

# Digital Electronics: Hardware Labs

Dr. I. J. Wassell

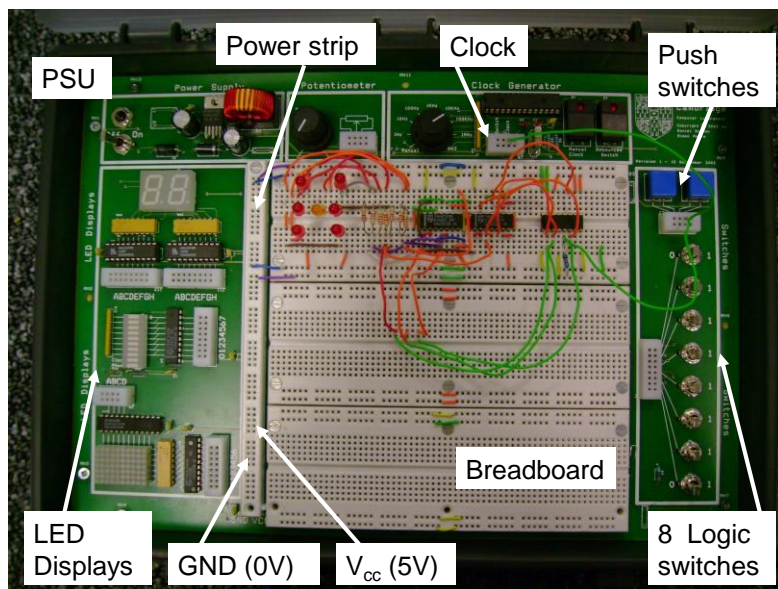
## Introduction

- In the hardware lab you will:
  - Construct logic circuits on breadboards and test them
  - Design logic circuits and implement them using
    - Logic gates (SSI) and counter chips (MSI) logic
    - Memory devices (VLSI)
    - Programmable array logic (PAL) type devices – specifically Generic array logic (GAL)

## Introduction

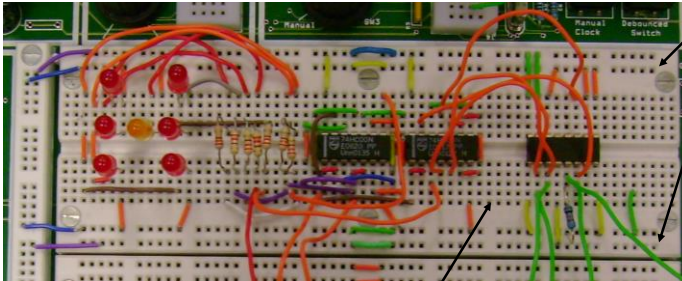
- In the labs you will make use of the self-contained Prototyping Box
- Contains:
  - Breadboard to build the circuits on
  - A power supply (PSU) – 5V
  - Clock signal (square wave) generator
  - Switches
    - Conventional push switches
    - Ones giving logic outputs for input to circuits
  - LEDs and displays for showing outputs

## Prototyping Box



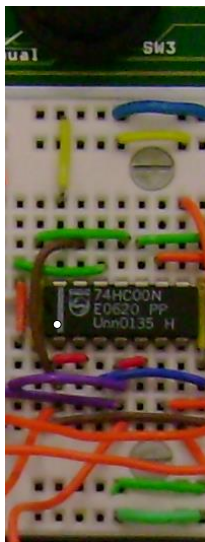
# Breadboard

Horizontal strips used to distribute  $V_{cc}$  (5V) and GND (0V)



Vertical five hole strips used to connect up components

# DIL Package



14-pin Dual in Line (DIL) package.  
74HC00 device contains 4, 2-input  
NAND Gates where:

74 identifies the series

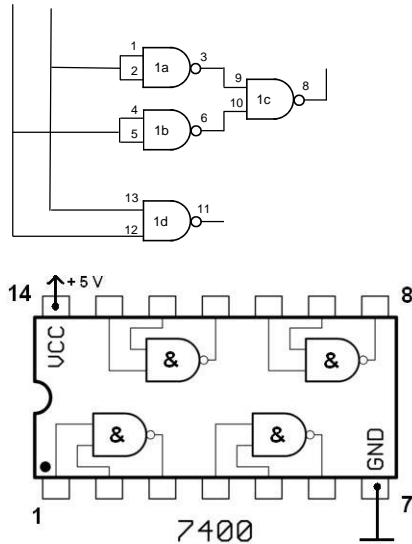
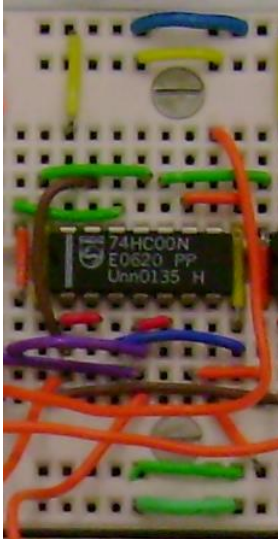
HC identifies the technology

00 identifies the function

Pin numbering – White dot indicates  
pin 1. Numbering increments as we  
move in an anticlockwise direction  
around the package

For 14(16) pin packages, pin 7(8)  
is usually GND (0V) and pin 14(16)  
 $V_{cc}$  (5V). However, there are exceptions!

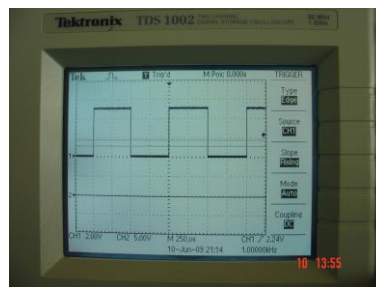
## Wiring



## Testing - Scope

- An oscilloscope (or scope) is a fundamental item used when testing electronic circuits.
- It allows the voltage at a point in a circuit to be displayed as a function of time.

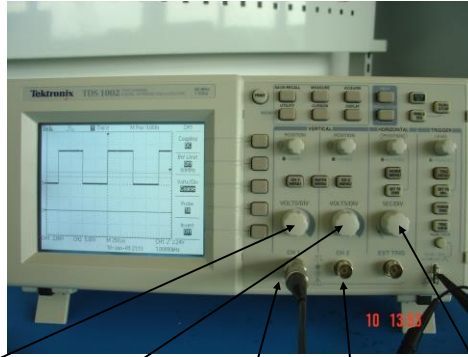
Voltage  
(Volts/division)  
'VERTICAL'



Time  
'HORIZONTAL' (Seconds/division)

## 2 Channel Scope

- Front panel controls



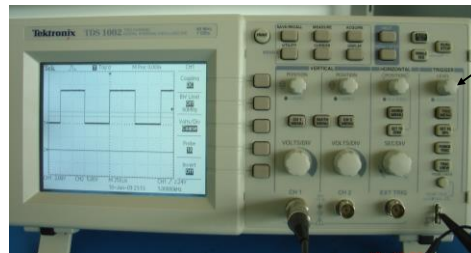
'VERTICAL' Channel 1 (Volts/division)   'VERTICAL' Channel 2 (Volts/division)   Channel 1 Input   Channel 2 Input   'HORIZONTAL' Time (Seconds/division)

## 2 Channel Scope

- So we adjust:
  - Volts/Div. to suit the amplitude of the input signal
  - Sec./Div. to suit the repetition rate (i.e., period or frequency) of the input signal
- The scope is primarily designed for displaying repetitive signals such as the square wave shown in the preceding pictures
- However, for such a signal to be displayed clearly, the scope must be 'Triggered' properly
  - This is done using the 'Trigger' front panel controls

## 2 Channel Scope

- Triggering:

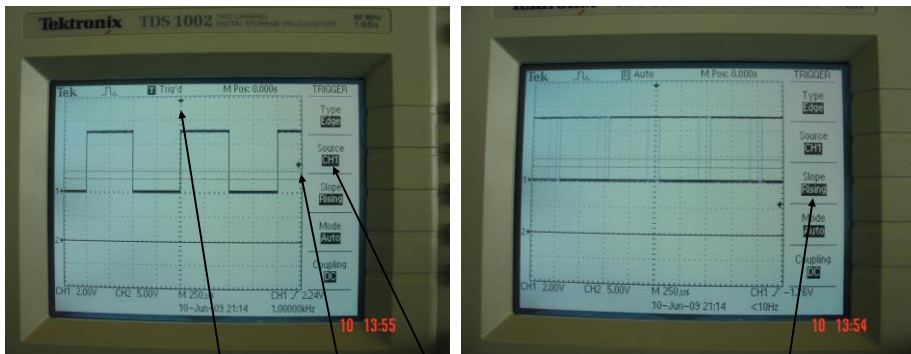


'TRIGGER'

- The trigger level knob is adjusted to ensure that the trace becomes stable on the screen
  - NOTE: Ensure that the trigger source is set to the channel of interest (in this case Ch1)

## 2 Channel Scope

- Triggering:



Triggered

Arrow shows trigger point

Arrow shows trigger level

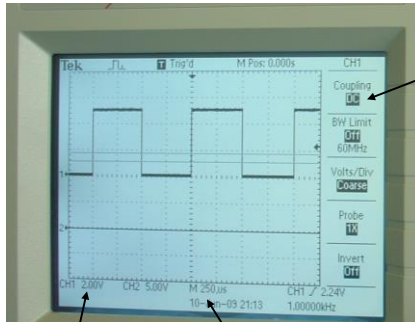
Not Triggered

Arrow shows Trigger source, i.e., Ch1

Trigger on rising edge

## 2 Channel Scope

- Other issues: Channel settings



Use '**DC coupling**' – if you use '**AC coupling**' you will not be able to measure absolute voltage levels, i.e., do we have voltage levels representing 1s or 0s.

Other possible setting is '**GND**' which effectively disconnects the circuit under test and applies a short circuit across the scope input.

Ch1 setting, i.e.,  
2V per div.

Timebase setting  
i.e., 250us per div.

## Building - Tips

- Draw a circuit diagram that clearly identifies the devices (e.g., gates, FFs), pin numbers and also the connections required. Give each package a unique number, e.g., IC1, and identify multiple gates on a single package using a letter, e.g., IC1a, IC1b etc.
- As you construct the circuit, cross off the connections (using a pencil) you make on your circuit diagram; this will help ensure that you make all the connections you need and also to identify wiring mistakes as you go along
- Think about the best position to put the IC packages on the breadboard to minimise 'wiring spaghetti' and so permit easier fault finding

## Building - Tips

- Don't wire over the top of IC packages since this will hinder access to their pins for the purposes of fault-finding and will also make it difficult to remove and replace suspected faulty packages
- Insert all the required devices in to the breadboard: ensure you identify them correctly, they are all the same orientation (usually pin 1 end to the left) and that they are inserted properly, e.g., none of the pins are bent under the devices or are broken off
- Then wire up the 5V and GND connections to each IC package.
  - CMOS circuits can power up from their gate inputs giving all kinds of odd behaviour!

## Building and Testing - Tips

- Ensure all unused gate inputs on an IC package are connected to GND.
  - CMOS circuits have a very high input resistance, hence any small currents they pick up can be translated into voltages that can cause random switching of the gate. This can give rise to high power consumption and miss operation of the other gates on the same package.
- Now insert rest of wiring
- If the circuit does not work as anticipated, the scope is the best way to 'view' what is actually going on in the circuit
- When using the scope, make sure the probe GND is connected to GND of the circuit



## Building and Testing - Tips

- Firstly, use the scope to ensuring that all the package pins expected to be at 5V or 0V actually are – Note that if all the 5V pins are at 0V this could indicate a ‘short’ between 5V and 0V
- Do the same for any ‘clock’ package pins to ensure the system clock is connected and working. Also check that the frequency of the clock signal is as expected.

## Building and Testing - Tips

- When fault finding, it is best to check inputs e.g., to a gate or FF, and then ensure the corresponding output is as expected – then check this signal is present at the next input pin(s) to confirm the connection(s) has/have been made as intended
- Incidentally, output signals that are not at either 0V or 5V (or switching between these levels) indicates that there is probably some sort of wiring problem at the output, possibly 2 outputs being inadvertently connected together

## Building and Testing - Tips

- If a faulty IC is identified, please throw it away, i.e., don't return it to the component store – this will save a lot of time in future labs!
- If you can't find the problem, please ask a demonstrator for help. However, if you don't have a clear circuit diagram and/or your circuit is very untidy, this will make finding the problem much more difficult and time consuming