Unit 4: Principles of Electrical and Electronic Engineering

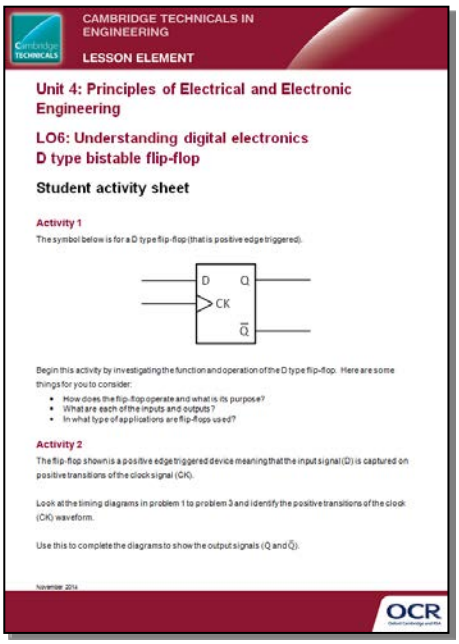
LO1: Understand digital electronics

D type bistable flip-flop

The expected duration is: 2 hours

Instructions and answers for teachers

These instructions should accompany the OCR resource 'Understand digital electronics – D type bistable flip-flop' *activity which supports Cambridge Technicals in Engineering Level 3.*


CAMBRIDGE TECHNICALS IN ENGINEERING
LESSON ELEMENT

Unit 4: Principles of Electrical and Electronic Engineering

LO6: Understanding digital electronics
D type bistable flip-flop

Student activity sheet

Activity 1

The symbol below is for a D type flip-flop (that is positive edge triggered).

Begin this activity by investigating the function and operation of the D type flip-flop. Here are some things for you to consider:

- How does the flip-flop operate and what is its purpose?
- What are each of the inputs and outputs?
- In what type of applications are flip-flops used?

Activity 2

The flip-flop shown is a positive edge triggered device meaning that the input signal (D) is captured on positive transitions of the clock signal (CK).

Look at the timing diagrams in problem 1 to problem 3 and identify the positive transitions of the clock (CK) waveform.

Use this to complete the diagrams to show the output signals (Q and $\overline{Q}$).

November 2014

OCR

The Activity:

In this task the students investigate the functions and operations of a D Type flip-flop featuring a set of tasks.

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

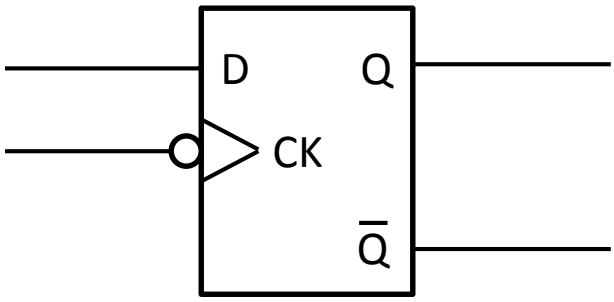
Suggested timings:

2 hours

Activity 1

In Activity 1 learners are tasked to investigate the function and operation of the D type flip flop and to consider:

- How does the flip flop operate and what is its purpose?
- What are each of the inputs and outputs?
- In what type of applications are flip flops used?



Solutions

- The D type flip flop is a latching device with outputs that have two stable states. This means that the output can be switched from logic 0 to logic 1, or logic 1 to logic 0 when required. Once set into either of these states it will remain there indefinitely so long as power is maintained to the device. For this reason it is often termed a 'bistable'.
- The purpose of a D type flip flop is to act as a latch or memory or storage device. It can store the information present on its inputs.
- The terminals are as follows:

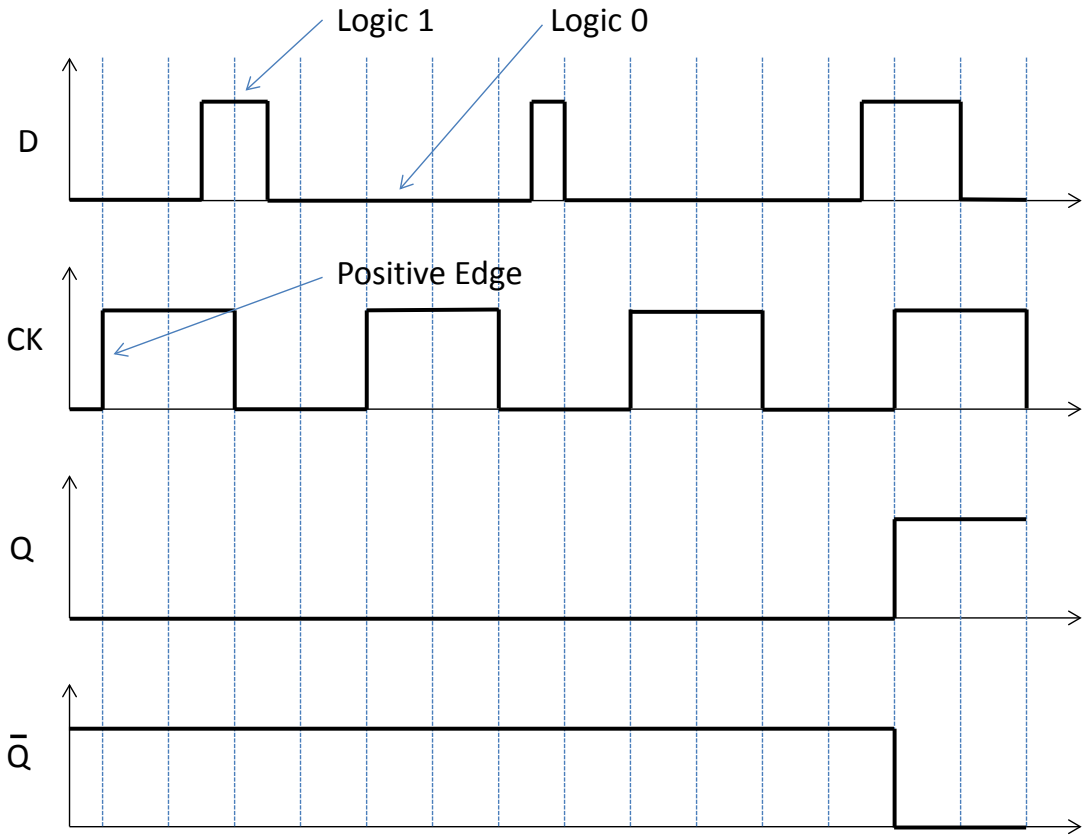
D	The terminal labelled D is called the data input terminal and is where the flip flop receives data
CK	CK is the clock input. When a logic 1 is applied to the terminal, whatever signal is on the D terminal (0 or 1) is transferred to the Q terminal. For the device shown this is usually referred to as rising edge triggered.
Q	Q is the output terminal
$\overline{Q}$	Q bar or NOT Q is another output terminal which is the inverse of Q

- Typical applications of the D type flip flop are: Latches, Counters, Memory Devices, Shift Registers.

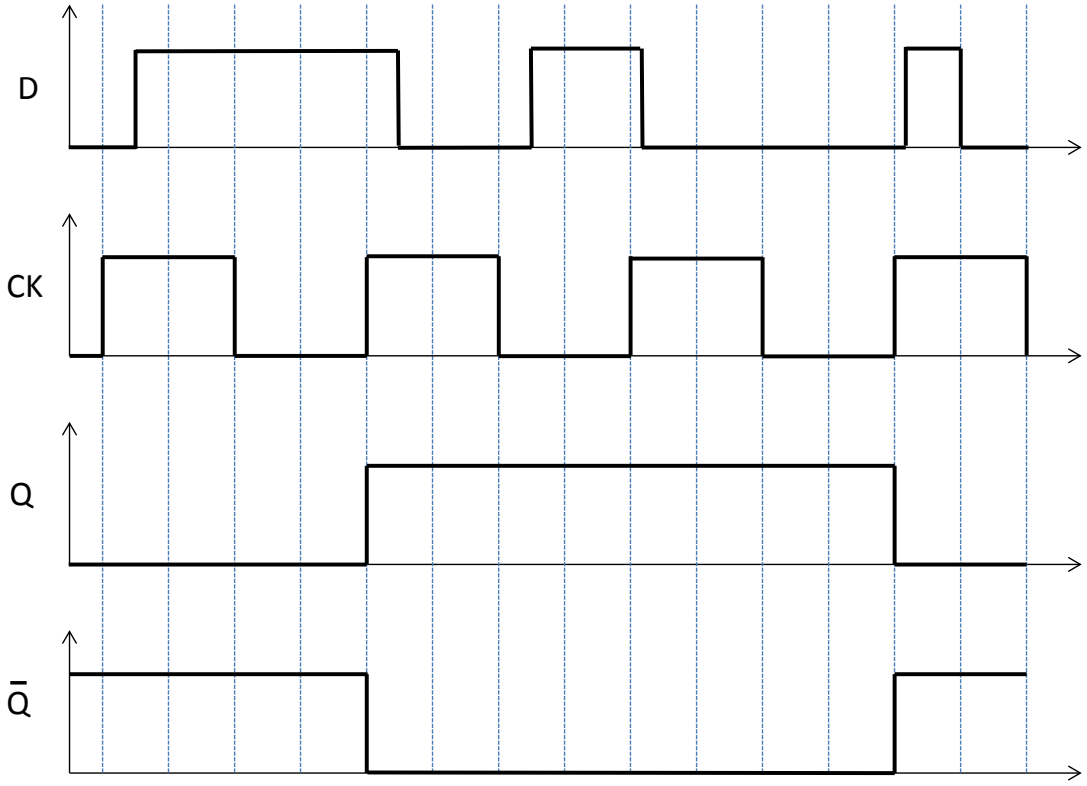
Activity 2:

In Activity 2 learners are asked to complete timing diagrams for a positive edge triggered D type flip flop. Solutions to Activity 2 are given below. Note that input signal D is captured on positive transitions of CK only. Learners are tasked to complete Q and $\overline{Q}$.

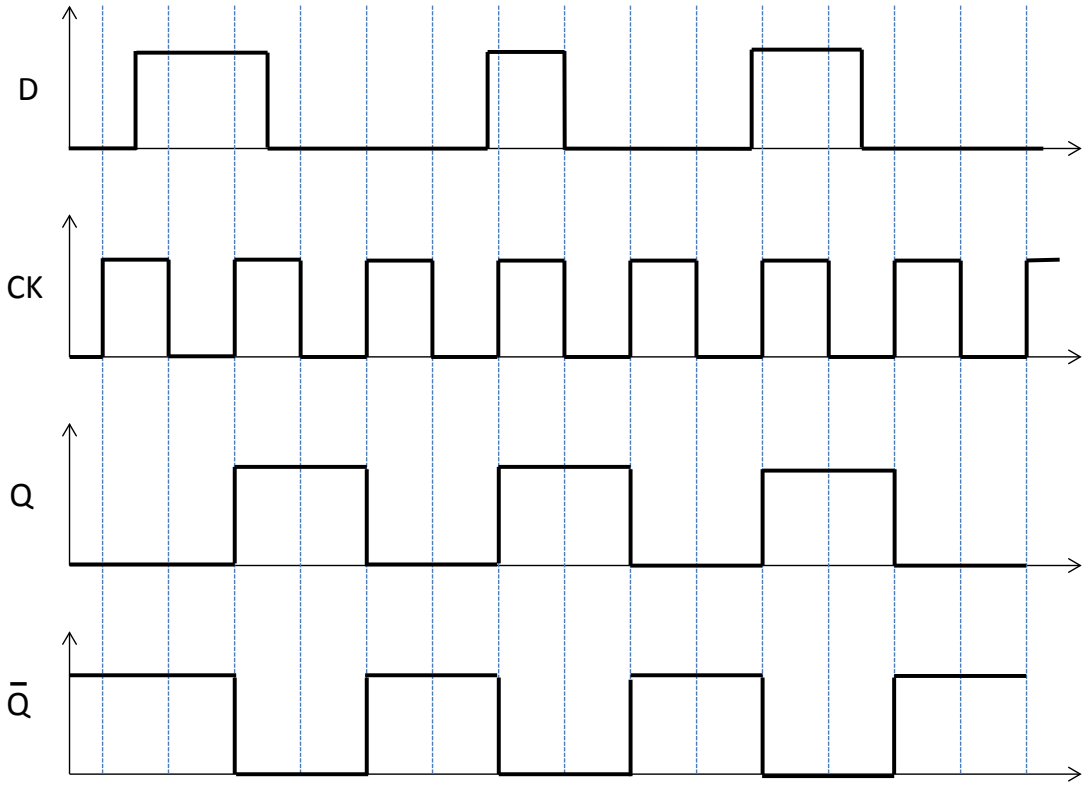
Solution to Problem 1



Solution to Problem 2



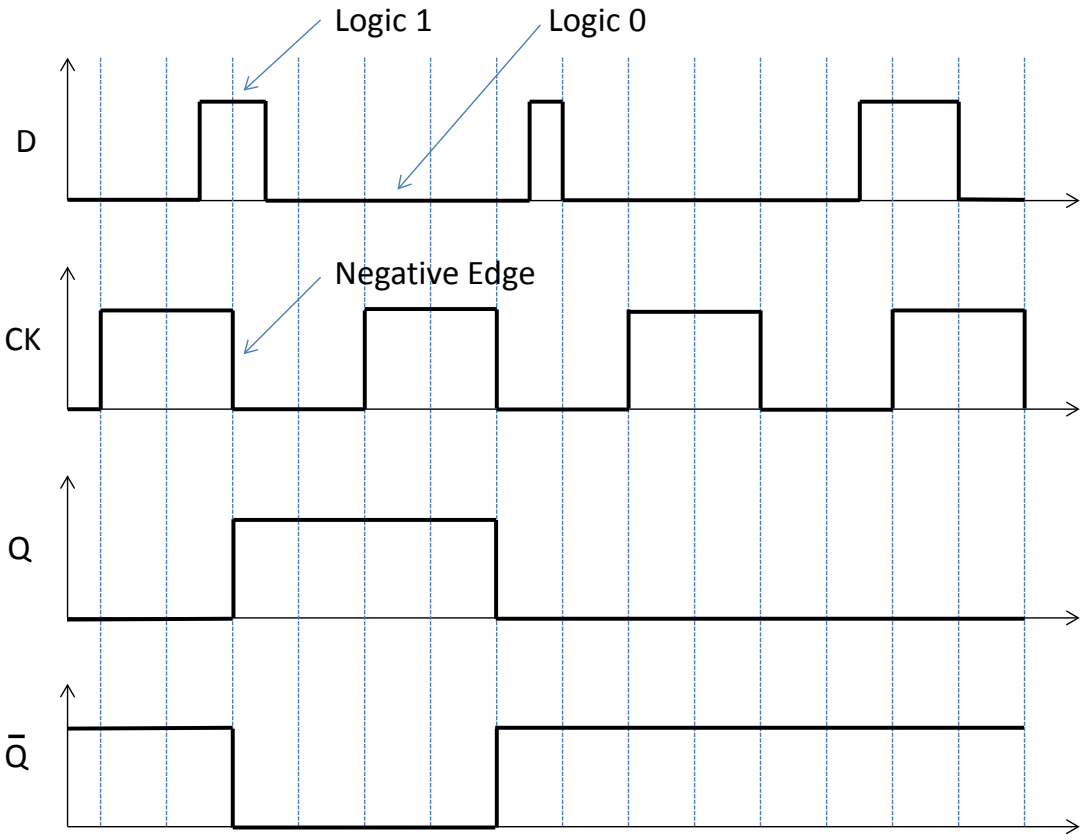
Solution to Problem 3



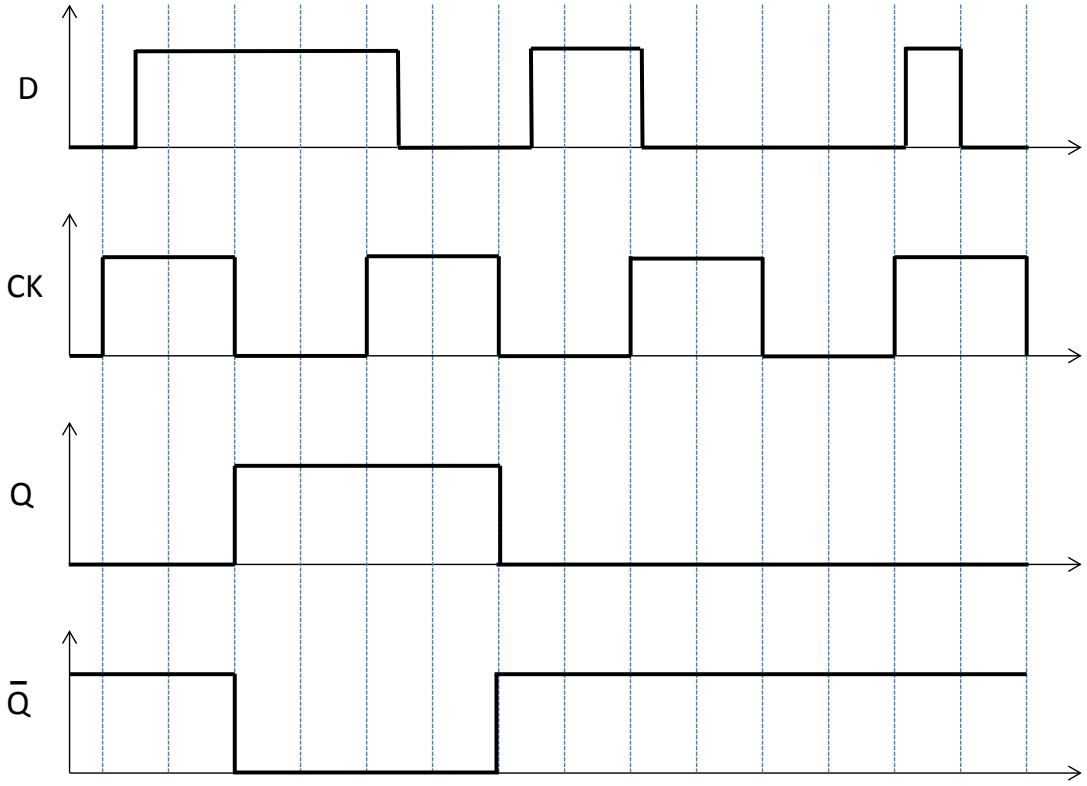
Activity 3:

In Activity 3 learners are asked to complete timing diagrams for a negative edge triggered D type flip flop. Solutions to Activity 3 are given below. Note that input signal D is captured on negative transitions of CK only. Learners are tasked to complete Q and $\overline{Q}$.

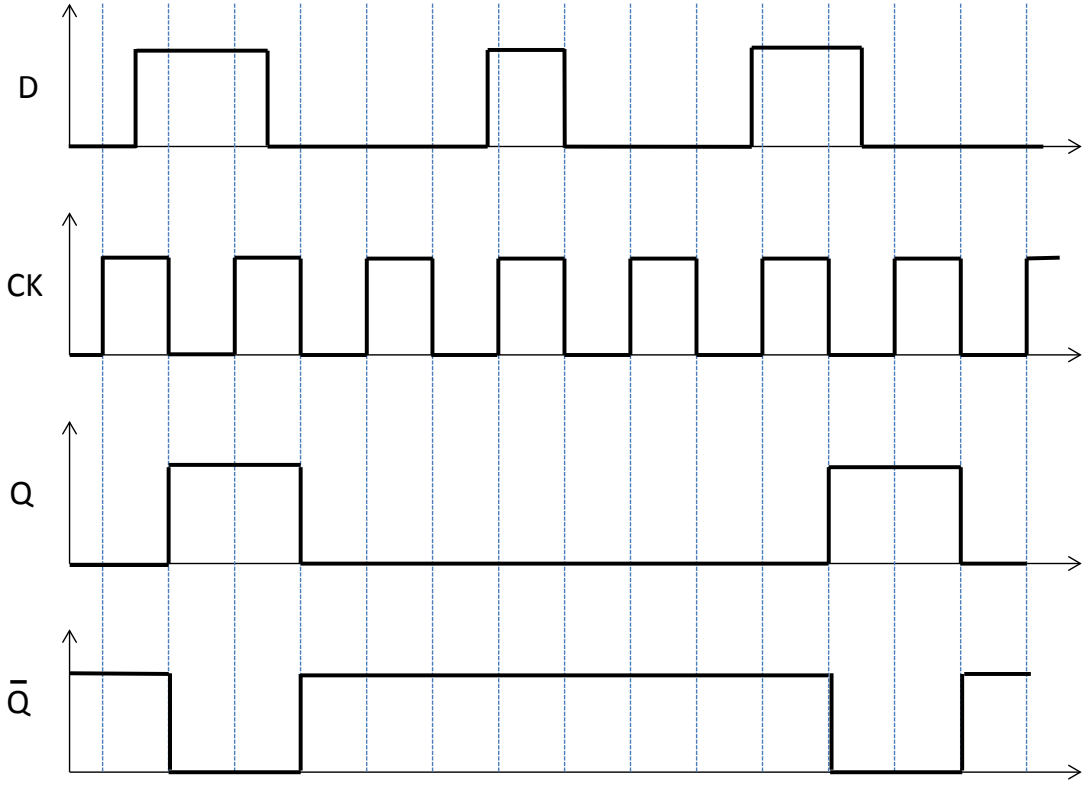
Solution to Problem 4



Solution to Problem 5



Solution to Problem 6



Activity 4:

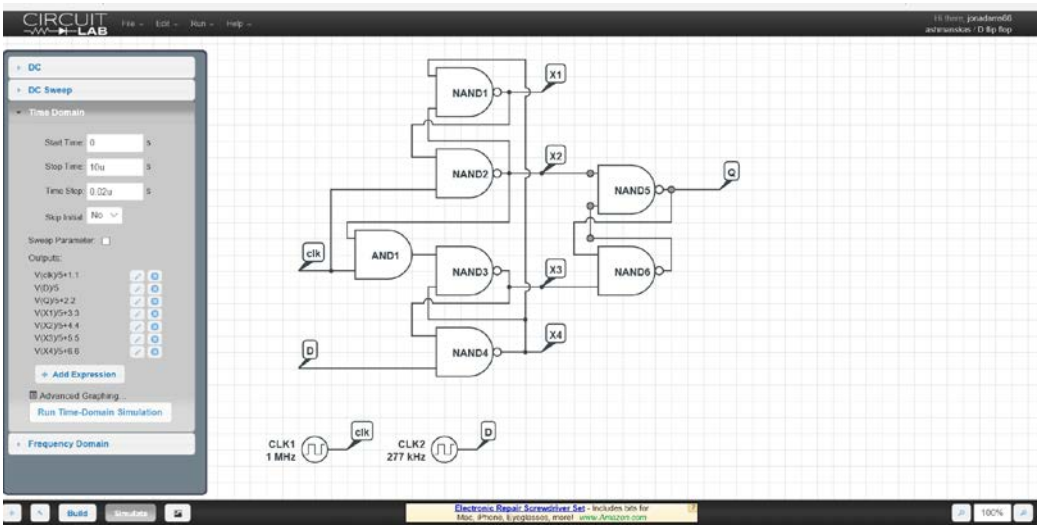
For Activity 4 learners are asked to consider building or simulating a circuit containing a D type flip flop.

Learners may have access equipment where this could be undertaken practically.

An alternative may be to undertake a simulation using simulation software.

Learners have been provided with a link to a free web-based simulation tool. This tool is free and will simulate many different types of circuit. Free sign up is required.

https://www.circuitlab.com/circuit/ywmw4t/d-flip-flop/



The simulation provided produces a timing diagram from which learners might determine that the D type flip flop is operating correctly. Typical simulation results are shown below. These show a change in output with a change in input based on the clock transition (from high to low).

To complete the activity learners are tasked to explain the function of the S and R input pins on the D type flip flop. These are not shown in this simulation.

S	S is the SET input. Applying a logic 1 to the S input will make Q logic 1, and $\overline{Q}$ logic 0. This will happen irrespective of the state of any signal on the D or CK inputs
R	R is the RESET input. Applying a logic 1 to the S input will make Q logic 0, and $\overline{Q}$ logic 1. This will happen irrespective of the state of any signal on the D or CK inputs

It should be noted that S and R pins are present on most flip flop devices.

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