Návrh, simulace a ověření elektronických obvodů na platformě NI ELVIS a Multisim

Ing. Roman Vala (National Instruments)

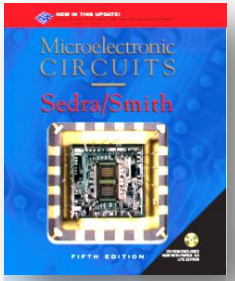
13. dubna 2012

Tato prezentace je spolufinancována Evropským sociálním fondem a státním rozpočtem České republiky.

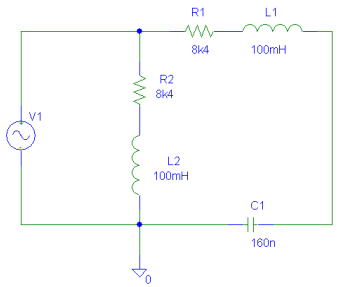
Agenda

- Úvod
- NI ELVIS II a NI MyDAQ
- Multisim
- Propojení s LabVIEW

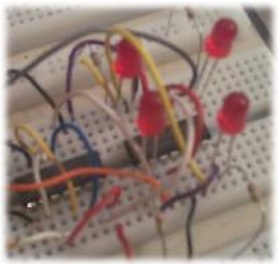
Traditionally…



Textbooks



Simulation

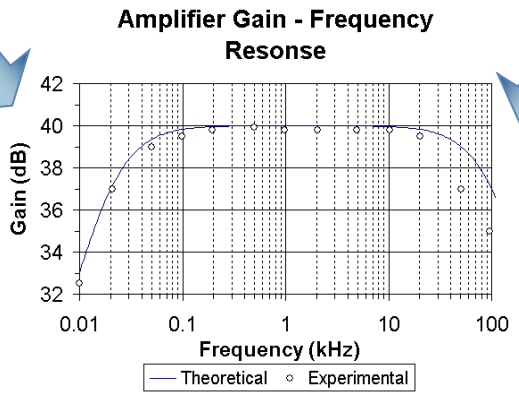


Hardware

Classroom

Laboratory

Comparing simulated data with measurements



PC-Based Electronic Circuit design

"We have never really, as educators, gotten these three elements [of theory, simulation, and experimentation] to work together well. The weakest has been the laboratory. With the advances in simulation with [NI] Multisim and the advances in experimentation with [NI] myDAQ, we'll be able to bring all of these elements together in a more exciting way."

- Adel Sedra, Dean and Professor of Engineering at University of Waterloo

http://www.ni.com/academic/circuits.htm

Used Worldwide

National Instruments

Offering graphical system design solutions for Test and Measurement and Industrial Embedded

Non-GAAP Revenue: $1.04B revenue in 2011, $280M revenue in Q4 2011

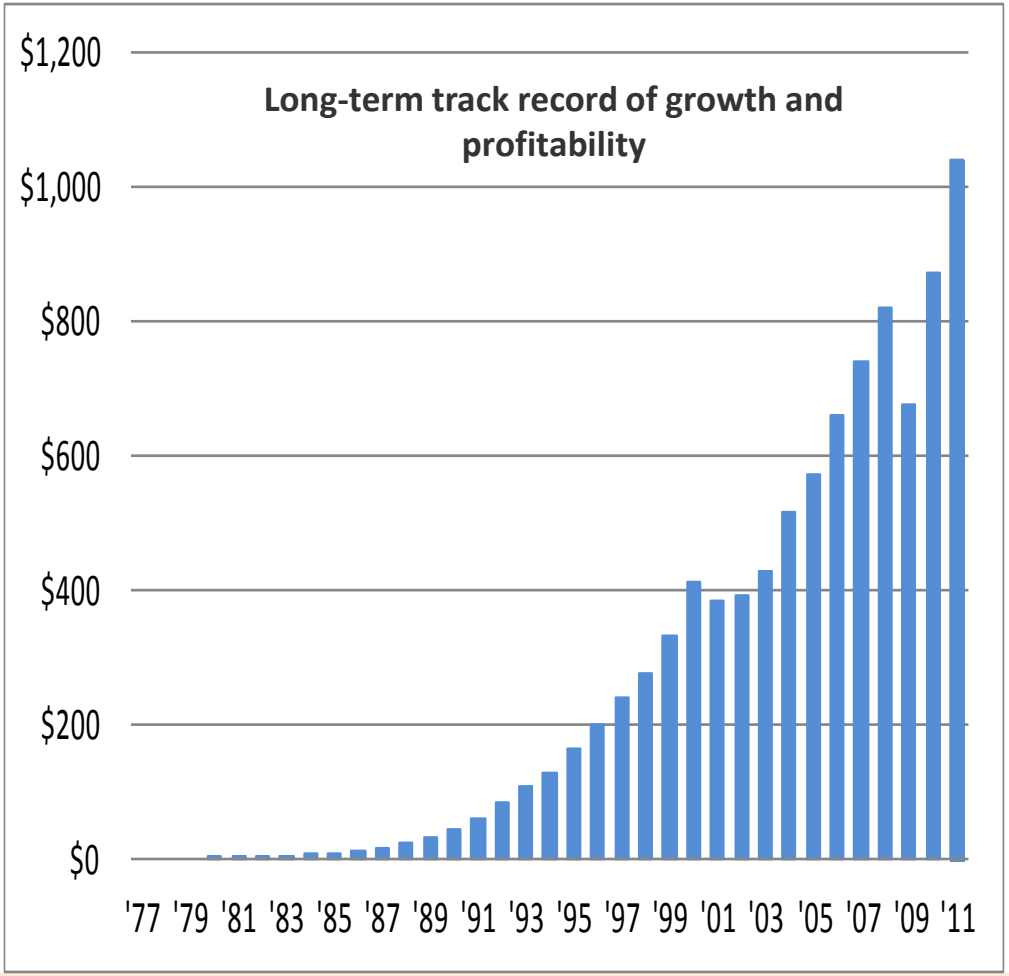
Global Operations: Approximately 6,200 employees; operations in more than 40 countries

Broad customer base: More than 35,000 companies served annually

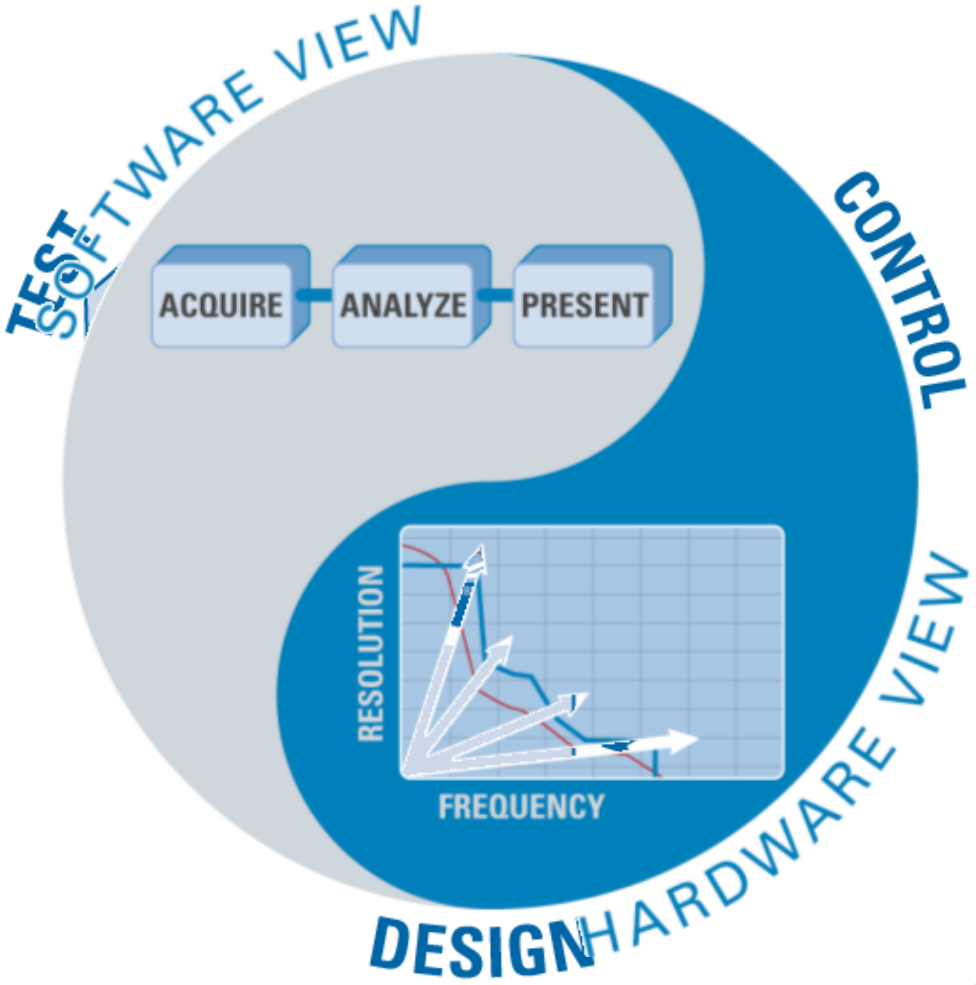
Diversity: No industry >15% of revenue

Culture: Ranked among top 25 companies to work for worldwide by *FORTUNE* Magazine and the Great Places to Work Institute

Strong Cash Position: Cash and short-term investments of $366M at December 31, 2011

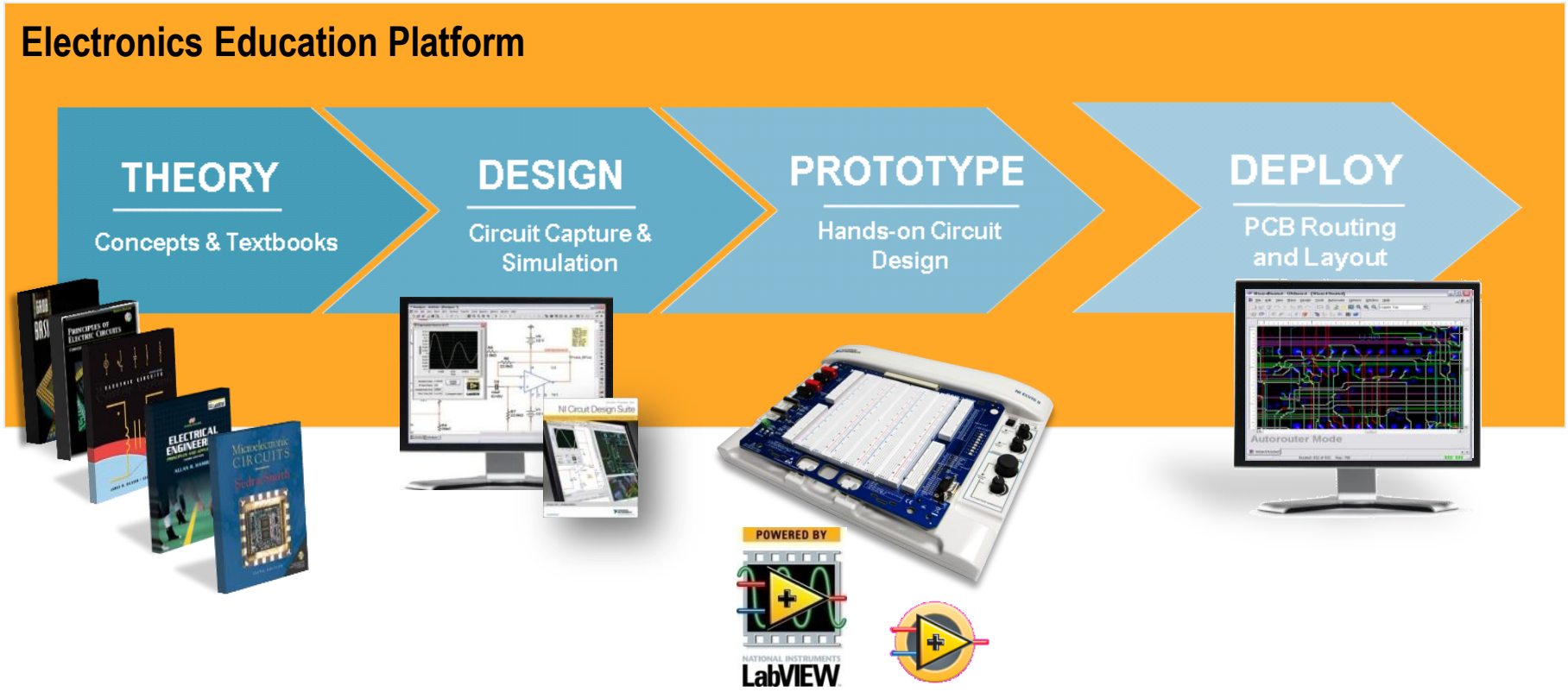


What is Virtual Instrumentation?



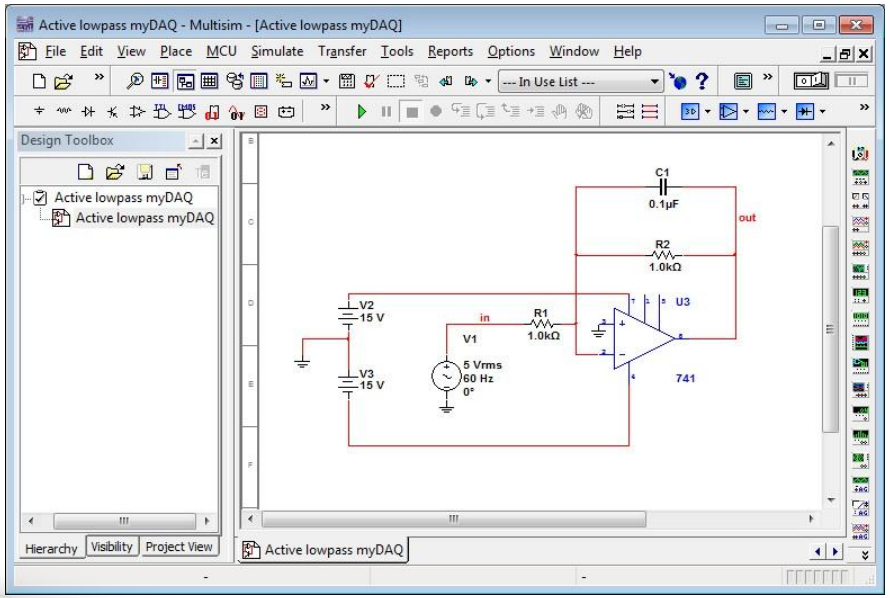
NI Electronics Education Platform

National Instruments tools address challenges of circuit education



Necessary Equipment

Multisim



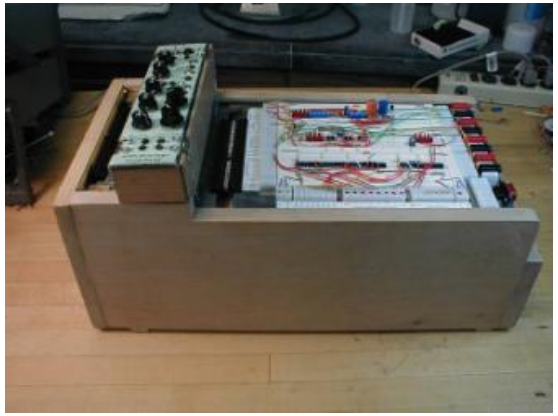
POWERED BY
NATIONAL INSTRUMENTS
LabVIEW

ELVIS HW

Agenda

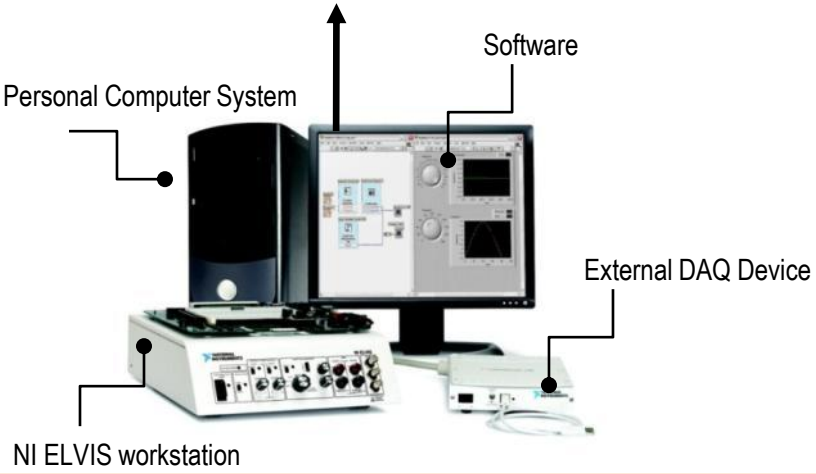
- ELVIS – Electronic Laboratory for Virtual Instrumentation
- ELVIS addons
- MyDAQ

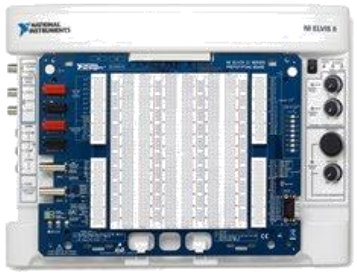
Introduction | From concept to reality



- LabVIEW / DAQ based system
- Removable prototyping board
- Integrated instrument capability

Earlier | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009

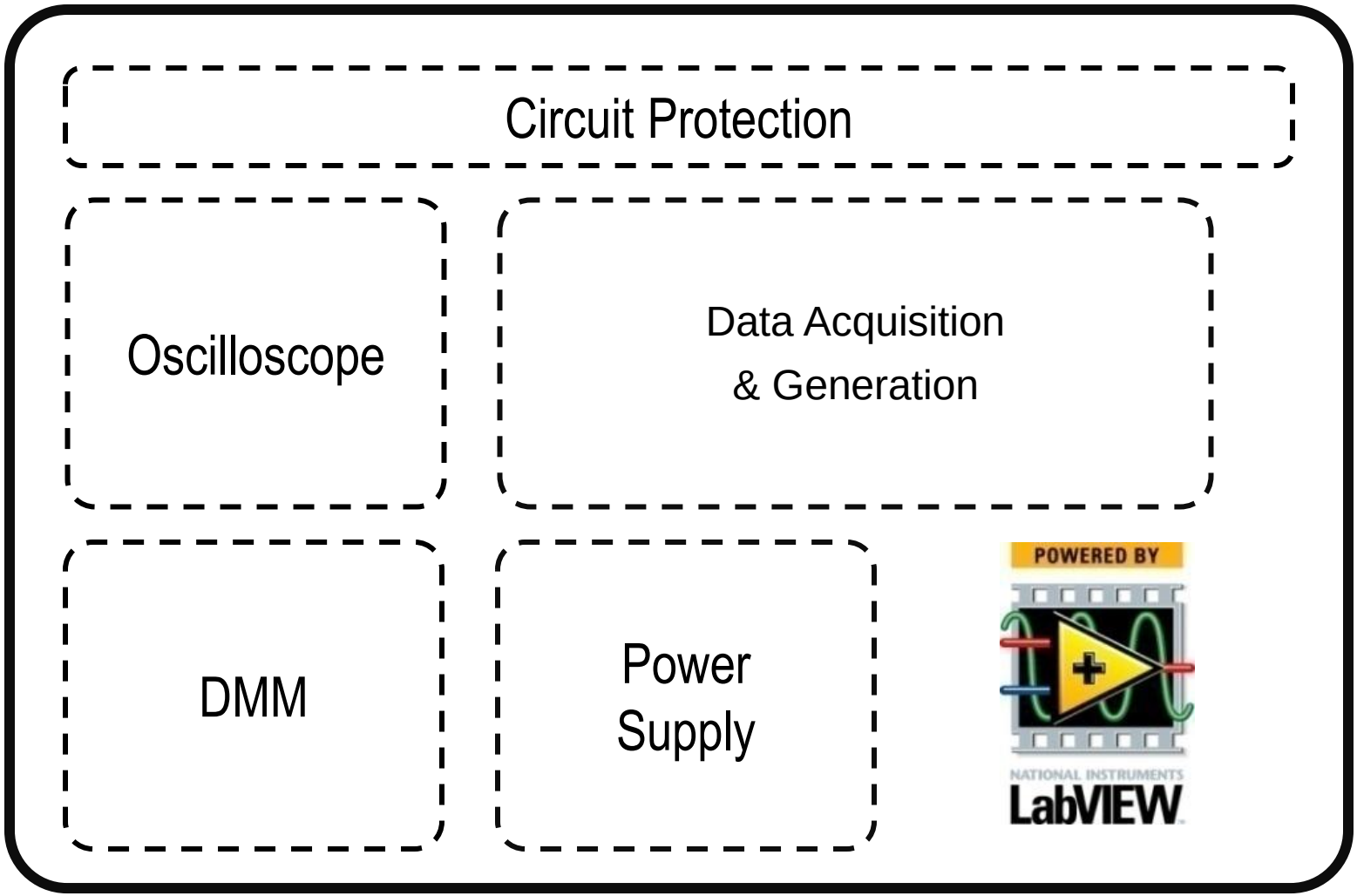




NI ELVIS II

NI ELVIS II+

What is NI ELVIS? | At the core…12 Instruments



NI ELVIS II | Hardware Specifications

Oscilloscope

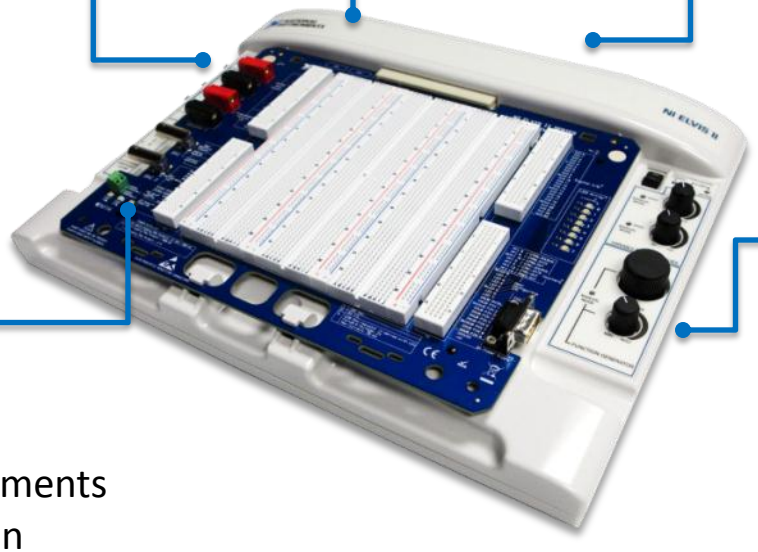
- 16-bit resolution
- 1.25 MS/s single channel, 500kS/s two channel aggregate
- 1 to 1.5 MHz Bandwidth
- 1x and 10x probe
- ±10 V input range
- AC/DC coupling

Internal Circuit Protection

- Resettable fuses

USB Connectivity

- Plug-and-play capability
- USB 2.0 Connection



Digital Multimeter

- Isolated measurements
- 5½ digit resolution
- 60 VDC, 20Vrms, 2 ADC, 2 Arms, 100MΩ

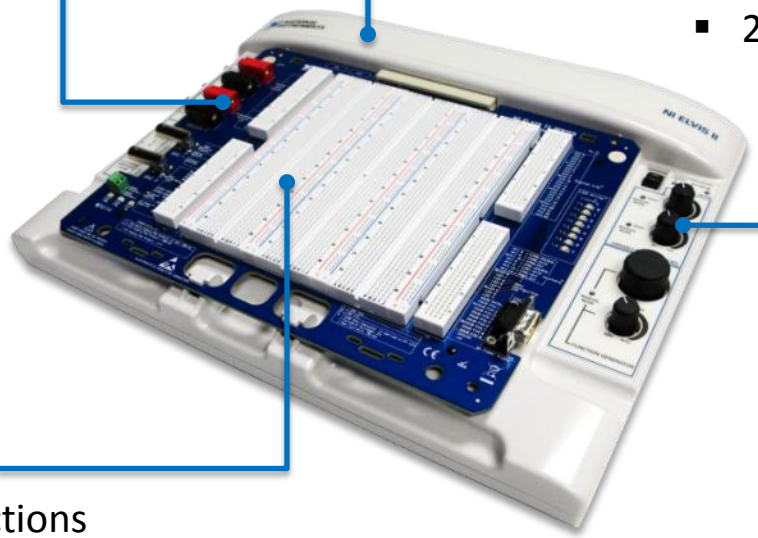
Function Generator

- 10 bit, ±5V range
- 0.2 Hz to 5 MHz Sine
- 0.2 Hz to 1 MHz Triangle/Square
- Software or manual control
- BNC or prototyping board connection

NI ELVIS II | Hardware Specifications

Impedance Analyzer
- 0.2 Hz to 35 kHz Range
- NPN, PNP, Diode

Other Analyzers:
- Bode Analyzer
- 2-wire Current Voltage Analyzer
- 3-Wire Current Voltage Analyzer



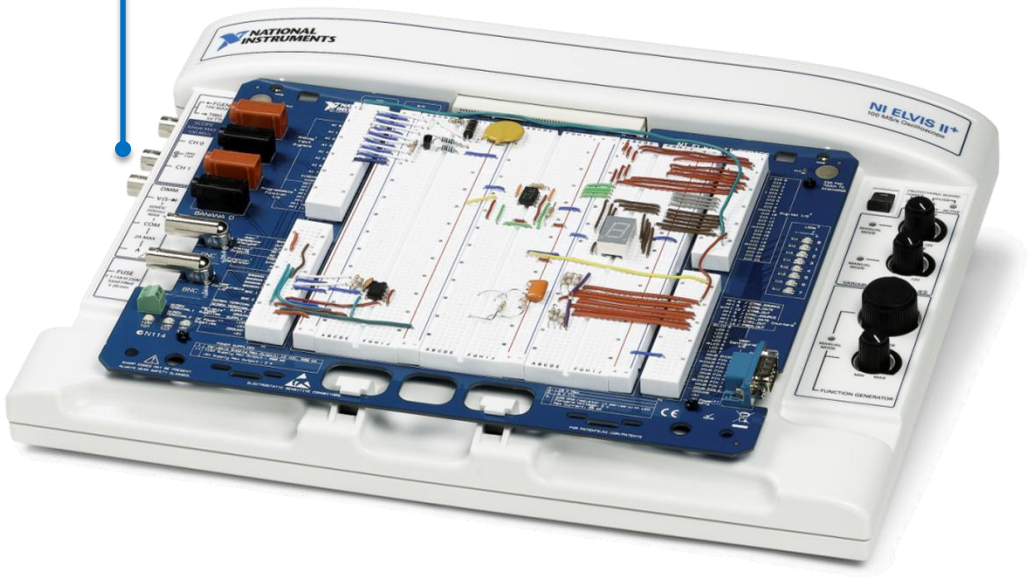
Integrated DAQ
- AI sampling rate 1.25 MS/s single channel, 500kS/s two channel
- 16-bit resolution
- AO 2.8 MS/s update rate
- 24 DIO lines,15 PFI, 2 CTR

Prototyping Board
- Updated connections
- Detachable
- User-defined Banana Plugs, BNC, D-Sub connectors

Variable Power Supply
- 10-bit resolution
- 0 to +12V, 0 to -12V
- 500 mA current range

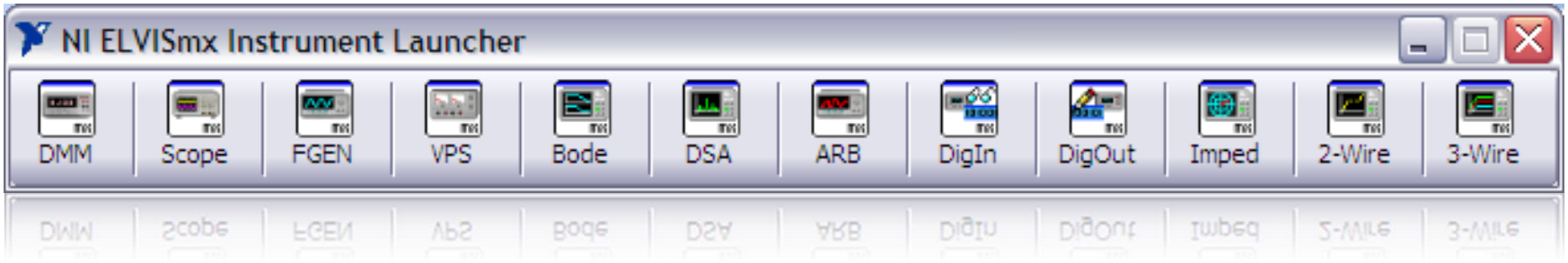
Oscilloscope

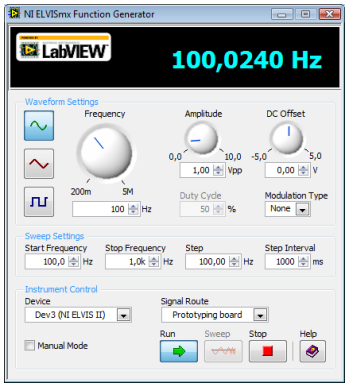
- 100MS/s Sampling Rate
- 50MHz Bandwidth(-3dB)
- 8-bit resolution
- ±20 V max. input range
- AC/DC/GND coupling
- 20MHz Optional Noise Filter
- BNC connection

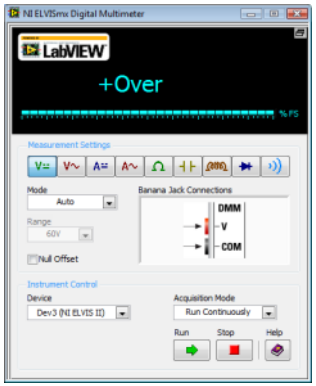


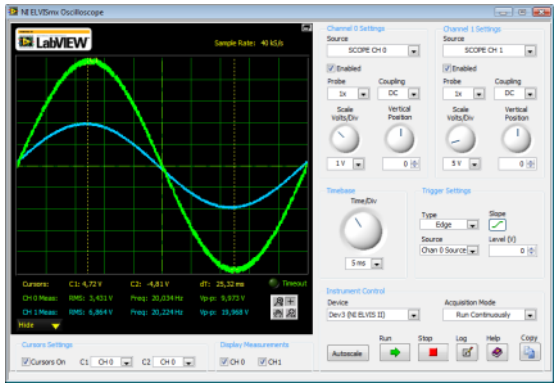
NI ELVISmx Driver | Software Specifications

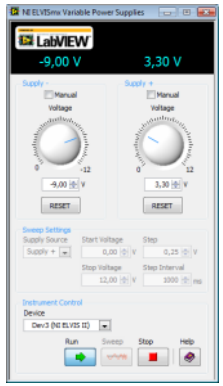
- Ready-to-use instruments – Soft Front Panels
- Customizable instruments





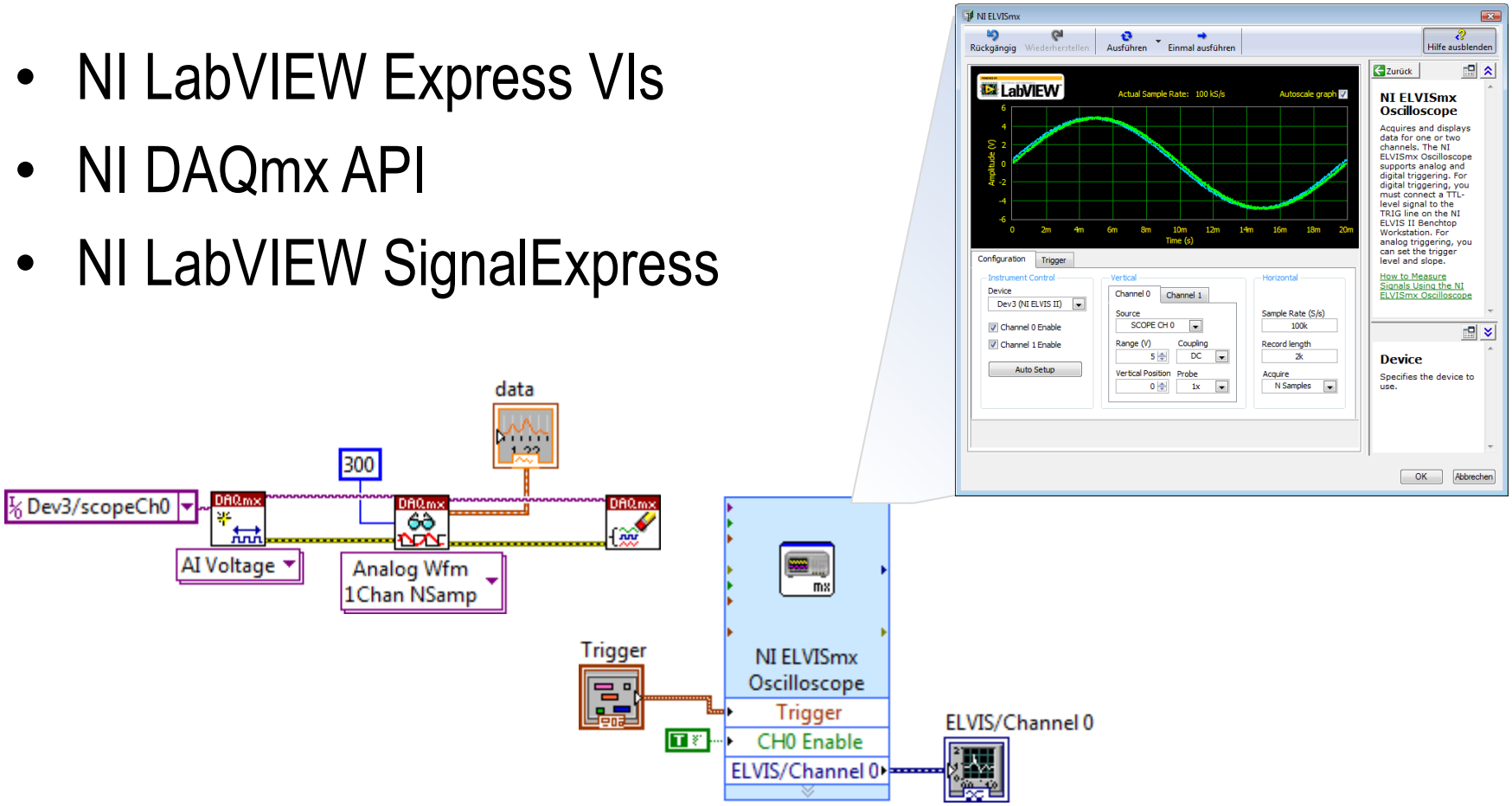




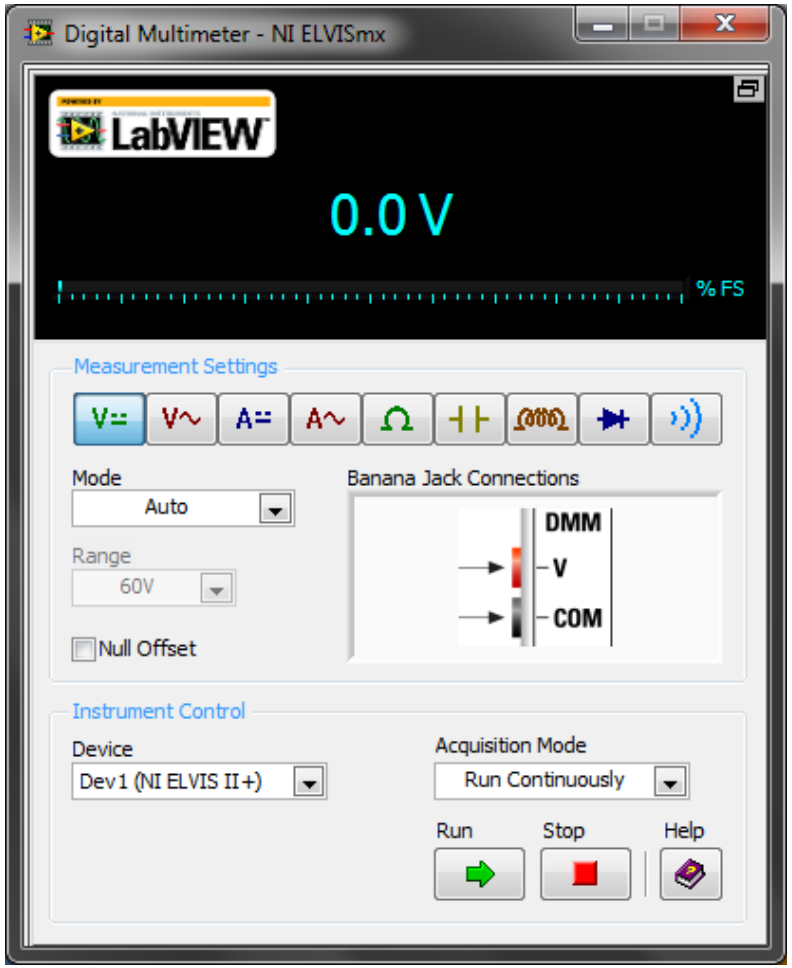


NI ELVISmx Driver | Software Specifications

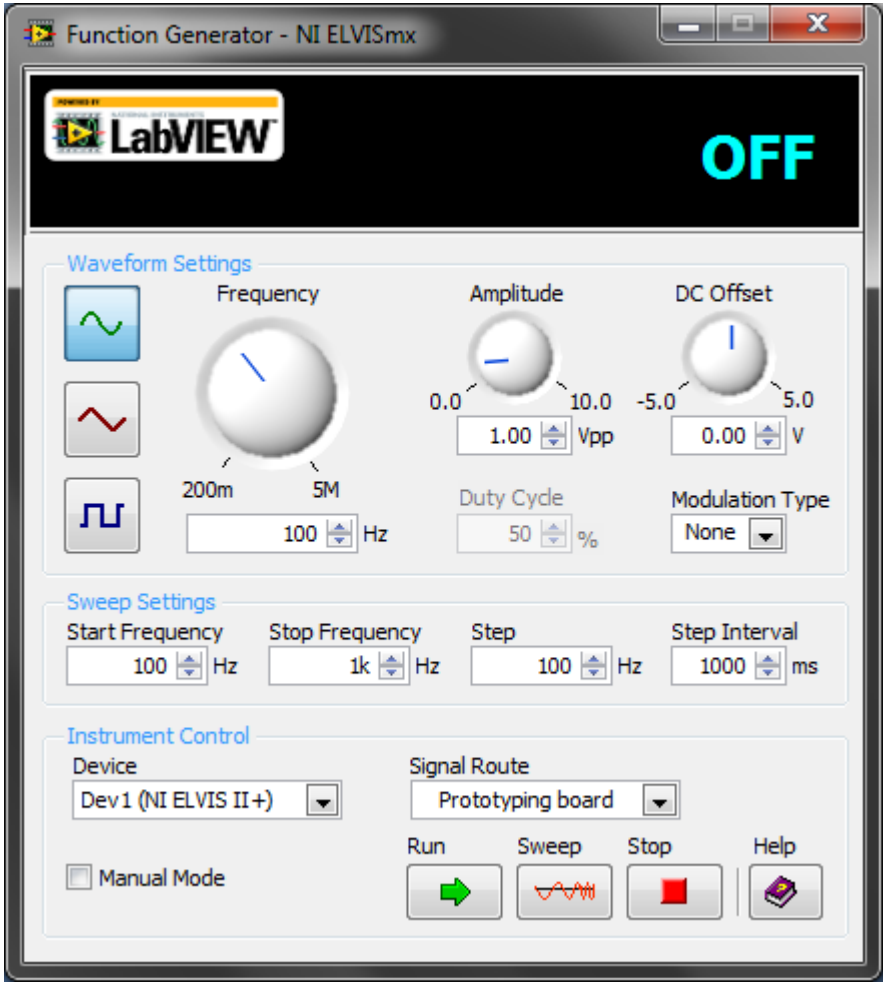
- NI LabVIEW Express VIs
- NI DAQmx API
- NI LabVIEW SignalExpress



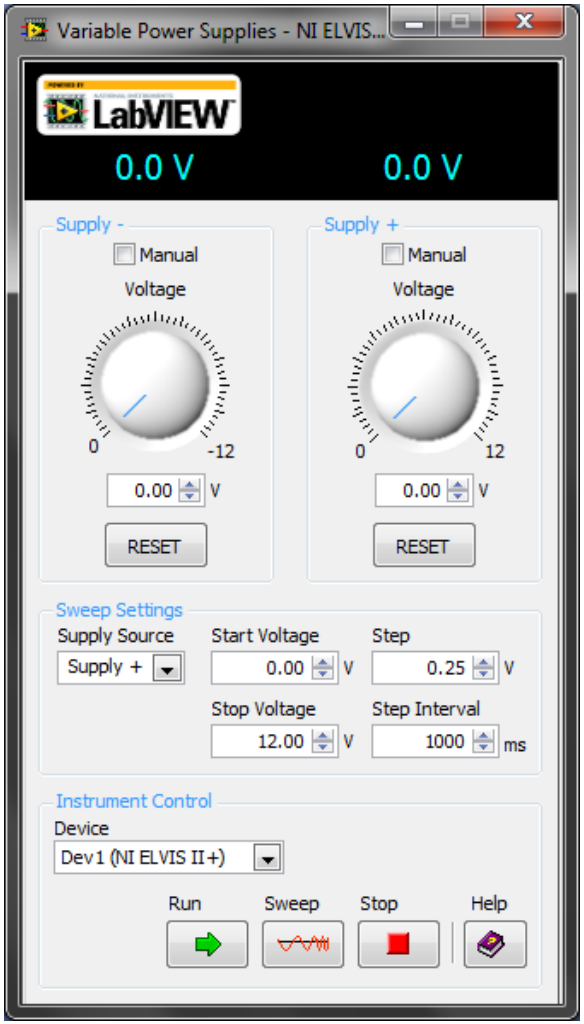
DMM


Digital Multimeter - NI ELVISmx
LabVIEW
0.0 V
% FS
Measurement Settings
Mode
Auto
Range
60V
Null Offset
Banana Jack Connections
DMM
V
COM
Instrument Control
Device
Dev1 (NI ELVIS II+)
Acquisition Mode
Run Continuously
Run
Stop
Help

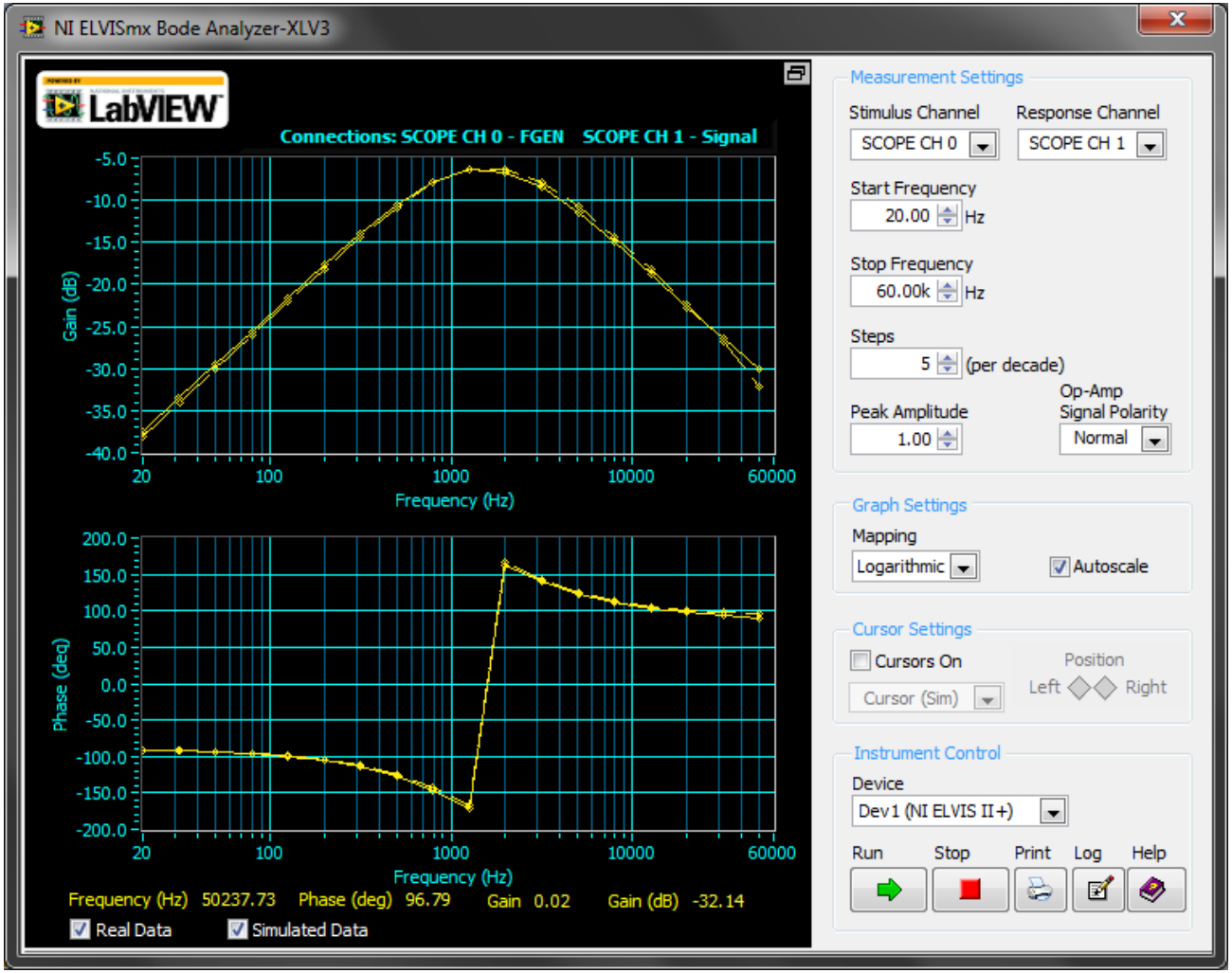
Function Generator



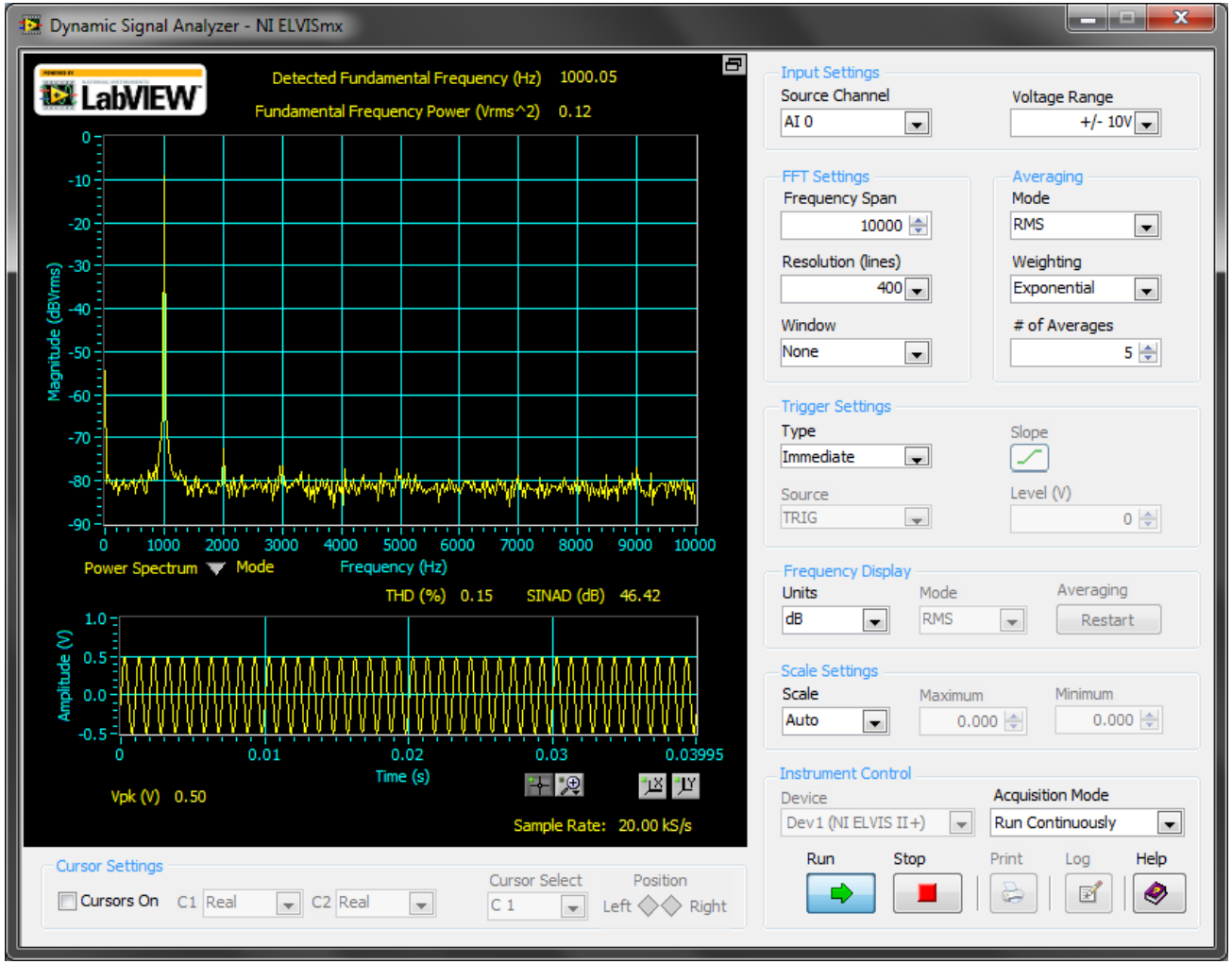
Programable Power Supply



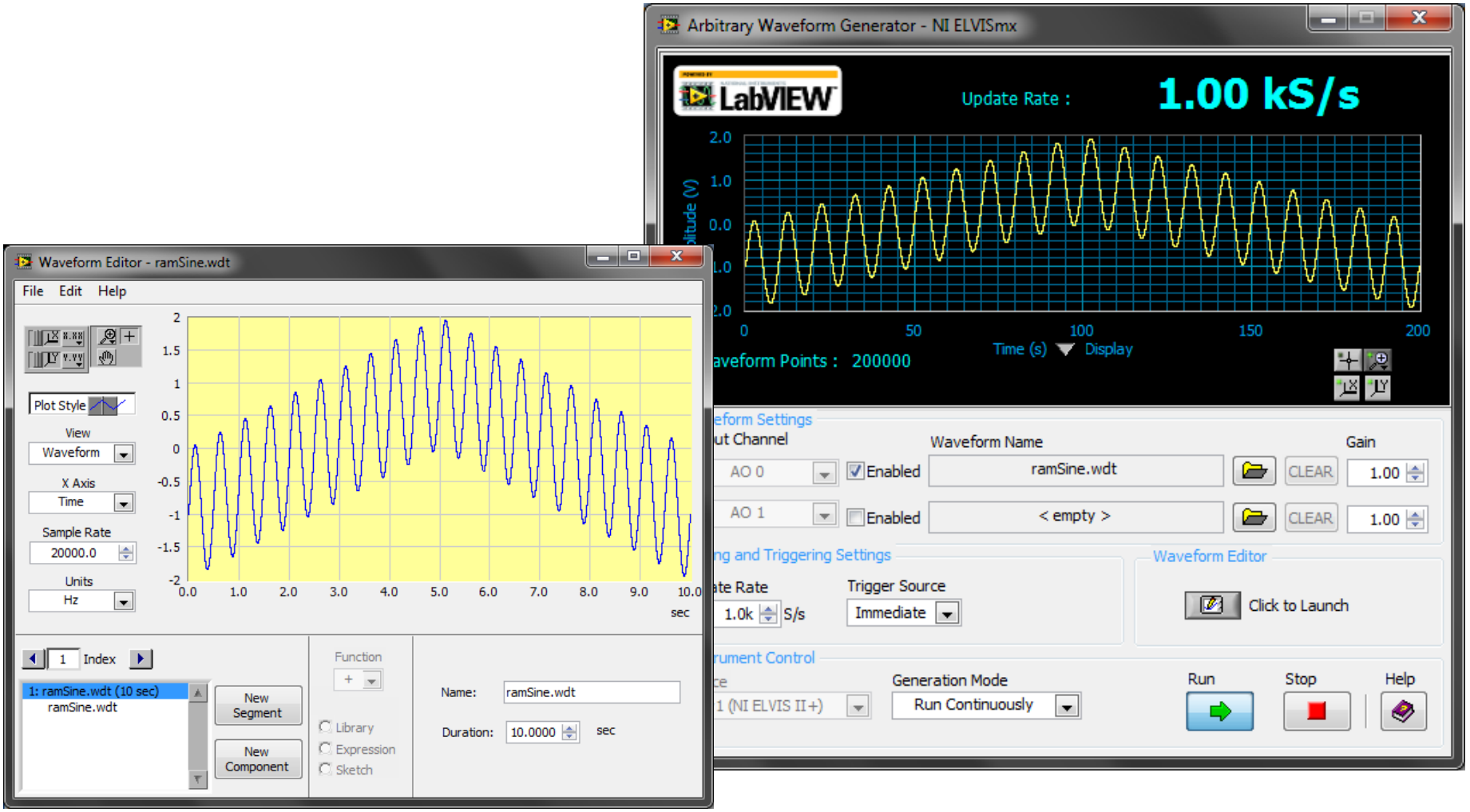
Bode Analyzer



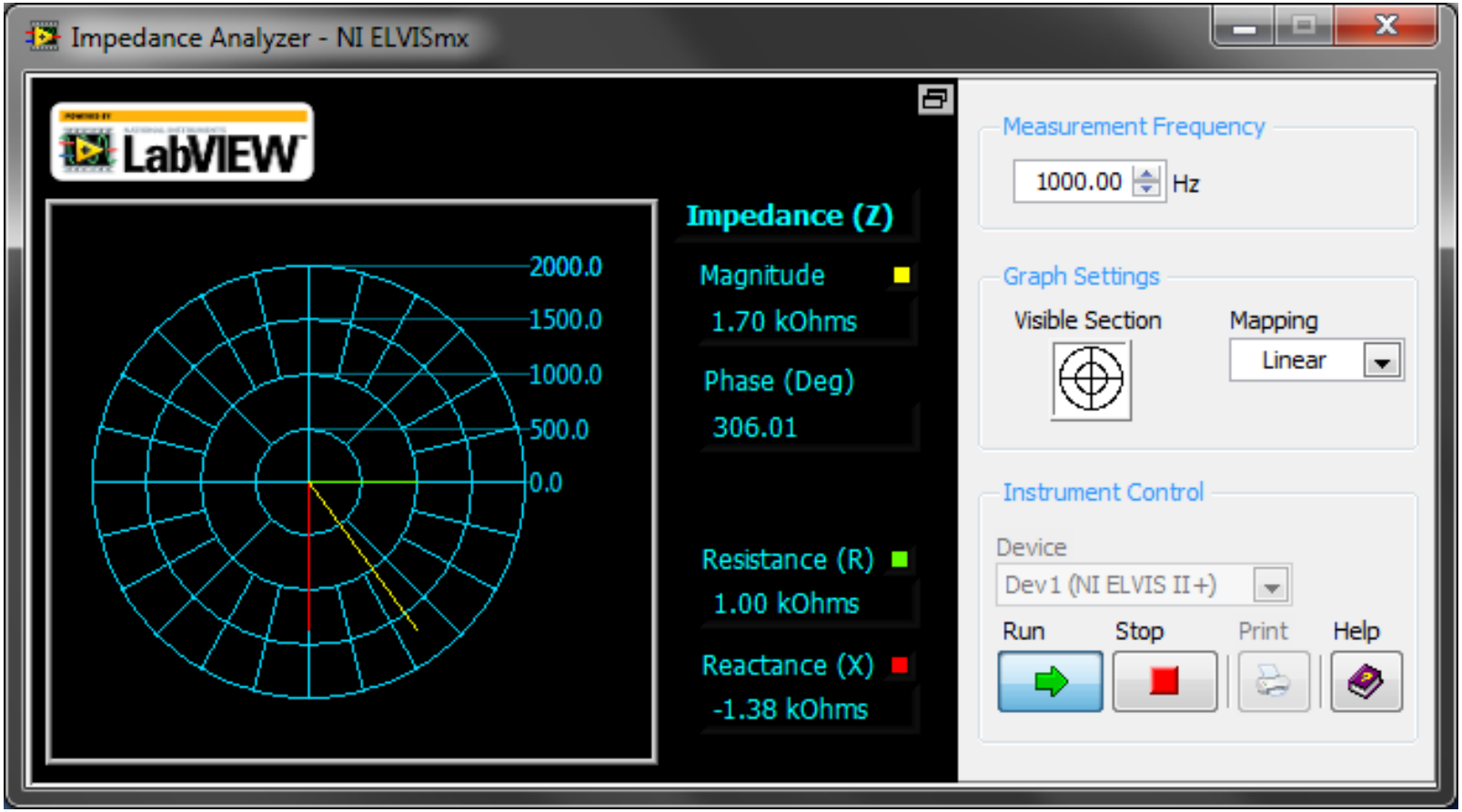
Dynamic Signal Analyzer



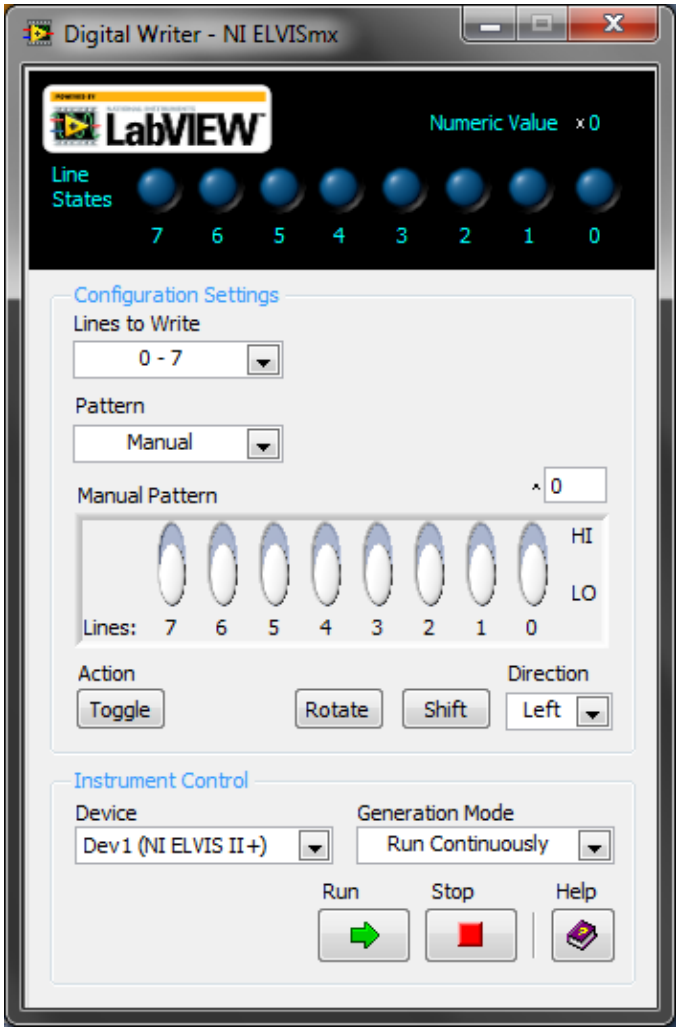
Arbitrary Waveform Generator



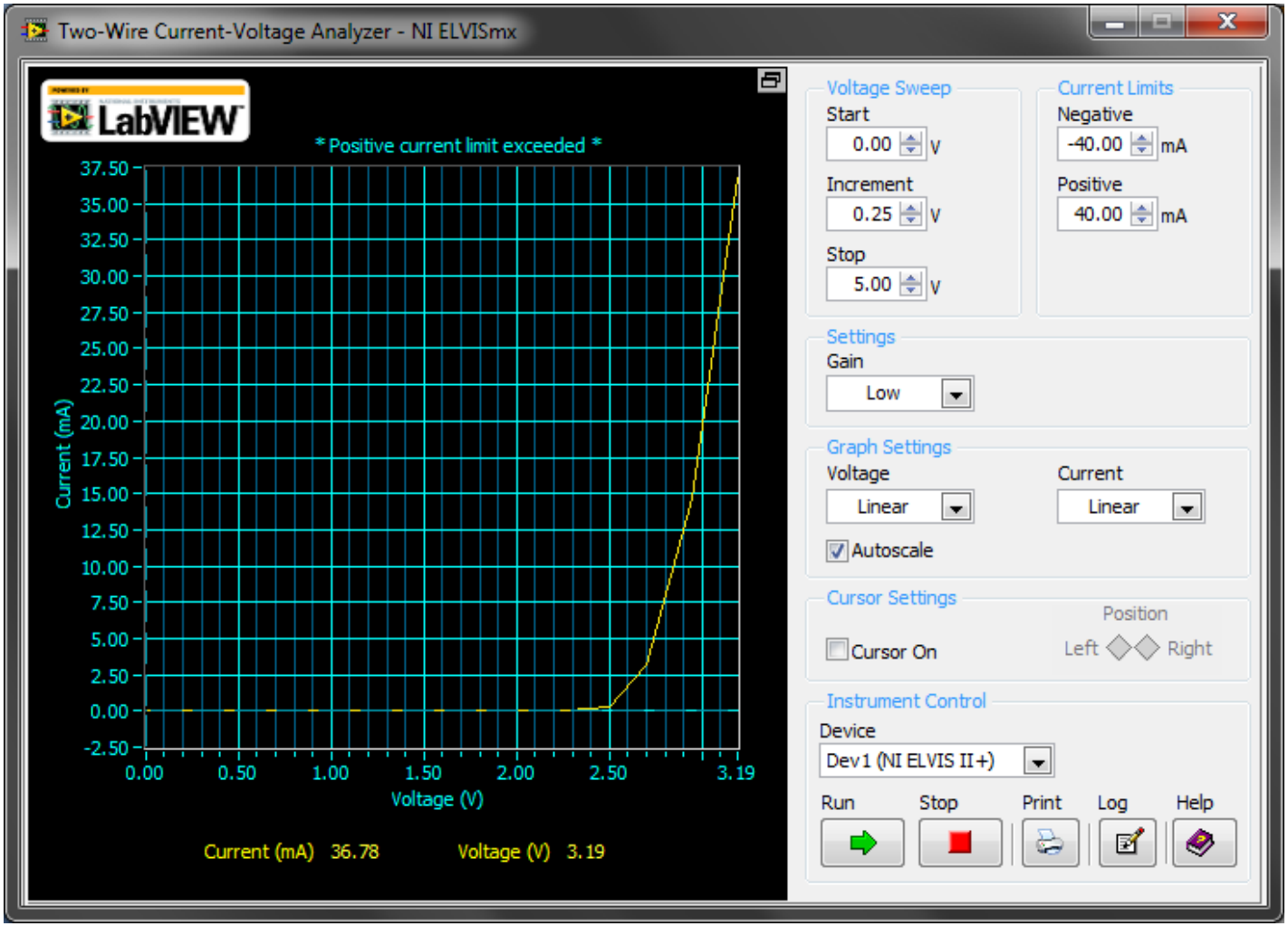
Impedance Analyzer



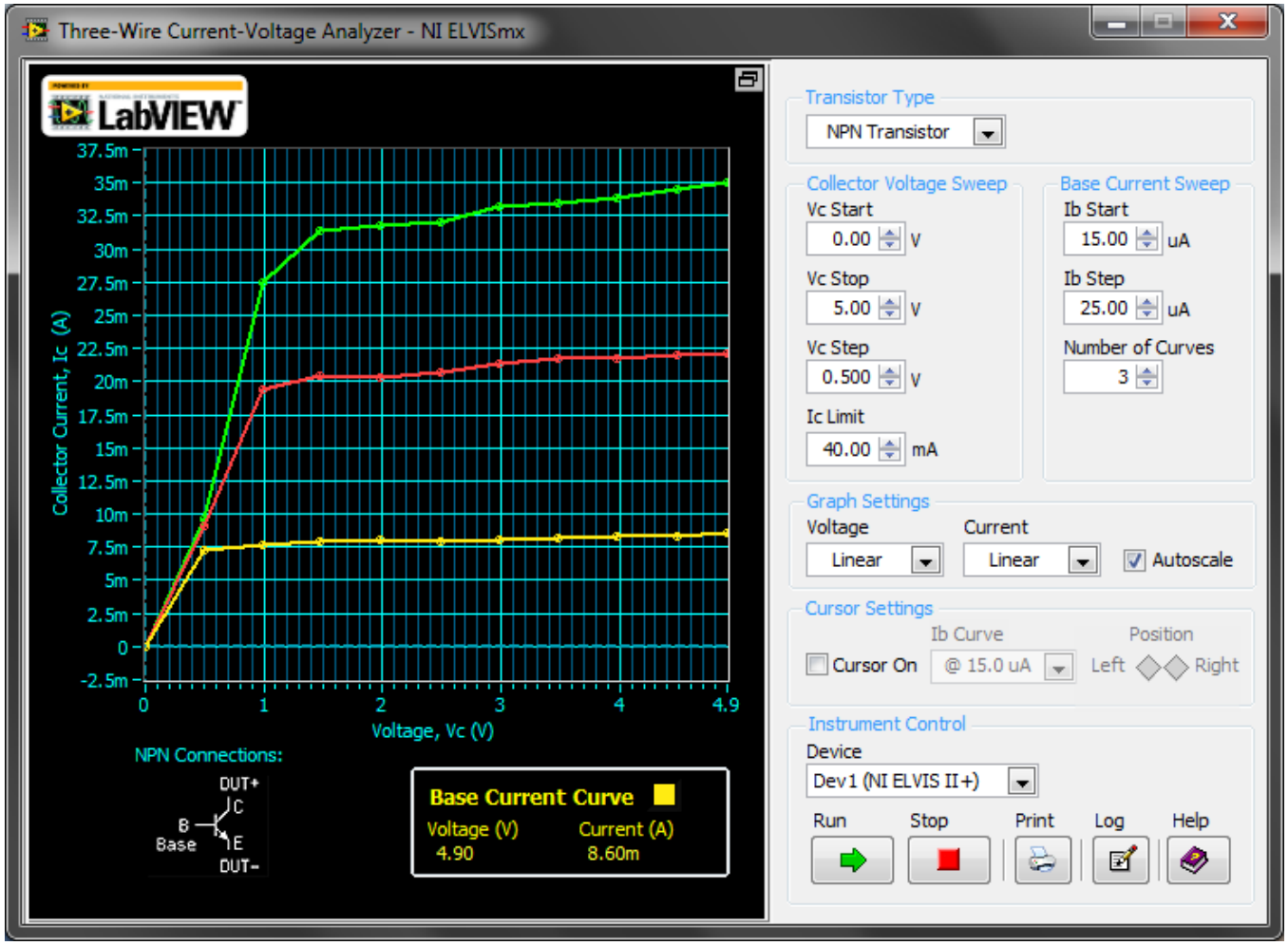
Digital In/Out

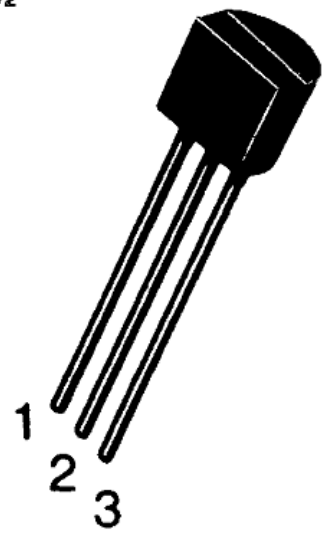


2-Wire Current Voltage analyzer



3-Wire Current Voltage Analyzer





1.Collector 2. Base 3. Emitter

Controls and Mechatronics

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INNOVATE. EDUCATE.

Telecommunications

EMONA tims

NATIONAL INSTRUMENTS

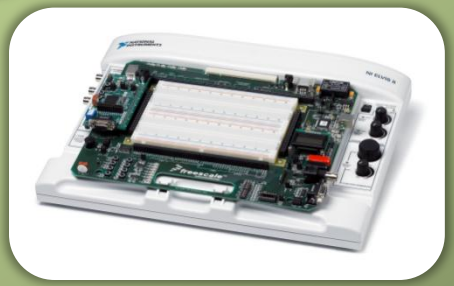
NI ELVIS Platform

Circuits and Measurements

NATIONAL INSTRUMENTS XILINX

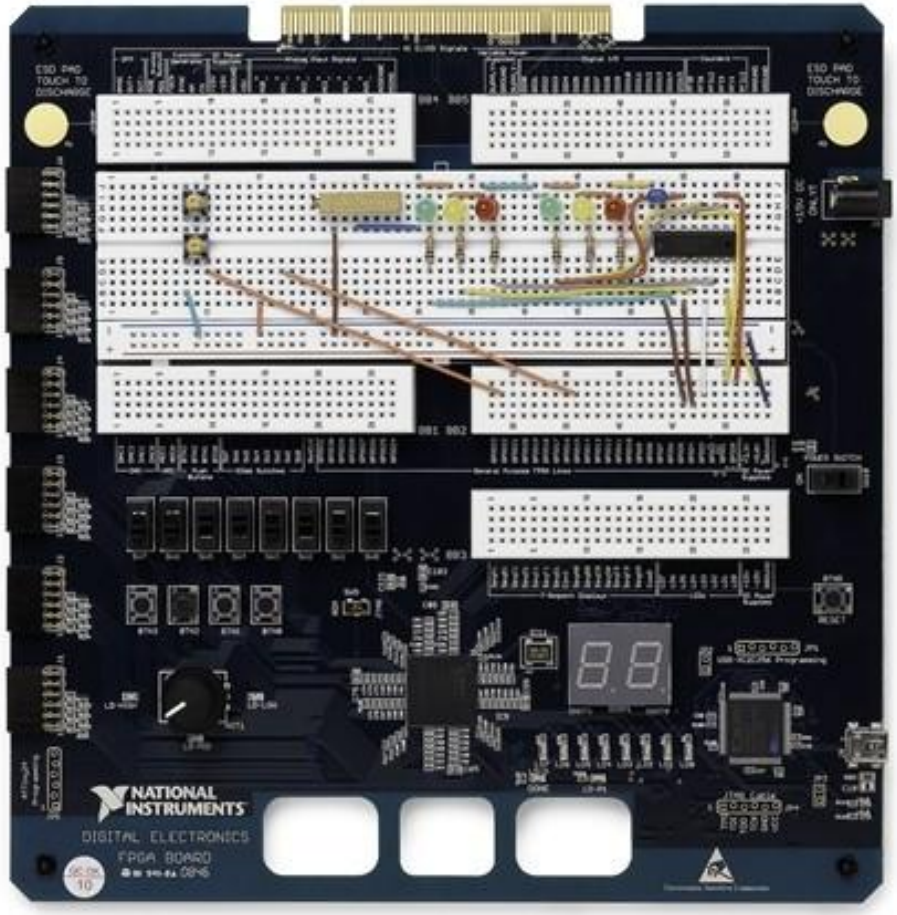
Digital Electronics

freescale semiconductor



Embedded Design

Digital Electronics FPGA

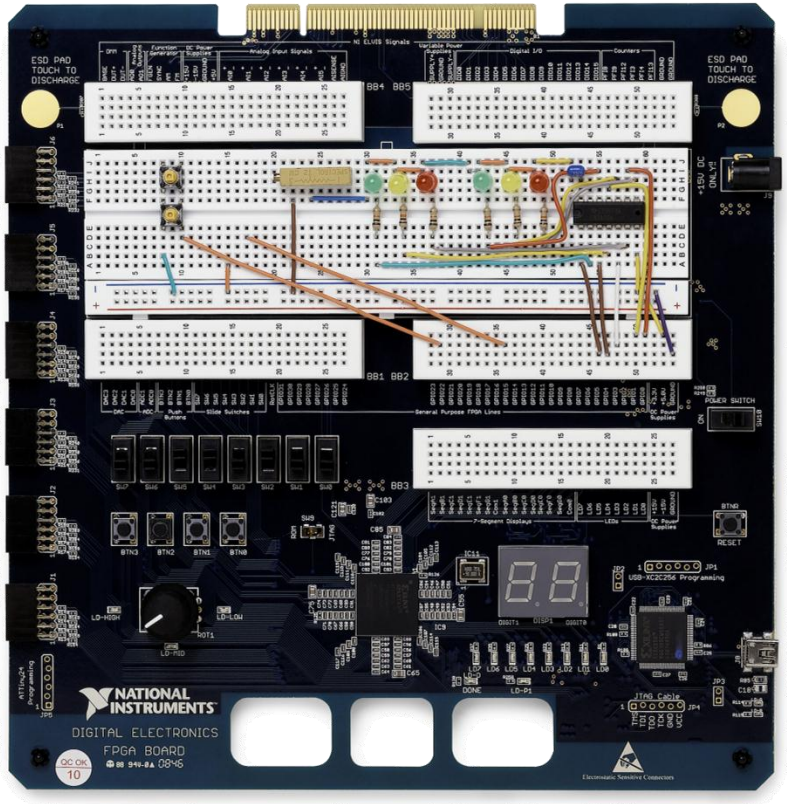


- Xilinx Spartan 3E FPGA
- Integrated Breadboard
- Power Supply
- ADC and DAC
- LEDs
- Push Button Encoder
- 7 Segment Display
- Switches & Buttons
- USB Connection

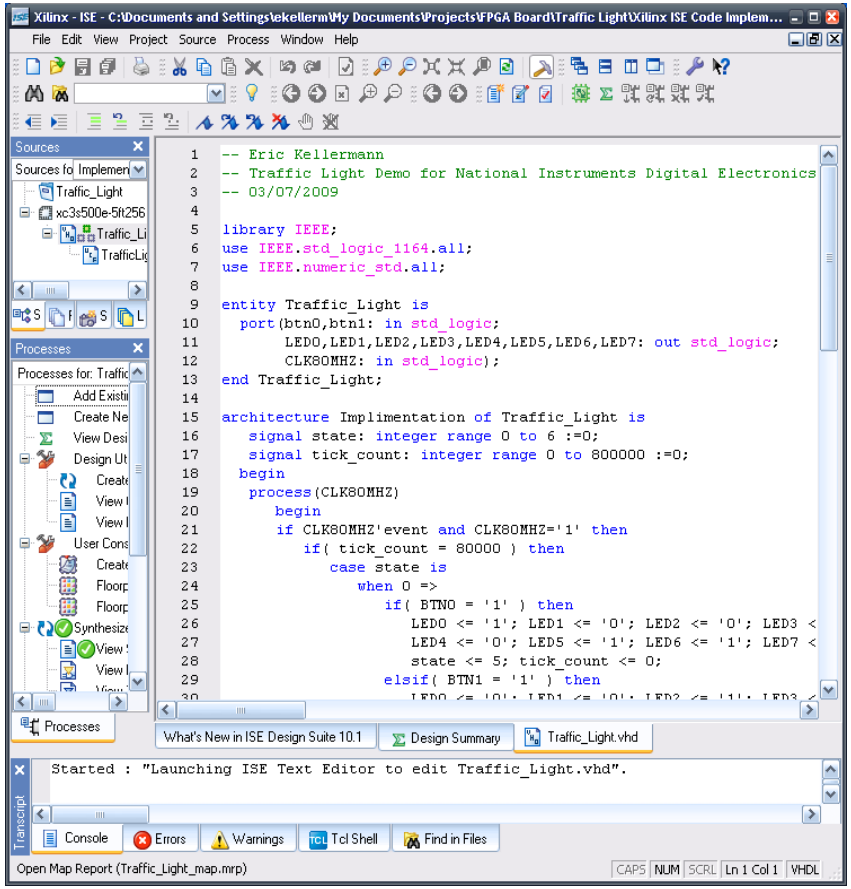
Digital Electronics FPGA

Digital Circuit development platform based on the Xilinx Spartan 3E FPGA

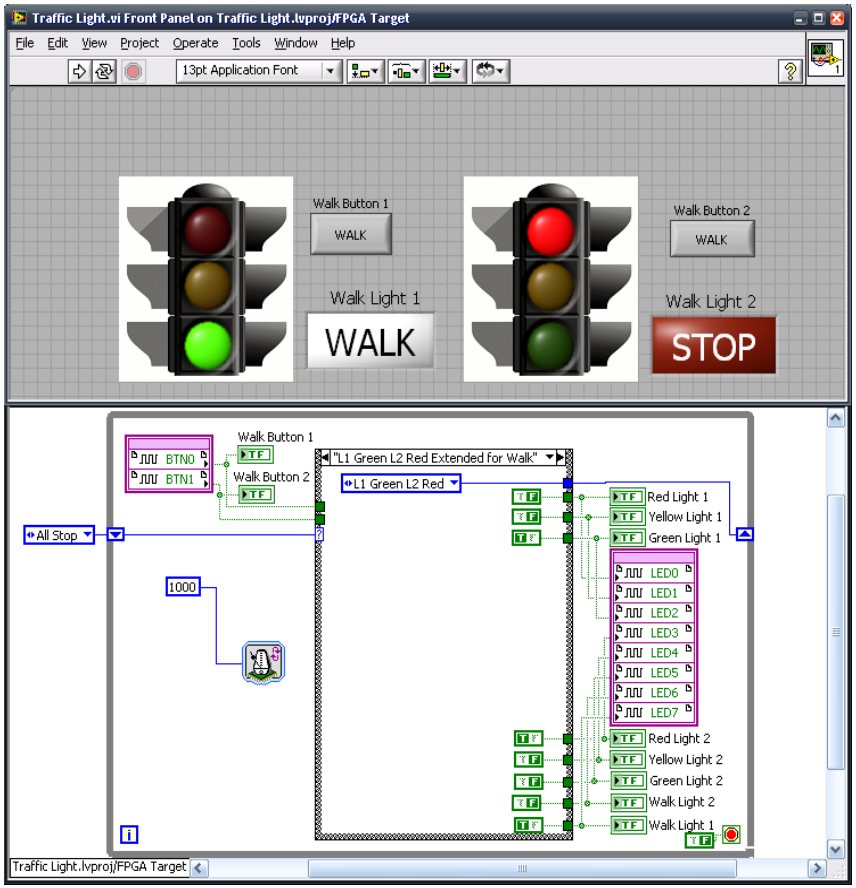
- I/O to teach basic to advance digital electronics concepts
- JTAG-over-USB connectivity
- 6 Pmod connectors



NI DE FPGA Board | Programming

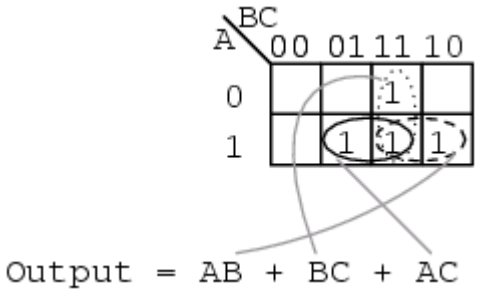


VHDL/Verilog

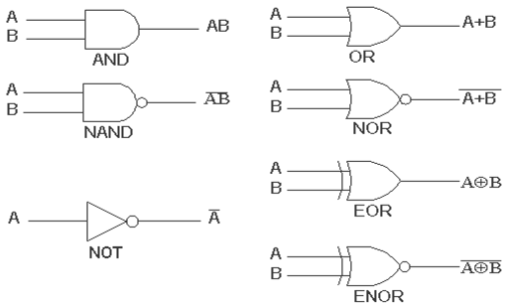


NI LabVIEW

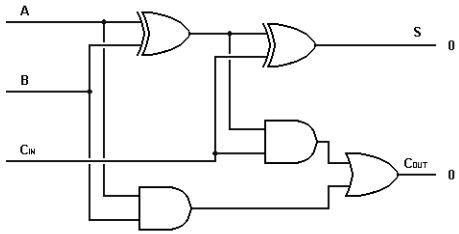
Challenge: Digital Electronics → VHDL



Boolean Algebra



Logic Gates

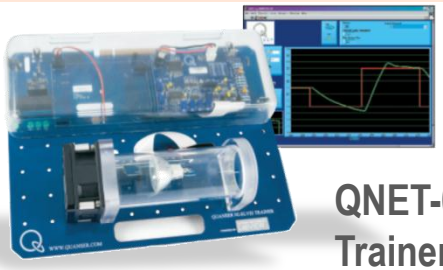


Digital Logic Design

DE FPGA

NI ELVIS | Controls & Mechatronics Plants

QNET-011 Rotary Inverted Pendulum



QNET-012 HVAC Trainer

QNET-010 DC Motor Control Trainer

NATIONAL INSTRUMENTS LabVIEW

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NEW! QNET-014 Mechatronics Sensors 1 Board

NEW! QNET-013 VTOL 1DOF Helicopter Plant

Exammple approach QPSK

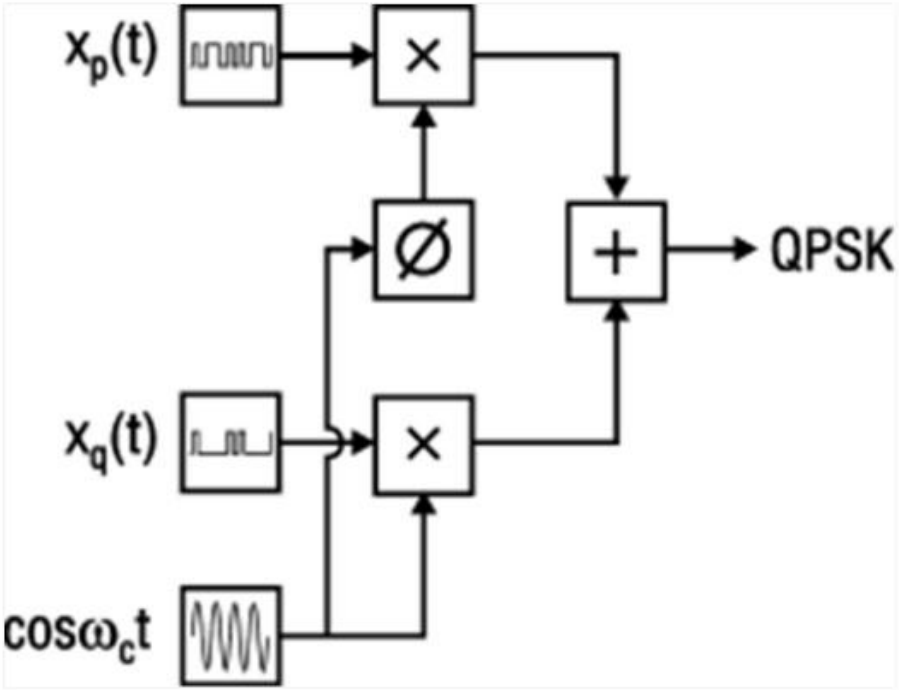
Quadrature Phase Shift Keying

Start with Math and Theory

QPSK = xp(t) * cos(w*t) + xq(t) * sin(w*t)

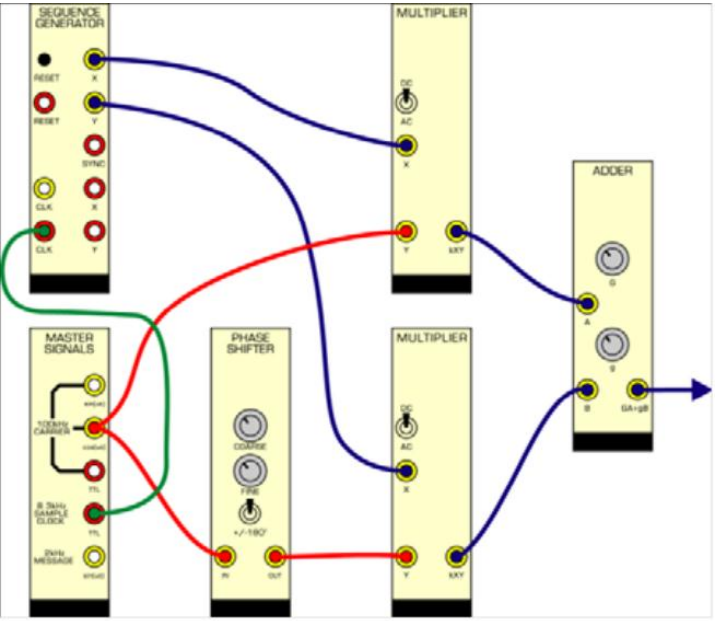
where xp(t) and xq(t) are aternate elements of a digital sequence

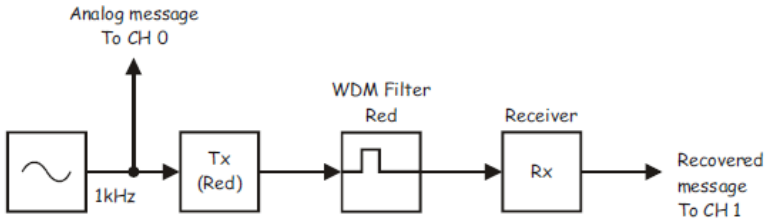
- Represent it as a Block Diagram



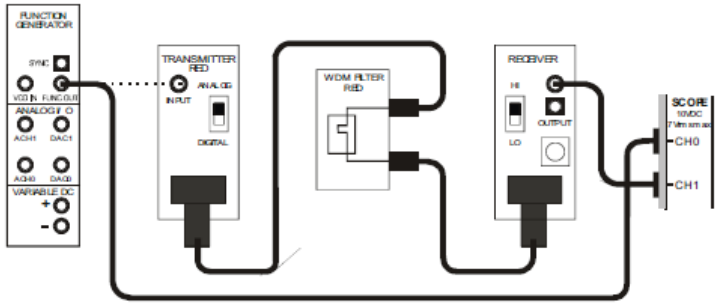
DATEx

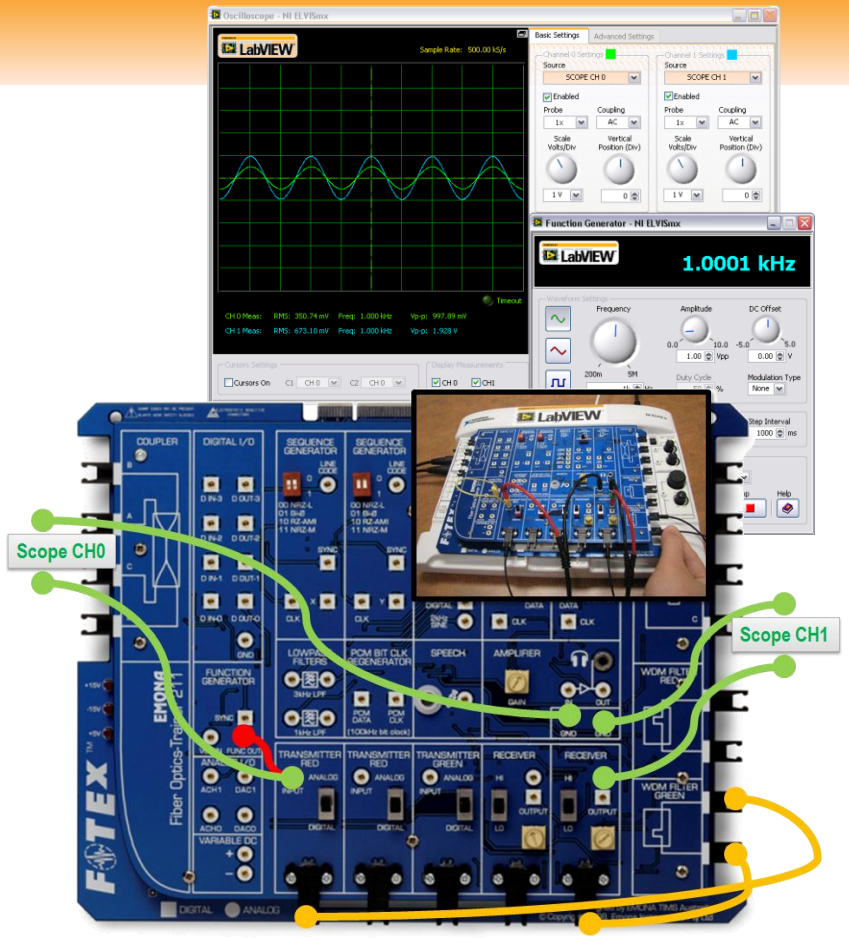
- Build it using DATEx modules





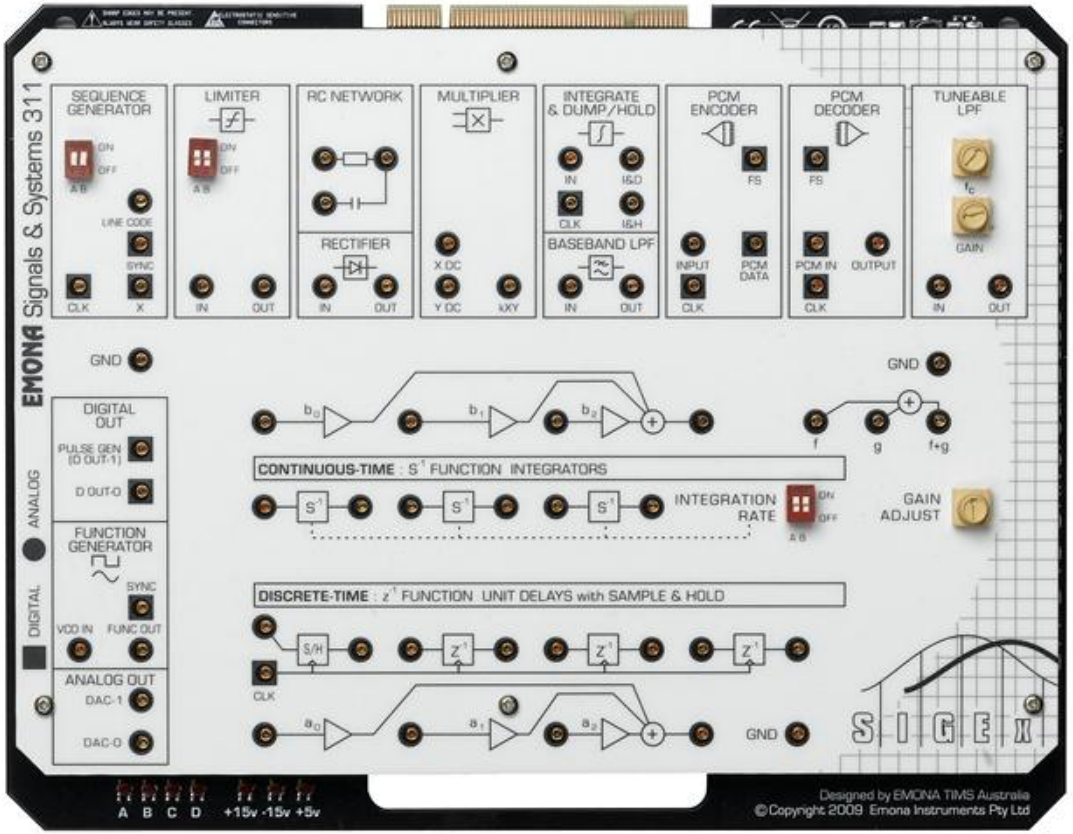
Step 1: Block diagram approach to optical signal filtering, splitting and combining





Step 2: Connecting FOTEx Modules and NI ELVIS Instruments

SIGEx


EMONA Signals & Systems 311
ANALOG
DIGITAL
SEQUENCE GENERATOR
LIMITER
RC NETWORK
RECTIFIER
MULTIPLIER
INTEGRATE & DUMP/HOLD
BASEBAND LPF
PCM ENCODER
PCM DECODER
TUNEABLE LPF
GND
DIGITAL OUT
FUNCTION GENERATOR
ANALOG OUT
CONTINUOUS-TIME : S⁻¹ FUNCTION INTEGRATORS
INTEGRATION RATE
GAIN ADJUST
DISCRETE-TIME : z⁻¹ FUNCTION UNIT DELAYS with SAMPLE & HOLD
A B C D
+15v -15v +5v
SIGEX
Designed by EMONA TIMS Australia
©Copyright 2009 Emona Instruments Pty Ltd

SIGEx

REAL HARDWARE FUNCTIONAL BLOCKS - FULLY INTEGRATED WITH NI ELVIS™

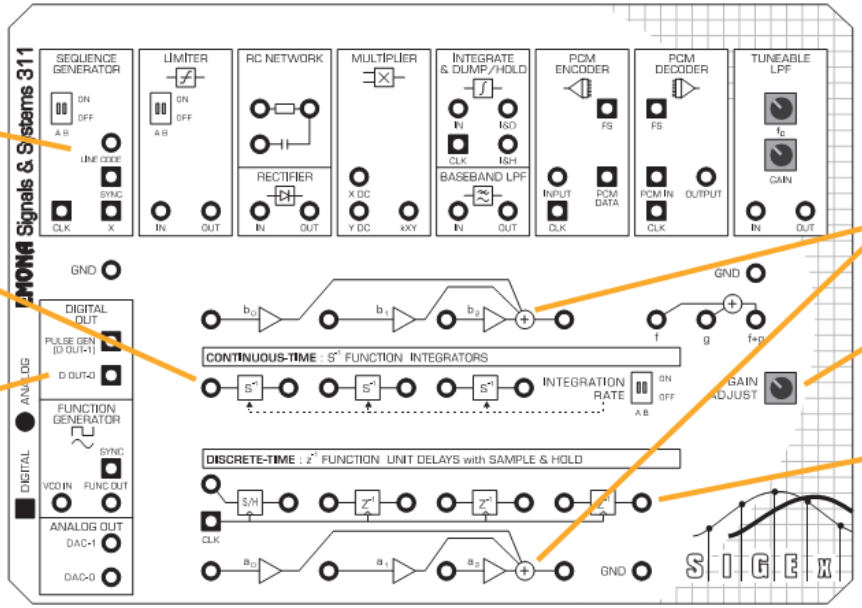
A Complete Suite of Signals & Systems Functional Blocks

The SIGEx-311 board includes all of the functional blocks - integrators, sample-and-hold, unit delays and supporting blocks - required for all experiments, as well as access to powerful instruments from NI ELVIS™.

A selection of independent functional SYSTEM blocks

Three 1/s functions

Access to NI ELVIS instruments, including
- Clock generator
- Function generator
- Dual ARB generator



Three input ADDERS with user adjustable gains

Manual adjustment of on-screen ADDER gain values

Three UNIT DELAYS, preceded by a SAMPLE & HOLD

SIGEx add-on board for the NI ELVIS™ platform

NI ELVIS | Telecommunications & Fiber Optics

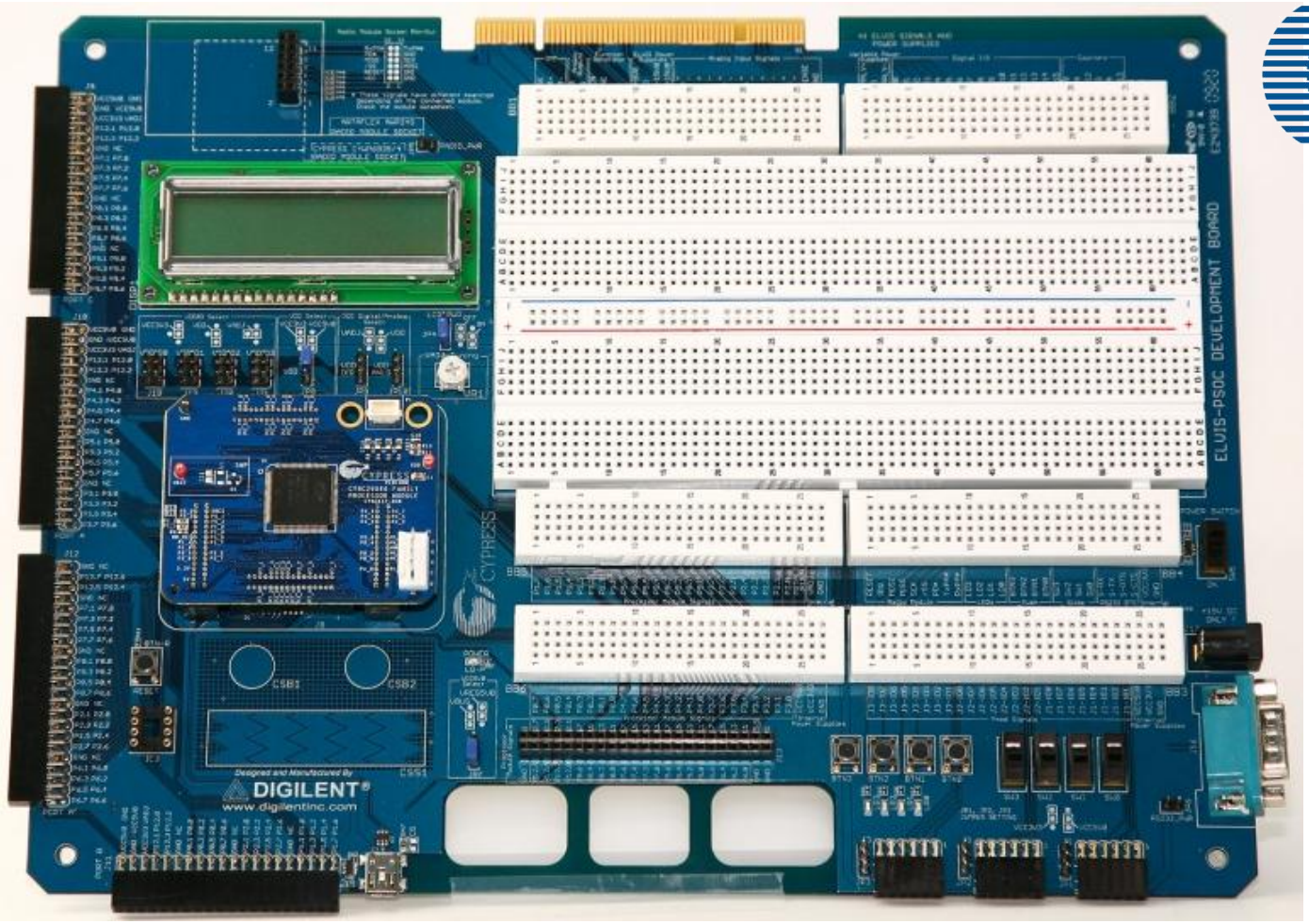
Emona FOTEx ETT-203

Emona DATEx ETT-202

Emona SIGEx ETT-311

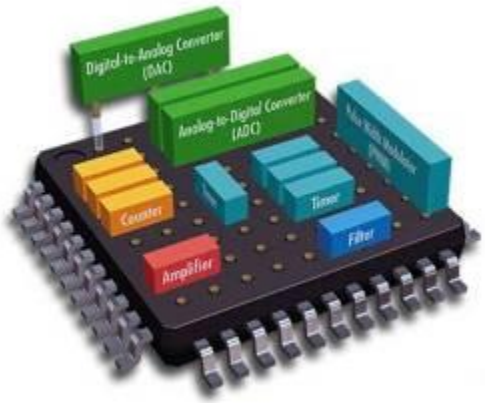
Teaching materials included

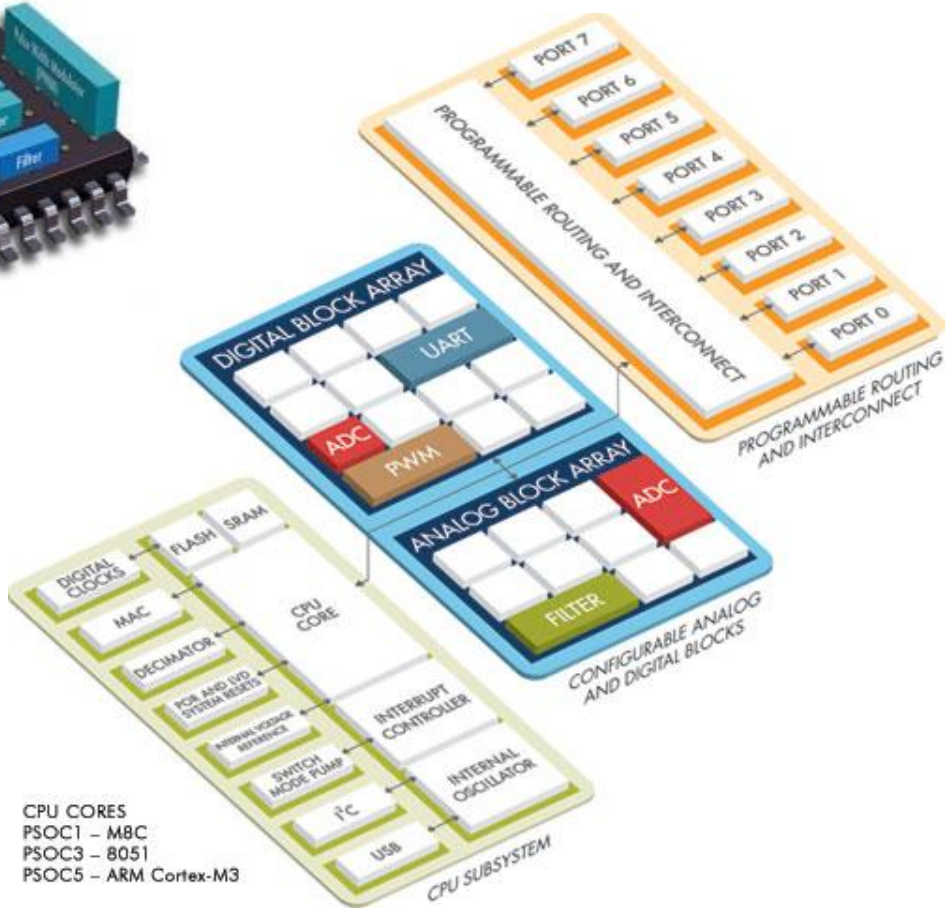
Cypress PSoc NI ELVIS board

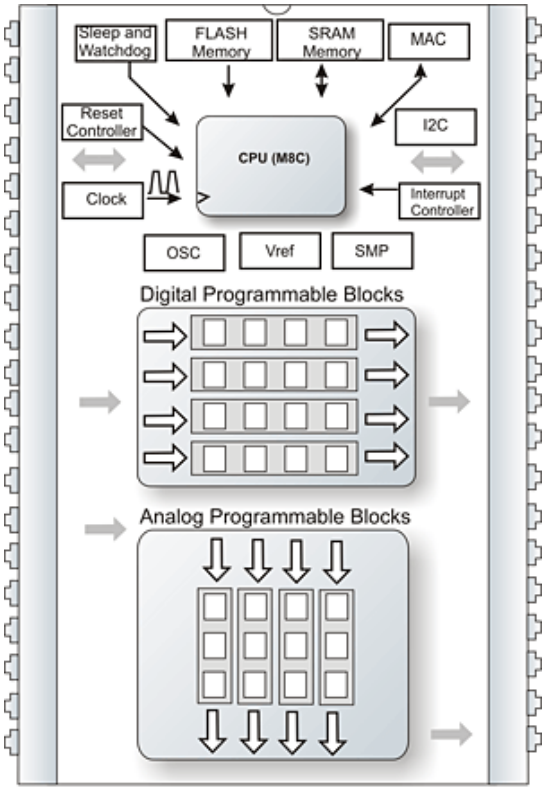


CYPRESS PERFORM

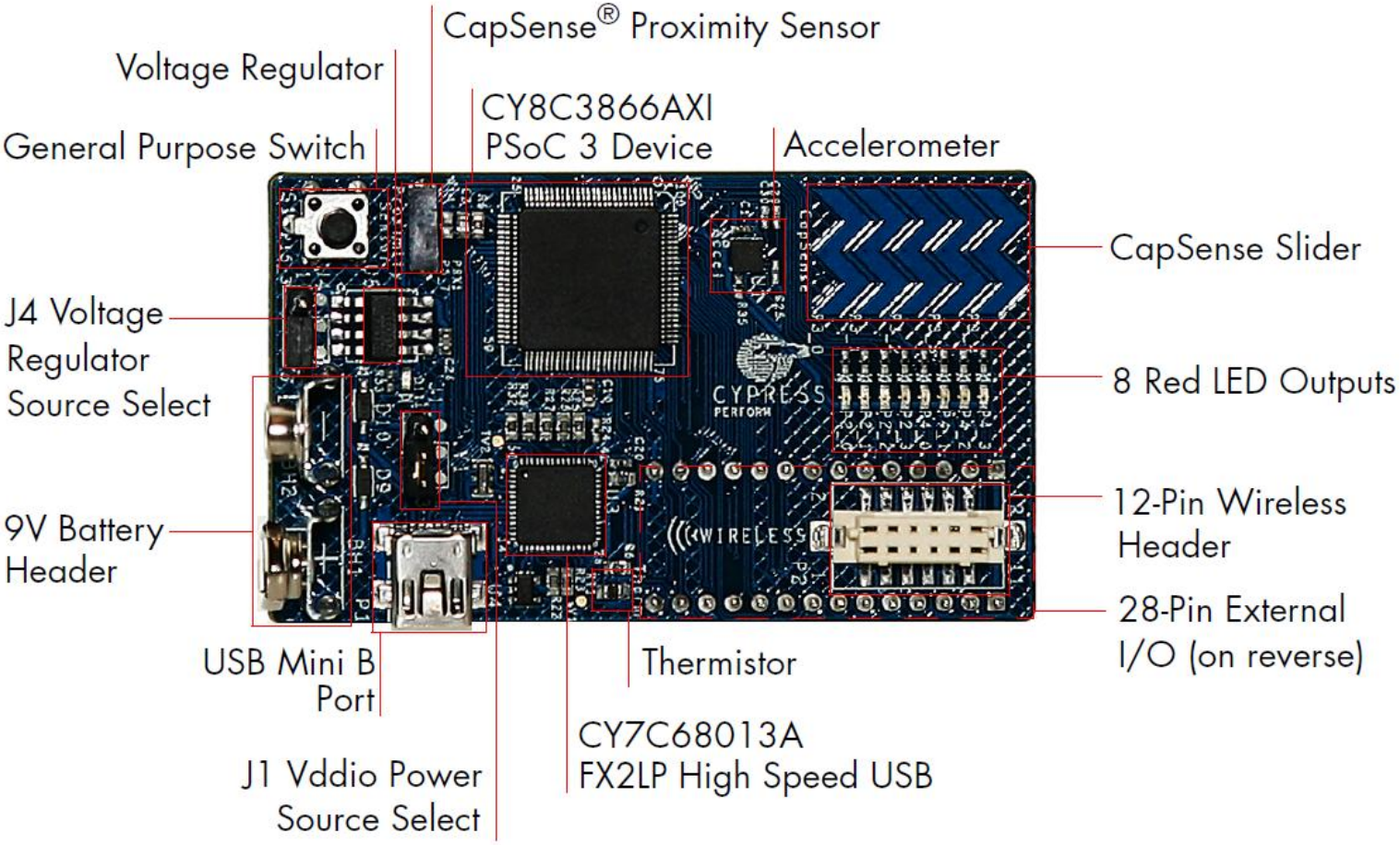
Cypress PSoc NI ELVIS board





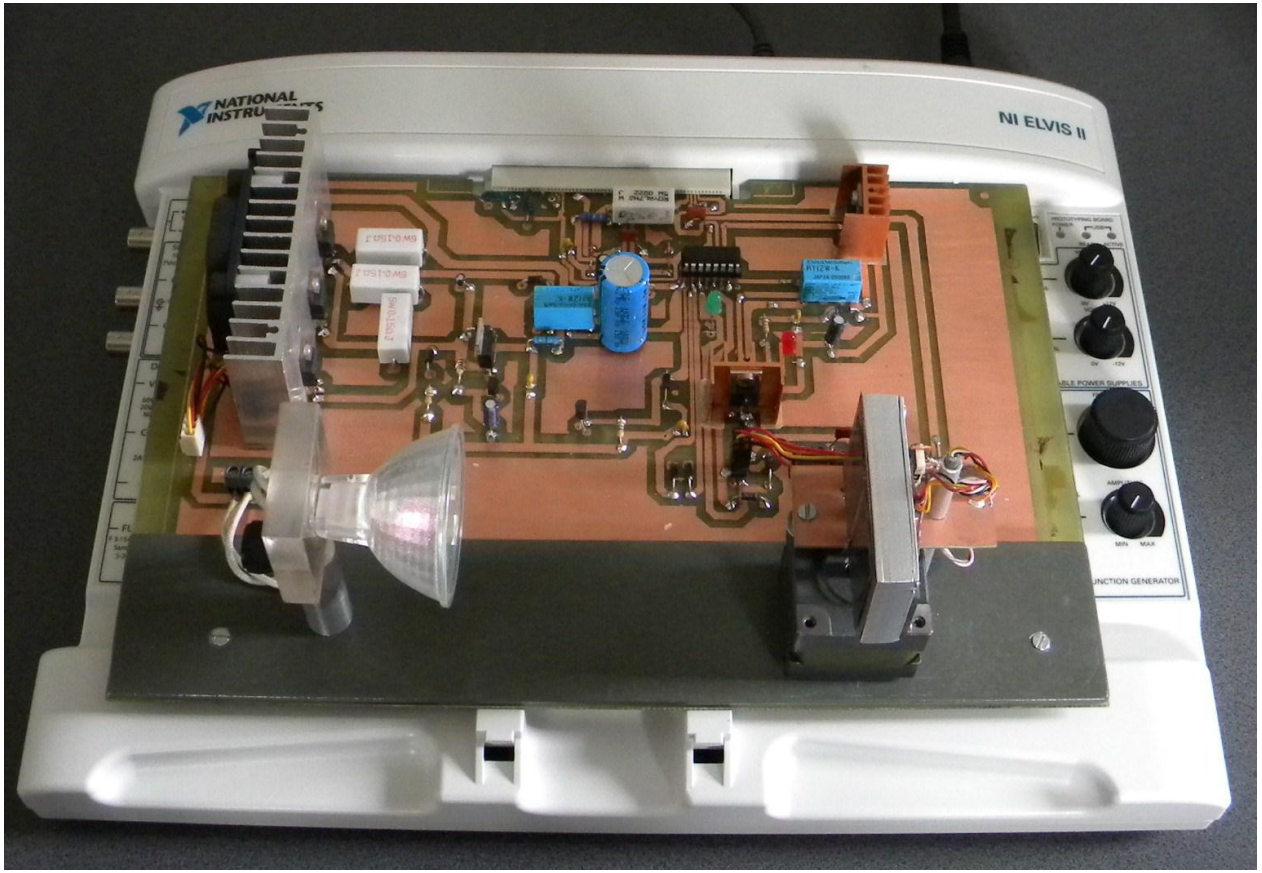


Example of daughterboard PSoC 3 kit



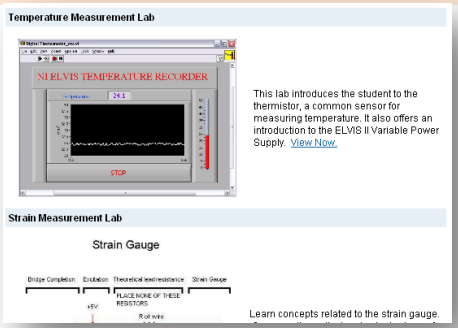
In case it’s still not enough….

DYI boards for Elvis

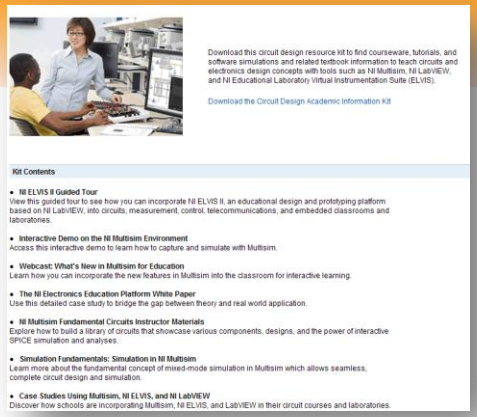


Online Resources

NI ELVIS II Guided Tour



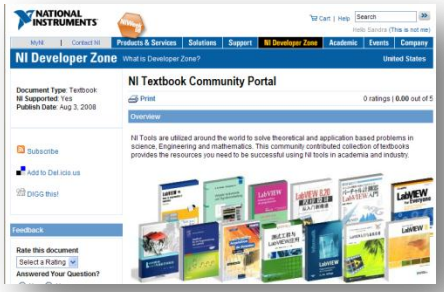
Courseware



Download Resource Kits

ni.com/nielvis

Webcast



Textbook Resources

Case Studies & White Papers

NI myDAQ Features

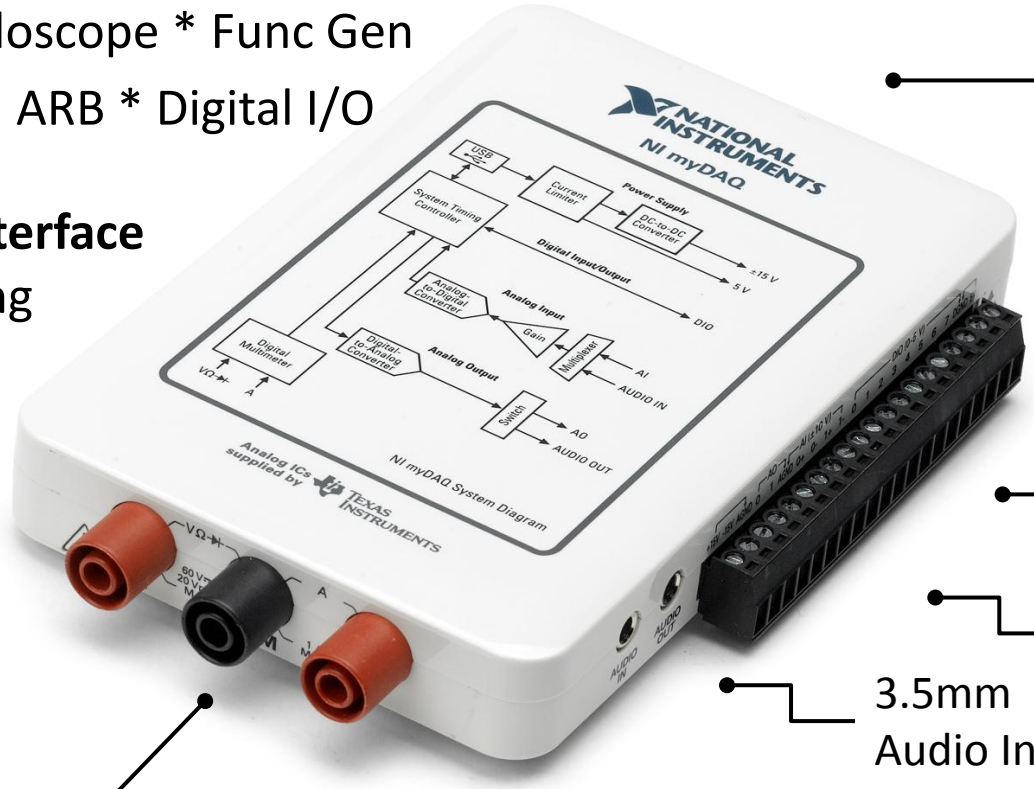
Plug & Play Instruments

DMM * Oscilloscope * Func Gen

Bode * DSA * ARB * Digital I/O

Computer Interface

LabVIEW using
NI DAQmx



USB Bus Powered

±15 V and 5V
Power Supply

8 Digital In/Out

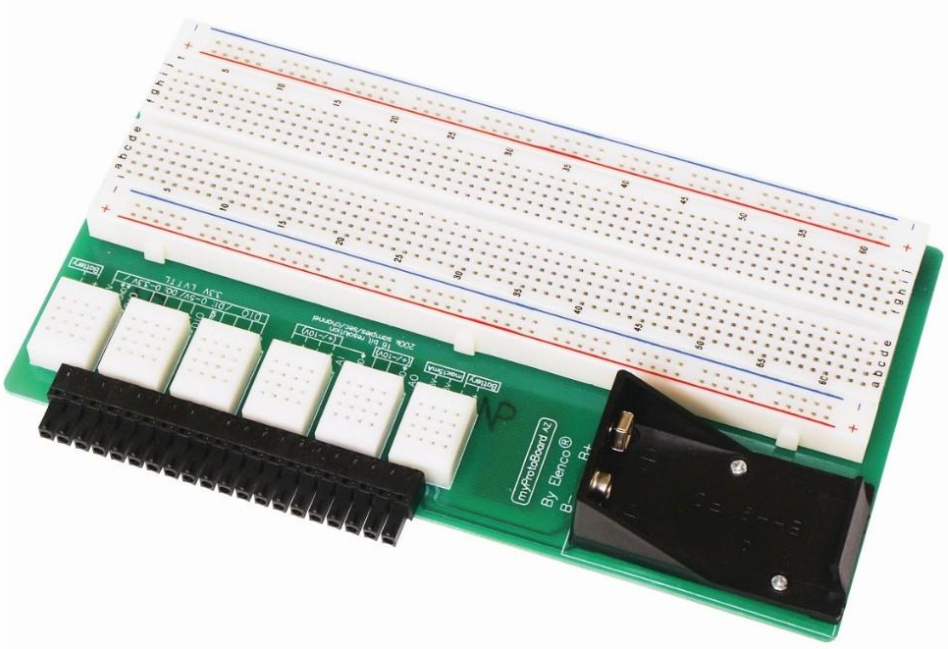
1 Counter

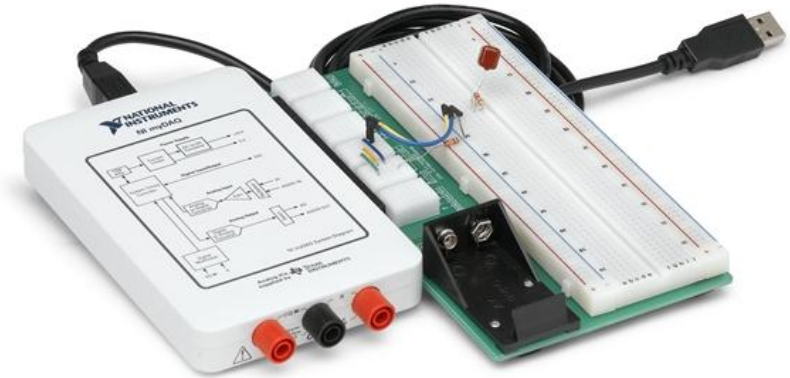
Analog In/Out
2 ch, 200ks/s

3.5mm
Audio In/Out

Integrated DMM
V, I, Ω, Diode

MyDAQ Prototyping Board





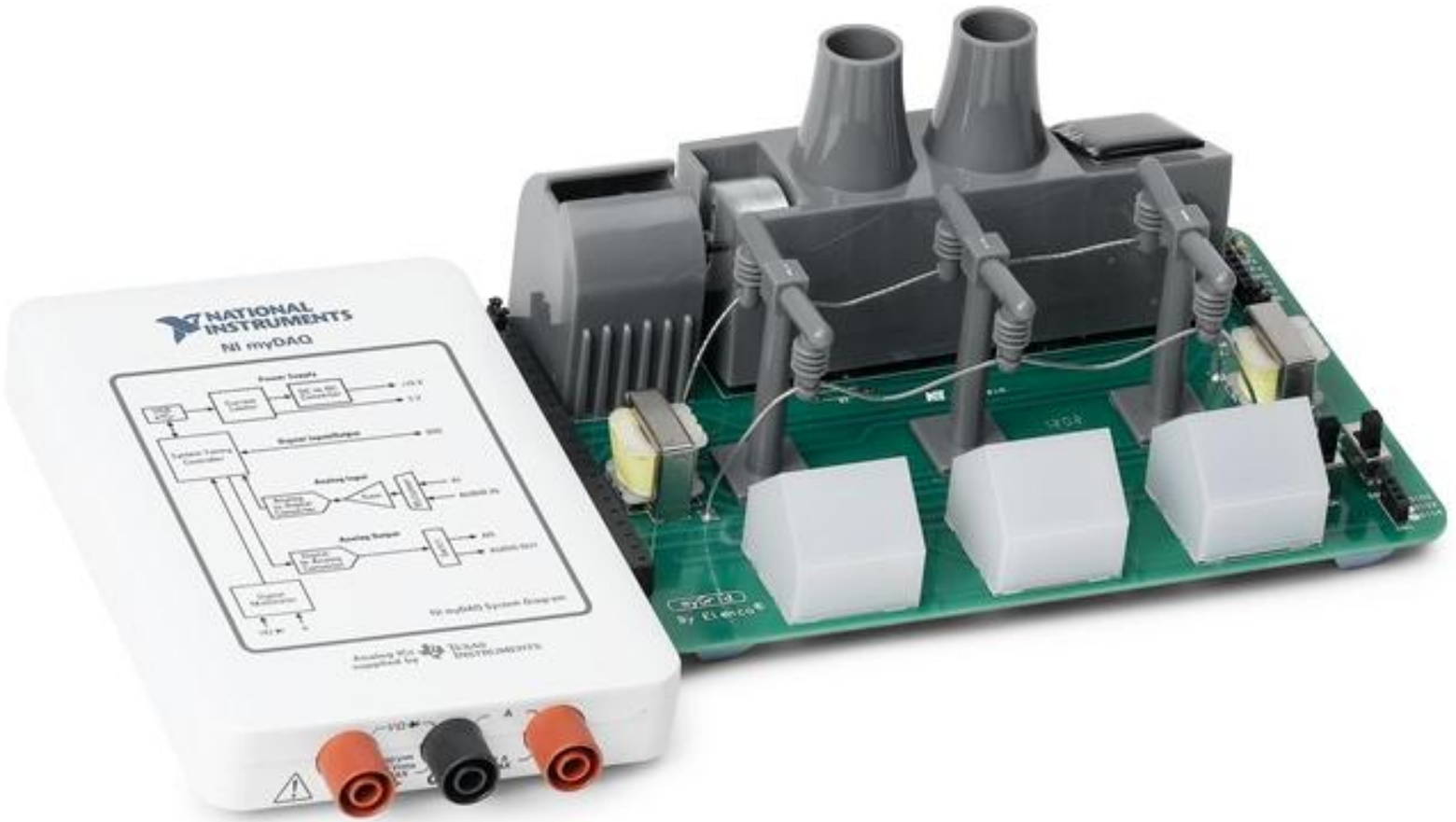
https://decibel.ni.com/content/groups/mydaq

My DAQ connectivity board

MyDAQ Agroentineering Farm plant

MyDAQ Dynamometer plant

MyDAQ Smartgrid plant

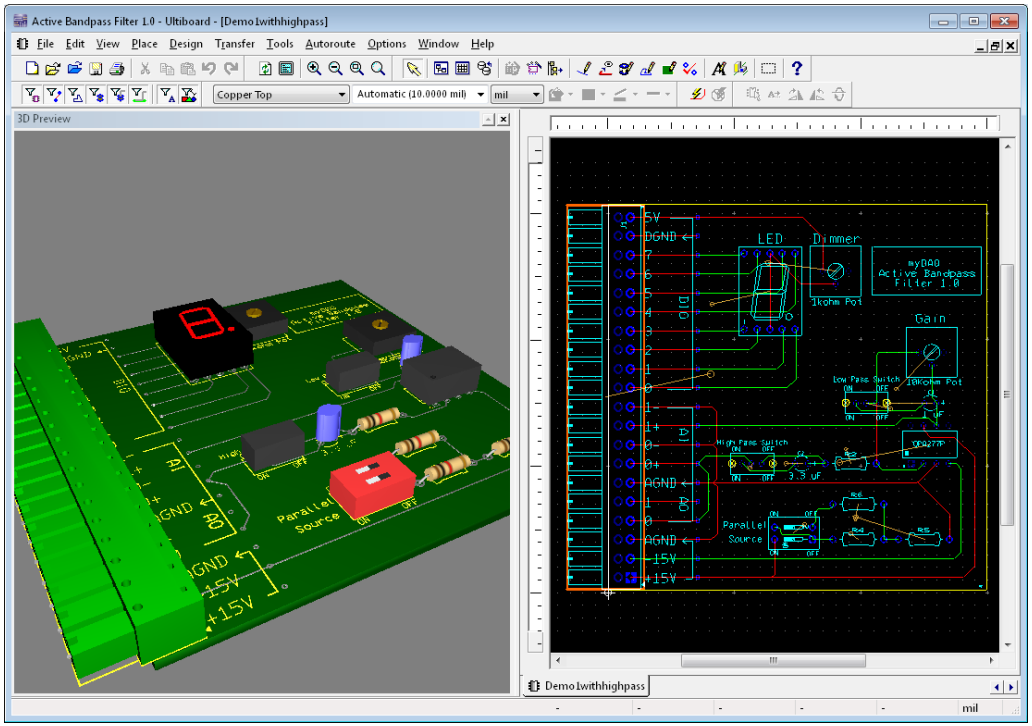


Endless Possibilities…

Extend learning with custom modules

- Custom signal conditioning
- Custom control plants
- Experiment kits
- Student design

Custom PCBs & Signal Conditioning

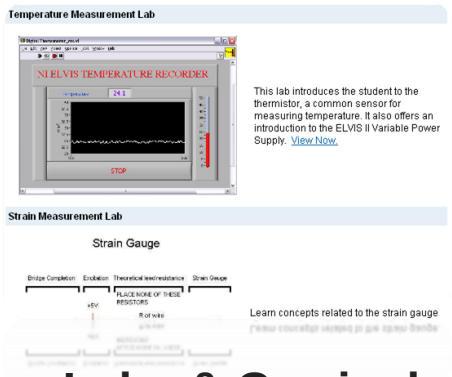


Low Cost Mini-System Experiments

(Custom PCB design templates available in NI)

Online Resources

Webcasts

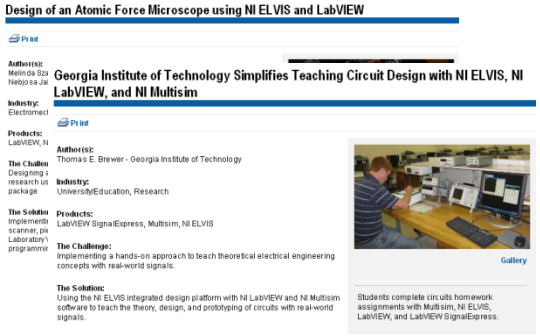


Labs & Curricula

ni.com/academic

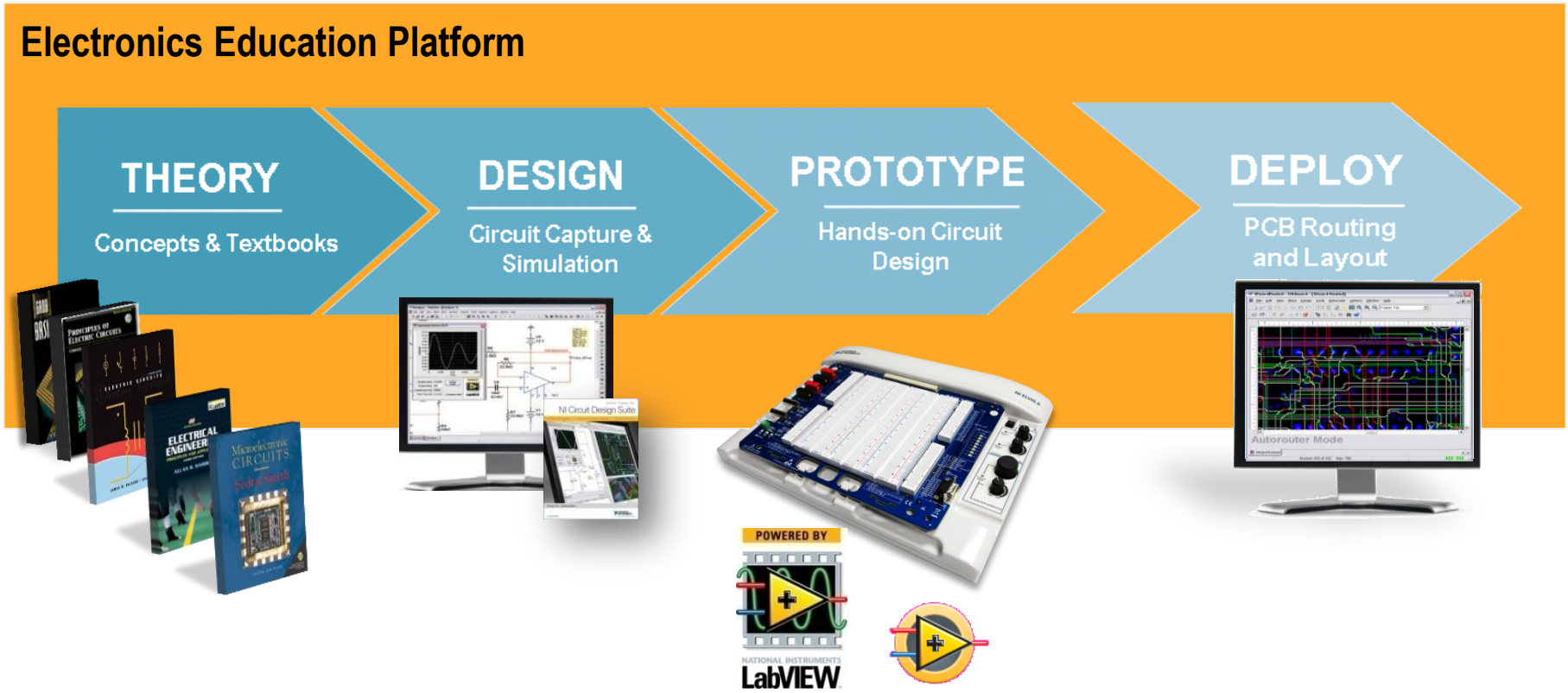
ni.com/nielvis

Textbook Resources



Case Studies & White Papers

NI Electronics Education Platform



Multisim & Other SW Tools

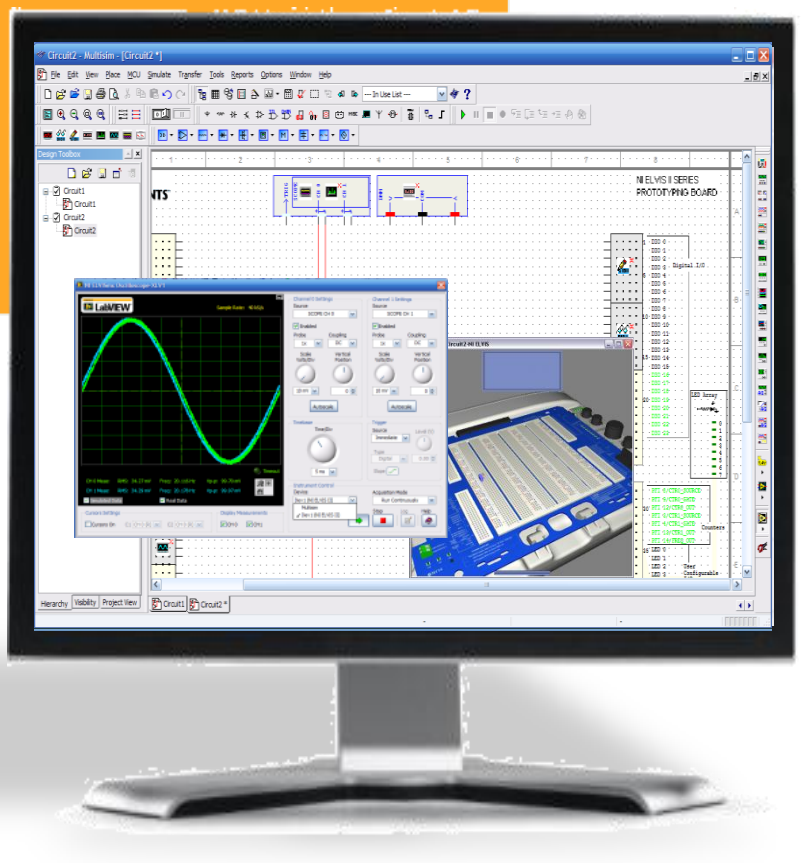
Agenda

A. Introduction to the NI Multisim
B. Schematic Capture
C. Simulation
D. Prototyping
E. Measurement and Comparison
F. Multisim Addons
G. other SW tools for co-simulation

NI Multisim 12

NI Multisim

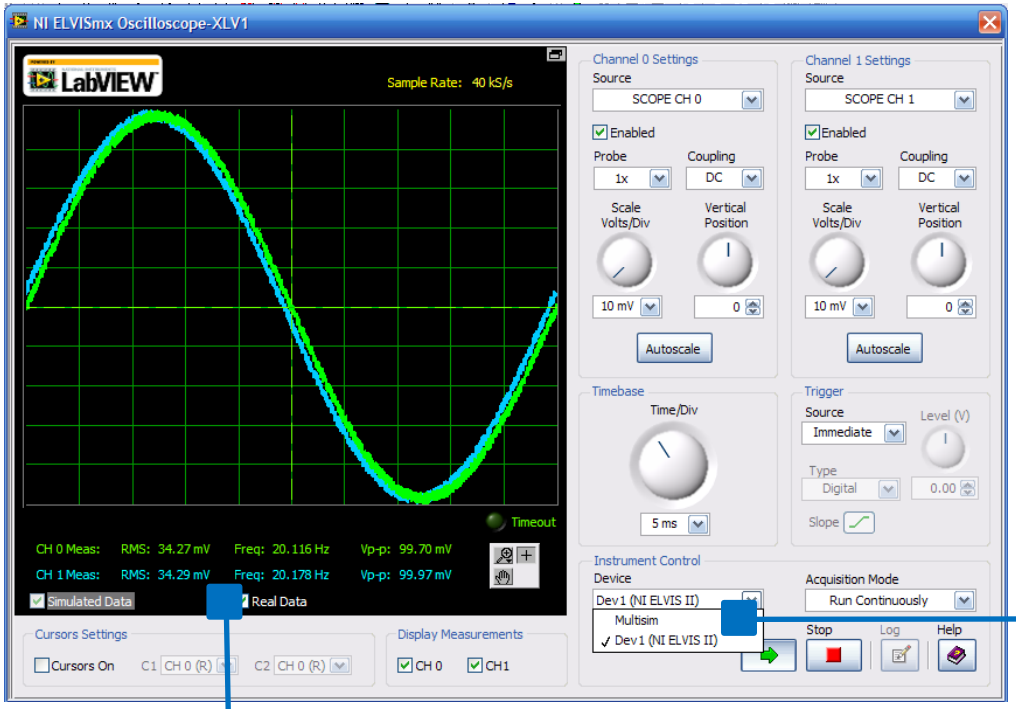
Unified environment for teaching circuit theory and design through capture and simulation



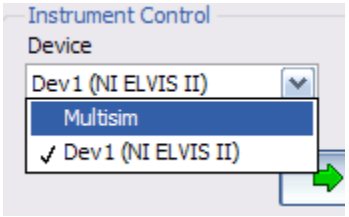
- SPICE-based simulation
- Interactive mixed-mode simulation
- NI ELVIS instruments inside Multisim
- 20 SPICE analyses
- 22 measurement instruments
- MCU simulation support
- Power and Machine components (motors..)
- PLD design tools
- Multisim and LabView Co-Simulation

Theory and Measurement

Compare simulated data and measured signal on the same instrument



Access NI ELVIS hardware With one click switch between simulated signals and acquiring signals from your NI ELVIS II hardware

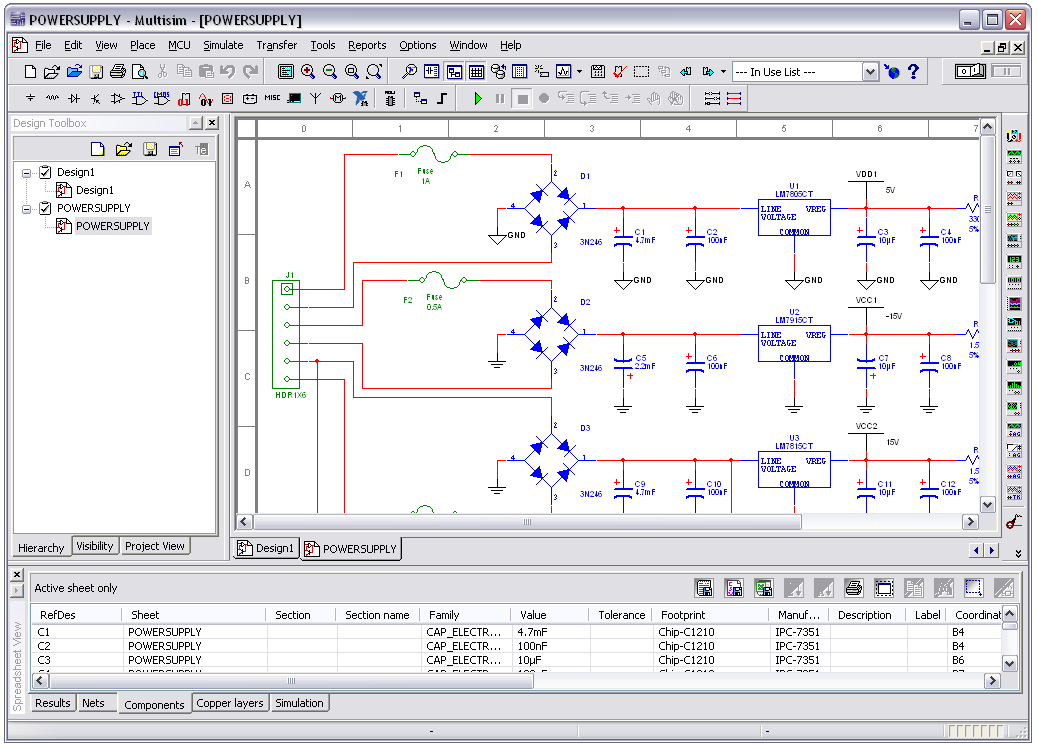


NI ELVIS II Instruments Compare simulated Multisim data with measured signals from NI ELVIS II within Multisim

What is Multisim?

- General purpose EDA tool
- Schematic Capture
- Simulation
- Analyses
- Integrated

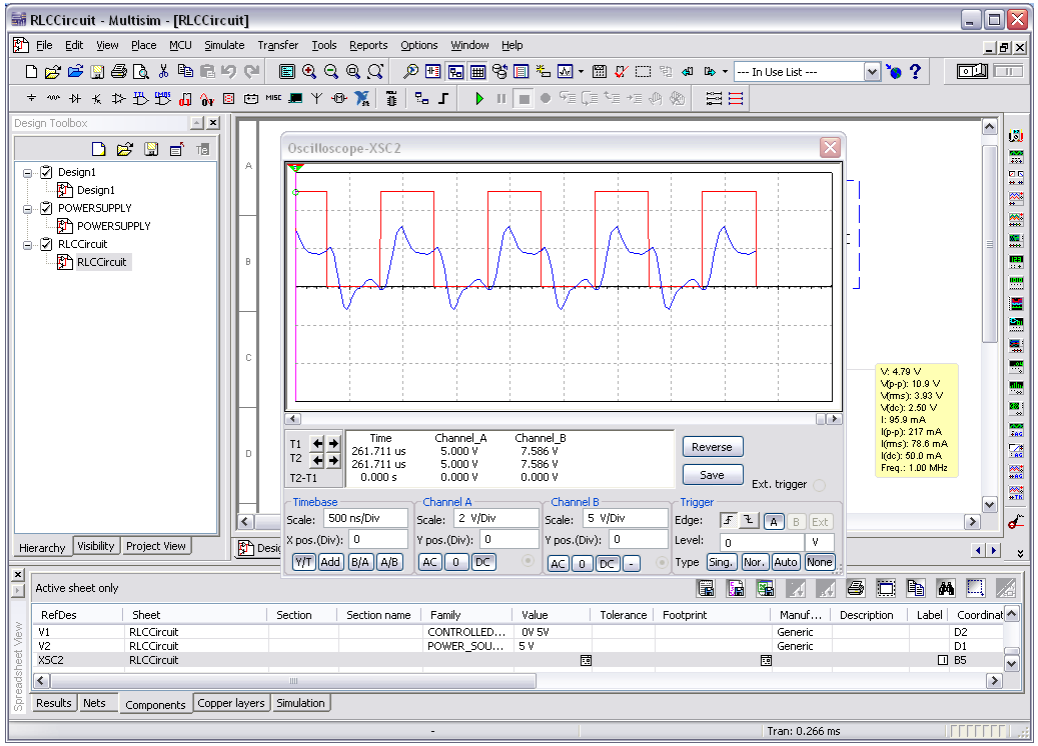
  Environment



Benefits of Integrated Capture & Simulation

- Preparation for simulation is as simple as drawing a circuit
- Interactive Simulation
- Animated Parts
- Virtual Instruments
- Analyses and Graphs

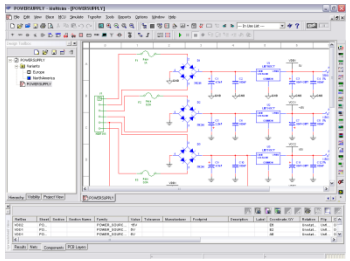
Effective use of your time!

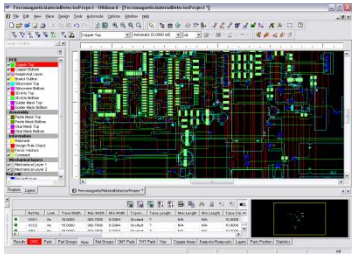


The Design Process

Where does Multisim fit in the design flow?

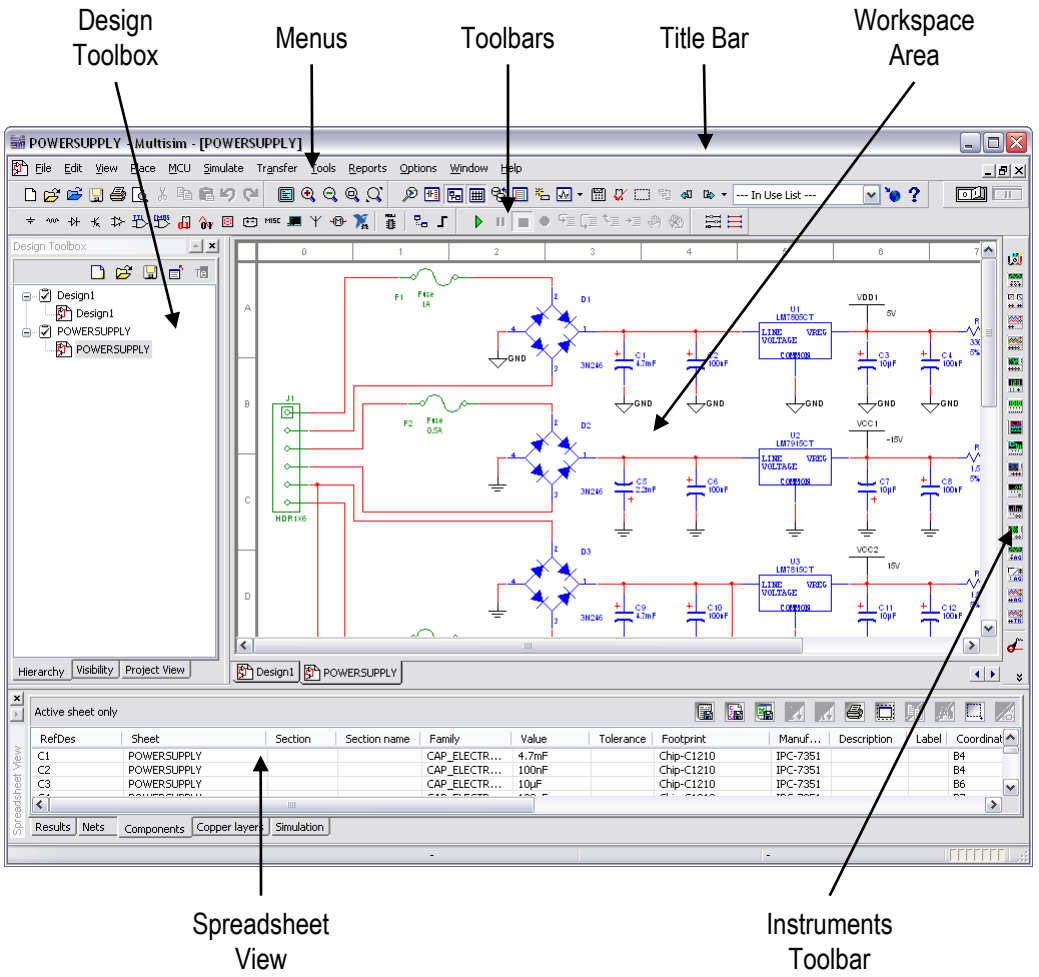
NI Multisim™ NI Ultiboard™ LabVIEW





The Multisim GUI

- Organized menus
- Quick access toolbars
- Design Toolbox
- Spreadsheet View
- Resizable Workspace

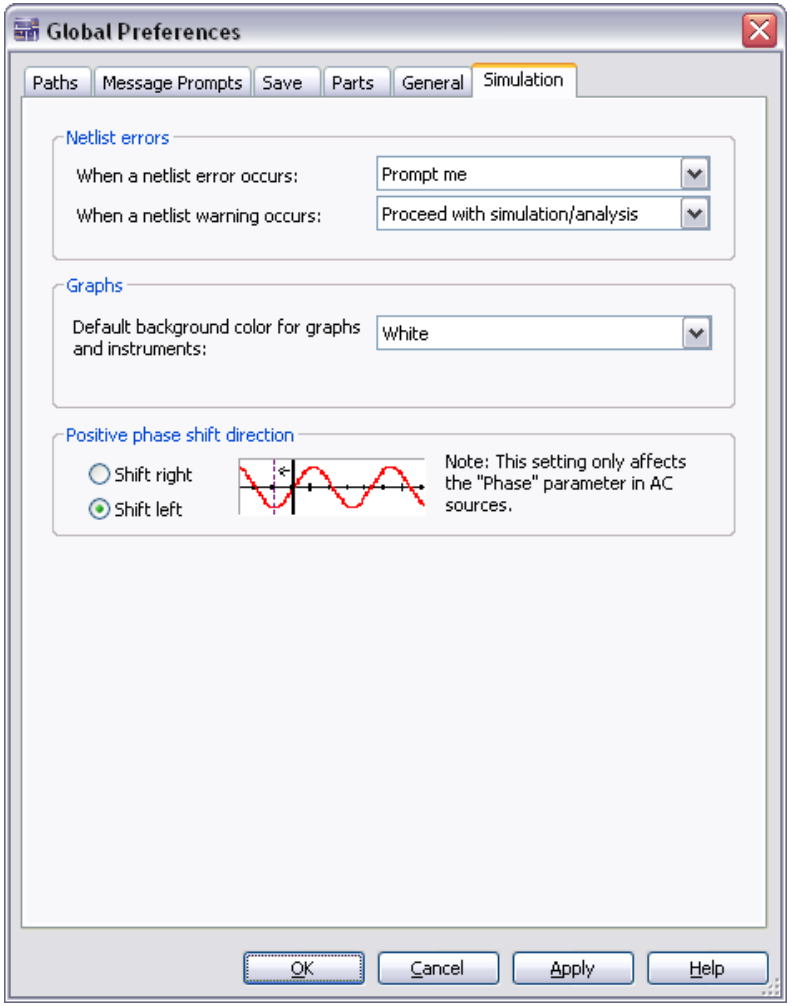


Global Preferences

- **Options»Global Preferences**
- Vary from computer to computer
- Stored in the User configuration file
  - Change config file and database paths
  - Save settings (security copy, backup, simulation data)
  - Component Placement mode, symbol standard
  - Rectangle behavior, mouse wheel behavior, bus wiring
  - Message prompts and general simulation settings

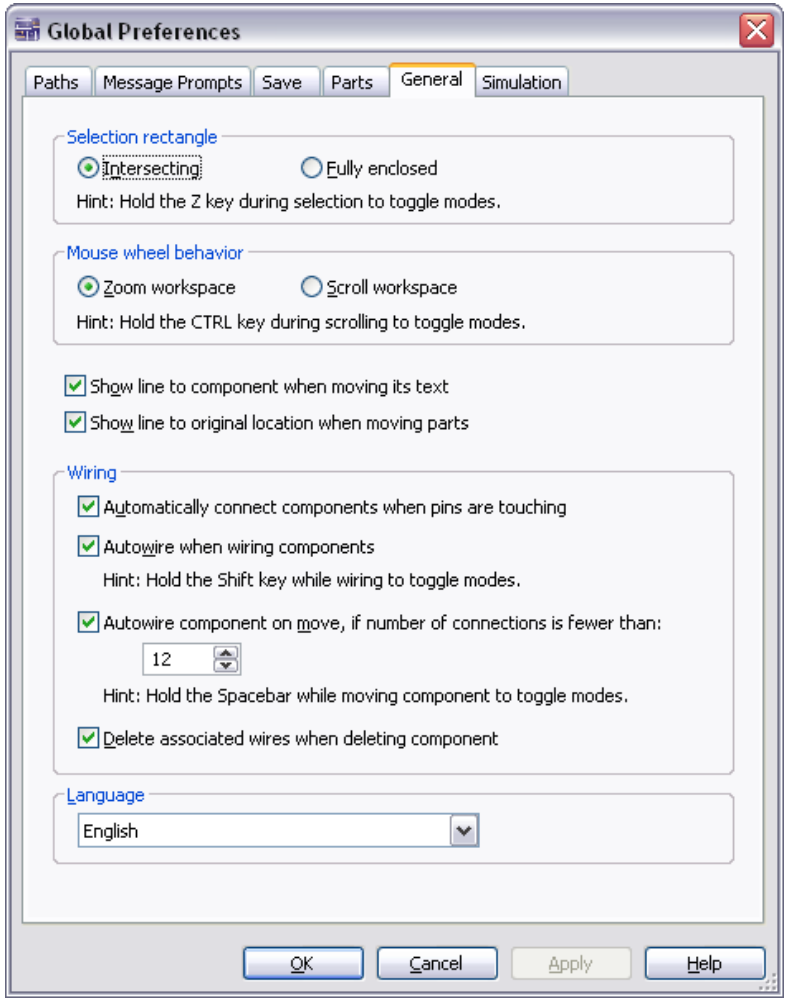
Global Preferences Simulation tab

- Netlist errors action
- Default background
- Phase shift direction



Global Preferences General tab

- Selection rectangle
- Mouse-wheel behavior
- Wiring mode
- Localization

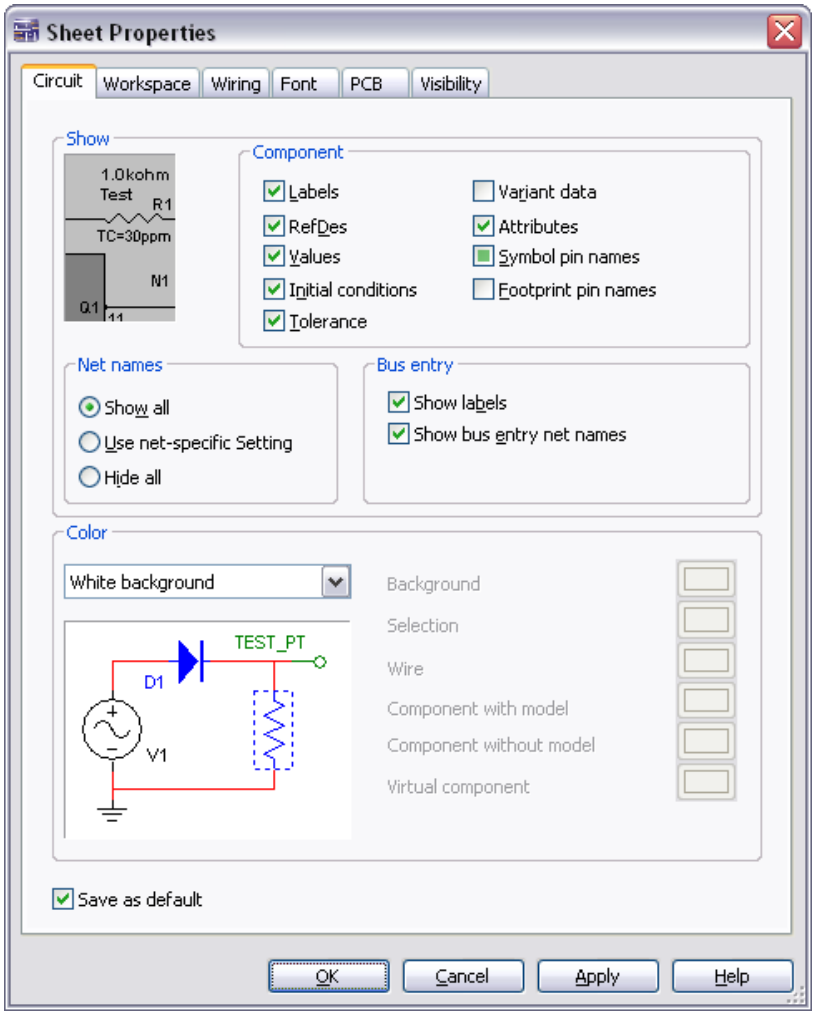


Sheet Properties

- **Options»Sheet Properties**
- Saved with the design file, if opened in another computer same settings will be used.
  - Color scheme and display properties
  - Sheet size
  - Wire and bus options
  - Font properties
  - PCB settings
  - Visibility status for annotation layers

Sheet Properties – Circuits tab

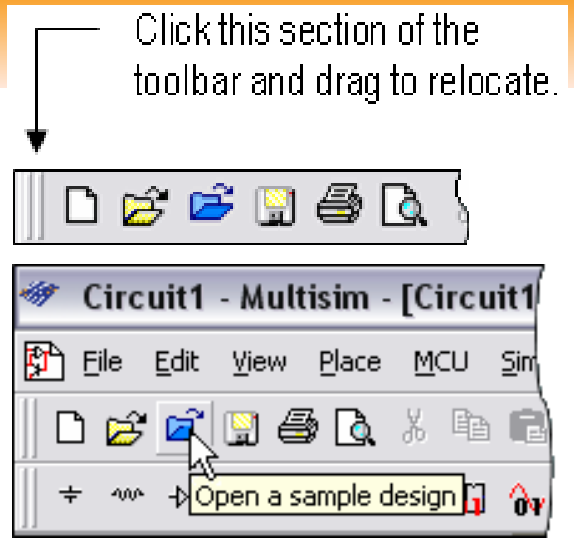
- Component display properties
- Net names display properties
- Bus entry display properties
- Color scheme

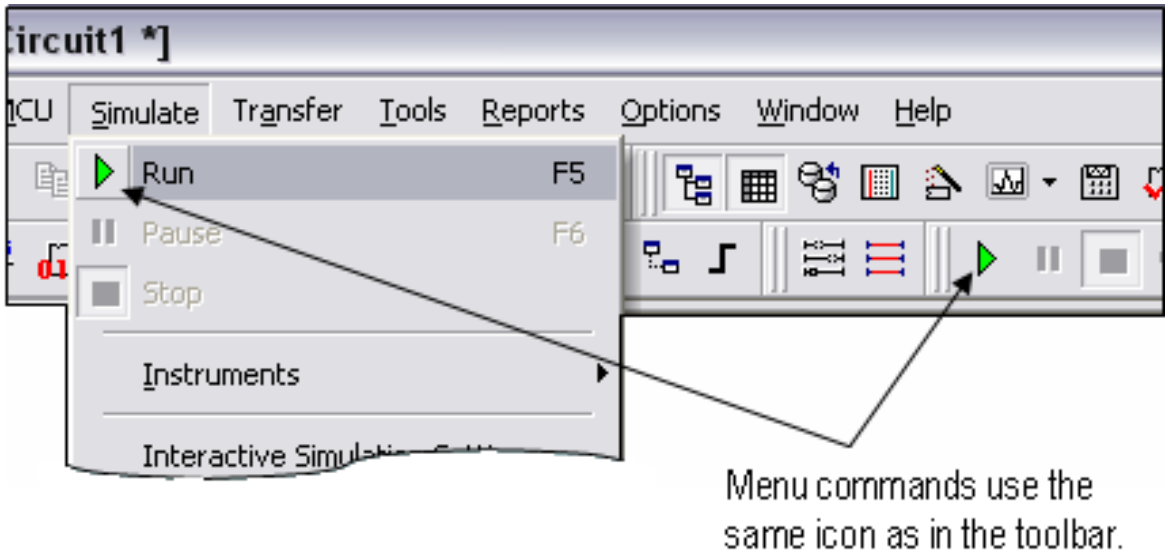


Tip: Experiment with changing the display properties of components, keep a balance between good visibility and optimum information display.

Toolbars and Menus

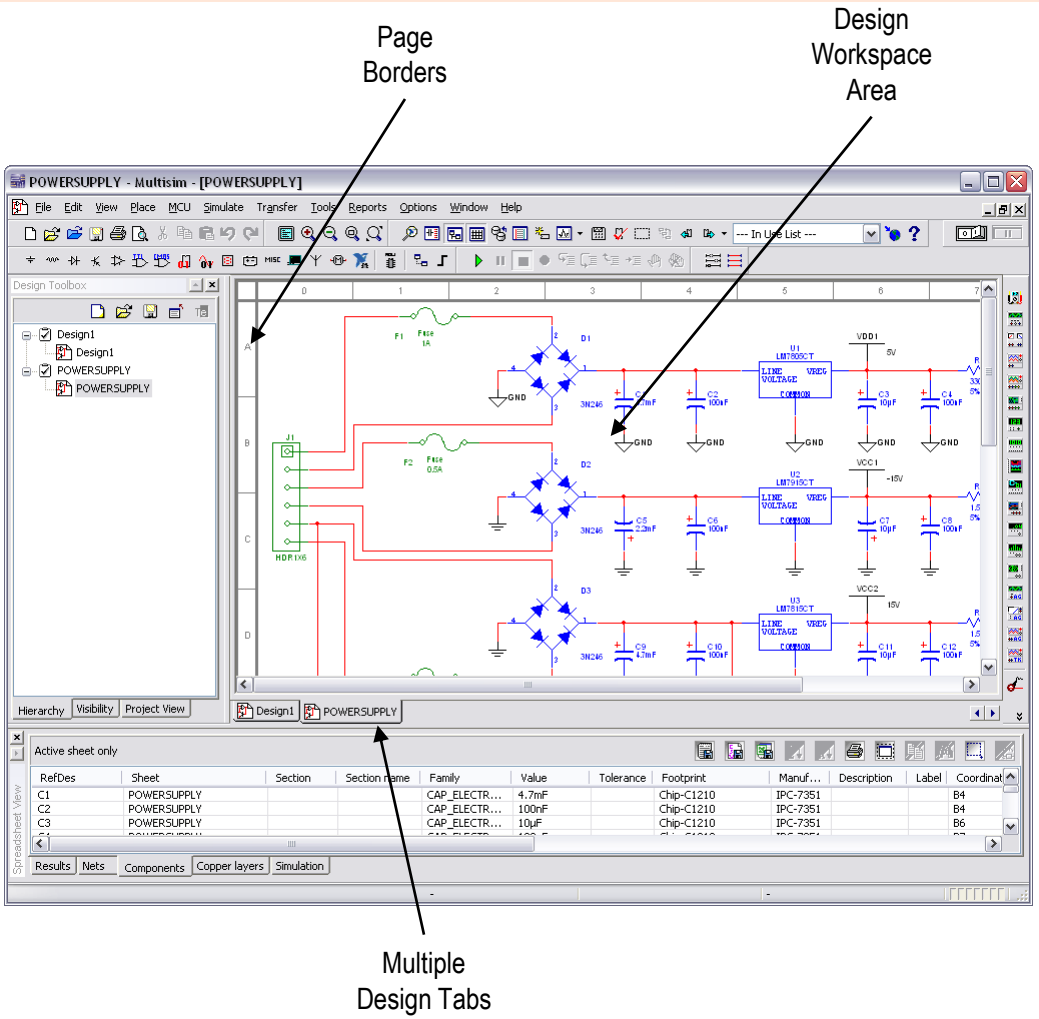
- Organized based in functionality
- All toolbar functions found in menus
- Right-click toolbar area and toggle toolbars
- Customizable (functions, location)
- ToolTips
- Lock toolbars





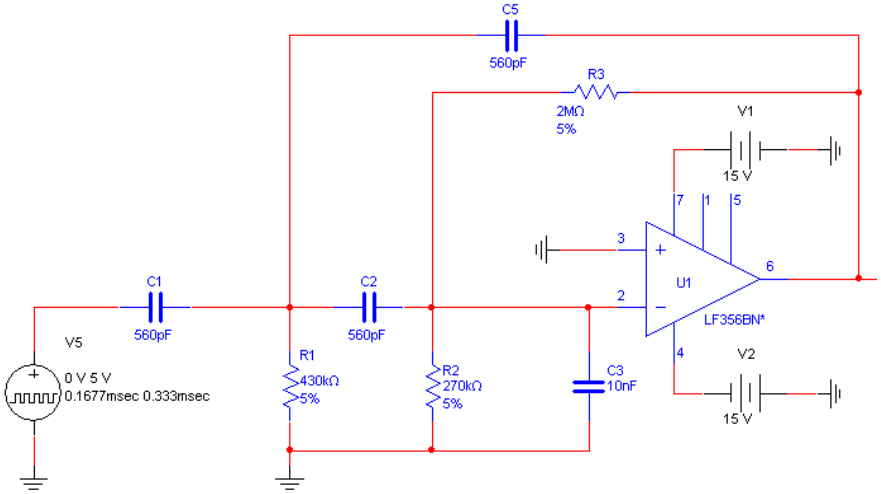
Workspace Area

- Schematic area
- Multiple tabs
- Zoom in and out with the mouse wheel (default)
- Use **View** menu to show/hide Grid and Page Border



Schematic Capture

- Multisim offers click-and-place capture mode
- Integrated with simulation



Three step process:

Select

Component Database
In-Use List
Copy
Replace

Place

Rotate
Flip
Multi-section

Wire

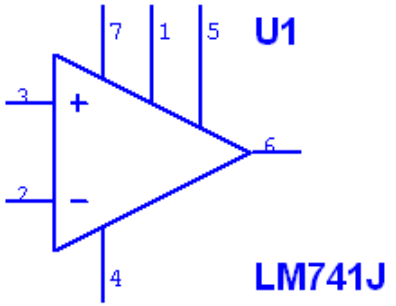
Automatic
Touching-pins
Dropping

Components

- Symbolic representation of actual parts
- All components have a symbol
- Many components have a SPICE model and footprint

Capture Area

Symbol



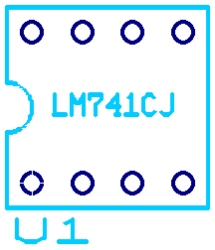
Simulation Engine

SPICE Model

```
.SUBCKT LM741 1 2 3
* 3 Terminal Op-amp Model
* A= 200000 RI= 2e+006 RO=
* Vos= 0.001 Ibs= 8e-008 I
* fu= 1.5e+006 fp2= 1e+032
    Vos 4 1 DC 0.001V
    Ib1 4 0 9e-008A
    Ib2 2 0 7e-008A
    G1 0 5 4 2 0.0584804
    G2 0 6 5 0 0.779738
    G3 0 3 6 0 0.779738
    Ri 4 2 2e+006ohm
    R1 5 0 1000ohm
    R2 6 0 75ohm
    R3 3 0 75ohm
    C1 5 0 2.12207e-005
    C2 6 0 2.12207e-035
    Cc 5 0 3e-011
.ENDS
```

PCB Layout

Footprint



Components – Properties

- Double-click component to:
  - Change Label, RefDes
  - Display properties
  - Value
  - Faults
  - Check Pin assignment
  - Set Variant information
  - Modify User Field information

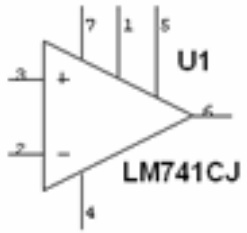
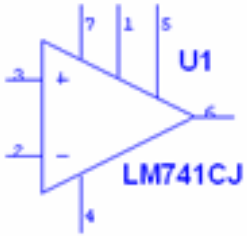
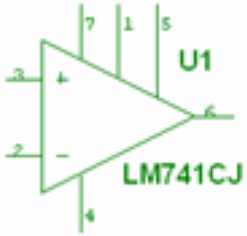
In the **Value** tab, click **Edit Component in DB** to customize the component.

(*not for RLC components*)

Components – Edit Component in DB

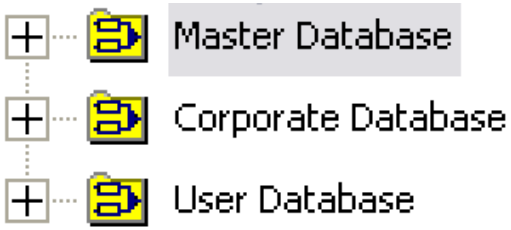
General	Component name, creation date, author, function.
Symbol	Number of pins, number of sections, symbol set, edit/copy symbol, pin mapping table.
Model	Model name, model data, add/edit/delete model, pin mapping table.
Pin Parameters	Component type, pin table.
Footprint	Footprint type, add/delete/change footprint, symbol pin to footprint pin mapping table, footprint preview.
Electronic Parameters	Common parameters, device specific parameters.
User Fields	User-defined fields.

Components – Virtual, Real, Layout-only

Component	Symbol	Model	Footprint	Default Color
Virtual *(simulation only)*	✓	✓	✗	 *(black)*
Real *(simulation and layout)*	✓	✓	✓	 *(blue)*
Layout-only *(layout only)*	✓	✗	✓	 *(green)*

Component Database

- **Tools»Database»Database Manager**
- Three levels:



- Parts bin up to 17,500 parts (Power Pro edition)
- Master database cannot be edited
- Database utilities let you merge other user's database, or convert a database from a previous version

Component Database

- **Corporate database**
  - Share components with colleagues
  - Located in local disk or network drive
- **User database**
  - Store your own custom components
- If you modify a Master database component, save it into the Corporate or the User database.

Caution: Always backup your Corporate or User database.

Component Browser

- **Place»Component**
- Most common tool to place components.
- You can select:
  - Database
  - Component
  - Model
  - Footprint
  - Search for components

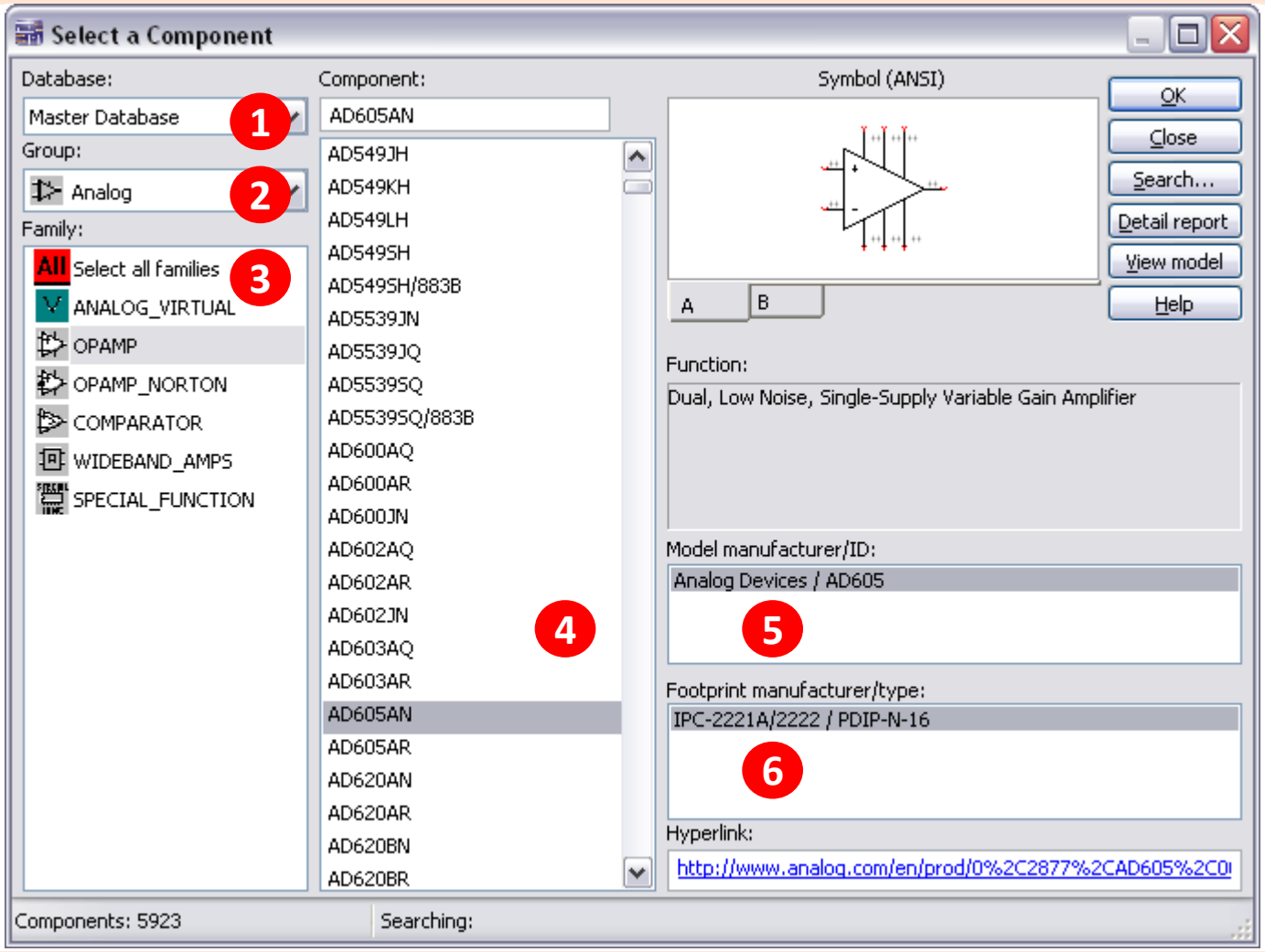
Tip: Right-click anywhere in the workspace and select **Place Component** to access the **Component Browser**.

To place a part, select:

1. Database
2. Group
3. Family
4. Part
5. Model
6. Footprint

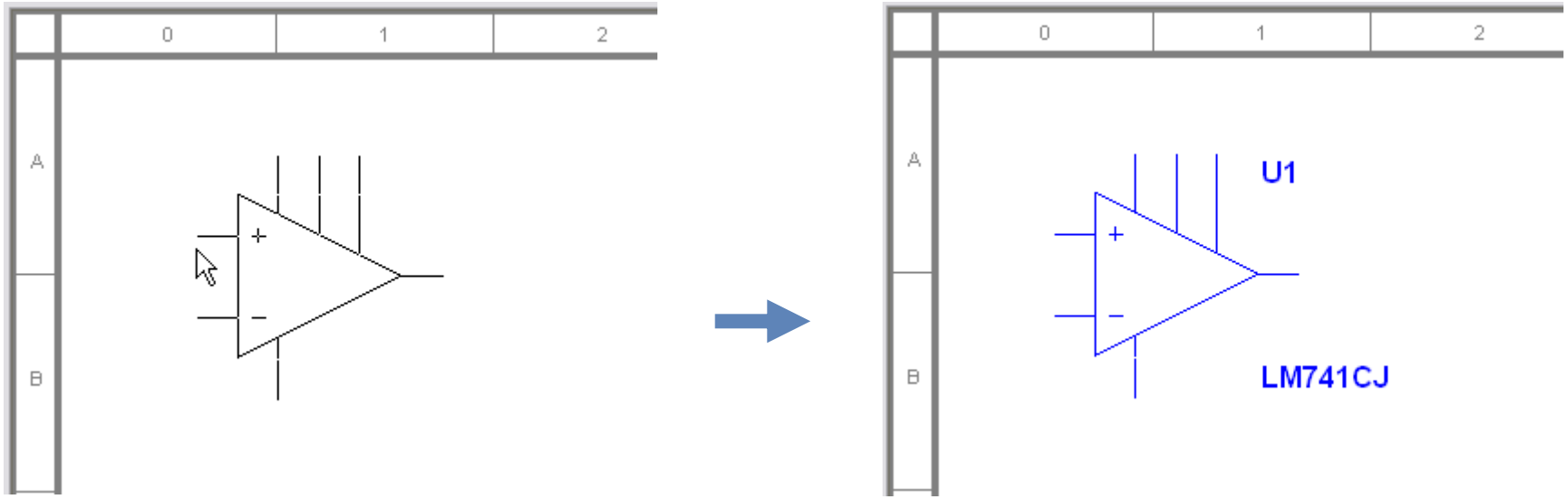
You can also:

- Search
- Obtain datasheet
- Print a detail report
- View model



Placing a Component

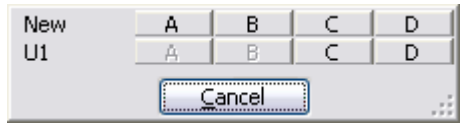
- After selecting a component, a ghost image is attached to the mouse pointer
- Click to place
- Next RefDes is assigned



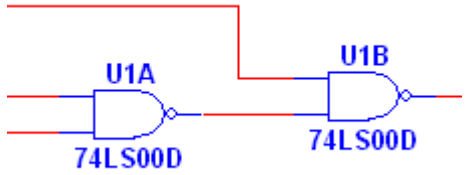
Placing Multi-section Components

Select any section for a new IC

Select C or D to place unused sections of U1



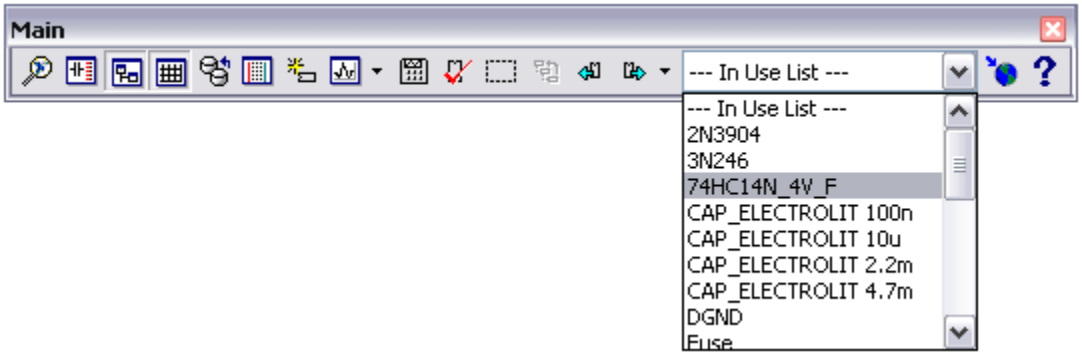
U1, section A and B are already placed, therefore they are not selectable



Component Toolbar and the In-Use List

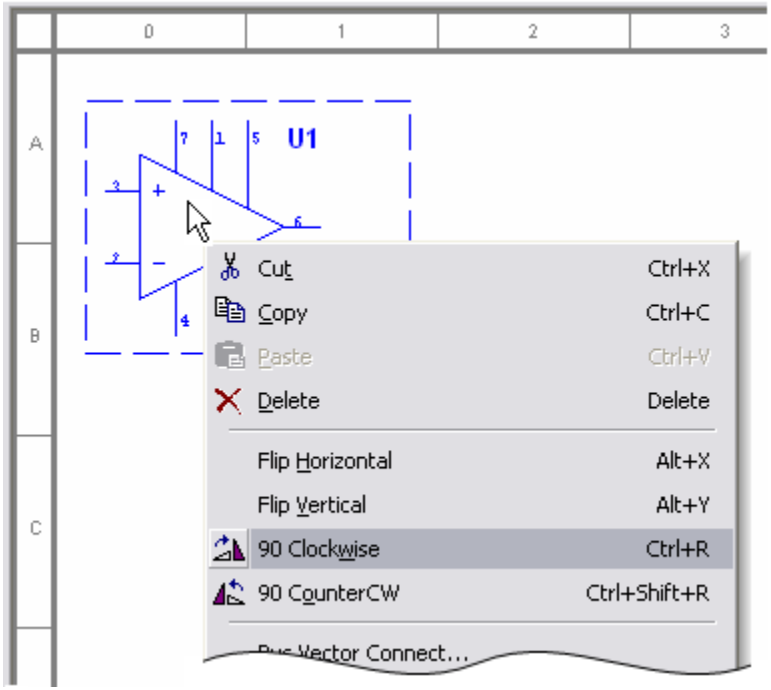
- Access Master database **Groups** from the **Components** toolbar.

- Use the **In-Use List** to place another instance of an already placed component.



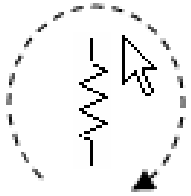
Rotating a Component

– If already placed



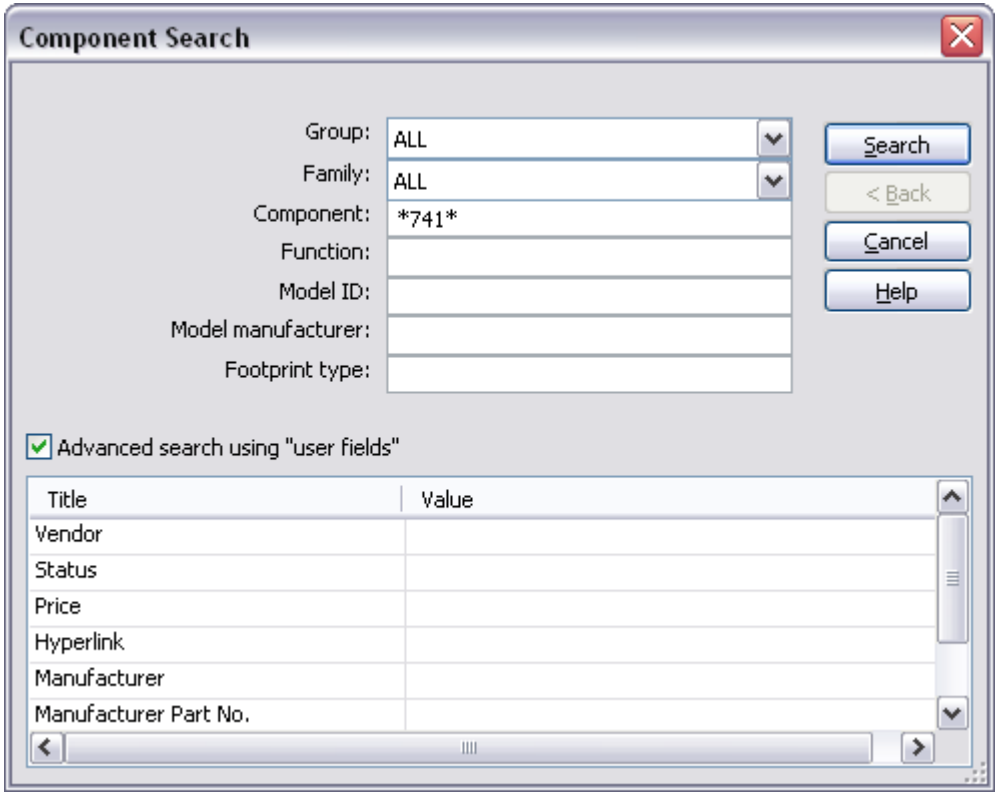
- While placing

While dragging the component… → Press <Ctrl+R>… → Then click to place.



Component Search

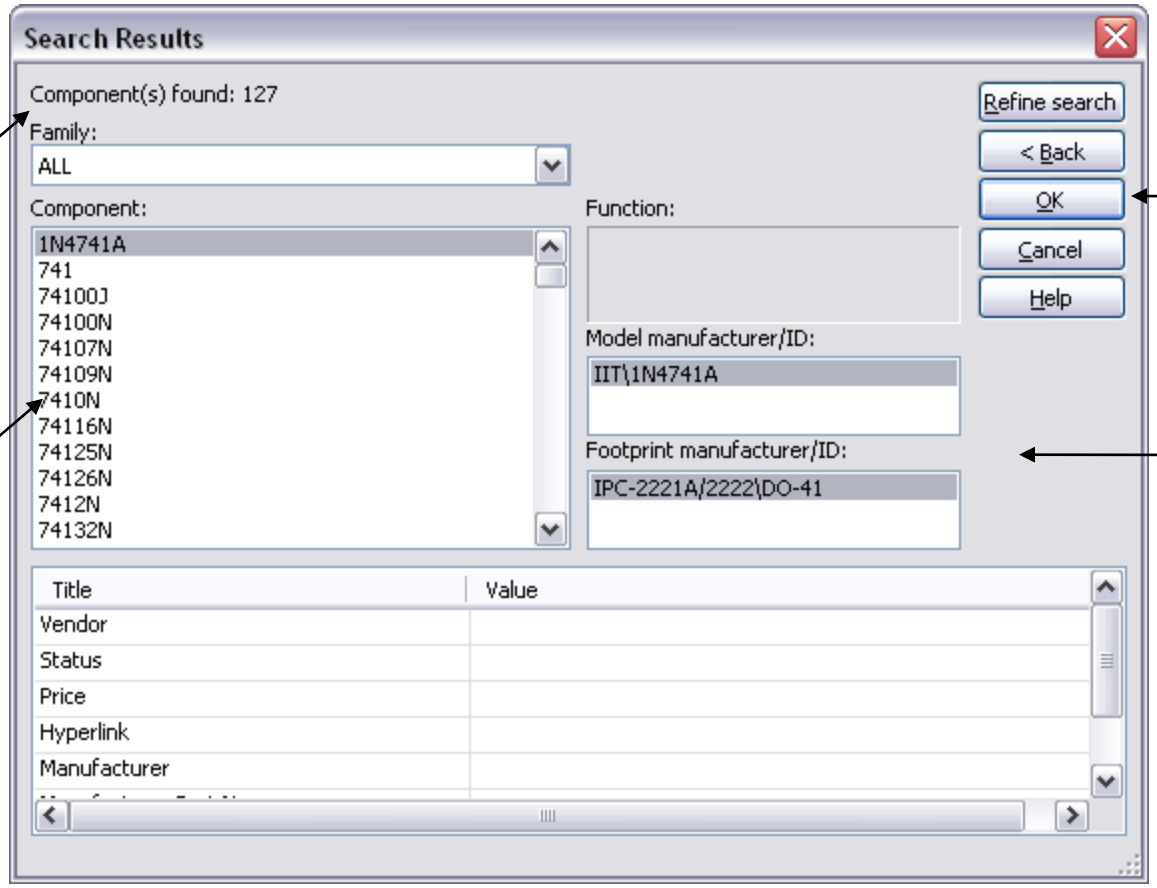
- From the **Component Browser**, click **Search**
- Use ***** as a wildcard



Component Search – Results

Number of components matching search criteria

List of components matching search criteria



OK will take you to the exact database location

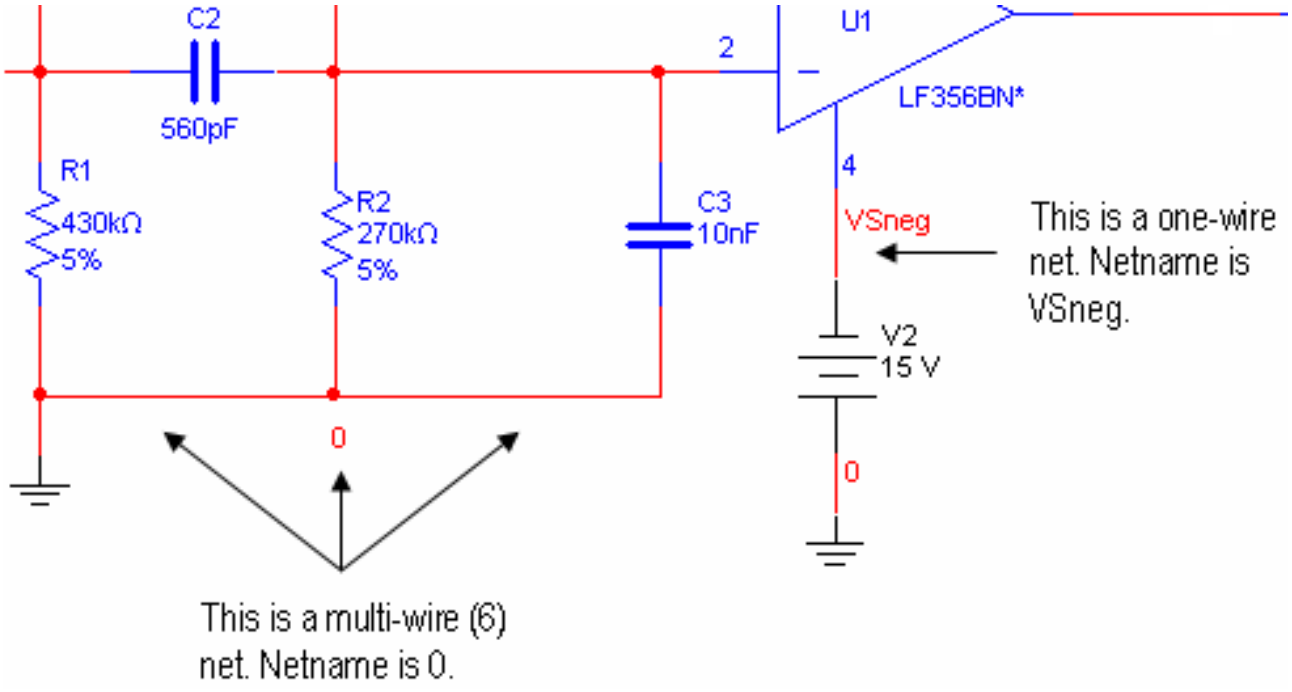
Details of component selected

Nets

- Wires are the graphical representation of nets
- Modeless (no *placing* vs. *wiring* mode)
- Mid-air wiring is allowed
- Real-time netlist is updated behind the scenes
- Easy to change wire connections once placed

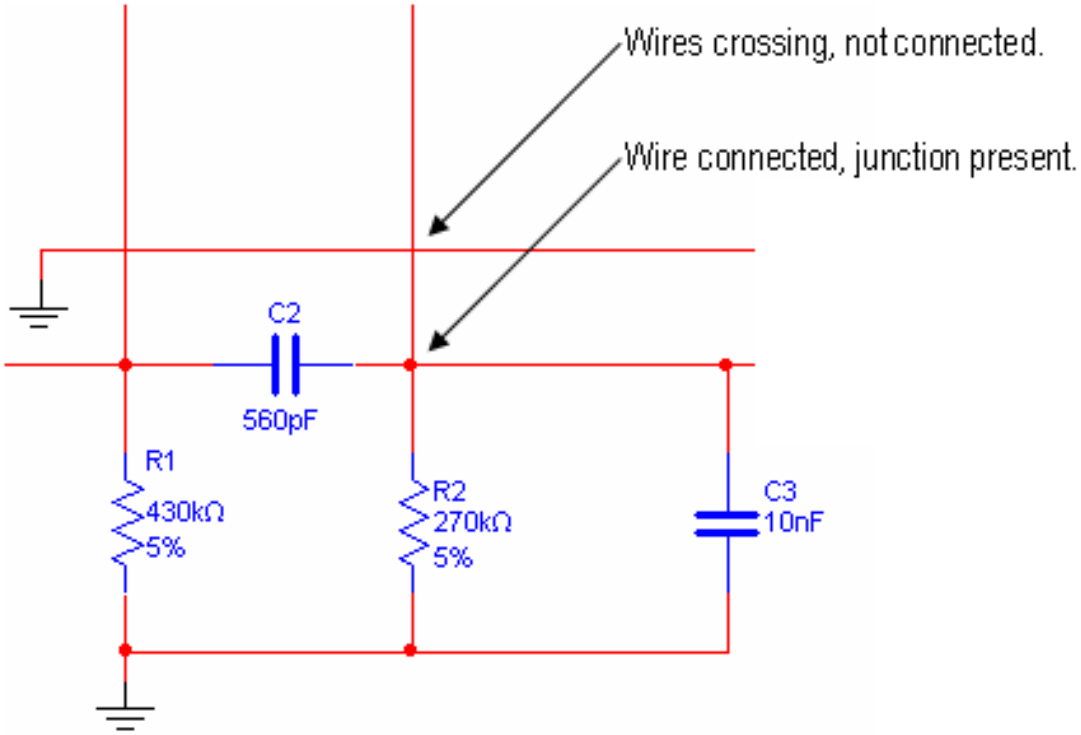
Nets

- Multiple wires can make one net or node

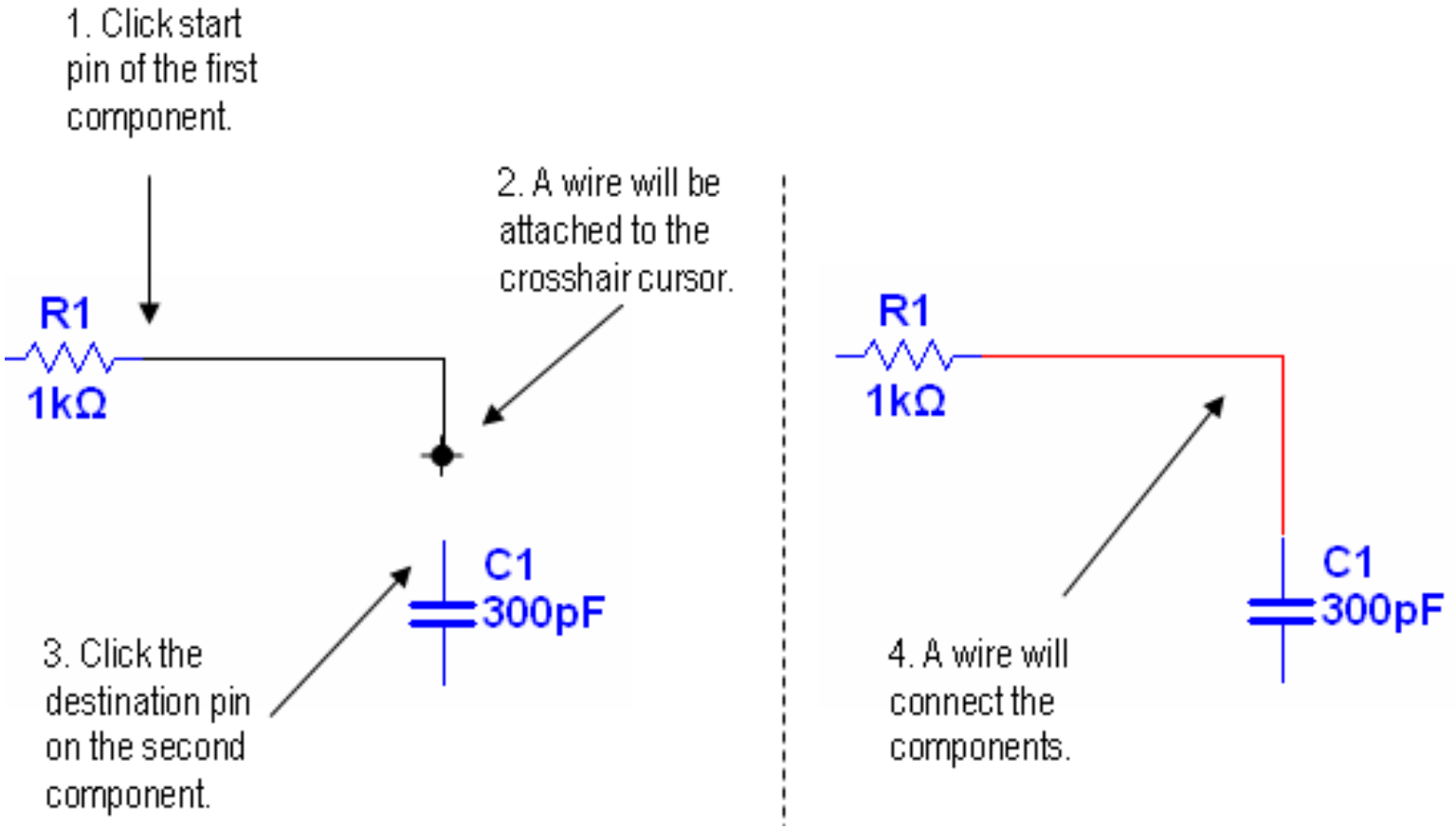


Junction Dots

- Junction dots represent a wire connection

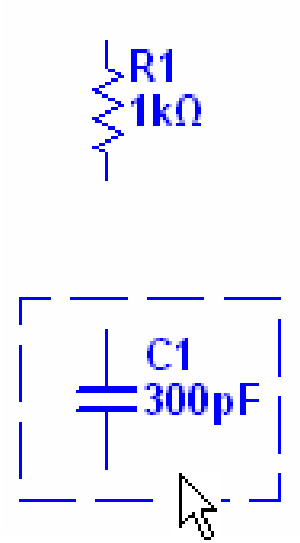


Methods for Wiring – Automatic

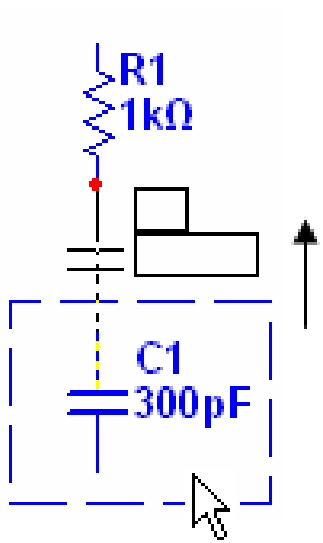


Methods for Wiring – Touching Pins

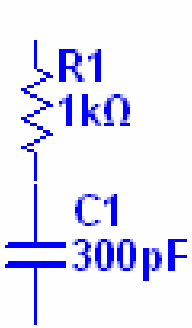
1. Select the component to wire.



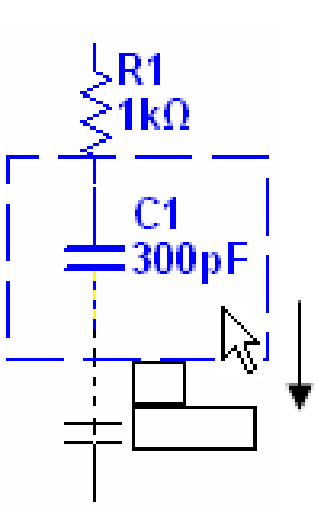
2. Move component and touch pins to be wired. Notice red dot.



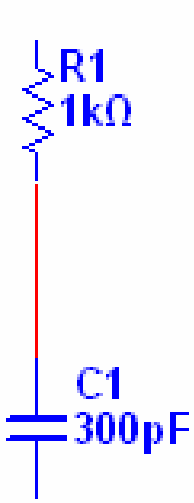
3. Drop the component. Connection is made.



4. Drag the component away.

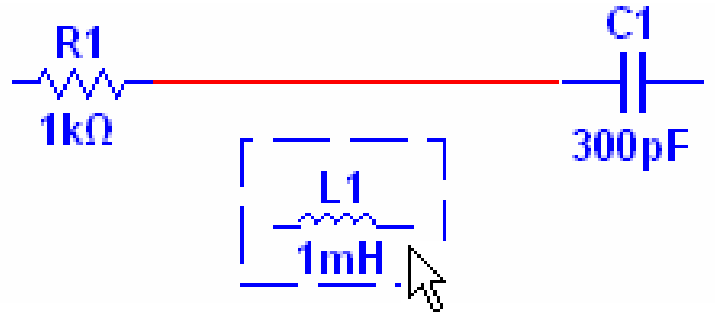


5. Drop the component. Wire is ready.

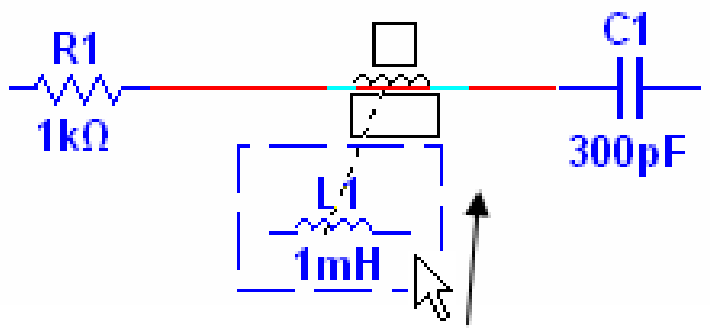


Methods for Wiring – Dropping

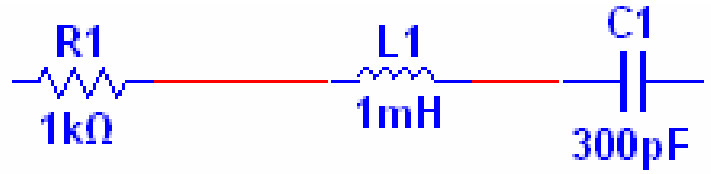
1. Select component to wire.



2. Move the component and place it over the wire to be connected in series.

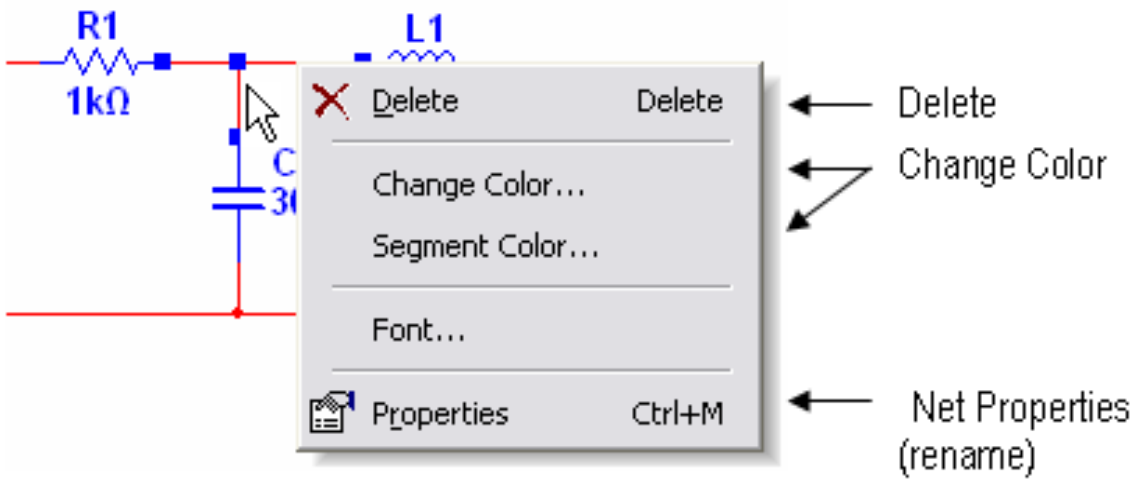


3. Drop the component. The connection is made.



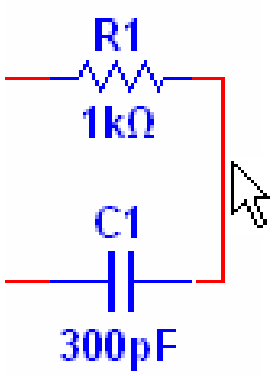
Changing Wire Properties

- Right-click the wire to access the run-time menu
- Change colors, net name font and properties

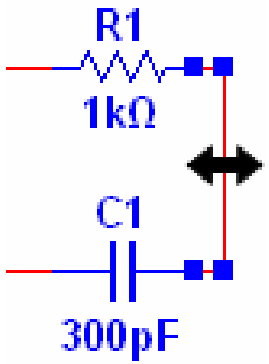


Moving Wires

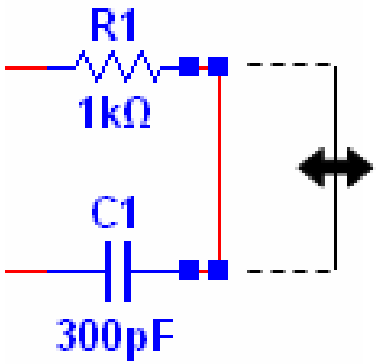
1. Click the segment of interest.



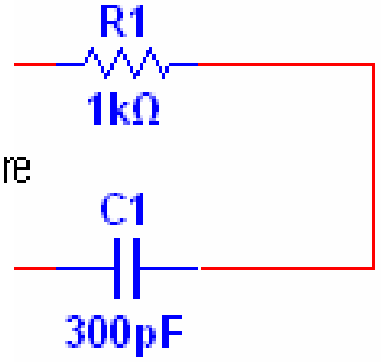
2. Notice the drag points and double arrow cursor.



3. Drag the line to the new position.

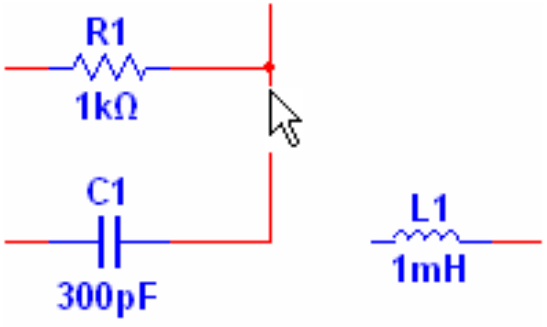


4. Click to drop the wire and finish.

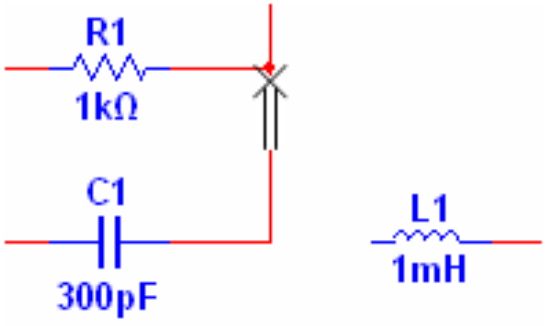


Re-wiring a Net

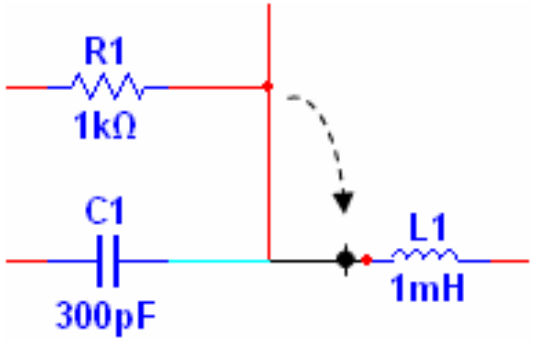
1. Move cursor close to pin or junction.



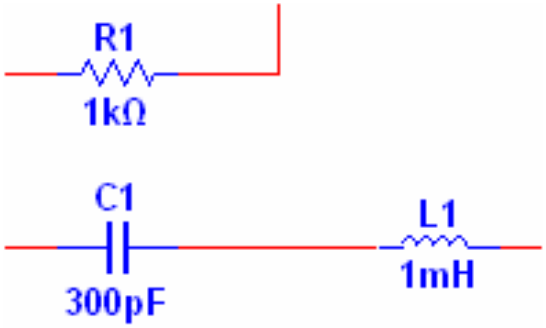
2. When cursor changes click to attach wire to cursor.



3. Click on new location to connect.



4. New connection is ready.



Virtual Wiring

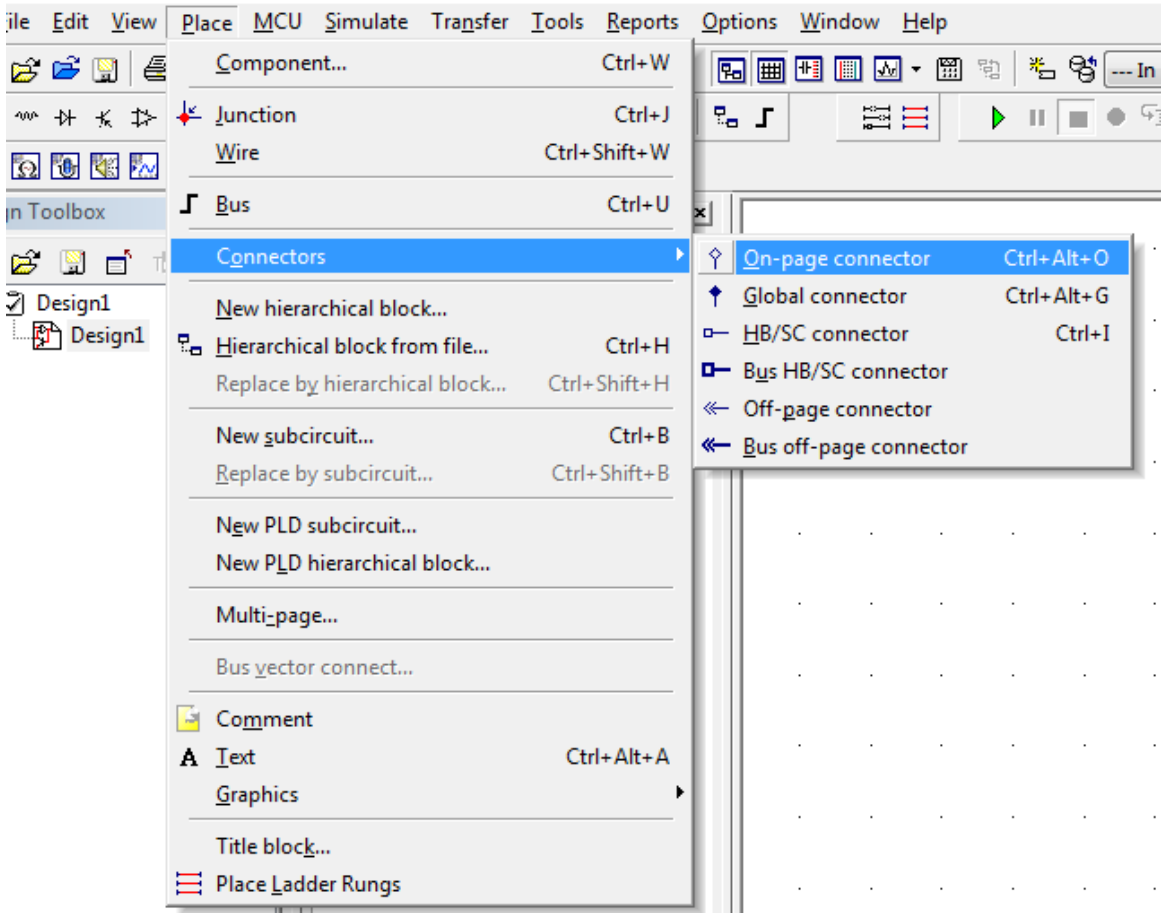
- Useful in large designs
- Avoids unnecessary wires crossing the schematic
- Give a net a name that already exists to create the virtual connection
- Use Global or On-page connectors


Global connectors are visible to the whole design


On-page connectors are visible to the sheet

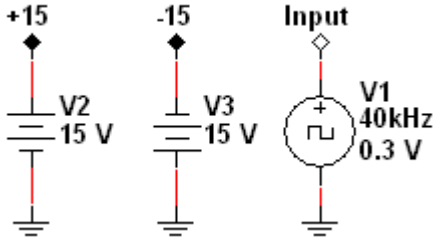

On-page connectors may connect to Global connectors

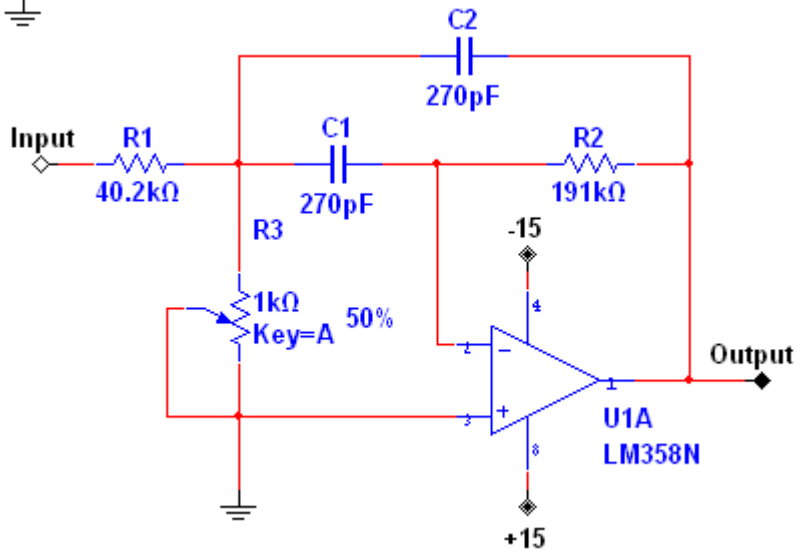
Virtual Wiring



Place/connectors/..

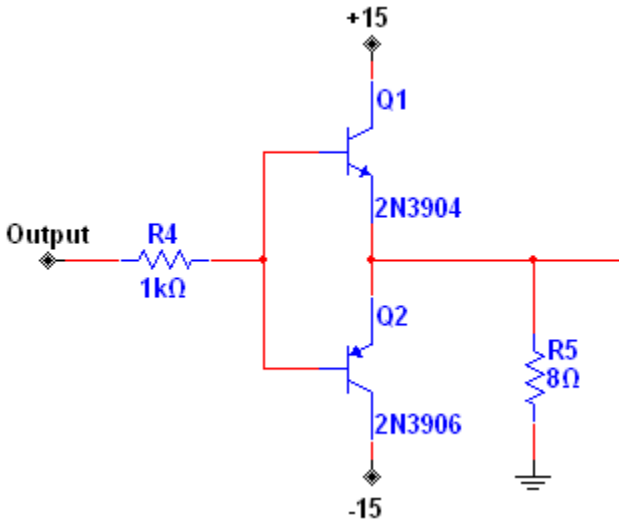
Virtual Wiring





My Design

Page X | Page Y



Analyses in Multisim

- Multisim provides analyses for examining circuit behavior
- Analyses require a circuit ready for simulation
- Custom expression can be added
- Grapher View helps to take precise measurements

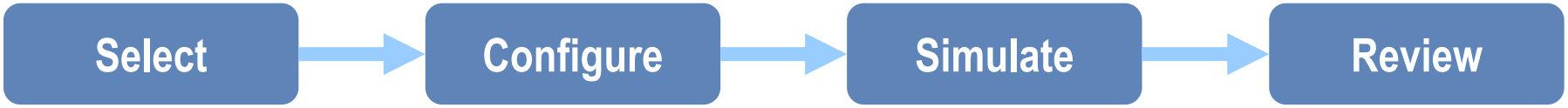
Analyses in Multisim

- The following analyses are available:

DC Operating Point	Distortion Analysis	Transfer Function
AC Analysis	DC Sweep	Worst Case
Single Frequency AC Analysis	Sensitivity	Monte Carlo
Transient Analysis	Parameter Sweep	Trace Width Analysis
Fourier Analysis	Temperature Sweep	Batched Analysis
Noise Analysis	Pole Zero	User Defined Analysis

Using Analyses

- **Simulate»Analyses»…**
- Four step process:



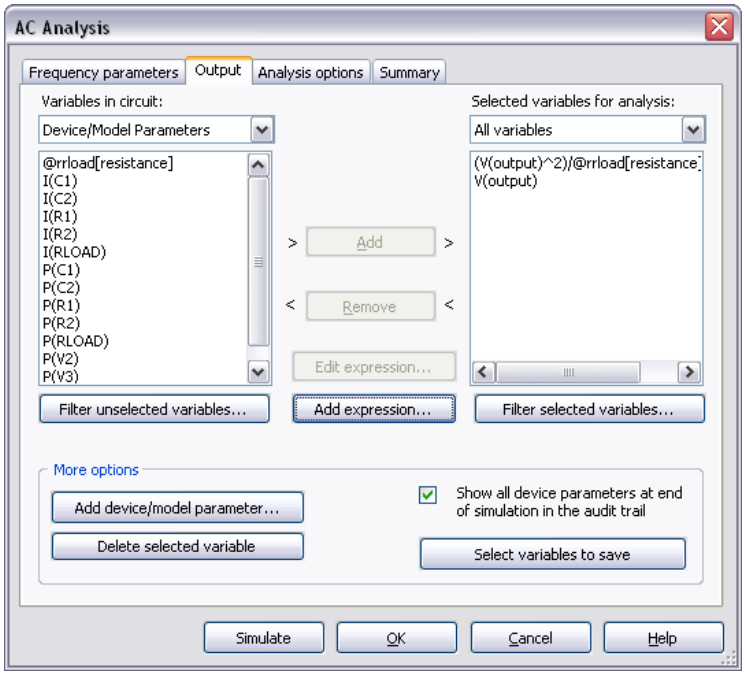
Select	Configure	Simulate	Review
Select analysis	Enter expressions Select output variables Configure analysis parameters and options	Click **Simulate**	Grapher View

Tip: Click **Help** on any window to access analysis-specific information.

Selecting Output Variables

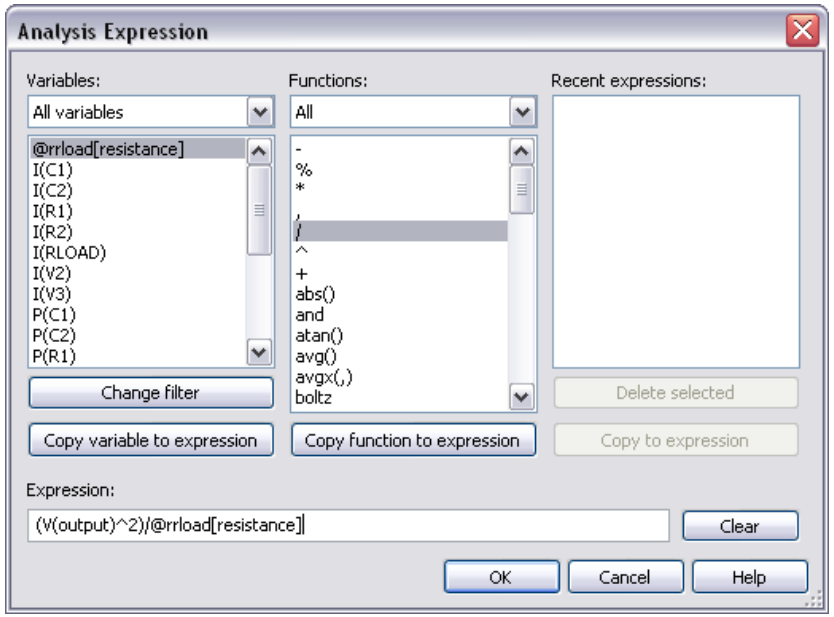
- Choose output variables from the list
- Voltages and currents per node (net) are listed as well as current and power per component
- Add model or device parameters
  - Resistance
  - Capacitance, and so on

– Add expressions



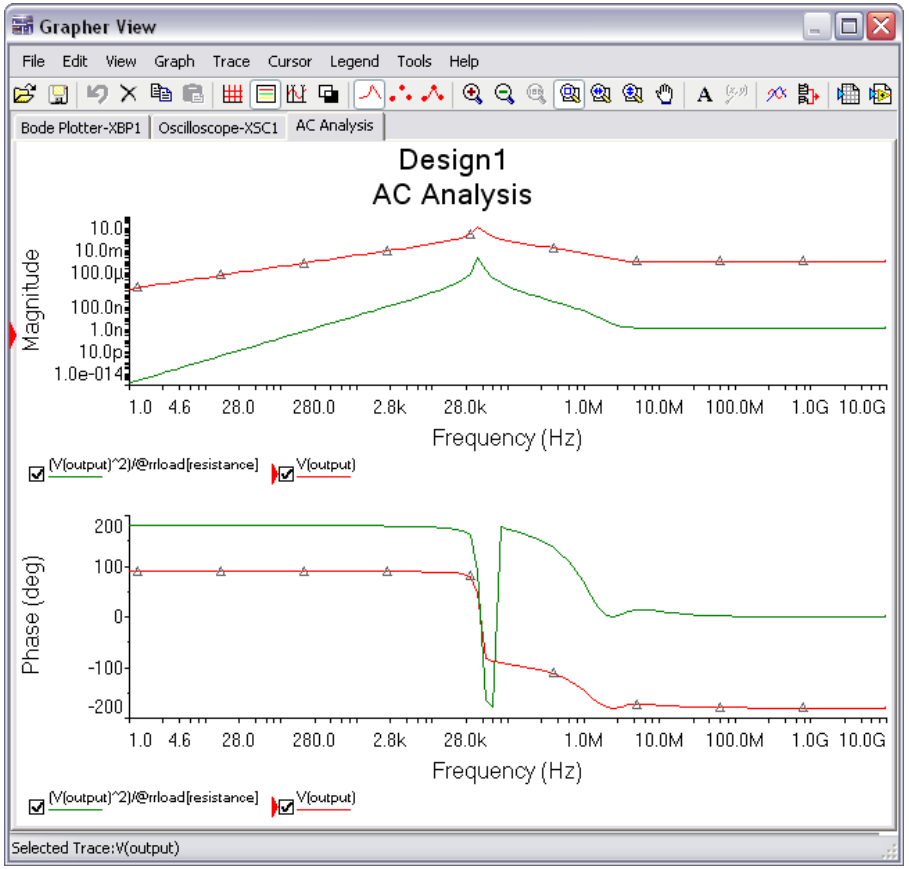
Adding Custom Expressions

- Double-click variable or operand to add it to the expression
- Type expression manually
- Use built-in functions to help create custom analysis outputs



The Grapher

- Displays simulation results from:
  - Virtual Instruments
  - Analyses
- View, adjust, save, print export data
- Precise cursor measurements
- Overlay different results to compare
- Make annotations and place data labels

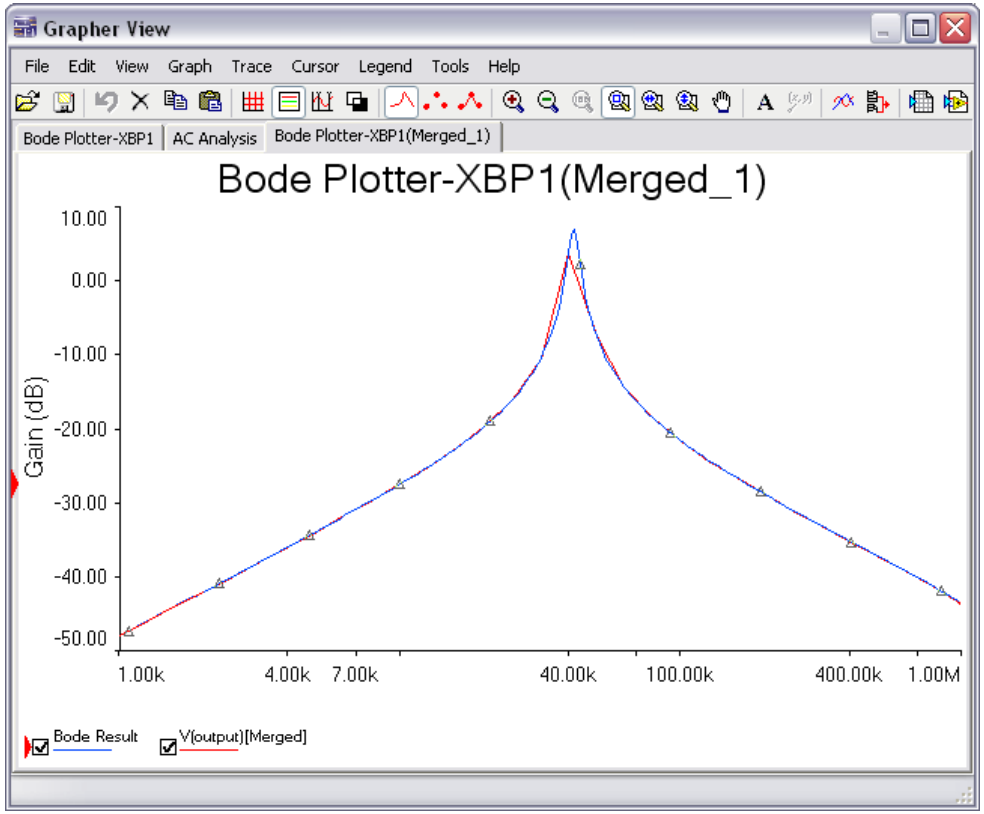


The Grapher – Cursors

- Take precise measurements with the cursors
- Right-click cursor to access functions for positioning and data labels

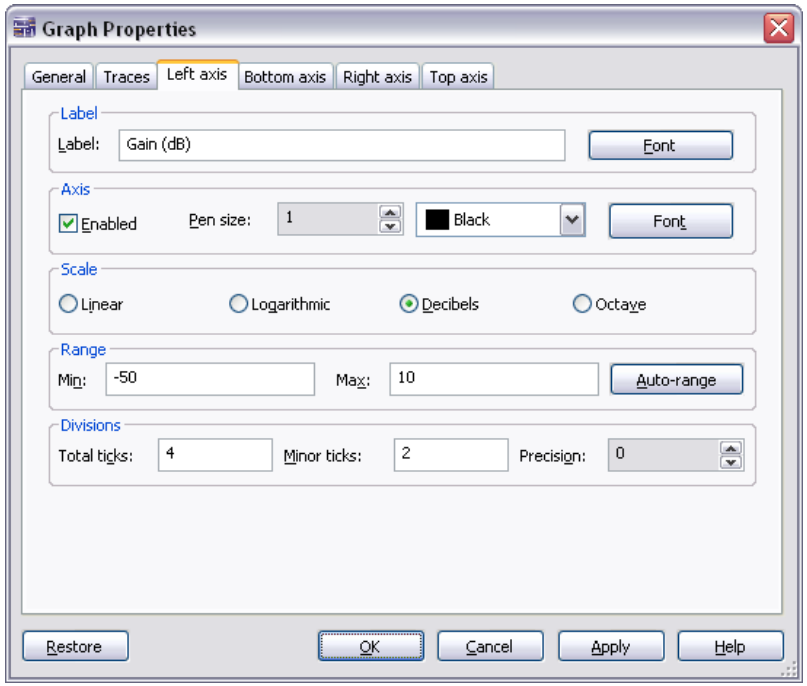
The Grapher – Overlay Traces

- Compare different graphs



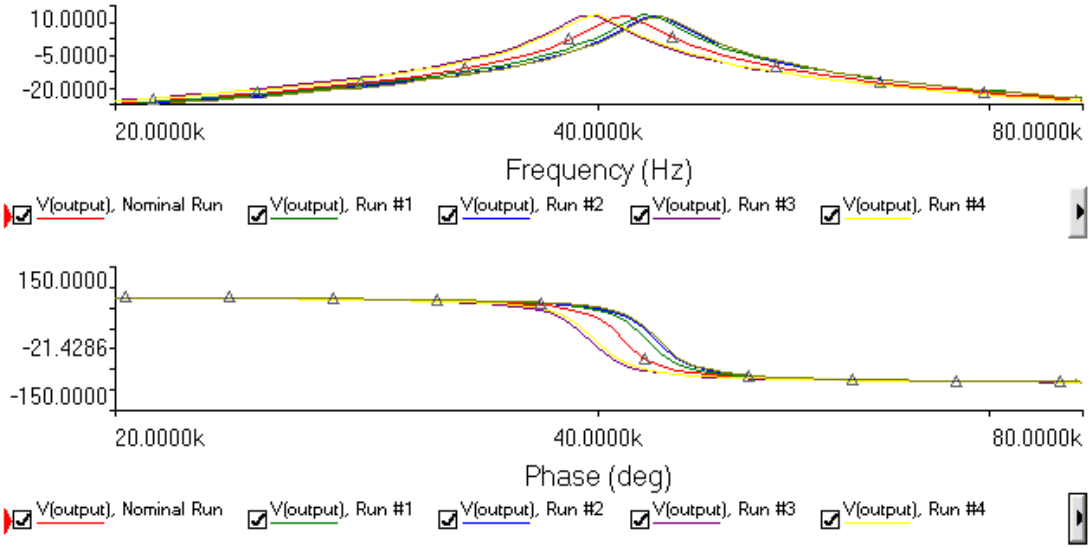
The Grapher – Properties

- Set custom properties for pages and graphs
- Modify the appearance of traces and axes



The Grapher – Mixed Displays

- Some analyses output table data instead of plot data



Run Log Descriptions

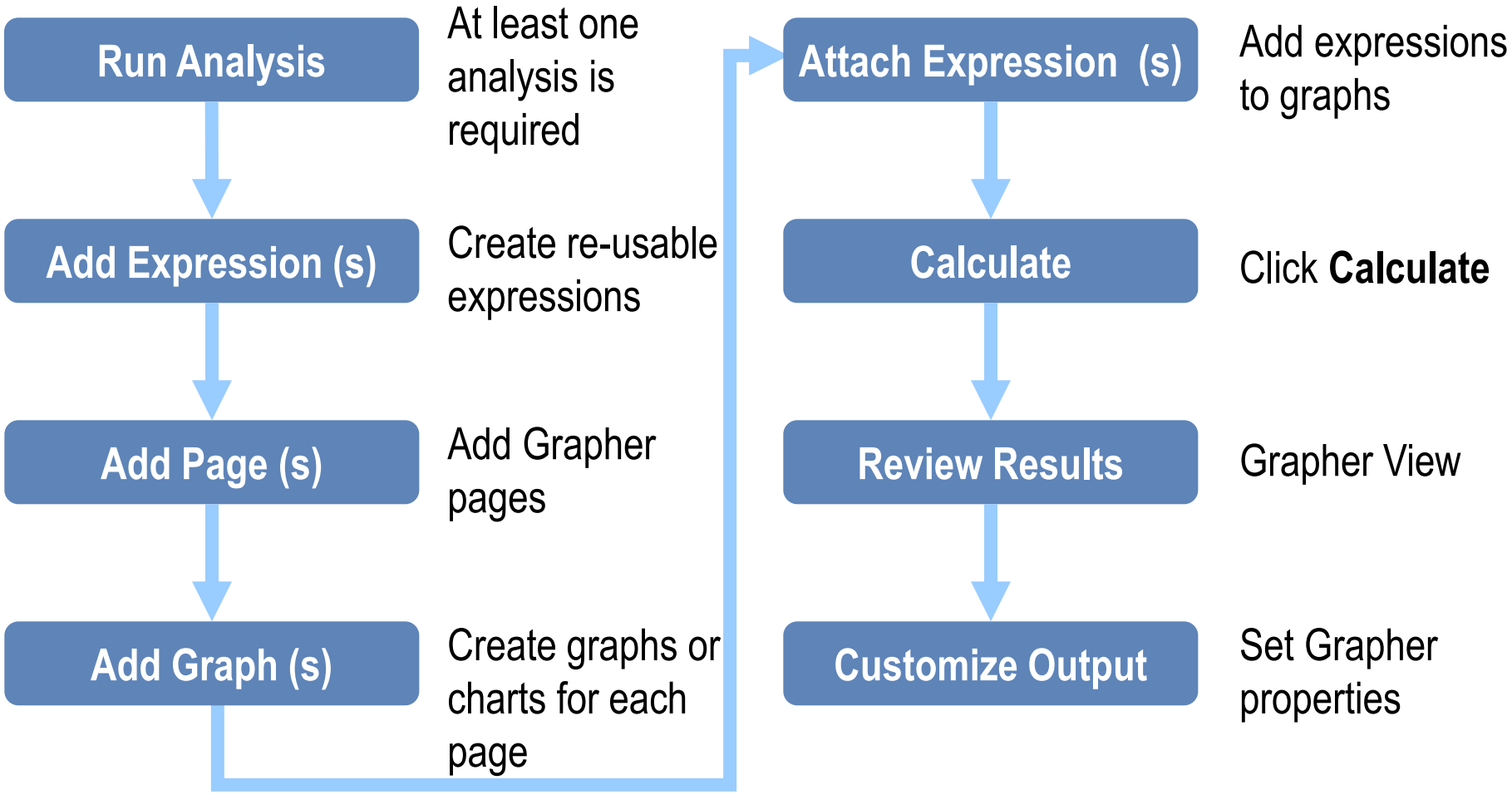
	# of run	time [sec]	output value
1	Nominal Run (Mean Frequency: 2.2392 6 Standard Deviation Frequency: 0.045		2.20422 (same as nominal, low er than mean by -0.0350466)
2			
3	Run #1		2.32573 (5.51293% higher than
4			
5	Run #2		2.19695 (0.329613% lower than

The Postprocessor

- Use the Postprocessor to:
  - Mathematically manipulate analyses results
  - Plot results in a graph or chart
  - Customize results output
- At least one analysis run is required

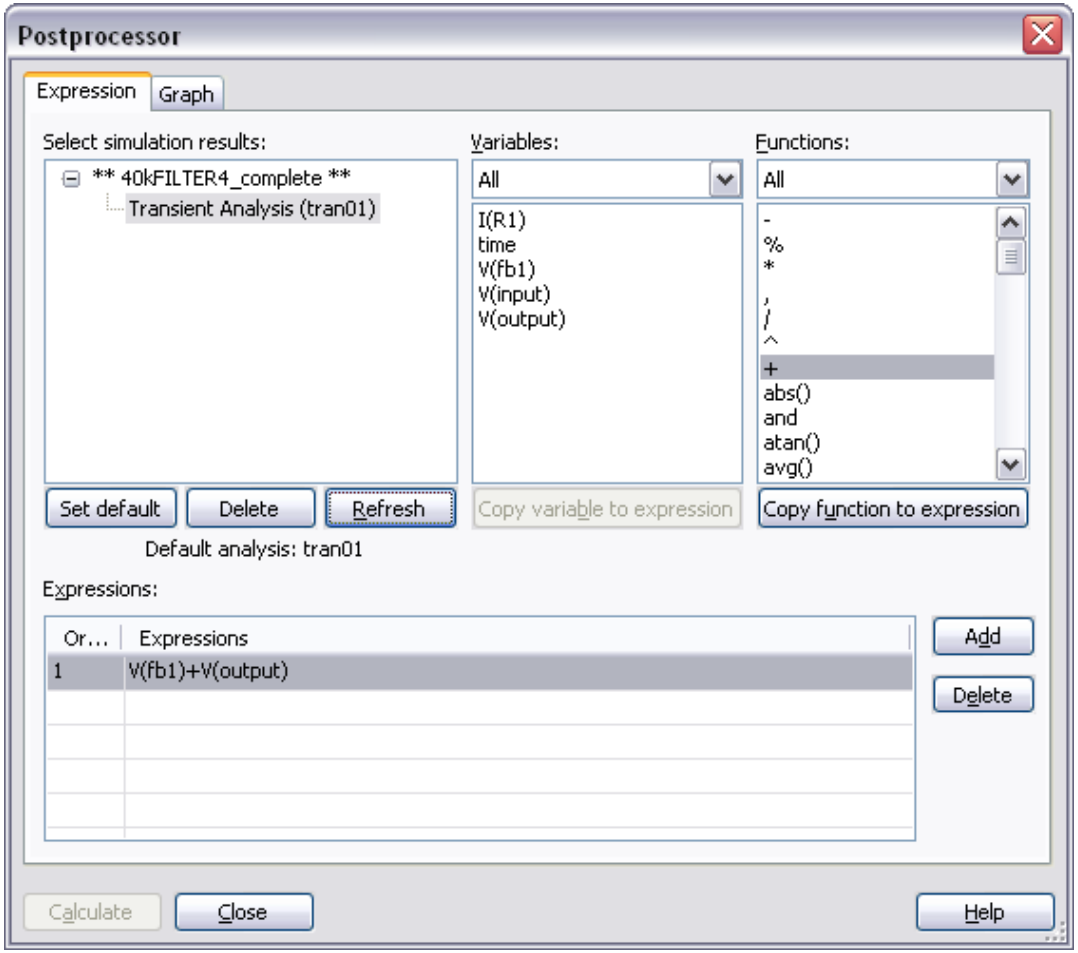
- **Simulate»Postprocessor**
- Examples:
  - Add voltages
  - Calculate power from voltage and current

Using the Postprocessor



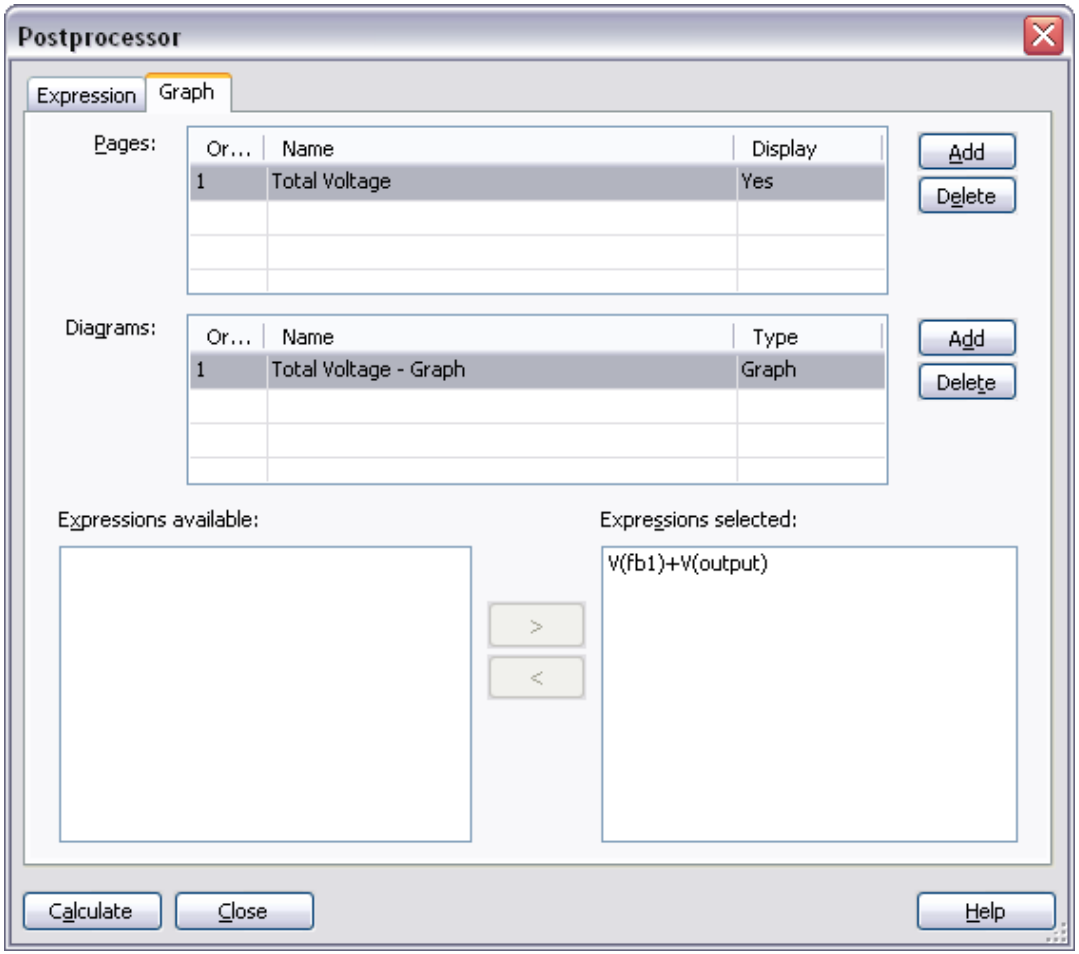
Using the Postprocessor – Expression Tab

- Select from available results
- Select from available variables
- Build expressions



Using the Postprocessor – Graph Tab

- Add Pages
- Add Graphs or Charts to Pages
- Assign Expressions
- Click **Calculate**



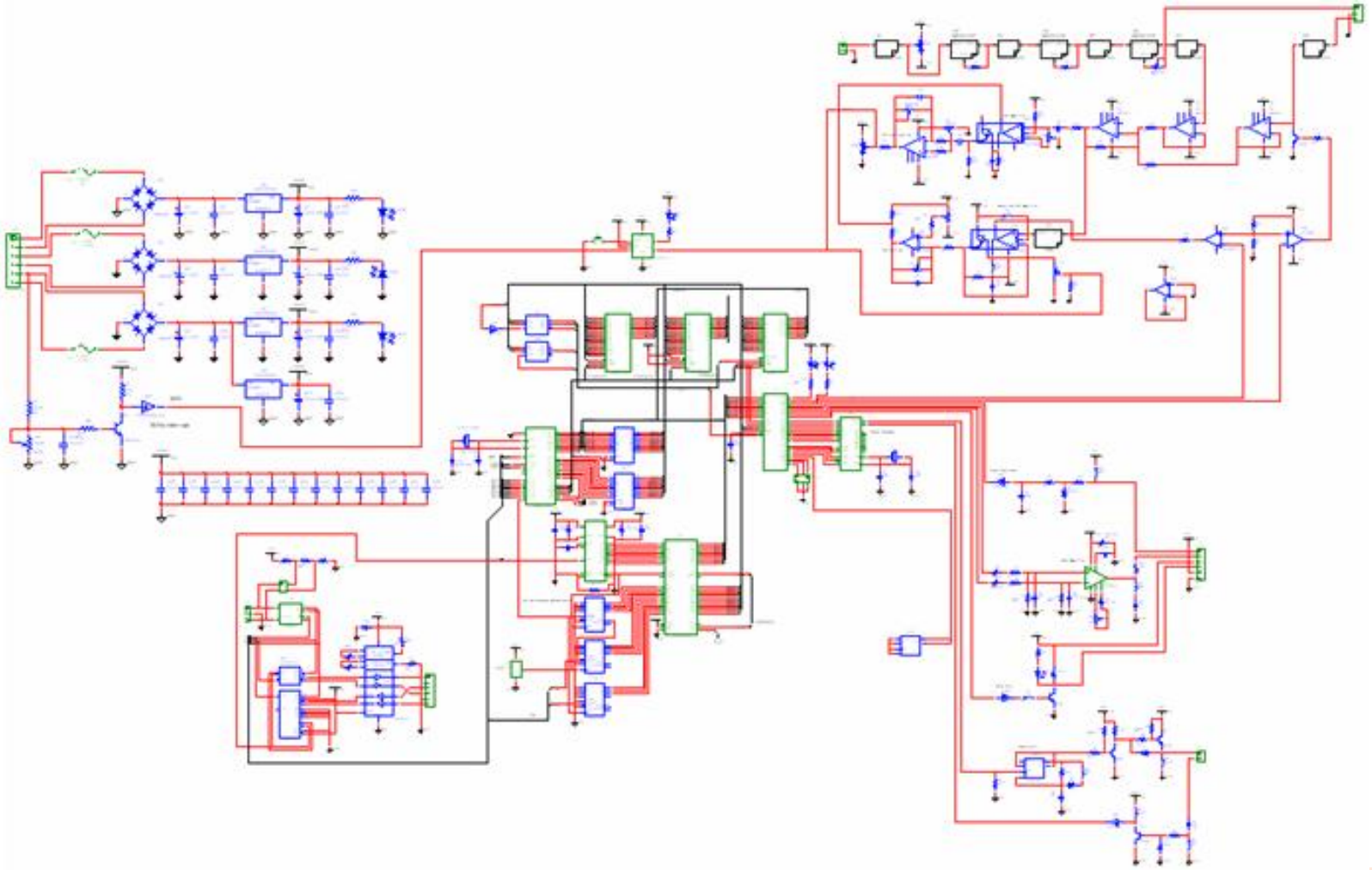
Viewing Results from the Postprocessor

- The Grapher displays Postprocessor results like any other instrument or analysis
- Use the cursors to make precise measurements
- Set the graph properties to fit your results
- Save, print or export results to external applications

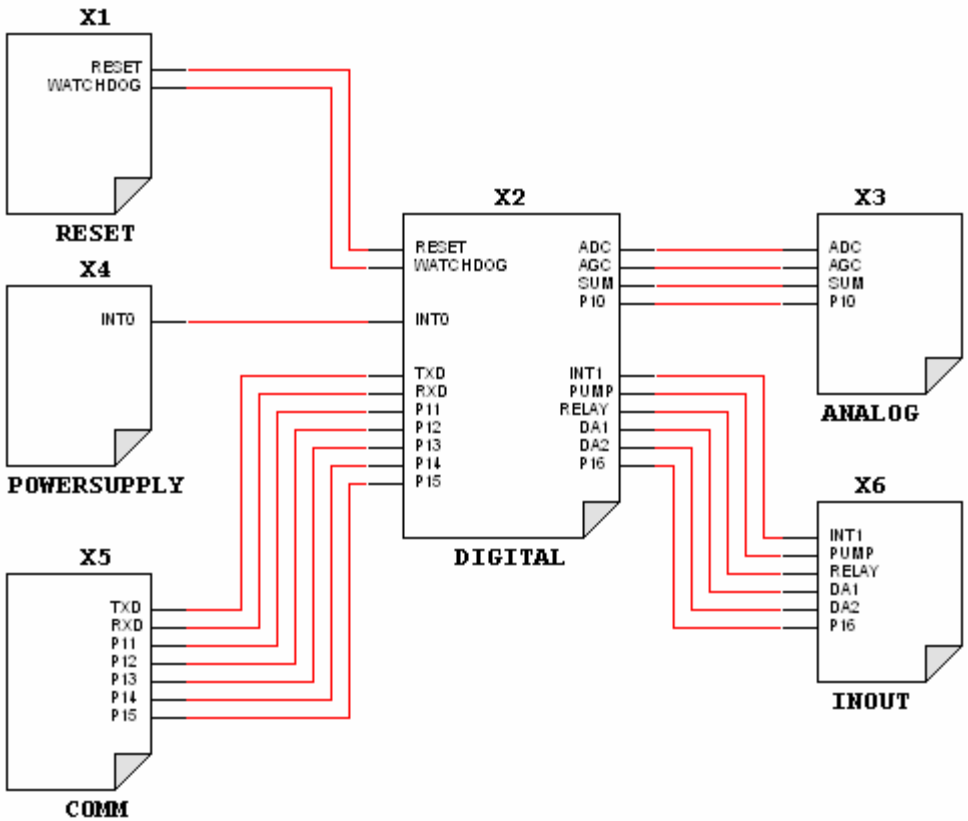
Design Blocks

- Build a library of commonly used circuits
- Reuse circuit models
- Changes propagate
- Cleaner, modularized architecture
- Use the Design Toolbox to browse through the hierarchy
- Three options:
    - Hierarchical Blocks
    - Subcircuits
    - Multi-page

Design Blocks – Before

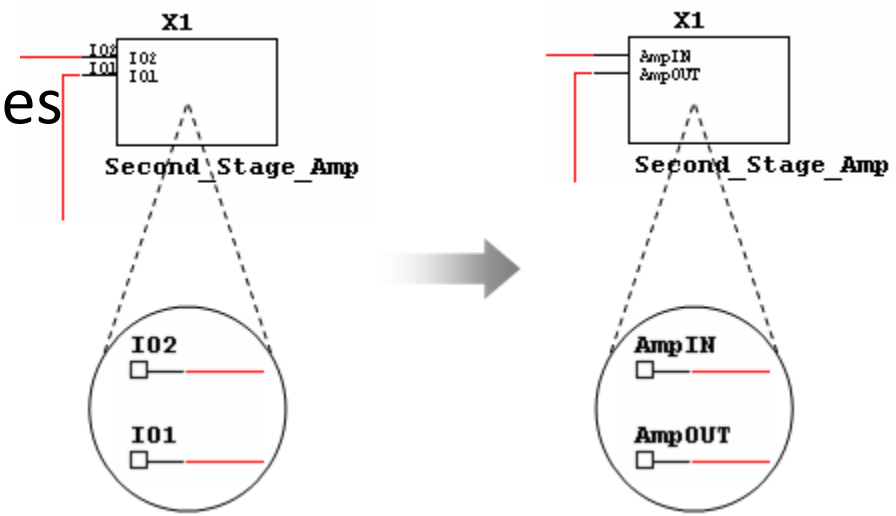


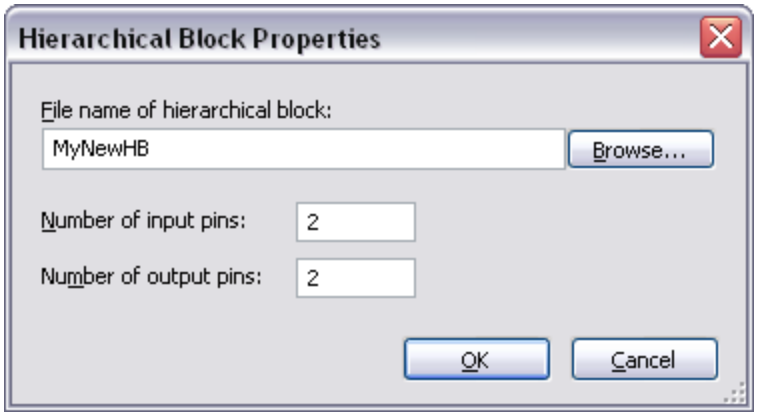
Design Blocks – After

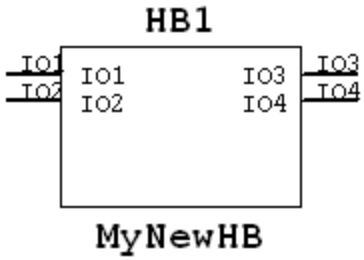


Design Blocks – Connectors

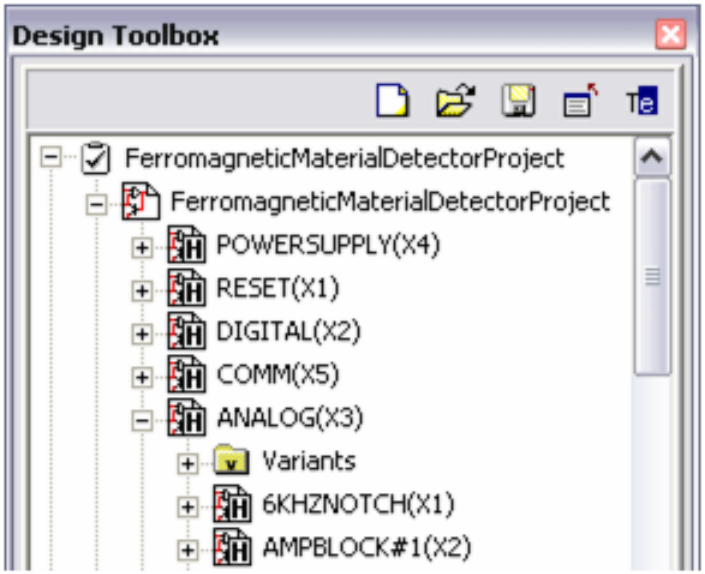
- Interconnect circuits with HB or SC connectors
- Rename connectors
- Connector name = netnames

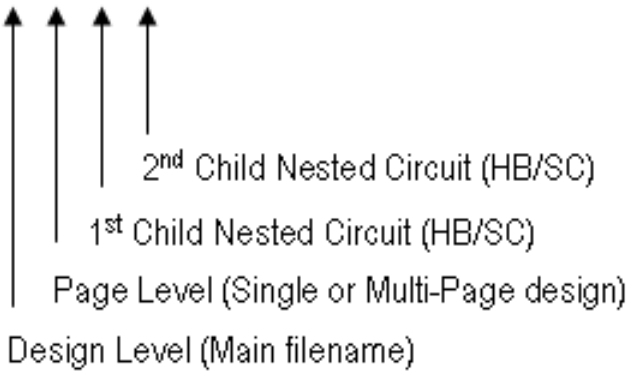


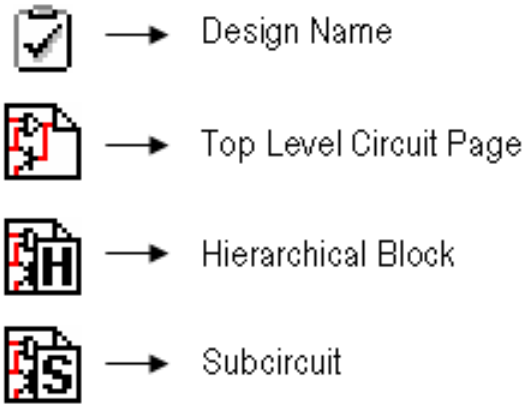




Nested Circuits



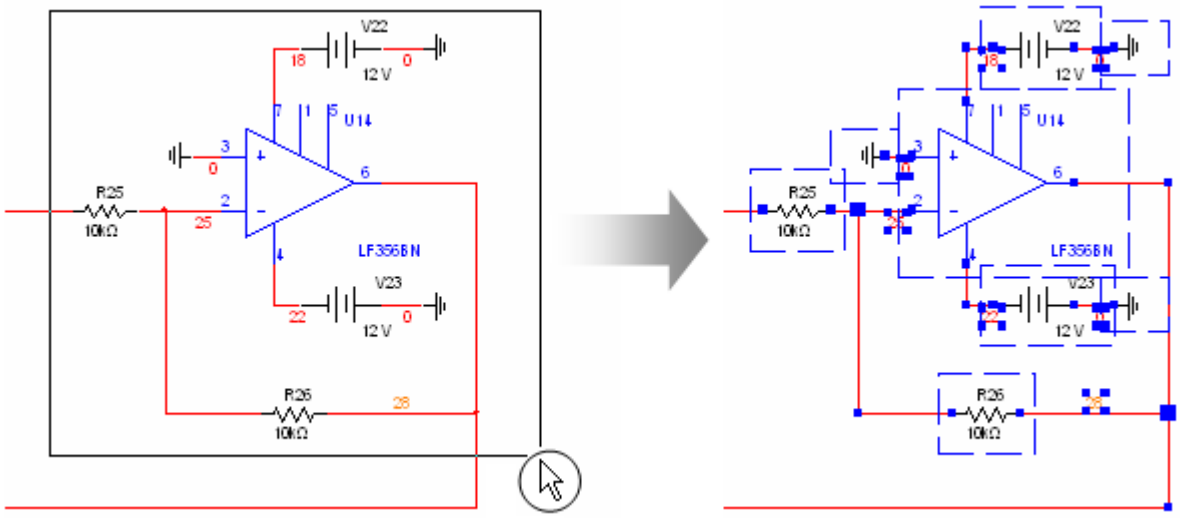




- Hierarchy tree organization
- Use Design Toolbox

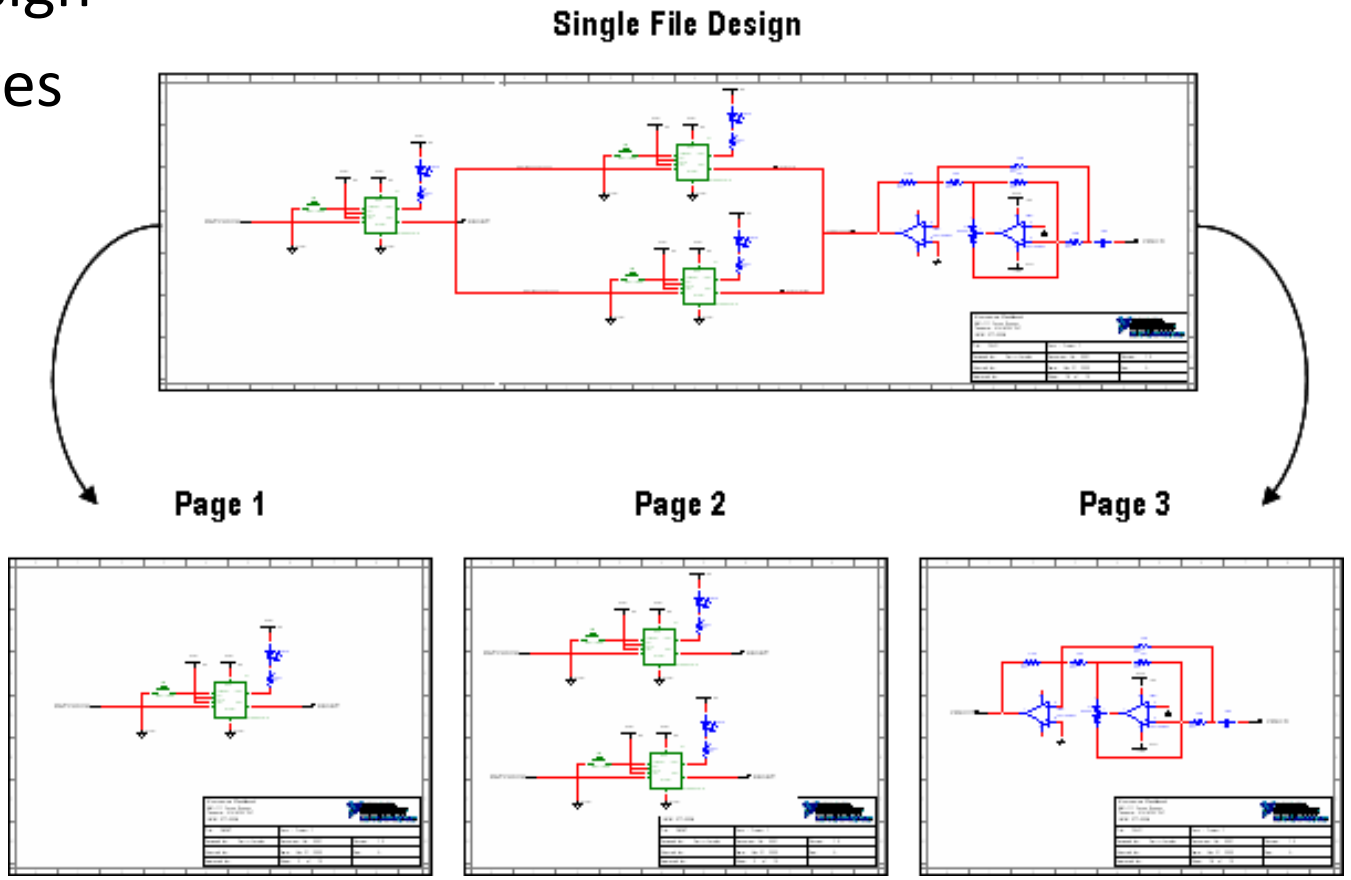
Creating Design Blocks

- Multiple options to create or use blocks
  - **Place»New Subcircuit (or Hierarchical Block)**
  - **Place»Hierarchical Block from File**
  - **Place»Replace by Subcircuit (or Hierarchical Block)**



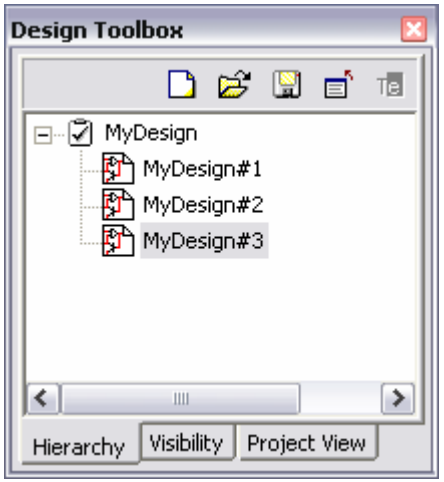
Multi-page Design

- For flat design
- Split in pages

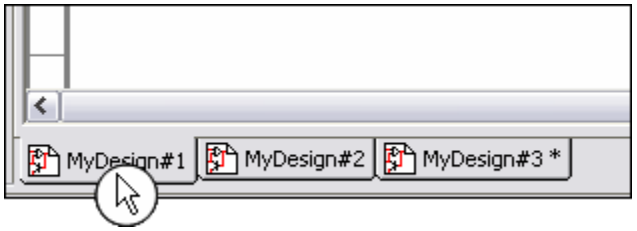


Multi-page Design

– Same hierarchy level as top-level page

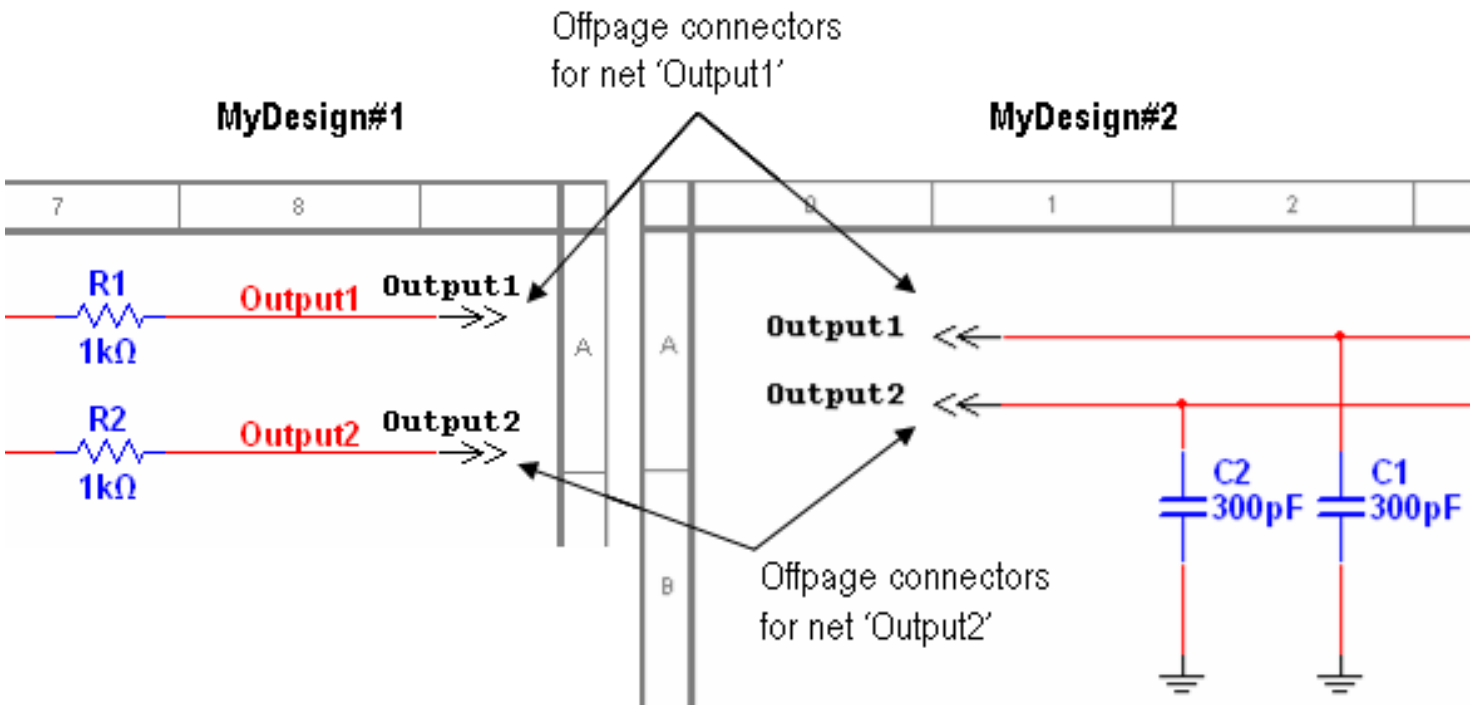


– Workspace tabs per page (reorder in Design Toolbox)



Multi-page Design

- Interconnect pages with Off-page connectors.
- Alternatively, you could use Global with On-page connectors.



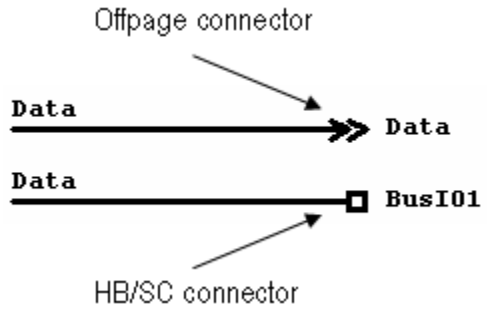
Modular Design Summary – Pros & Cons

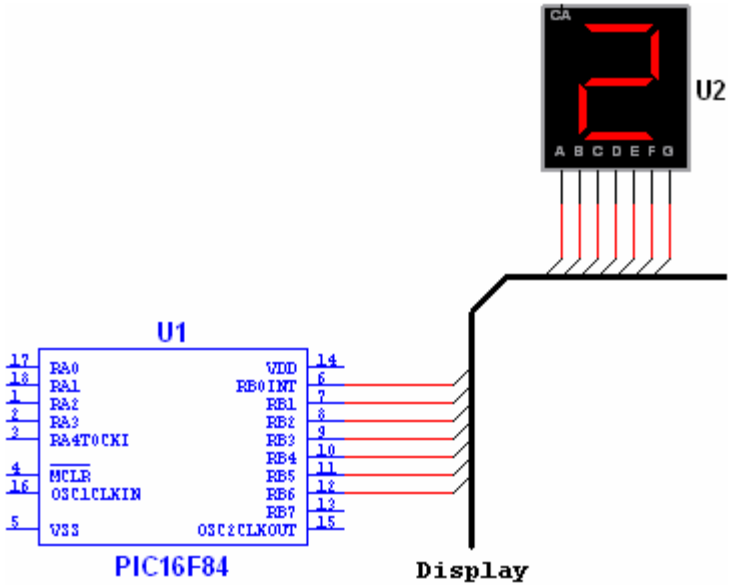
	Pros	Cons
Multi-page	• Good for flat designs • Every page saved in the same circuit file • Organized horizontal view of design	• Not for reusing blocks in a later project • Not recommended for non-flat designs • File size is bigger • Updating a section requires the complete circuit to be open
Subcircuits (SC)	• Every page saved in the same circuit file • Symbol is editable • Easy to visualize functional blocks	• Not for reusing blocks in a later project • File size is bigger • Updating a section requires the complete circuit to be open
Hierarchical Blocks (HB)	• Best option to reuse circuit blocks • Symbol is editable • Smaller file size • Easy to visualize functional blocks • Updating the HB updates all designs where it is used	• HBs need to accompany the main design file every time you move it

Recommended

Buses

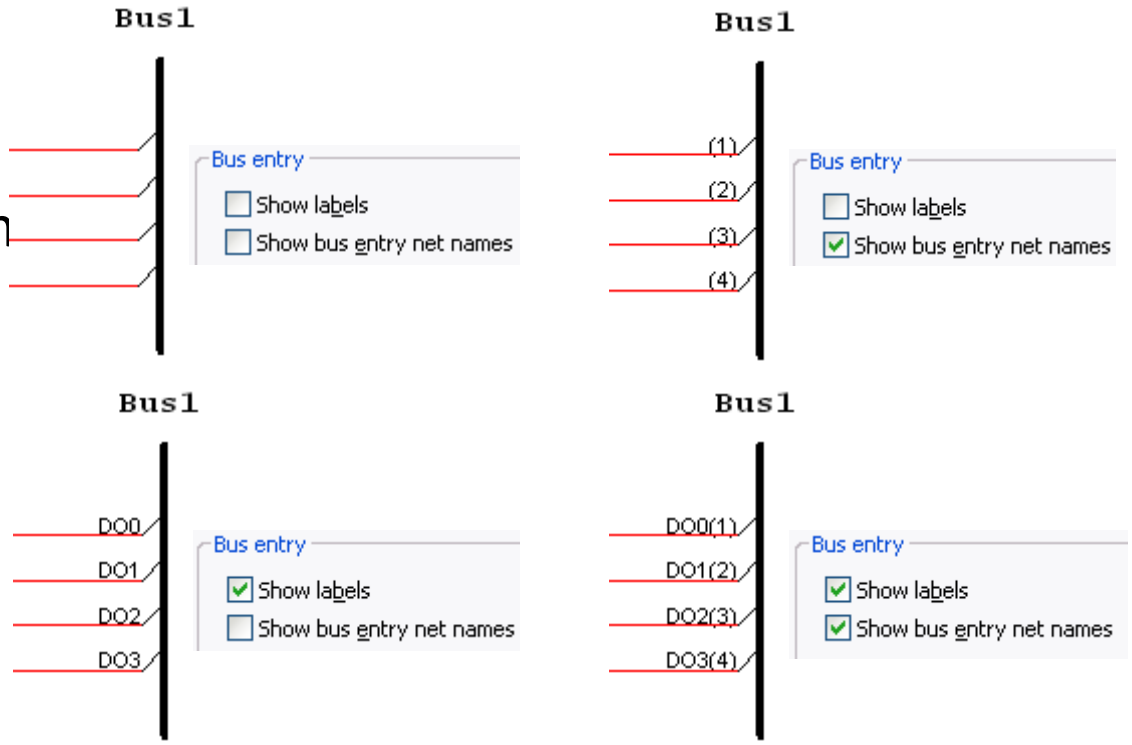
- Buses simplify wiring
- Carry multiple nets
- Used within:
  - a page
  - across pages
  - across design blocks



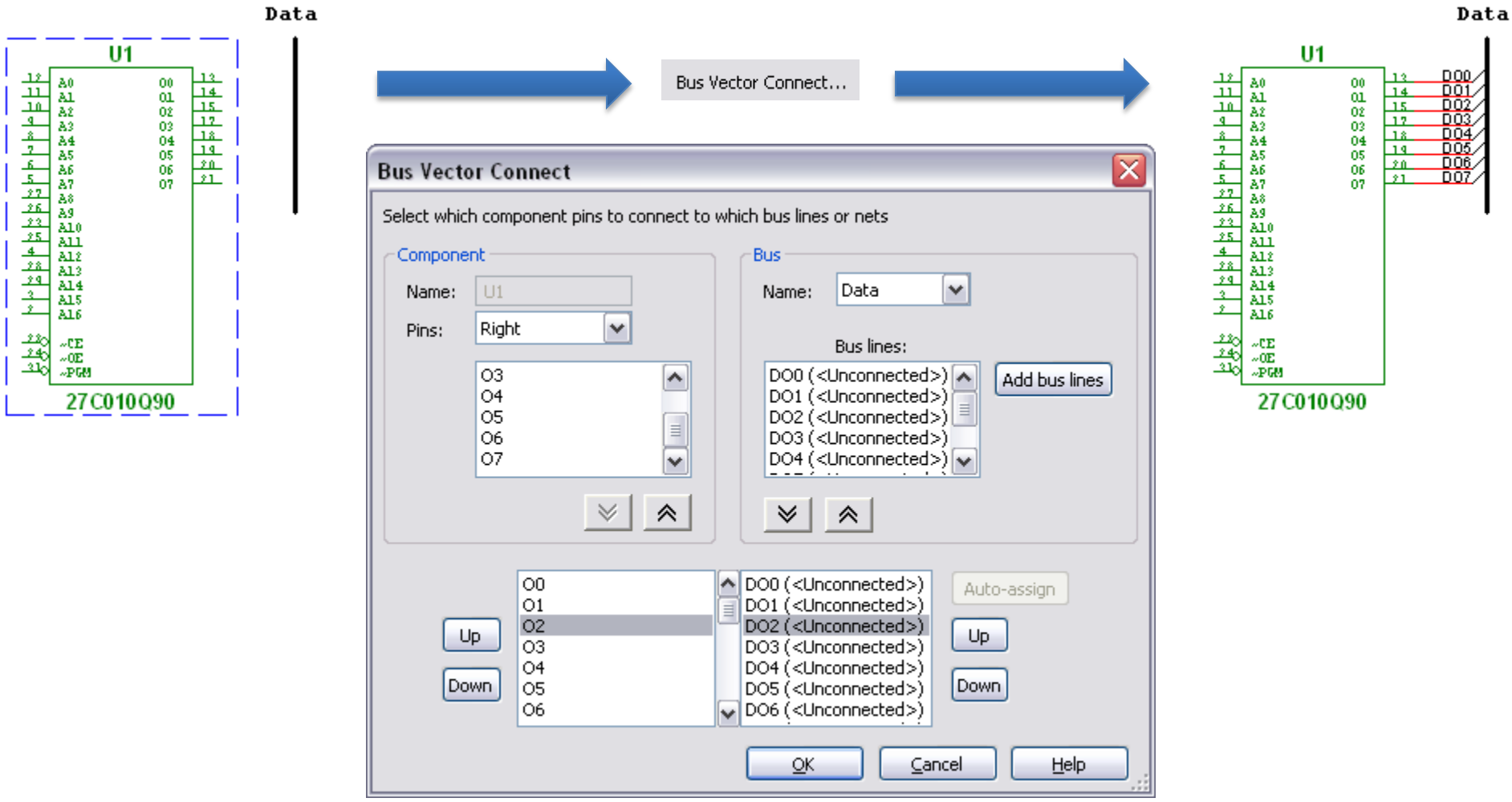


Bus Wiring Modes

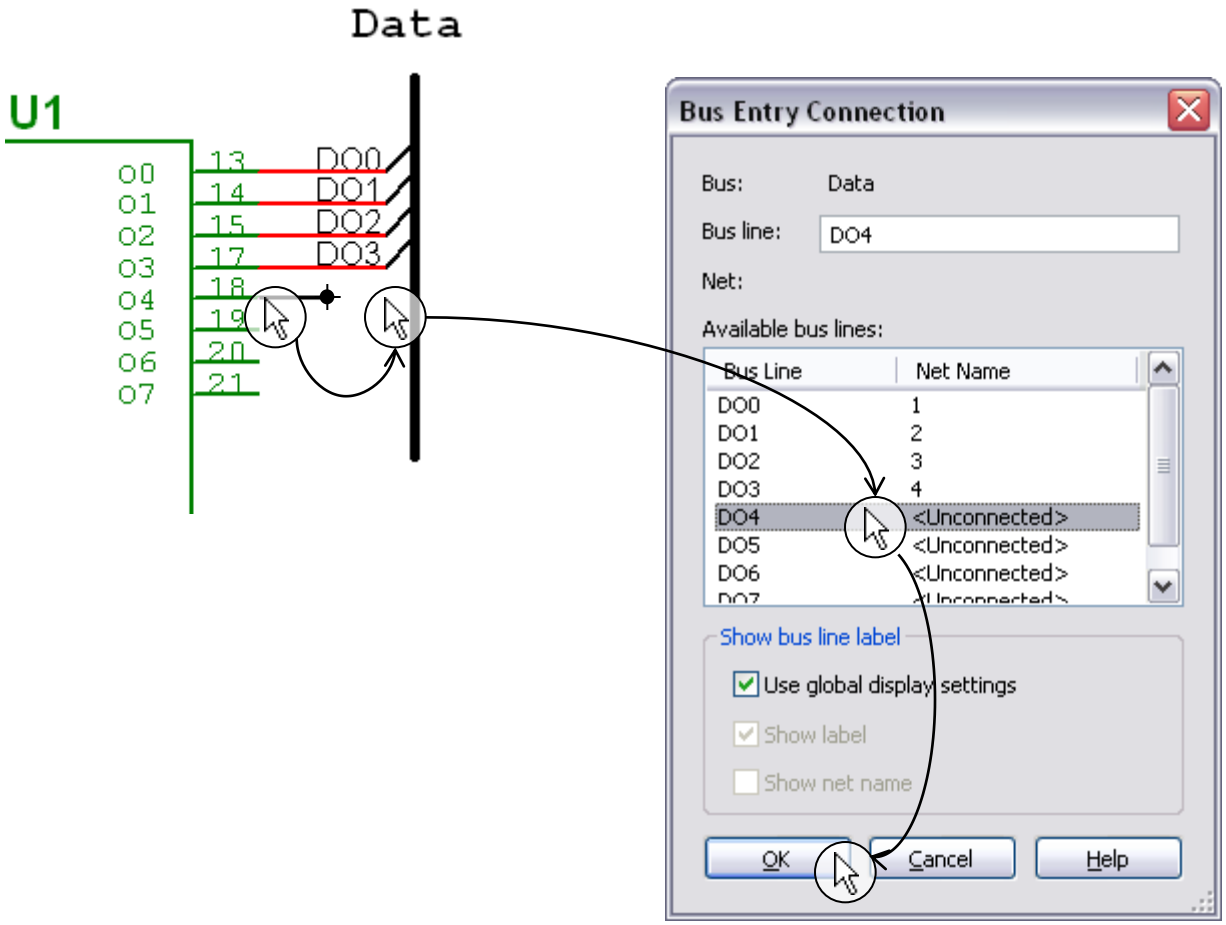
- Set mode in **Options»Sheet Properties»Circuit** tab
- Bus wiring modes:
  - no labels,
  - net names,
  - busline nam



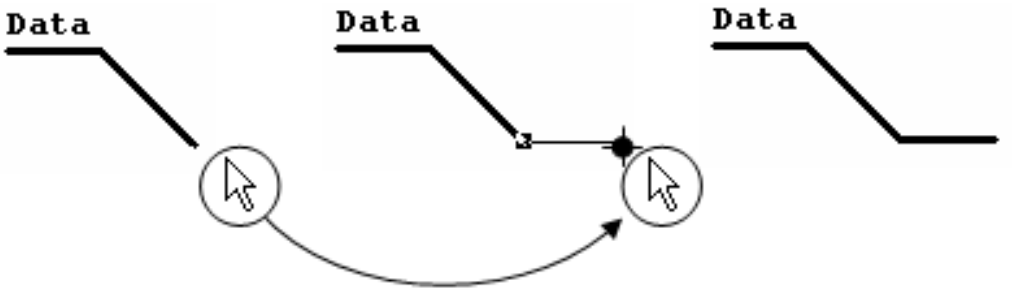
Bus Vector Connect

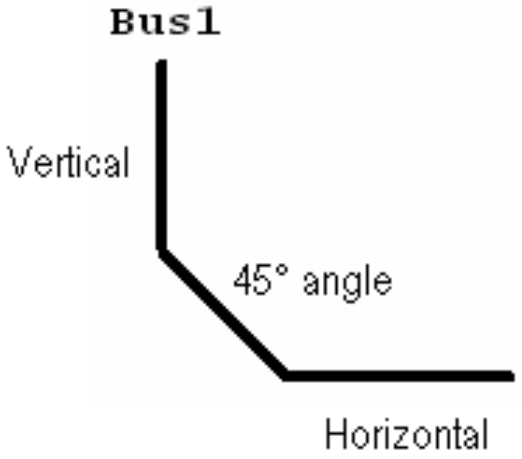


Bus Entry Connect

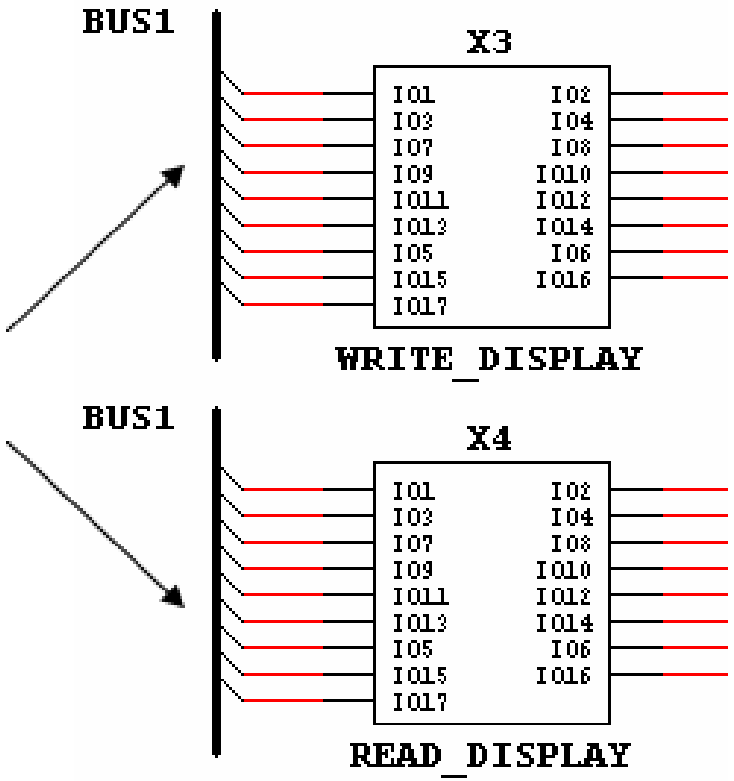


Bus Manipulation





These two buses are virtually connected since they have the same name

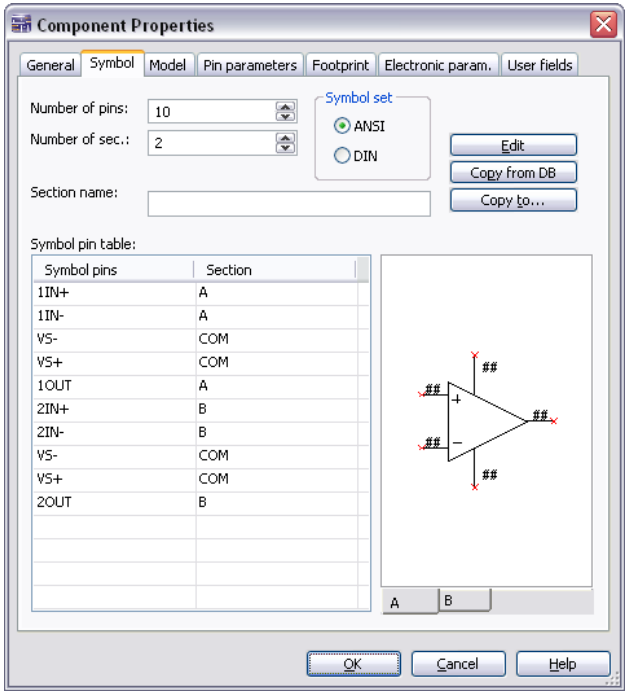


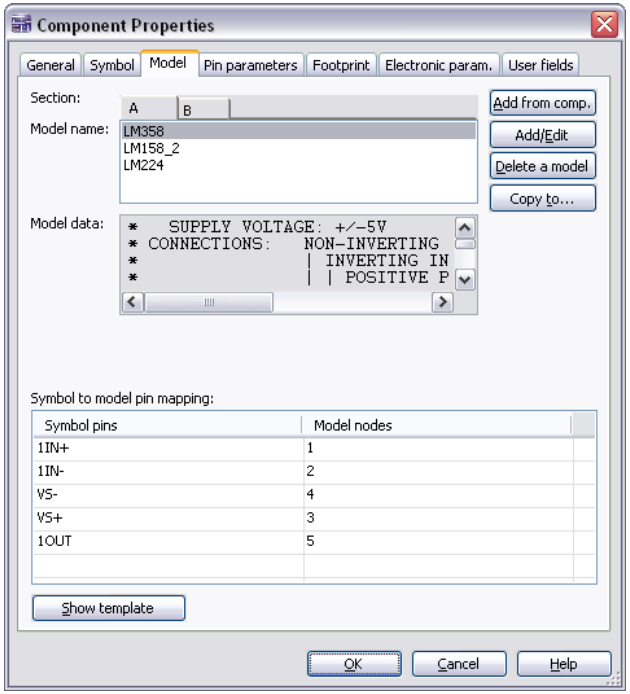
Tools Available to Customize Components

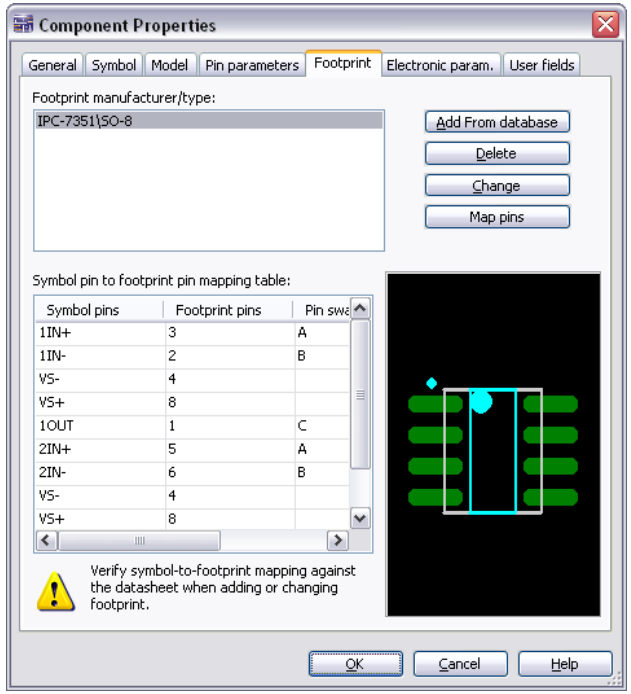
- Component Properties – edit components
- Corporate/User DB – save custom components
- The Component Wizard – create new components
- Model Makers – create new SPICE models
- The Symbol Editor – create new symbols
- Database Manager – manage custom components

Component Properties

- Double-click a component to access the Properties window
- Click **Edit component in DB** to edit the component
- Use the tabs to modify component information or configuration





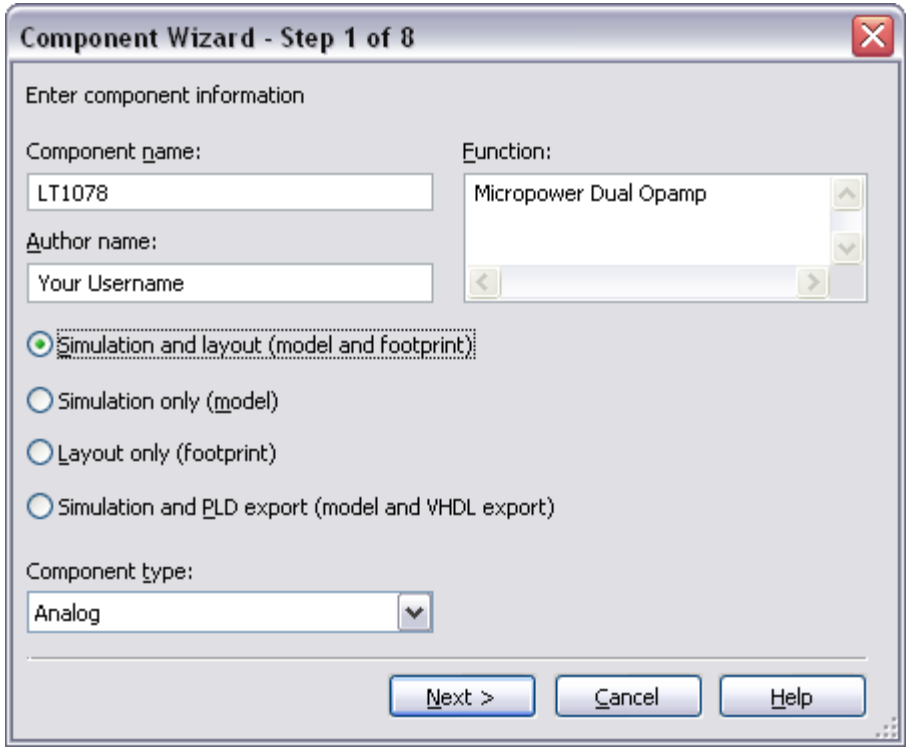


The Component Wizard

- Step by step assistant guides you in the new component creation
- Store the new component in the User or Corporate database
- Number of steps depend on intended use of component:
    - Simulation and Layout *(model and footprint)*
    - Simulation only *(model)*
    - Layout only *(footprint)*
- **Tools»Component Wizard**

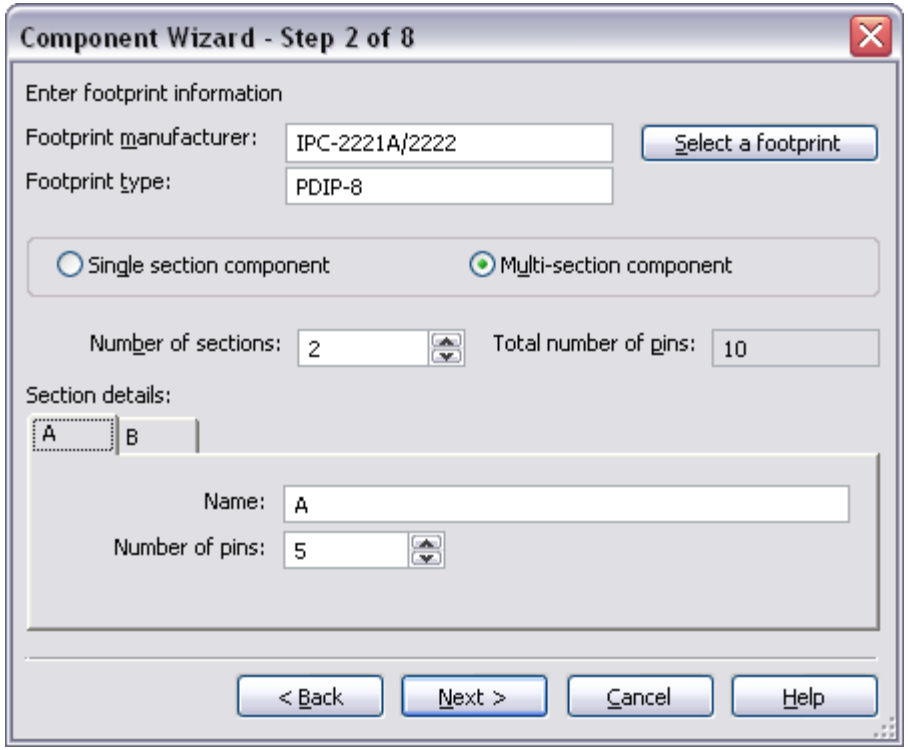
The Component Wizard Step 1

- **Step 1: Enter Component Information**
- Name, author, function
- Component type:
  - *Analog* for most components
  - *Digital* if you have XSPICE
- Select use of component



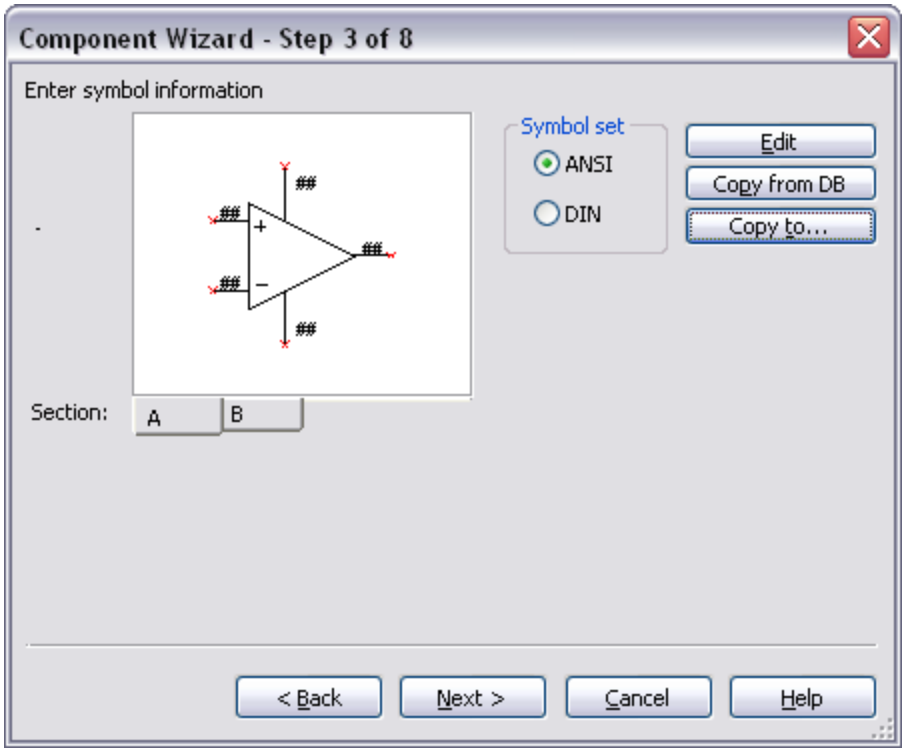
The Component Wizard Step 2

- **Step 2: Enter Footprint Information**
  - Select footprint from database
  - Use custom footprints from Ultiboard
  - Define number of sections
  - Define number of pins per section



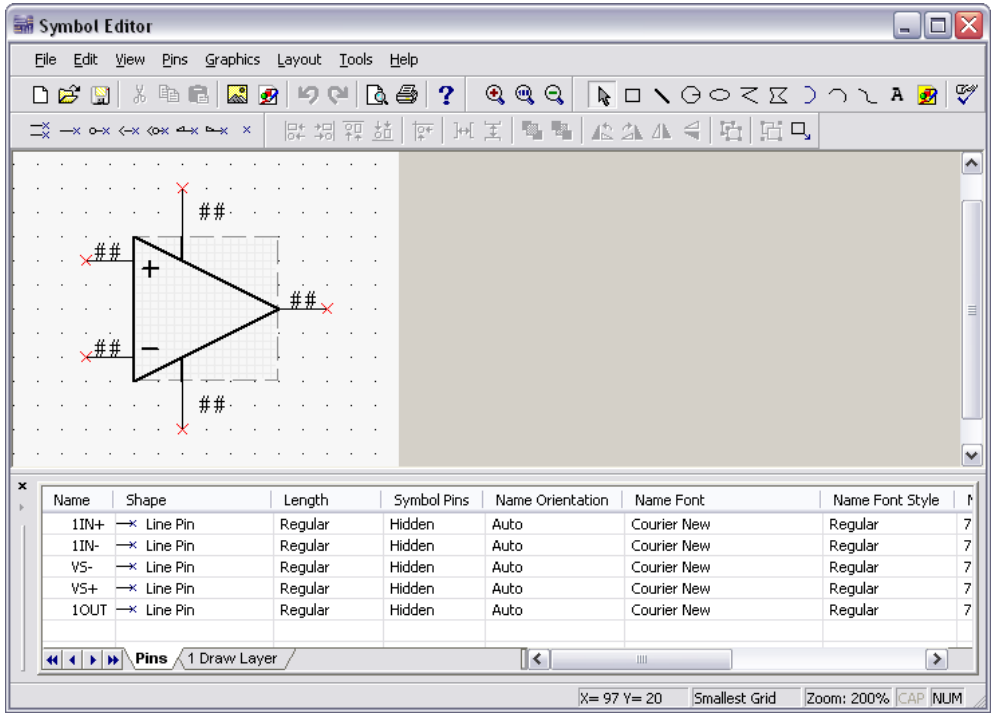
The Component Wizard Step 3

- **Step 3: Enter Symbol Information**
  - Copy symbol from database components
  - Copy symbol to DIN
  - Create symbol per section
  - Click **Edit** to launch **Symbol Editor**



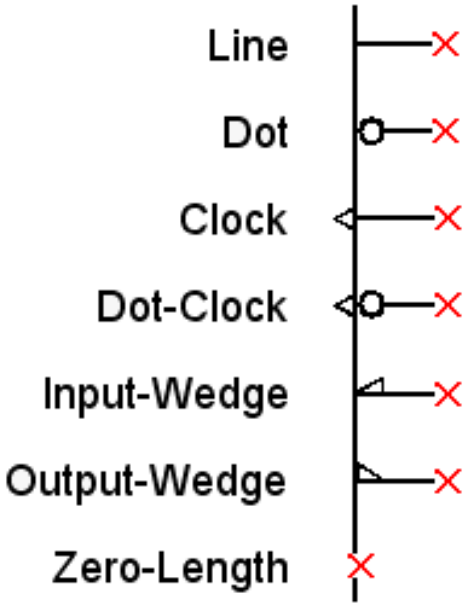
The Symbol Editor

- Specialized graphics editor
- Create / modify symbols
- Save symbol files
- Also access from:
  - **Tools»Symbol Editor**



The Symbol Editor

- Define pin shapes



- *Define pin names and properties using the Spreadsheet View*

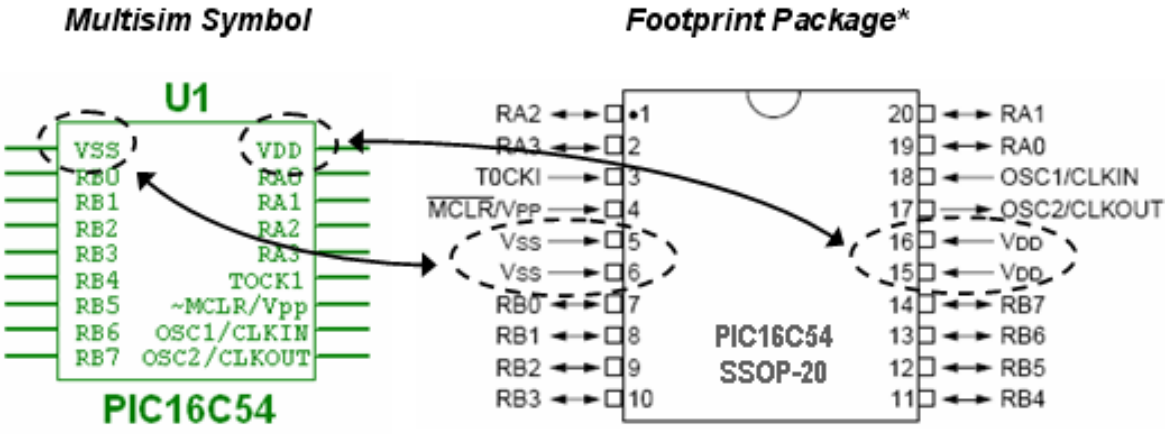
Spreadsheet

Name	Shape	Length	Symbol Pins	Name Orientation	Name Font
VIN-	Line Pin	Short	Visible	Auto	Courier New
VCC+	Line Pin	Short	Visible	Auto	Courier New
VCC-	Line Pin	Short	Visible	Auto	Courier New
REF	Line Pin	Short	Visible	Auto	Courier New
SHDN	Line Pin	Short	Visible	Auto	Courier New
G0	Line Pin	Short	Visible	Auto	Courier New
G1	Line Pin	Short	Visible	Auto	Courier New
G2	Line Pin	Short	Visible	Auto	Courier New

Pins | 1 Draw Layer

The Symbol Editor – Repeated Pins

- **Method 1**: One single pin representing multiple pins



* Microchip® PIC16C54 Datasheet

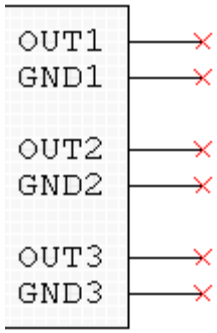
Duplicated footprint pins mapped to one single symbol pin

Symbol Pin to Footprint Pin Mapping Table:

Symbol Pins	Footprint Pins	Pin Swa
VSS	5,6	
RB0	7	
RB1	8	
RB2	9	
RB3	10	
RB4	11	
RB5	12	
RB6	13	
RB7	14	
VDD	15,16	
RA0	19	

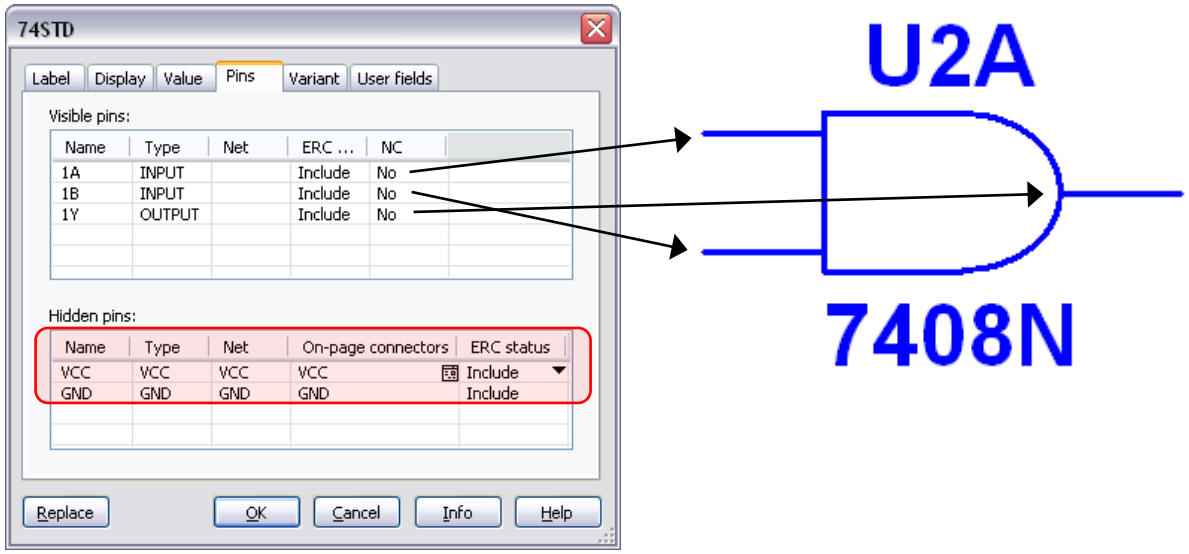
The Symbol Editor – Repeated Pins

- **Method 2**: One pin with an appended suffix



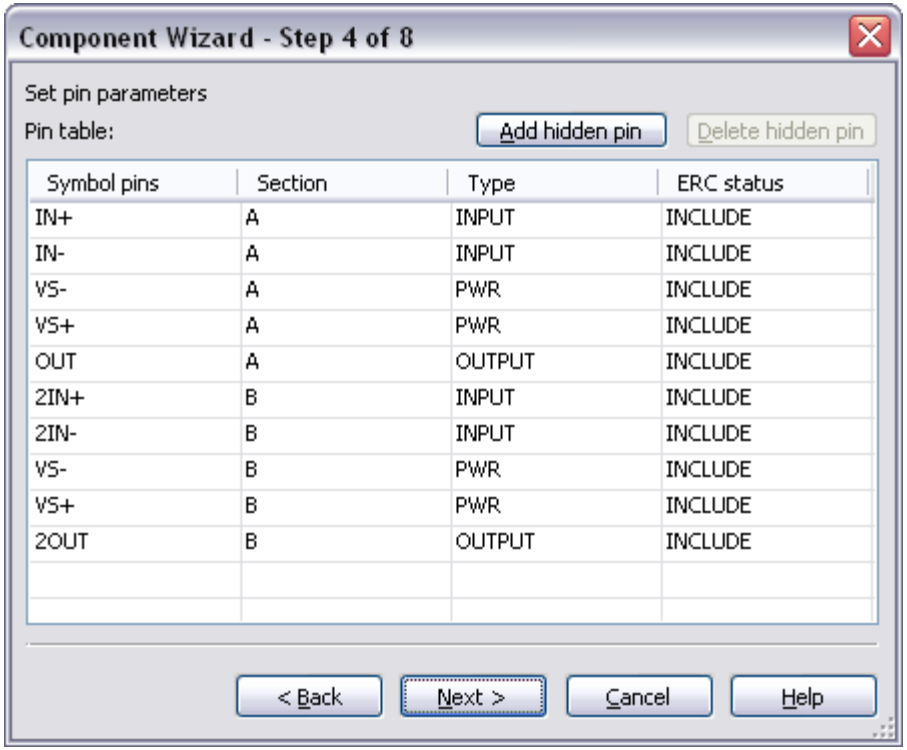
The Symbol Editor – One Shared Pin

- If a component shares one single pin across multiple sections, such as a GND connection:
  - Create a duplicate pin per section
  - In **Step 5** assign the same footprint pin to every instance of that pin in each symbol
- The other option is to add that pin as a *hidden pin*, which is part of the model and/or footprint but does not show in the schematic.



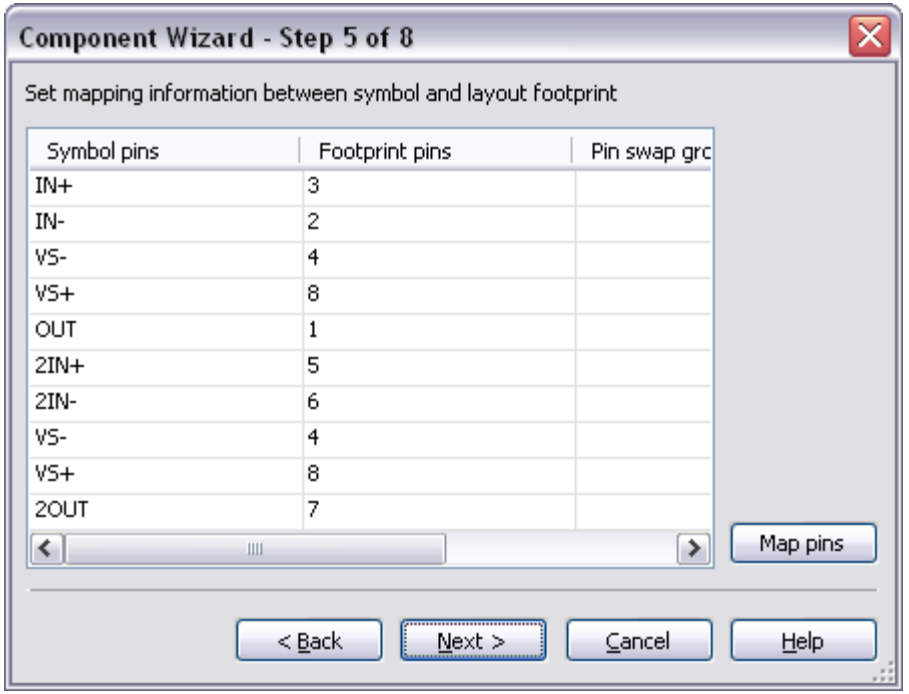
The Component Wizard Step 4

- **Step 4: Set Pin Parameters**
- Set sections:
  - A, COM, Power, …
- Set pin types for ERC
- Set ERC status
- Add hidden pins (not in the symbol but needed for model and/or footprint



The Component Wizard Step 5

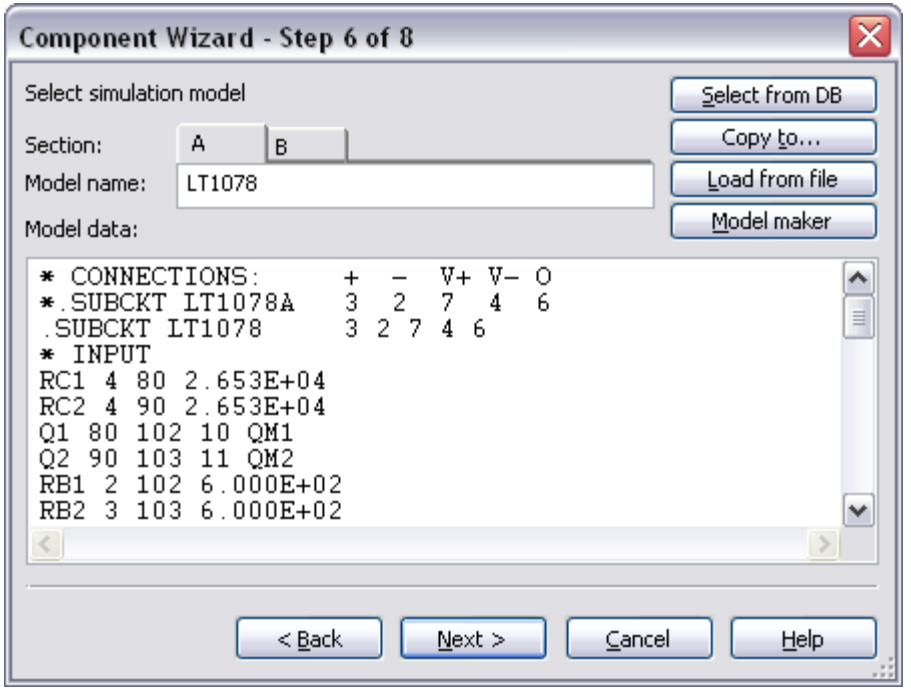
- **Step 5: Set Mapping Information Between Symbol and Layout Footprint**
  - Multiple footprint pins can be mapped to a single symbol
  - Set Pin and Gate Swap Group Information



Caution: The accuracy of this mapping will impact the PCB layout design.

The Component Wizard Step 6

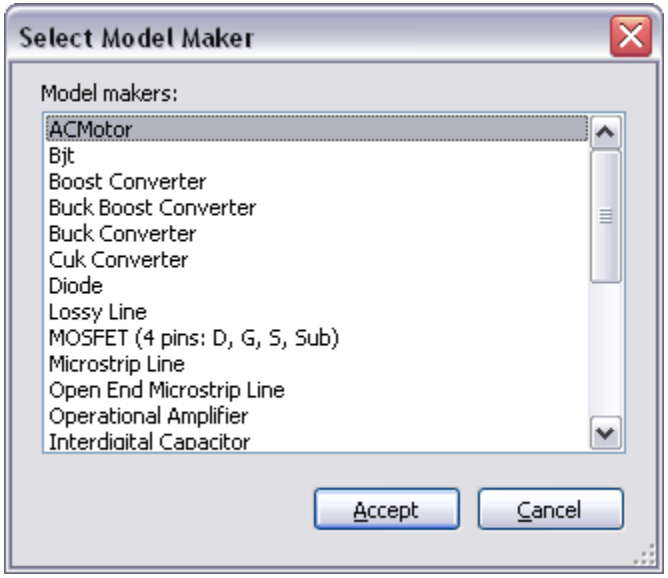
- **Step 6: Select Simulation Model**
  - Define model per section
  - Copy model from database
  - Load model from file
  - Use the Model Maker



Note: The quality and sophistication of a SPICE model directly impacts the ability to simulate that component correctly and accurately.

Model Maker

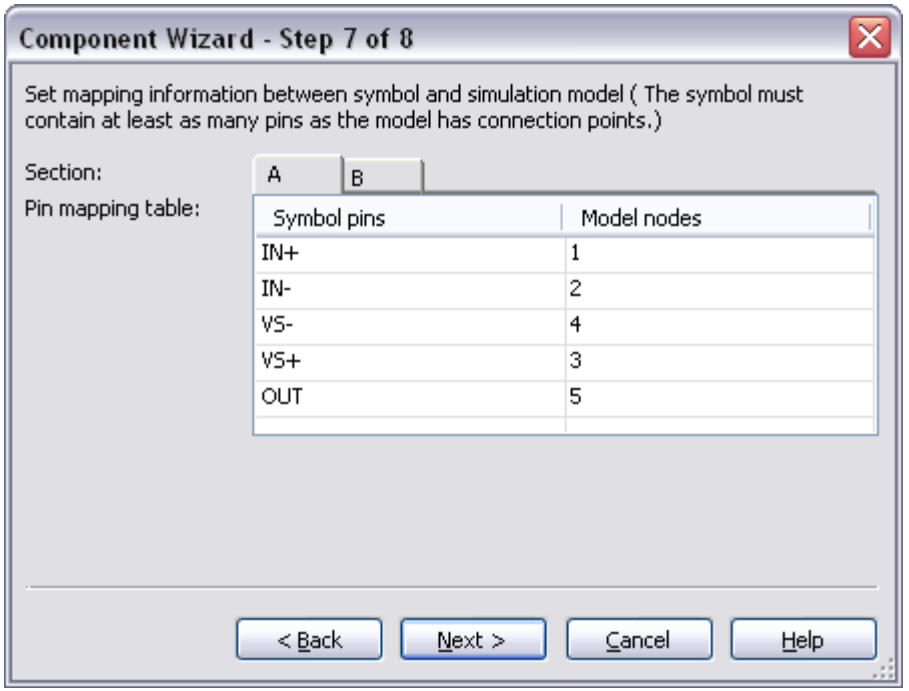
- Automatically generate simulation models
- Use datasheet parameters
- Preset values provided



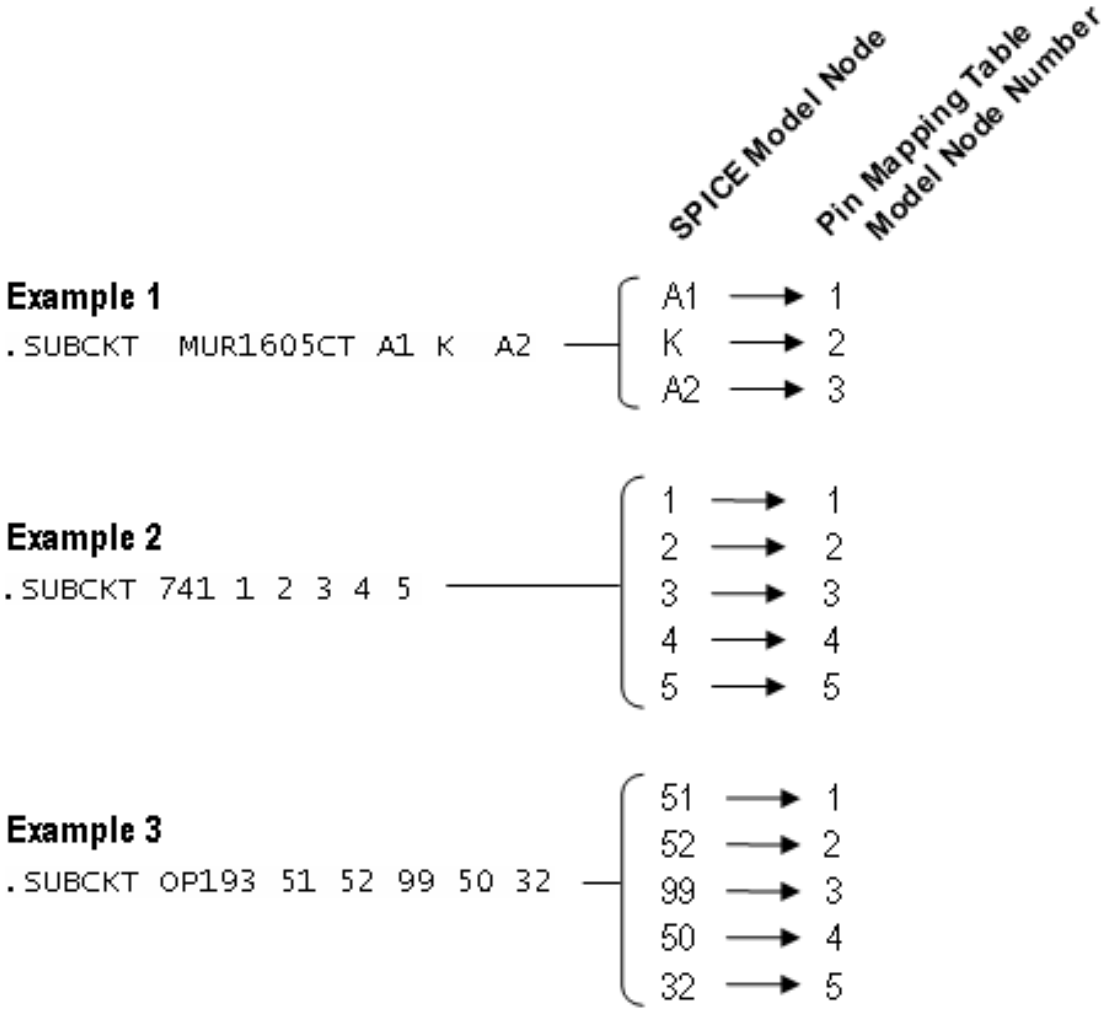
Caution: Model accuracy can only be guaranteed by the component manufacturer.

The Component Wizard Step 7

- **Step 7: Set Mapping Information Between Symbol and Simulation Model**
  - Model nodes are in order of appearance
  - Set model node per pin
  - Set model nodes per section



Caution: The accuracy of this mapping will impact the simulation results.

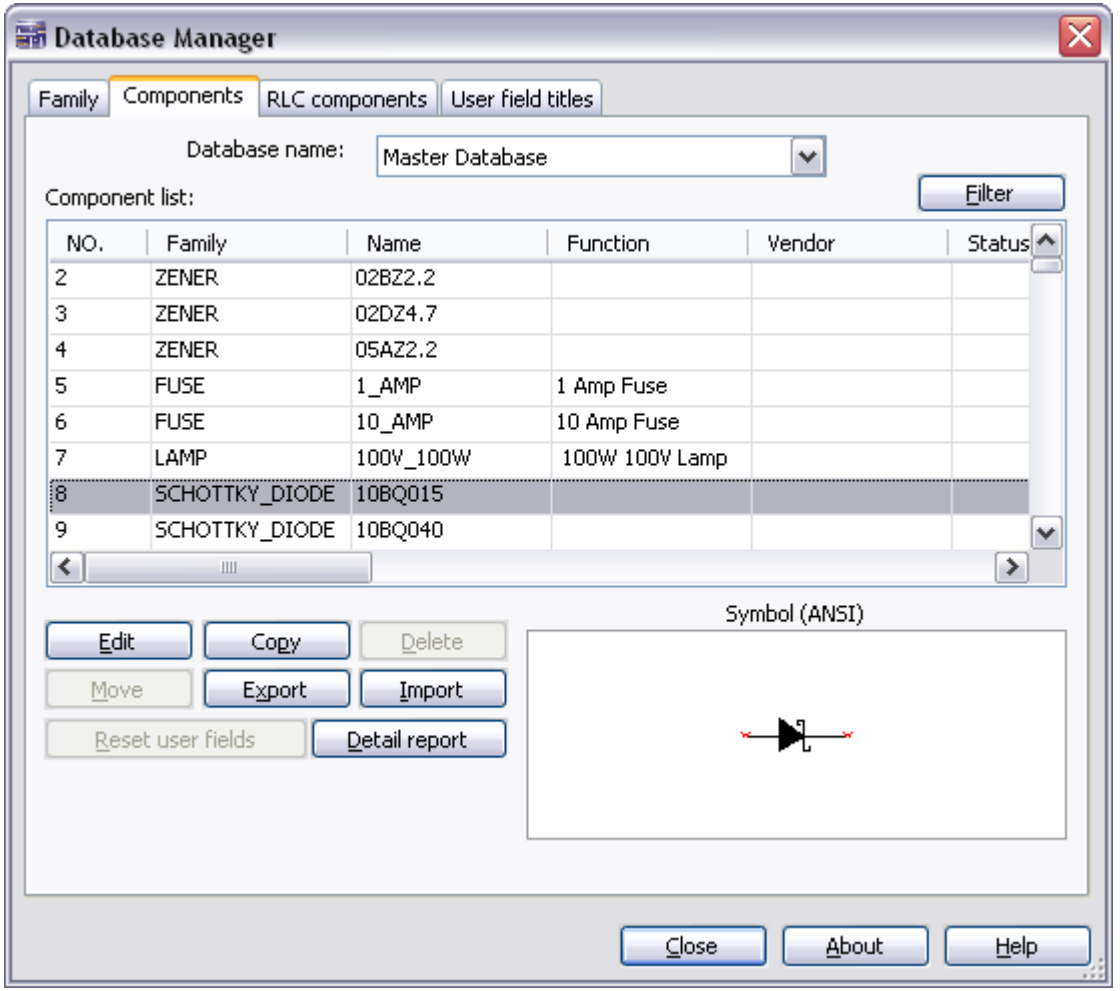

SPICE Model Node
Pin Mapping Table
Model Node Number
Example 1
.SUBCKT MUR1605CT A1 K A2
A1 → 1
K → 2
A2 → 3
Example 2
.SUBCKT 741 1 2 3 4 5
1 → 1
2 → 2
3 → 3
4 → 4
5 → 5
Example 3
.SUBCKT OP193 51 52 99 50 32
51 → 1
52 → 2
99 → 3
50 → 4
32 → 5

The Component Wizard Step 8

- **Step 8: Save Component to Database**
  - Select User or Corporate Database
  - Select Group and Family
  - Modify Family icon from the Database Manager

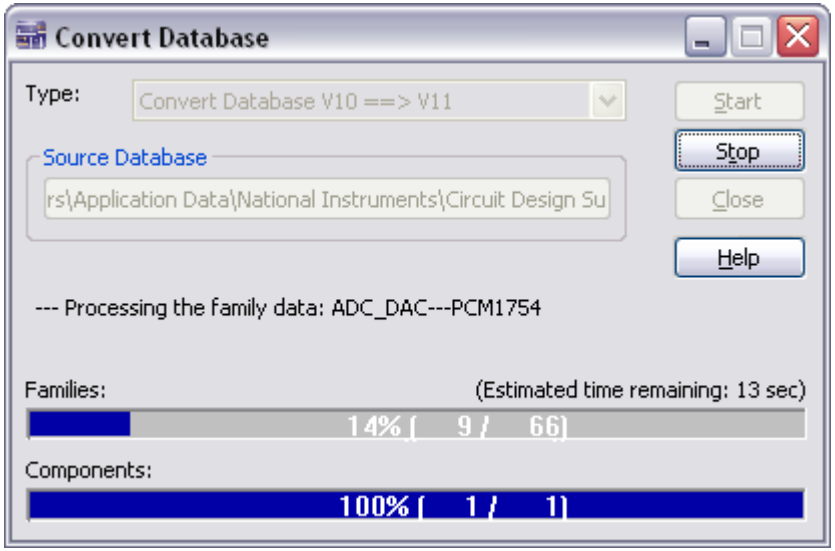
Database Manager

- Manage Master, Corporate and User database
- Edit, copy, delete and move parts
- Import and export components
- Filter allows you to browse quickly
- Create and modify new Families
- Set User Fields



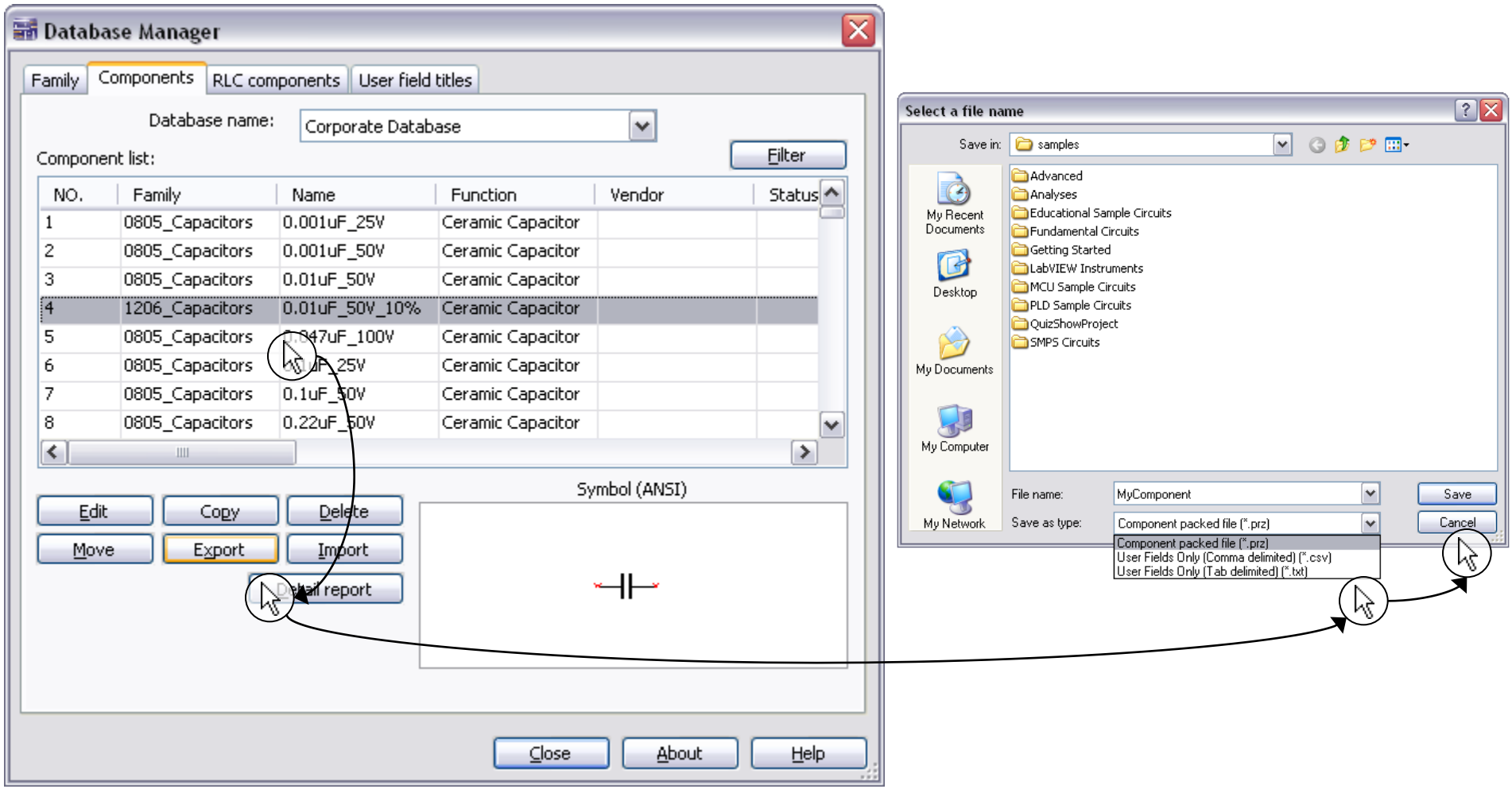
Converting and Merging Databases

- **Tools»Database»Convert Database**
  - Convert an older version (2001, 7, 8, 9 or 10) database to 11



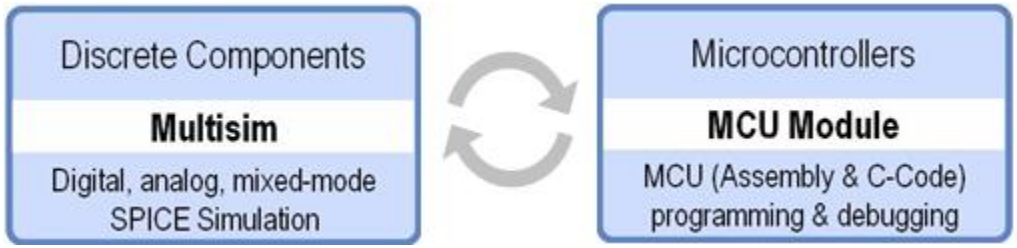
- **Tools»Database»Merge Database**
  - Merge an existing version 11 database

Importing and Exporting Components



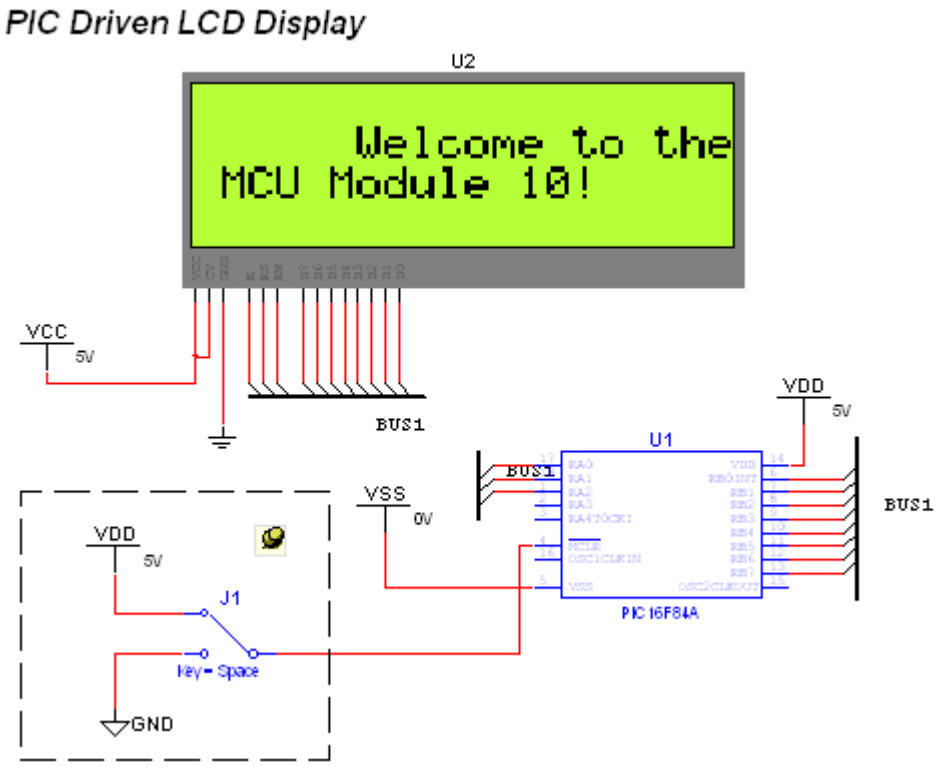
MCU Co-simulation

- Adds co-simulation capabilities
  - C or assembly with SPICE components
- Simulate like any other circuit



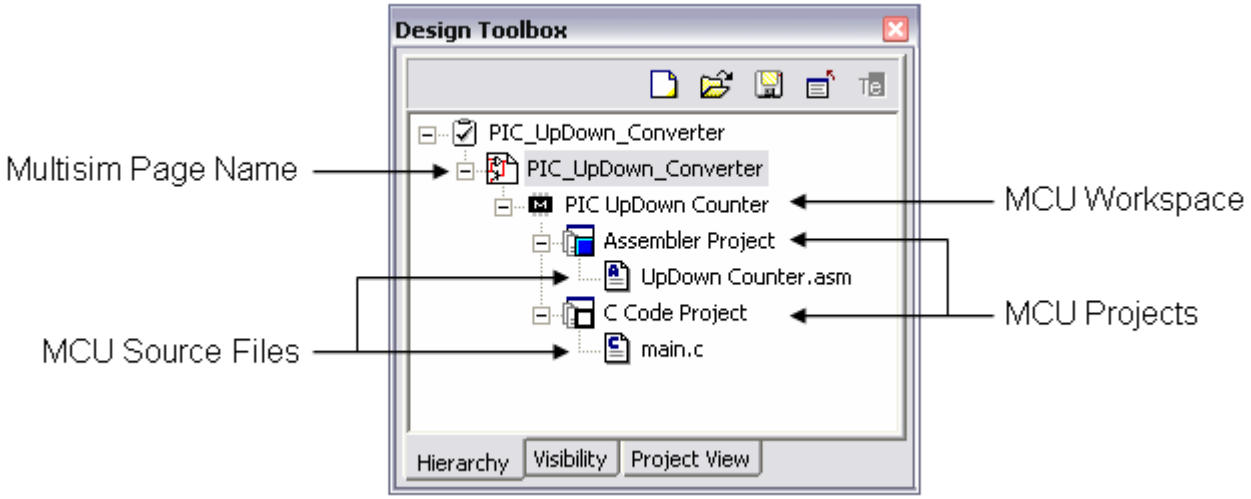
MCU Co-simulation

- Supports:
  - 8051, 8052
  - PIC16F84, PIC16F84A
- Includes peripherals like ROM and RAM
- Advanced peripherals:
  - Keypads
  - LCD Displays
  - VTERM terminal



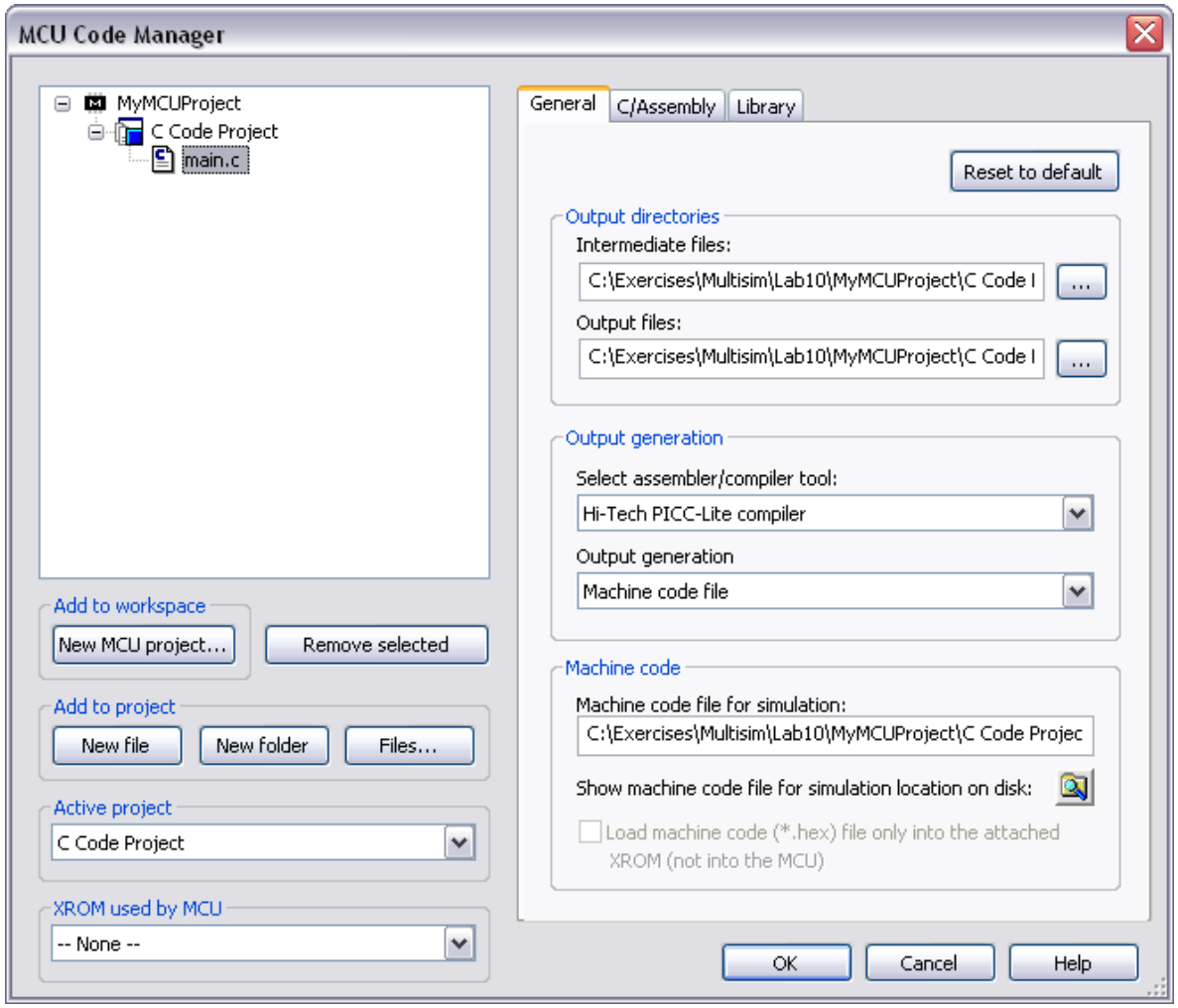
MCU Workspace

- Dedicated hierarchy in the Design Toolbox
- Organized in projects



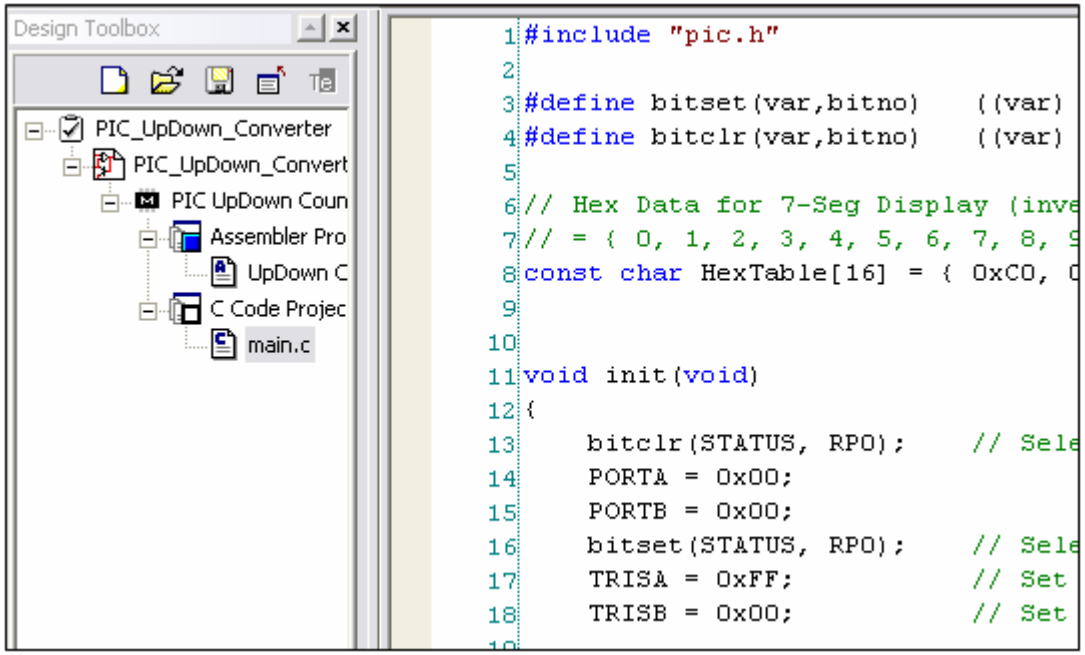
Code Manager

- Manage MCU files
- Enter build settings for source code
- Define compilers
- Create new projects
- Define external ROM (XROM)
- Set special Link or library calls
- **MCU»<MCU name>»MCU Code Manager**


MCU Code Manager
MyMCUProject
C Code Project
main.c
Add to workspace
New MCU project...
Remove selected
Add to project
New file
New folder
Files...
Active project
C Code Project
XROM used by MCU
-- None --
General
C/Assembly
Library
Reset to default
Output directories
Intermediate files:
C:\Exercises\Multisim\Lab10\MyMCUProject\C Code I
Output files:
C:\Exercises\Multisim\Lab10\MyMCUProject\C Code I
Output generation
Select assembler/compiler tool:
Hi-Tech PICC-Lite compiler
Output generation
Machine code file
Machine code
Machine code file for simulation:
C:\Exercises\Multisim\Lab10\MyMCUProject\C Code Projec
Show machine code file for simulation location on disk:
Load machine code (*.hex) file only into the attached XROM (not into the MCU)
OK
Cancel
Help

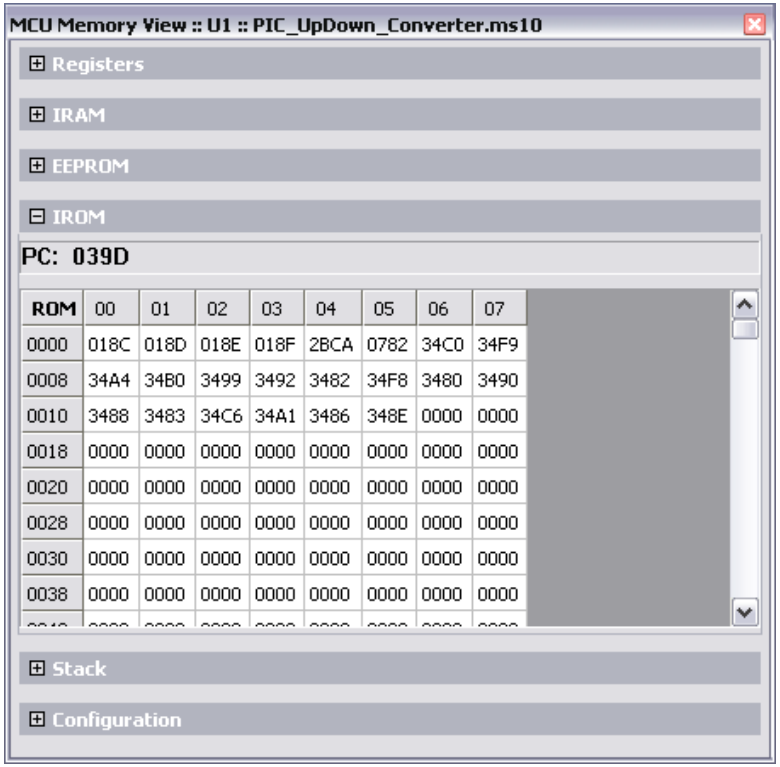
Source Code Editor

- Click source file in the Design Toolbox to open editor
- Color coded text editor
- Similar to other programming IDEs



Memory View

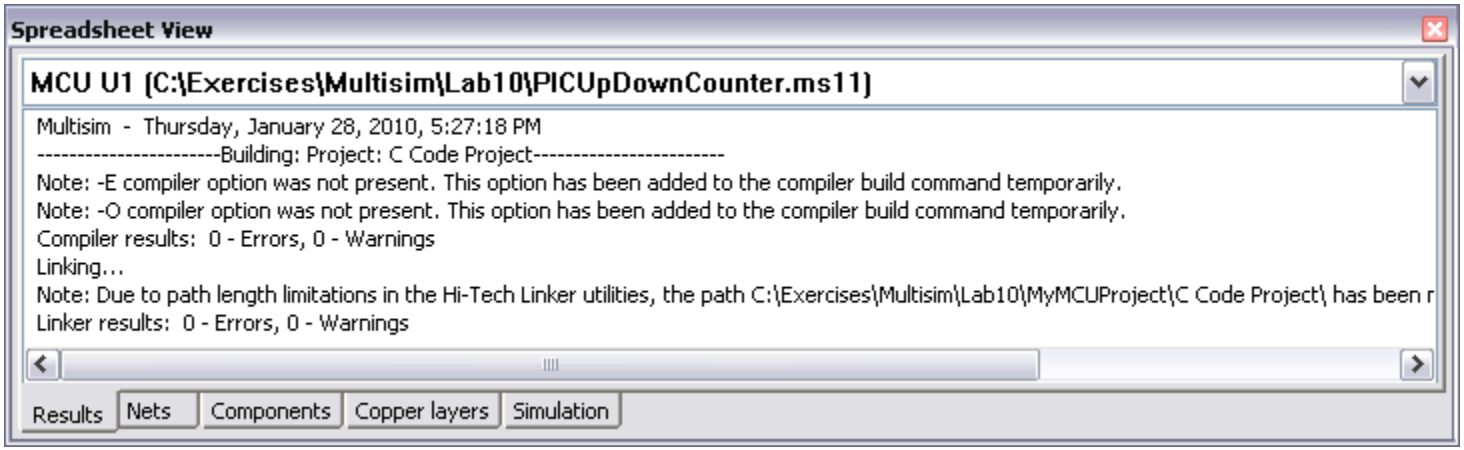
- **MCU»<MCU name>»Memory View**
- Pause simulation to view memory addresses in real-time
- Click an address to change its value
- Load or save EEPROM hex values



ROM	00	01	02	03	04	05	06	07
0000	018C	018D	018E	018F	2BCA	0782	34C0	34F9
0008	34A4	34B0	3499	3492	3482	34F8	3480	3490
0010	3488	3483	34C6	34A1	3486	348E	0000	0000
0018	0000	0000	0000	0000	0000	0000	0000	0000
0020	0000	0000	0000	0000	0000	0000	0000	0000
0028	0000	0000	0000	0000	0000	0000	0000	0000
0030	0000	0000	0000	0000	0000	0000	0000	0000
0038	0000	0000	0000	0000	0000	0000	0000	0000

Debugging Features

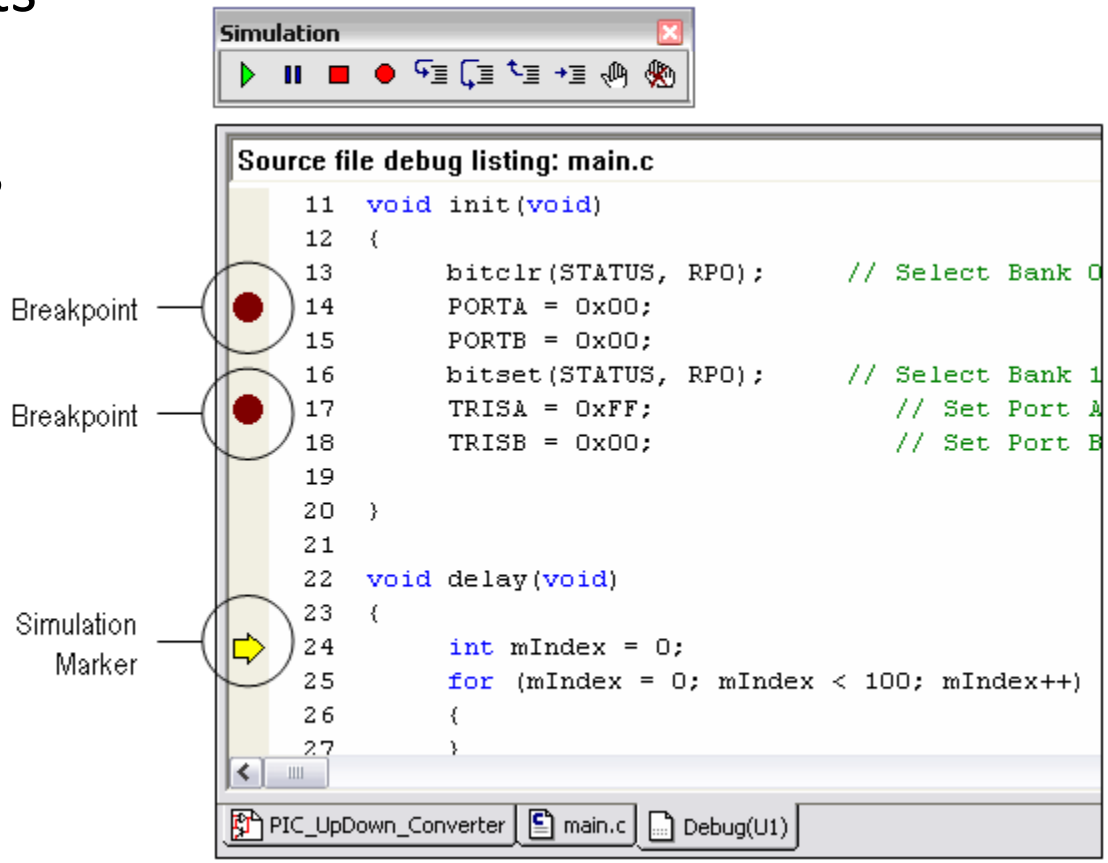
- Build Process messages in the Results tab of the Spreadsheet View



- Debug View lets you follow and track a sequence of events
  - Breakpoints
  - Debug Stepping

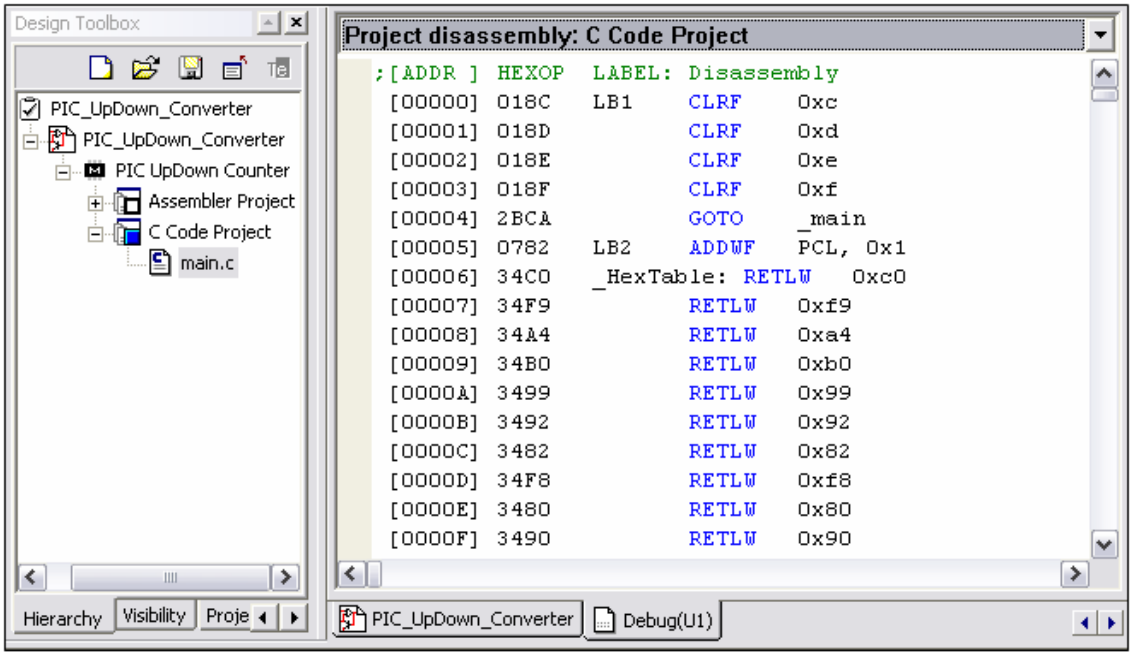
Debugging Features – Breakpoints

- Place breakpoints in left margin
- Simulation stops at breakpoint
- Use stepping functions
  - Step Into
  - Step Over

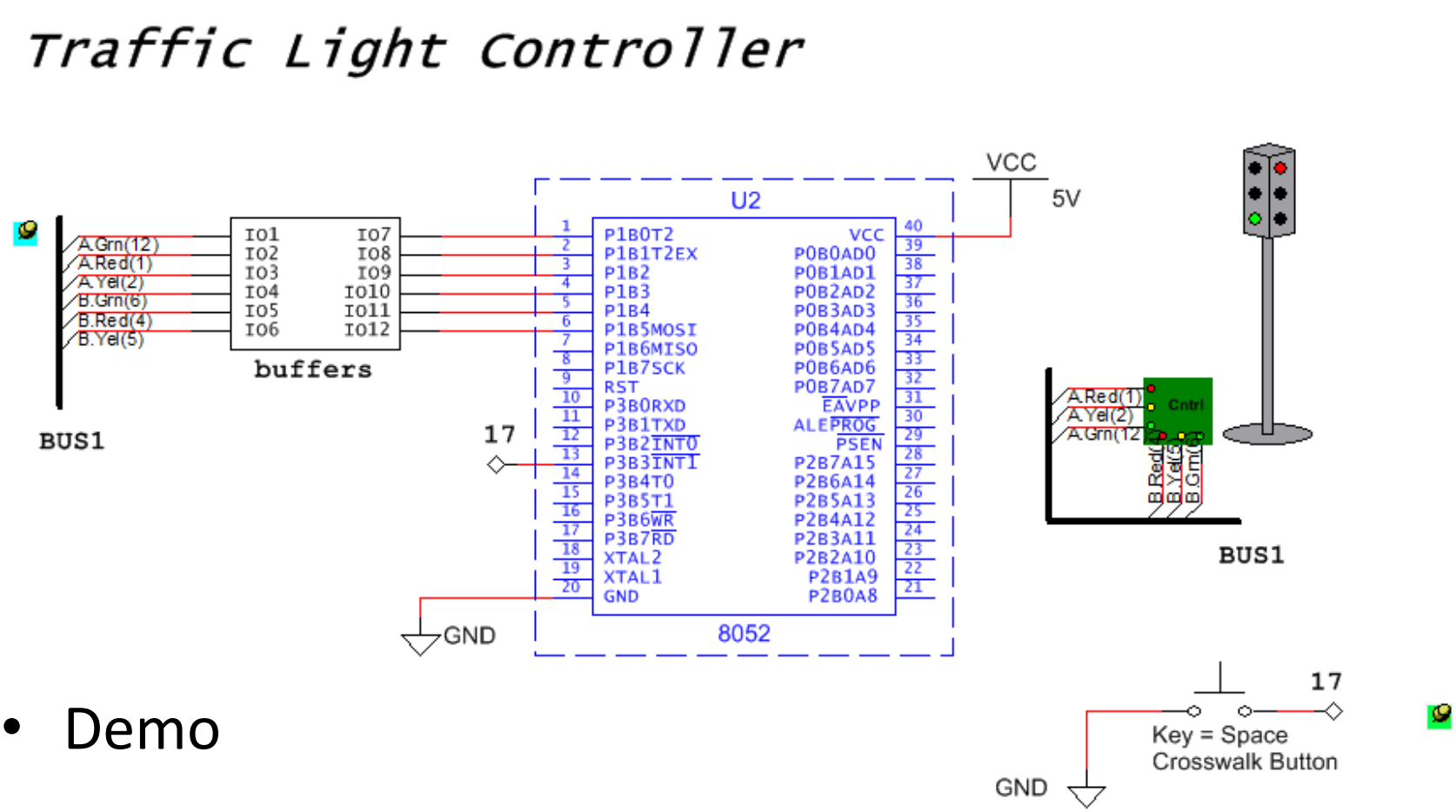


Debugging Features – Disassembly

- Debug View drop-down list lets you select
  - Source Code View
  - Disassembly View

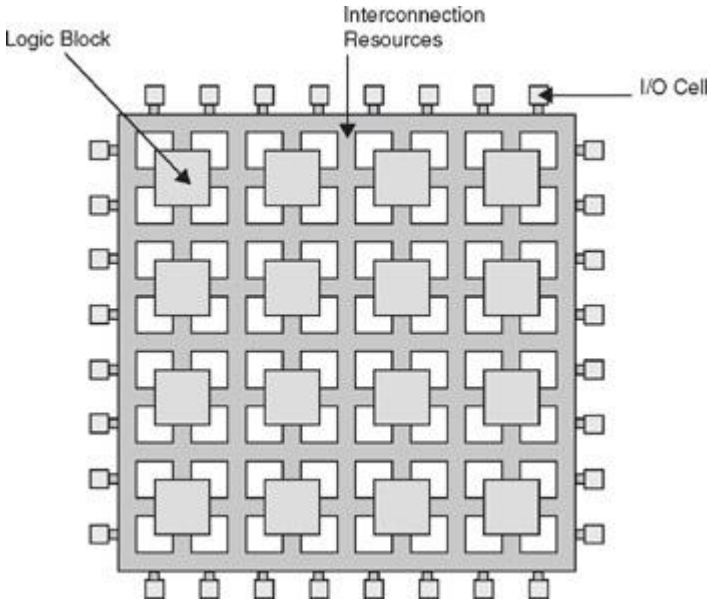


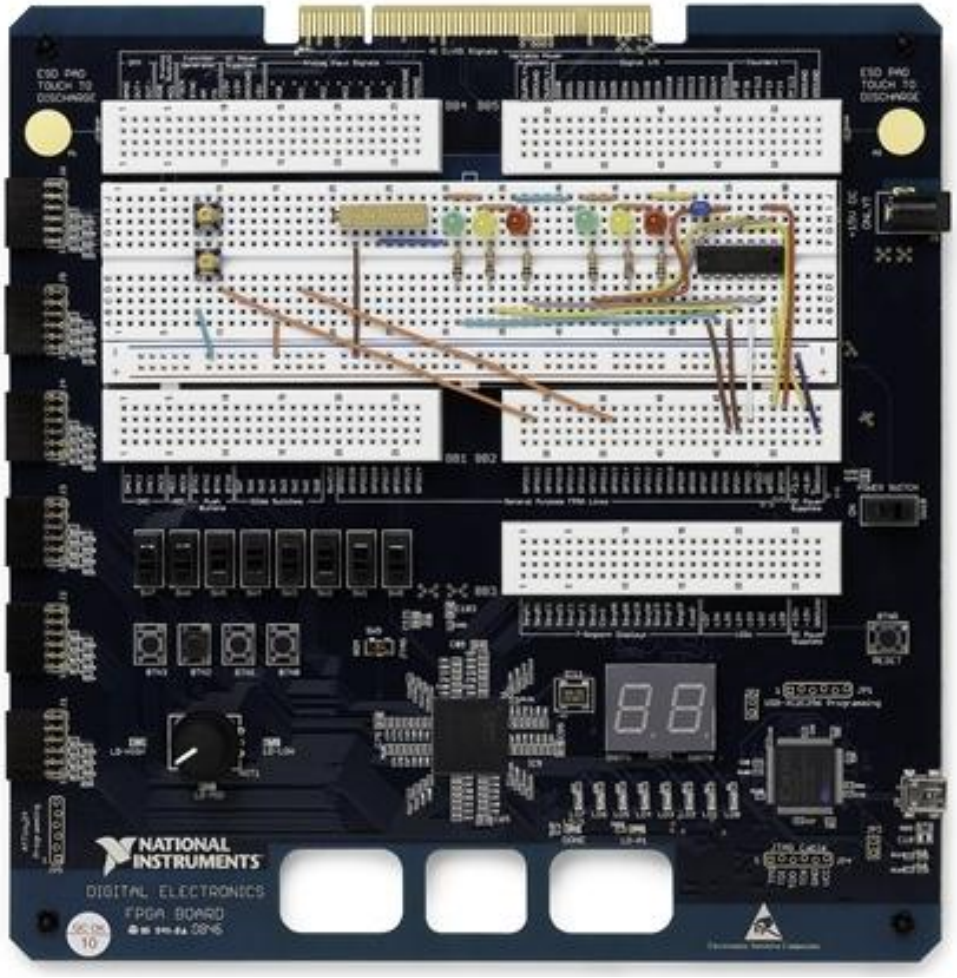
MCU modul



- Demo

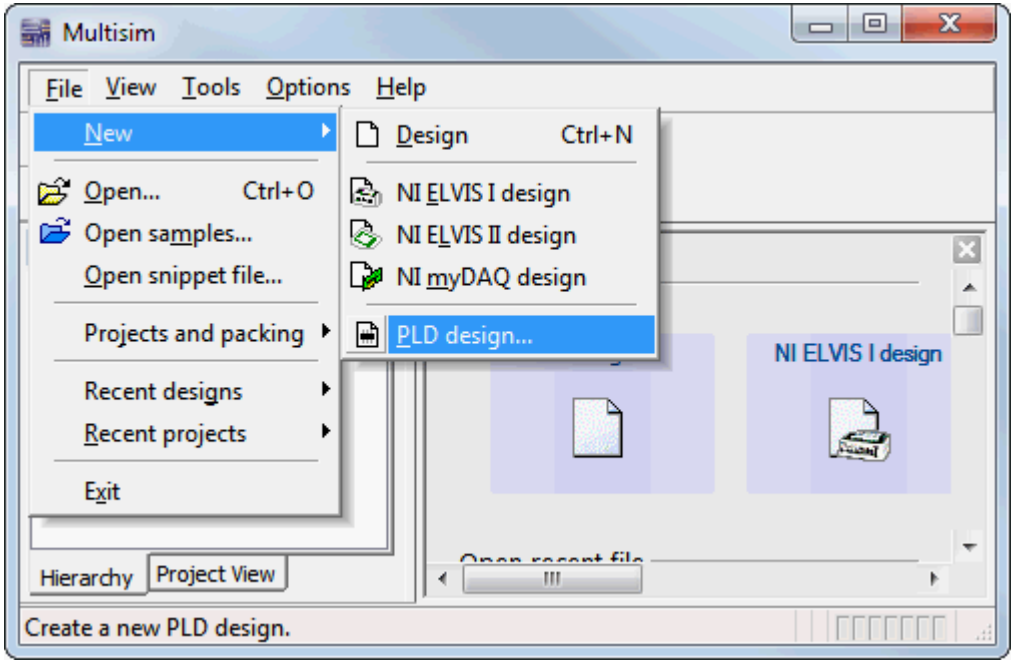
PLD / FPGA modul





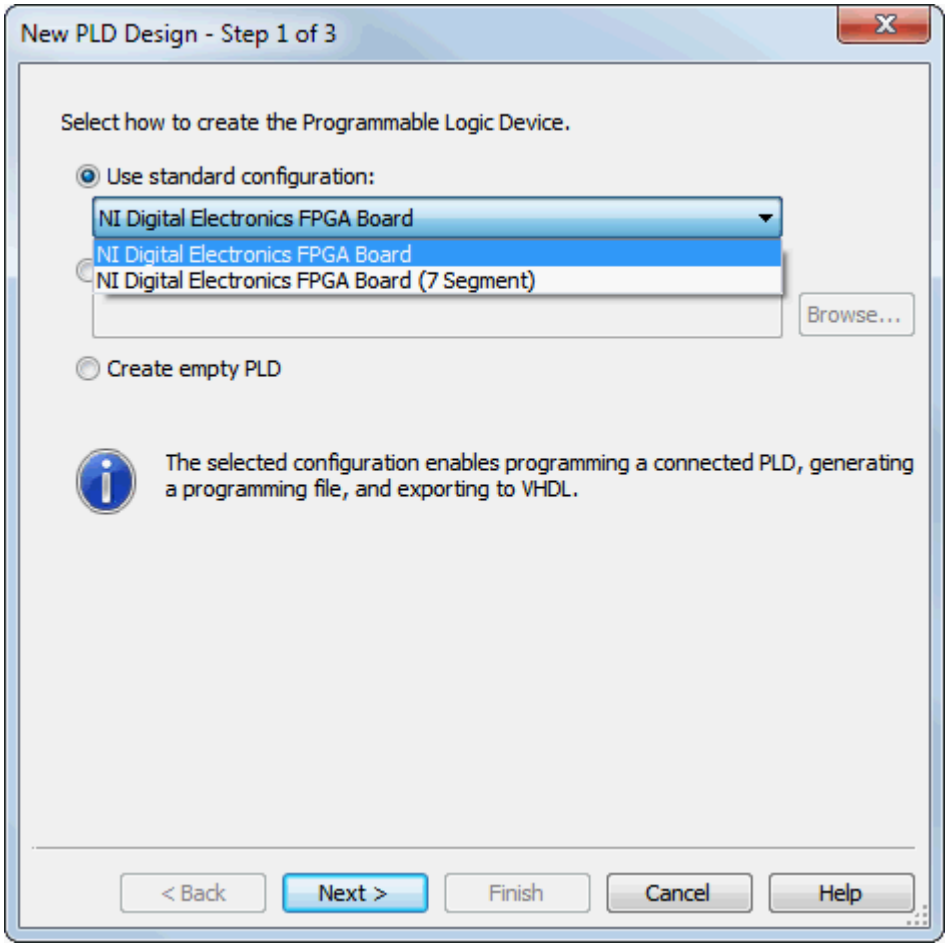
PLD / FPGA modul

- Create new PLD Design in Multisim



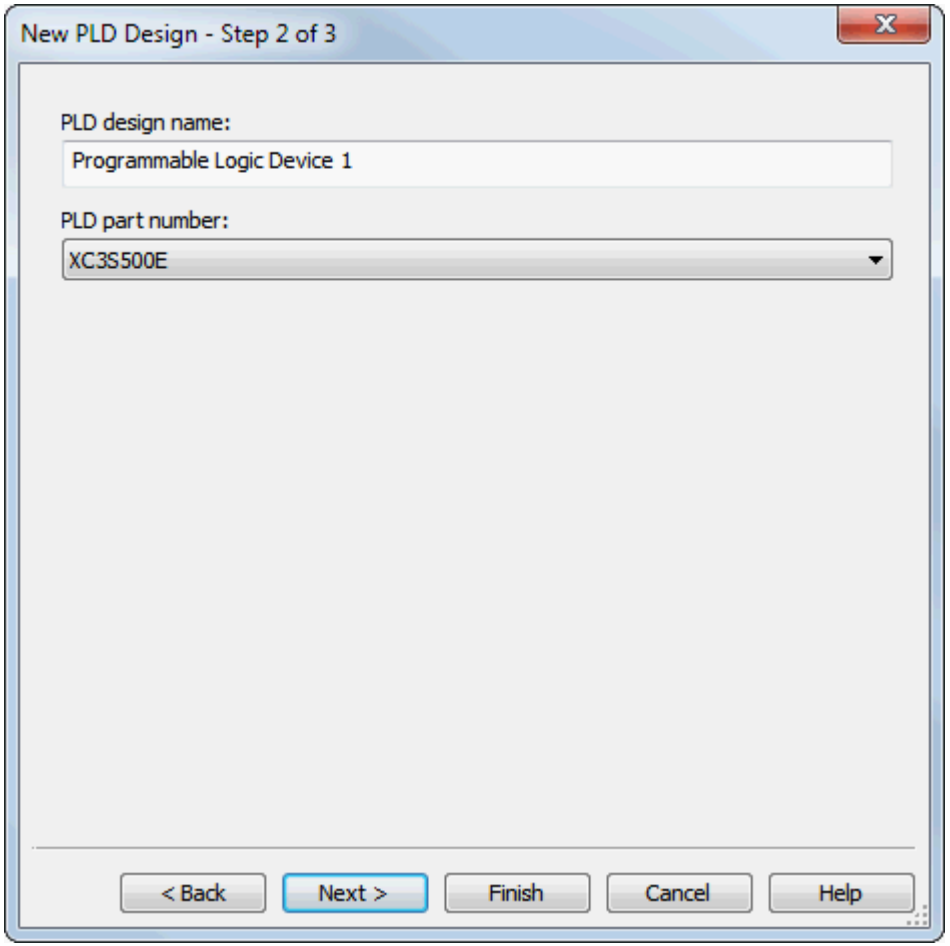
PLD / FPGA modul

- Select PLD Target



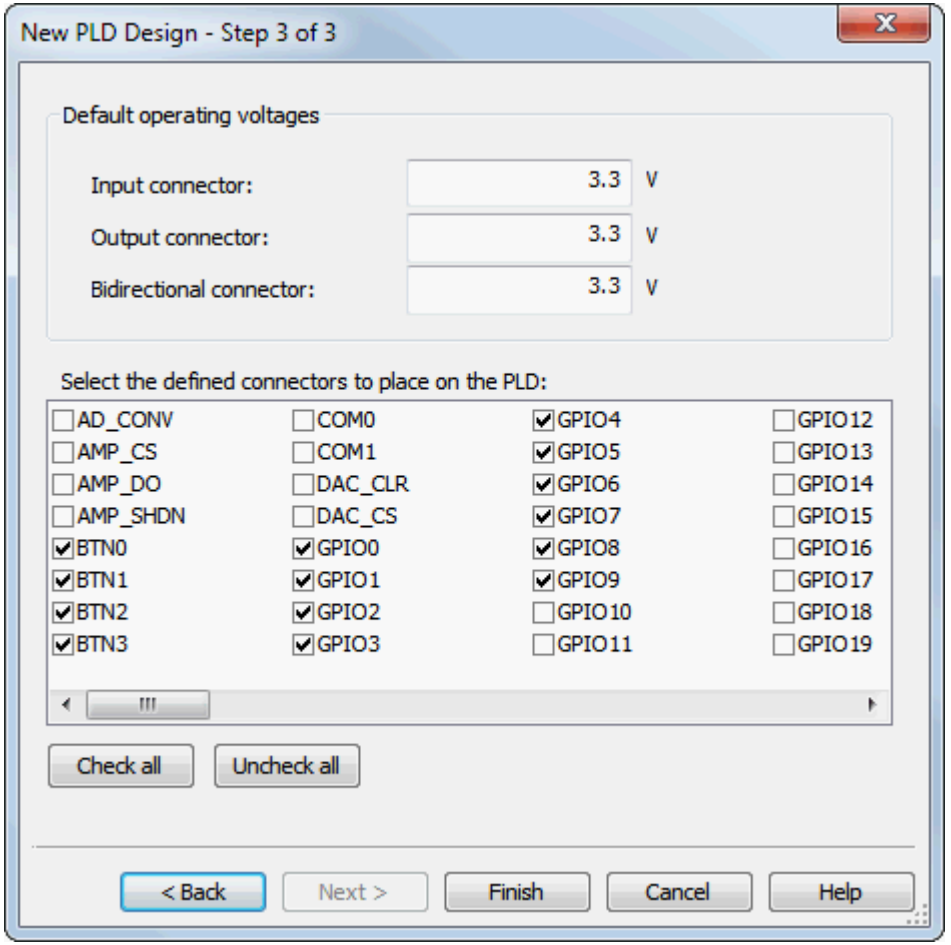
PLD / FPGA modul

- Select PLD family

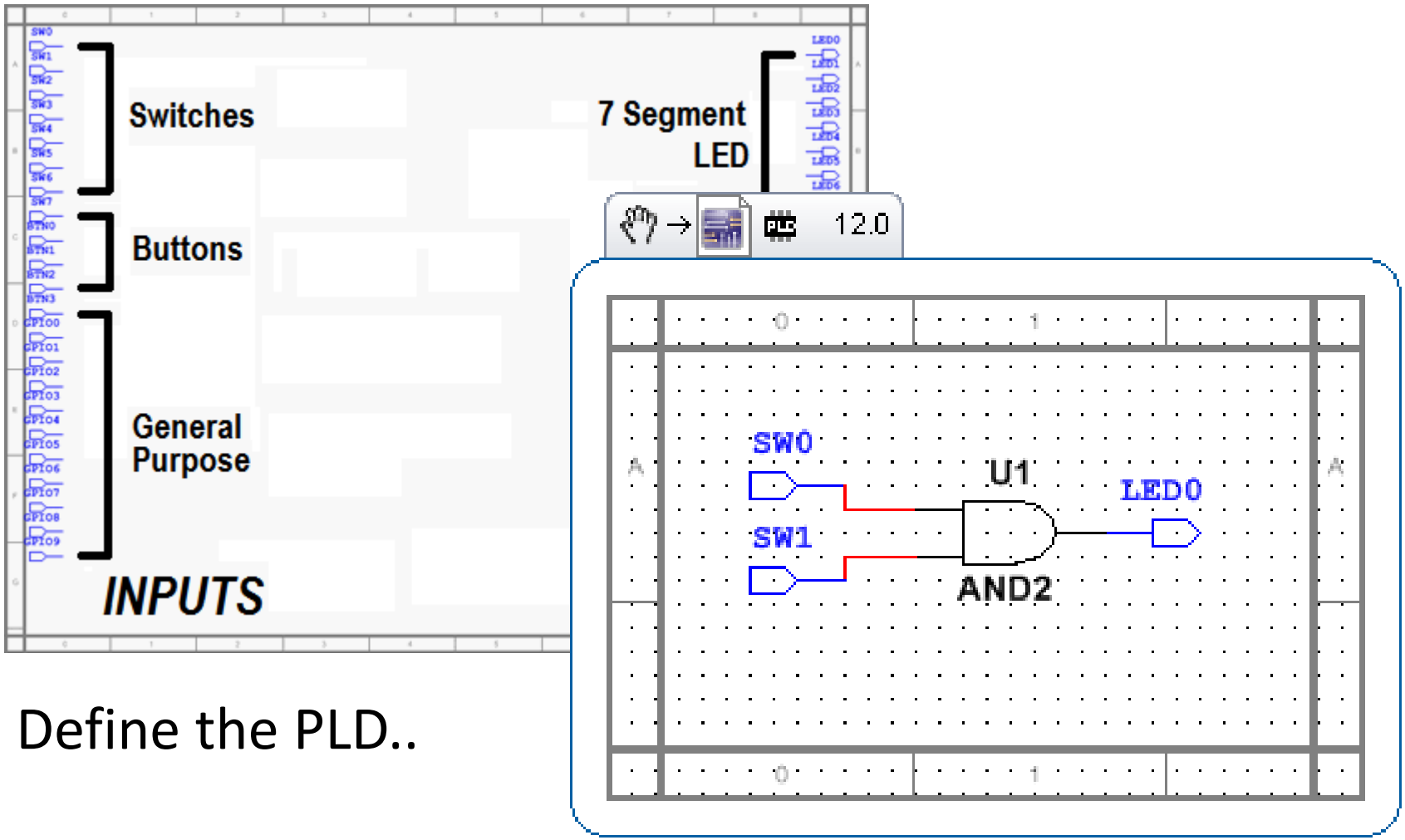


PLD / FPGA modul

- Select I/Os



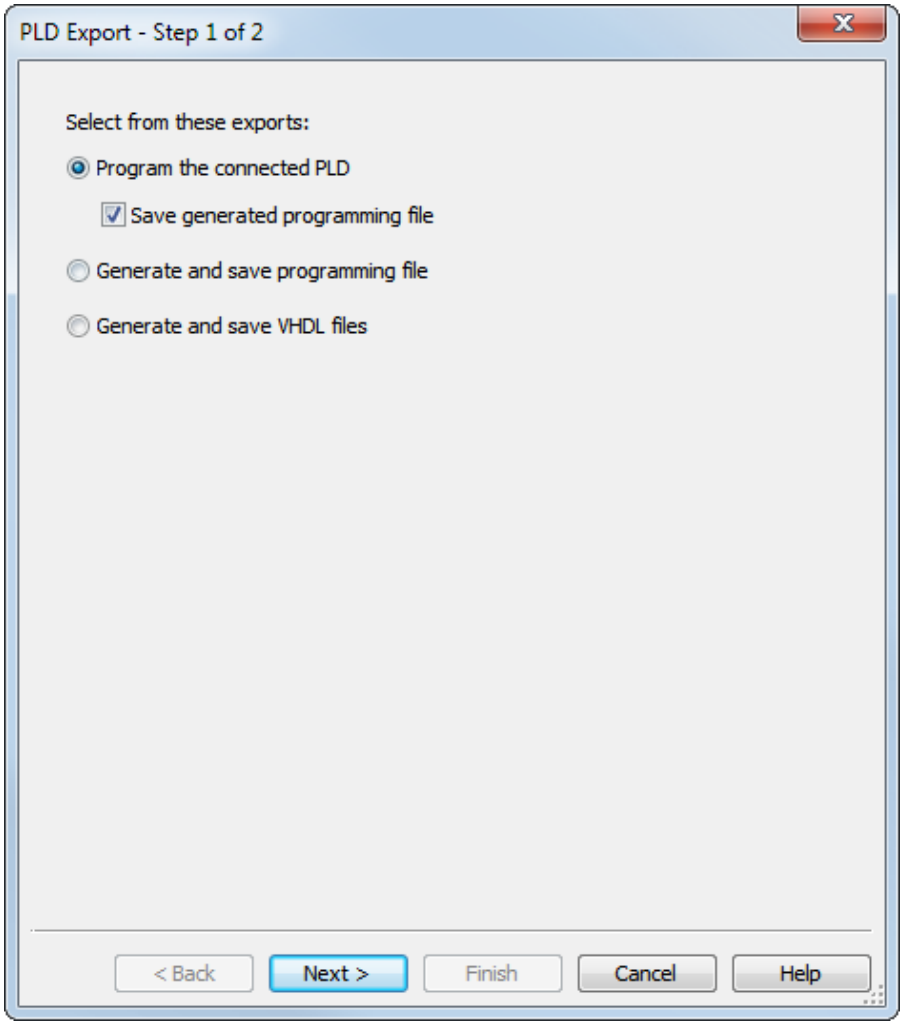
PLD / FPGA modul



- Define the PLD..

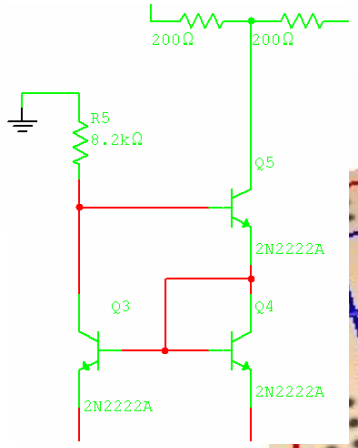
PLD / FPGA modul

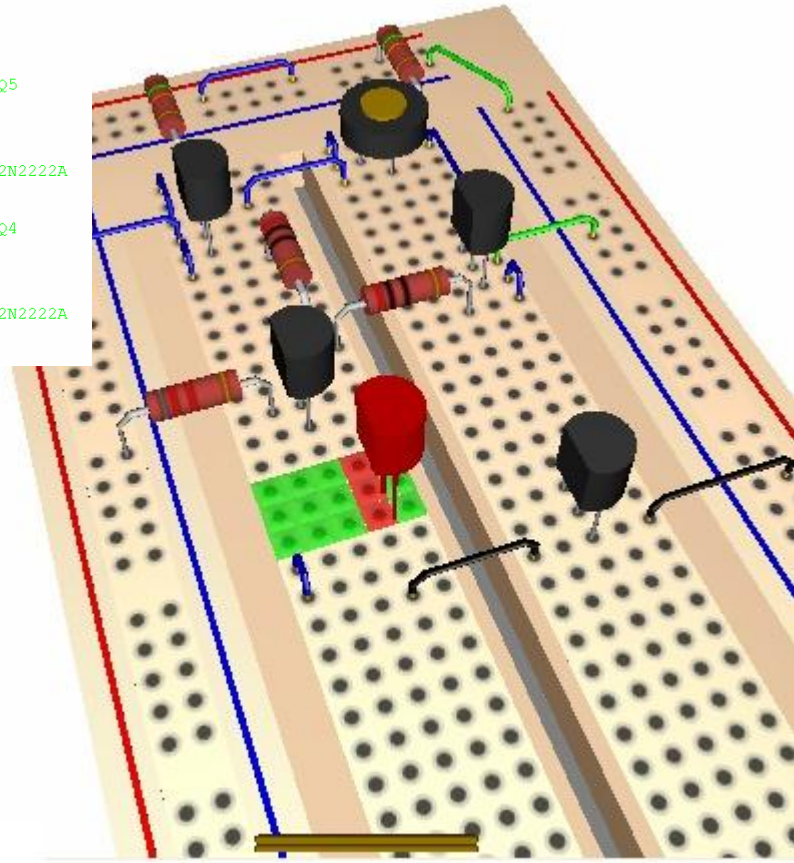
Transfer»Export to PLD...



3D Breadboard

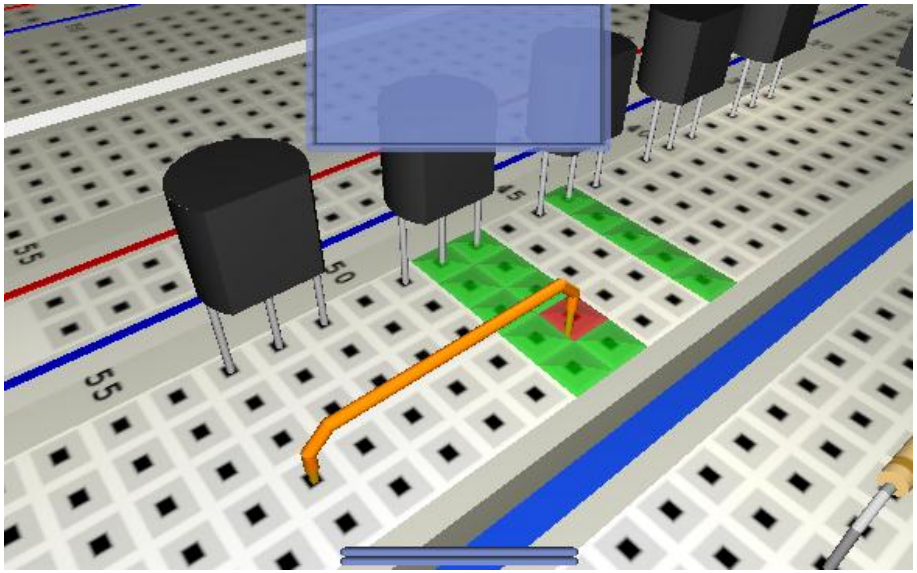
- Place components in 3D on a virtual breadboard
- Practice wiring a breadboard based on a circuit diagram
- Component symbols and wires turn green when placed correctly on breadboard

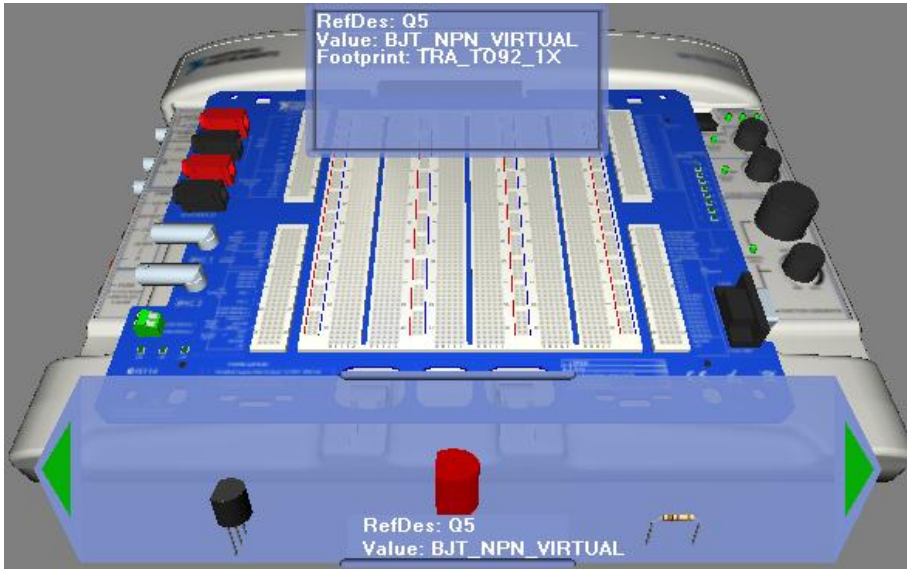




3D ELVIS Breadboard

- **File»New»NI ELVIS I Design ... Or NI ELVIS II Design**
- Interact with NI ELVIS instruments
- Place and verify diagram similar as the virtual breadboard



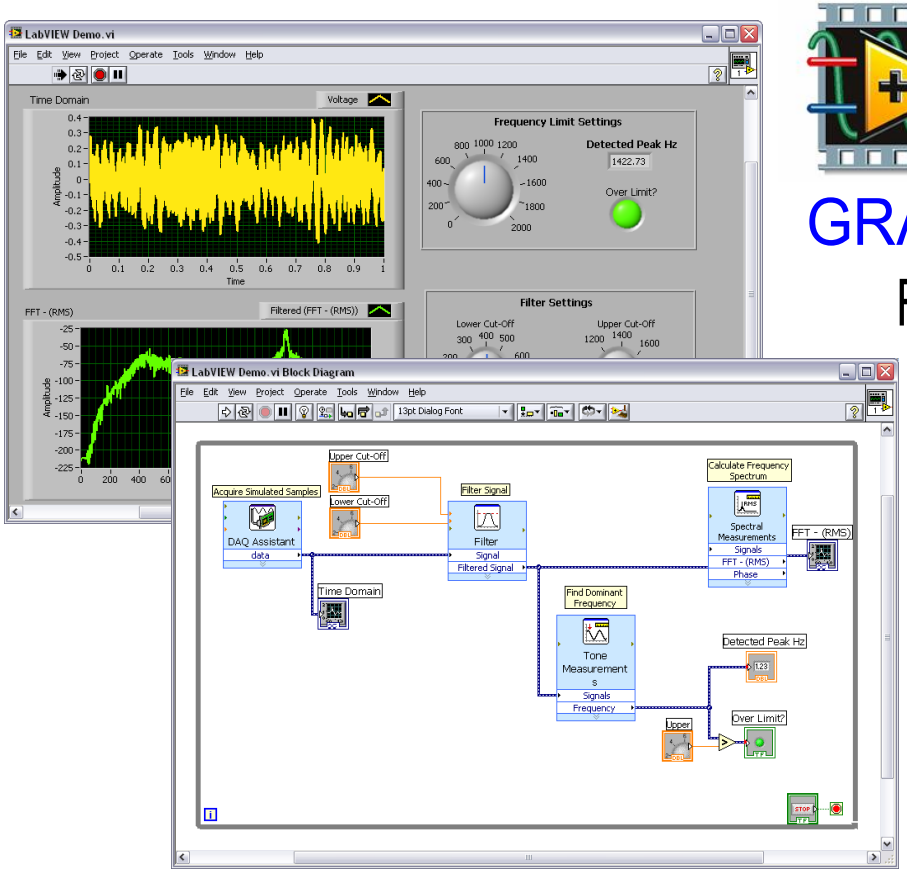


E. Measurement and Comparisons

"In theory, theory and practice are the same.
In practice, they are not."

- "Yogi" Berra

Introduction to LabVIEW



NATIONAL INSTRUMENTS

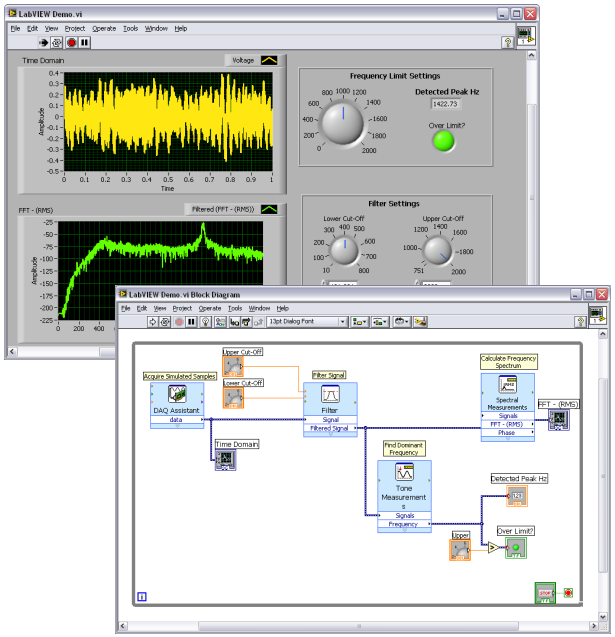
LabVIEW™

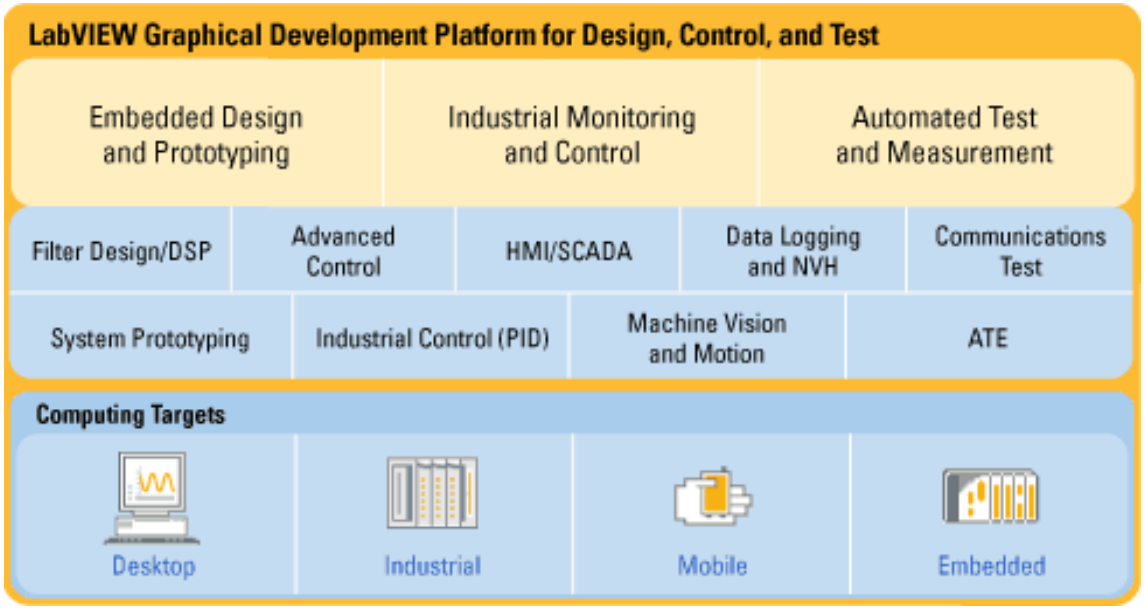
GRAPHICAL PROGRAMMING

FOR ENGINEERS AND SCIENTISTS

LabVIEW Graphical Development System

- Graphical Programming Environment
- Compile code for multiple OS and devices
- Useful in a broad range of applications





Virtual Instrumentation Applications

- **Design**
  - Signal and Image Processing
  - Embedded System Programming
    - (PC, DSP, FPGA, Microcontroller)
  - Simulation and Prototyping
  - And more…
- **Control**
  - Automatic Controls and Dynamic Systems
  - Mechatronics and Robotics
  - And more…
- **Measurements**
  - Circuits and Electronics
  - Measurements and Instrumentation
  - And more…

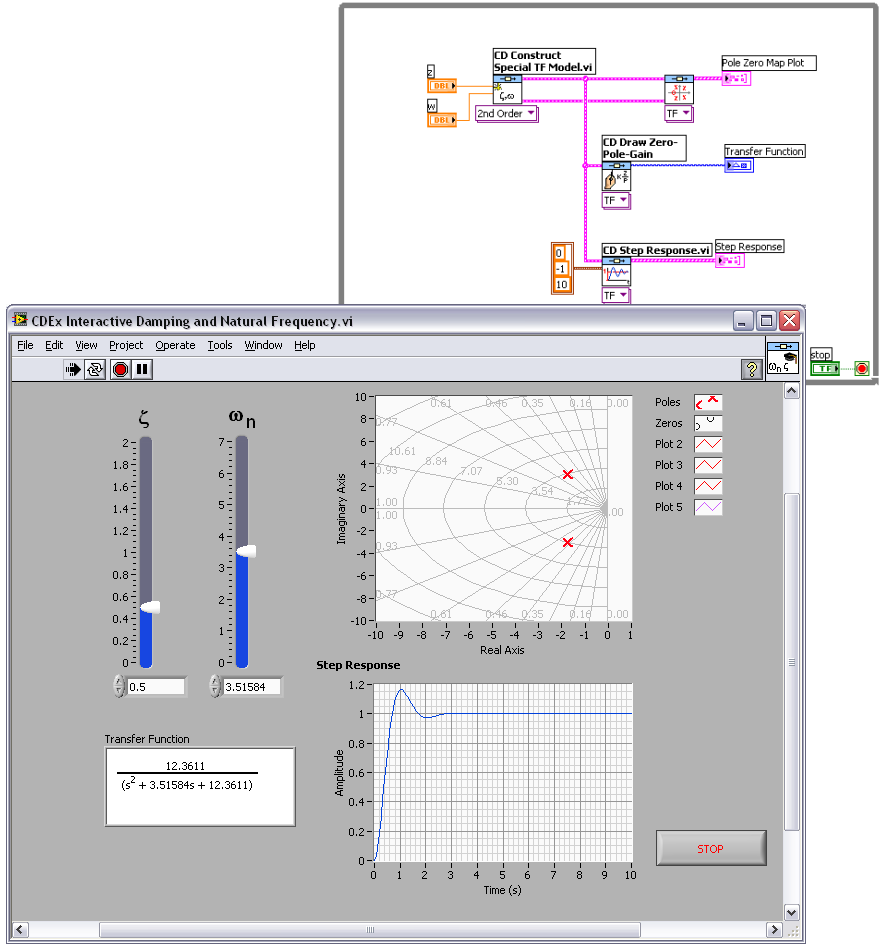
Graphical System Design

NATIONAL INSTRUMENTS LabVIEW™

Demo

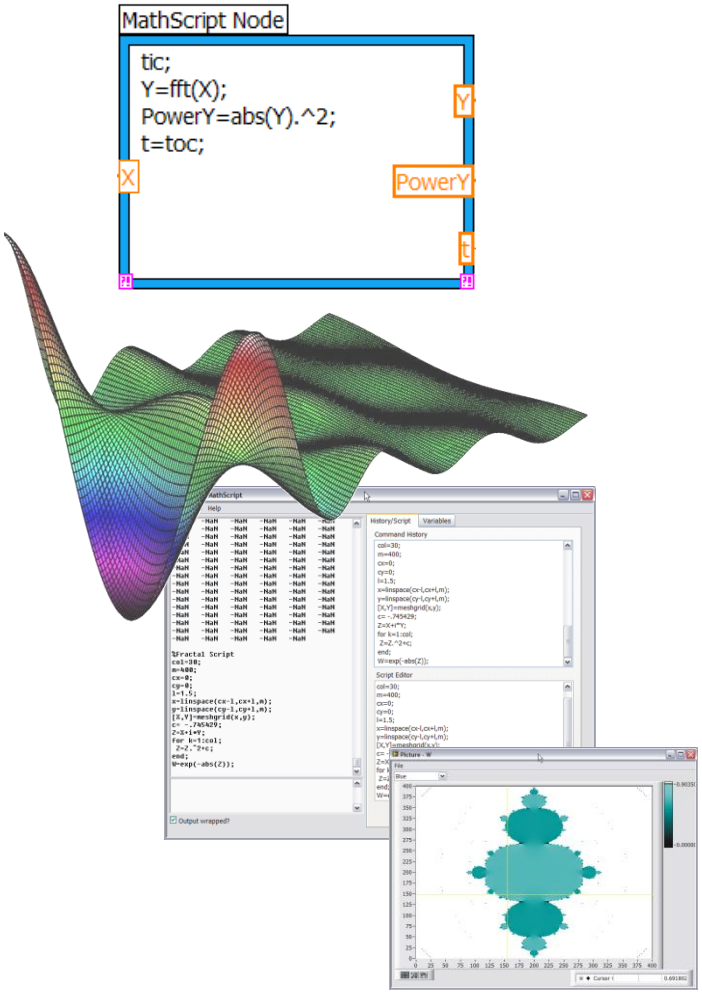
LabVIEW Control Design

- **Easily create interactive control design and analysis VIs**
- **Use both textual .m file and graphical approach**
- Model construction, conversion and reduction
- Time and frequency response
- Dynamic characteristics
- Classical control design including *analytical PID*
- State-space control and estimation - *LQR, LQG, Model Predictive Control, Kalman Filter..*



LabVIEW MathScript RT

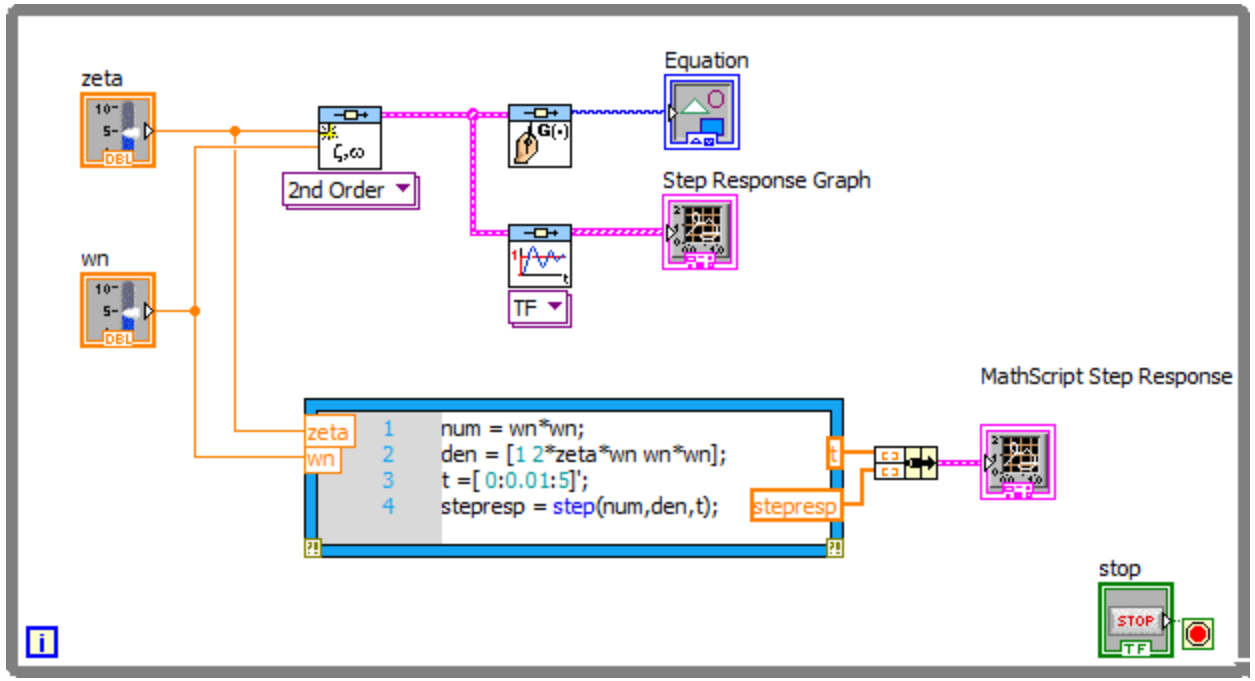
- **Powerful textual programming for Control Design, Signal Processing, and Math**
  - Hundreds of built-in functions
  - Reuse many of your m-file scripts created with The MathWorks, Inc.'s MATLAB® software and others
  - Partially based on original math from MATRIX$_x$
- **A native LabVIEW solution**
  - Interactive and programmatic interfaces
  - Does not require 3rd party software



MATLAB® is a registered trademark of The MathWorks, Inc.

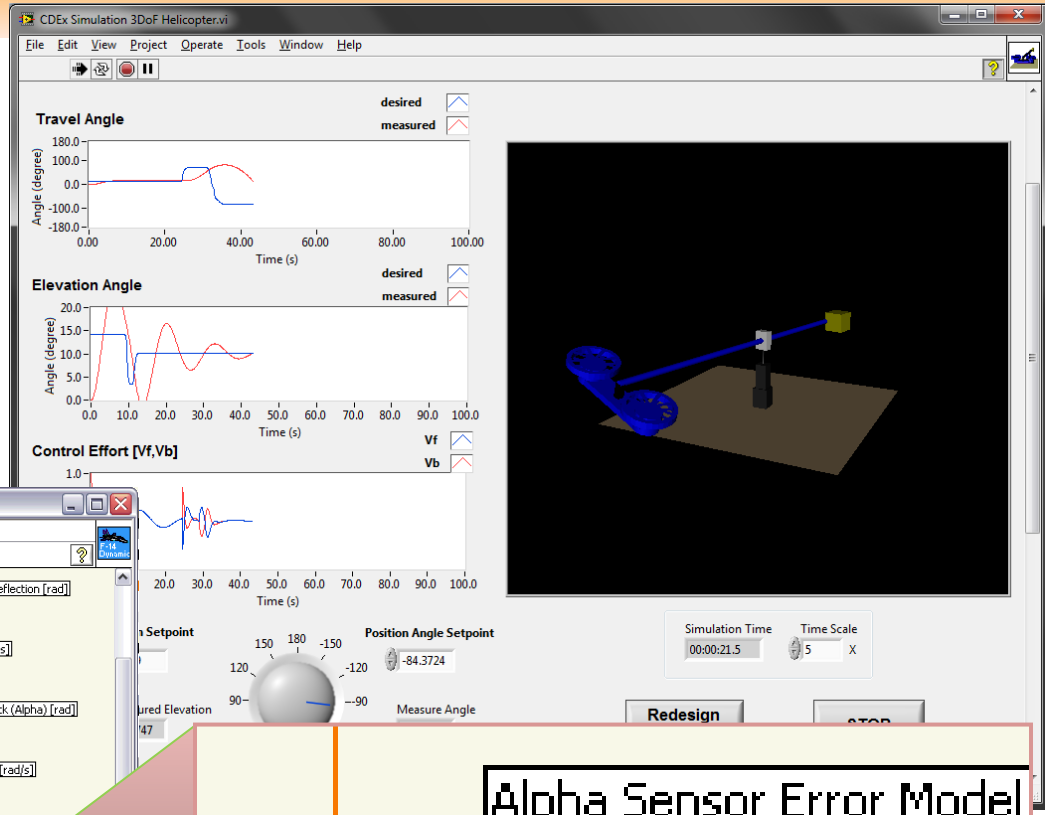
LabVIEW MathScript RT Demo

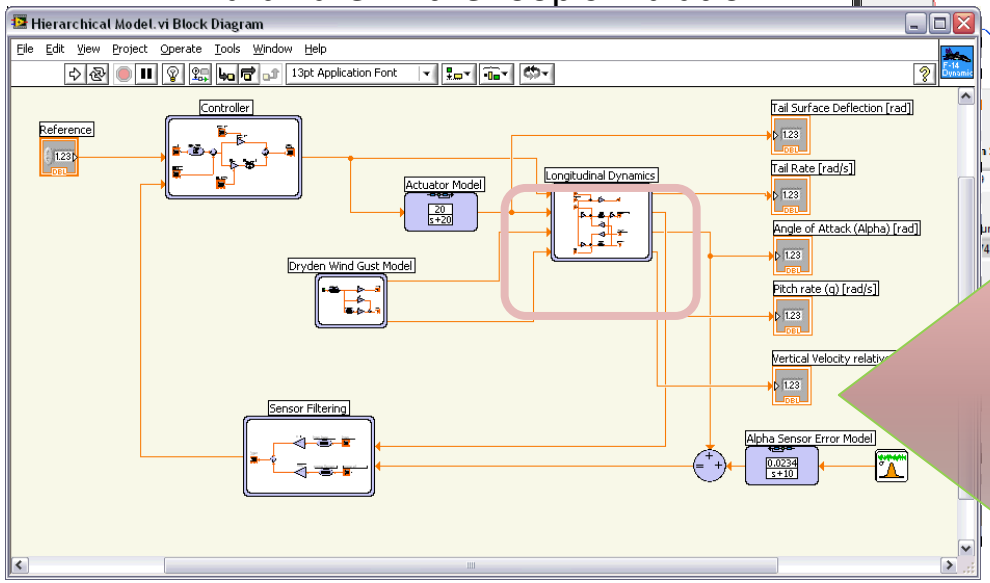
- Graphical and textual programming
- Interactive user-interface

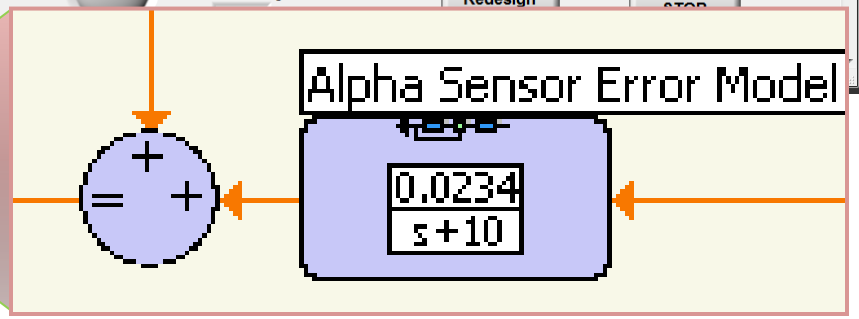


Dynamic System Simulation & Control

- Both signal flow and .m file development
- Single environment for:
  - Simulation of dynamic systems
  - Real-time implementation for rapid control prototyping or hardware-in-the-loop simulation

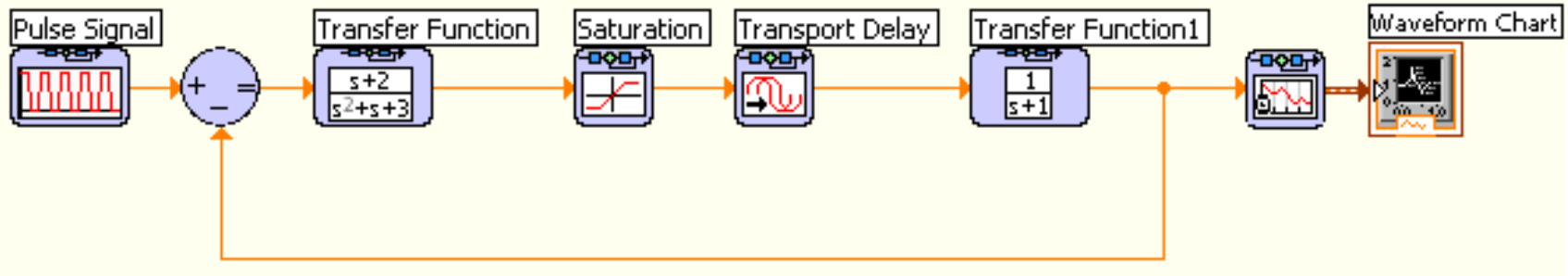




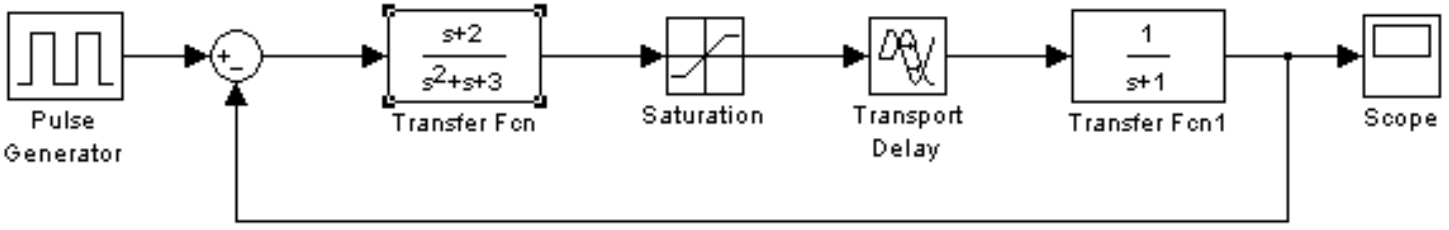


Standard Notation Reduces Learning Curve

- LabVIEW Control Design & Simulation Module

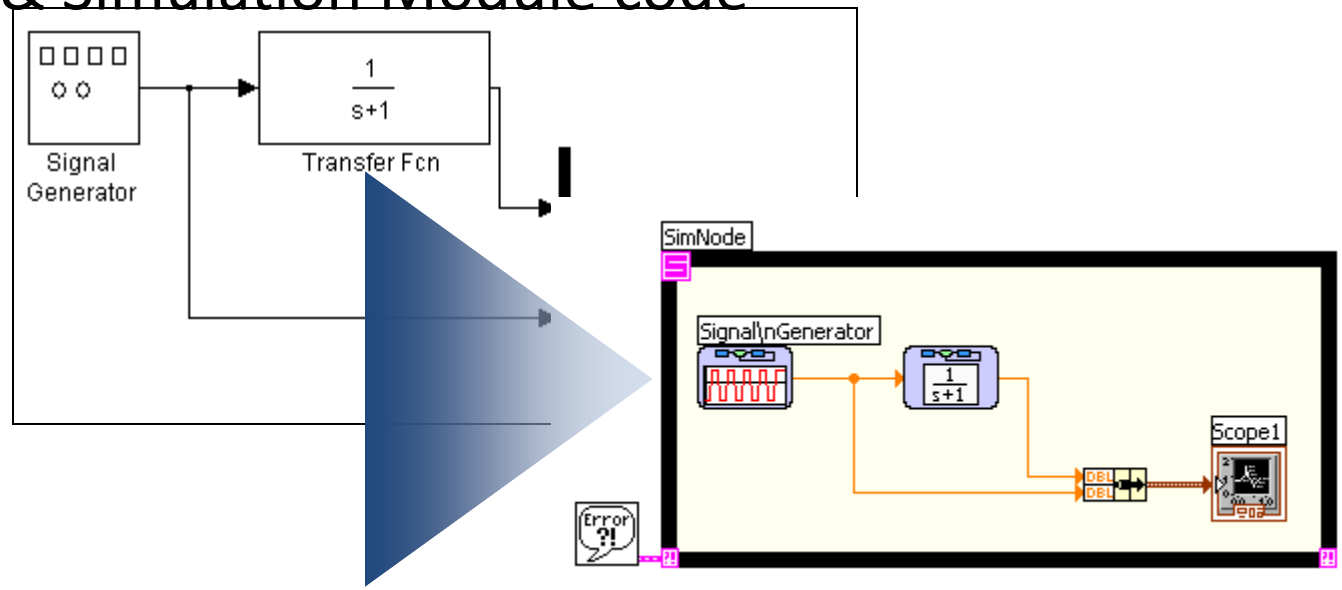


- The Simulink® software environment



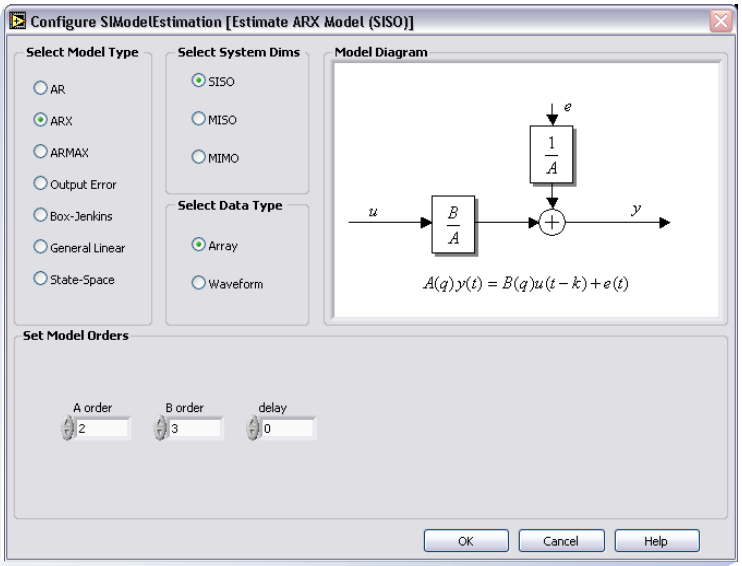
Simulink® conversion

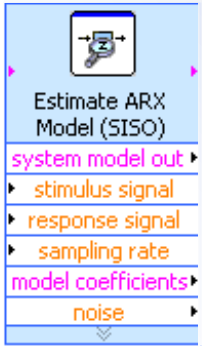
Convert plant and controller models you create in the Simulink® environment into LabVIEW Control Design & Simulation Module code



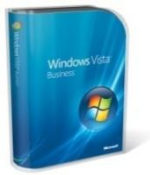
LabVIEW System Identification Toolkit

- Data preprocessing
  - Down Sampling, Remove Trends, Split Signal, Filters
- Parametric model estimation
- Nonparametric model estimation
- MIMO capability
- Nonlinear model estimation
- Grey box system identification
- Closed-loop system identification
- Model validation
- System identification assistant

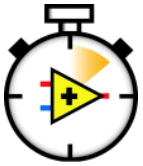




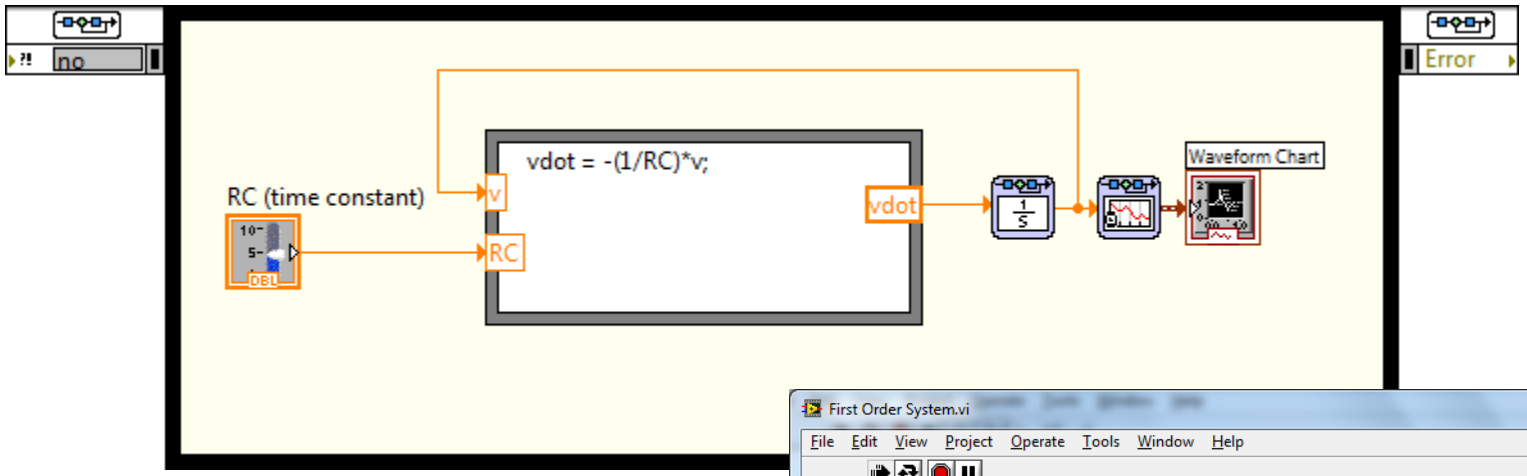
Windows

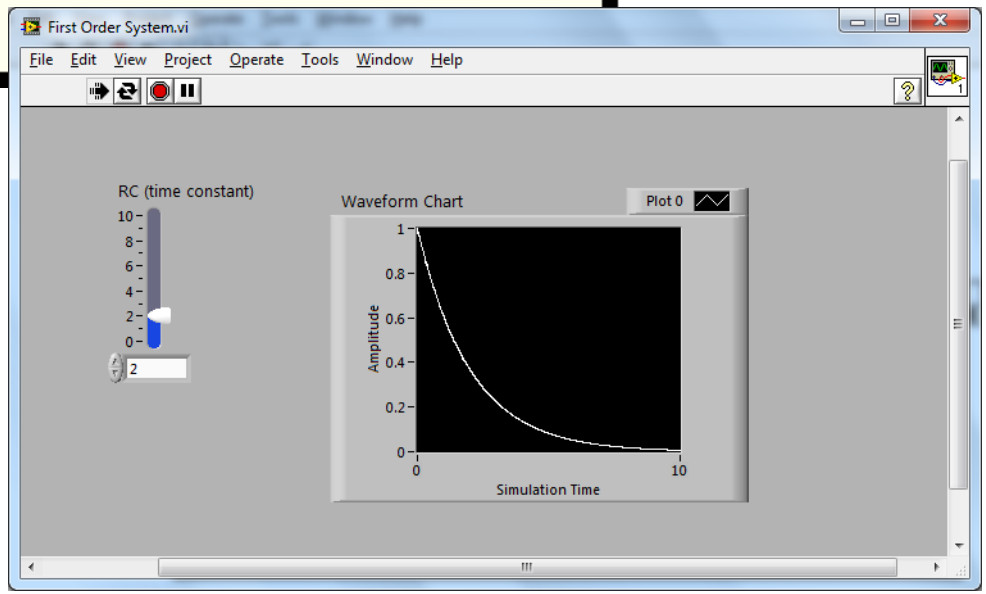


Real-Time



Solving ODE Example





NI Platform for Control

LabVIEW Development Environment

- Control Design & Simulation Module
- System ID Toolkit
- Statechart Module
- DFD Toolkit
- Simulation Interface Toolkit
- NI Motion Control

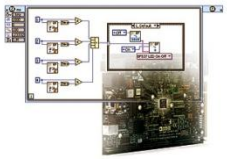
- LabVIEW Real-Time
- LabVIEW FPGA
- LabVIEW Microprocessor

Targets

PXI

cRIO, sbRIO

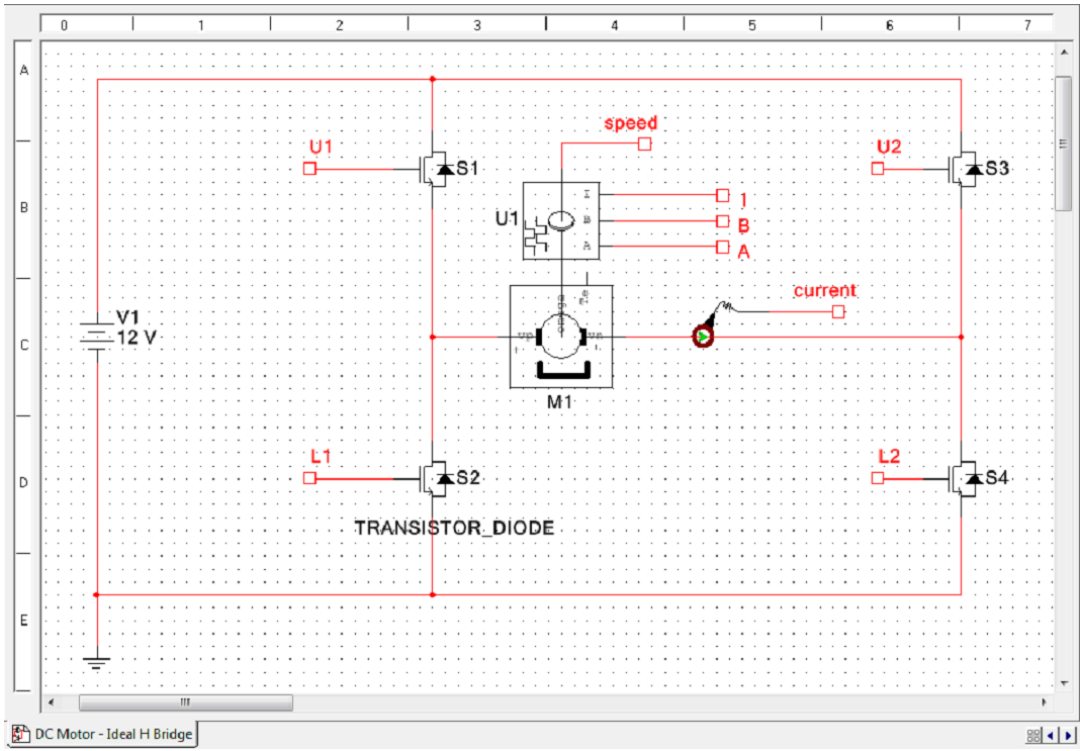
Desktops & SBC's



32-bit µp

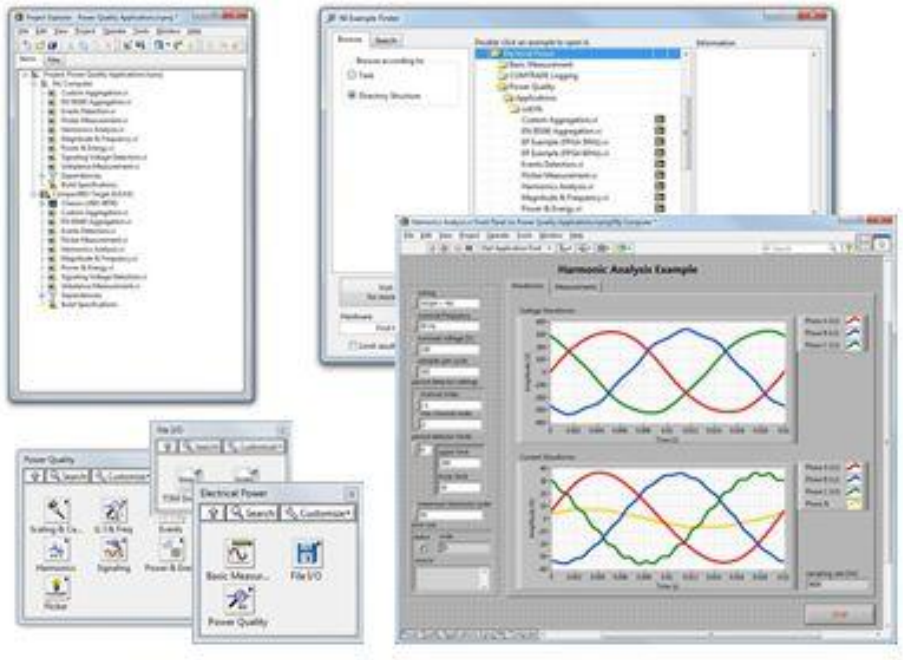
Multisim Power Components

- 92 new component models of power and electromechanical devices
- Reconfigurable transformers
- Power switches
- Power controllers
- Non-ideal RLCs



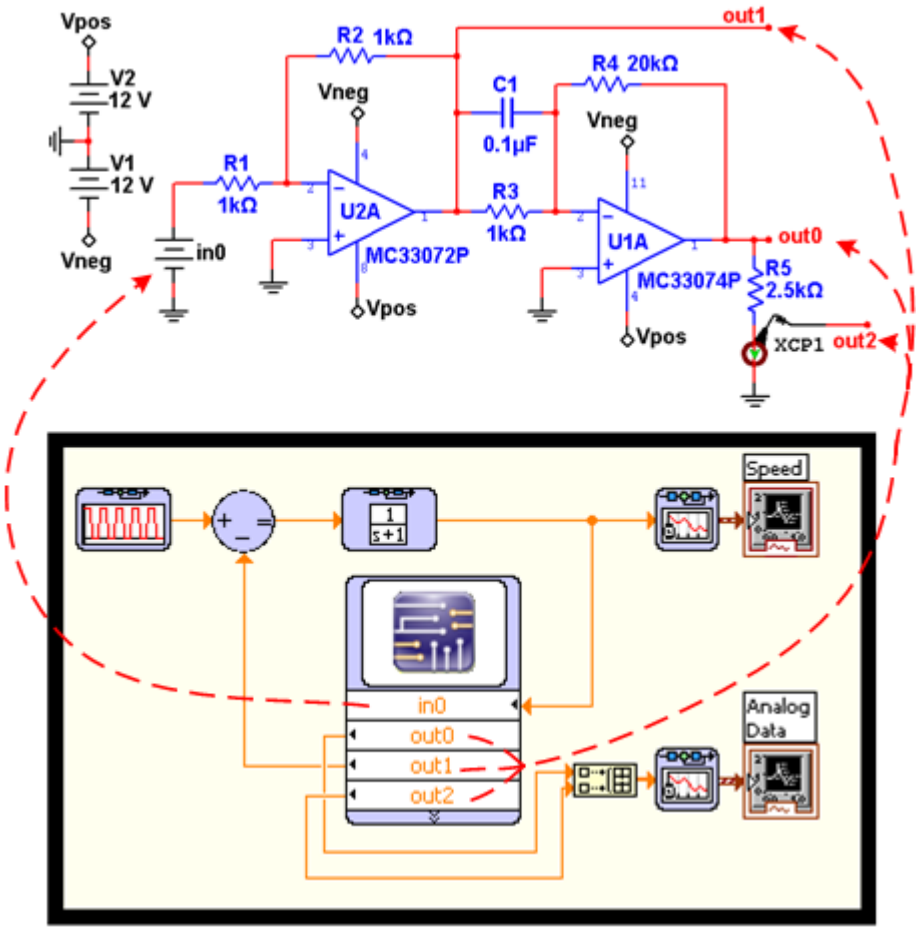
Electrical Power Measurement Suite

- Measure power quality and energy features to IEC, EN, and IEEE standards
- Harmonics (IEC 61000-4-7)
- Flicker (IEC 61000-4-15)
- Sag/sell/interruption with standard or custom levels (IEC 61000-4-30)
- Rapid voltage change with standard or custom levels (IEC 61000-4-30)
- Compatibility with the COMTRADE (IEEE 37.111) file format



Multisim-LabVIEW Co-simulation

- Control Design and Simulation Module
  - External Modeling Interface (EMI)
- Prototype features:
  - Lock-step synchronization
  - Step-size negotiation
  - Support for all continuous-time LabVIEW solvers
  - Multisim block configuration



Demo