board

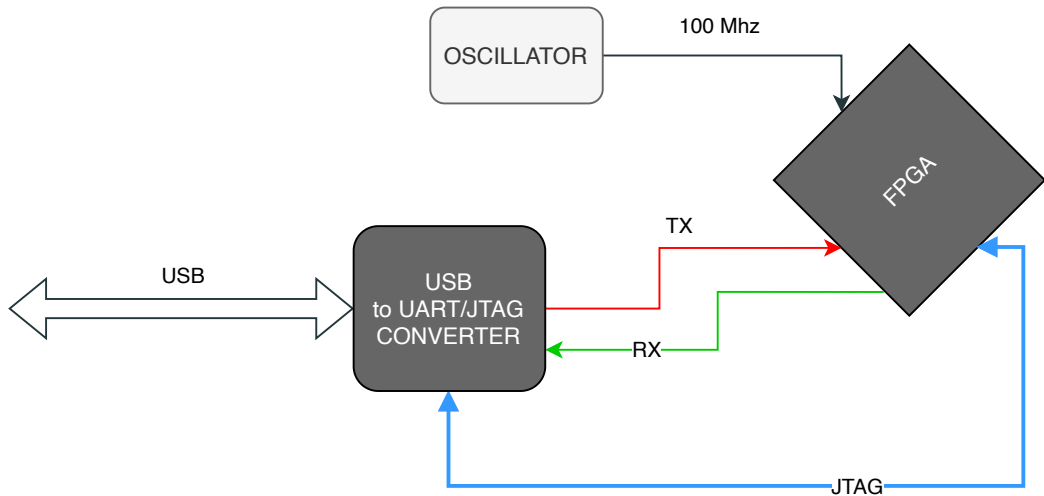


Figure 6: Arty7 Uart schematic

## Build a UART transmitter

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# The Baudrate generator

- it is basically a counter
- it has only one output
- output is equal to '1' for exactly one clock cycle every *bit time* (*T<sub>bit</sub>*)

## Motivation

We need a periodic signal ( another clock ) at the rate of the transmission. **Baudrate:** speed in symbol/s ( 1 symbol carries 1 bit)

BOARD clock frequency = 100 Mhz ( 10 ns period)

BAUDRATE = 115200 (bit/s)

DIVIDER=  $100.000.000 / 115200 = 868.055$

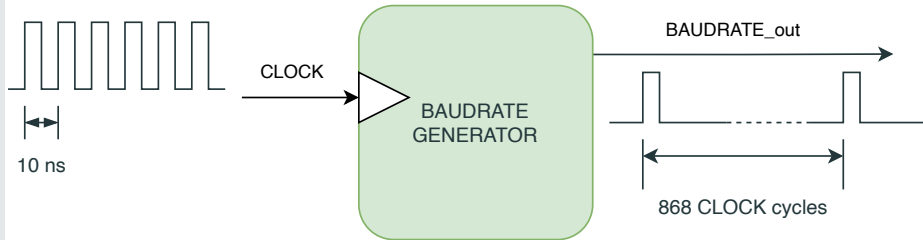


Figure 7: The Baudrate generator

Write a Baudrate generator in VHDL, in the case of:

- Clock frequency= 100 Mhz
- Baudrate = 115200

# The Uart Transmitter

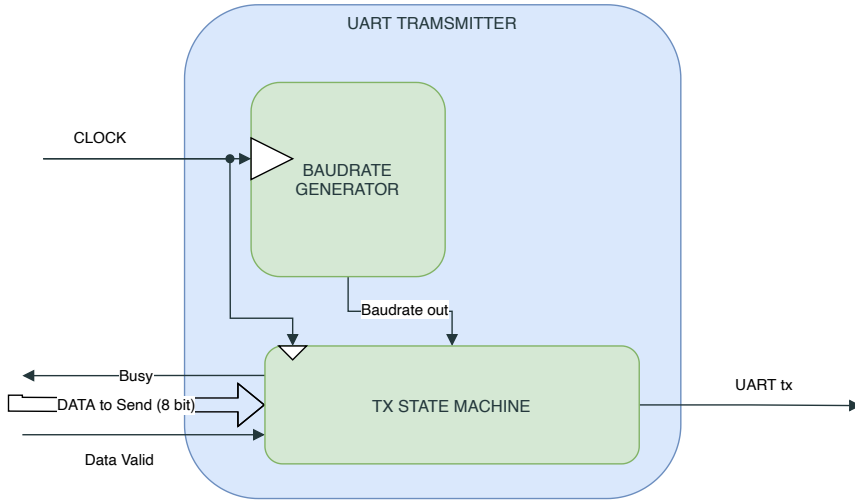


Figure 8: The Uart Transmitter

# The Uart Transmitter State machine

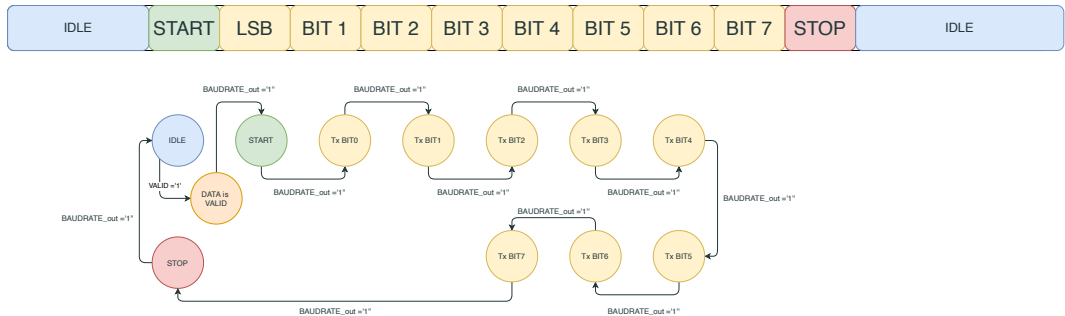


Figure 9: tx State machine idea

The BAUDRATE out signal make possible to switch from a state to another

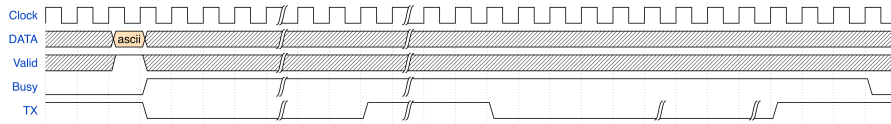


Figure 10: UART transmitter waveform

## Homework

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- Build a complete Uart transmitter working at data rate of 115200 baud