



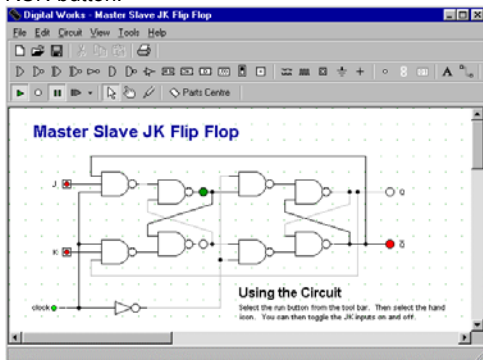
- Software for simulating digital logic circuits
- Create your own macros - highly scaleable
- Create your own circuits, components, and ICs
- Easy-to-use digital interface
- Animation brings circuits to life
- Vast library of 74 series ICs

Digital Works is a graphical design tool that enables you and your students to construct digital logic and computer architecture circuits and analyse their behaviour.

It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability.

## How does it work?

Getting started is simple. You use the drag and drop interface to position your gates and devices, wire them up with the wiring tool and then press the RUN button.



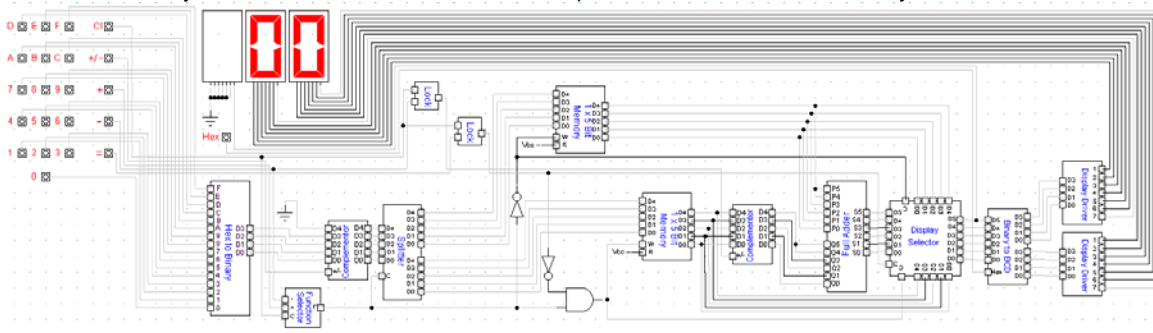
When you 'run' the design a logic 0 node is shown as a grey wire and logic 1 as a black wire – this allows you to follow the flow of logic through the most complex sequential logic circuit (and of course you can alter the speed of simulation).

Features include:

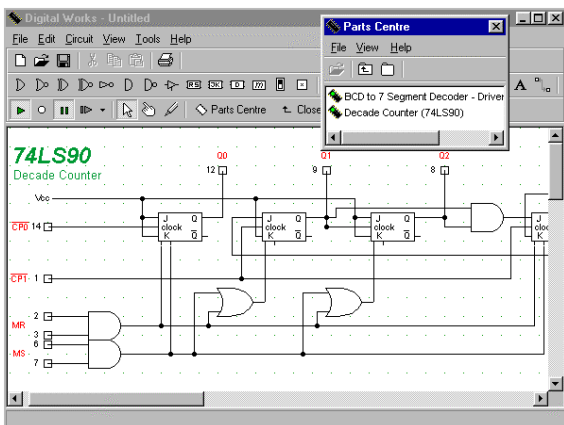
- Macro capability allows complex circuits to be built
- Create your own circuits, components, and ICs
- Animation brings circuits to life and facilitates understanding
- Vast library of 74 series IC's, datasheets and macros (registered version only)
- Several license types including:
  - Single user
  - Site license
  - Student license

Over 30,000 copies of Digital Works are already in use World-wide.

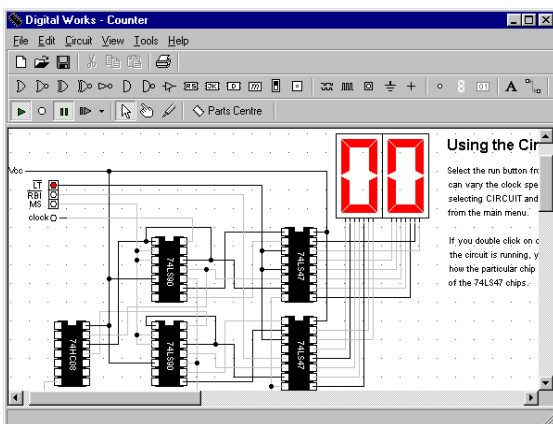
The flexibility of Digital Works is amazing – here you can see the result of a student assignment to build a fully functional calculator: Courtesy of Mihalts Tsan, Lecture of Advanced Diploma of IT, Queensland University.



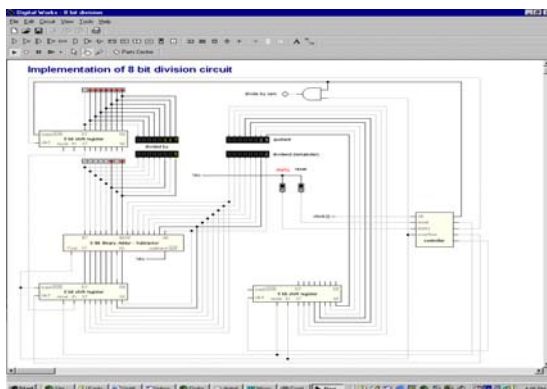
## Here's some more examples showing you how you can use Digital Works:



The thumbnail above shows the macro definition for a 74LS90 decade counter. The macro feature can be used to either make a schematic of the circuit block or you can wire integrated circuits themselves together so that you can use existing 74 series ICs to build up your circuit.



Here you can see an example of a counter circuit that uses macro ICs. The complexity of circuits that can be achieved is amazing - one user has even designed a complete 8 bit microprocessor with more than 100 instructions.



Here you can see a high level hardware implementation of an 8 bit division circuit.

## Complementary courses

We now have several courses that will guide you through digital electronics - from functions of basic gates, through to implementation of digital logic circuits in VHDL:

### Digital Electronics version 2

The Digital Electronics CD ROM is designed for those students who have little or no experience of digital electronics and want to learn more about simple logic circuitry.

### Degree level Digital Electronics 1 and 2

These CD ROMs are designed specifically for undergraduates who need to know how to design a wide variety of different types of logic circuitry, but who also need to understand how digital logic is used to form the basic building blocks of micro architecture. These products are designed around the University of Huddersfield's undergraduate program.

### Demo version and registration

You can download a demo version from [www.matrixmultimedia.co.uk](http://www.matrixmultimedia.co.uk).

The Digital Works demo lasts for 30 days. To use Digital works after the 30 day demo period you will need to purchase a copy. A registration key is not needed to run the demo, only to register the purchased full version. You can contact us at the email address below for registration.

### Patches and upgrades

See [www.matrixmultimedia.co.uk](http://www.matrixmultimedia.co.uk) for patches and upgrades for this product.

### Circuits, challenges and solution packs

Below you will find several challenges you can use with your students. If you have further challenges you would like to share with us then please email them to us.

You can have these, and other, documents in Word format by request.

Files available are:

Calc.exe – solution to Calc challenge

Dwpack1.exe – other challenges and solutions.

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# Challenge 1 – calculator parts

Submitted by Mihalis Tsan, Lecture of Advanced Diploma of IT, Queensland University

This challenge is a real assignment given to students. It asks them to build adders, complimenters, subtractors, memories, converters and eventually calculators.

The recommended time for this assignment is two weeks. There is no solution available.

1. In this assignment you are required to put into practice what we have been discussing in lectures and tutorials. We have been discussing how a computer might carry out the rules of arithmetic, ie addition and subtraction, and how to construct 'memory' devices. We have also looked at various arithmetic systems and determined that the Binary system may suit our purposes. The deliverable for this subject will be a series of Digital Works 2.0 circuits with accompanying documentation.

2. The assignment is divided into various sections and these should be dealt with separately. Unless otherwise stated you may assume the number system to be employed is Binary.

## Adders

3. You are required to produce a Digital Works icon that functions as a 2 x 6-bit Adder. The deliverable is a Digital Works circuit that demonstrates the functioning of your adder. The suggested approach is build in succession and then make use of, a 1-bit Half-Adder, 1-bit Full Adder and eventually a 2 x 6-bit Full Adder.

## Complementers

4. You are first required to produce a Digital Works icon that functions as a 6-bit 2's Complementer. The deliverable is a Digital Works circuit that demonstrates the functioning of your Complementer. You may employ the 2 x 6-bit Full Adder created previously.

5. Secondly you are to produce a Digital Works icon that functions as a 6-bit 2's Optional Complementer. The deliverable is a Digital Works circuit that demonstrates the functioning of your Optional Complementer. An Optional Complementer is such as to produce either the input or the 2's Complement of the input. You may employ the previously created Complementer.

## Subtractors

6. In modern day computers the subtraction operation is 'simulated' by evaluating X-Y by first converting Y to its 2's complement form and then adding this to X. Any resultant negative output is converted back to 'normal' format by complementing as required.

7. You are required to produce a Digital Works icon that functions as a 2 x 6-bit Subtractor. The deliverable is a Digital Works circuit that demonstrates the functioning of your Subtractor. This Subtractor is to make use of the Adder and Optional Complementer created above.

8. Although modern systems employ 2's Complement to avoid the expense of creating a Full Subtractor, such devices can be created. You are next required to produce a Digital Works icon that functions as a 2 x 6-bit Subtractor. The deliverable is a Digital Works circuit that demonstrates the functioning of your Subtractor. It is not to employ Complementation.

9. The first stage in designing your Full Subtractor is to complete the appropriate Truth Table for a 1-bit Subtractor as follows:

Inputs		Outputs		
$X_{In}$	$Y_{In}$	$B_{In}$	$X_{In} - Y_{In} - B_{In}$	$B_{Out}$

Based on this you should design your Full Subtractor. A suggested icon is as follows.

Using this icon you should then construct a 6-bit Subtractor.

## Memories

10. Firstly you are to construct an 'R-S Flip Flop'. This is then to be converted to a Gated D Latch. This is the basic circuit for a 1-bit Memory Cell. We then add a TRI-STATE to the output and we have a circuit that can be 'abstracted to give a '1-bit Memory Cell'. A suggested icon is as follows:

11. Utilising this 1-bit Memory Cell you are to construct a 4 x 6-bit Memory Unit ie a Memory Unit that will store four (4), different six (6) bit numbers and return them on request. It should be created from four (4), 1 x 6-bit. A suggested icon for a 1 x 6-bit memory unit is as follows:

12. Four such devices can then be combined to produce the required 4 x 6-bit device. A suitable icon is given in the following:

Note that there are four (4) memory locations, numbered 00, 01, 10, 11 in Binary, or if you prefer 0, 1, 2, 3 if you prefer, but only two 'signal lines' to select which location. (Hint: See the text book in respect of decoders.)

12. The deliverable is a Digital Works circuit that demonstrates the functioning of your 4 x 6-bit Memory Unit.

## Convertors

13. Thus far we have developed our devices for the Binary Arithmetic system. In lectures we demonstrated that all number systems are equivalent. To this end you are to design a Digital Works circuit to act as Decennary to Binary Converter and a Binary to Decennary Converter. Suitable icons are given below:

14. The deliverable is a Digital Works circuit that demonstrates the functioning of your Decennary to Binary and your Binary to Decennary Converter, by connecting the output of the former to the input of the latter.

## Calculator

15. The final requirement is to combine the above items to produce two Calculators. The first will accept two single digit 'Decennary' numbers and output their sum as a 'Decennary' number. The second will accept two single digit 'Decennary' numbers and subtract the second from the first, output their difference as a single 'Decennary' number. For the subtractor the answer may be negative and you will need to cater for this. The following is an icon that will suffice for both of your devices.

## Challenge 2 – hand held calculator

Submitted by: Tery Anstey, Northern Territory University, Australia.

This challenge was an assignment for students at the Northern Territory University, Australia. We thought that you too might want to have a go. There is no set of components for this challenge, but as this is such a complex challenge there is a solution pack – please refer to the download section of our web site.

1. This assignment requires you to implement a small ‘hand held’ calculator using the Digital Works software.
2. As a minimum, your calculator should incorporate two 4-bit memory units. These two units must be able to be ‘loaded’ from a single input device, and be able to be separately loaded. The outputs of these memory units are the inputs to a 2x 4-bit Full Adder. The memory units must be able to be cleared i.e. set to zero. To facilitate subtraction, the technique of 4-bit complementation should be employed. Any negative result should be identified but displayed as a magnitude and sign as appropriate.
3. Additional functionality may be added at your discretion.
4. The input can be a simple ‘on-off’ binary switch, and the output can be a simple binary ‘on-off’. The seven segment LED device may be used if required but is not essential.