Microprocessor Interfacing Laboratory
ICOM-5217

Tutorial:

How to Use MSO6012A Oscilloscope and Logic Analyzer

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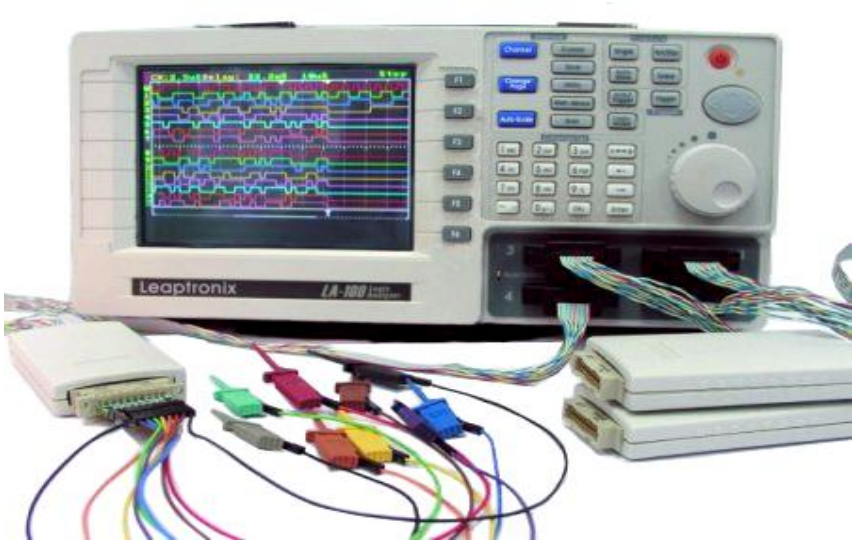
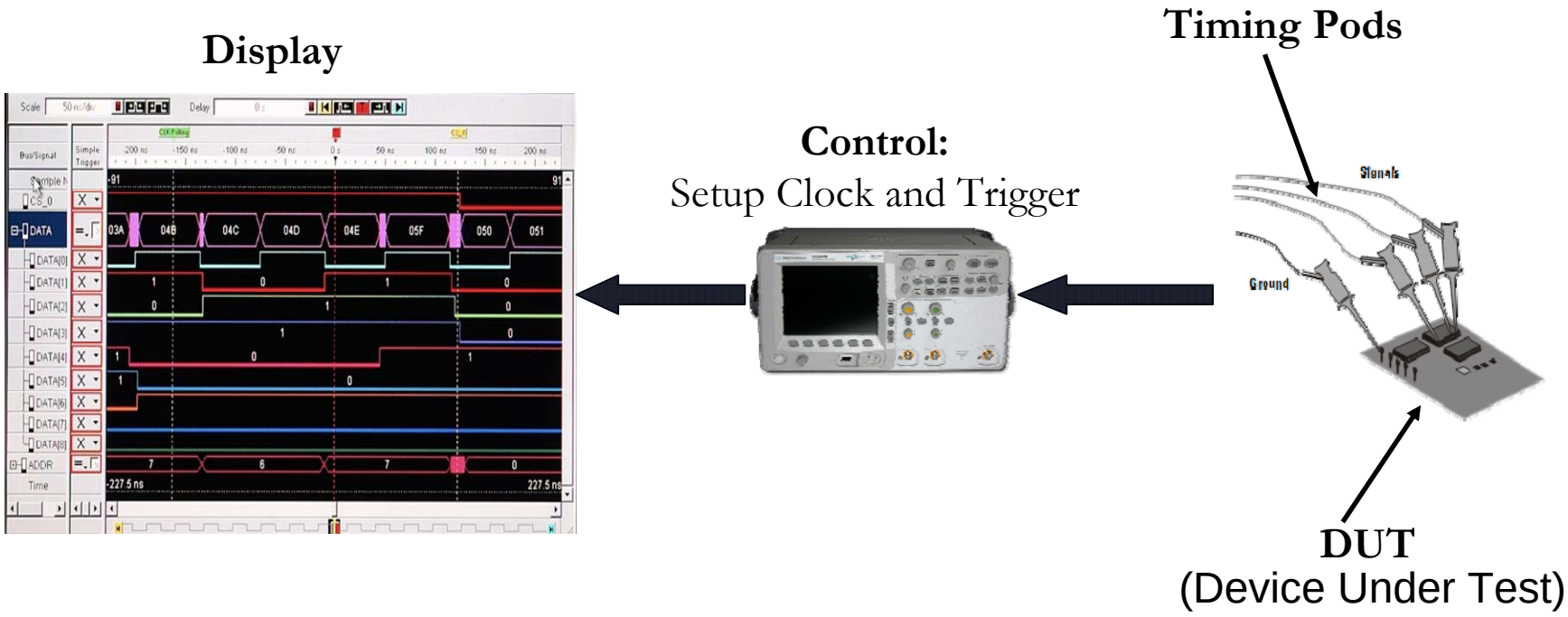
What is a Logic Analyzer?

- Is a measurement instrument that can display many digital signals at a time
- Similar to oscilloscopes, they present time in the horizontal axis and logic level in the vertical axis
- Displays signal timings in a similar way to the timing diagram in a device datasheet
- Do not provide voltage resolution or time-interval accuracy like a oscilloscope



Logic Analyzer Parts



Logic Analyzer Specifications?

- Numbers of digital channels: Numbers of signals that can be display at a time.
- Depth memory: Specify the numbers of samples that can be acquired.
- Sample rate: Determines the maximum sampling frequency for a digital channel.
- Trigger flexibility: Events to start the sampling process.
- Operating modes: Modes of operation and clock sources.

When to and not to use a Logic Analyzer

Do

- To analyze multiple signals at a time
- To debug and verify digital circuits
- To trace embedded software integration within a circuit
- To look at many signals in your system the same way your hardware does
- To detect and analyze bus timing

Don't

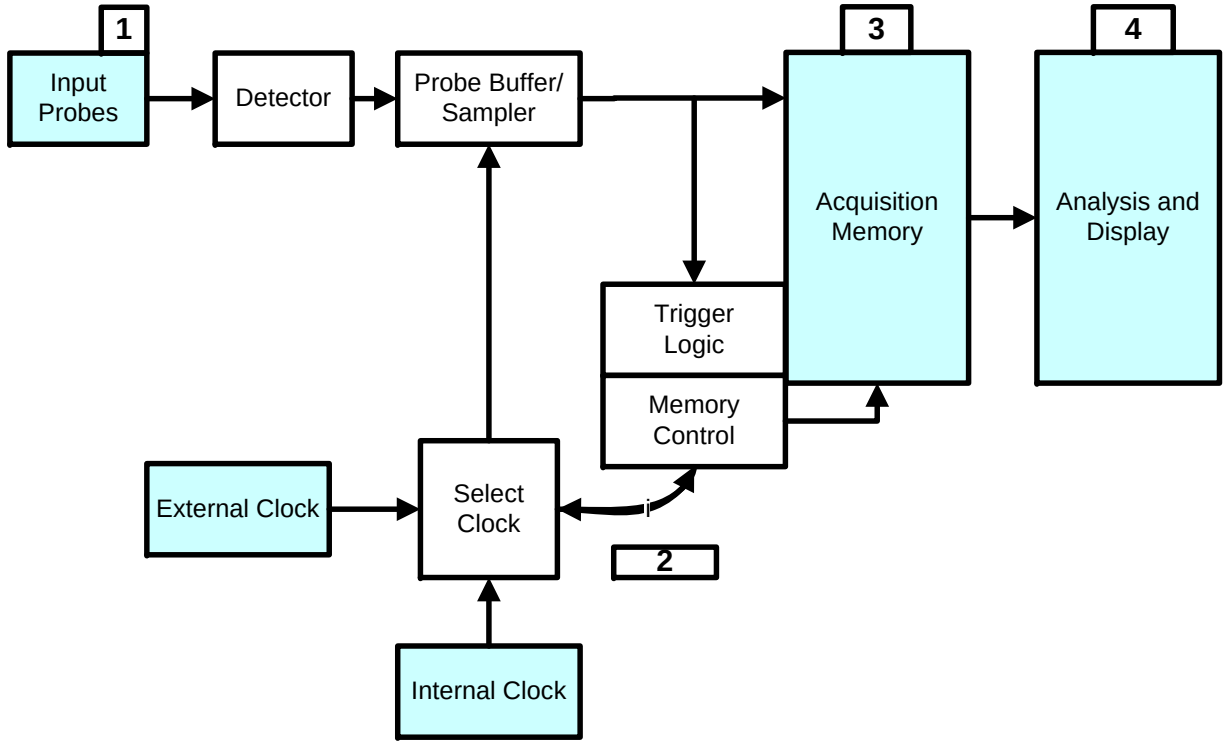
- When you need to see amplitude details of signals
- For analyzing parameters such as rise time, fall time, etc.
- If you need to see low voltages or noise
- If you need high time interval accuracy

Trigger Conditions

- The trigger signal indicates when the Logic Analyzer is going to capture the inputs
- One or more data signals are use to configure the trigger conditions
- The trigger conditions can be: (depending on the Logic Analyzer that you are using):

  - Signal edge
  - Pattern on signals or a full bus
  - Ranges of time between events
  - Glitches
  - Timers
  - Sequence of events
  - Signal duration
  - Signal edge duration
  - Depending on communication protocol

The Logic Analyzer Architecture



1. Probes
2. Clock mode and triggering
3. Acquire
4. Analyze and display

Logic Analyzer Operation

- A Logic Analyzer detects the logic level threshold of sampled signals
- When you use a Logic Analyzer you will see just the Logic levels not analog details
- Logic threshold can be configured depending the technology (CMOS, TTL , ECL)

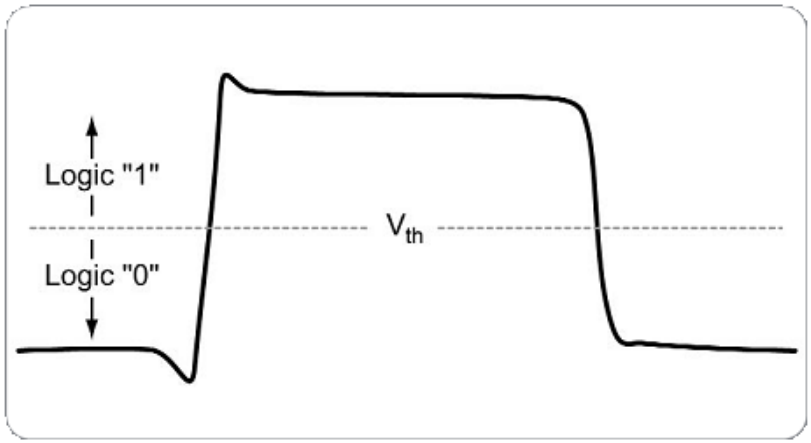


Figure 2. *A logic analyzer determines logic values relative to a threshold voltage level.*

Probes

- The probes can detect the logic levels
- The impedance of the probes becomes part of the digital circuit
- Probes impedance can affect the signal timing
- Is important not to add cables to the probe
  - They are designed to compensate the impedance effect whenever possible

Clock Modes

- The clock modes determine how the data are sampled and the resolution of the measurement
- Depending on the clock source the Logic Analyzer can acquire the data in two different way, this is it can operate in two different modes:
  - Timing Analyzer (Asynchronous to the measured signals)
  - State Analyzer (Synchronous to the measured signals)

Clock Mode: Timing Analyzer

- Is similar to a DSO (Digital Store Oscilloscope)
- The signals are sampled with an internal clock source that depends on the selected time base
- The measurement accuracy depends on the clock source as well as the time base
- The number of samples depends on the time base and memory depth
- Is important to select an appropriated time base:
  - For example with a Logic Analyzer with 8 Mpts: If you set a 10ms time base you will have sampling for 100ms

Clock Mode: State Analyzer

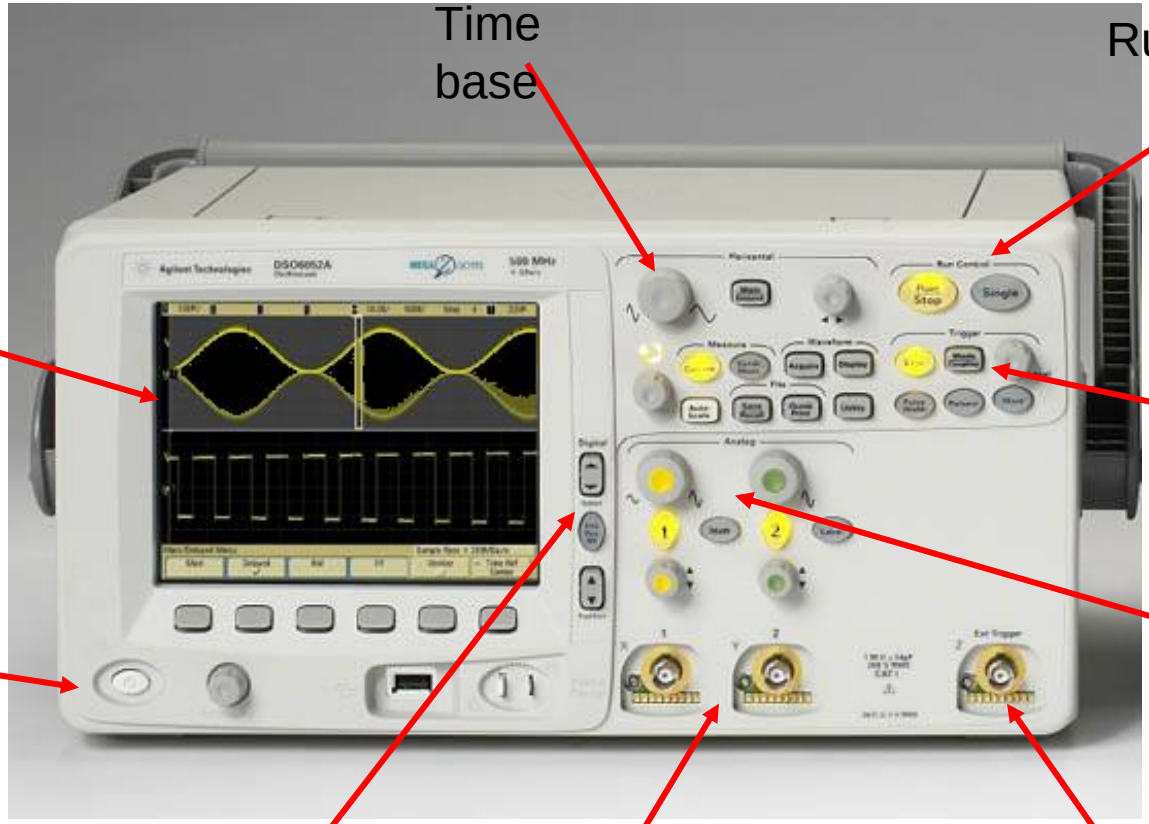
- The signals are sampled at a external clock source rate. This clock source is one of the input signals
- This mode is very common for microprocessor systems
- As an example suppose you want to see what is written to a parallel memory connected to a 80c51 bus:
  - Data are present in the bus when the /WR signal is active
  - With a Logic Analyzer working as state analyzer the data lines are sampled when /WR signal is active if you use this signal as clock source

The Logic Analyzer in MIL MSO6012A

- The MSO6012A is digital oscilloscope and Logic Analyzer, as Logic Analyzer has the next features:

  - 16 Digital inputs
    - Single 16-bit bus
    - Two separate 8-bit buses (D_7-D_0 and D_{15}-D_8)
  - 8 Mpts Memory Depth
  - Internal sample rate 2 GSa/s
  - Multiple Logic thresholds
    - TTL, CMOS, ECL and user defined (-8 V to +8 V)
  - 13 trigger types:
    - Edge (slope), Pulse width (glitch), Pattern, CAN, Duration, FlexRay, I2C, Nth Edge Burst, LIN, Sequence, SPI, TV, USB

MSO6012A Controls



Using the MSO6012A as Oscilloscope

1. Connect the analog probes to your circuit and the MS06012A

2. Select time base

- Is important to select an appropriate time base depending on the signals you are going to view

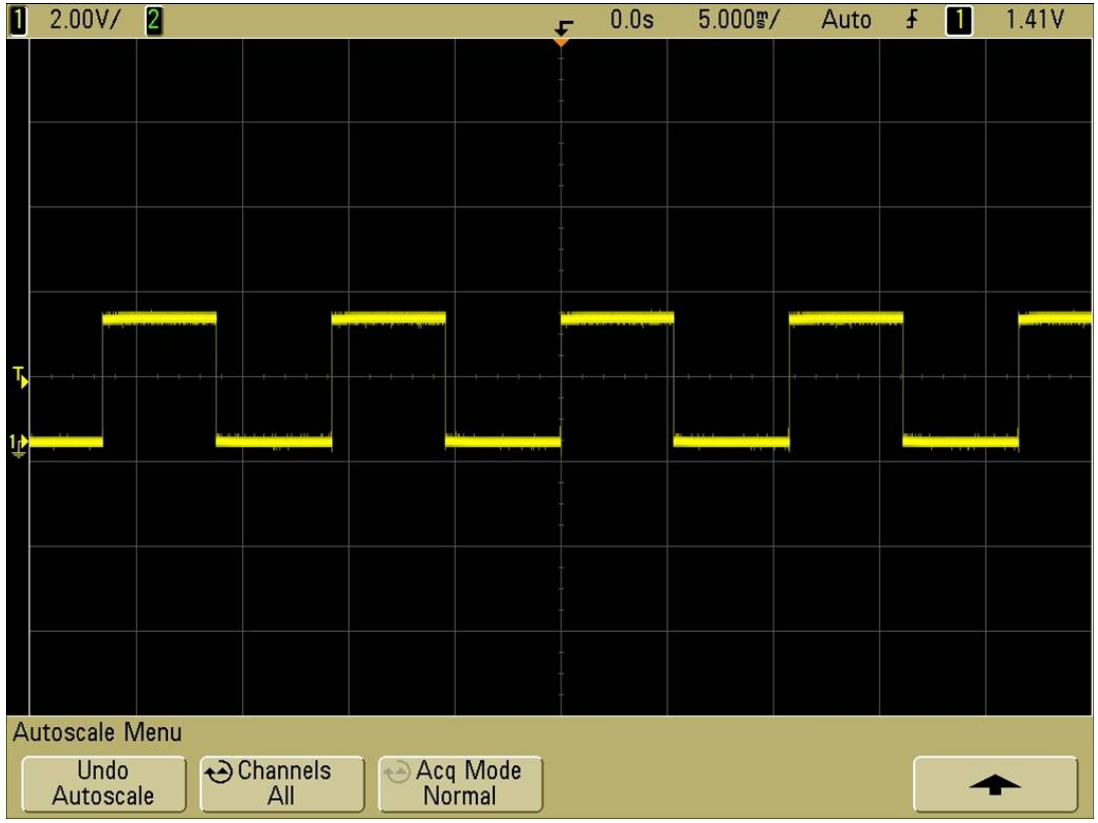
3. Select trigger

- Select the trigger mode using the trigger selection buttons

4. Start measuring

- Press RUN button for continuous measuring
- Press single button for only one capture

Display Data

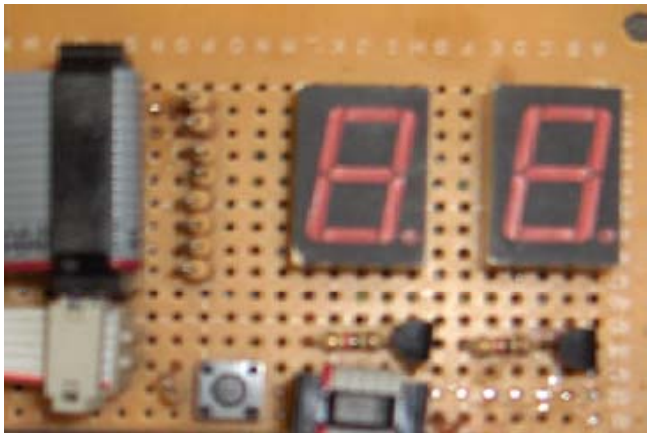


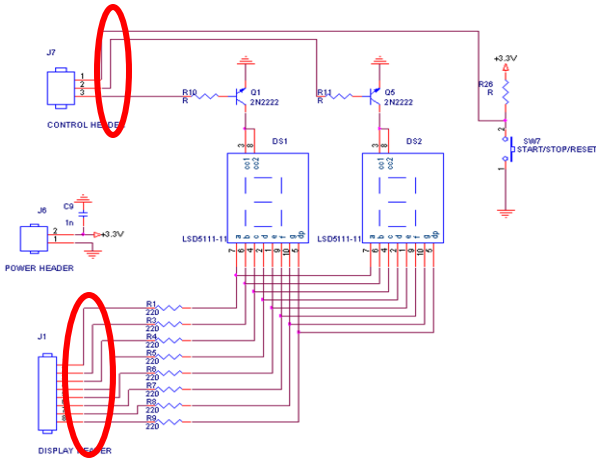
Using the MSO6012A Logic Analyzer

- **Debug a circuit (DUT):**

  The circuit to debug is a seconds stop watch, it has two 7-segment displays and a start/stop/reset button.

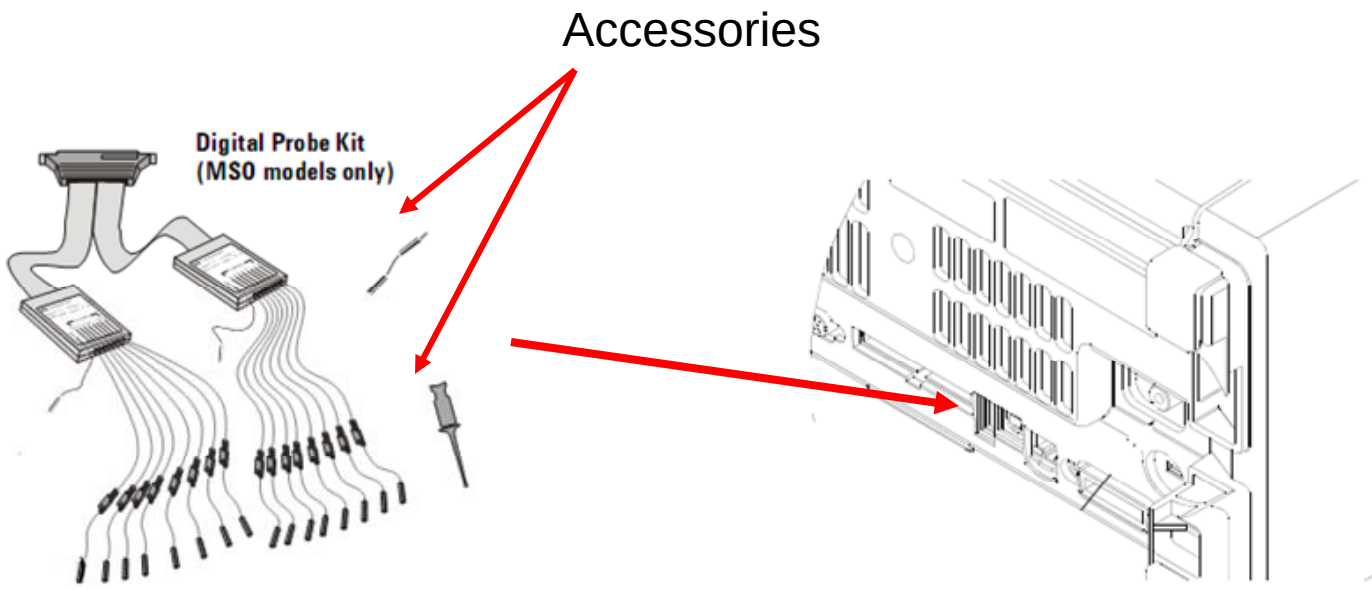
  We are going to debug the data signals to decode displays, the control signals for the displays and the reset function.





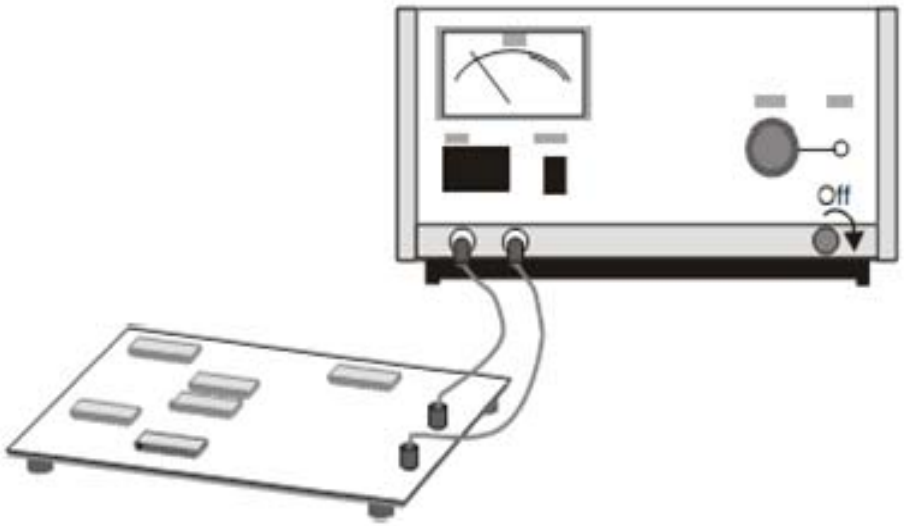
Hardware Setup

1. **Connect the digital probes in the back panel**



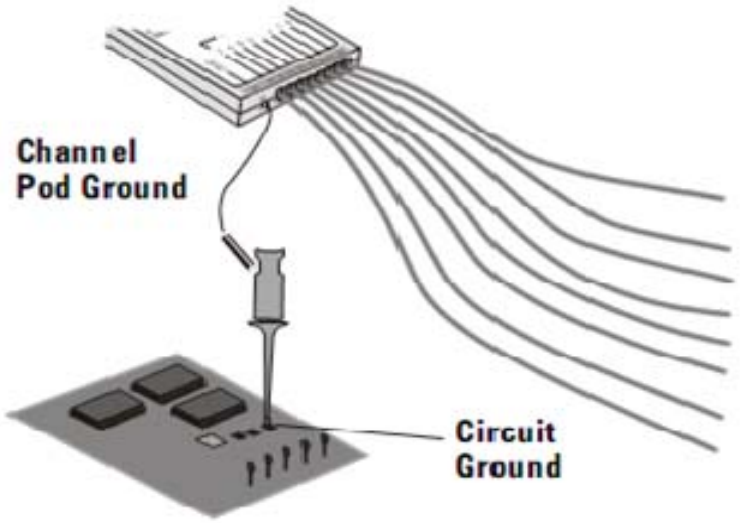
2. **Connect the digital probes to the circuit under test:**

It's recommended to turn off the power supply to the circuit under test, to prevent damage that might occur if accidentally two lines are shorted together while connecting probes

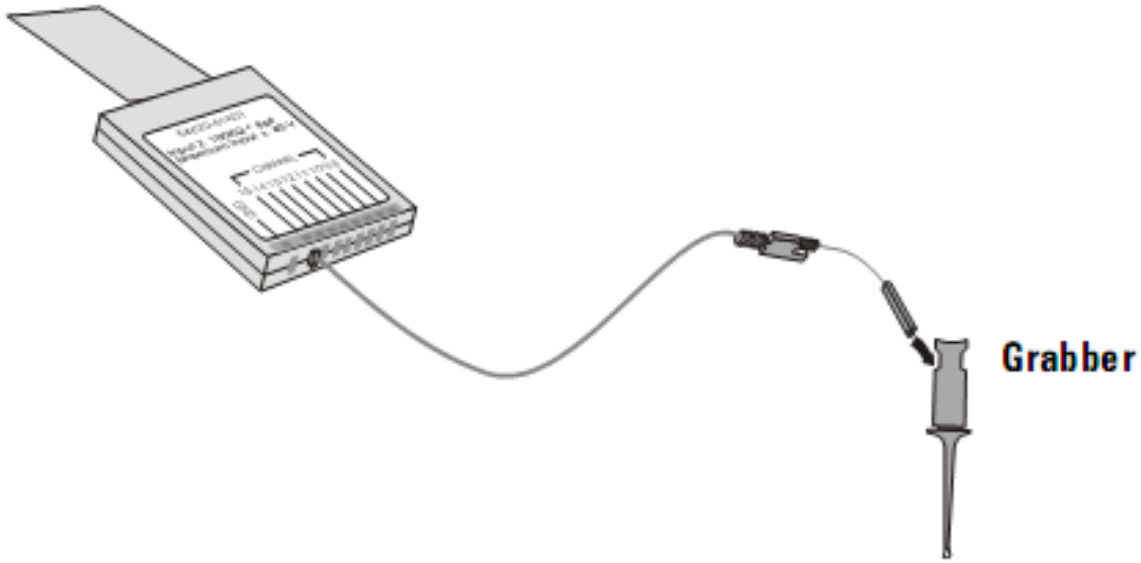


3. **Connect the ground lead on each set of channels**

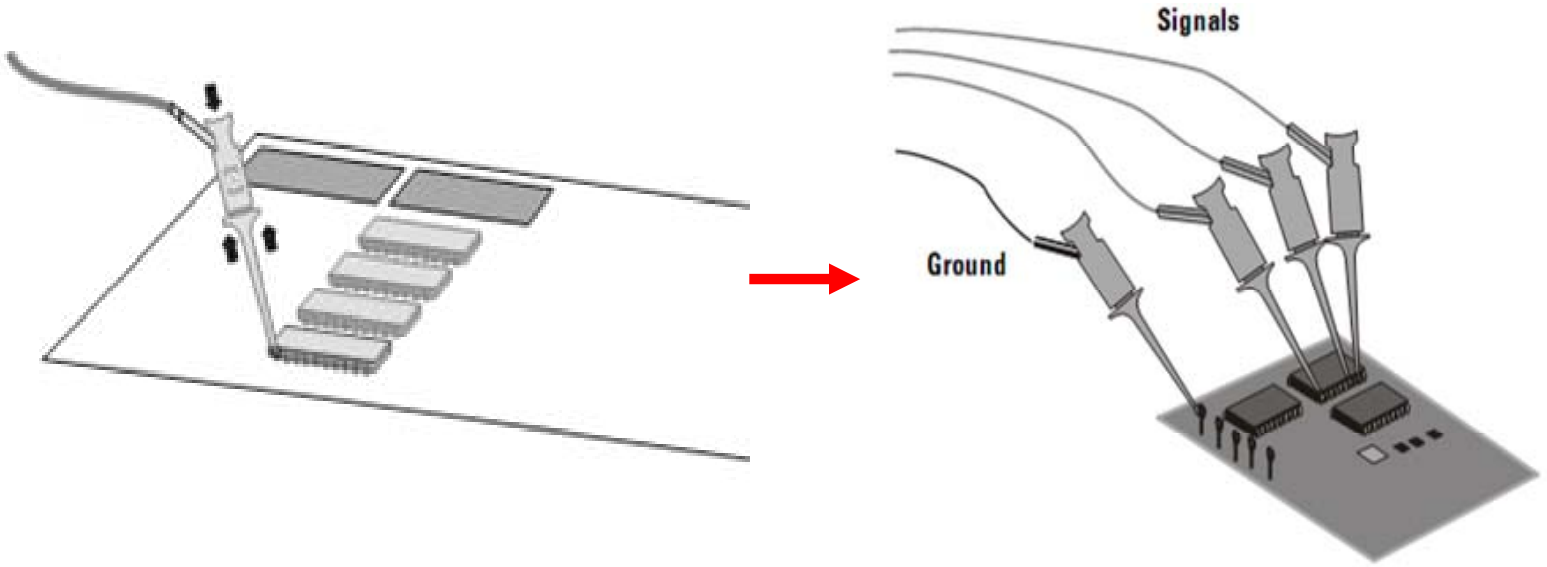
Setting the ground lead improves signal fidelity to the Logic Analyzer ensuring accurate measurements



4. **Connect the grabbers to a nodes in the circuit you want to test**



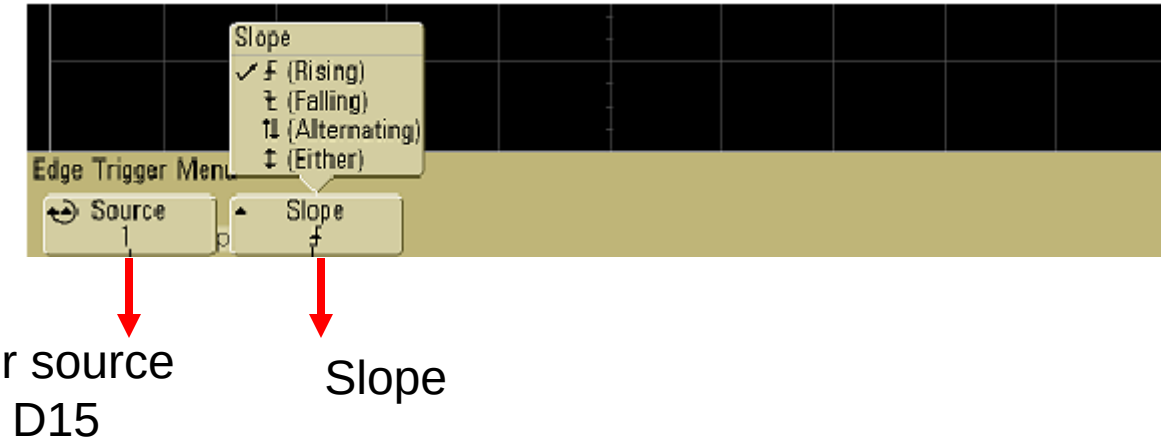
5. **Connect a grabber to one of the probe leads you are going to use**



Software Setup

6. **Select trigger source and type of trigger:**

- To select trigger go to the triggers selection buttons and configure your trigger
- For Edge Trigger



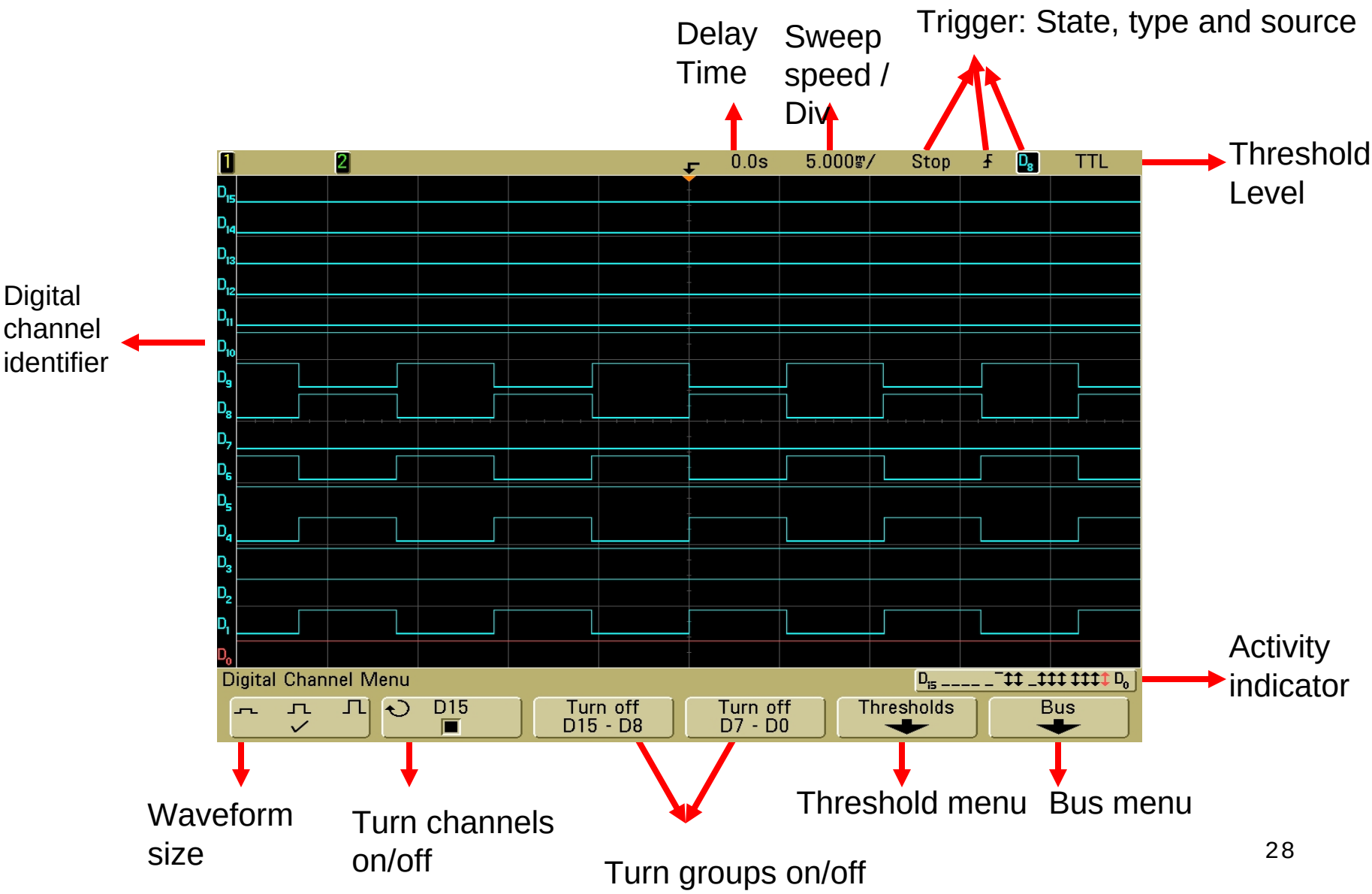
7. Select time base

- Is important to select an appropriate time base
- The resolution of the signals are going to depend on the time base selected
- For example for a time base of 10ms it will capture the signal for 100ms

8. Start measuring and displaying data

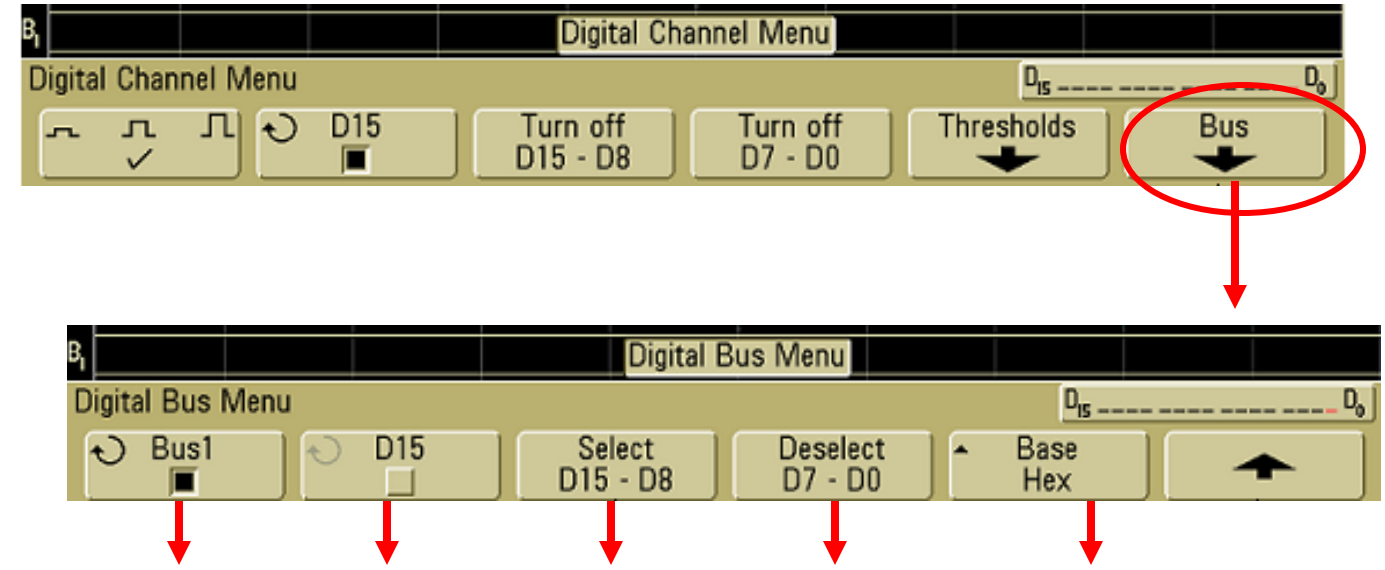
- Press RUN button for continuous measuring
- Press single button for only one capture
- RUN the oscilloscope and press button D0 thru D15 to view digital channel and options.

Interpreting the measurement screen



Display digital channels as a bus

Press D0 thru D15 and select Bus Menu



Bus1/Bus2 select

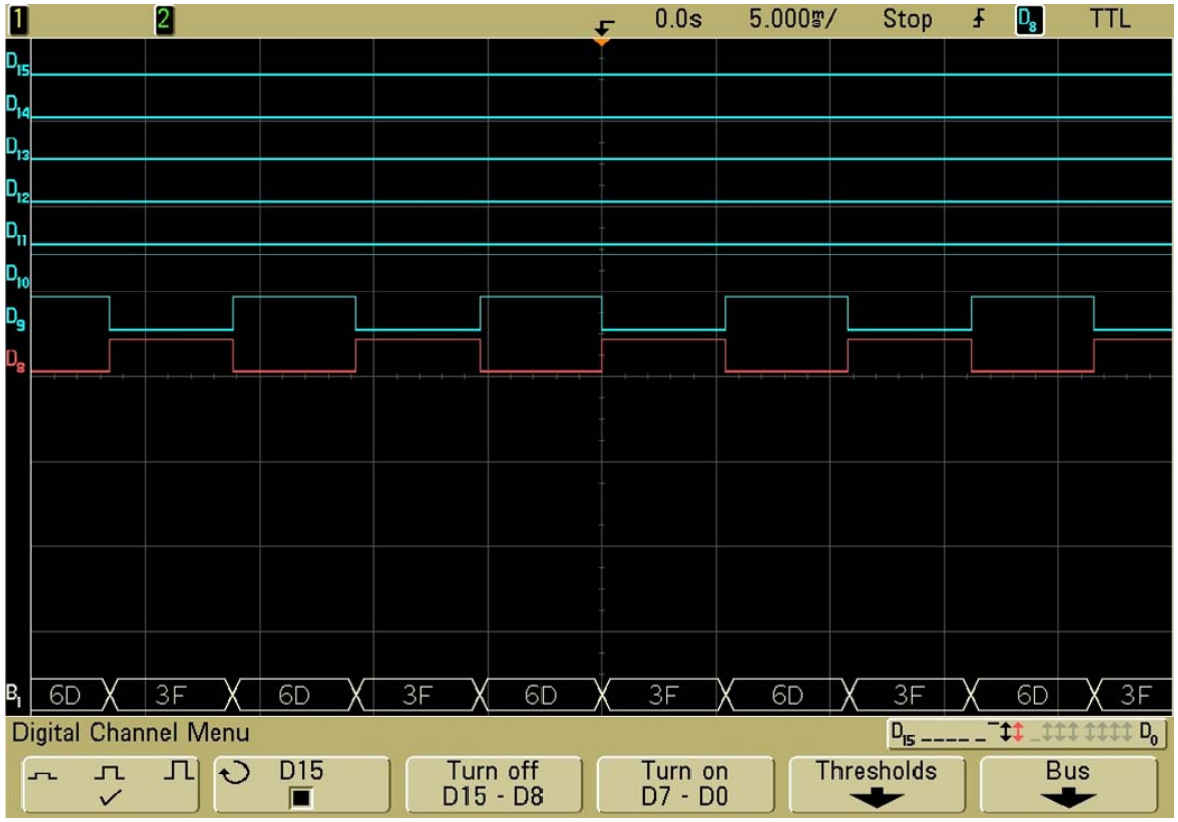
Select individual channels

Select channel group

Select channel group

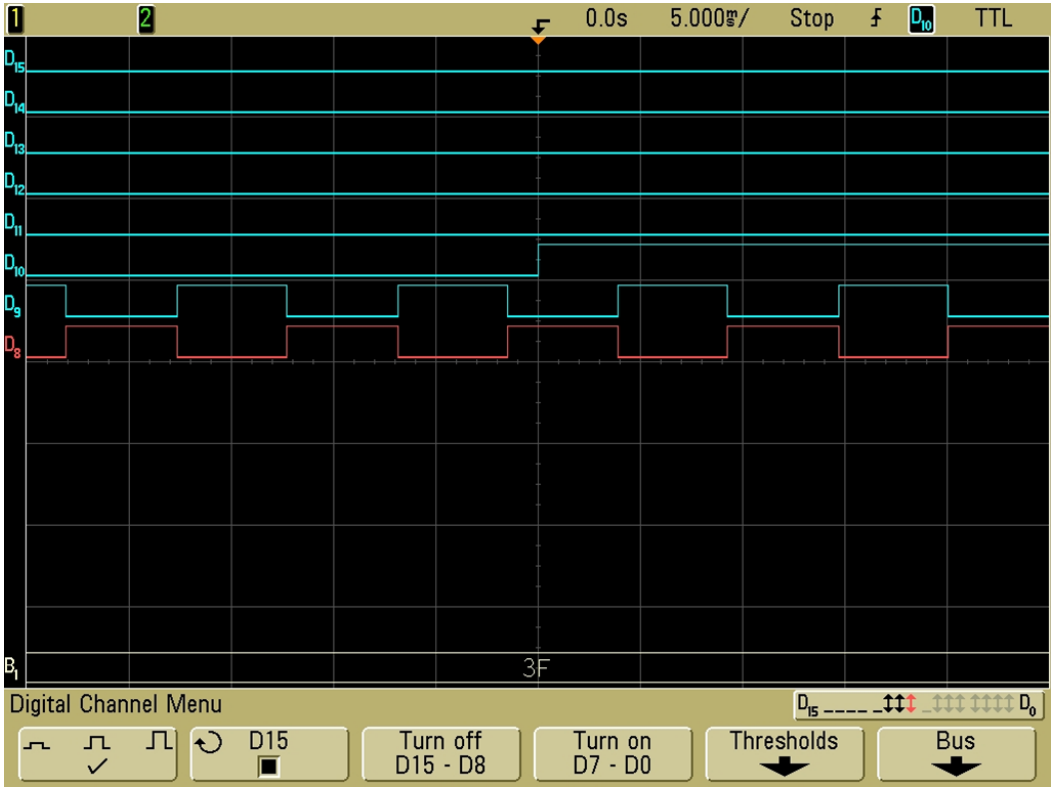
Select base to present bus data

Display digital channels as a bus



Change trigger source

- Go to step 7 and select a different clock source



Code verification

- After reset the count in the 2 displays must be 0.

```
//Lookup Table to decode BCD to 7-Segments
unsigned char lookup[] = {0x3F,0x06,0x5B,0x4F,0x66,0x6D,0x7D,0x07,0x7F,0x6f,0x77,0x7c,0x39,0x5e,0x79,0x71};
```

Displaying data

- To zoom in or out just use the time base button
- Use cursor as normal to measure bus data and signals timing

REFERENCES

[1] “Agilent InfiniiVision 6000 Series Oscilloscopes: User’s Guide”, Agilent Technologies.

[2] “Feeling Comfortable with Logic Analyzers”, Agilent Technologies.

[3] “The XYZs of Logic Analyzers”, Tektronix.