DesignScope™
a product of BrainPower

Demonstration Disk Documentation

About DesignScope

DesignScope is the first simulation program that you use *before* you design component circuitry. DesignScope helps determine how best to develop an optimum system without knowing component values in advance!

DesignScope allows the engineer working with electronics to place system blocks on a worksheet, connect them into a block diagram, assign them parameters, and finally, run a simulation of the system and view the waveforms. It does this without needing specific component values or a prototype circuit design. If the results warrant, the entire system can be changed in seconds and a new simulation attempted.

The paradox of other simulation programs is that they require the engineer to input a hand-designed circuit composed of known resistors, capacitors, inductors, and active components before getting simulation results. This is not time-cost effective, because only after the first version circuit design is done and circuit level simulations are begun, will the engineer discover problems. Then the whole system, and then circuit, has to be redesigned.

This Demonstration Disk Documentation has three parts. Part I is a quick-start. You will build a circuit and run a simulation, step-by-step. Part II provides details on the operation of Design Scope. Part III provides details on the components that make up DesignScope.

This Demonstration Disk has the following limitations built-in:

1. Files cannot be saved or printed.
2. The Paste command is deactivated.
3. No more than 6 components and text blocks may be used.
4. Filters are limited to 2 second order sections (the real program allows 8 sections).

The Demonstration Disk contains sample files built using the real DesignScope (containing more than 6 modules).

DesignScope's Documentation Assumes...

- you are bringing to DesignScope a knowledge of electronic circuit design adequate for the project you want the program to assist you with.

- you are bringing to DesignScope a non-technical knowledge of the Macintosh environment (the mouse, windows, pull-down menus, the Finder, dialogue boxes, saving files, etc.). This can be gained from the manual titled *Macintosh* that came with your computer.

Part I: Quick-Start

What 's going to happen.
In this quick-start, you are going to build a simple circuit which will simulate an amplifier changing the amplitude of a waveform. Then you will change the input waveform and see another simulation.

Booting
>1. Turn on your Macintosh and boot the DesignScope disk. Double-click on the DesignScope program icon.

>2. After the program loads, a window labelled **Untitled** appears.

Selecting the Circuit Components
>3. Components are selected from the **Analog**, **Digital**, and **In/Out** menus. Pull down the Analog menu and select **Voltage Controlled Oscillator** (VCO). A VCO icon appears at the bottom, right corner of the window. Drag it up to the left side of the window.

>4. Select **Amplifier** from the **Analog** menu. Its icon appears in the same place the VCO's did. Drag it up to the middle of the ndow, but below the level of the VCO icon.

>5. Select **Output Plotter** from the **In/Out** menu. It appears where the other two did. Drag it up to the right side of the widow, on the same level as the VCO.

Connecting the Components
>6. There are three connection points on the right side of the VCO icon. The top is for sine wave output, the middle is for square wave output, and the bottom is for triangular wave output. Click in the sine wave output connector and drag the cursor across to the top connector on the left side of the Output plotter. Release the mouse and a wire is drawn.

>7. Now make a connection in the same manner from the same sine wave output connecting point on the VCO to the top connector on the left side of the Amplifier.

>8. Finally, make a connection between the output connector on the Amplifier's right side to the bottom connector on the left side of the Output Plotter.

Entering Component Parameters
>9. Double click on the VCO. A dialogue box opens. Enter 2.0 for frequency at 0.0 and 1.0 volts. Click OK.

>10. Double click on the Amplifier. Enter .5 for Top Gain. Click OK.

Running a Simulation
>11. Double click on the Output Plotter. Click the **Run Simulation** button in the dialogue box. When the Run Setup dialogue appears, press Return. Two waveforms are drawn on the scope. The gray waveform represents the input to the top connector on the plotter. This is the output directly from the VCO. The black line represents the input to the bottom connector on the plotter. This is the waveform that is being amplified by the amplifier. After the waveform is drawn, click **Done!**

Change Input waveform
>12. Now click on the wire from the VCO to the Output Plotter. Press the Backspace key to erase it.

>13. Erase the wire from the VCO to the amplifier the same way.

>14. Now reconnect the VCO to the other two components using the triangle wave output connector (the bottom one) on the VCO.

New Parameters

>15. Open the VCO and change both frequency parameters to 4.0.

>16. Open the Amplifier and change the Top Gain to 1.5.

Another Simulation Using the Same Circuit

>17. Open the Output Plotter, wait for it to finish redrawing the sine waves, and click **Run Simulation**. Notice the smooth shape has become a triangular one. Notice, too, that the plot is now too large for the axis.

>18. Change the value of the Y Amplitude limits from 1.0 and -1.0 to 5.0 and -5.0. Click Plot. Notice that you do not have to rerun a simulation to replot its resultant waveform.

The following section provides details on operation.

Part II: General Operation

Overview

Circuit Layout

• Select components from the Analog, Digital, and I/O menus. They appear at the bottom right corner of screen when selected. Drag them with the mouse into desired position.

• Connect components by clicking in a small connector area of one, dragging the cursor to a connector area of another, and releasing the mouse button. The "wire" connection is made.

Specify Component Parameters

• Double-clicking on components opens them. A dialogue box appears in which you may enter parameters for that component.

Run Circuit Simulation

• Run a simulation by selecting Run Simulation from the Run Menu.

• The Set Up... menu choice on the Run Menu allows specification of the simulation time. It also allows selection of the number of steps in the simulation. "Autostep Fast" gives good results quickly. "Manual" allows explicit entering of the "Number of steps." If too few, the simulation will be inaccurate or unstable.

• After a simulation is run, change Start and End times Output window, and plot to view different areas of the output waveform (the entire signal time span in the "Set up..." is kept in memory).

Macintosh Interface

Edit and Notate Block Diagram

• To edit diagram, select the component by clicking it. Drag selected components using the mouse. Typing backspace erases a selected component, component connection, or block of text.

• Multiple selected components can be dragged in unison. To make multiple selections either hold down the Shift key and click on multiple components; or click in a blank area of the window and drag the cursor making a frame. All material partially enclosed in frame when mouse is released is selected.

• Enter text by clicking on the window (makes an "insertion point") and typing.

• The block diagrams or resultant plots can be copied to the clipboard and then pasted to the scrapbook or any other application that accepts a picture. Make a scrapbook of often used pieces of block diagrams (boilerplate) to be pasted back into DesignScope™. (NB: Copy and Paste functions not implemented on DesignScope™ demonstration disk.)

• Error messages can be spoken if Macintalk driver is present on the program disk. The Speech menu allows dialog box error messages, if desired.

Part III: The Modules: Overview

(DesignScope's documentation provides more detail about each module.)

Amplifier, Linear -

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The Amplifier is a summing amp with three separate input gain channels. Gains are user specified and may be in decibels or value.

Output = (TopGain*TopInput)+(MidGain*MidInput)+(BotGain*BotInput)

Amplifier, Log/Ex/Root/Power

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Choose Log, Exp, or Root/Power output with user specified base or power.

LogOutput = Log$_{Base}$(Input)
ExpOutput = Base$^{(Input)}$

Clipper -

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Limits output voltage based on parameters specified.

Output = Input if (Input >= Lowest AND Input <= Highest)
Output = Lowest if (Input < Lowest)
Output = Highest if (Input > Highest)

Comparator-

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The comparator has a parameter for hysteresis. It defaults to no hysteresis.

Output High if (+Input > -Input+Hysteresis);
Output Low if (+Input <= -Input-Hysteresis);

Delay Line -

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Enter the time delay in sceonds. This component is memory intensive for long delays (4 bytes per sample point delay).

Output = Input delayed by DelayTime

Differentiator -

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Output is differentiation of input multiplied by user specified constant.

Output = (∂Input/∂Time)*(Volts out per Volt–sec–in)

Filter -

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Filters come in four types: Lowpass, Bandpass, Highpass, or Notch. The buttons that control the type of filter only change the viewed icon; and the QuickFilter dialog box; however, functionally, filter types depends on Pole and Zero parameters. Pole and Zero values are published in numerous books on filters such as Zverev Handbook of Filter Synthesis, (Wiley) or Williams Electronic Filter Design Handbook, (McGraw Hill).

QuickFilter (available through a button in the Filter dialog box) calculates Pole and Zero values using parameters in its dialog box. Filter responses can be plotted using the Response button in the Filter dialog box.

Filter Output is equivalent to the solution of the convolution integral of the transfer function below, where the A's and B's are the coefficients of the characteristic equation having as its roots, the input poles and zeroes.
m

$$H(s) = \prod_{n=0} (A_{n2}s^2 + A_{n1}s + A_{n0}) / (B_{n2}s^2 + B_{n1}s + B_{n0})$$

Integrator -

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Output equals the integration of the input multiplies by the user specified parameter Volts Out per Volts–Sec In. The reset discharges the integrator to zero volts.

Output = ∫ Input*VoltsOutPer
Output = 0.0 if Reset goes High

Multiplier , Divider-

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Four quadrant multiplier or divider (parameter determines function).

Output = TopInput*BotInput (if multiplier)
Output = TopInput/BotInput (if divider)

Noise Source-

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)'˘˛JH) JH ‡1ƒ(picture)(picture)˚(picture)(picture)˚(picture)(picture)˚(picture)(picture)˚(picture)(picture)˚(picture)
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Generates white noise within user specified voltage. Can be seeded by constant (determined in Run Simulation Set Up dialog box in Storage Scope).

Output = Random*(HighestVOut-LowestVOut)+LowestVOut

Peak Detector -

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The parameter determines the exponential droop rate (R*C Time Constant) when the input drops below the current output level. The reset, as in the integrator, zeroes the output.

Output = Input if (Input >= PrevInput)
Output = $e^{-Time/DroopTimeConstant}$

Phase Locked Loop -

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This is a combination of a Phase Detector (EXOR Type 1, Frequency Type 2, or Flip Flop Type 3), Voltage Controlled Oscillator, Filter (Passive or Active), and Frequency Multiplier to allow frequency multiplication. This is a second order loop specified with Bandwidth and Damping (see Gardner Phaselock Techniques, Wiley).

DesignScope modules can be combined separately to synthesize a more flexible PLL, but this combination part is a time saver for almost all cases. The VCO parameters cause limiting of frequency as a real world PLL would.

FreqOutput = Output of VCO
DemodOutput = voltage at input of VCO
H(s) = (Ko*Kd*F(s))/(s+Ko*Kd*F(s))
where Ko = VCO gain, Kd = Phase Detector Gain, and F(s) = F(Ω,∂)

Rectifier -

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Full or half wave output.

FullWaveOutput = Absolute Value(Input)
HalfWaveOutput = Input*(Input > 0.0)

Sample & Hold / Ramp & Hold–

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Sample and Hold Logic

Output = Input at the moment (Control *goes* high)

Output = Input at the moment (Control *went* high)
until next positive edge.

Ramp and Hold Logis

Output = Input, if (Control > .5v)
Output = PreviousOutput if (Control <= .5v)

Switch -

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If the control input is high, output equals input from high input terminal. If the control input is low, output equals input from low input terminal.

Voltage Controlled Oscillator -

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¿˝Ä˛(picture) í≤˛@˝Ä˛(picture)dR[3éLó„¿∆s¨ƒaRRí˛ê°!)I1$˘˘œ˘˛□˘,A:R^í˛ìô· I!$˙AJRPí˛îÖ(picture))I!
$˙(picture)A:NLq˛ì∏¿∆H†ƒ˜˝˛□˝˛ÎÁ†è†É˘

This is a great little VCO. In addition to the parameters describing frequency control sensitivity, it has a phase control that has a 2π/volt (360°/volt) fixed sensitivity.

OutFreq = FreqControl*(Freq at 1v-Freq at 0v)+ Freq at 0v
OutPhase = PhaseControl*2*π

Voltage Source -

(picture)óµÉ,¬(picture)†09†Ç†é(picture)–@òµÄ,»µÉ,¬µÉ,¬˜˙(picture)˘˙(picture)˘˚KÄ ˝˜˘âI˘ ˝Ä I˘ ˝Ä I˘
˝Ä8Ä˝Ä¸˜˛(picture)‡¸˛(picture) ¸˛(picture) ¸˛(picture) ¸˛(picture) ¸˛(picture)‡¸˛(picture)¸˛(picture)¸˛(picture) Ç¸˛(picture)
Ç¸˛(picture)C·¸˛(picture)@Å¸˛(picture)@Å¸˛(picture)@(picture)¸˛(picture)@(picture)¸˛(picture)
¸˛(picture)#,¸˛(picture)¸˛(picture)¸˛(picture)‡¸˛(picture) ¸˛(picture) ¸˛(picture) ¸˛(picture) ¸˛(picture)‡¸˜˜˛Ä¸˝Ä¸
¿Ä¸ Ä¸!˘˜Ä¸(picture) ˘(picture) ˘˜†è†É˘

Adds the parameter voltage, positive or negative, to the voltage in.

Output = VoltsOut+ VoltageIn

Digital Logic Gates–

ƒ?(picture)I(picture)†09†Ç†é(picture)–@ò(?(picture)P?(picture)I?
(picture)IŸ˘˚ÄÈ˘˚ÄÈ˙(picture)g¸å„Ä¸(picture)∞¸(picture)∆X¸âñ˙˙(picture)§¸BîÄ¸(picture)
¿¸(picture))`¸RX˙˙(picture)t§¸NîÄ¸(picture)Ä¸(picture))@¸"P˙˙(picture)î§¸RîÄ¸(picture)Ä¸(picture))@¸RP˙˙(picture)tú¸NìÄ¸(picture)Ä¸(picture)&@¸âê˙ŸŸÄÄ fiÄ fi (picture)Aπ…p?˝(picture)?¿˝(picture)?¸(picture)˘˝(picture)˘˘"(picture)@•) $˝(picture)
$p˝(picture)&¸a¿¸q¿˙"‡•)#˘˘$˝(picture)$˝(picture)#¸0`¸8`˙" •) $(picture)˝(picture)$˝(picture) Å¸¸˙#   •«<(picture)Ä¸(picture)<˝8¡Äå¸ö˙$
(picture)˝Ä¸(picture)¸(picture)@Ä¸(picture)˝(picture)˝˜$(picture)˝¿¸(picture)¸(picture)`¿¸(picture)4˝(picture)˝˜#˙x¸∏˝(picture)
x¸OÄ¸Äó˘#˙H¸H˝(picture) H¸ÑÄ¸Äí˘#˙H¸H˝(picture) H¸ÑÄ¸á˘¸í˘#˙H¸H˝(picture) H¸ÑÄ¸Äí˘#˙x¸∏˝(picture) x¸OÄ¸Äq˘!   ¿Ä
¿¸(picture)¸(picture)`¿¸(picture)4˝(picture)˙!   Ä¸(picture)¸(picture)@Ä¸(picture)˝(picture)˙#   !π…
p<(picture)Ä¸(picture)<˝8¡Äå¸ö˙"¿•) $(picture)˝(picture)$˝(picture) Å¸¸˙" •)#˘˘$˝(picture)$˝(picture)#¸0`¸8`˙" •) $˝(picture)
$p˝(picture)&¸a¿¸q¿˙ ¿•«?˝(picture)?¿˝(picture)?¸(picture)˘˝(picture)˘˘(picture)‹(picture)‹Ÿ†è†É˘

AND: Both inputs high, output high. Either input low, output low.
NAND: Both input high, output low. Either input low, output high.
OR: Either inputs high, output high. Both inputs low, output low.
NOR: Neither inputs high, output high. Either inputs high, output low.
EXOR: Both inputs the same, output low. Inputs different, output high.

Divide By–

(picture)>§S˘(picture)†09†Ç†é(picture)–@ò>ûS¸>§S˘>§S˘ı˝(picture)˘¸˝(picture)¸˝(picture)¸˝(picture)¸˝(picture)¸Ä(picture)˝Ä˝(picture)˝Ä
(picture)∏%¿
§   §Ä
§˘˘…˘‰§Ä
§   §Ä
§@˝(picture)¸˝(picture)¸˝(picture)¸˝(picture)¸˝(picture)¸˝(picture)¸˝(picture)˘¸ı†è†É˘

Divides input frequency by parameter. Always symmetrical with symmetrical input.

Output = InputFrequency/DivideBy

D Flip Flop -

t∞Ö‰(picture)(picture)†09†Ç†é(picture)–@ò∞Ä‰(picture)∞Ö‰(picture)∞Ö‰
(picture)Ô˘@¯˘@¯˚(picture)Ã‡¯˚@¯˚(picture)û@¯˙(picture)P@¯˚å ¯Ô˙˜˙˜˙˜Ô˙|˜˝D˜˝D¸Ä¸Œ`?˘¯ÄÄ¸$$$HÉ%¿¸$‰s˘˘I˘˘àÑ§Ä¸%
$ê&£»Ñ§Ä¸,p>⌡¯Ñ§Ä¸˚ä¿@¸˚3¿(picture)˚˚@¯˚@¯˚@¯˚@¯˚¿¯Ä8@¯Ä+¿ (picture)âåê<⌡¯Ä JR†%2»Å∆pd∏P√˘˘&+…˘˘àÅ) îêJR†$HΩ)
îê(picture)âåê?˘¯Å) îê˙D¸(picture)&cà˙D¸(picture)˚˙|˜Ô˙˜˙˜˙˜˙(picture)(picture)¯˘(picture)¯   ˚,«3Ä˘˚1(I¯˚!Êy¯˚!(picture)A¯   ˚
Œ0Ä˘Ô†è†É˘

The Clock input is Positive edge trigger.

In order of precidence:

QnotOutput = NOT(QOutput)
Output = Low if (Reset > 0.5v)
Output = High if (Set > 0.5v)
QOutput = DataInput (at time of Clock positive edge)

Voltage Controlled One Shot -

\(picture)†(picture)1(picture)O(picture)†09†Ç†é(picture)–
@ò(picture)†(picture)1(picture)P(picture)†(picture)1(picture)O(picture)†(picture)1(picture)OÎÄ¸0˙Ä@˘Ä¸˙@@˘D≈ÃsŒ≥˘¸Aí‡˘)
$ÇîÑ•$ƒê$BR@˘)$éóÑ%$Ñë˘˘í$˘˘ƒBR@˘$íî•$ÑêA‰BR@˘ƒNs"ÉÒ|Åé ˘¸˙A`¸Ä˝¸˙A‡˘˘H ˘˘0 ˘˘ ˘˘ ˘˘(picture)‡˘˝(picture)Ä˝
Ä˝(picture)˚ï‡@˝≠úÊX]|@„82\˝(picture)0•)`ôd@îêJH˝(picture) •/A˘˘ì‰˘˘ƒ^îêJH˝(picture) •(@$@îêJH¸†úÊ@˘¸Äì1ƒ˚(picture) ˝"˝Ä˝˚(picture)
¿˝"¯ı>¯Iı¯ı¯ı¯ı¯ı¯ı¯Ù˘Ù˘˘Yég˘˘bPí˘˘CÃÚ˘˘BÇ˘˘Aúa˘Î†è†É˘

Can be retriggerable or non-retriggerable. Positive edge Trigger Input.

In order of precidence.

QnotOutput = NOT(QOutput)
QOutput = High if (Trigger > 0.5v)
QOutput = High for (Seconds)(Voltage Control)
QOutput = Low if (Reset > .5v)

Transient Input Generator -

‰˝d(picture)ö(picture)†09†Ç†é(picture)–@ò˝ˆ(picture)†˝d(picture)ö˝d(picture)ö˘˘¿¸@¸@¸@¸@¸ @@˛(picture)(picture) @˛(picture)
(picture) ‹xKÄ RH I RI˘˘âI RH I Rx8Ä@¸@¸@¸@¸@¸@¸ˇ¿¸˘†è†Éˇ

Generates an Impulse function (Dirac) or a unit step.

UnitStepOutput = 1.0 volts at for all steps except 1 (zero v)
DiracOutput = (Number of Steps/Time) at second step (all else zero v)

Storage Scope–

(picture)îÒº(picture)(picture)H(picture)†09†Ç†é(picture)–@òÒ∏(picture)(picture)HÒº(picture)(picture)HÒº(picture)(picture)HÔ˝Äı □
Î2A∏˘˘˛Î2@…p(picture),@§Ä (picture),A) (picture)(:@§˘˘‰øÈ?˘˘(:A) (picture)(J@§øÈ(picture)(JA) Ë9¿§º/˛Ë9¿«
@˝(picture)πË˛
@ˇ¿(picture)Ä˝(picture)≥Ë˛¿(picture)Ä˘˘(picture)ßË˘˘(picture)øË˘˘(picture)øË˘˘(picture)Ä˘˘(picture)Ä˘0(picture)Ä˛(picture)µh˛Ü
(picture)¸(picture)±h˛Ç !∏Å˛,c$. ê•@§¥i˛í®%$ì°Ä§˘˘‰∞iˇ¸ít0%$ î•@§Ä ˛íî®%$ ô §˘˘˛,s$,Ô†è†Éˇ

All simulations run from this box. The top input is plotted in gray; the bottom in black.

Stores four simulation results. FFT available for black wave through Transform button in dialog box.

Tips

No connection to an input is equivalent to zero volts in.

The digital "High" is 1.0 volts; "Low" is 0.0 volts. The digital input threshold is 0.5 volts.

A VCO component with no inputs can be set up as a fixed frequency input generator by entering the desired frequency into both the "Freq at zero volts" and "Freq at 1.0 volts" parameters.

DesignScope requires 512K to operate. It works on the Macintosh, Macintosh Plus, and XL.

DesignScope is available from BrainPower, Inc. at a suggested list price of $249.95. To purchase DesignScope, or for more information, contact:

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24009 Ventura Boulevard

Calabasas, CA 91302
(818) 884-6911