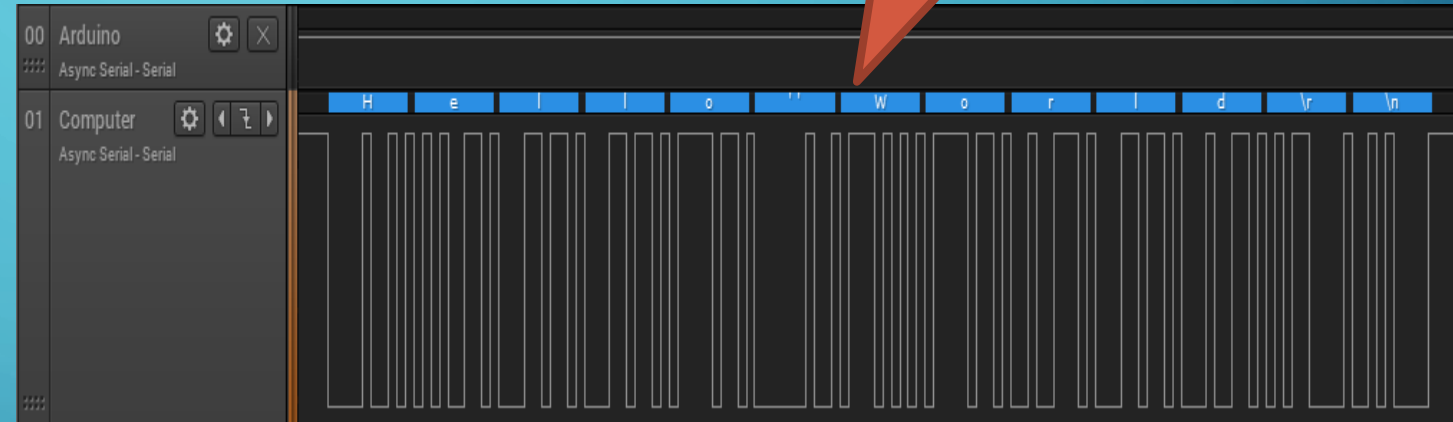


COMMUNICATION PROTOCOLS REVERSE ENGINEERING

LECTURE 1



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GITHUB: [HTTPS://GITHUB.COM/RXTXINV/COMMUNICATION_PROTOCOLS_REVERSE_ENGINEERING_COURSE/](https://github.com/RXTXINV/COMMUNICATION_PROTOCOLS_REVERSE_ENGINEERING_COURSE/)

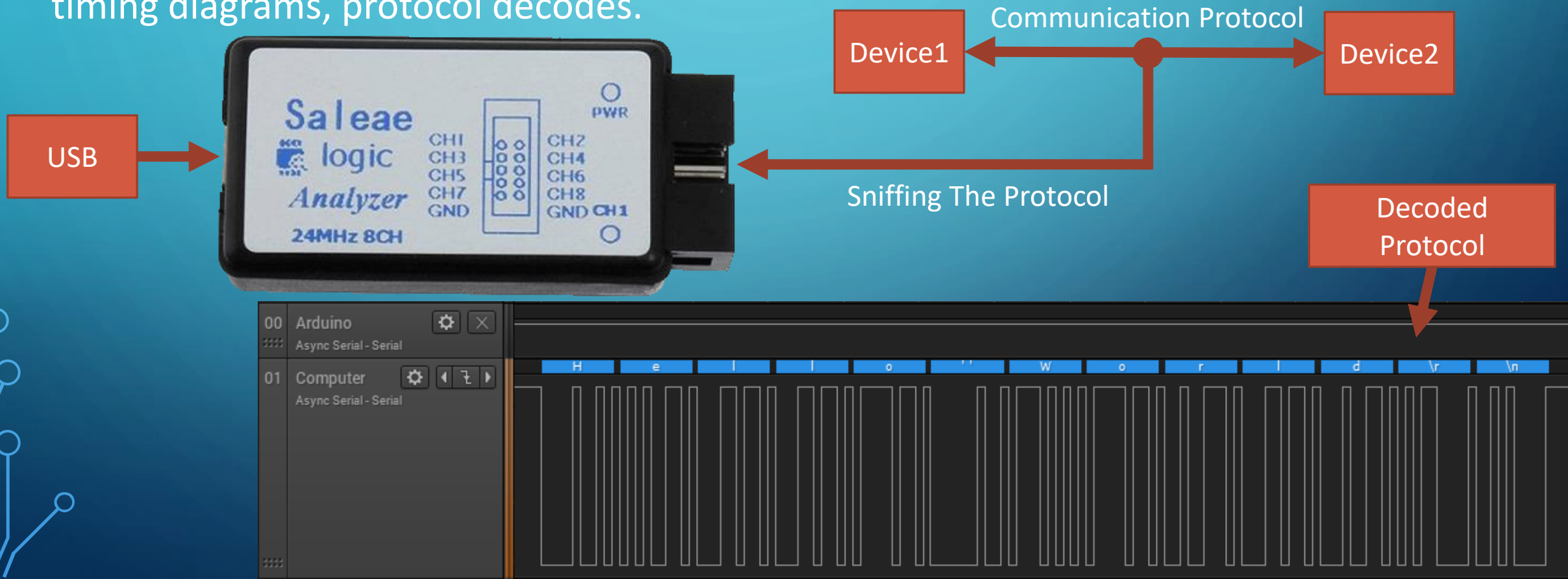
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LECTURE 1 AGENDA

- What is the Logic Analyzer ?
- What is the importance of the logic analyzer ?
- The physical components of the logic analyzer.
- The Software interface.
- Why using Arduino in this course ?
- Example 1: LED Blink.
- Example 2: Sniffing UART Protocol.

WHAT IS THE LOGIC ANALYZER

- The logic analyzer is an electronic instrument that captures (Samples) and displays multiple signals from a digital system or digital circuit without affecting the communication between them. A logic analyzer may convert the captured data into timing diagrams, protocol decodes.



WHAT IS THE IMPORTANCE OF THE LOGIC ANALYZER

- Its importance:
 - Useful tool when **learning the communication protocols** (UART, I²C, SPI, 1-Wire, CAN, LIN, SMBus, I²S).
 - Useful tool when debugging the embedded hardware.
 - Useful tool when trying to reverse-engineer the communication protocols for a product.
 - Capturing the data for later use and documentation purposes.
- Its considered as a **skill** for most of the embedded systems companies.
- Supported Protocols:
 - I²C, SPI, 1-Wire, CAN, I²S – PCM, JTAG, LIN, Modbus, SMBus, ... more.
- Support 8 Digital Channels with sampling rate up to 24Ms/S.

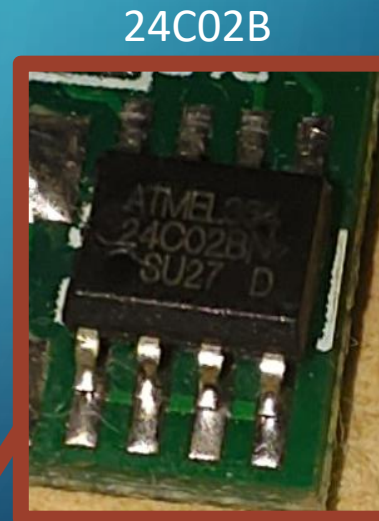
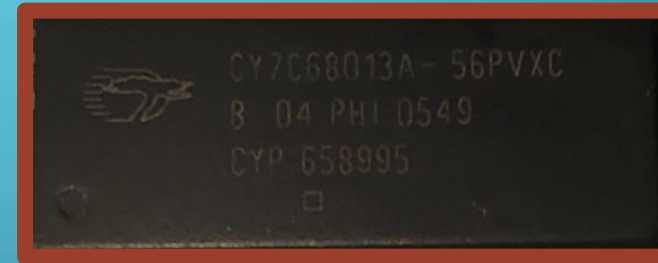
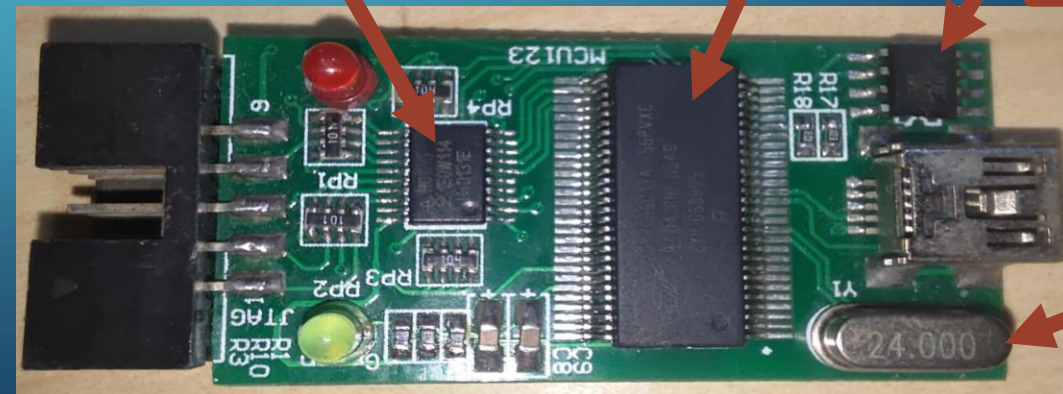
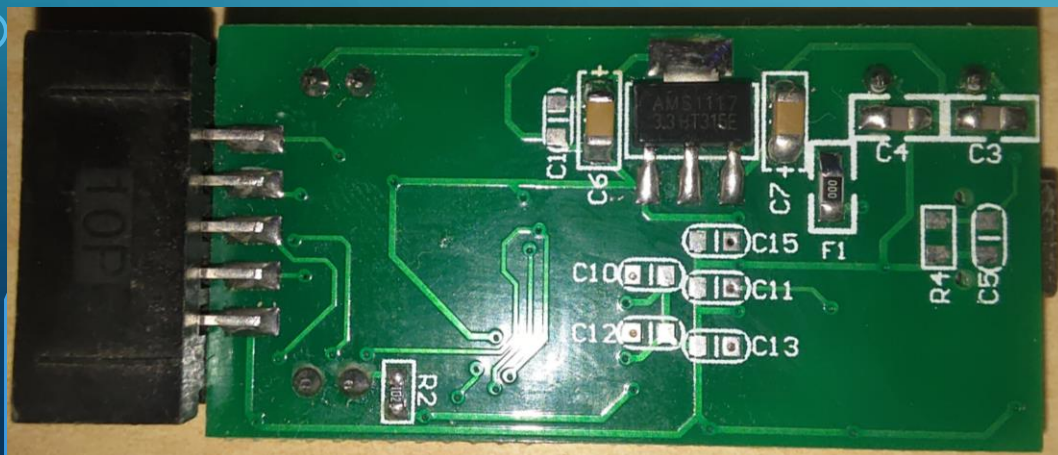
Supported Protocols



- Async Serial
- I2C
- SPI
- Hide
- 1-Wire
- Atmel SWI
- BiSS C
- CAN
- DMX-512
- HD44780
- HDLC
- HDMI CEC
- I2S / PCM
- JTAG
- LIN
- MDIO
- Manchester
- Midi
- Modbus
- PS/2 Keyboard/Mouse
- SMBus
- SWD
- Simple Parallel
- UNI/O
- USB LS and FS

THE PHYSICAL COMPONENTS OF THE LOGIC ANALYZER

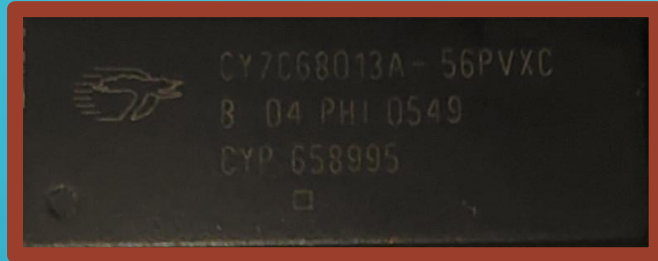
- Main components of the **Saleae Logic 8 (Chinese Clone)**
 - Cypress CY7C68013A Microcontroller.
 - 74HC245 (Octal Bus Transceiver) used for **level shifting** and **protection**.
 - 24C02B EEPROM.
 - AMS1117 3.3V voltage regulator.



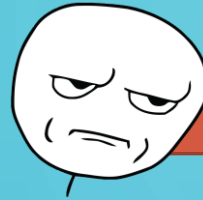
24MHz
Crystal

THE PHYSICAL COMPONENTS OF THE LOGIC ANALYZER

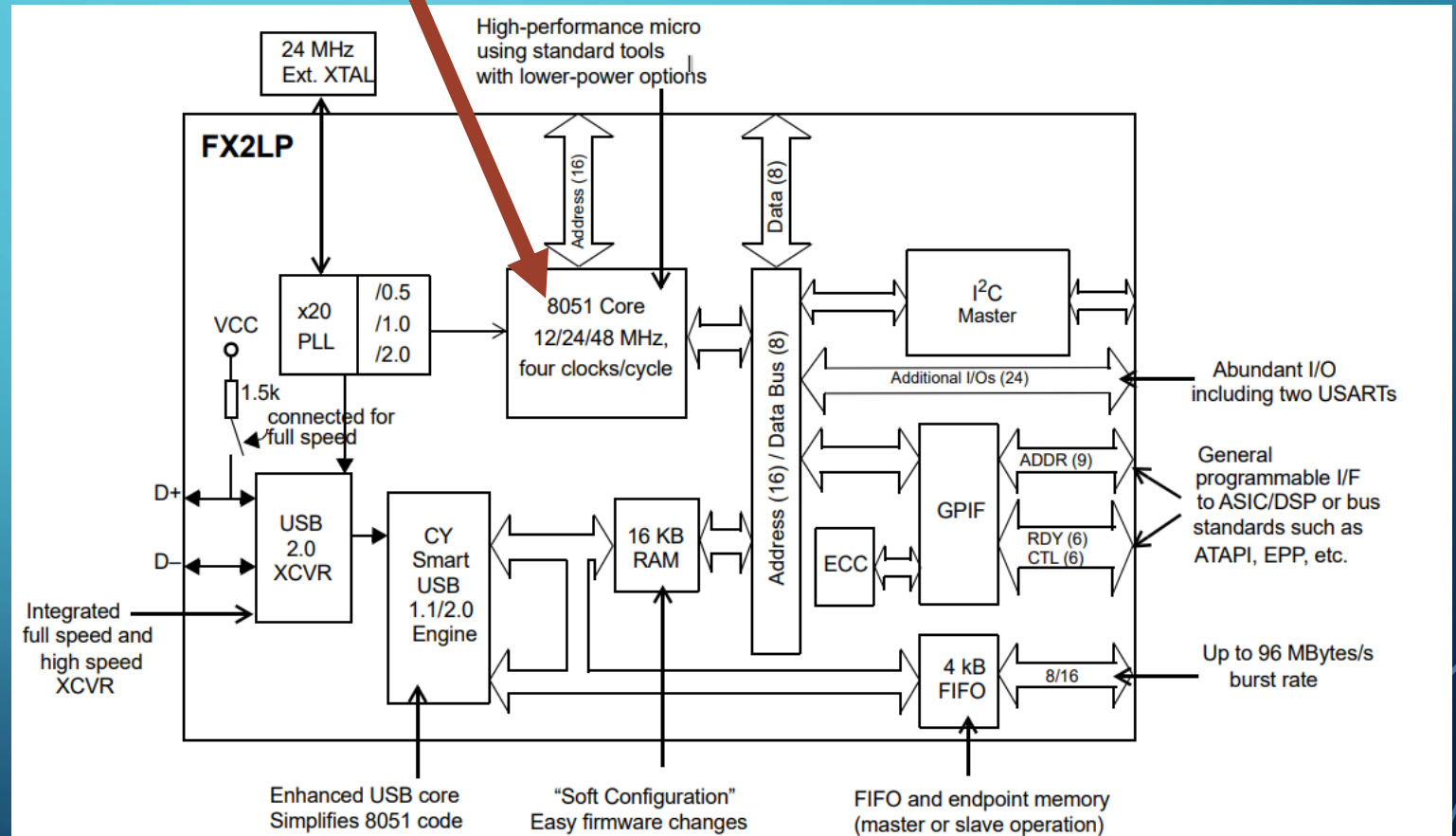
Cypress CY7C68013A



8051 Inside ?!



Confirmed, **8051** Is Here !!



THE PHYSICAL COMPONENTS OF THE LOGIC ANALYZER

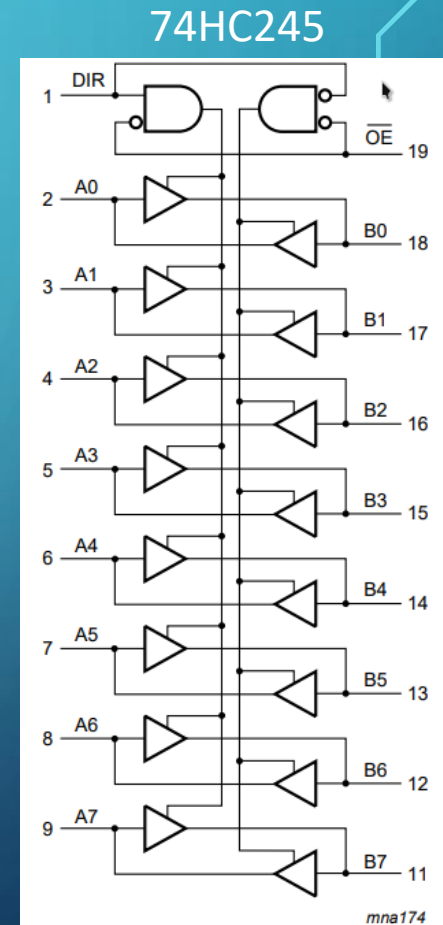
74HC245



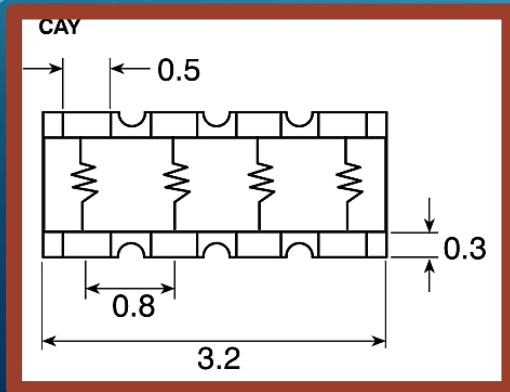
Maximum Input Voltage = 5V



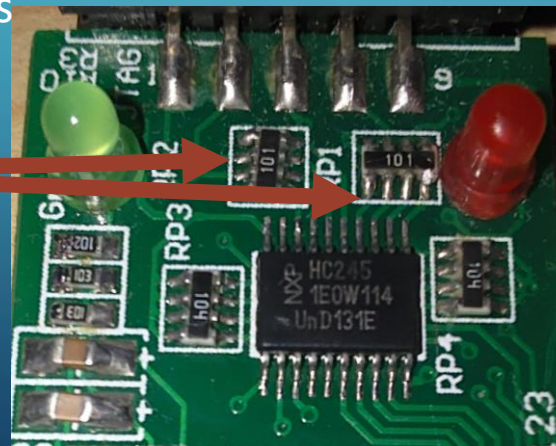
The 74HC245; 74HCT245 is an 8-bit transceiver with 3-state outputs. The device features an output enable (\overline{OE}) and send/receive (DIR) for direction control. A HIGH on \overline{OE} causes the outputs to assume a high-impedance OFF-state. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of V_{CC} .



Current Limiting Resistors

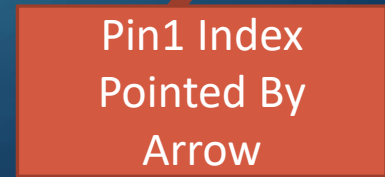
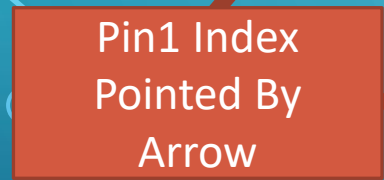


100 Ohm
Resistor
Network



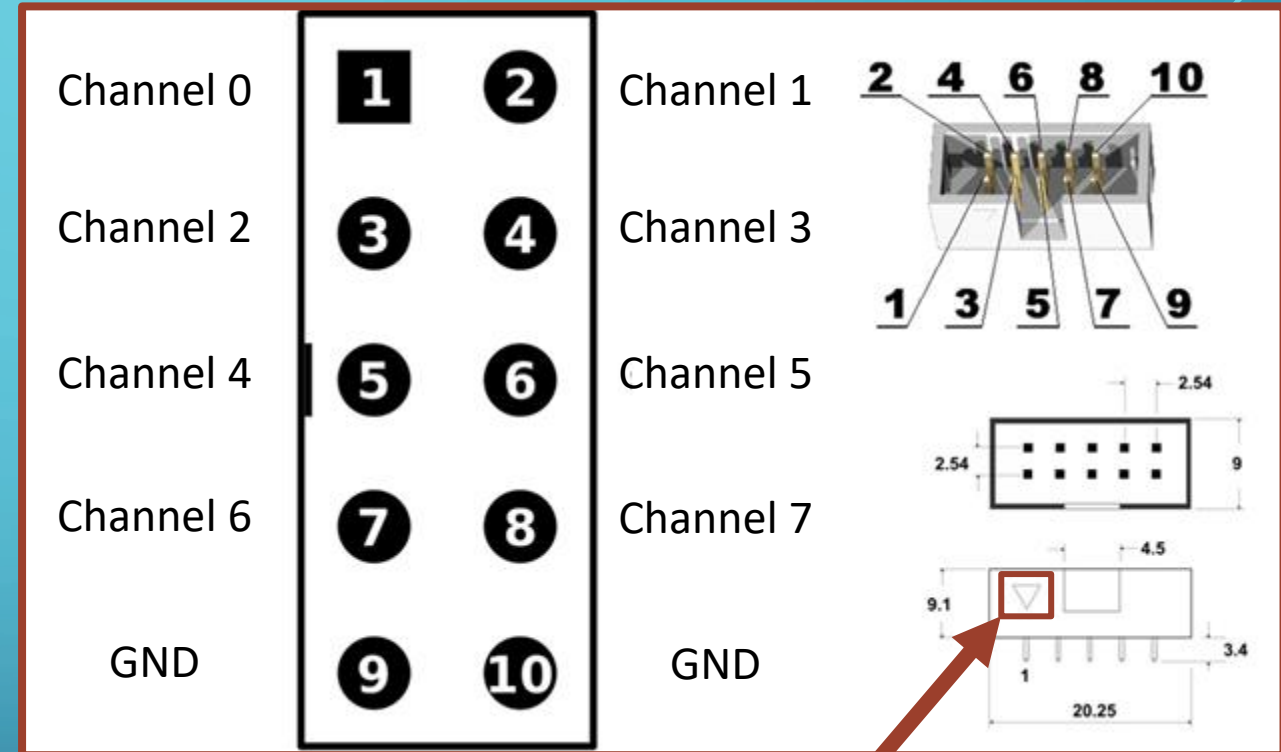
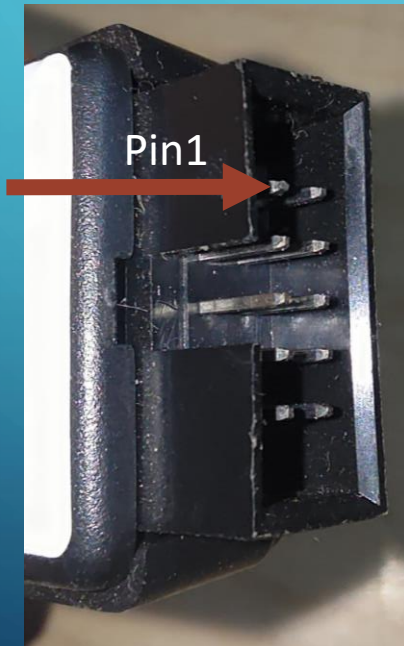
Power
LED

Channel 0
LED

[illegible]

THE PHYSICAL COMPONENTS OF THE LOGIC ANALYZER

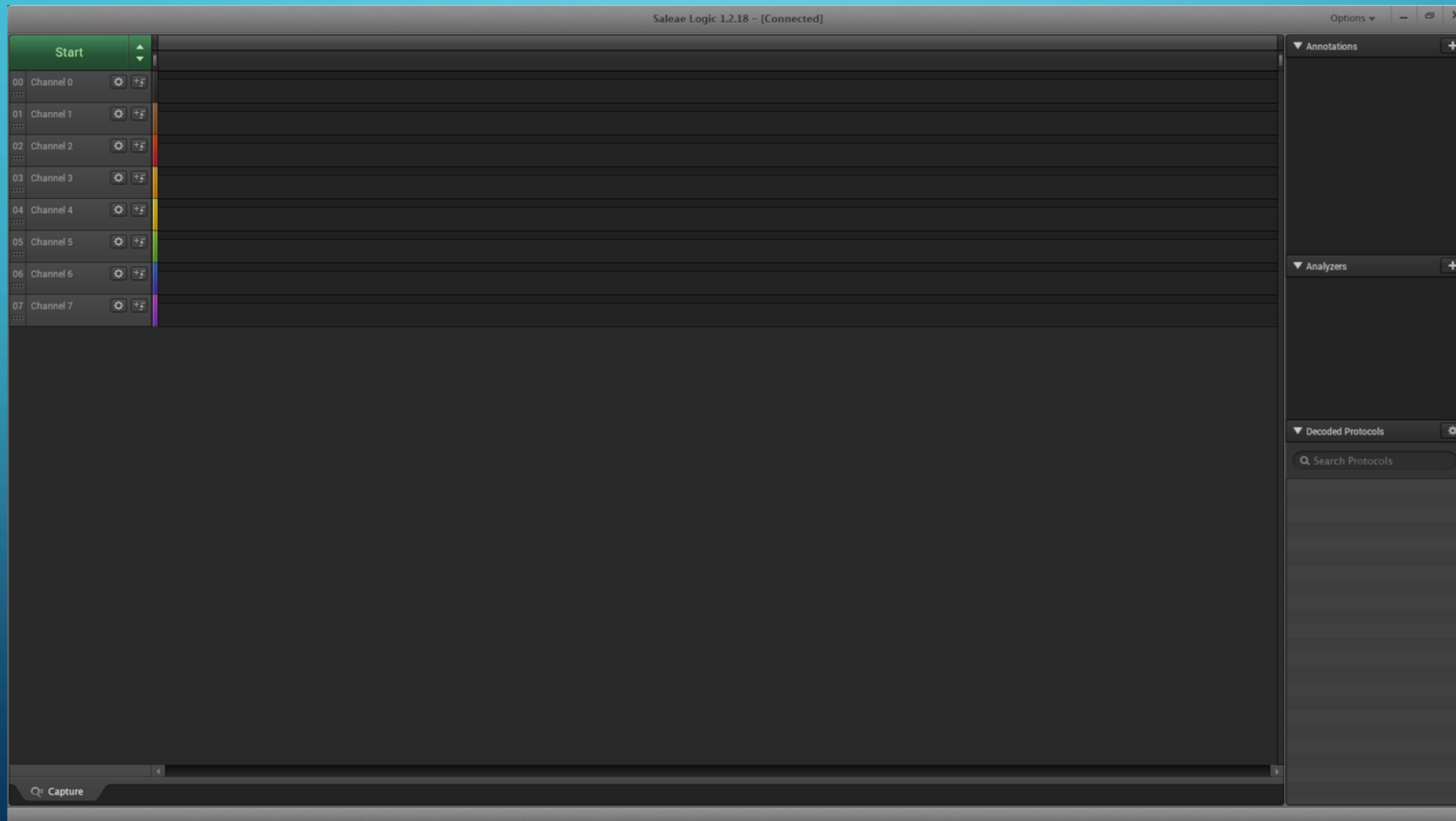
Pin1 Index
Pointed By
Arrow



Pin1 Index
Pointed By
Arrow

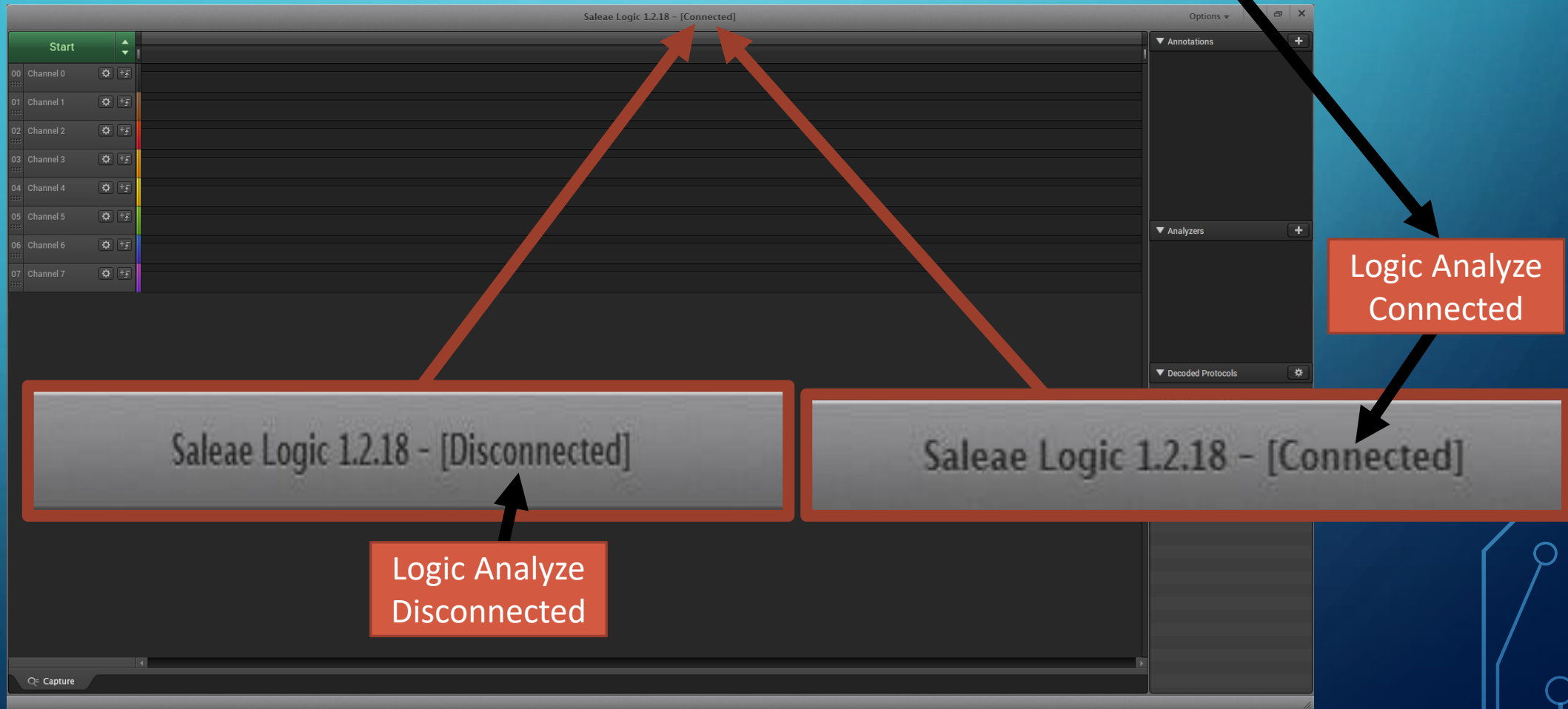
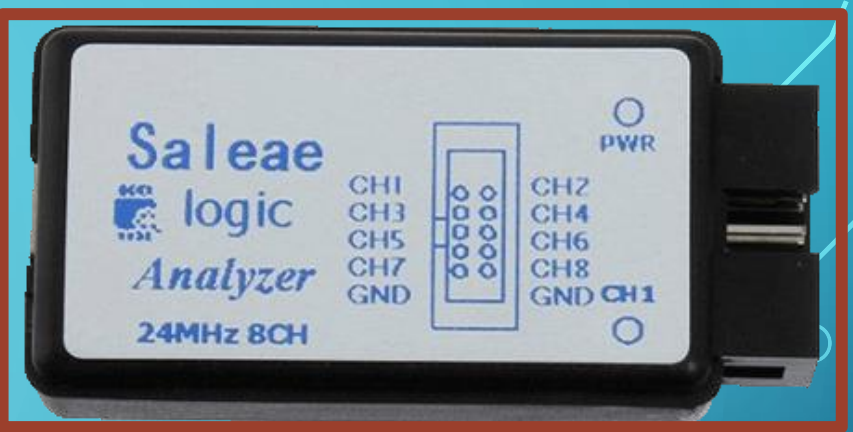
THE SOFTWARE INTERFACE

- Software Installing & How To Use:
 - Download the software [Saleae Logic 1.2.18](#) and install it like any program.



THE SOFTWARE INTERFACE

USB

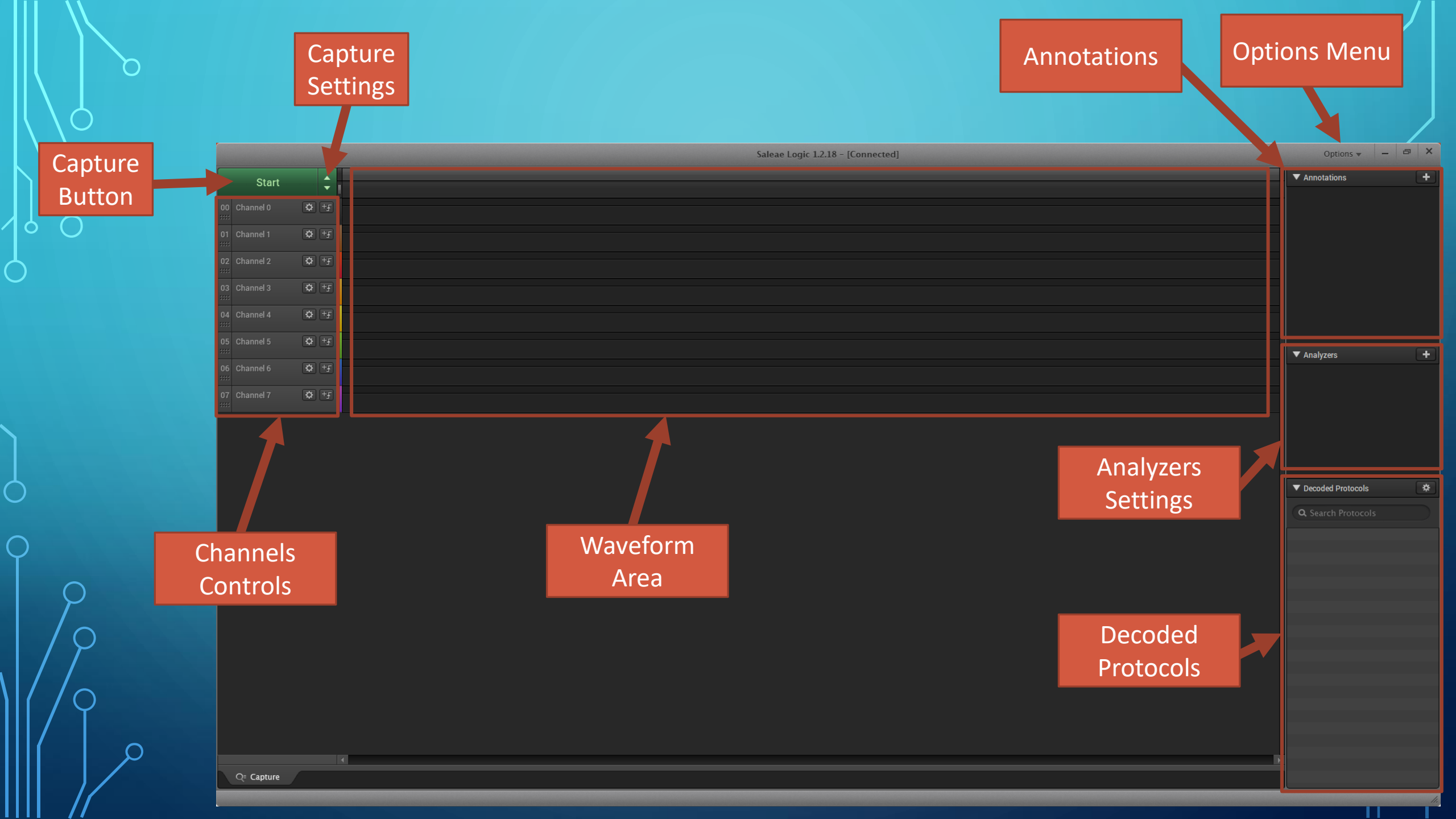


Logic Analyze
Connected

Logic Analyze
Disconnected

Saleae Logic 1.2.18 - [Connected]

Saleae Logic 1.2.18 - [Disconnected]



Capture Button

Capture Settings

Annotations

Options Menu

Channels Controls

Waveform Area

Analyzers Settings

Decoded Protocols

ANNOTATIONS

- Used for:

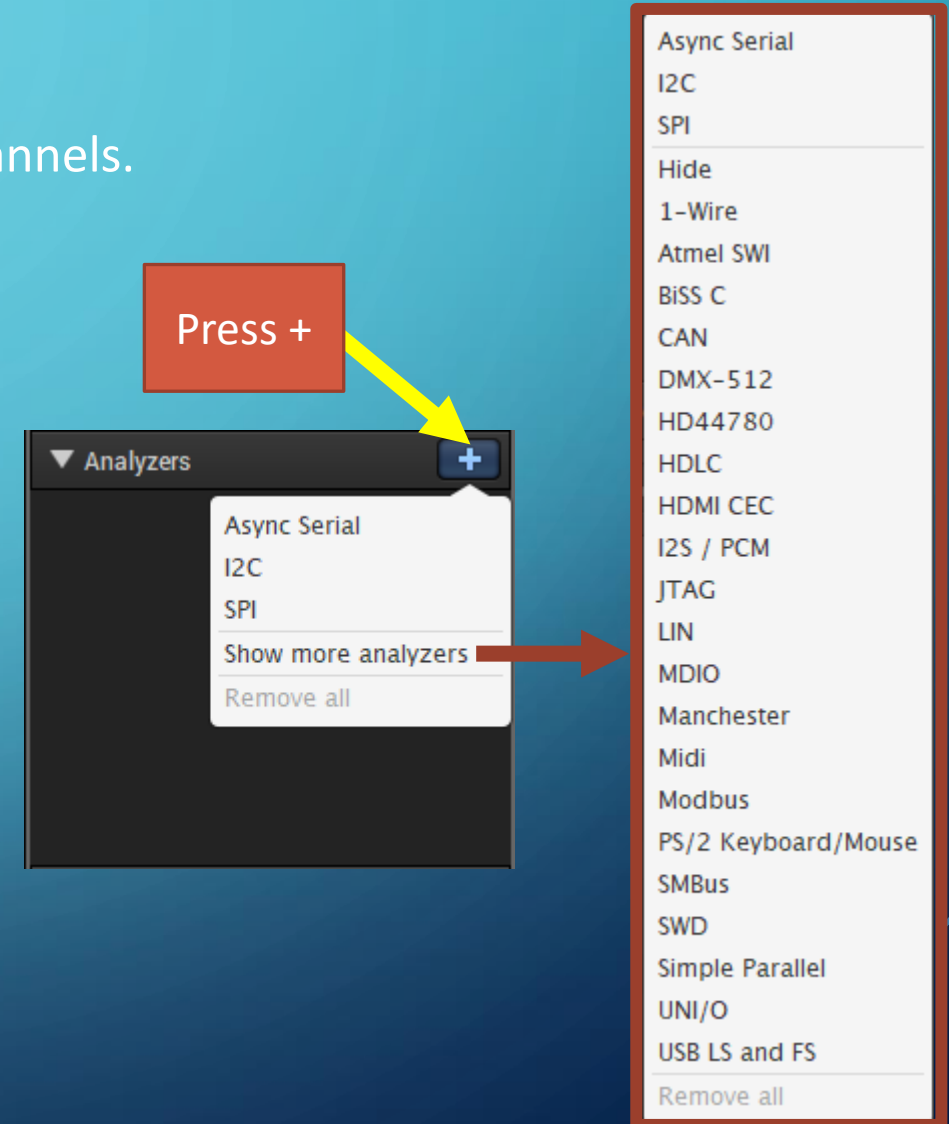
- Adding Bookmarks, timing markers, and various measurements

The image illustrates the workflow for adding annotations to a waveform in a digital oscilloscope. It is divided into three main sections:

- Annotations Menu:** A list of available annotation types is shown on the left. It includes 'Delete Measurement' at the top, followed by 'Width' and 'Frequency' (both checked). Below these are various measurement options: 'Average Frequency', 'Average Duty Cycle', 'Rising Edges', 'Falling Edges', 'Positive Pulses', 'Negative Pulses', 'Minimum Pos Pulse', 'Maximum Pos Pulse', 'Minimum Neg Pulse', 'Maximum Neg Pulse', 'Period', 'Average Period', 'Complete Periods', 'Min-Max Voltage', 'Start Voltage', 'End Voltage', 'Delta Voltage', and 'Peak To Peak Voltage'. A red arrow points from the 'Measurement' option in the central menu to this list.
- Annotations Menu Trigger:** In the center, a panel shows the 'Annotations' menu with a '+' button. A red box labeled 'Press +' has a yellow arrow pointing to this button. A red arrow points from the '+' button to the 'Timing Marker Pair' option in the menu.
- Waveform and Annotations Panel:** On the right, a waveform is displayed. Two yellow arrows point to markers labeled 'A1' and 'A2' on the waveform. A yellow double-headed arrow between these markers is labeled 'Measuring Time'. To the right of the waveform is an 'Annotations' panel. It shows a 'Timing Marker Pair' with the calculation $| A1 - A2 | = 48.29166667 \mu s$. Below this, it lists the timestamps: 'A1 @ 16.03433617 s' and 'A2 @ 16.03438446 s'. A yellow box highlights this entire calculation and timestamp information.

ANALYZERS

- Used for:
 - Adding one/many protocol analyzer(s) to the digital channels.

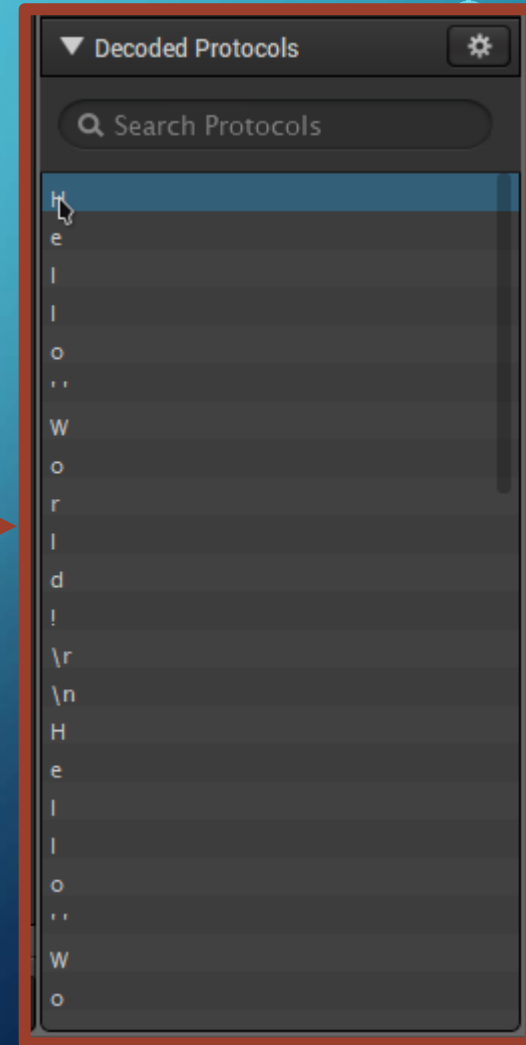
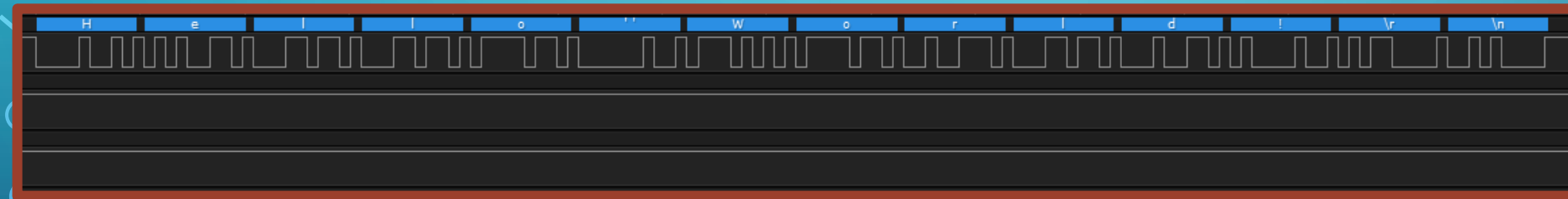


DECODED PROTOCOLS

- Used for:

- Showing the decoded results of the protocol analyzers once the data has been processed.
- Searching within the decoded data.

Decoded UART Data



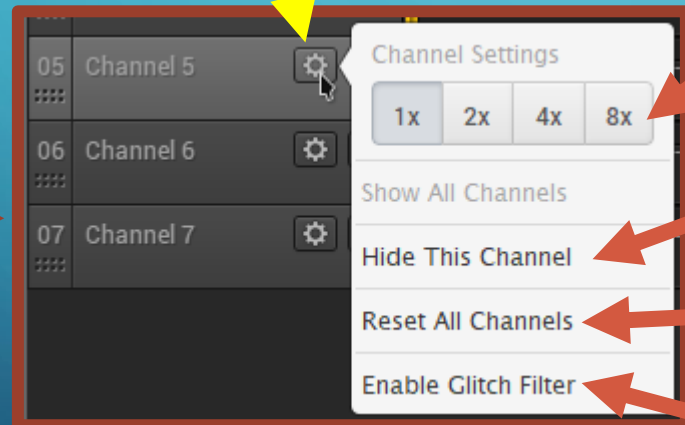
CHANNELS CONTROLS

- Used for:

- Controlling the channels (Trigger, Zoom, Sort channels, Hide Channels)
- Controlling the data capture (Sampling Rate, Sampling Duration)



Click on



Zoom (1,2,4,8)x

Hide Channel

Reset All Channels

Enable Glitch Filter

Double click to change channel's name

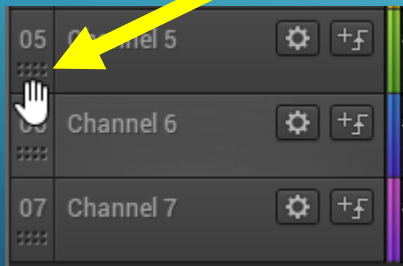


CHANNELS CONTROLS

- Used for:

- Controlling the channels (Trigger, Zoom, Sort channels, Hide Channels)
- Controlling the data capture (Sampling Rate, Sampling Duration)

Hover on  and drag (up/down) to move the channel

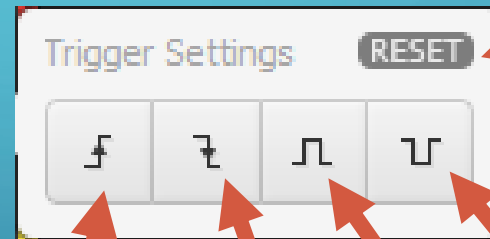
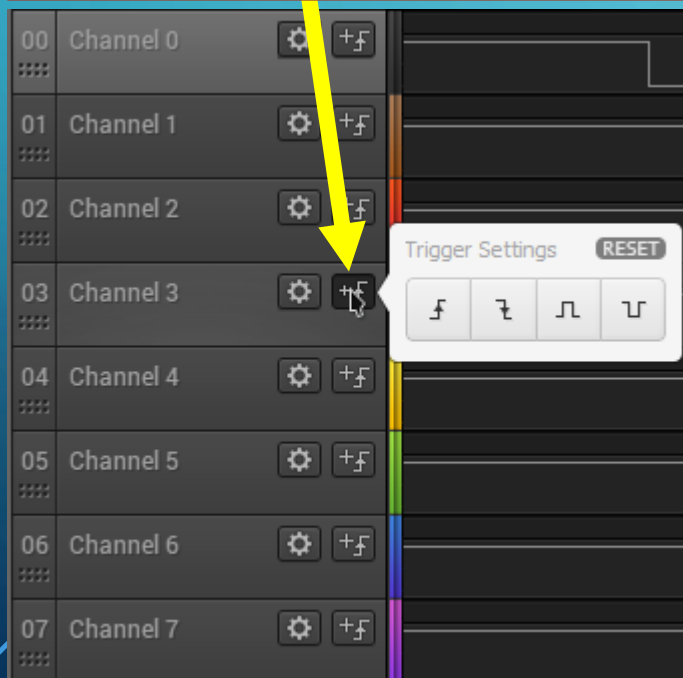


CHANNELS CONTROLS

- Used for:

- Controlling the channels (Trigger, Zoom, Sort channels, Hide Channels)
- Controlling the data capture (Sampling Rate, Sampling Duration)

Click on  to choose triggering settings for the channel



Reset Trigger (Remove Trigger)

Trigger on Rising Edge

Trigger on Falling Edge

Trigger on Negative Pulse Width

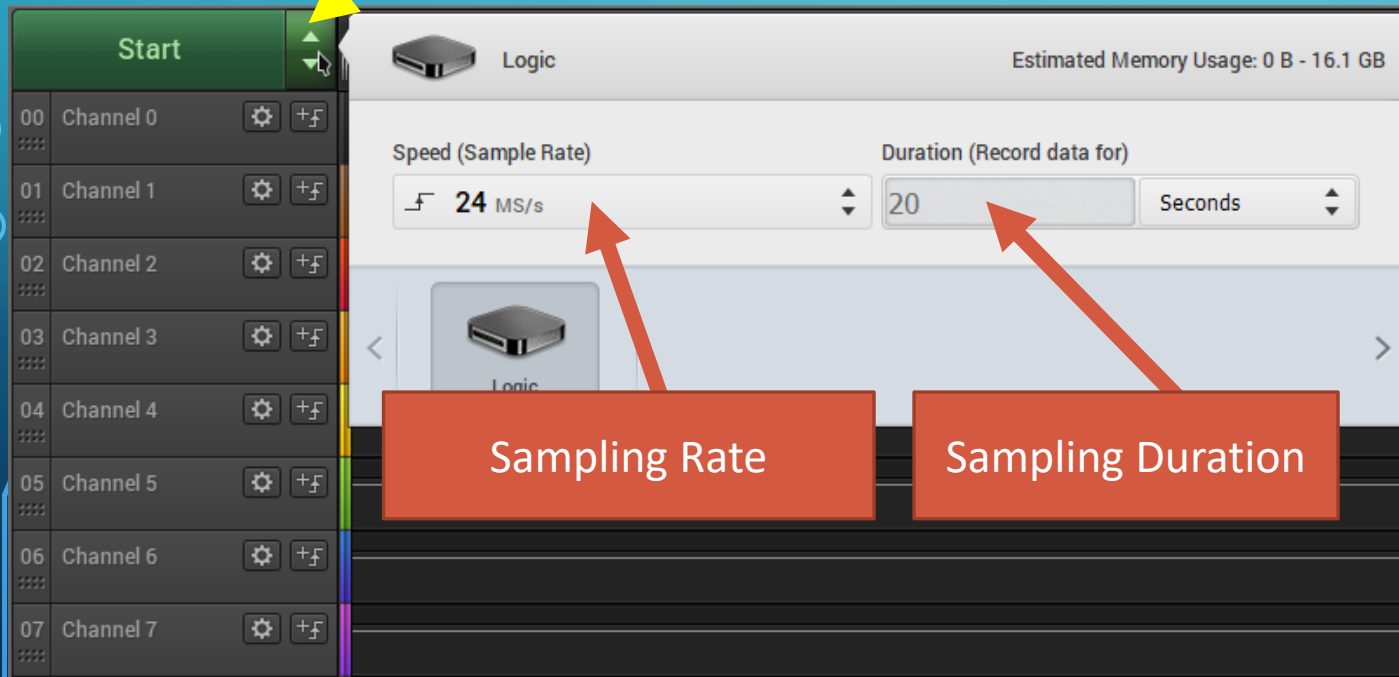
Trigger on Positive Pulse Width

CHANNELS CONTROLS

- Used for:

- Controlling the channels (Trigger, Zoom, Sort channels, Hide Channels)
- Controlling the data capture (Sampling Rate, Sampling Duration)

Click on  to choose triggering settings for the channel



The screenshot displays the Logic Analyzer software interface. On the left, a vertical list of channels (00 to 07) is shown, each with a gear icon and a waveform icon. A yellow arrow points from the 'Start' button to the gear icon of Channel 0. The main panel shows the configuration for Channel 0, titled 'Logic'. It includes a section for 'Speed (Sample Rate)' and 'Duration (Record data for)'. The 'Speed' is set to '24 MS/s' and the 'Duration' is set to '20 Seconds'. Two red arrows point from labels below to these settings: 'Sampling Rate' points to the '24 MS/s' value, and 'Sampling Duration' points to the '20' value. The 'Estimated Memory Usage' is shown as '0 B - 16.1 GB'.

Start

Logic Estimated Memory Usage: 0 B - 16.1 GB

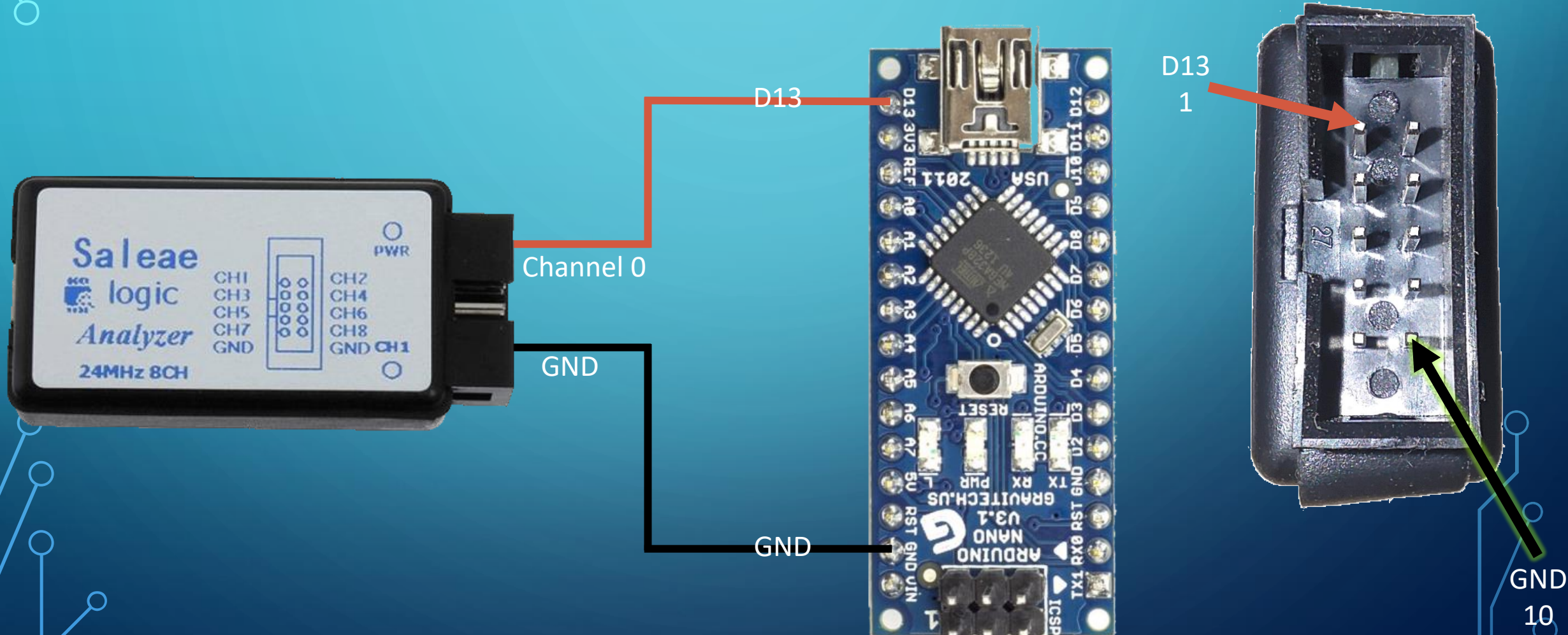
Speed (Sample Rate) Duration (Record data for)

24 MS/s 20 Seconds

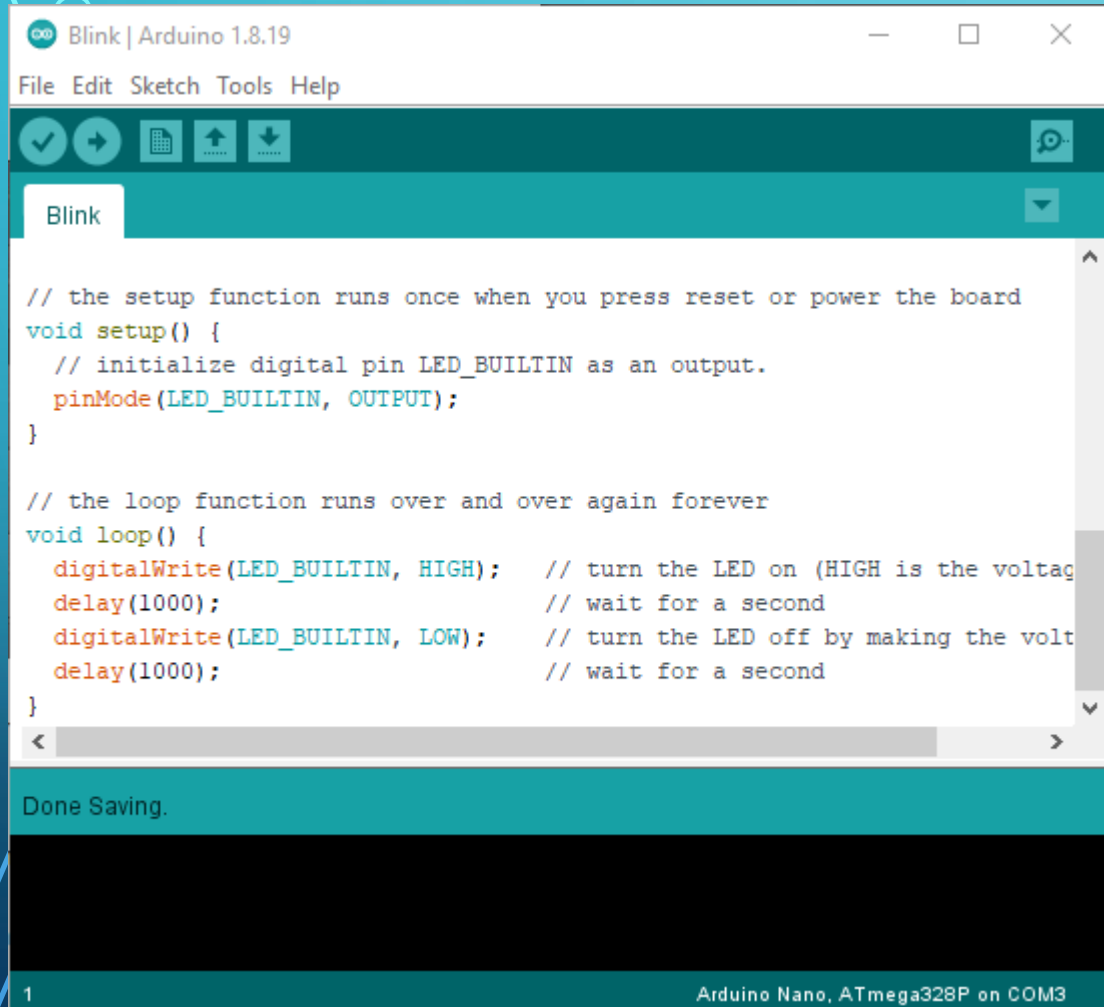
Sampling Rate Sampling Duration

EXAMPLE 1 (LED BLINK)

- This example blinks a LED every 1 second, lets record its GPIO data.



EXAMPLE 1 (LED BLINK)

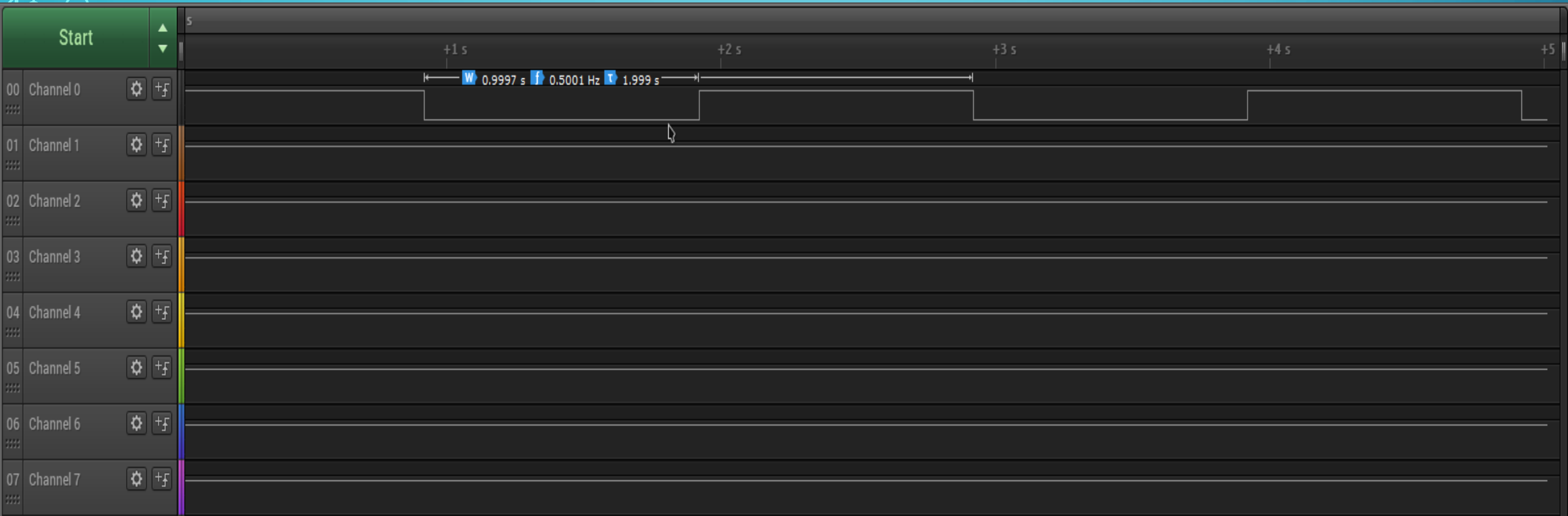
A screenshot of the Arduino IDE interface. The window title is "Blink | Arduino 1.8.19". The menu bar includes "File", "Edit", "Sketch", "Tools", and "Help". Below the menu bar is a toolbar with icons for saving, running, uploading, and downloading. The main text area shows the "Blink" sketch with the following code:

```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
  delay(1000);                     // wait for a second
  digitalWrite(LED_BUILTIN, LOW);  // turn the LED off by making the voltage LOW
  delay(1000);                     // wait for a second
}
```

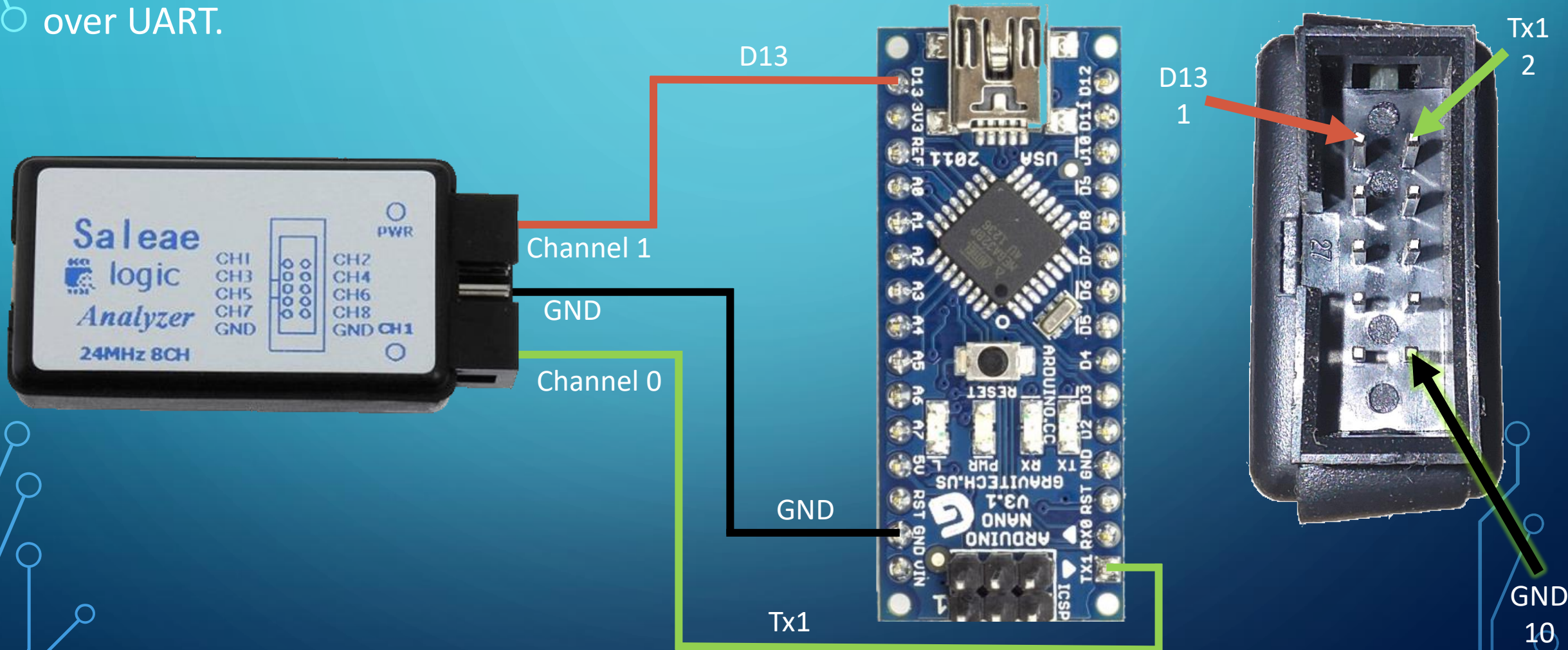
A status bar at the bottom indicates "Done Saving." and "1 Arduino Nano, ATmega328P on COM3".

EXAMPLE 1 (LED BLINK)



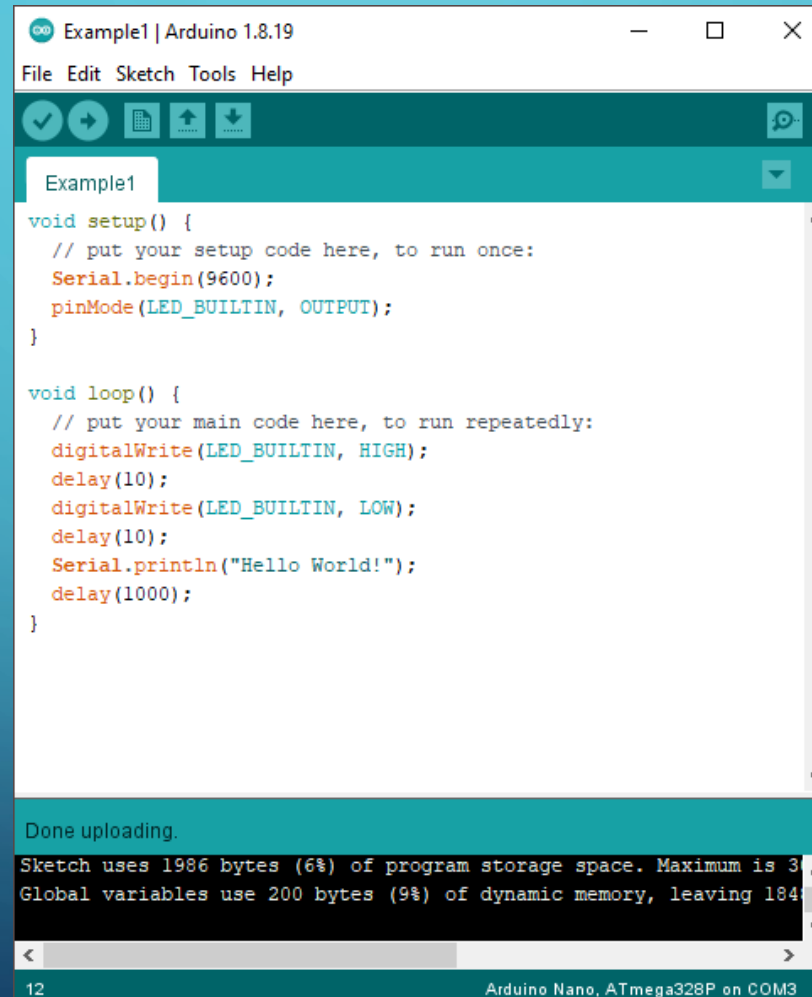
EXAMPLE 2 (LED BLINK + UART)

- This example generates a pulse with duration of 10ms on LED and sends “Hello World” over UART.



EXAMPLE 2 (LED BLINK + UART)

- This example generates a pulse with duration of 10ms on LED and sends “Hello World” over UART.



```
Example1 | Arduino 1.8.19
File Edit Sketch Tools Help

Example1
void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(LED_BUILTIN, OUTPUT);
}

void loop() {
  // put your main code here, to run repeatedly:
  digitalWrite(LED_BUILTIN, HIGH);
  delay(10);
  digitalWrite(LED_BUILTIN, LOW);
  delay(10);
  Serial.println("Hello World!");
  delay(1000);
}

Done uploading.
Sketch uses 1986 bytes (6%) of program storage space. Maximum is 3
Global variables use 200 bytes (9%) of dynamic memory, leaving 184
12 Arduino Nano, ATmega328P on COM3
```

EXAMPLE 2 (LED BLINK + UART)

- This example generates a pulse with duration of 10ms on LED and sends "Hello World" over UART.

