

# Features of Basic Electronics Virtual lab

Guidelines on how to design effective  
experiments

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# Broad Goal of the presentation

Help engineering instructors to design effective virtual lab experiments

# Objectives

- The engineering instructors should be able to understand the various features of the Circuit Simulation Virtual lab
- The engineering instructors should be able to design effective experiments utilizing these features
- The experiment designs should incorporate the various experiment design guidelines proposed in the SDVIcE tool

# Sample Circuit Simulation Virtual lab

- In this presentation the DoCircuits Virtual lab is considered as the sample example but there are numerous such virtual labs available online.
- You may select any one of the labs for your experiment design
- The labs available online along with their URL are
- [https://www.circuitlab.com/editor/#?  
id=7pq5wm](https://www.circuitlab.com/editor/#?id=7pq5wm)
- <http://www.partsim.com/simulator>

# Landing page of the Circuit Simulation vlab

The screenshot shows the landing page of the DoCircuits website, which is a circuit simulation platform. The background features a large, stylized circuit board or circuit diagram.

**Header:**

- Address bar: DoCircuits – Circuit Simulator
- Address bar: www.docircuits.com
- Page title: DoCircuits
- Navigation menu: BLOG, CLIENTS, NEW!, LOGIN, SIGNUP, a dropdown menu icon, and a search bar labeled "Search Circuits" with a magnifying glass icon.

**Middle Section:**

*Virtual labs to acquire real skills*

Over 1474044 Simulations

**Build Circuits**  
Have fun building and burning circuits

**Test & Measure**  
With real lab equipments

**Share**  
Your design with community

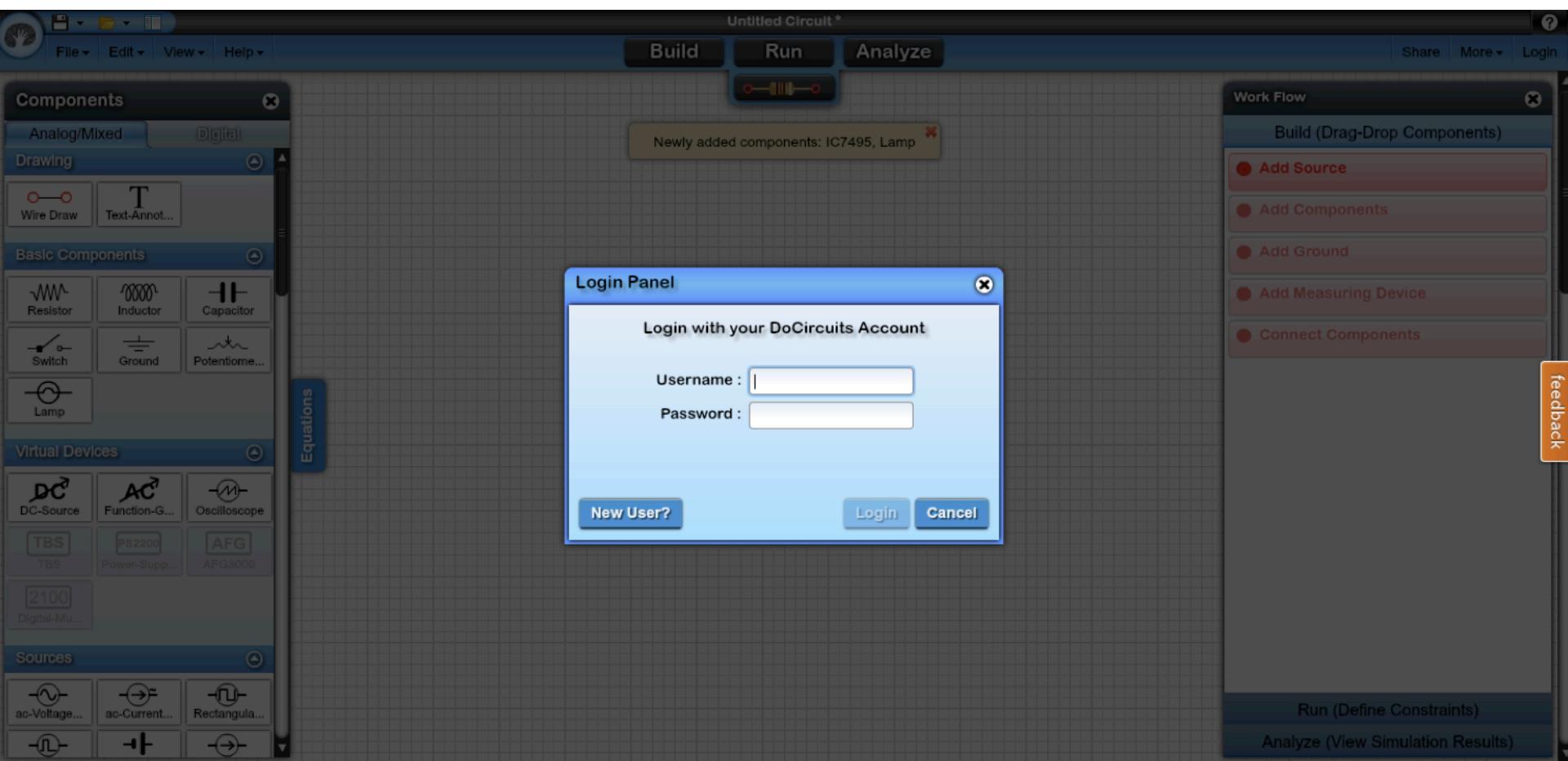
**Try Circuit Simulator**  
Create your first circuit in minutes

**Get started in 5 minutes!**

**Bottom Navigation:**

[www.docircuits.com/circuit-editor](http://www.docircuits.com/circuit-editor)

# After you select the vlab you need to register with a username and password



# This is the Sign Up registration form

ⓘ Not Secure | [www.docircuits.com/register](http://www.docircuits.com/register)

**DoCircuits**

BLOG LOGIN SIGNUP 🔍 Search Circuits

## Sign Up

Welcome aboard.

Username \*

E-Mail \*

Password \*

Retype password \*

College / University

Verification code

maaega

Get a new code

Please enter the letters as they are shown in the image above.  
Letters are not case-sensitive.

**Sign Up**

### Who is using DoCircuits?

DoCircuits is being used by thousands of individuals and premier organizations across the world.



### What our users say:

"I like docircuits. I think your web app is wonderful for beginners like me!"  
- Jak Rogers, Hobbyist

"I really like that DoCircuits can show both the schematic version and the actual parts."  
- Dr Richard Wolfson, Benjamin F. Wissler Professor of Physics, Middlebury College

"DoCircuits is the easiest way to get started on building circuits."  
- Robert Anderson, DIY Guru

"DoCircuits is best place to try out virtual test and measurement devices. I love the way you can play with the oscilloscopes, function generators and power supplies - just like the real thing."  
- Patricia Mathias, Test Engineer

# The Simulators have the components as seen in the figure

The screenshot shows the DoCircuits circuit editor interface. On the left is a 'Components' panel with tabs for Analog/Mixed and Digital. It contains sections for Drawing (Wire Draw, Text-Annot...), Basic Components (Resistor, Inductor, Capacitor, Switch, Ground, Potentiometer, Lamp), Virtual Devices (DC-Source, AC-Function-G..., Oscilloscope, TBS, PS2200, AFG3000, 2100, Digital-Mu...), and Sources (ac-Voltage..., ac-Current..., Rectangular...). A blue 'Equations' tab is selected. On the right, there's a toolbar with 'Build', 'Run', and 'Analyze' buttons. The 'Run' button is highlighted with a blue box and has a yellow arrow pointing to it from the text 'Types of tasks that can be performed'. The 'Work Flow' panel lists tasks: Add Source, Add Components, Add Ground, Add Measuring Device, and Connect Components. Arrows point from the text boxes to specific components in the 'Components' panel: 'Set of Components Linear and Non-linear' points to the Basic Components section; 'Set of Devices' points to the Virtual Devices section; 'Set of Sources' points to the Sources section; and 'Scaffolds for circuit design' points to the 'Work Flow' panel.

Set of Components Linear and Non-linear

Set of Devices

Set of Sources

Types of tasks that can be performed

Scaffolds for circuit design

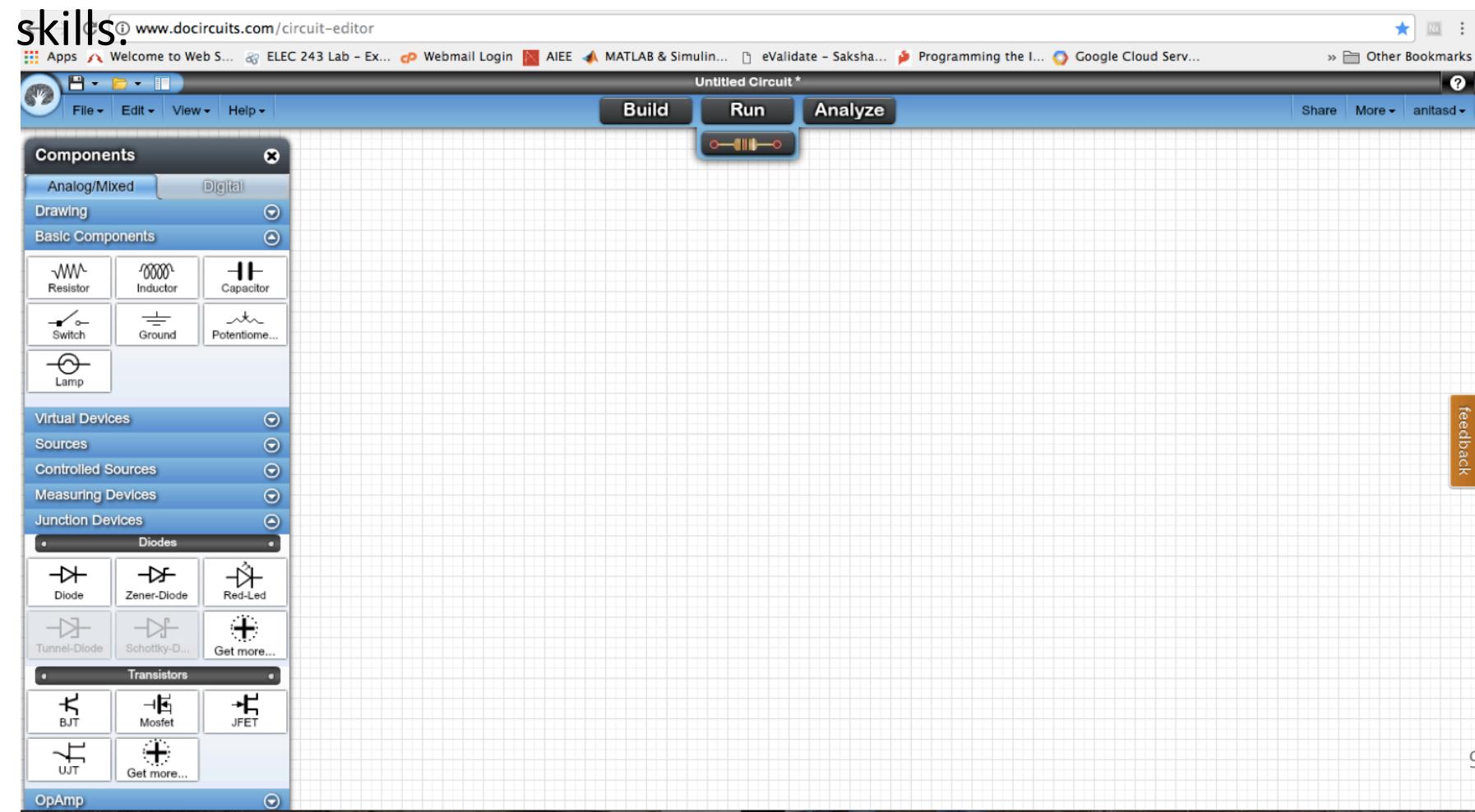
Build (Drag-Drop Components)

- Add Source
- Add Components
- Add Ground
- Add Measuring Device
- Connect Components

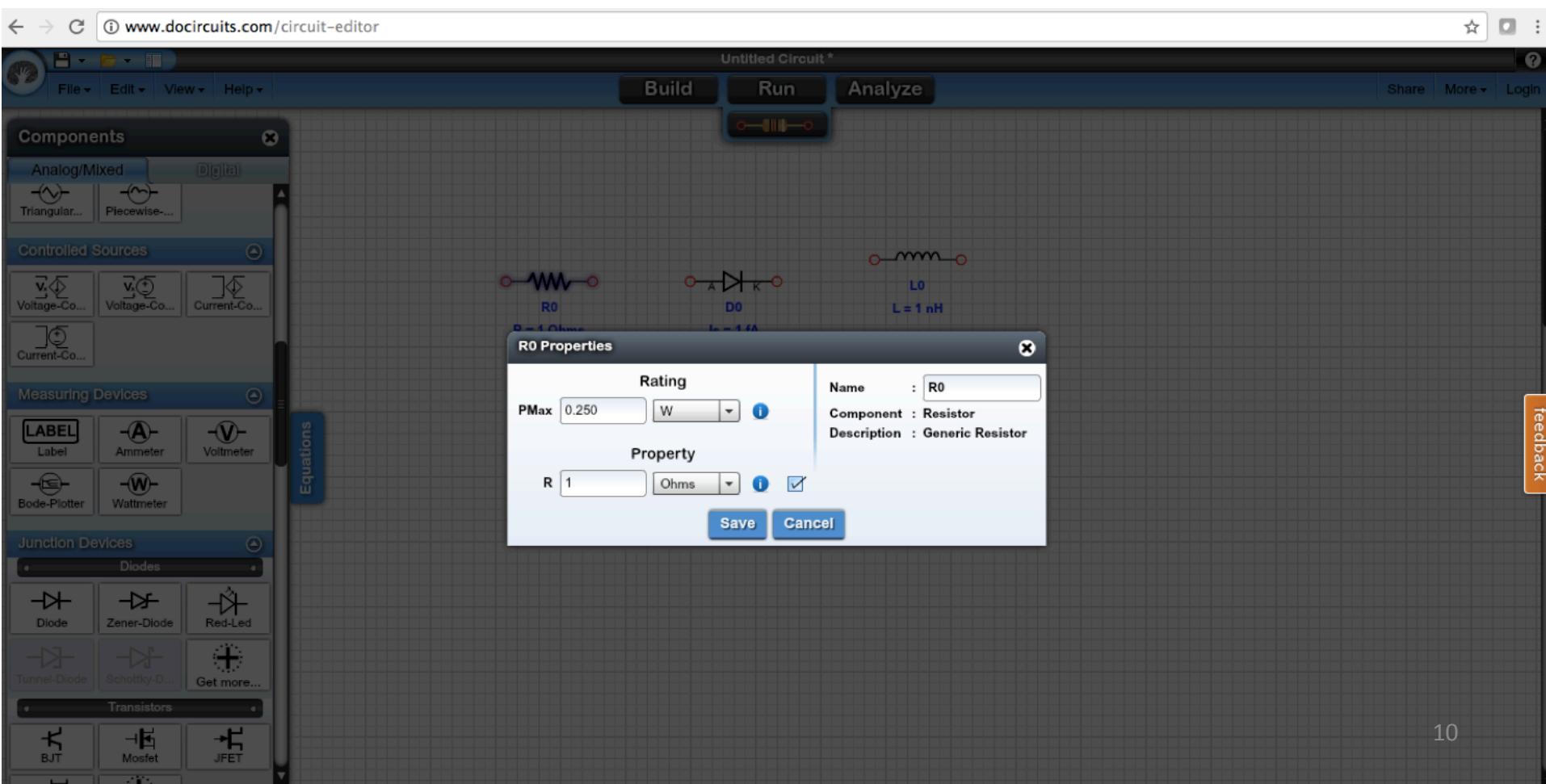
Run (Define Constraints)

Analyze (View Simulation Results)

**Feature 1:** A library of a variety of components and types of instruments are available for the students. This provides them an opportunity to play around with them. This is one of the most important feature as although there are a variety of components and equipment in physical lab too there are constraints and we do not allow the students to play around. This helps in the development of practical



**Feature 2:** Students can vary the properties or specifications of all the components. In physical labs although this is possible the students are not provided the opportunity of selecting the different components due to various constraints. This helps the students in understanding the concept of specifications. You can design experiments so as to make students vary the specifications and analyse the effect on the results.



**Feature 2:** As seen in the figure the students can vary the values of specifications such as temperature, junction capacitance etc. You can design experiments to enable students understand the effect of these on the V-I characteristics of the diode. This helps in the development of higher order objectives such as analysis and evaluation.

The screenshot shows the Docircuits.com circuit editor interface. The main window displays a toolbar with 'Build', 'Run', and 'Analyze' buttons. On the left, there's a 'Components' panel with categories like Analog/Mixed, Digital, Measuring Devices, Junction Devices (Diodes, Zener-Diode, Red-Led, Tunnel-Diode, Schottky-D, Get more...), Transistors (BJT, Mosfet, JFET, UJT, Get more...), and OpAmp (OpAmp, AD825, Get more...). The central part of the screen shows the 'BJT0 Properties' dialog box. The 'Library Components' dropdown is set to 'BJT' and lists various BJT models: 2N2222, 2N2219A, 2N2905A, 2N2907, 2N2955, 2N3053, 2N3055, 2N3904, and 2N3906. A note at the bottom of this list says: '\* Purchase the product to use all the components.' The main properties panel contains fields for parameters like Is (0.1 fA), Nf (1), Nr (1), Vaf (0 V), Var (0 V), Ise (0 A), Ne (1.5), Isc (0 A), Nc (2), Bf (100), Br (1), Cje (0 F), Vje (0.75 V), and Cjc (0 F). The 'Type' is set to 'npn'. The 'Name' is 'BJT0', 'Component' is 'BJT', and 'Description' is 'Generic BJT'. At the bottom of the dialog are 'Save' and 'Cancel' buttons. A 'feedback' button is visible on the right edge of the editor window.

**Feature 3:** As seen in the figure whenever a particular component is selected the entire specifications are visible. Also as the students selects the components one by one they can compare the specifications. You can ask questions in the experiment design related to the reasons for the selection of a particular component. This helps in the development of higher order objectives such as evaluation.

The screenshot shows the CircuitLab software interface. On the left is a component library sidebar with sections for Essentials, Ideal Sources, Passive Elements, Signal Sources, Operational Amplifiers, and Diodes. A red arrow points from the 'Diodes' section to a component labeled 'D1' in the main workspace. A red callout box highlights the part number '1N4148' below the component. In the center, a modal dialog box displays detailed specifications for the selected diode:

Part Number	Datasheet	Buy	name:	Part#:
1N4004	Datasheet	Buy	D1	1N4148
1N4005	Datasheet	Buy	I_S: 2.52e-9	A: 1.752
1N4006	Datasheet	Buy	R_S: 0.568	Ω: 2e-8
1N4007	Datasheet	Buy	CJO: 9e-13	F: 0.25
1N4148	Datasheet	Buy	V_Z: 0.0000000000000001	V: Default
1N5408	Datasheet	Buy		
1N5817	Datasheet	Buy		

Below the table are two buttons: 'Save Custom Device Model' and 'Import SPICE Model'. At the bottom of the dialog is a blue button labeled 'View All Diodes In Stock'.

At the top of the screen, there is a navigation bar with 'File', 'Edit', 'Run', and 'Help' menus, and a sign-in/click-to-create account link. A warning message at the top right says 'Warning: unsaved changes! Now editing: Unnamed Circuit'.

**Feature 3:** As seen in the figure there is a link provided for the entire datasheet of the component. They can refer to them as and when they want. This is also provided in the physical lab but not so many copies are normally kept that each student can refer separately.

The screenshot shows the CircuitLab software interface. On the left is a toolbar with various circuit element icons: Essentials (Down arrow, Name Node, Wire), Ideal Sources (Voltage, Current), Passive Elements (Resistor, Capacitor, Inductor), Signal Sources (Voltage, Current, AC), Operational Amplifiers (Op-Amp, Inverting Op-Amp), and Diodes (Diode, Zener Diode, Varistor). A search bar at the top says "Press '/' to search". The main workspace has a red callout pointing to a component labeled "D1 1N4148". A modal dialog box is open, listing components and their properties. The dialog includes a table of components and a form for entering specific values for the selected component (D1).

Part Number	Action	Value	Unit
1N4004	Datasheet	Buy	
1N4005	Datasheet	Buy	
1N4006	Datasheet	Buy	
1N4007	Datasheet	Buy	
1N4148	Datasheet	Buy	
1N5408	Datasheet	Buy	
1N5817	Datasheet	Buy	

Component Properties (for D1):

- name: D1
- Part#: 1N4148
- I\_S: 2.52e-9 A
- N: 1.752
- R\_S: 0.568 Ω
- T<sub>T</sub>: 2e-8 S
- C\_J0: 9e-13 F
- M\_J: 0.25
- V<sub>BR</sub>: 50 V
- P<sub>DS</sub>: 0.25 W

Buttons in the dialog:

- Save Custom Device Model
- Import SPICE Model
- View All Diodes In Stock

**Feature 4:** The students can get the feel of operating a real equipment as the image is real life and the various functions and adjustments are exactly same as in actual. The students are not distracted due to non-functioning of the equipment as in physical lab. You can design experiments with the objective of developing the students practical skills such as operating equipment, taking measurements etc.

The screenshot shows a web-based circuit editor interface at [www.doccircuits.com/circuit-editor](http://www.doccircuits.com/circuit-editor). The top menu includes File, Edit, View, Help, Share, More, and Login. The main workspace is titled "Untitled Circuit \*". At the top, there are three buttons: Build (highlighted), Run, and Analyze. Below them is a toolbar with icons for basic components: Resistor, Inductor, Capacitor, Switch, Ground, Potentiometer, and Lamp. A "Components" sidebar on the left lists categories: Analog/Mixed (selected), Digital, Basic Components, Virtual Devices, and Sources. Under Basic Components, icons are shown for Resistor, Inductor, Capacitor, Switch, Ground, Potentiometer, and Lamp. Under Virtual Devices, icons are shown for DC-Source, AC-Source, Function-G., Oscilloscope, TBS, PS2200, AFG, and 2100. Under Sources, icons are shown for ac-Voltage..., ac-Current..., Rectangular..., Pulse-Volt..., dc-Voltage..., dc-Current..., and ac-Current... (repeated). An "Equations" tab is also visible in the sidebar. In the workspace, a circuit diagram is shown with a DC voltage source labeled "DCSource0 U = 1V" connected in series with a diode (D0) and a resistor (R0). The current through the diode is labeled as  $I_S = 1 \text{ fA}$ . To the right of the circuit, a digital multimeter is displayed with its screen showing "Constant Voltage 01.000 V". The multimeter has a keypad with numbers 0-9, a power button, a voltage/current selector, and a dial. A red probe is connected to the positive terminal of the multimeter. The page number "14" is located in the bottom right corner.

**Feature 5:** The students can drag and drop any component and equipment and construct the circuits multiple times with minimum time. In case of physical labs it takes a lot of time for the students to assemble the circuit on a breadboard. You can design experiment in which the students understand and analyse the different variations of the same circuit or compare multiple designs. This feature helps in the development of circuit design skill.

The screenshot shows the CircuitLab software interface. At the top, there is a navigation bar with links for 'Home', 'About', 'Support', 'Source', and a URL 'https://www.circuitlab.com/doc/v1'. On the right side of the header, there are buttons for 'Sign in or create an account' and a warning message 'Warning: unsaved changes! Now editing: Unnamed Circuit'. Below the header, there is a toolbar with buttons for 'File', 'Edit', 'Run', and 'Help'. The main workspace is a grid where a circuit diagram is drawn. The circuit consists of a voltage source V1 (1V), a diode D1 (1N4005), a resistor R1 (100 Ω), and an ammeter AM1. A voltmeter VM1 is also present. On the left side of the image, there is a vertical toolbar containing icons for various components: 'Essentials' (ground, name node, wire), 'Ideal Sources' (voltage, current), 'Passive Elements' (resistor, capacitor, inductor), 'Signal Sources' (AC voltage, DC voltage, CSV file), 'Operational Amplifiers' (op-amp symbols), 'Diodes' (various diode symbols), and 'Capacitors' (various capacitor symbols). The circuit diagram is enclosed in a black rectangular border.

**Feature 6:** In some of the circuit simulators If students do not complete the circuit construction correctly, an explanation is provided in the form of a concise informative message. Scaffolds provided for completion of circuit construction help students and keep them motivated and engaged.

The screenshot shows a circuit simulation interface with the following components and settings:

- Top Bar:** File, Edit, View, Help, Build, Run, Analyze, Share, More, anitasd.
- Left Panel:** Analog/Mixed Simulation (DC Analysis, Frequency Domain Analysis, Time Domain Analysis, Run with Default Settings checked, Analysis Time: 0.01 sec, Output Accuracy slider from Low to High).
- Middle Panel:** A circuit diagram for a CE Amplifier. It includes:
  - A voltage source  $V_{dc0}$  of 1V connected to ground.
  - A resistor  $R_1$  of 100 Ohms connected between the collector terminal and ground.
  - A resistor  $R_0$  of 1 KOhms connected between the base terminal and ground.
  - An operational amplifier (Osc0) with its non-inverting input connected to ground and its inverting input connected to the collector terminal via a current meter  $IMeter0$ .
  - A current source  $IMeter1$  connected between the inverting input of Osc0 and the base terminal of a BJT transistor (BJT0).
  - The BJT0 has its base connected to ground, collector connected to the inverting input of Osc0, and emitter connected to ground.
  - A scope (Osc) with two channels (Ch1, Ch2) connected between the collector of BJT0 and ground.
  - A current meter  $IMeter1$  connected between the collector of BJT0 and ground.
- Bottom Panel:** Equations tab (Run Power Analysis, Run Time Domain Analysis).
- Right Panel:** Work Flow panel titled "Build (Drag-Drop Components)". It lists steps:
  - Add Source (checked)
  - Add Components
  - Add Ground
  - Add Measuring Device
  - Connect ComponentsEach step has an "Edit Properties" button (Optional). An arrow points from the text "Scaffolds for circuit design" to the "Edit Properties" button of the "Add Source" step.
- Bottom Right:** Run (Define Constraints), Analyze (View Simulation Results).

**Scaffolds for circuit design**

**Feature 7:** The circuit simulator requires less setup time and Students can perform more experiments and thus gather more information in the same amount of time it would take to do the physical experiment.

The screenshot shows the Docircuits.com circuit editor interface. At the top, there is a browser header with the URL [www.docircuits.com/circuit-editor](http://www.docircuits.com/circuit-editor). Below the header is a toolbar with tabs for **Build**, **Run**, and **Analyze**. The **Build** tab is currently selected. To the right of the toolbar, there is a status bar with options for **Share**, **More**, and a user account icon.

The main area of the interface is a workspace with a grid background. In the bottom right corner of the workspace, there is a small vertical orange box labeled "feedback".

On the left side of the workspace, there is a vertical sidebar containing several component libraries:

- Components**:
  - Analog/Mixed (selected)
  - Digital
  - Drawing
  - Basic Components
  - Virtual Devices
  - Sources
  - Controlled Sources
- Measuring Devices**:
  - LABEL
  - Ammeter
  - Voltmeter
  - Bode-Plotter
  - Wattmeter
- Junction Devices**:
  - OpAmp
- Power Electronics**
- Sensors**
- Integrated Circuits**
- Miscellaneous**

Below the component libraries, there are three small preview icons for the selected components: a voltage-controlled voltage source, a voltage-controlled current source, and a current-controlled current source.

**Feature 8:** After the students construct the circuit they can carry out five types of analysis – DC without sweep, Power Analysis, DC with sweep, Time Domain and Frequency Domain. This provides results of lengthy investigations instantaneously and accurately. This helps in the development of analytical and manipulative skills.

The screenshot shows the DocCircuits software interface. At the top, there's a menu bar with Chrome, File, Edit, View, History, Bookmarks, People, Window, Help. Below the menu is a toolbar with icons for Build, Run, and Analyze. The main area is titled "Untitled Circuit \*". On the left, there's a panel titled "Analog/Mixed Simulation" with sections for DC Analysis, Sweep 1, Sweep 2, and Frequency Domain Analysis. A blue bracket labeled "Equations" points from the "Equations" section of the DC Analysis panel to a callout box containing a list of analysis types. The circuit diagram in the center shows a diode (D1) connected to a dependent current source (IS = 1 fA) which is in series with a resistor (R1 = 1 Ohm). A voltage source (U = 1 V, f = 1 KHz) is connected to the common ground rail. An oscilloscope probe is connected across the dependent current source. The callout box lists the following types of analysis:

Types of analysis can be carried out

1. DC without sweep
2. Power Analysis
3. DC with sweep
4. Time Domain
5. Frequency Domain

At the bottom, there's a status bar with "Free License, 46 Simulation Remaining" and a system tray with various icons.

**Feature 8:** After the students construct the circuit they can carry out five types of analysis – DC without sweep, Power Analysis, DC with sweep, Time Domain and Frequency Domain. You can design experiments in which students can carry out the analysis of the same circuit multiple times by changing a particular component or changing the specification of a particular component.

The screenshot shows a web-based circuit simulation tool. At the top, a browser header displays 'DoCircuits - Circuit Labs' and 'Clipper Circuits - Clipping Ci...'. The main interface has tabs for 'Build', 'Run', and 'Analyze'. A sub-menu under 'File' includes 'Edit', 'View', 'Help', 'Share', and 'More'. The 'Analyze' tab is active, showing an 'Untitled Circuit' window. On the left, an 'Analog/Mixed Simulation' panel for 'DC Analysis' is open, containing fields for 'Type', 'Instance', 'Parameter', 'Sweep Start', 'Sweep End', and 'Output Accuracy' (with a slider from Low to High). Below this is a section for 'Sweep 2' with similar fields. At the bottom of this panel are buttons for 'Run Power Analysis', 'Run DC without Sweep', 'Frequency Domain Analysis', and 'Time Domain Analysis'. A blue bracket on the right side of the panel points to a list of analysis types. The central workspace shows a circuit diagram with a voltage source (Vac0, U = 1 V, f = 1 KHz), a diode (D0, Is = 1 fA), a resistor (R0, R = 1 Ohms), and an oscilloscope (Osc0) connected to the circuit. The bottom status bar indicates 'Free License, 46 Simulation Remaining' and shows system icons.

Types of analysis can be carried out

1. DC without sweep
2. Power Analysis
3. DC with sweep
4. Time Domain
5. Frequency Domain

## Feature 9: The various DC Analyses that are possible are

1. DC without sweep – This helps the students to measure the voltages at various locations in the circuit and currents through different components. You can design experiment so that the students analyse the change in these values depending on the change in the circuit components or component specifications. This develops their analytical, manipulative and investigative skills

Untitled Circuit\*

File Edit View Help

Build Run Analyze

Analog/Mixed Simulation

DC Analysis

DC with Sweep

Type :   
Instance :   
Parameter :   
Sweep Start :   
Sweep End :

Output Accuracy

Low Med High

Sweep 2

Type :   
Instance :

Run Power Analysis

**Run DC without Sweep**

Frequency Domain Analysis

Time Domain Analysis

Equations

Osc0

Ch1 Ch2

Vac0 U = 1 V f = 1 KHz

D0 Is = 1 fA R0 R = 1 Ohms

K A

1.DC without sweep  
2. Power Analysis  
3.DC with sweep

feedback

## Feature 9: The various DC Analyses that are possible are

2. Power Analysis – This helps the students to measure the power in the circuit. You can design experiment so that the students analyse the change in these values depending on the change in the circuit components or component specifications. This develops their analytical, manipulative and investigative skills. This is difficult in the physical labs as the equipment for power analysis are normally not available.

Untitled Circuit \*

File Edit View Help

Build Run Analyze

Analog/Mixed Simulation

DC Analysis

DC with Sweep

Type :

Instance :

Parameter :

Sweep Start :

Sweep End :

Output Accuracy

Low Med High

Sweep 2

Type :

Instance :

Run Power Analysis

**Run DC without Sweep**

Frequency Domain Analysis

Time Domain Analysis

Osc0

Ch1 Ch2

Vac0 U = 1 V f = 1 KHz

D0 Is = 1 fA R0 R = 1 Ohms

K A

feedback

**Equations**

1.DC without sweep  
2. Power Analysis  
3.DC with sweep

## Feature 9: The various DC Analyses that are possible are

3. DC with sweep – This feature helps in obtaining the various plots of the continuous change in the value of a particular parameter with respect to another such as the V-I Characteristics of diode, Input Characteristics of BJT etc. The plots can be obtained instantaneously and accurately. You can design experiments in which the students plot the graphs of the different variables and carry out analysis immediately. This is not possible in the physical labs as lot of time is required for the data collection.

Screenshot of a circuit simulation software interface showing a DC Analysis setup and a circuit diagram.

The left sidebar shows the "Analog/Mixed Simulation" tab selected. Under "DC Analysis", there is a section for "DC with Sweep" with fields for Type, Instance, Parameter, Sweep Start, and Sweep End. A slider for Output Accuracy is set to High. Below it is a "Sweep 2" section with similar fields. At the bottom are buttons for "Run DC without Sweep" (with a checked checkbox for "Run Power Analysis") and other analysis options like Frequency Domain Analysis and Time Domain Analysis.

A blue bracket labeled "Equations" points from the "Equations" section in the sidebar to a list of three items in a box:

1. DC without sweep
2. Power Analysis
3. DC with sweep

The main workspace displays a circuit diagram with a voltage source  $V_{ac0}$  (U = 1 V, f = 1 KHz), an oscilloscope probe labeled "Osc0" connected to node K, a diode  $D_0$  with parameters  $I_s = 1 \text{ fA}$ ,  $R_0 = 1 \text{ Ohms}$ , and a load resistor  $R$ . The circuit is connected to ground.

**Feature 10:** The students can carry out Frequency Domain Analysis. The plots of the variables in the frequency domain can be obtained instantaneously and accurately. This reduces the time required as in case of the physical labs where the students initially gather the data for the plot, then plot the graph using paper and pencil and then they can analyse it. In the virtual lab as the graphs are obtained within no time you can design experiments in which the emphasis is on analysing the graphs, improving students understanding of the relationships between the different variables.

Untitled Circuit \*

Build Run Analyze

Analog/Mixed Simulation DC Analysis Frequency Domain Analysis

Run with Default Settings

Low Frequency : 0.1 Hz  
High Frequency : 10 KHz

linear  log

Output Accuracy

Low Med High

Run Power Analysis

Run Freq. Domain Analysis

Time Domain Analysis

Vac0 U = 1 V f = 1 KHz

Osc0

D0 Is = 1 fA R0 R = 1 Ohms

K A

feedback

The screenshot displays a virtual circuit simulation environment. The main window is titled "Untitled Circuit \*". At the top, there are three buttons: "Build", "Run", and "Analyze". The "Run" button is currently highlighted. Below the buttons, there is a toolbar with icons for file operations like "File", "Edit", "View", and "Help". On the left side, there is a sidebar with tabs for "Analog/Mixed Simulation", "DC Analysis", and "Frequency Domain Analysis". Under "Frequency Domain Analysis", there is a checkbox for "Run with Default Settings" which is checked. Below that, there are input fields for "Low Frequency" (set to 0.1 Hz) and "High Frequency" (set to 10 KHz). There are also radio buttons for "linear" and "log" scales, and a slider for "Output Accuracy" set to "Med". At the bottom of the sidebar, there are checkboxes for "Run Power Analysis" and "Run Freq. Domain Analysis", with "Run Freq. Domain Analysis" being checked. The main workspace shows a circuit diagram on a grid. The circuit consists of a voltage source labeled "Vac0" (U = 1 V, f = 1 KHz), an oscillator component labeled "Osc0" (labeled Ch1, Ch2), a diode labeled "D0" with current "Is = 1 fA", and resistors labeled "R0" and "R1". A switch labeled "K" is connected to node "A". The circuit is powered by a ground connection at the bottom. The right side of the interface has a vertical bar with the word "feedback" and a scroll bar.

**Feature 10:** The students can carry out Time Domain Analysis. The plots of the variables in the frequency domain can be obtained instantaneously and accurately. This reduces the time required as in case of the physical labs where the students initially gather the data for the plot, then plot the graph using paper and pencil and then they can analyse it. In the virtual lab as the graphs are obtained within no time you can design experiments in which the emphasis is on analysing the graphs, improving students understanding of the relationships between the different variables.

Untitled Circuit \*

Build Run Analyze

File Edit View Help

Analog/Mixed Simulation

DC Analysis

Frequency Domain Analysis

Time Domain Analysis

Run with Default Settings

Analysis Time : 0.004 sec

Output Accuracy

Low Med High

Run Power Analysis

Run Time Domain Analysis

Vac0 U = 1 V f = 1 KHz

Osc0

D0 Is = 1 fA

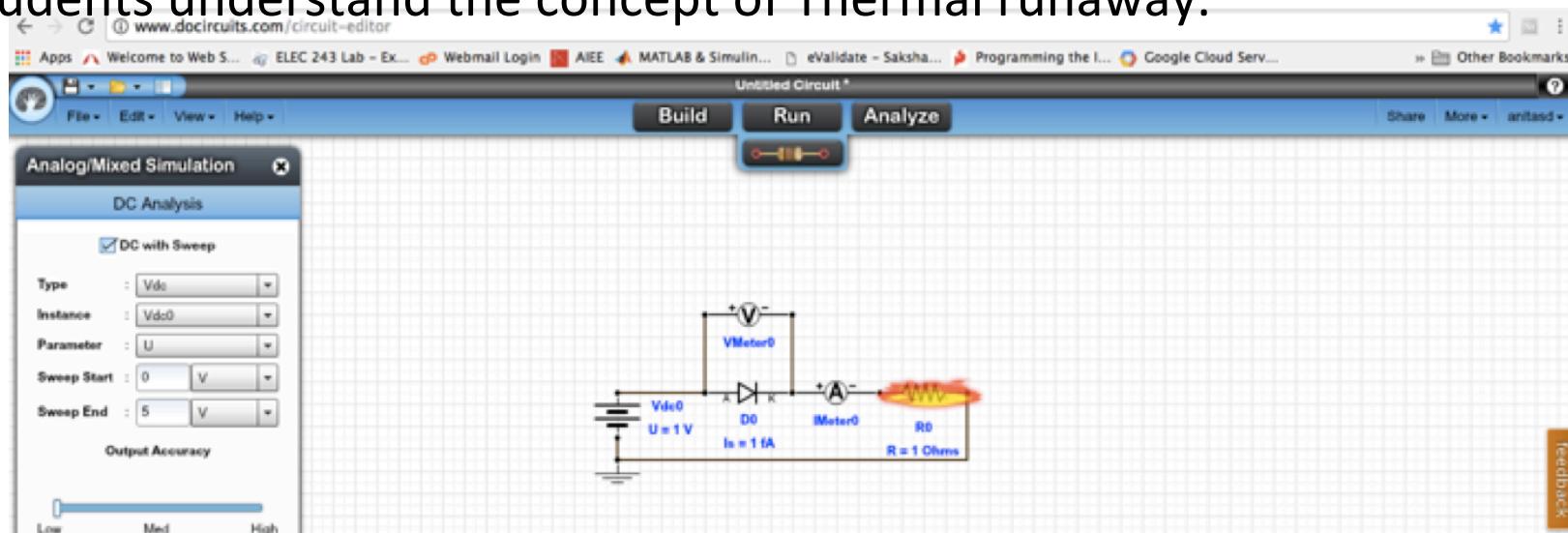
R0 R = 1 Ohms

K A

feedback

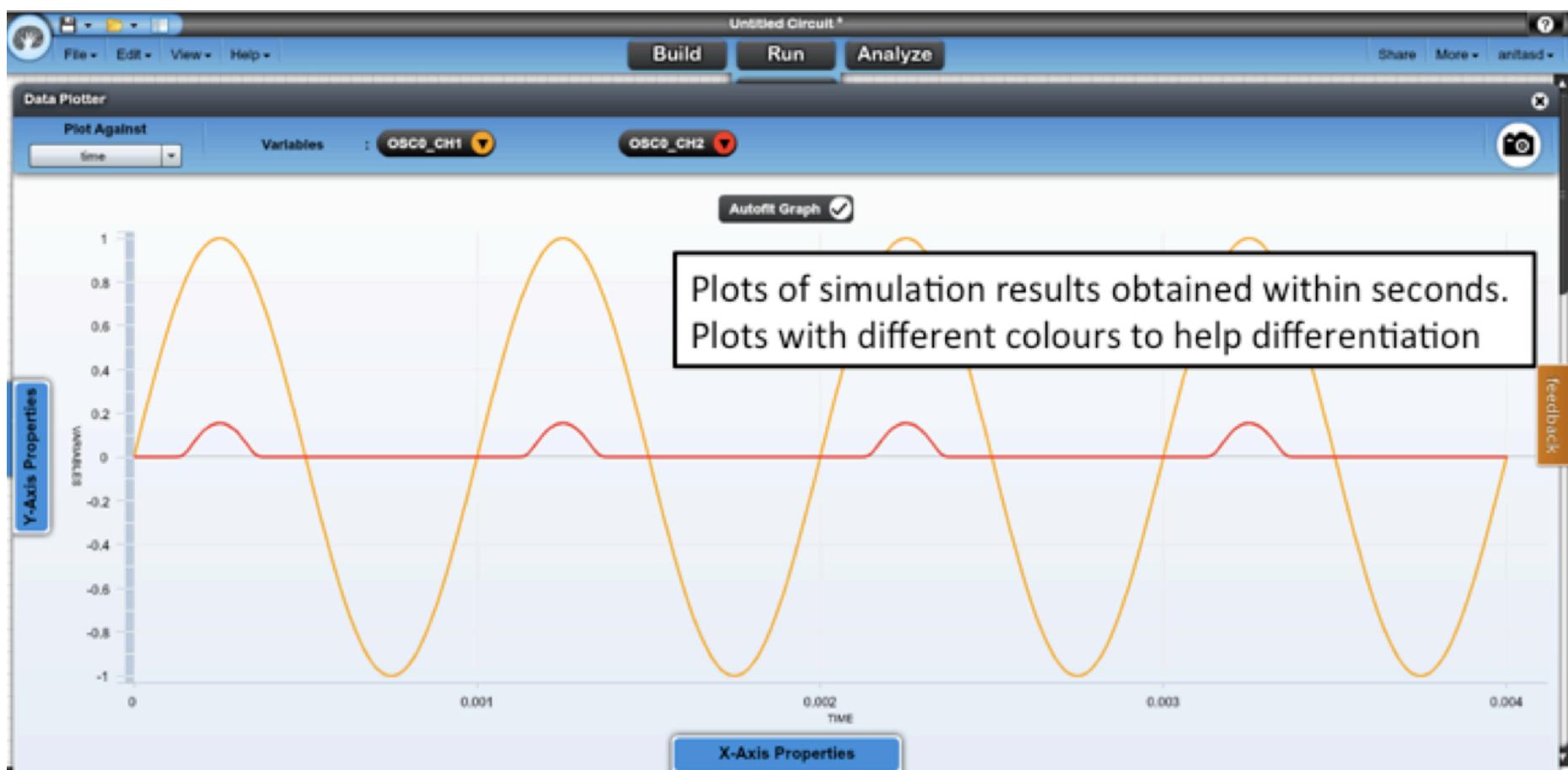
24

**Feature 11:** A very important feature is the visual of the component burning when the current flowing through it exceeds the power rating of the component as shown in the figure. This is not allowed in physical labs as it damages the component. This is a very important part of students learning as they get to learn from failure. You can design experiments in which the students are given a circuit with higher currents and then make them adjust the values of the parameters in order to rectify the problem. This helps the students understand the concept of Thermal runaway.

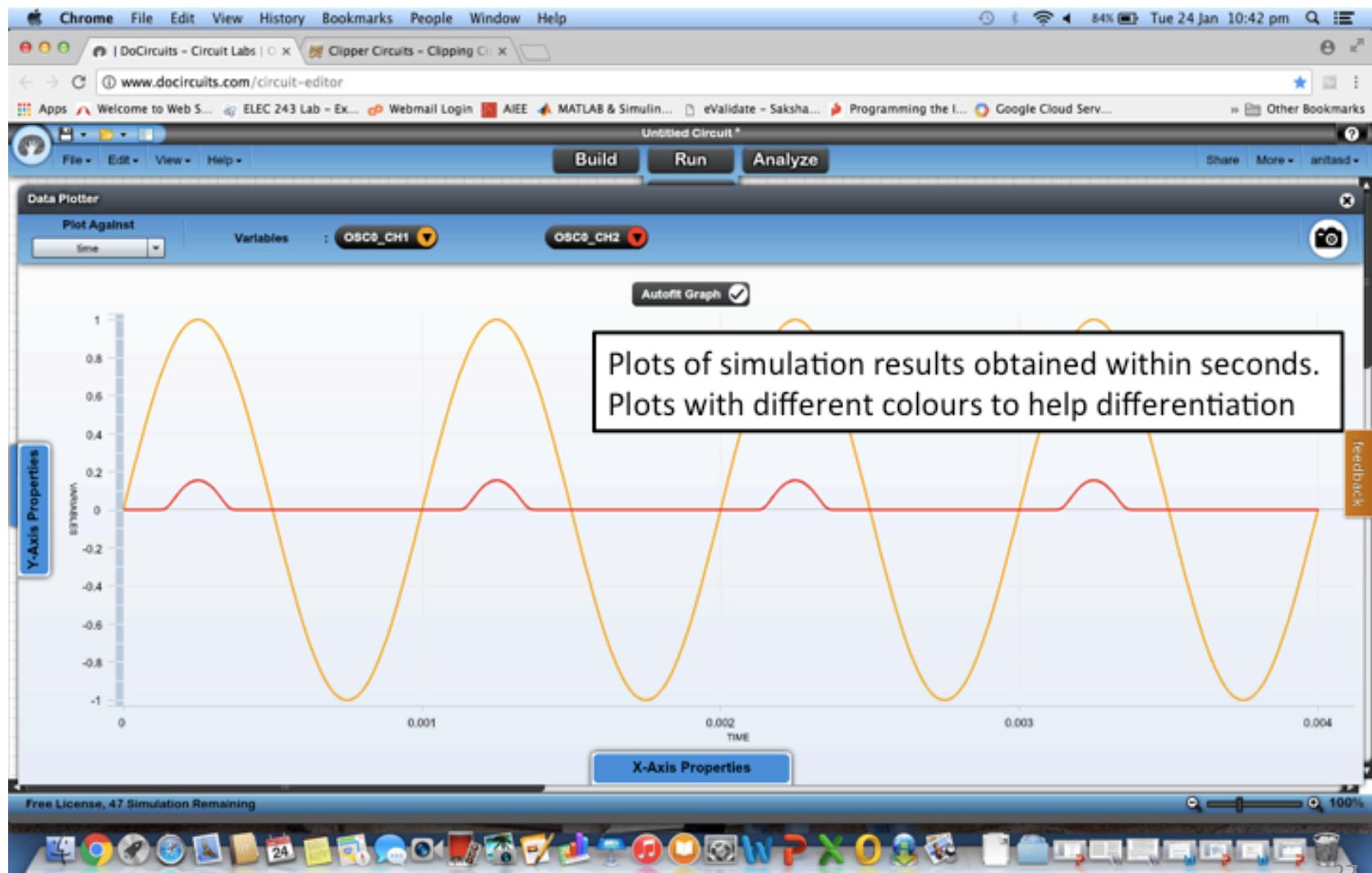


Visual representation of resistor burning due to thermal runaway

**Feature 12:** Facilitates recording measurements and plotting of data (e.g., semi-log graphing of the transfer function of a low-pass filter). As can be seen from the figure the graphs of three variables can be seen simultaneously. This feature can help students understand and analyse the relationships between the different variables. You can design experiments at higher cognitive levels such as analyse and evaluate.



# Extract valid information from a complex visualization when they draw what they observed in an experiment



**Feature 13:** Students can also directly link unobservable processes to symbolic equations and observable phenomena, which encourages them to make abstractions over different representations. This feature allows the students to plot the graphs of equations. You can design experiments in which the students can see the relations of variables for example the Vdc,Vrms,Vac simultaneously

The screenshot shows a web-based circuit editor interface. At the top, there's a browser header with tabs like 'www.docircuits.com/circuit-editor', 'Welcome to Web S...', 'ELEC 243 Lab - Ex...', 'Webmail Login', 'AIEE', 'MATLAB & Simulin...', 'eValidate - Saksha...', 'Programming the I...', 'Google Cloud Serv...', and 'Other Bookmarks'. Below the header is a toolbar with 'Build', 'Run', and 'Analyze' buttons. The main workspace is titled 'Untitled Circuit'. On the left, there's a sidebar with sections for 'Analog/Mixed Simulation', 'DC Analysis', 'Frequency Domain Analysis', and 'Time Domain Analysis'. It includes a checkbox for 'Run with Default Settings', a 'Analysis Time' input set to 0.004 sec, and a 'Output Accuracy' slider between 'Low', 'Med', and 'High'. A blue vertical bar labeled 'Equations' is positioned next to the sidebar. In the center, a modal window titled 'Equations Panel' is open. It has fields for 'Name' and 'Equation', both currently empty. Below these are buttons for 'Need Help?', 'Add', 'Clear', and 'Close'. There's a numeric keypad with digits 0-9, operators +, -, \*, /, and functions like min, max, abs, ceil, floor, round, log10, log2, angle, pi, exp, and mag. At the bottom of the keypad are buttons for 'Devices' and two specific device labels: 'V|OSC0\_CH1]' and 'V|OSC0\_CH2]'. To the right of the keypad is a table with columns 'Use', 'Name', and 'Equation', which is currently empty. A 'Pin to Grid' button is located at the bottom right of the panel. A small orange 'feedback' button is visible on the far right edge of the screen.

**Equations can be added and plotted. Thus relations between different variables can be observed**

# Design experiments with learning objectives at higher cognitive levels

- Students should be able to analyze the plot and identify linear and non-linear regions in the V-I characteristics of diode.
- Students should be able to identify the most suitable diode for a particular application.

- In order to achieve this learning objective you can use different instructional strategies
- The next slide gives the design of an experiment for the instructional strategy

# Instructional Strategy - Discovery

- Focus question: Determine if the given PN junction diode is suitable to function as a rectifier or switch?
- Procedure: To carry out this analysis what procedure will you follow? What circuit will you use? What are the observations necessary to carry out the experiment? What data will you gather? How will you represent the data? What type of data analysis will you carry out? What can you infer from the analysis of the data? Do the results answer the focus question? What can you conclude from the results?

# Instructional Strategy - Discovery

- This learning objective can be achieved using the vlab as it has the necessary features so that students can carry out the tasks and answer the assessment questions

# Tasks to be performed by the students and corresponding vlab feature

Task	Vlab feature
What circuit will you use?	Students can construct their own circuit using various components
What are the observations necessary to carry out the experiment?	Students can decide the simulation properties
What data will you gather?	Students can observe the graph and find out values of parameters from the graph
How will you represent the data?	Students can decide the axes for plotting the various parameters
What type of data analysis will you carry out?	Students can decide the type of analysis to be carried out and based on that can decide the simulation properties
What can you infer from the analysis of the data?	As students are given the theoretical background and can observe various waveforms and circuit diagrams simultaneously they can draw inferences <sup>33</sup>

# Instructional Strategy - Structured Problem Solving

- Measure the forward voltage drop of a silicon rectifying diode, such as a model 1N4001. How close is the measured forward voltage drop to the “ideal” figure usually assumed for silicon PN junctions? What happens when you increase the temperature of the diode? What happens when you decrease the temperature of the diode?

# Tasks to be performed by the students and corresponding Vlab feature

Task	Vlab feature
Measure the forward voltage drop of a silicon rectifying diode, such as a model 1N4001.	Students can construct their own circuit using various components
How close is the measured forward voltage drop to the “ideal” figure usually assumed for silicon PN junctions?	Students can decide the type of analysis to be carried out and based on that can decide the simulation properties
What happens when you increase the temperature of the diode?	Students can change the internal properties of the components , observe the graph and find out values of parameters from the graph
What happens when you decrease the temperature of the diode?	Students can change the internal properties of the components , observe the graph and find out values of parameters from the graph

# Instructional Strategy - Problem-based

- Procedure: In PBL the problem needs to be solved in a group. So students may be asked to form groups and work together towards the solution. They may use the online resources to arrive at the solution.
- Design the circuit for using PN junction diode as a switch. Compare your design with that of your peers. Are all the designs same? Which of the designs do you think are optimum? Why?

# Tasks to be performed by the students and corresponding DoC vlab feature

Task	Vlab feature
Design the circuit for using PN junction diode as a switch.	Students can construct their own circuit using various components. Scaffolds are provided while they are constructing the circuit. They can carry out various analysis and so find out if the circuit is working and check the results of the analysis from the graphs obtained.
Compare your design with that of your peers.	Students can save their circuits and share it with peers. They can analyse the circuits and the outputs for various circuit designs and compare the results.
Are all the designs same?	Students can share their designs with their peers and so compare the various designs
Which of the designs do you think are optimum? Why?	Students can analyse all the waveforms as there is a provision of saving the waveforms that is the outputs of the various circuits.

# Conclusion

The Vlab has the following features

- The library of components and equipment is large
- More specifications of components can be varied
- Scaffolds provided to students while they are constructing the circuit
- Type of analysis that can be carried out is
- Graphs that can be plotted can be seen in different colours
- More number of graphs can be plotted together
- The scales for both axes can be adjusted
- Graphs of parameter equations can be plotted together so students can compare the natures of various parameters
- If the current flowing through a particular component is more than the power rating of the component it is shown as a visual of a burning component.

# Conclusion

As the Vlab has these important features you can design experiments with learning objectives at higher cognitive levels, use different instructional strategies and assign tasks with different cognitive structures

# Conclusion

The various examples illustrate how learning objectives at higher cognitive levels can be achieved using the Vlab

# Design your own experiment for the vlab

- Now that you have understood the features of vlab and how experiments with learning objectives at higher cognitive levels, various instructional strategies, various cognitive structures can be designed using vlab go ahead and design your own experiment.