Electronics
Serial Communication-UART

Terry Sturtevant

Wilfrid Laurier University

June 28, 2017

Serial Communication -UART

Serial Communication -UART

- Universal Asynchronous Receiver Transmitter

Serial Communication -UART

- Universal Asynchronous Receiver Transmitter
- Simplest form of serial communication

Serial Communication -UART

- Universal Asynchronous Receiver Transmitter
- Simplest form of serial communication
- Between 2 devices

Serial Communication -UART

- Universal Asynchronous Receiver Transmitter
- Simplest form of serial communication
- Between 2 devices
- Uses 2 signals (and Ground), Rx and Tx

Serial Communication -UART

- Universal Asynchronous Receiver Transmitter
- Simplest form of serial communication
- Between 2 devices
- Uses 2 signals (and Ground), Rx and Tx
- Asynchronous, so both must agree on baud rate

Communication parameters

Communication parameters

- 1 Start bit at “0” level

Communication parameters

- 1 Start bit at “0” level
- LSB transmitted first

Communication parameters

- 1 Start bit at “0” level
- LSB transmitted first
- Can have odd, even, or no parity bit

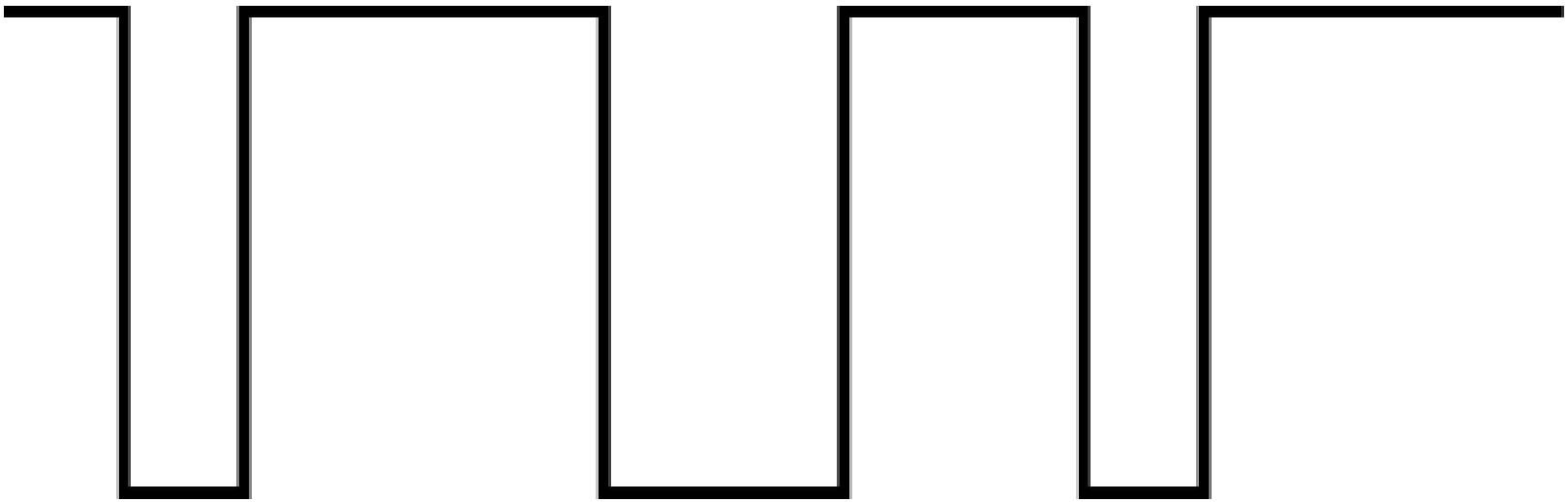
Communication parameters

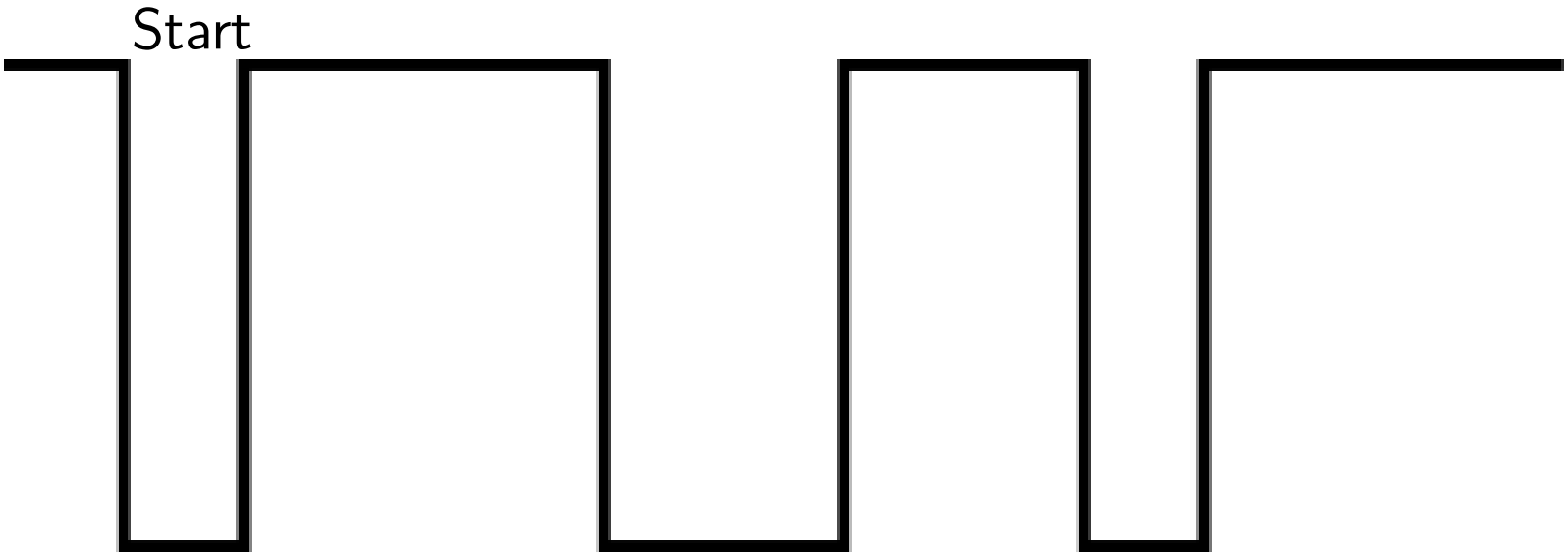
- 1 Start bit at “0” level
- LSB transmitted first
- Can have odd, even, or no parity bit
- 1 or 2 Stop bits at “1” level

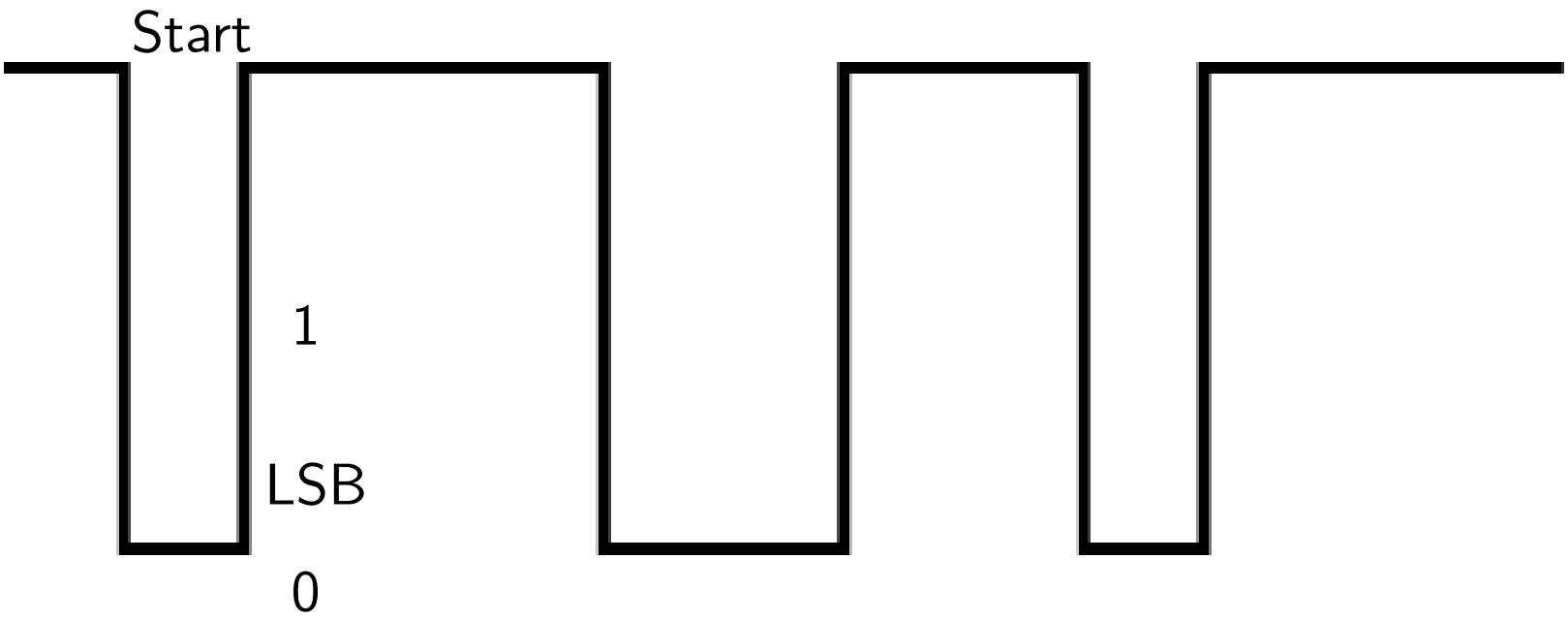
Communication parameters

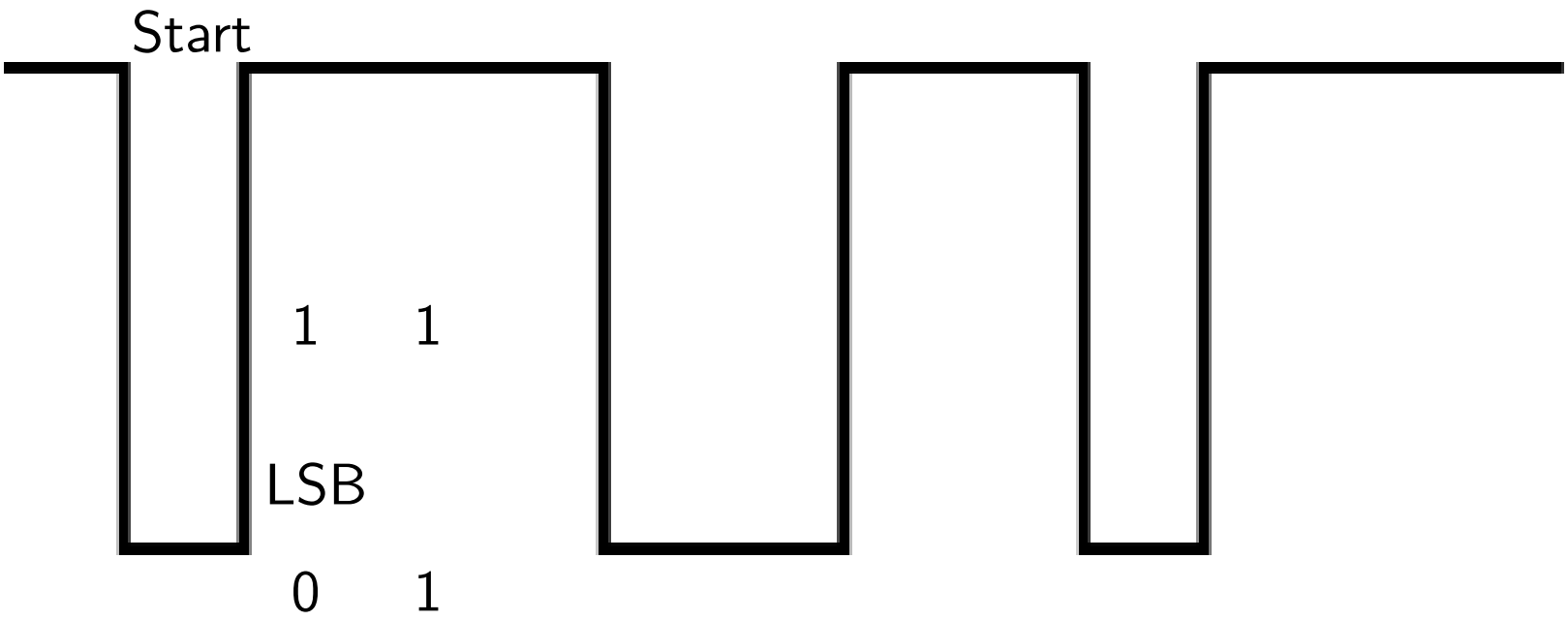
- 1 Start bit at “0” level
- LSB transmitted first
- Can have odd, even, or no parity bit
- 1 or 2 Stop bits at “1” level

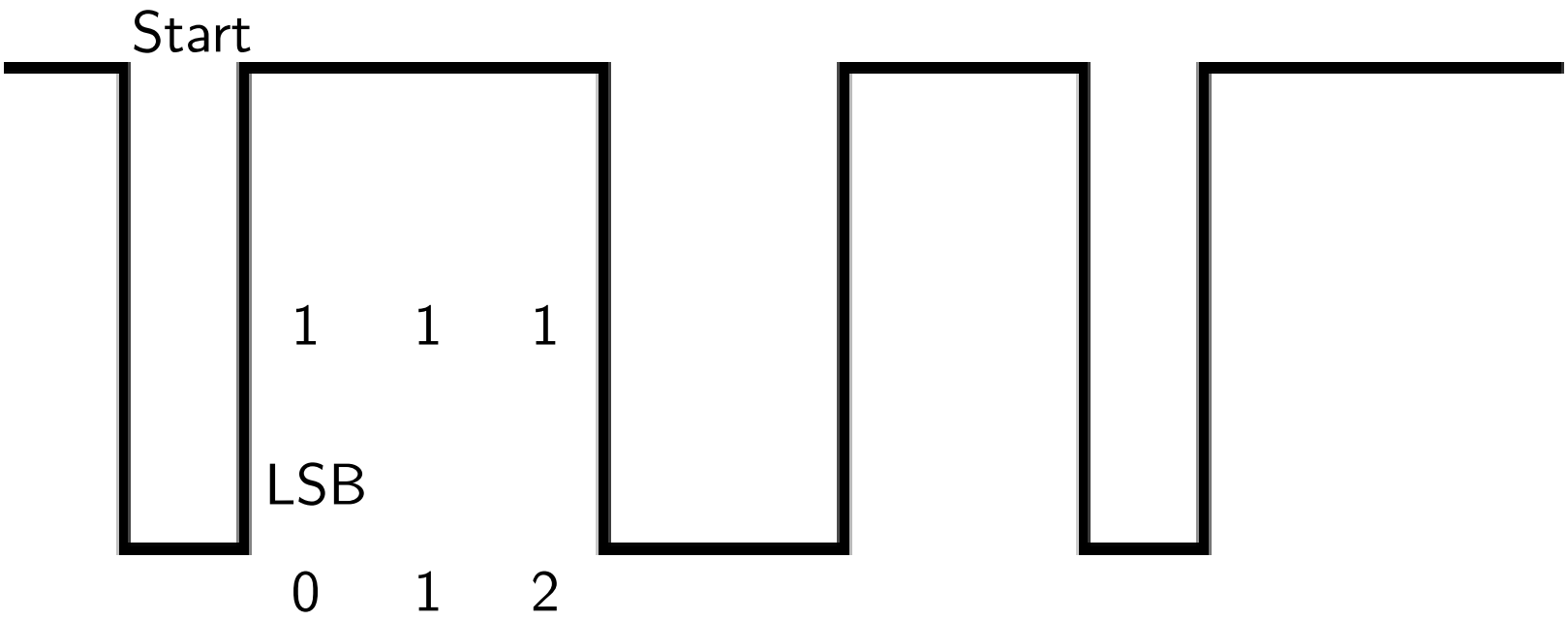
Since start and stop bits are opposite, new characters can always be detected.

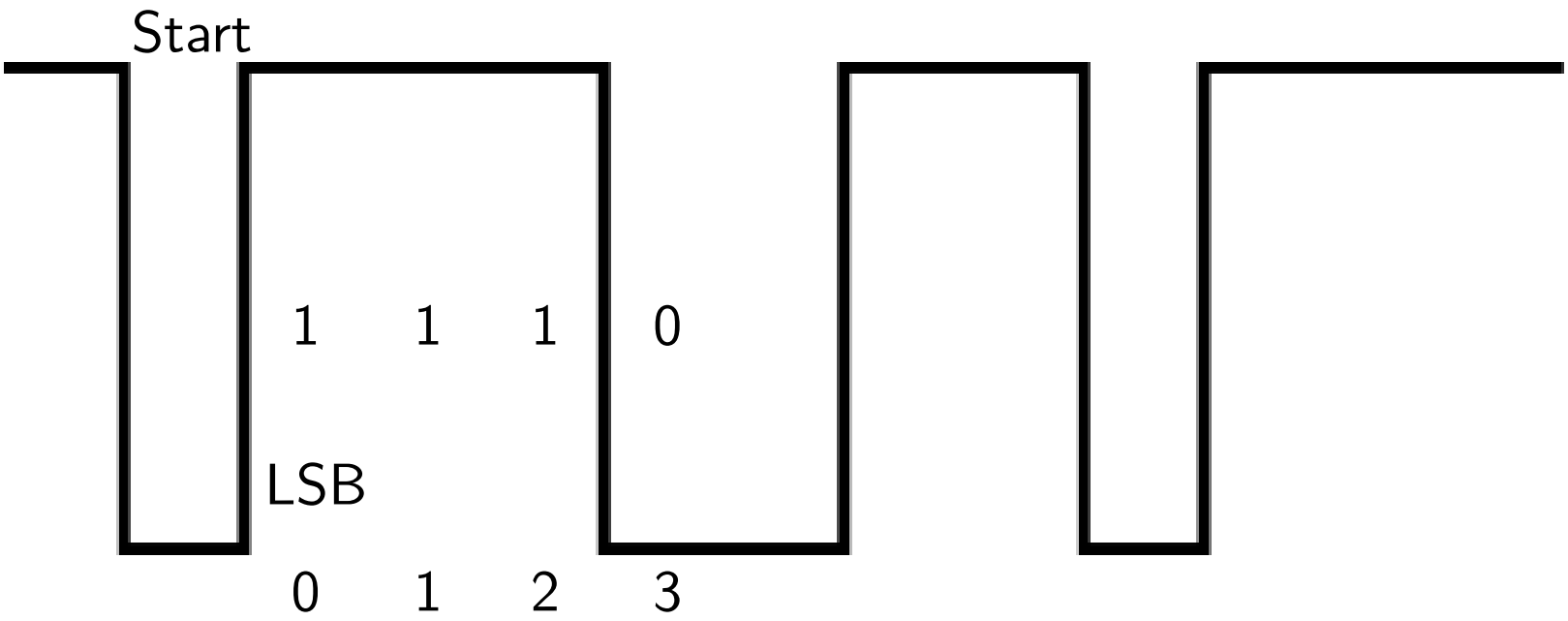


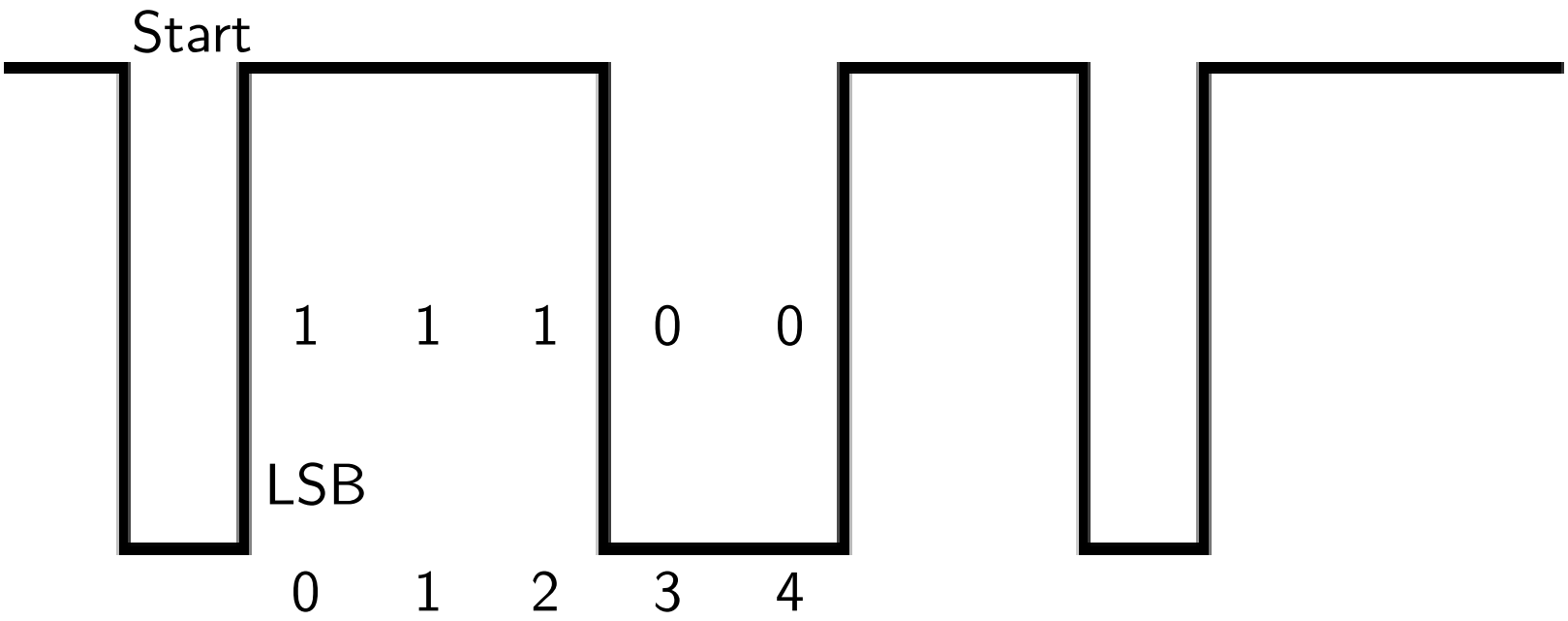

Start

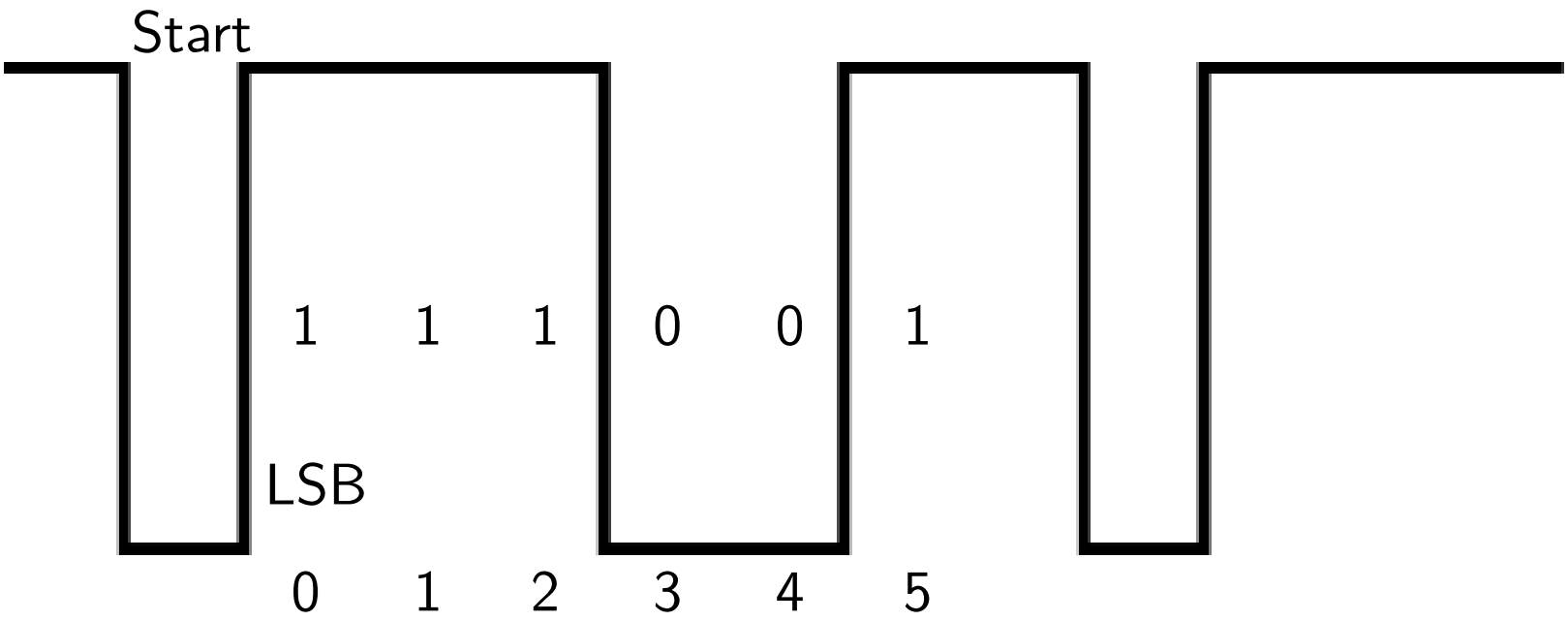

Start
1
LSB
0

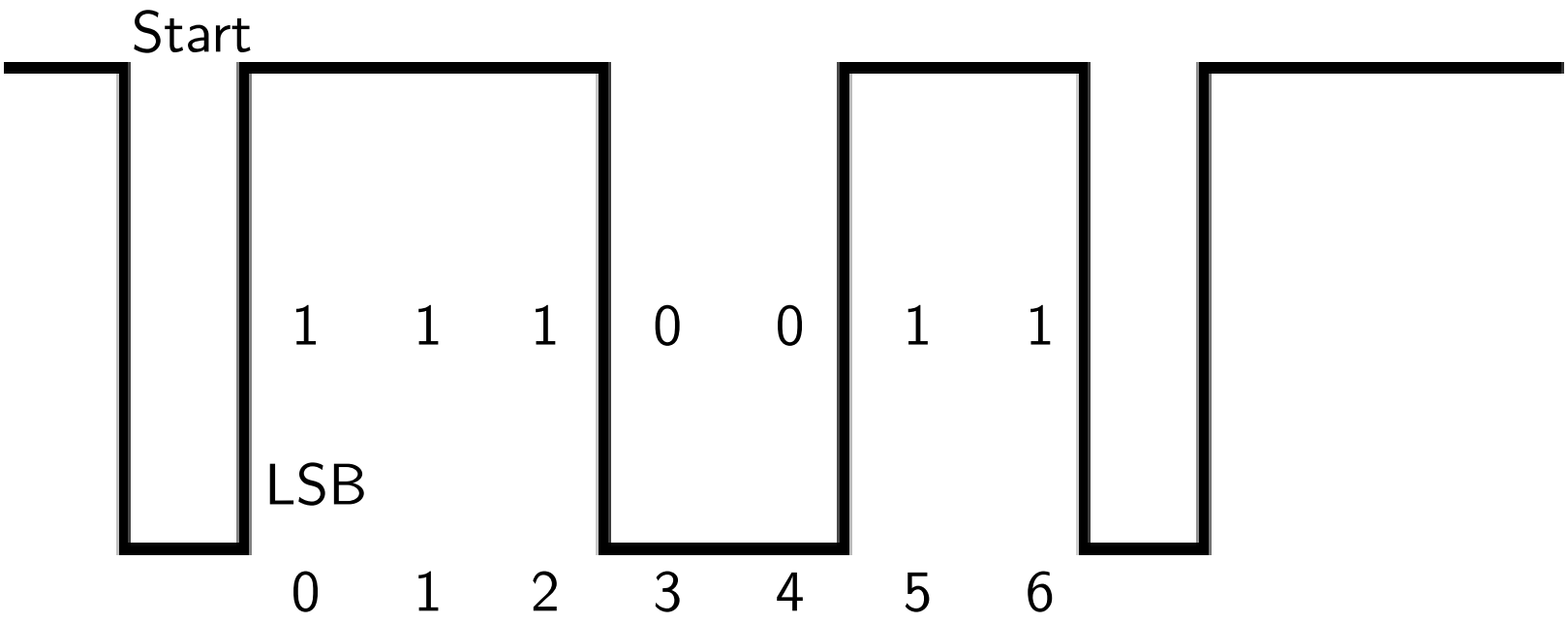

Start
1
1
LSB
0
1

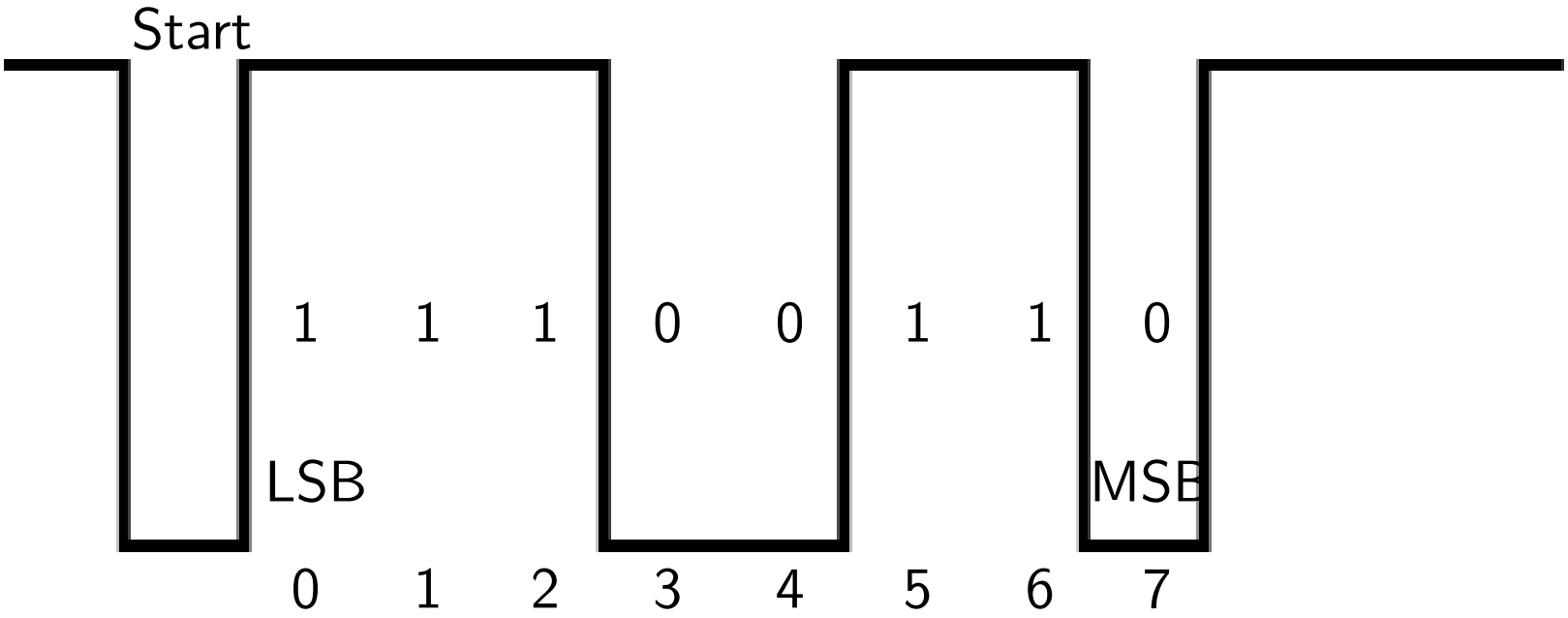

Start
1
1
1
LSB
0
1
2

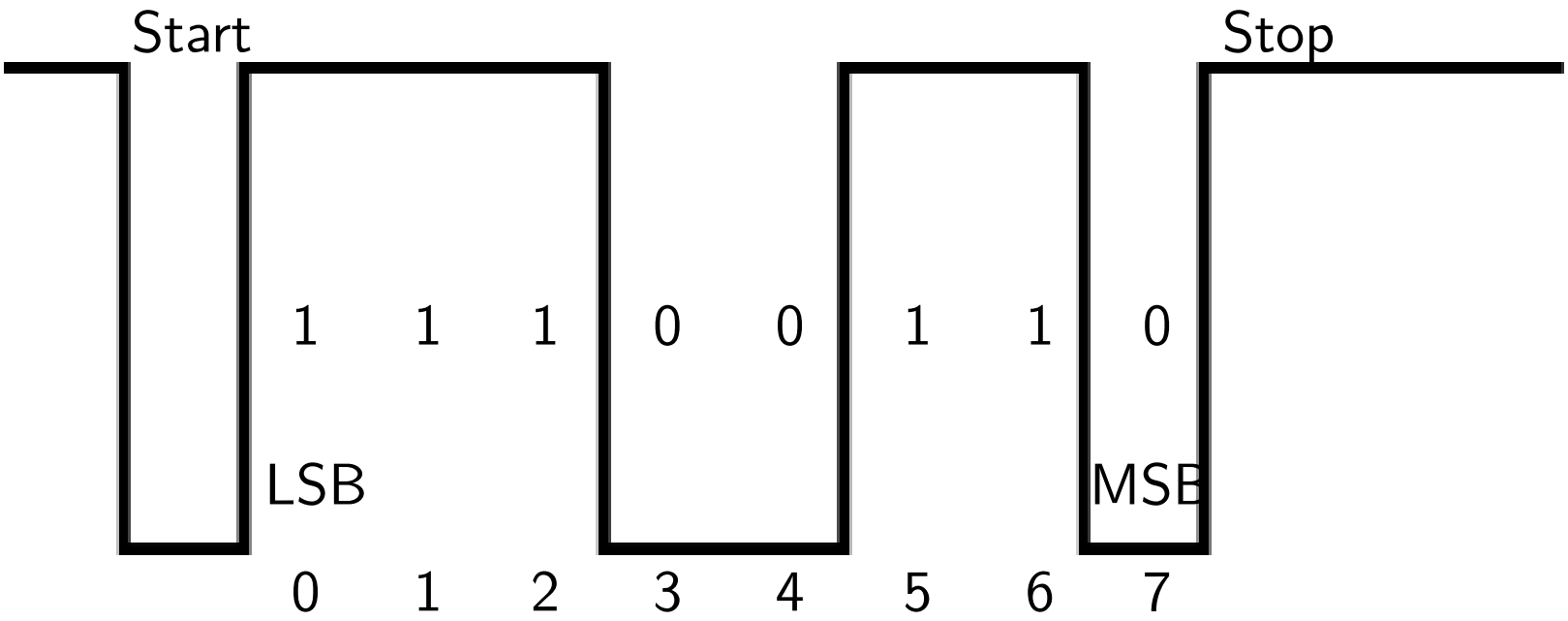

Start
1
1
1
0
LSB
0
1
2
3

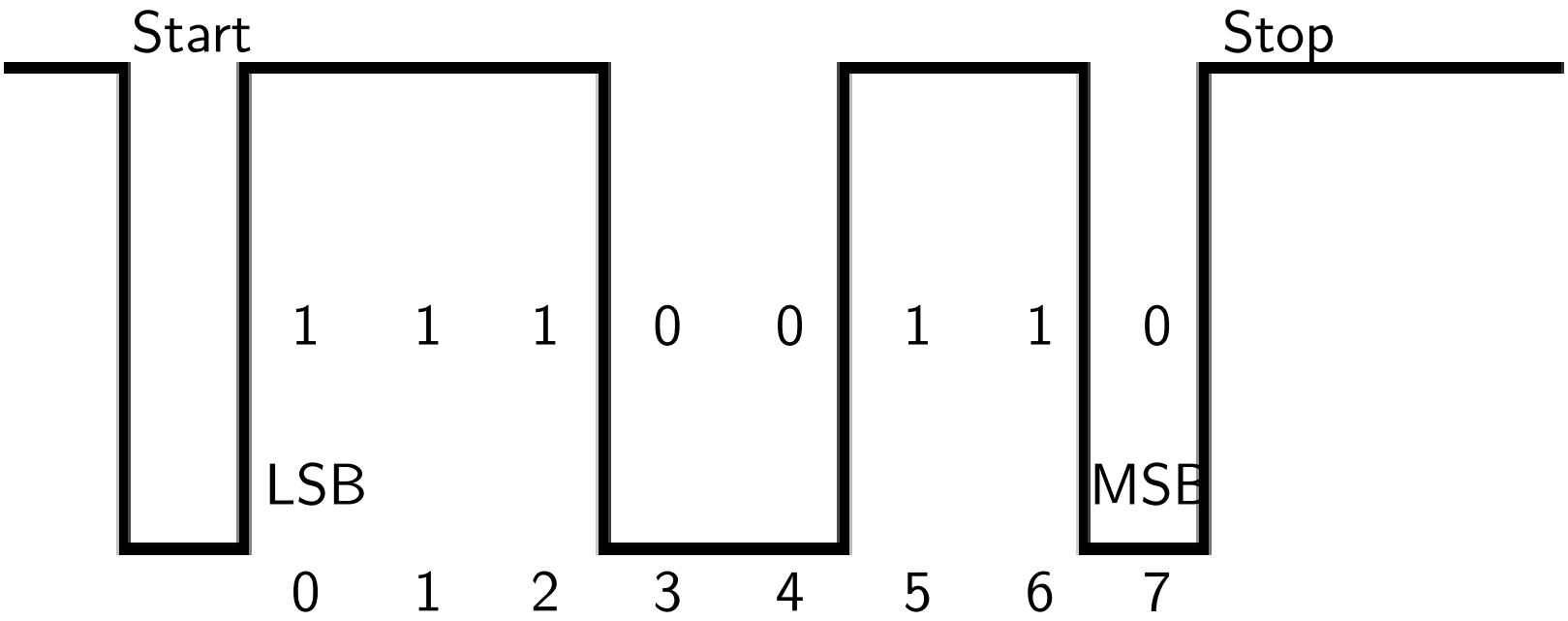

Start
1
1
1
0
0
LSB
0
1
2
3
4


Start
1
1
1
0
0
1
LSB
0
1
2
3
4
5

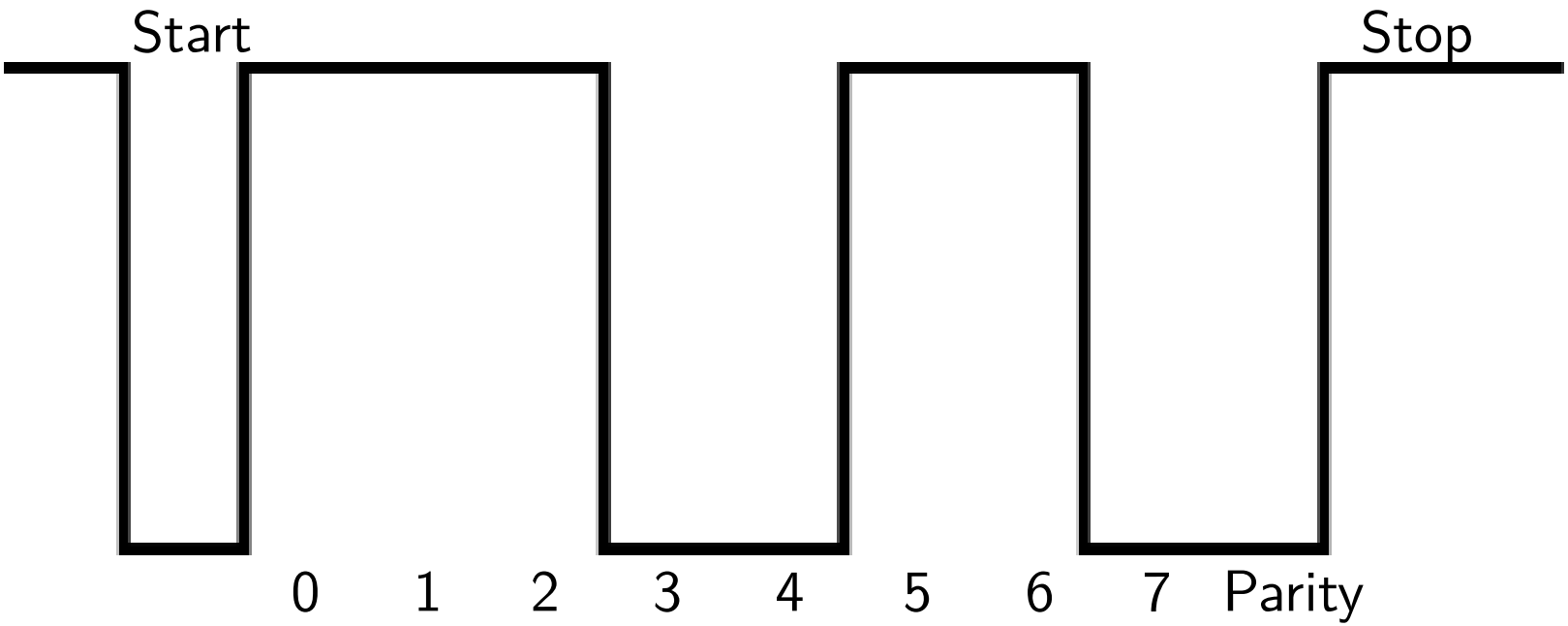

Start
1
1
1
0
0
1
1
LSB
0
1
2
3
4
5
6

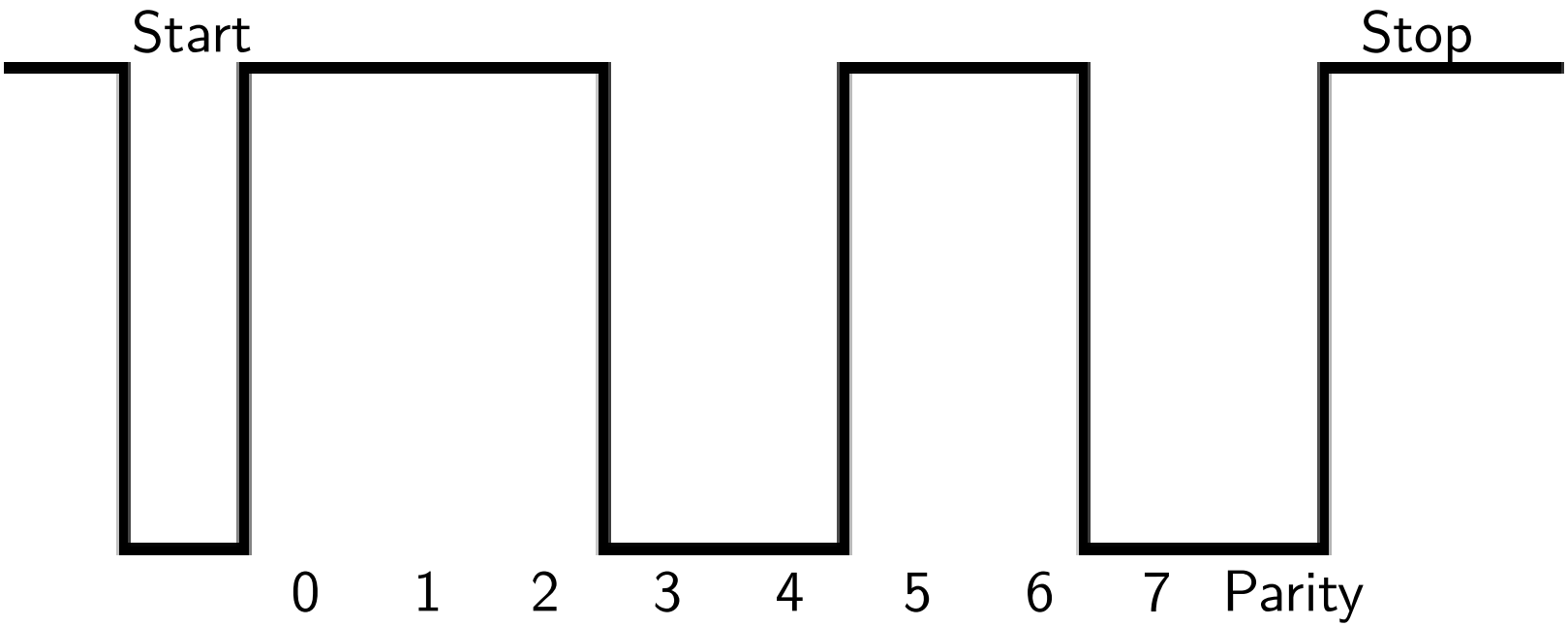

Start
1 1 1 0 0 1 1 0
LSB
MSB
0 1 2 3 4 5 6 7


Start
Stop
1 1 1 0 0 1 1 0
LSB
MSB
0 1 2 3 4 5 6 7

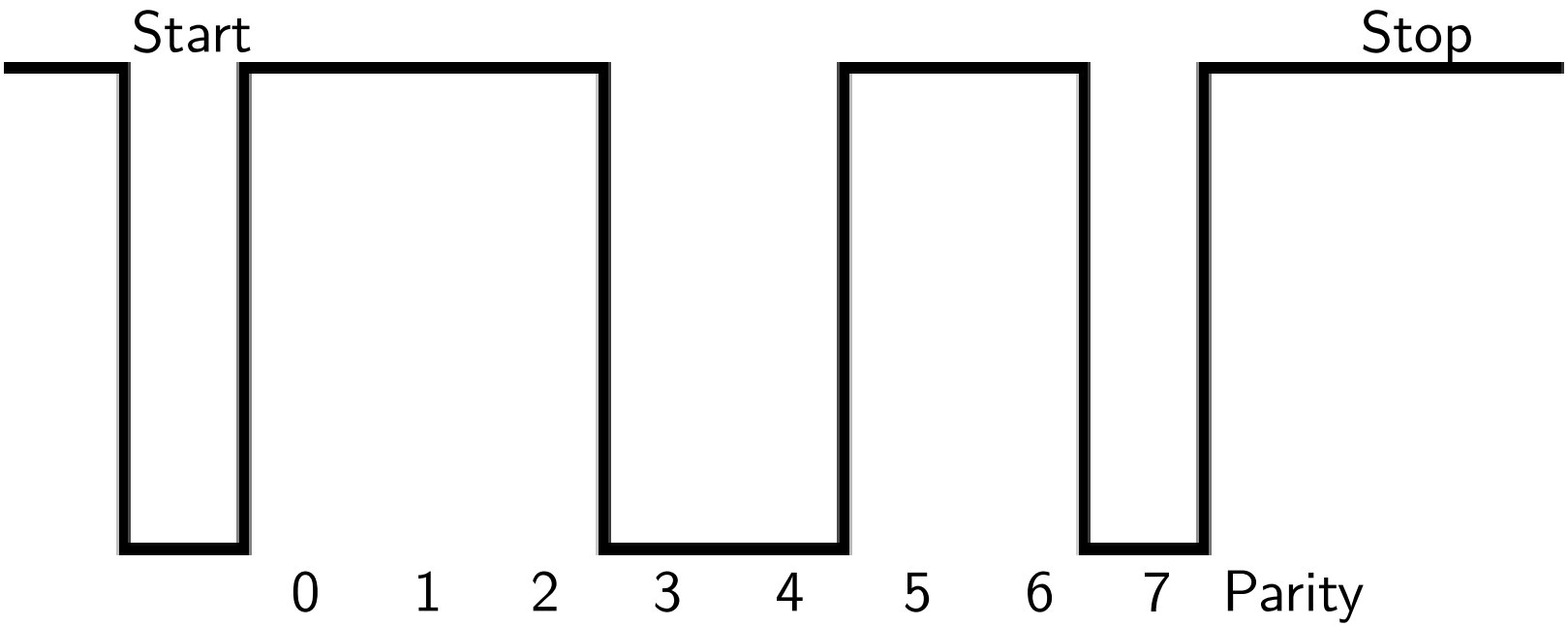


UART no parity - 01100111


Start
Stop
0
1
2
3
4
5
6
7
Parity



UART even parity



UART odd parity

Baud rate calculation

Baud rate calculation

- Baud rate is the number of bits possible in a second

Baud rate calculation

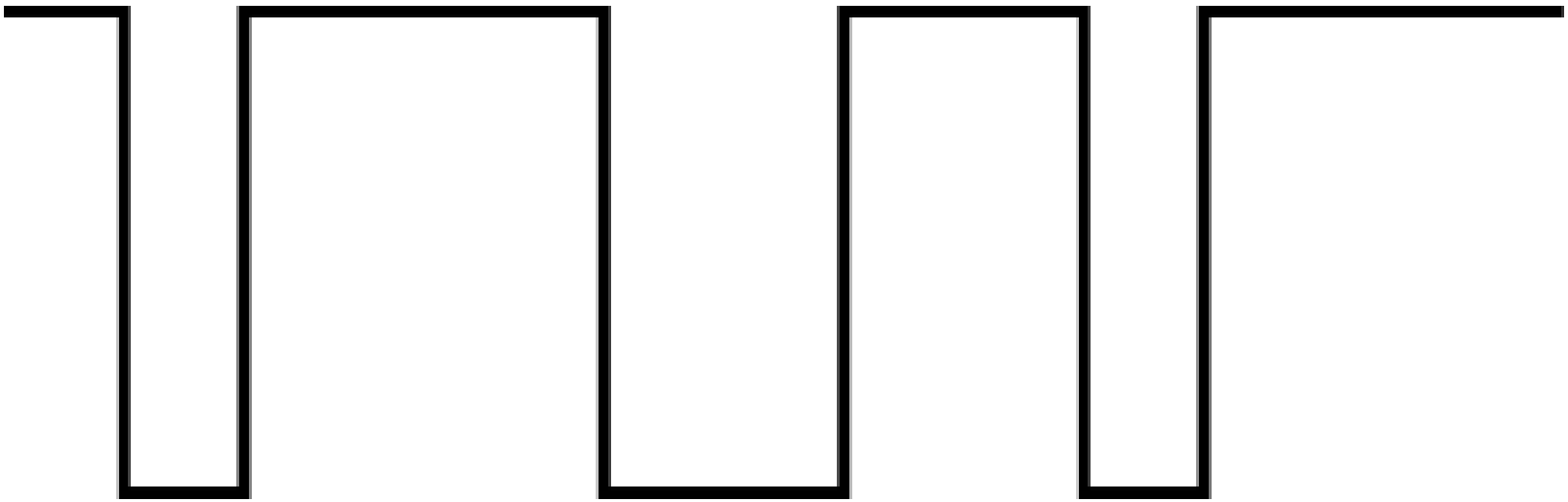
- Baud rate is the number of bits possible in a second
- e.g. 9600 baud $\rightarrow$ 1 bit takes $\frac{1}{9600}$ second

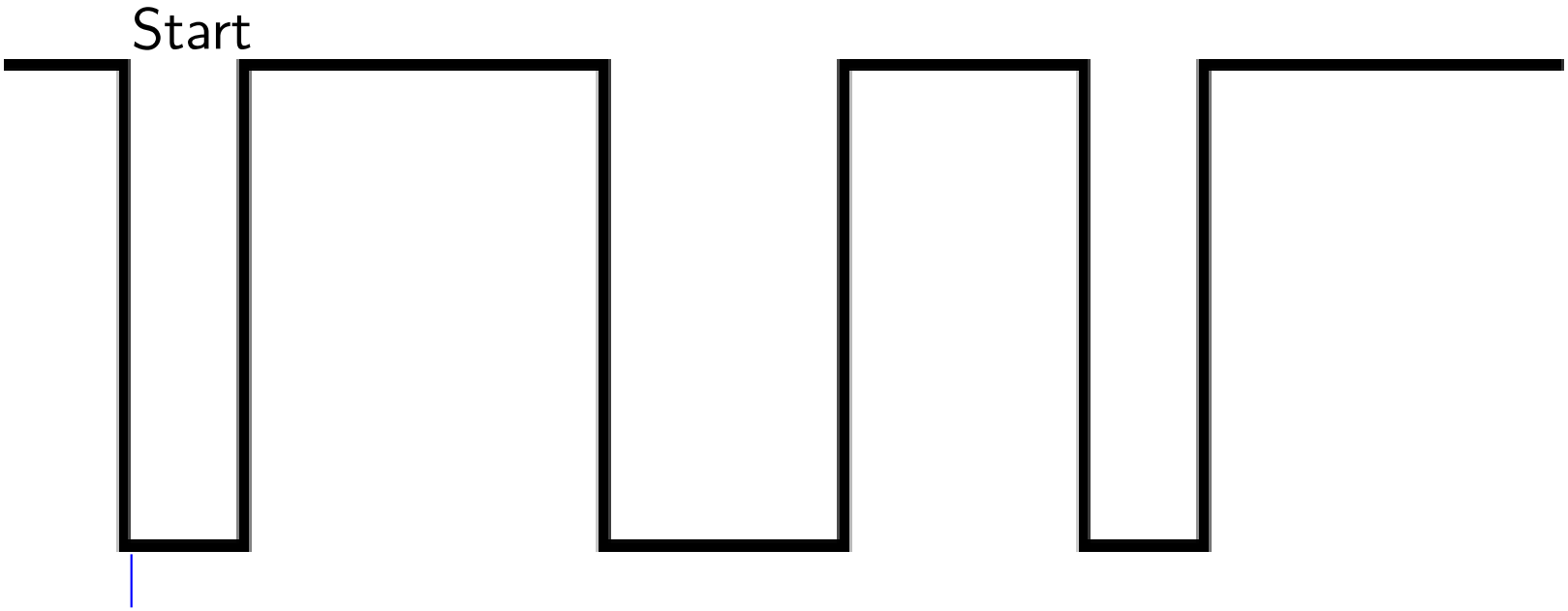
Baud rate calculation

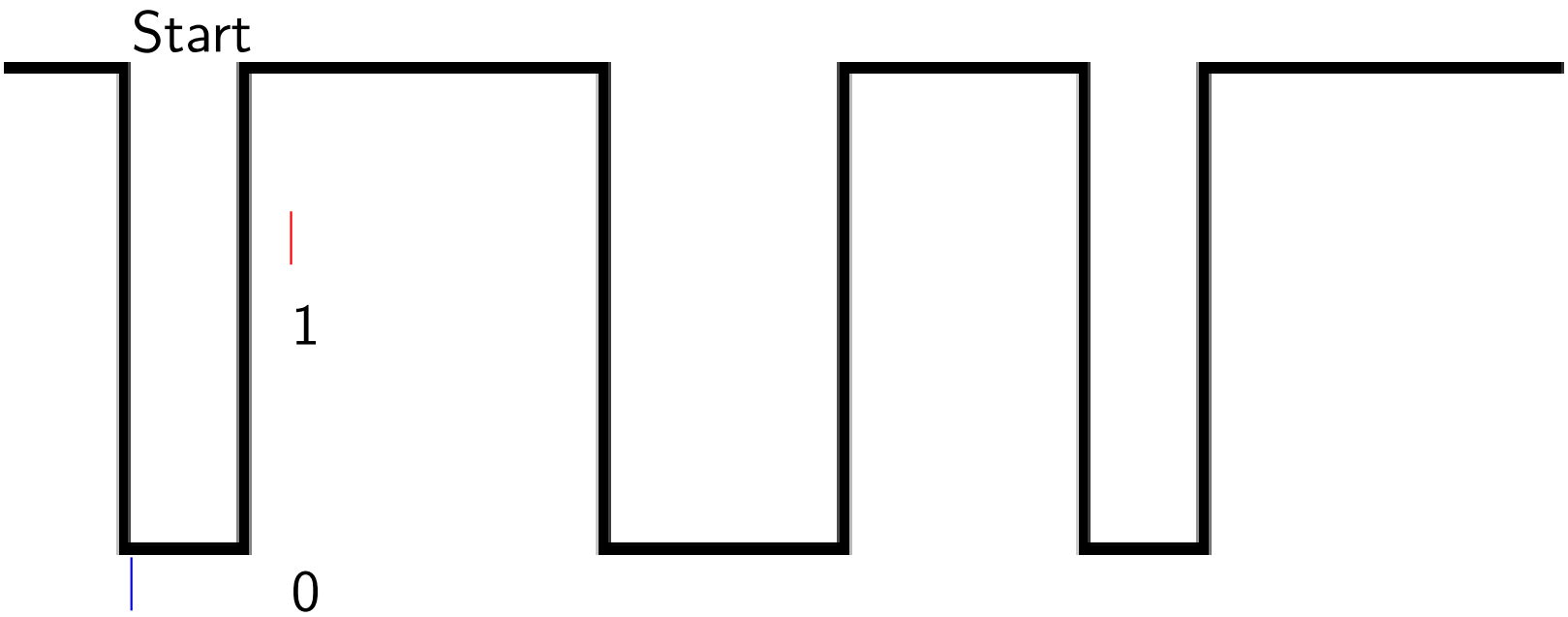
- Baud rate is the number of bits possible in a second
- e.g. 9600 baud $\rightarrow$ 1 bit takes $\frac{1}{9600}$ second
- After start bit is detected, wait time for $1\frac{1}{2}$ bit to test for first data bit and then after every 1 bit interval

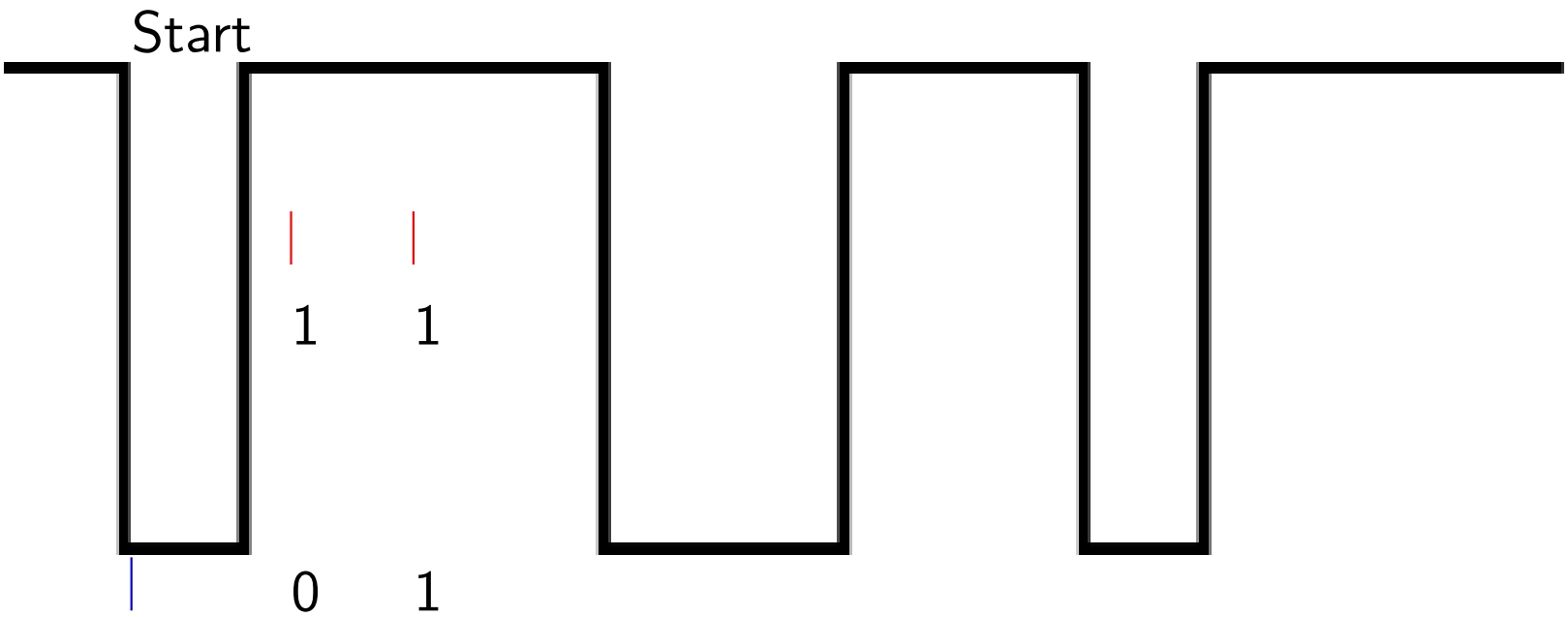
Baud rate calculation

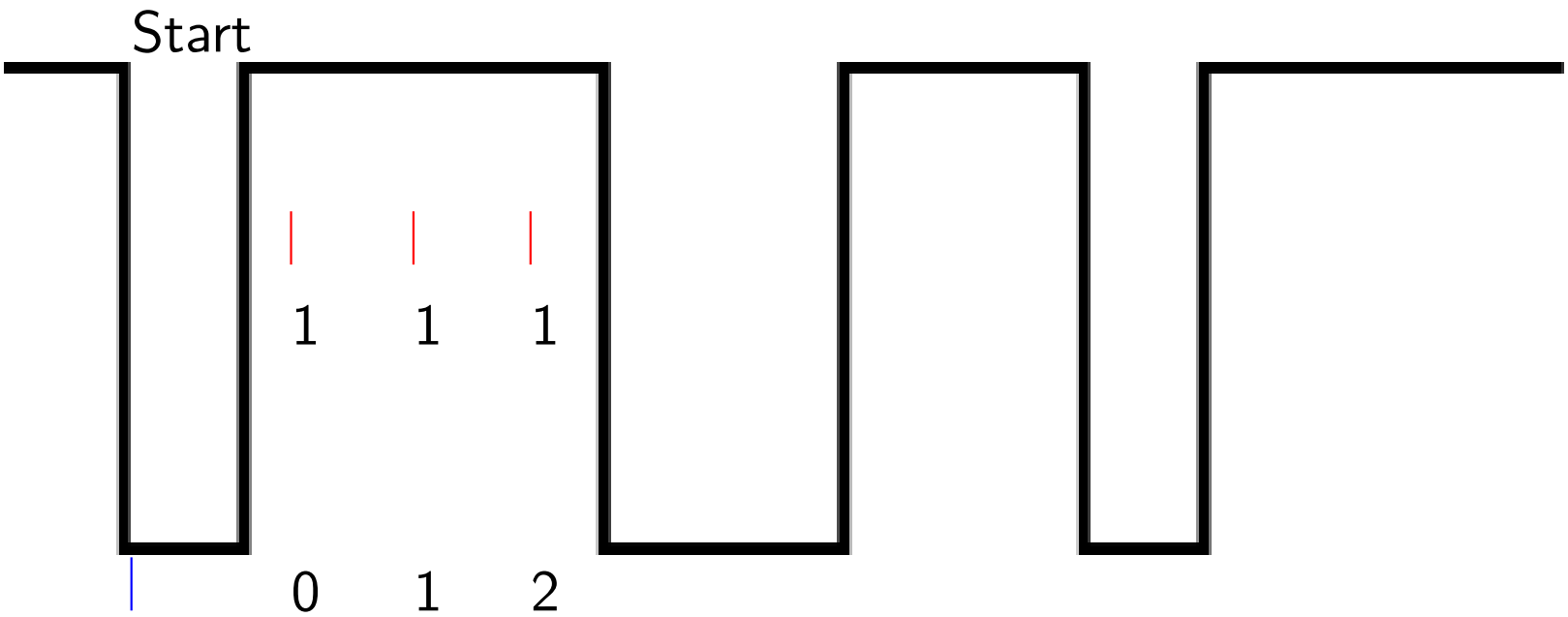
- Baud rate is the number of bits possible in a second
- e.g. 9600 baud $\rightarrow$ 1 bit takes $\frac{1}{9600}$ second
- After start bit is detected, wait time for $1\frac{1}{2}$ bit to test for first data bit and then after every 1 bit interval
- Resetting at the start bit allows some clock variation

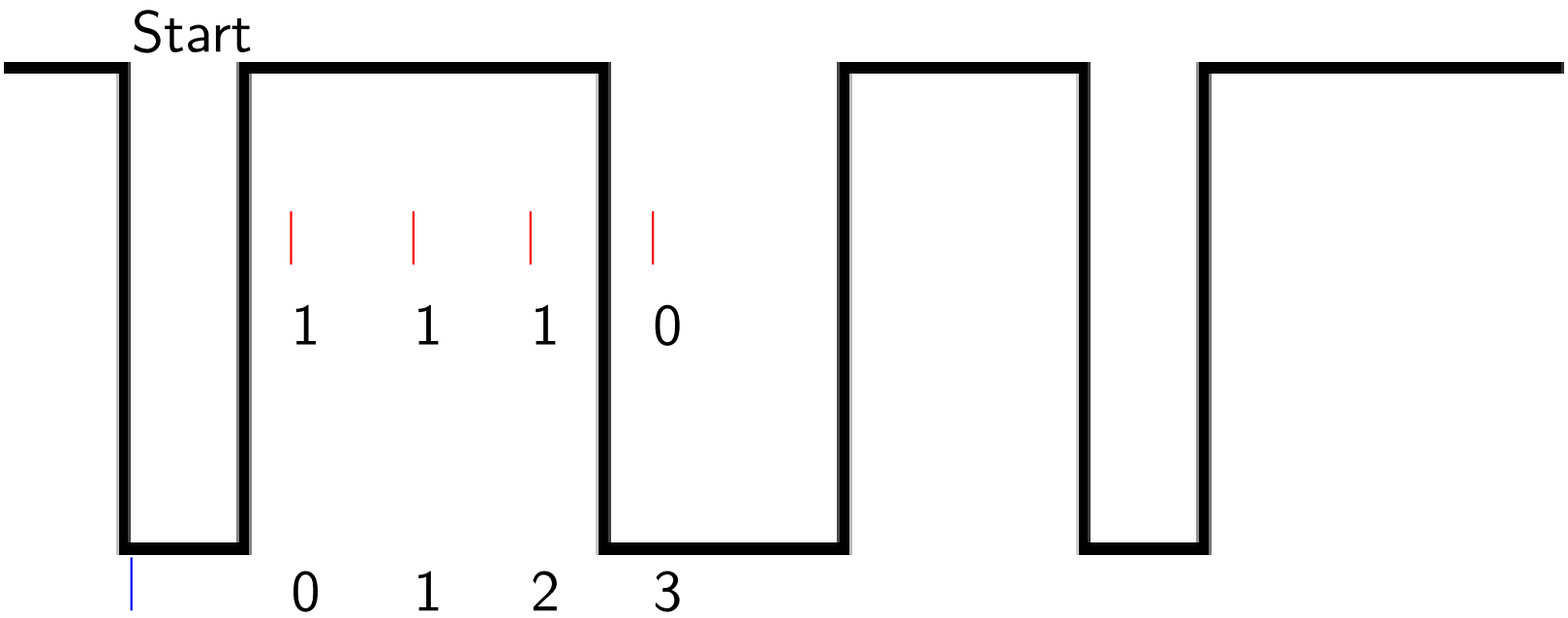


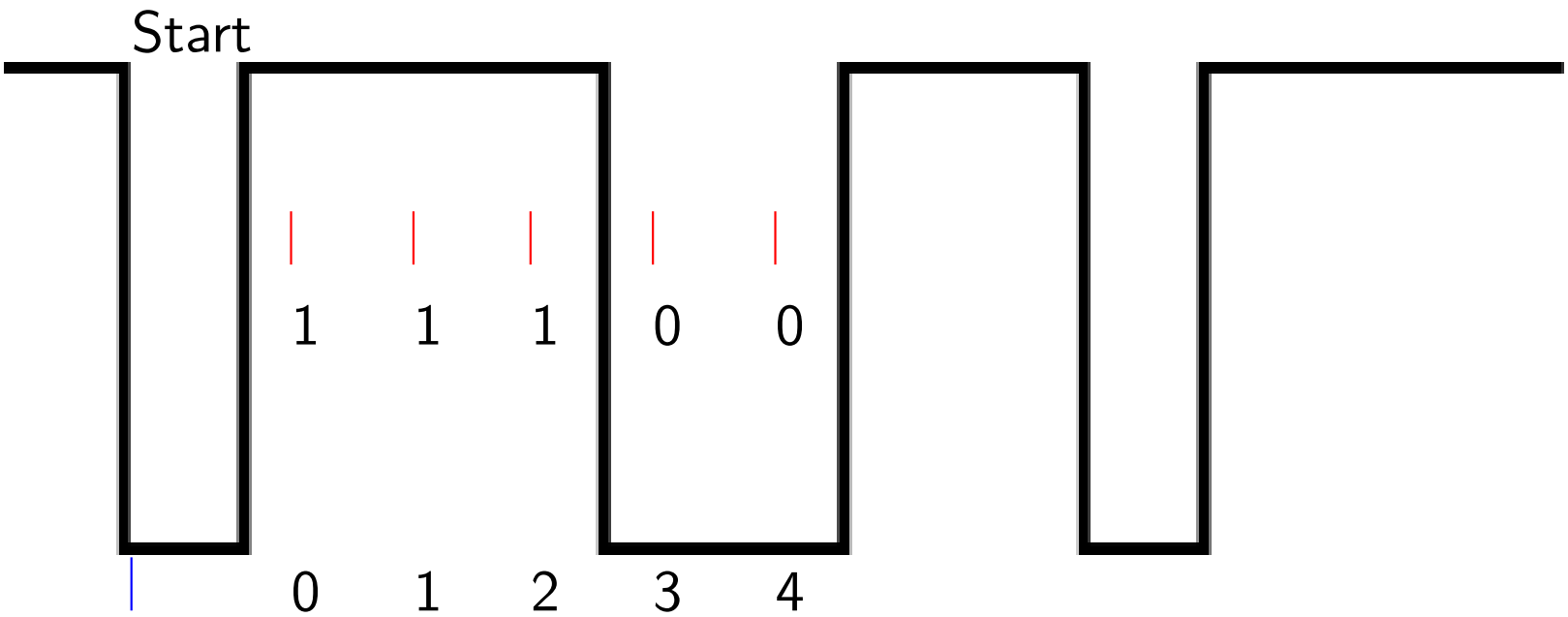

Start

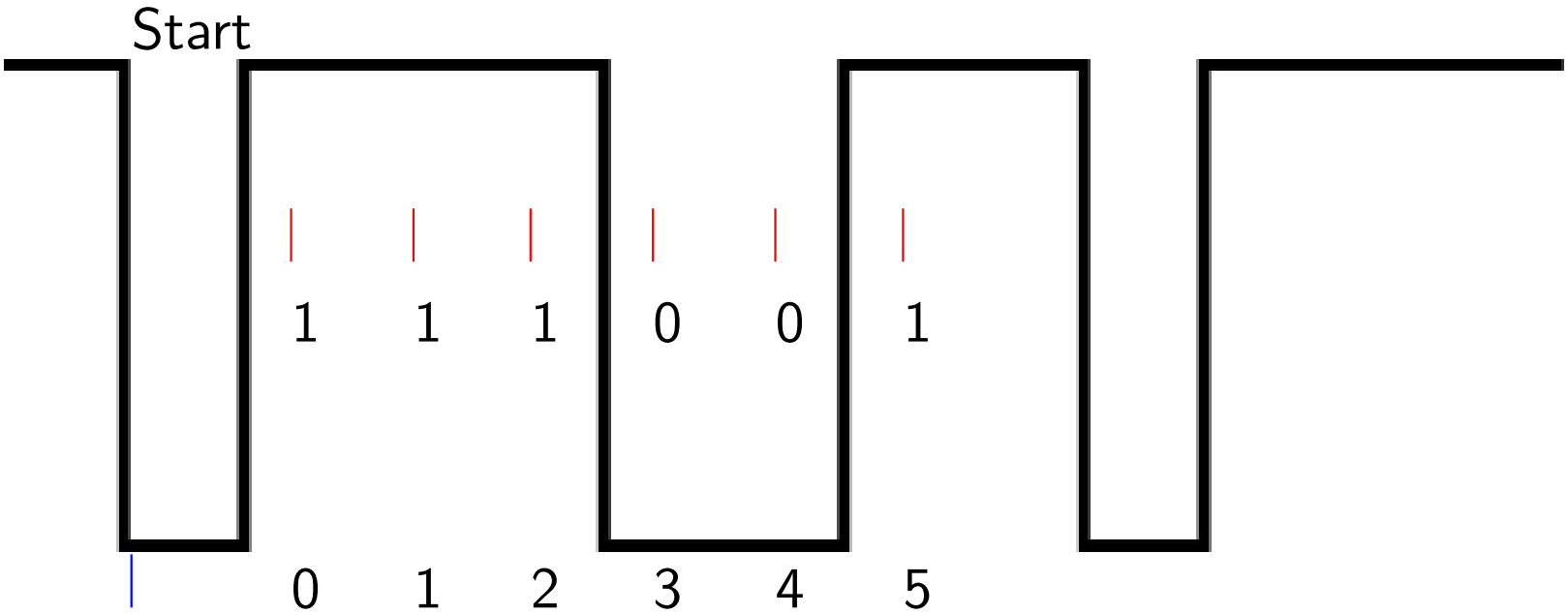

Start
1
0

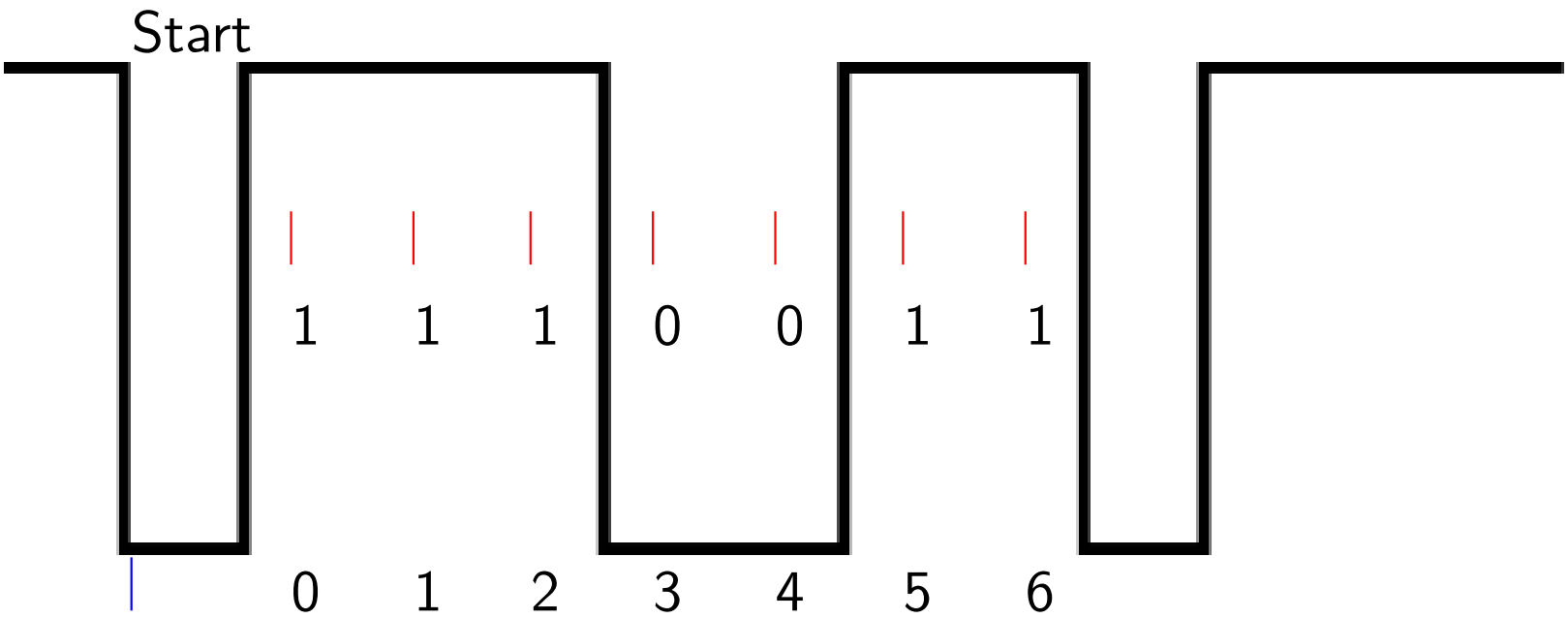

Start
1
1
0
1

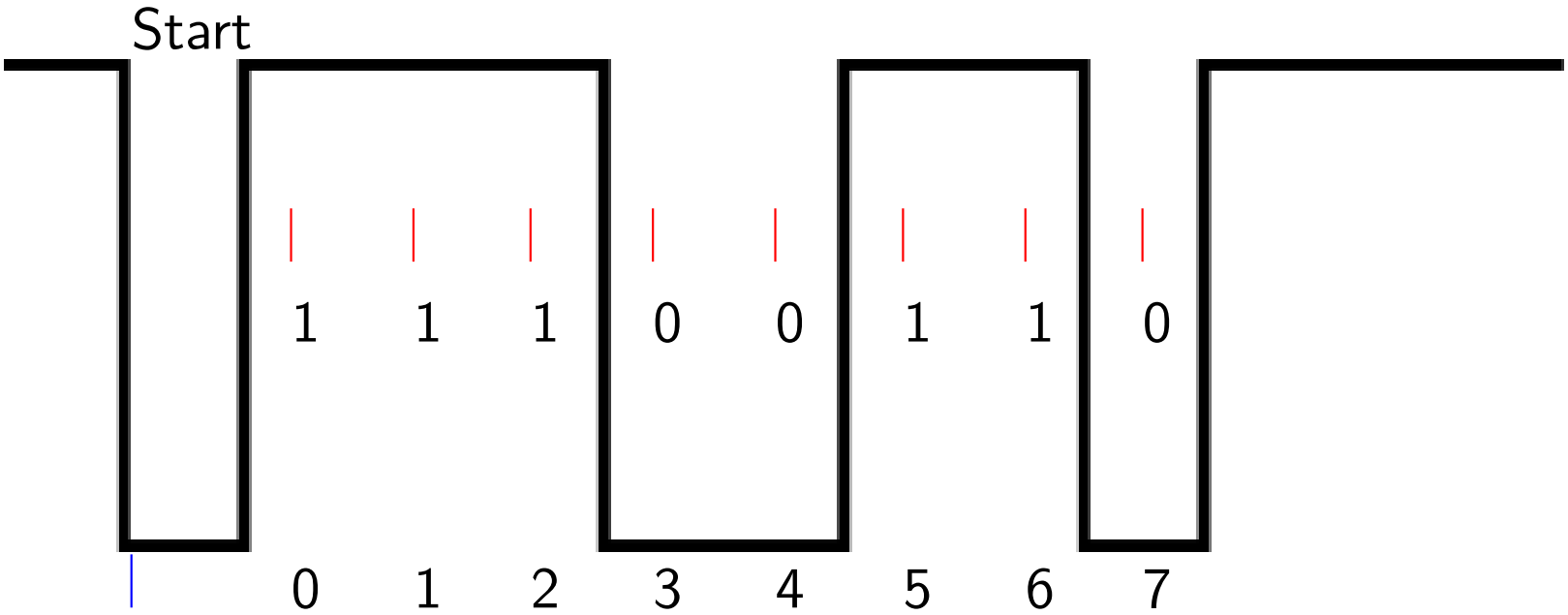

Start
1
1
1
0
1
2

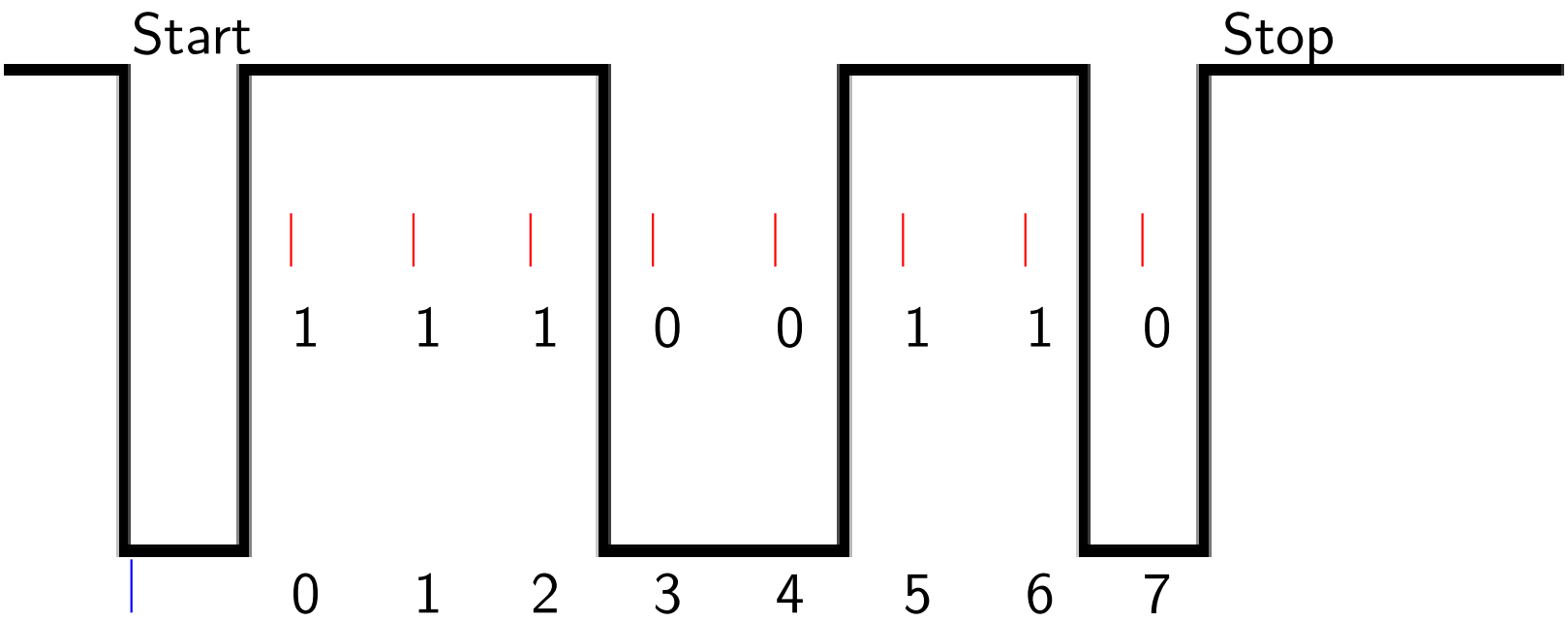

Start
1
1
1
0
0
1
2
3

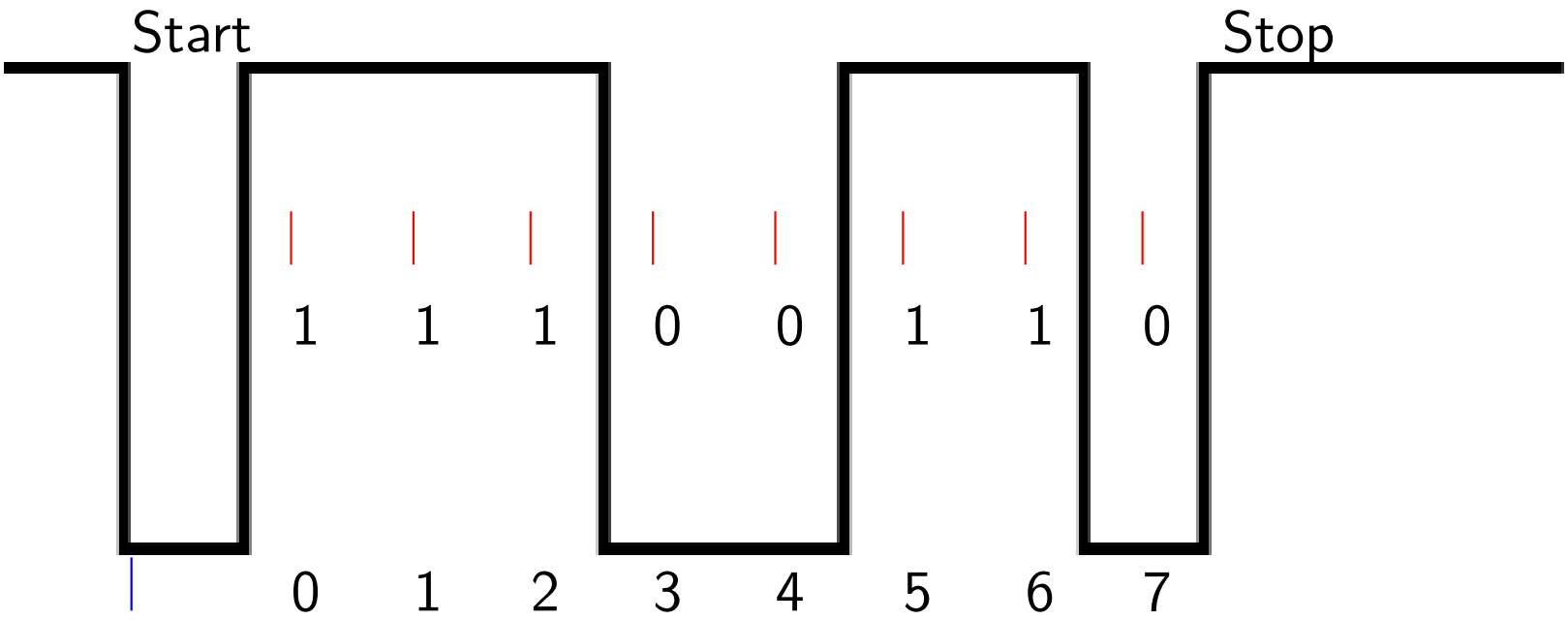

Start
1
1
1
0
0
0
1
2
3
4


Start
1
1
1
0
0
1
0
1
2
3
4
5


Start
1
1
1
0
0
1
1
0
1
2
3
4
5
6


Start
1
1
1
0
0
1
1
0
0
1
2
3
4
5
6
7


Start
Stop
1 1 1 0 0 1 1 0
0 1 2 3 4 5 6 7



Bit timing

RS232 communication

RS232 communication

- Voltages are inverted

RS232 communication

- Voltages are inverted
- $\pm 3 \rightarrow \pm 12$

RS232 communication

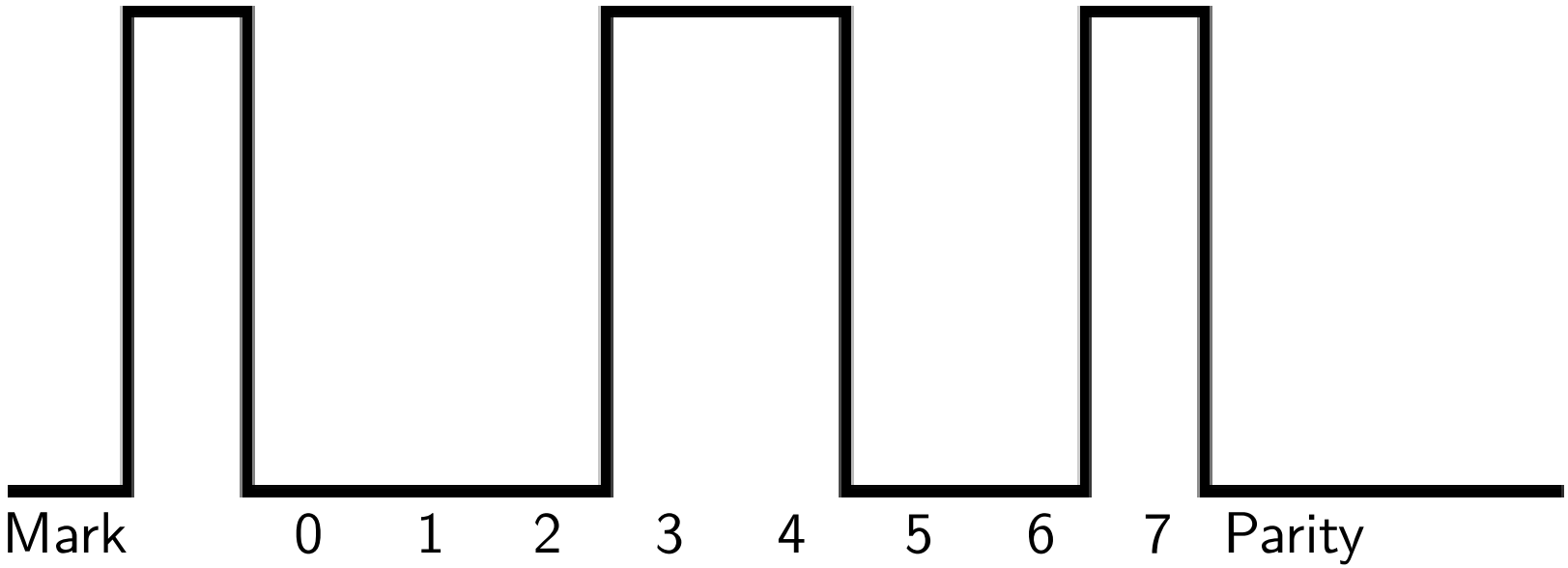
- Voltages are inverted
- $\pm 3 \rightarrow \pm 12$
- Zero is not a valid voltage

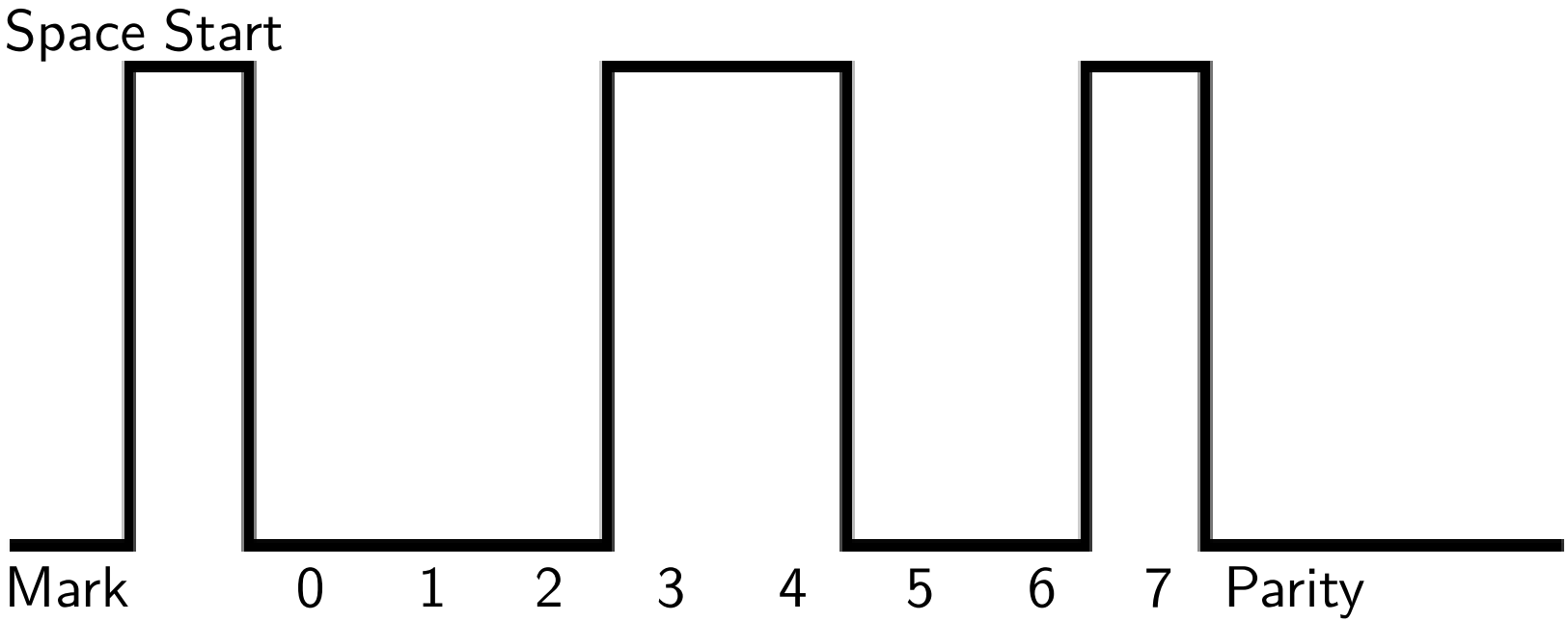
RS232 communication

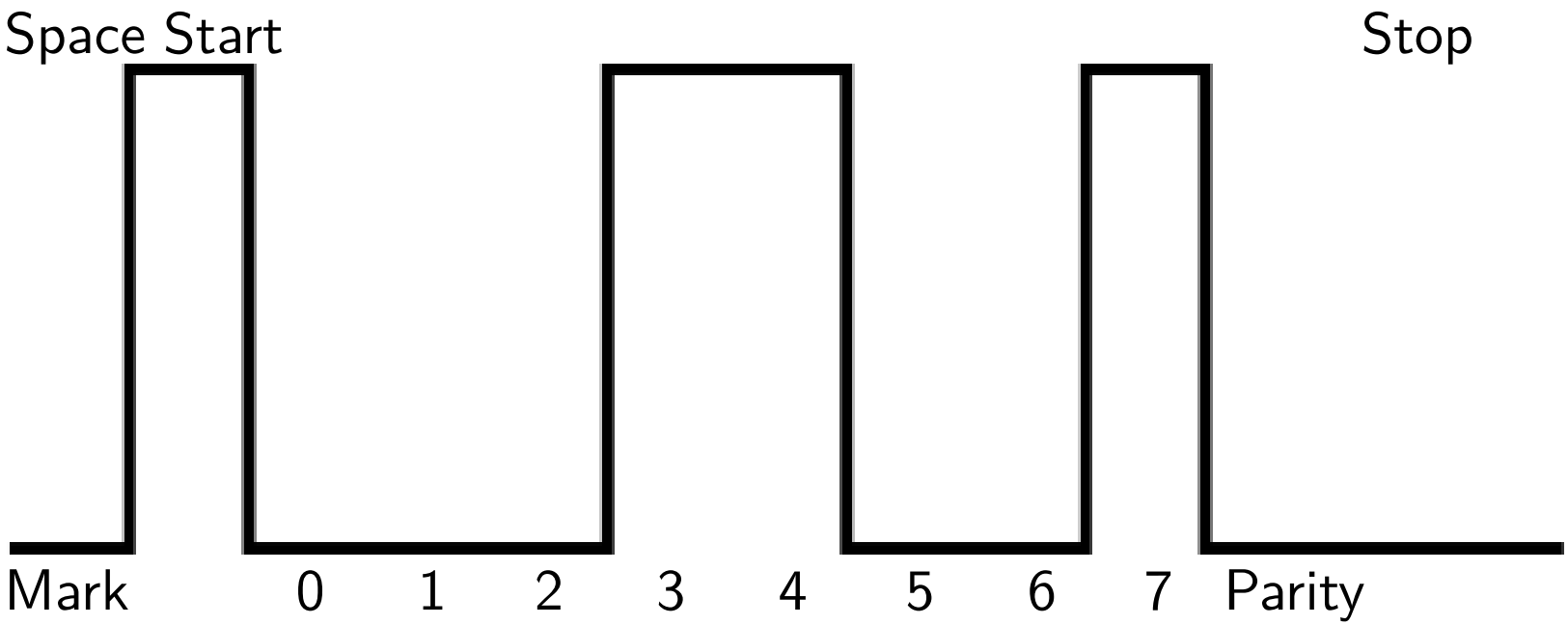
- Voltages are inverted
- $\pm 3 \rightarrow \pm 12$
- Zero is not a valid voltage
- Mark level (inactive/1) is a negative voltage

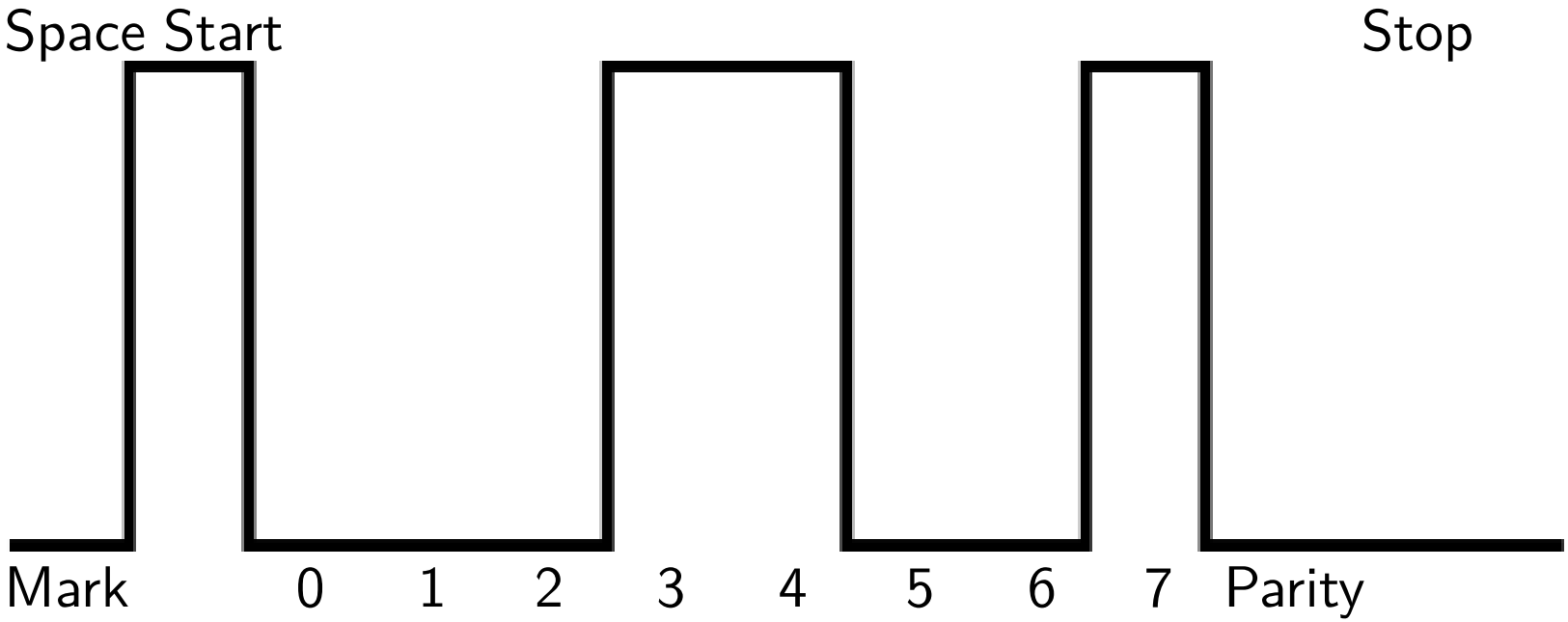
RS232 communication

- Voltages are inverted
- $\pm 3 \rightarrow \pm 12$
- Zero is not a valid voltage
- Mark level (inactive/1) is a negative voltage
- Space level (active/0) is a positive voltage


Mark
0
1
2
3
4
5
6
7
Parity


Space Start
Mark
0
1
2
3
4
5
6
7
Parity


Space Start
Stop
Mark
0
1
2
3
4
5
6
7
Parity



RS232 levels

Arduino Serial

Arduino Serial

- **Serial.begin(9600)**

  start port and set baudrate

Arduino Serial

- **Serial.begin(9600)**

  start port and set baudrate
- **while(!Serial)**

  wait to connect

Arduino Serial

- **Serial.begin(9600)**

  start port and set baudrate
- **while(!Serial)**

  wait to connect
- **if (Serial.available() $>$ 0)**

  returns *True* if data available, *False* if not

Arduino Serial (continued)

Arduino Serial (continued)

- **Serial.write(value)**

  write value

Arduino Serial (continued)

- **Serial.write(value)**

  write value
- **Serial.print('A')**

  write string as ASCII

Arduino Serial (continued)

- **Serial.write(value)**

  write value
- **Serial.print('A')**

  write string as ASCII
- **inByte = Serial.read()**

  read byte

Arduino Serial (continued)

- **Serial.write(value)**

  write value
- **Serial.print('A')**

  write string as ASCII
- **inByte = Serial.read()**

  read byte
- **Serial.end()**

  close port

Arduino Serial sample code

Arduino Serial sample code

```
void setup() {
  Serial.begin(9600);
  while (!Serial) {
    ;
  }
}

void loop() {
  if (Serial.available() > 0) {
    inByte = Serial.read();
    Serial.write(inByte);
    }
}
```