What is the real frequency of the UART baud rate?

Created by: David Rubio G.

Blog post: https://soceame.wordpress.com/2025/03/02/what-is-the-actual-baud-rate-of-the-uart/

Blog: https://soceame.wordpress.com/

GitHub: https://github.com/DRubioG

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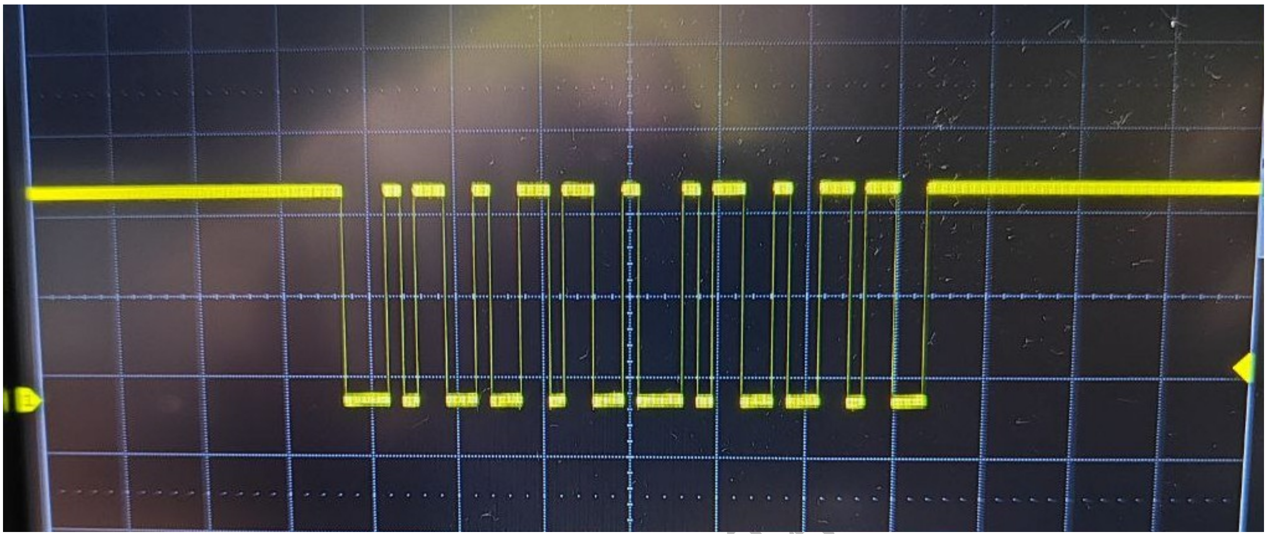
If you have worked with the serial communication protocol par excellence, you will know what baud is. For those who don't, baud is the number of bits that can be sent per second in the UART (universal asynchronous receiver-transmitter) protocol. For two devices to communicate using the UART protocol, both must communicate using the same baud number.



Bauds are standardized to different values:

- 300 baud
- 600 baud
- 1200 baud
- 2400 baud
- 4800 baud
- 9600 baud
- 19200 baud
- 31250 baud
- 38400 baud
- 57600 baud
- 74880 baud
- 115200 baud
- 230400 baud
- 250000 baud
- 460800 baud
- 500000 baud
- 921600 baud
- 1000000 baud
- 2000000 baud

These values are the typical ones that serial port readers usually offer you.

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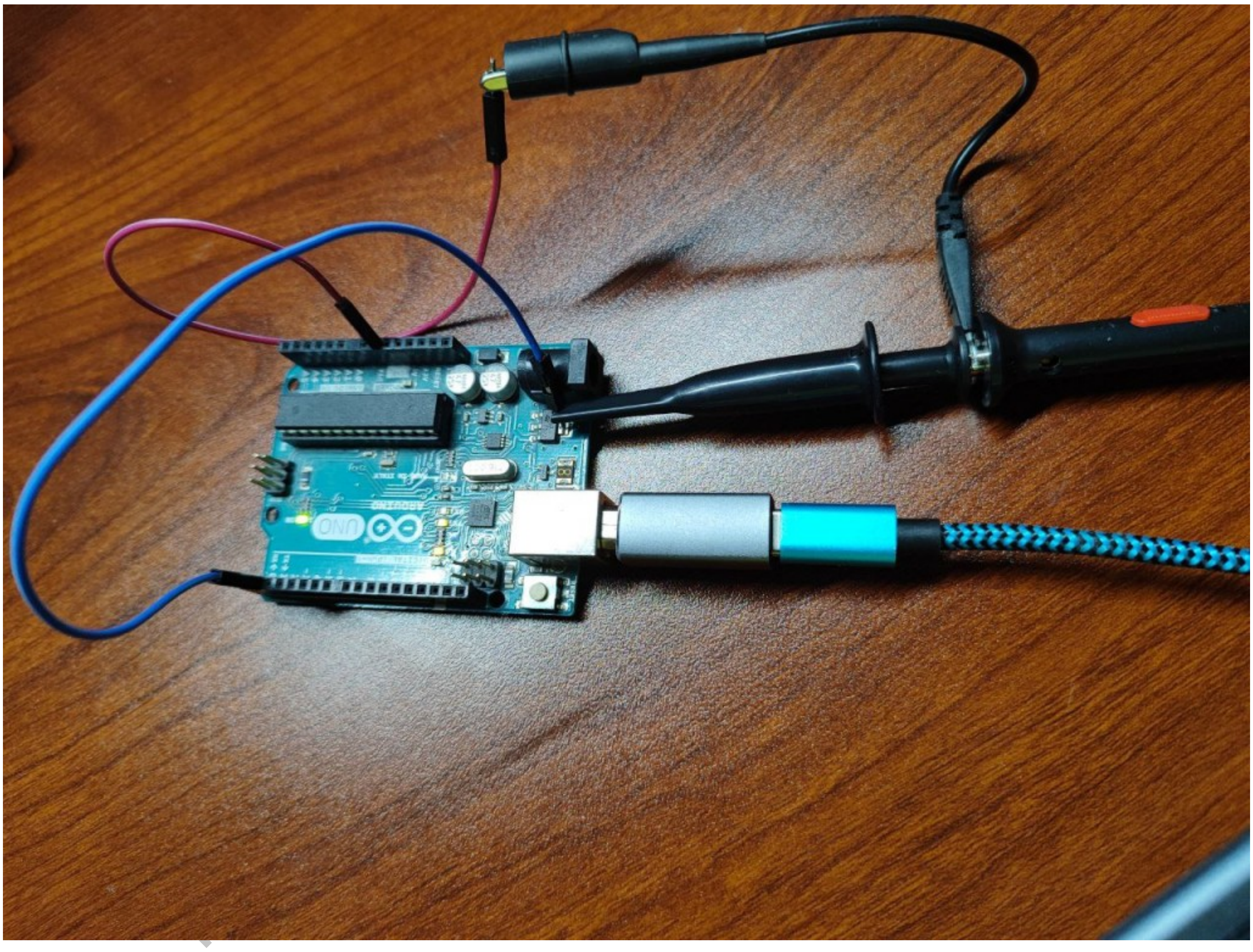
Well, if you now review the information on the Internet to find out what frequency values the previous values correspond to, you will probably not find anything clear. That's what this entry on this blog is for.

How to know the value of the frequency

In order to know the real baud frequency value, an experiment is going to be done. In this experiment, the Tx signal of a device communicating via UART will be sampled on an oscilloscope.

This system is going to be an Arduino with an oscilloscope hooked to digital pin 1.

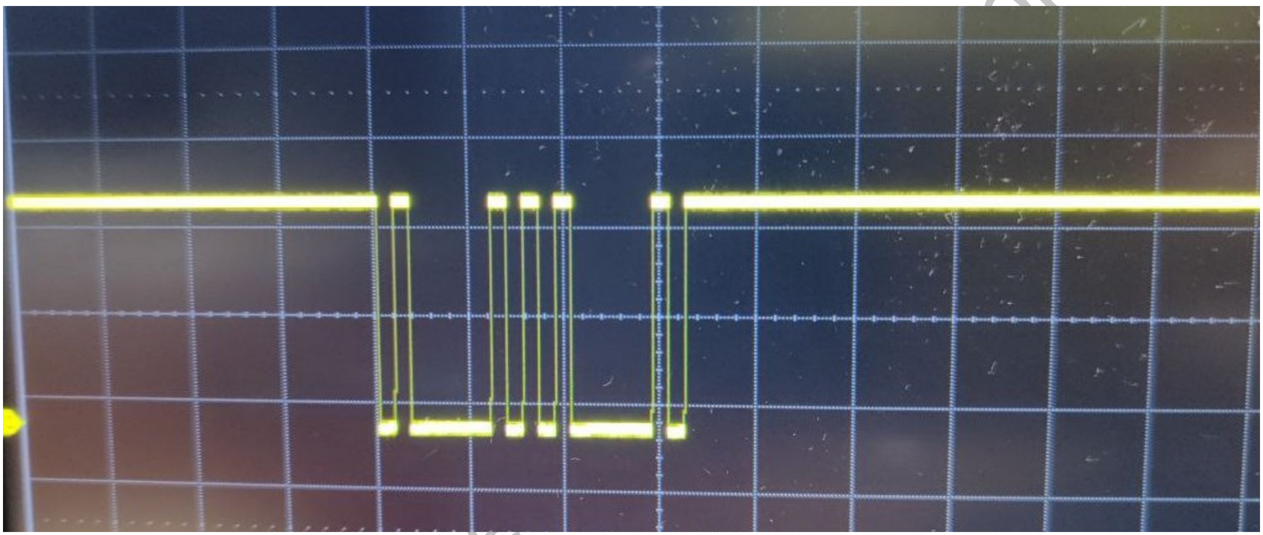


To carry out tests with the device, an example program will be loaded that runs cyclically at 115200 baud, the one in the image.

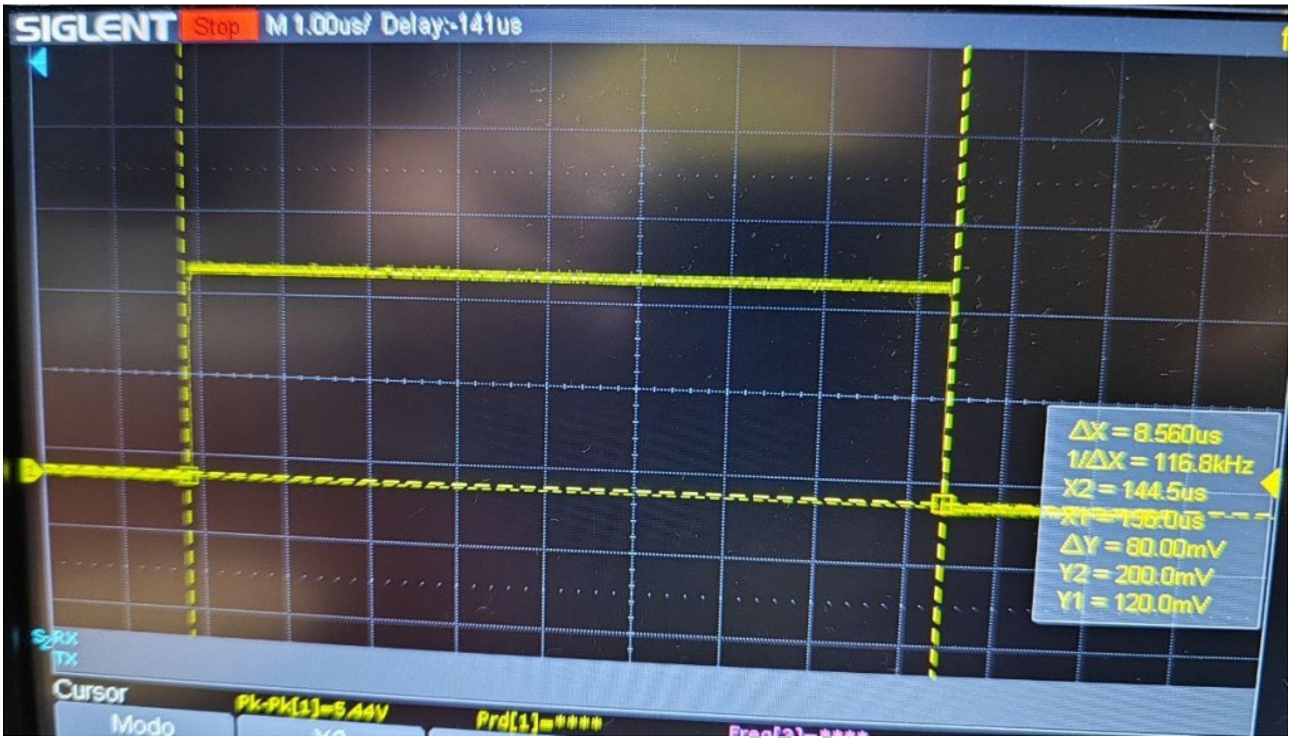
```
void setup() {
  // put your setup code here, to run once:
  Serial.begin(115200);
}

void loop() {
  // put your main code here, to run repeatedly:
  Serial.print("AA");
  delay(100);
}
```

When you run it, you can check on the oscilloscope that it has rising and falling pulses with different periods.

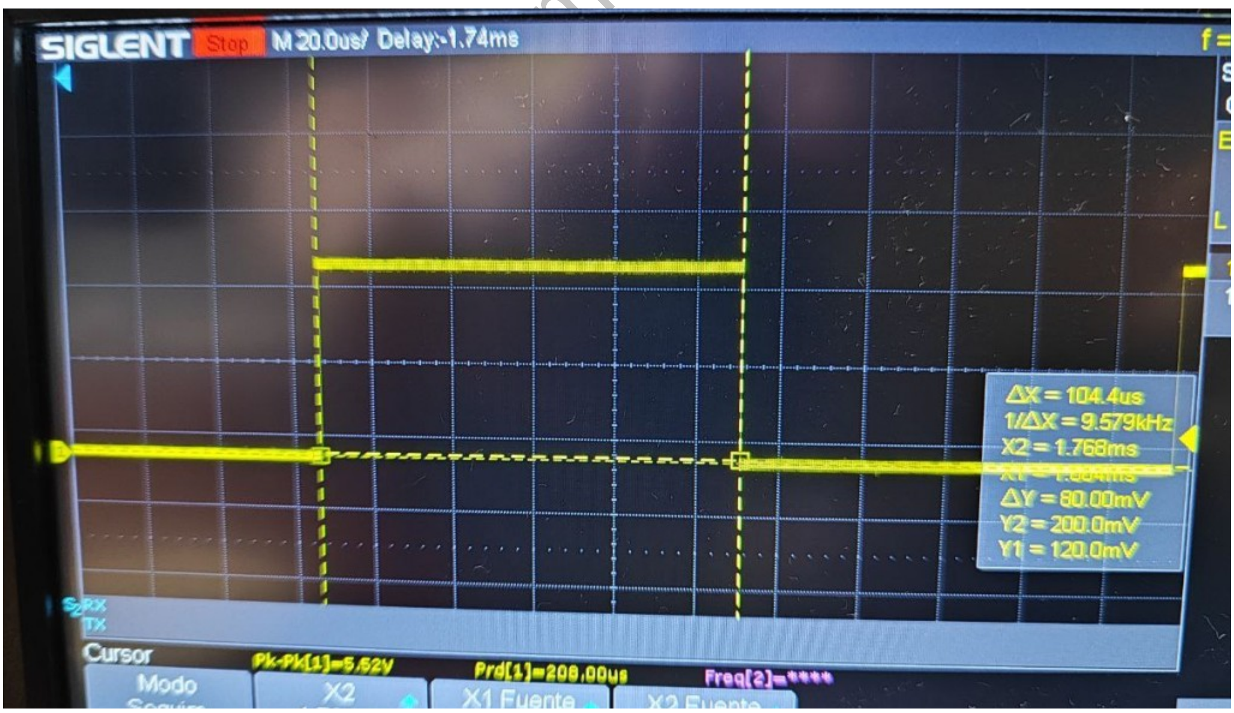


So in order to check the duration of a UART bit, one of the smallest pulses is zoomed in, and the cursors are placed on it to measure the duration of each bit.



Then, analyzing the period it can be verified that each bit has a period of 8.560 us, which in frequency (1/Tbit) is 116822.43 Hz. This value is for 115200 bauds. From what you can see, the baud value is quite close to the real frequency of each bit.

To corroborate this, the same test is carried out but at 9600 baud.



Now the period of each bit is **104.4 us,** which is equivalent to **9.579kHz**, for **9600** baud.

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So it can be confirmed that the baud value is the frequency value of each communication bit.

This knowledge has great implications when designing hardware systems with standard UART communication.

And to finish I leave a small list so that whoever needs it has the period values of each bit for each baud value.

Baud rate (bauds)	**Bit period** (s)	**UART package period (s)** [Periodo de bit x 10*]
300	0,003333333 **(3,333 ms)**	0,03333333 **(33,33 ms)**
600	0,001666667 **(1,666 ms)**	0,01666667 **(16,66 ms)**
1200	0,000833333 **(833 us)**	0,00833333 **(8,33 ms)**
2400	0,000416667 **(416,66 us)**	0,00416667 **(4,1666 ms)**
4800	0,000208333 **(208,333 us)**	0,00208333 **(2,0833 ms)**
9600	0,000104167 **(104 us)**	0,00104167 **(1,04 ms)**
19200	0,000052083 **(52 us)**	0,00052083 **(520 us)**
31250	0,000032 **(32 us)**	0,00032 **(320 us)**
38400	0,000026042 **(26 us)**	0,00026042 **(260 us)**
57600	0,000017361 **(17,61 us)**	0,00017361 **(176,1 us)**
74880	0,000013355 **(13,355 us)**	0,00013355 **(133,55 us)**
115200	0,000008681 **(8,681 us)**	0,00008681 **(86,81 us)**
230400	0,00000434 **(4,34 us)**	0,0000434 **(43,4 us)**
250000	0,000004 **(4 us)**	0,00004 **(40 us)**
460800	0,00000217 **(2,17 us)**	0,0000217 **(21,7 us)**
500000	0,000002 **(2 us)**	0,00002 **(20 us)**
921600	0,000001085 **(1,085 us)**	0,00001085 **(10,85 us)**
1000000	0,000001 **(1 us)**	0,00001 **(10 us)**
2000000	0,0000005 **(500 ns)**	0,000005 **(5 us)**

** If parity bit is included, it is multiplied by 11*

And finally, to know the real period of each frame per UART, it must be multiplied by the number of bits that each UART packet has.

Each packet has 8 bits of information + 1 Start bit + 1 Stop bit = which means that 10 bits are needed for each UART, which multiplies the period of each bit x10 to obtain the period of the packet.

Note: if a parity bit is included within the UART communication, this period is multiplied by 11.

Recommendation

If you want to use this information to program an FPGA in VHDL, you have this repository to simulate a UART signal in a testbench, with all the UART bit periods already entered:

https://github.com/DRubioG/UART_pkg