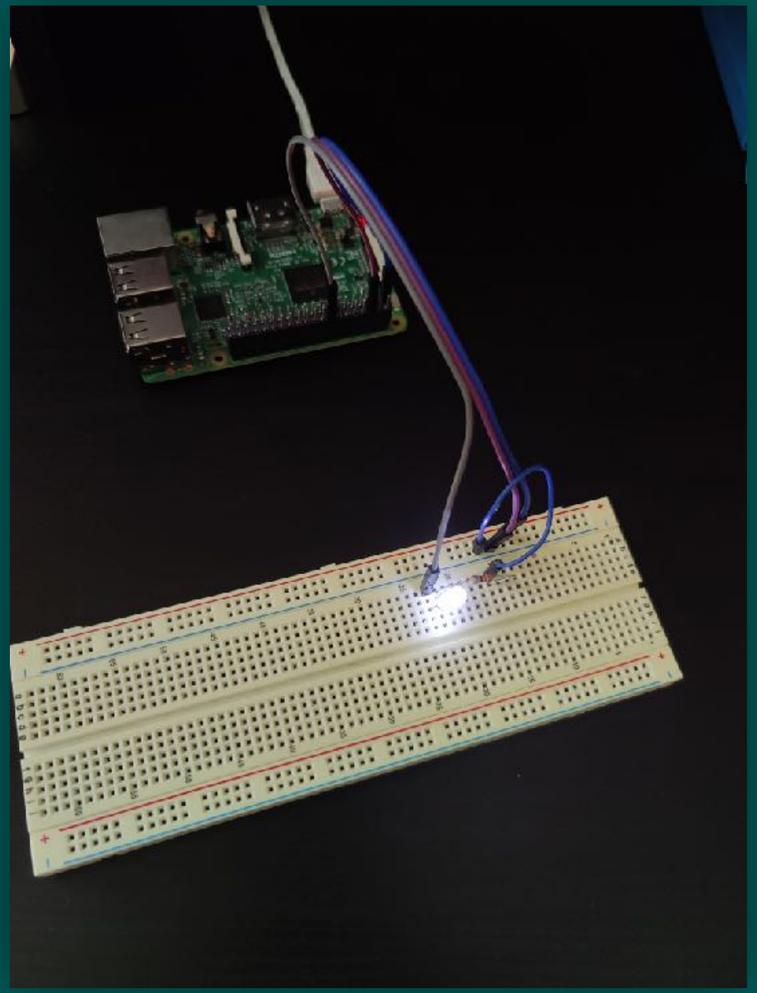
VLC

with a smartphone camera

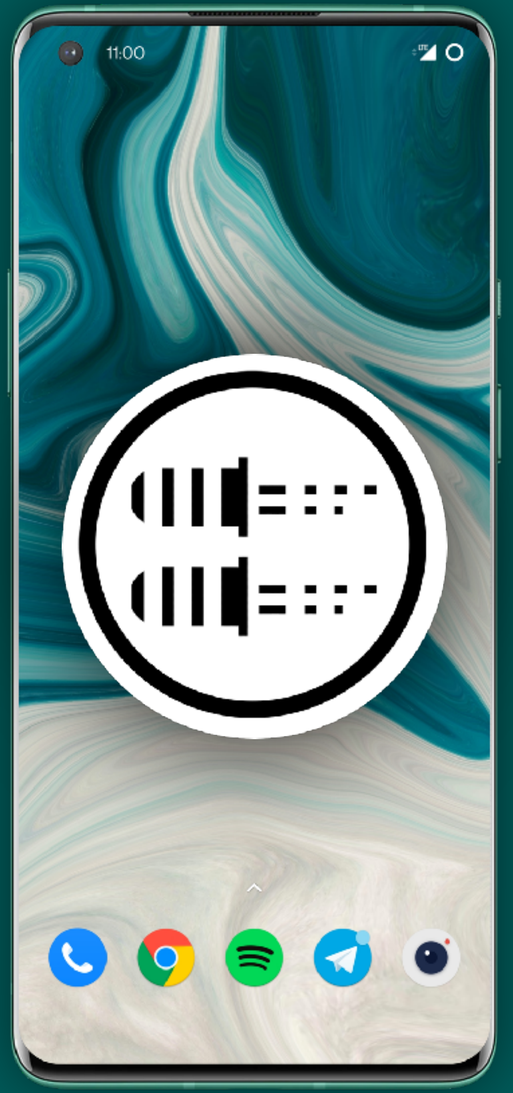
VLC
Visible Light Communication

- Visible Light Communication (VLC) refers to optical wireless communication
- data communications variant
- uses modulated light in a wavelength spectrum, that is perceivable by the human eye
  - between 400 nm and 700 nm
  - usually used for illumination

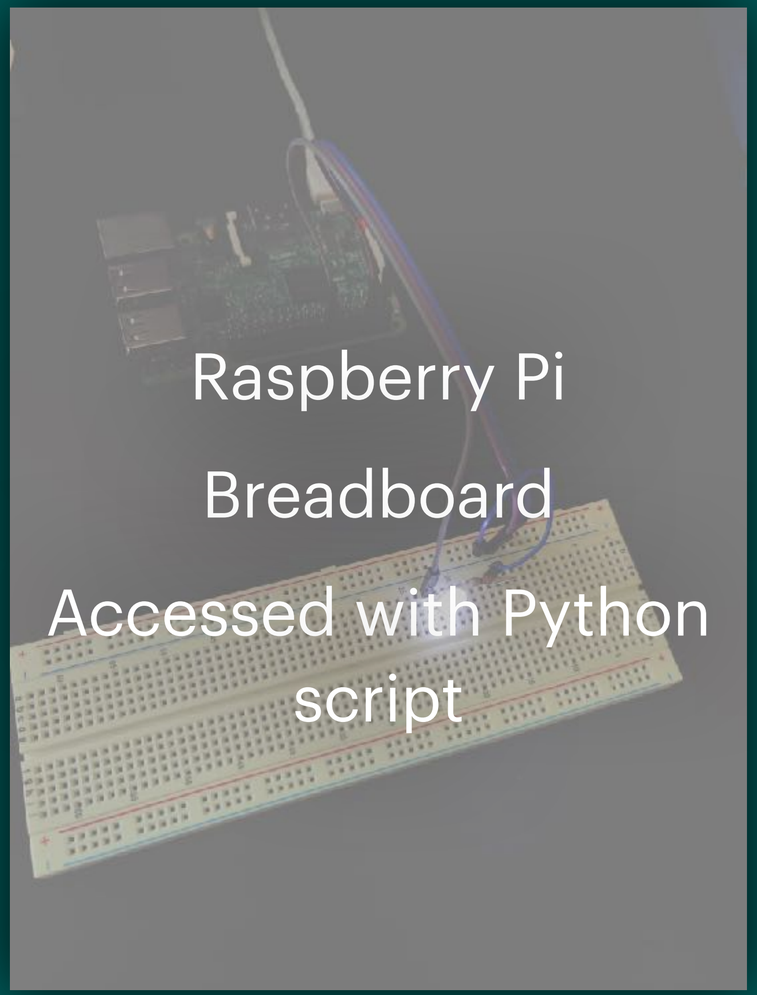


Sender

2 components

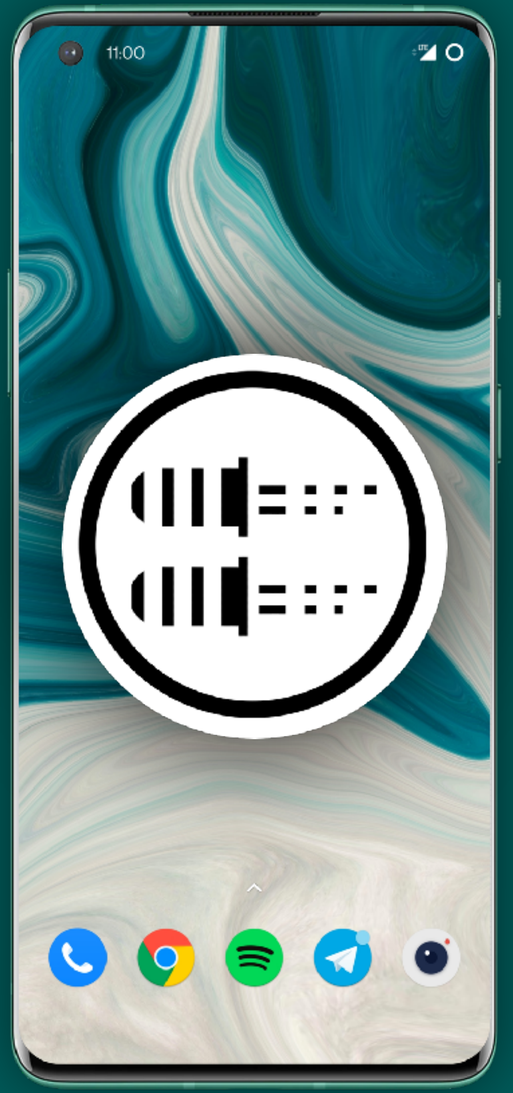


Receiver

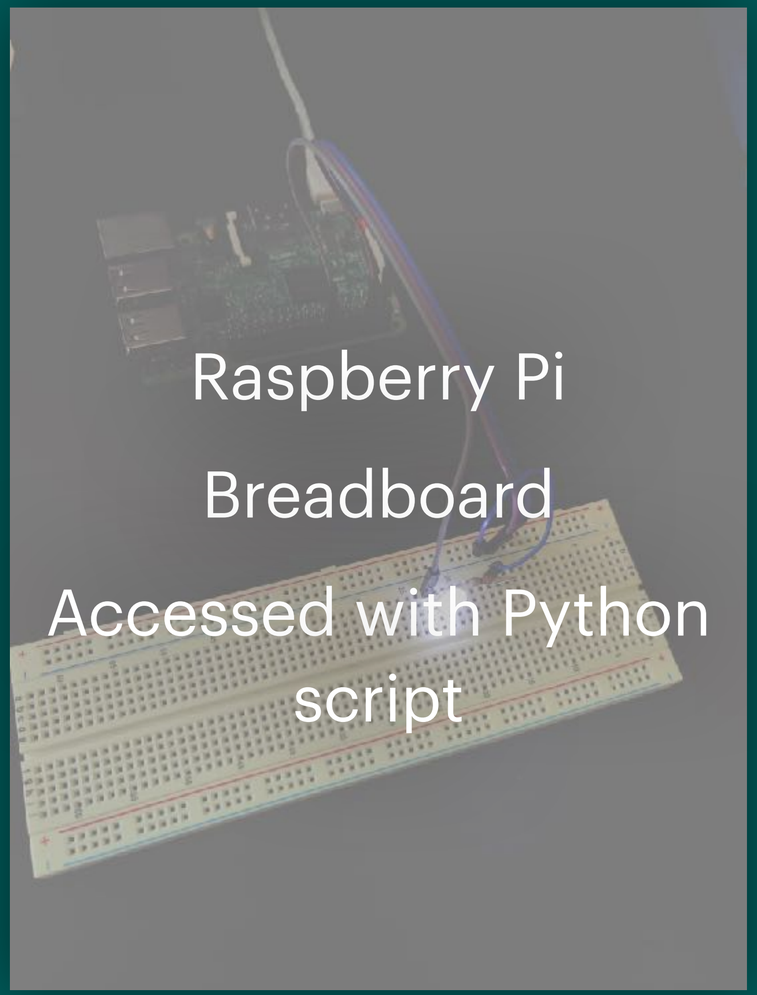


Sender

2 components



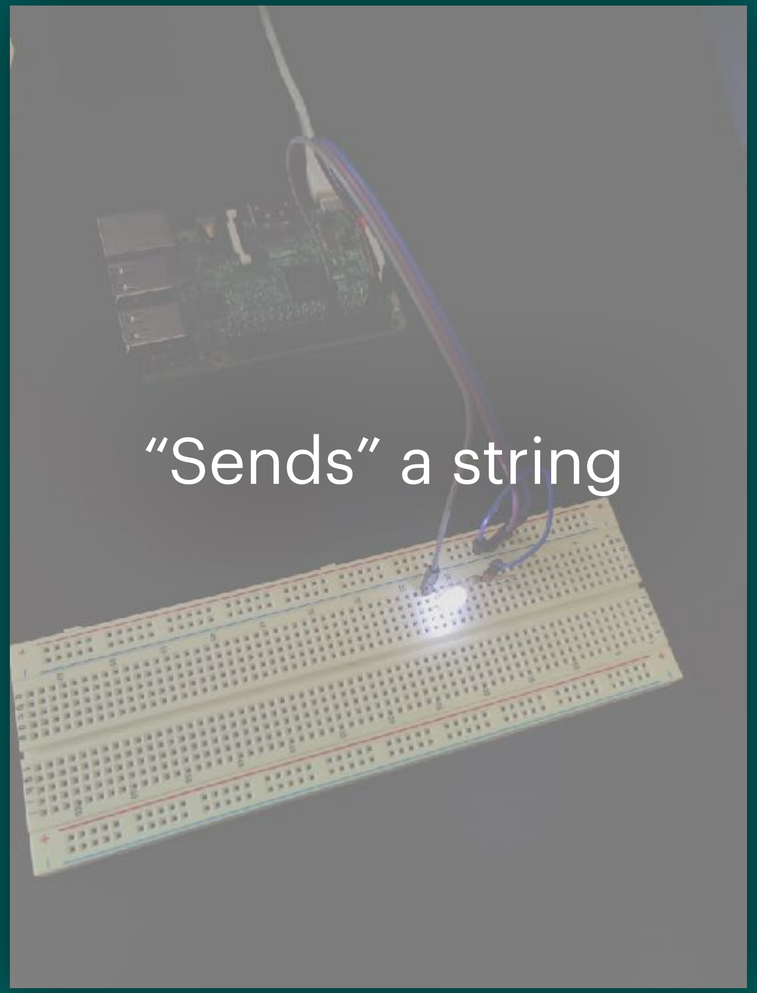
Receiver



Sender

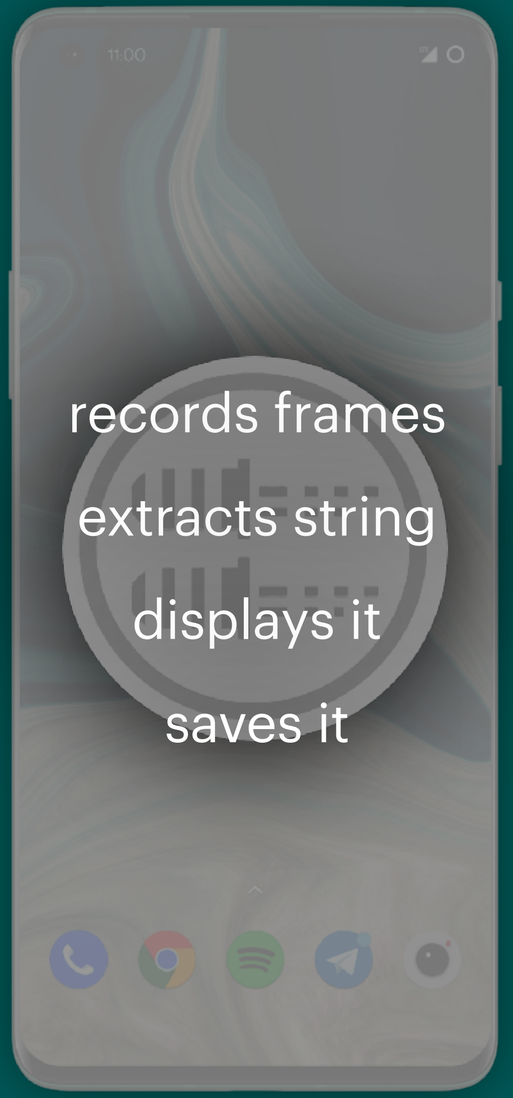
2 components

Receiver



Sender

2 components

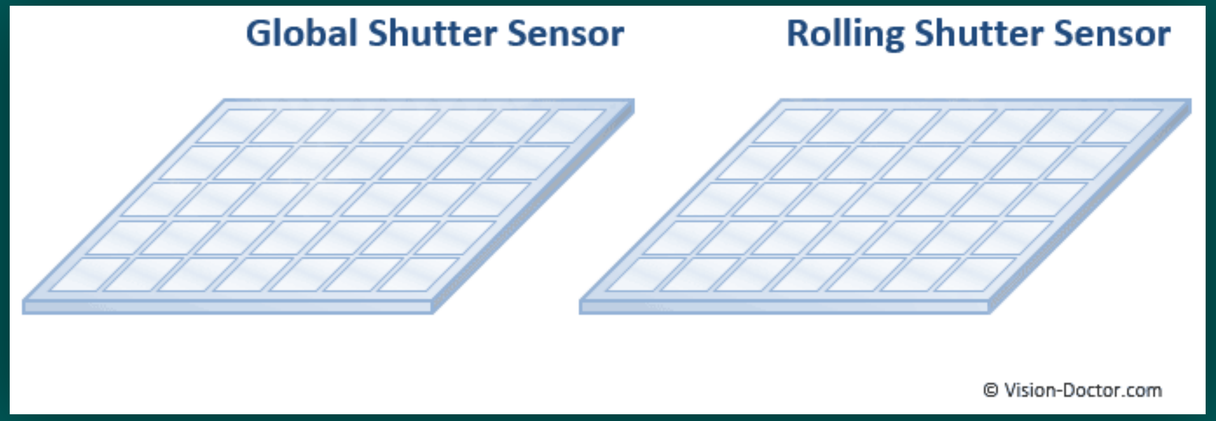


Receiver

How to extract information out of one frame?

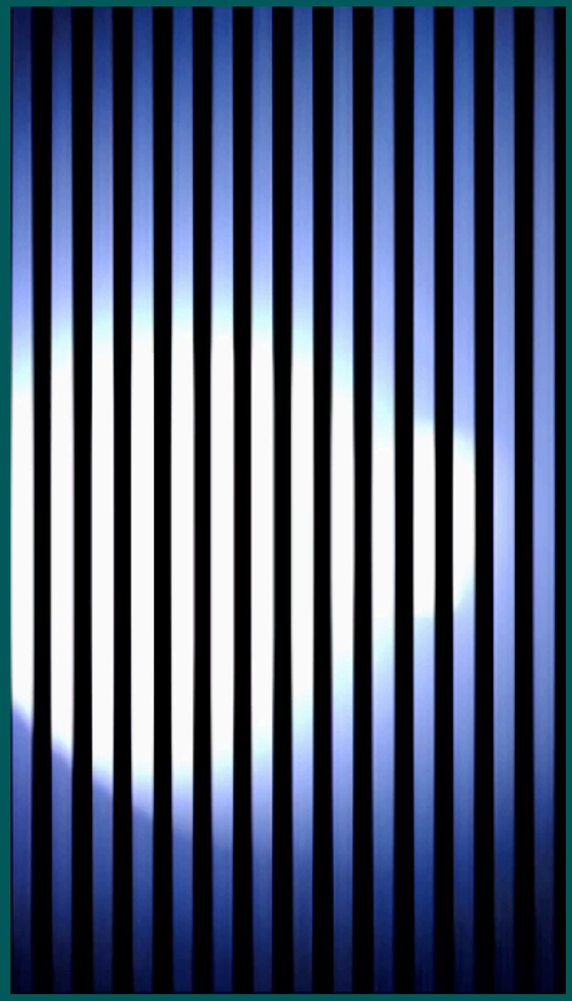
Rolling Shutter effect

- Only works with CMOS cameras
  (which are principally built into smartphones)
- Frame doesn’t get captured all at once
- Rather gets captured row per row



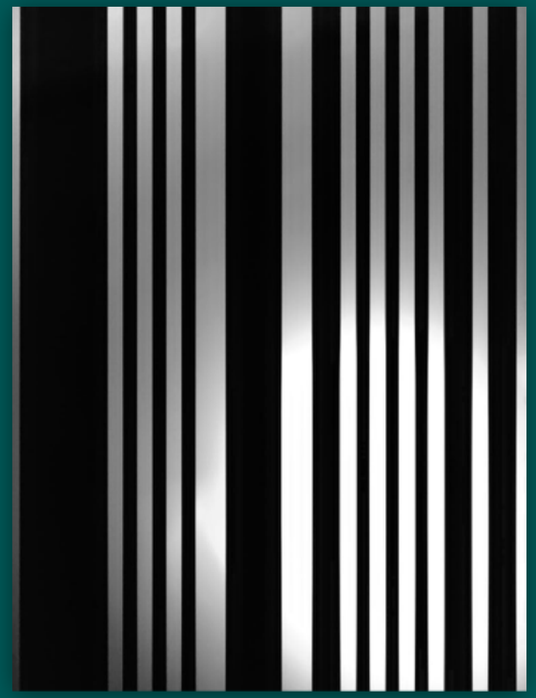
Rolling shutter effect
LED

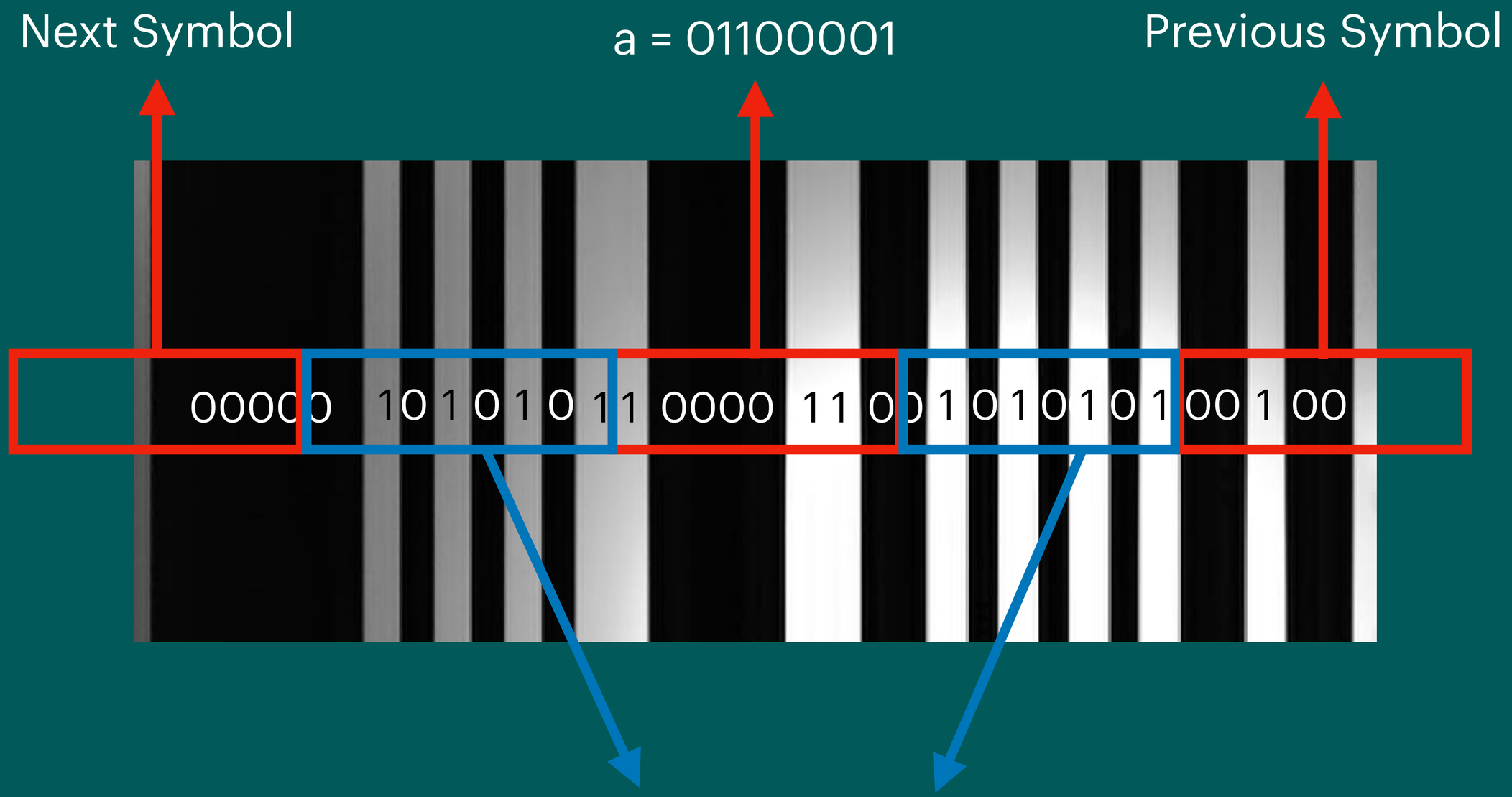
- Switching a LED on and off at a very high frequency results in following for CMOS sensor
- Black stripes show when LED is off
- White stripes show when LED is on



How does the sender (LED) transmit a string?

- Converts a string into binary representation and switches LED on and off respectively
- Follows specific schema to send data



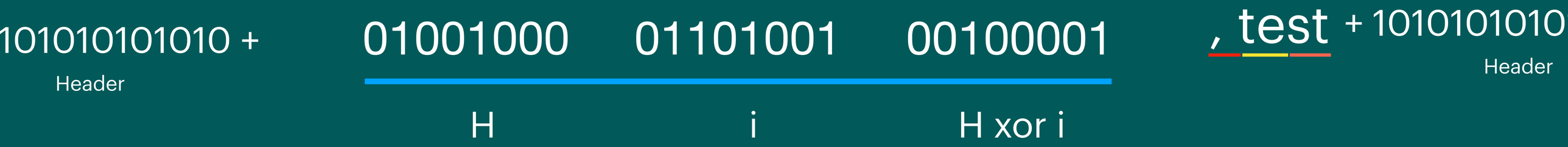

Next Symbol
a = 01100001
Previous Symbol
0000 0 10 1 0 1 0 11 0000 11 0 0 1 0 1 0 1 0 1 00 1 00
Splitter = 10101010

Schema of a sent message

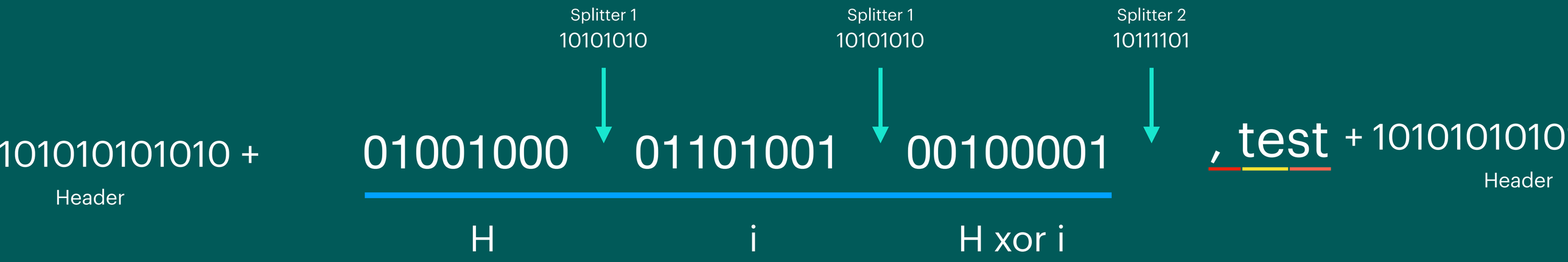
1010101010101010 + “Hi, test” + 1010101010101010

Header Header

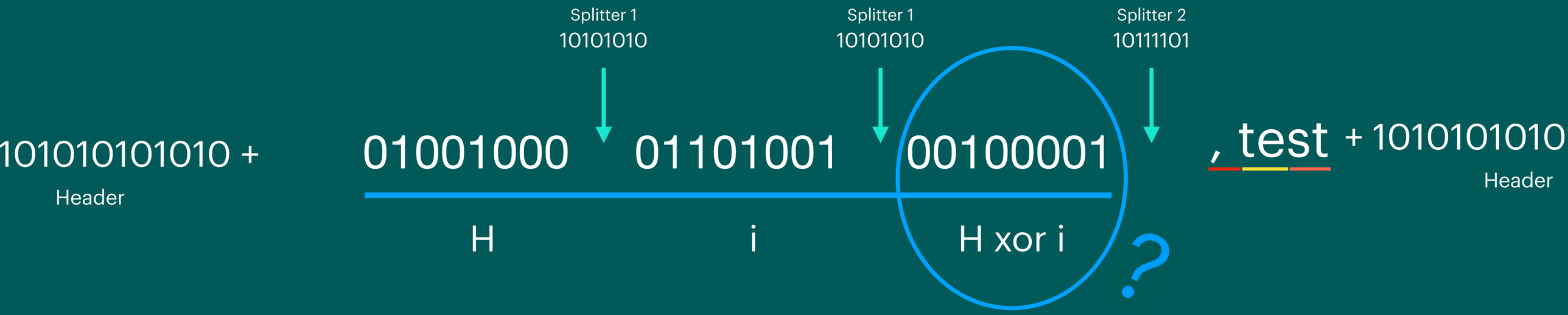
Schema of a sent message



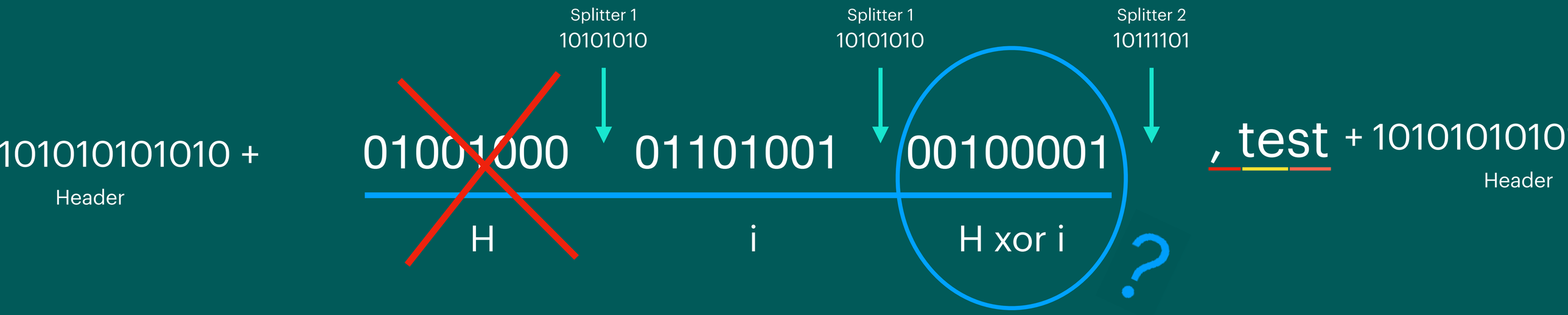
Schema of a sent message



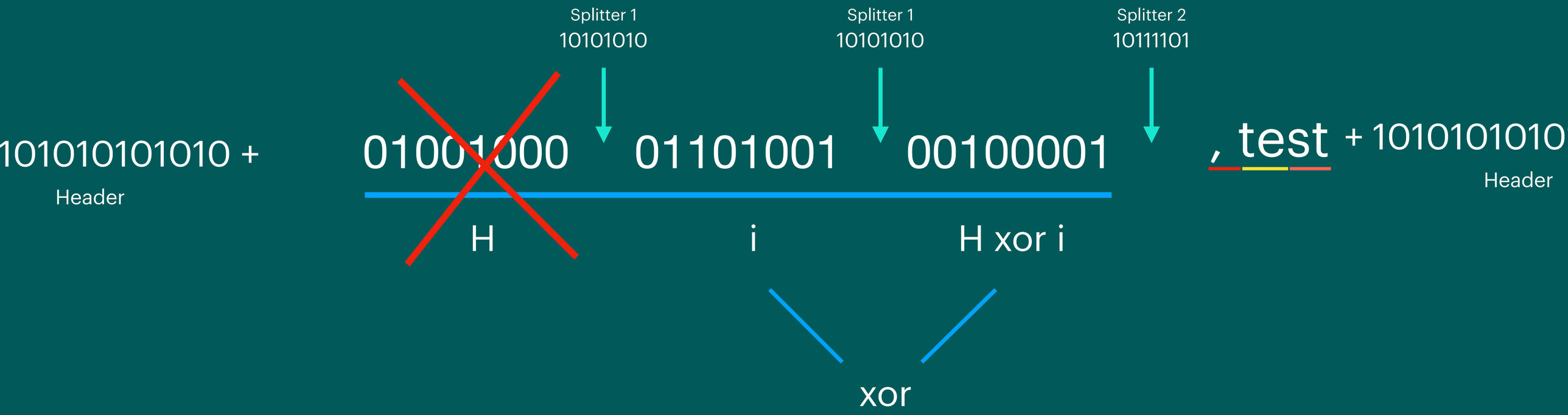
Schema of a sent message



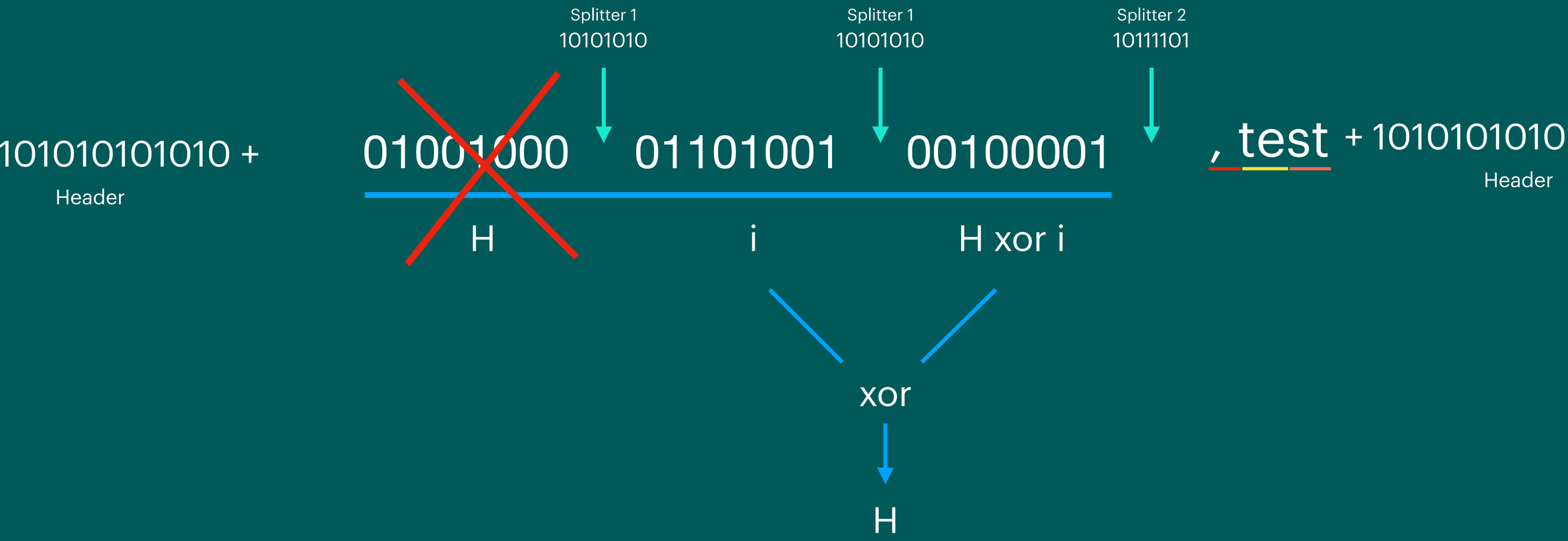
Schema of a sent message



Schema of a sent message

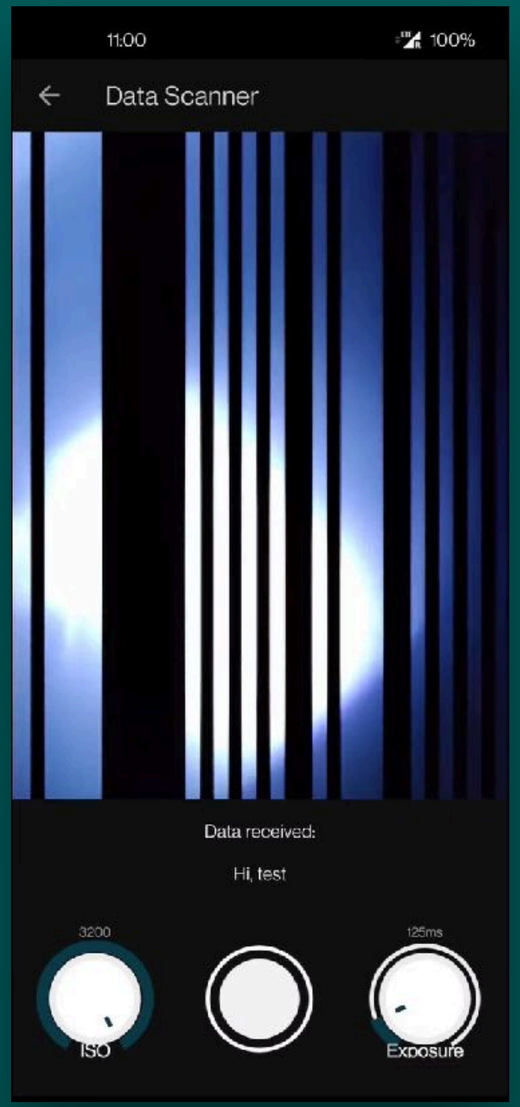


Schema of a sent message



What does the receiver do?

- records frames
- extracts the transferred string from it
- provides possibility to change ISO (100-3200) value and exposure time (125 microseconds - 1 millisecond)
- saves it



The extraction process of a single frame

Get luminance values of frame

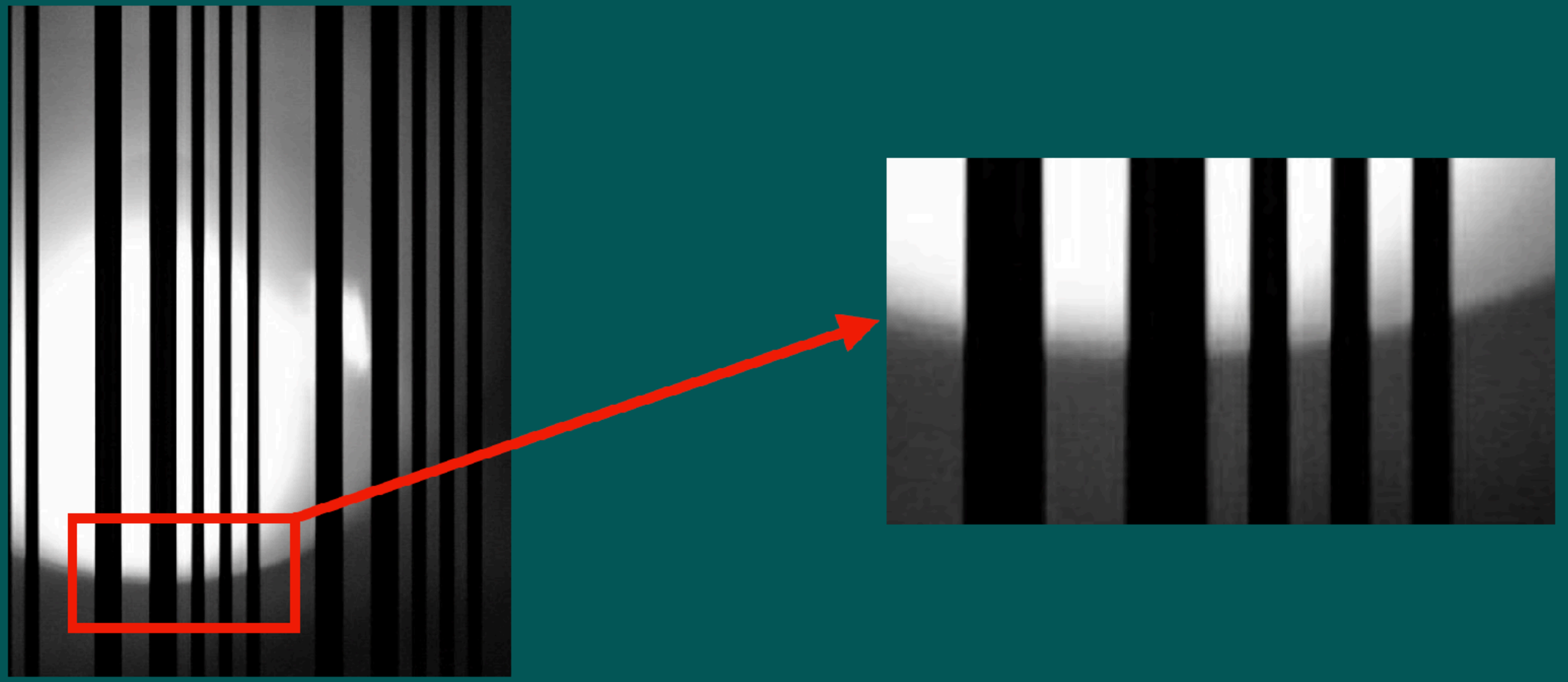
The extraction process of a single frame

Get luminance values of frame

↓

Get medium lighted row (decrease blooming effect)

Get medium lighted row (decrease blooming effect)



The extraction process of a single frame

Get luminance values of frame

↓

Get medium lighted row (decrease blooming effect)

↓

Split row into black & white pixels and form groups of them

The extraction process of a single frame

Get luminance values of frame

↓

Get medium lighted row (decrease blooming effect)

↓

Split row into black & white pixels and form groups of them

↓

Increase size of black groups

The extraction process of a single frame

Get medium lighted row (decrease blooming effect)

↓

Split row into black & white pixels and form groups of them

↓

Increase size of black groups

↓

Get median size of group -> size of single stripe

The extraction process of a single frame

Split row into black & white pixels and form groups of them

↓

Increase size of black groups

↓

Get median size of group -> size of single stripe

↓

Size of group decides about amount of 0’s or 1’s

How to cope with continuous frames?

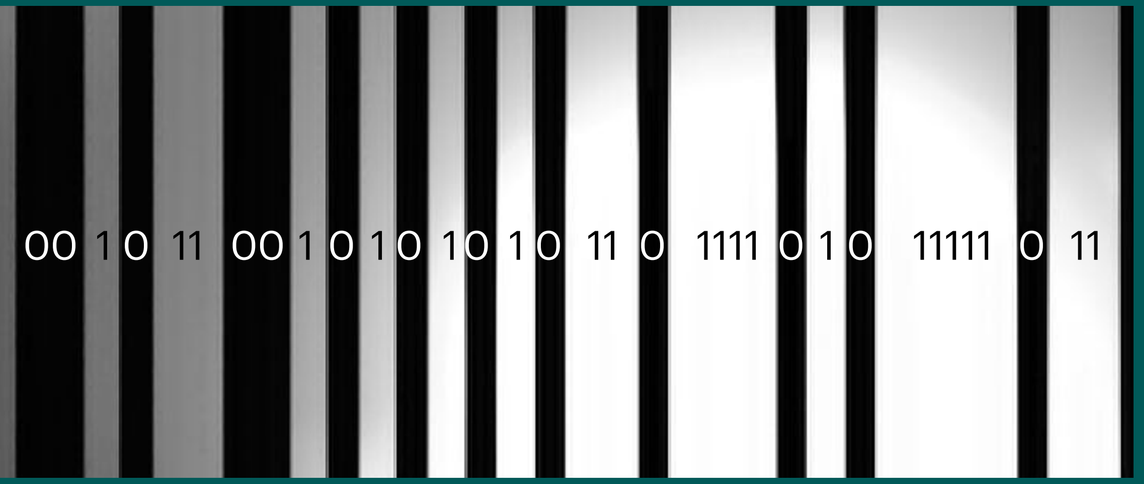
How to cope with continuous frames?

↓

Add ‘x’ between every analysed frame for better error detection

+ ‘x’ +

How to cope with continuous frames?



+ ‘x’ +

If ‘x’ is in between symbol bits then recover with XOR