

GLASSWARE
AUDIO DESIGN SOFTWARE

Tube CAD

Version 1.1.2

USER GUIDE

DISCLAIMER

This program and User Guide are intended for amusement and instructional purposes—solely. We at GlassWare assume no responsibility for the use of any of the information provided. Much of what is detailed in the User Guide and program refers to potentially lethal voltages. Always let an electronically trained person review what you are planning on building and what you have built.

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GLASSWARE™

www.glass-ware.com

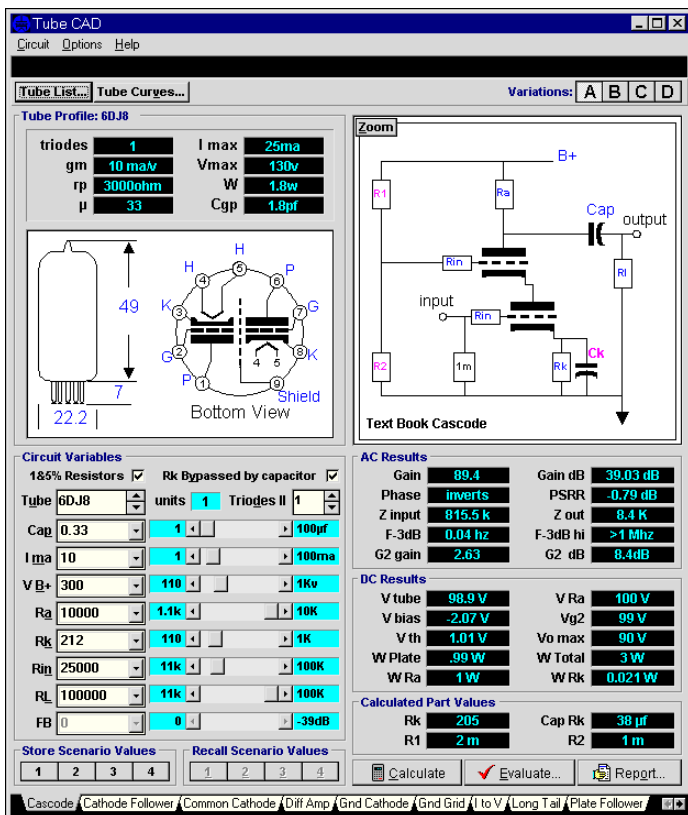
USA

Tube CAD User Guide

INTRODUCTION

Welcome to Tube CAD, the program that helps you understand and design tube audio circuits. Its name gives the best answer to what Tube CAD is all about: CAD means Computer Aided Design. Tube CAD makes the design of a tube-based project much easier by doing the electronic math for you.

As circuit variables are adjusted by the user, Tube CAD displays the effects on the circuit's performance in AC and DC terms, such as PSRR, gain, Z_o , and plate dissipation. Tube CAD also aids by providing tube specifications, tube plate curves and tube envelope profiles for most of the commonly used tubes in audio practice. Tube CAD also prints reports and tube spec sheets.



Tube CAD includes 13 types of tube circuits, divided into four variations each—52 circuits in all. The metaphor used is that of a notebook with 13 pages, one for each circuit type. Clicking on the tabs at the bottom of the program brings up that circuit page. Circuit schematics and plate curves require just a button click to be seen. Circuit variables such as tube type, B+ voltage, plate and cathode resistor values, and coupling capacitor value are entered in field boxes or changed by sliding a horizontal slider control. After the “Calculate” button has been pressed, the AC and DC results are then displayed.

INSTALLATION

The Tube CAD program cannot be run from the diskette; it must be installed to a hard drive. Furthermore, the installation program and the program itself must be run under Windows 3.1 or better. A 1.44 Mb floppy drive and at least 2 megabytes worth of free space are required to install Tube CAD. The program's executable is a single file that does not litter your hard drive with DLL's or VBX's; consequently, uninstalling the program is a breeze. Just use the uninstall utility program titled UNINSTALL.EXE that can found in the same directory in which the program resides.

Start by placing the floppy disk into its drive, either “A” or “B”; then, under the “File” heading of Program Manager in Windows 3.1 or at the pressing of the “Start” button in Windows 95, select RUN. From there press the “Browse” button to bring up the drive that contains the Tube CAD diskette. Once that drive is highlighted, select “INSTALL.EXE” Press the “OK” button and the installation program will come up.

The installation program will need to know where you wish to copy Tube CAD on your hard drive, the default being a directory named “Audio.” It will further need to know if you wish to make a program group to hold the Tube CAD program icons.

TWO POINTS

ONE. Please do not give copies of this program to your friends. This program took lots of work and sweat to create. It is intellectual property that belongs to GlassWare. Simply put: there are not that many audiophiles left; you are one of them, as are we at GlassWare; in order to make a go of writing audio-related software there must be honesty and consideration amongst ourselves.

TWO. If you find something missing or wrong or troublesome or even wonderful, take notes. Given enough interest, Tube CAD will evolve and develop into something better in the future. We have several ideas about what might be added to version 2. But is you the user who knows what would really excite you and, unlike so many programs that are written only to fill a marketing segment, we at GlassWare believe in and design and build and use tube equipment exclusively. We, as much as anyone else, want Tube CAD to evolve into a better program we can use ourselves. With your help, it will be even better still. So please let us know what you think. If you have a pet circuit not in Tube Cad or variation on a circuit in Tube CAD, let us know what it is. A letter, post card or e-mail would be great.

MOVING ABOUT AND GETTING HELP IN TUBE CAD

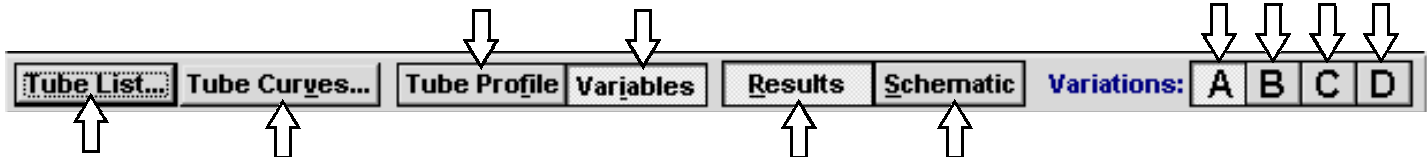
↓ Click on page tabs to change to the desired circuit type.

Click here to display more page tabs. ↓



Press the “**Tube Profile**” or the “**Variables**” button to toggle between viewing the tube profile on the tube in use or the entry controls for the circuit variables .

Press the “**Variations**” buttons to toggle viewing the four circuit variations per circuit type—either the schematic or results for each.



Press the “**Tube List**” button to bring up the tube list dialog box or press the “**Tube Curves**” button to bring up the tube curves form.

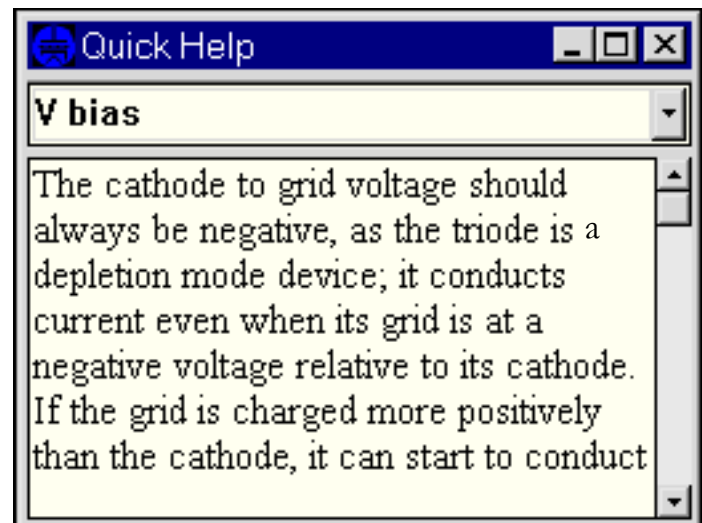
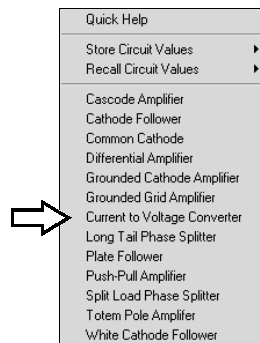
Press the “**Results**” or the “**Schematic**” button to toggle between viewing the calculated results or the schematic for the circuit being evaluated.

Speed Menu

Clicking the right mouse button brings up the floating menu displayed to the right. This menu allows the user to move quickly from one page to another.

is to leave the Quick Help window up and running while you use the program, as it will track your movements.

More Help



Quick Help

The Quick Help window provided by this program is not part of the Windows help database hypertext program. It is less cumbersome and quicker, and much less weighty. To bring it up, just press the “F1” key when a control has emphasis (Computerese for when you move the mouse into a data entry box or have checked an options eyelet) or right mouse button click to bring up the speed menu, whose first entry is “Quick Help”; or when the cursor is over a description label, press the button, which appears below the label, and Quick Help comes up instantly. One good idea, if you have the screen area for it,

As for 1-800 help lines, there are none. As for 1-900 you-pay-for help line, ditto. At least not yet. As for e-mailing us questions, no problem. We are at:

Sales@glass-ware.com

or write us

POB 231

Fenton MI 48430 USA

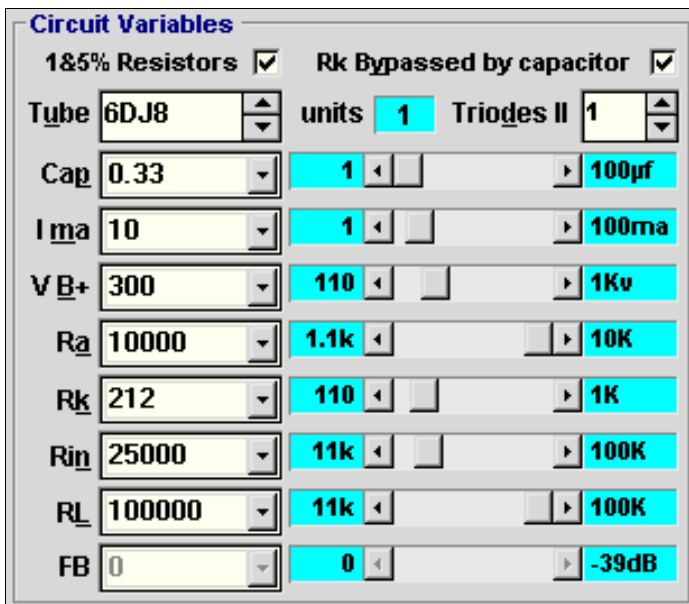
CIRCUIT VARIABLES

Circuit variables, such as tube type, B+ voltage, plate and cathode resistor values, and coupling capacitor value are entered in field boxes at the left or changed by sliding the horizontal slider control at the field box's right. The results are then displayed at the program's right.

When a slide control is at one extreme or the other, clicking on the displayed limit values will automatically move the slide control to the other extreme and continue the value progress; for example, when the slider is at the extreme right and the limit displayed is 1k, clicking on the 1k display will move the slider to the extreme left and its new value will be 1.1k.

When entering large values, such as, 105,000 the easier entry method is to use abbreviations. For example, to enter 150,000, type "105" and then "k." Similarly, if entering 1,100,000, the quick way is to enter "1.1" followed by "m."

After a change in value of a circuit variable, those results that



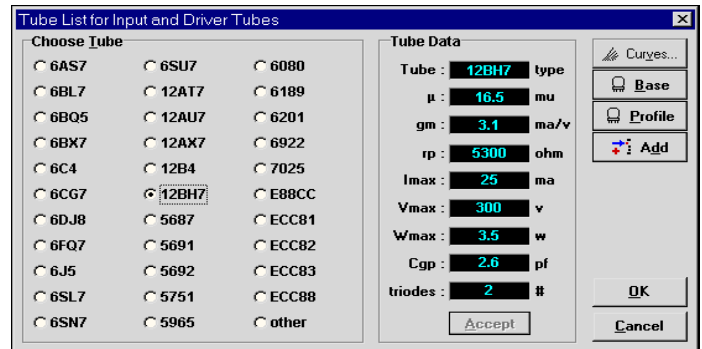
are determined in part by that variable are displayed in fuchsia, until the "Calculate" button has been repressed, which will restore the font color to aqua. If an error condition, such as a positive grid bias voltage arises, the result's font color turns to red and returns to aqua when the problem has been corrected.

The "1 & 5% Resistor" check box serves to limit Tube CAD to its calculated resistor values that are found in the standard list of 1% and 5% resistors. For example, the cathode resistor's absolute calculated value might be 101 ohms, but the closest standard value is 100 ohms, which is what Tube CAD will display, if the "1 & 5% Resistor" check box has been checked.

TUBE LIST

The list of tubes that are known to TubeCAD can be brought up by holding down the "Alt" key and pressing the "T" key or by clicking on the "Tube List" button on the speed bar. The maximum ratings and essential characteristics are displayed for each tube type.

- μ** refers to a triode's amplification factor or mu.
- gm** refers to a triode's transconductance and is measured in milliamps/volt.
- rp** refers to a triode's plate resistance.
- I_{max}** refers to a triode's maximum plate current and is measured in milliamps.
- V_{max}** refers to the maximum static plate voltage at which a triode should be operated.
- W_{max}** refers to the maximum static plate dissipation (watts) which a triode should undergo in normal operation.
- C_{gp}** refers to a triode's grid to plate capacitance in pf.

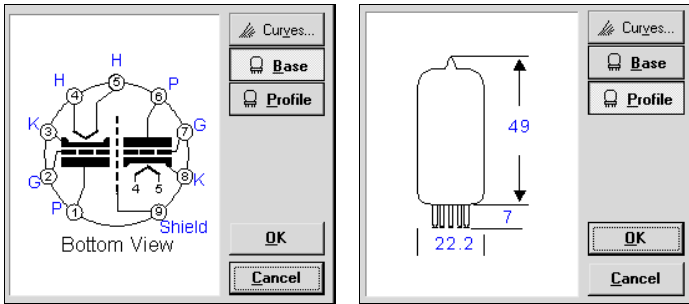


Although 32 types of tubes are displayed, there are actually only 14 core tube types represented by this list: for example, the 6AS7 and the 6080 differ in name and shape of envelope, but not in essential electrical characteristics.

After checking one of the tube type choice eyelets, pressing the up and down arrow keys will move the selected tube up and down the list, which allows the user to compare quickly the characteristics of all the triodes available.

PROFILES & BASE PINOUTS

While in the Tube List dialog box, a tube's base pin out schematic or its profile can be seen by pressing the "Base" or the "Profile" buttons. The tube outlines are marked in millimeters. The tube pin schematics are referenced from the bottom of the tube.



AC & DC RESULTS

Tube CAD divides the results of its calculations into two groups: those that are primarily determined by the tube's AC attributes, such as g_m and μ ; and those that are primarily determined by the specified power supply, B+ voltage, idle current, and the resistor values. The AC results are softer than the DC results in that the tube's g_m and r_p are not perfectly constant for all voltages and currents. The DC results are harder than the AC results in that a specified current flowing through a fixed resistor value will absolutely define a determined voltage and heat dissipation.

The key AC results are usually gain, Z_o and PSRR. To see the influence a component value has on these results or any other that is in part determined by the component value, slide the variable slider that is associated with the value and watch the effect on the results, as they are recalculated automatically after a slider control has been moved.

ADDING TUBES

If you would like to model a circuit with a tube that does not appear on the list, it can be added by checking "other" at the bottom of the list, which will bring up the edit fields for defining the tubes characteristics. This new tube type will be used in the Tube CAD AC & DC results display fields. Although the user-defined tube type is stored for future use, it is not part of Tube CAD's original tube library; consequently Tube CAD cannot display the plate curves for this tube.

User Defined Tubes	
<input type="radio"/> 6080	Tube : <input type="text" value="6AQ8"/> type
<input type="radio"/> 6189	μ : <input type="text" value="57"/> mu
<input type="radio"/> 6201	g_m : <input type="text" value="5.9"/> ma/v
<input type="radio"/> 6922	r_p : <input type="text" value="9600"/> ohm
<input type="radio"/> 7025	I_{max} : <input type="text" value="15"/> ma
<input type="radio"/> E88CC	V_{max} : <input type="text" value="250"/> v
<input type="radio"/> ECC81	W_{max} : <input type="text" value="2.25"/> w
<input type="radio"/> ECC82	C_{gp} : <input type="text" value="1.8"/> pf
<input type="radio"/> ECC83	triodes : <input type="text" value="2"/> #
<input type="radio"/> ECC88	<input type="button" value="Accept"/>
<input checked="" type="radio"/> other	

AC Results			
Gain	89.4	Gain dB	39.03 dB
Phase	inverts	PSRR	-0.79 dB
Z input	815.5 k	Z out	8.4 K
F-3dB	0.04 hz	F-3dB hi	>1 Mhz
G2 gain	2.63	G2 dB	8.4dB
DC Results			
V tube	98.9 V	V Ra	100 V
V bias	-2.07 V	Vg2	99 V
V th	1.01 V	Vo max	90 V
W Plate	.99 W	W Total	3 W
W Ra	1 W	W Rk	0.021 W
Calculated Part Values			
Rk	205	Cap Rk	38 μ f
R1	2 m	R2	1 m

The key DC results are the voltage drop across the tube and the plate dissipation, as these can determine tube performance and life expectancy.

The "Calculated Part Values" grouping is where Tube CAD displays the results of its best guess about the correct values for those circuit parts that are not freely definable by the user, say, the resistor values for a voltage divider needed in a circuit or the amount of capacitance needed to bypass a specified cathode resistor value in order to ensure low frequency bandwidth to 20 Hz.

PLATE CURVES

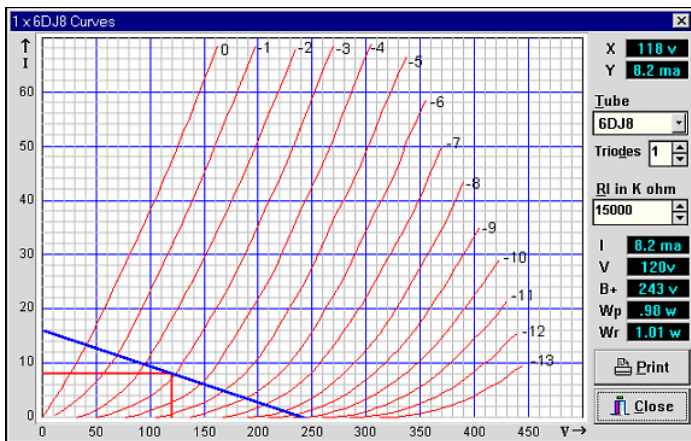
Don't have a tube manual? No problem; Tube CAD does. Each of the tube types listed in the program has its curves, that is, the plate voltage versus plate current relative to the grid voltage (along with its base and profile) ready to be displayed and printed. Two or more curve forms can be viewed at once, if you have the monitor area for it.

Interactive Load-Line Superimposition

As the cursor is moved across the tube's plate curves, the readouts at the top of the form display the XY values of the cursor's position. When the left mouse button is clicked, the load line is displayed with the bold blue line and the plate voltage and current are marked by the right angle red line. Furthermore, the needed B+ voltage and idle current along with the plate and plate resistor dissipation are displayed in the middle readouts at the right.

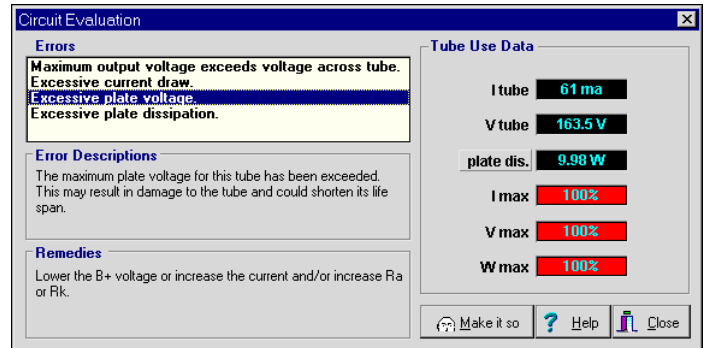
Printing a Copy of the Curves

Pressing the "Print" button will print a large copy of the plate curves, the tube's base pin out schematic, its profile, and the essential tube characteristics. Print a set of curves and break out a ruler and look for the sweet spots. Or burn off a copy of each tube and make your own tube manual.



EVALUATION DIALOG BOX

This dialog box gives your circuit a quick going over and evaluation. After defining all the circuit's variables, such as B+ voltage, idle current, and plate load resistance, Tube CAD can search for error conditions and provide error descriptions and remedies.



Error List

The errors caught are of the gross kind—excessive plate voltage, excessive plate dissipation, current, and positive grid voltages—that could damage the tube or greatly compromise the circuit's performance. Each line represents one type of error.

Error Description

When a line in the Error List box is selected, a description of that error is displayed below in the Error Description bracket. Each error gets its own explication.

Error Remedies

Each type of error finds its remedy displayed in the Error Remedies bracket. Not every solution need be tried, as a change in one the variables usually results in a change more than one operating parameter. For example, lowering the B+ voltage would lower both the excessive plate voltage and the excessive plate dissipation.

Make It So

Pressing the "Make it so" button will let Tube CAD correct the error conditions for you. It does this by auto-loading the circuit part values and operating points that will return the circuit to something closer to normal and eliminate the error conditions.

SCENARIOS

“What if...?” is the question that a spreadsheet helps to answer. “What if I used a 12AU7 with less idle current over a 5687 with a greater B+ voltage?” This scenario can be saved with a click of the mouse. Tube CAD also holds 52 temporary circuit arrangements, four per circuit page, called scenarios. These allow push button comparisons of circuit values or variations on topology. When a filled scenario button is clicked, the circuit variation type and circuit variables contained in that scenario are automatically loaded. When the scenario is empty, the load scenario button’s font color is grayed. As a scenario becomes filled, its load scenario button’s font color changes to dark blue.



In the above image we can see that no scenario has been saved because the all the “Recall Scenario” buttons are still grayed.

Scenario Display box

To see what is being stored in the scenario memory slots, click “View” on the menu and then click “Circuit Scenarios” and the Scenario Display box will be shown. It allows the user to see all four saved scenarios for a given circuit type.

Scenarios for Grounded Cathode				
Scenario	1	2	3	4
Variation	A	A	A	A
Tube	12AT7	6FQ7	12AU7	6DJ8
Triodes	1	1	1	1
Cap	0.33 µf	0.33 µf	0.33 µf	0.33 µf
Current	3 mA	10 mA	5 mA	10 mA
B+	300 v	300 v	300 v	200 v
Ra	50 k	15 k	30 k	10 k
Rk	523 ohm	274 ohm	1 k	205 ohm
Rin	25 k	25 k	25 k	25 k
Rload	100 k	100 k	100 k	100 k
NFB dB	0 dB	0 dB	0 dB	0 dB
Gain	41.38	12.58	12.75	24.81
Gain dB	32.3 dB	22 dB	22.1 dB	27.9 dB
Zo	10.3 k	4.84 k	5.77 k	2.26 k
PSRR	-13.7 dB	-9.82 dB	-14.3 dB	-12.9 dB
-3 dB Low	4.37 Hz	4.6 Hz	4.56 Hz	4.72 Hz
-3 dB Hi	103 kHz	137 kHz	333 kHz	183 kHz

Scenario Reports

Tube CAD
Grounded Cathode Amplifier

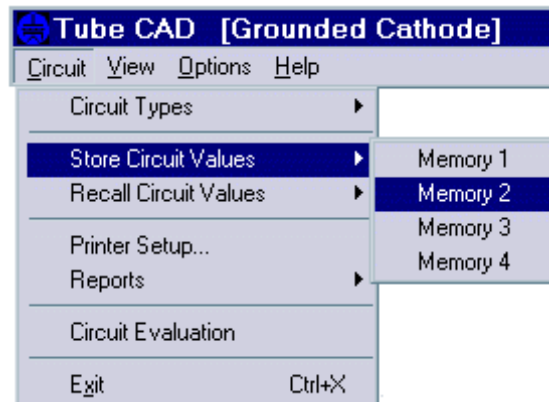
Scenario 1 Variables	Scenario 2 Variables	Scenario 3 Variables	Scenario 4 Variables
Tube = 6DJ8	Tube = 6FQ7	Tube = 12AT7	Tube = 5687
Number = 1	Number = 1	Number = 1	Number = 1
Rk = 212 ohm	Rk = 698 ohm	Rk = 523 ohm	Rk = 681 ohm
Rk bypassed	Rk bypassed	Rk bypassed	Rk bypassed
Rin = 25 k	Rin = 25 k	Rin = 25 k	Rin = 25 k
RL = 100 k	RL = 100 k	RL = 100 k	RL = 100 k
Ra = 10 k	Ra = 25 k	Ra = 50 k	Ra = 15 k
Cap = 0.33µf	Cap = 0.33µf	Cap = 0.33µf	Cap = 0.33µf
I = 10ma	I = 6ma	I = 3ma	I = 10ma
V B, = 200v	V B, = 300v	V B, = 300v	V B, = 300v

Scenario 1 Results	Scenario 2 Results	Scenario 3 Results	Scenario 4 Results
Gain = 24.81	Gain = 14.44	Gain = 41.38	Gain = 14.74
Gain dB = 27.9 dB	Gain dB = 23.2 dB	Gain dB = 32.3 dB	Gain dB = 23.4 dB
V tube = 97.9 v	V tube = 146 v	V tube = 148 v	V tube = 143 v
Vg DC = 0 v	Vg DC = 0 v	Vg DC = 0 v	Vg DC = 0 v
PSRR = -12.9 dB	PSRR = -13.1 dB	PSRR = -13.7 dB	PSRR = -18.7 dB
Vth = 3.66 v	Vth = 8.31 v	Vth = 2.42 v	Vth = 8.85 v
Vmax out = -50/+90.9 v	Vmax out = -58/+120 v	Vmax out = -65/+100 v	Vmax out = -99/+130 v
Vgk bias = -2.03 v	Vgk bias = -3.99 v	Vgk bias = -1.57 v	Vgk bias = -6.72 v
Z input = 186 k	Z input = 130 k	Z input = 114 k	Z input = 119 k
Z output = 2.26 k	Z output = 5.56 k	Z output = 10.3 k	Z output = 1.73 k
F -3dB low = 4.72 hz	F -3dB low = 4.57 hz	F -3dB low = 4.37 hz	F -3dB low = 4.74 hz
F -3dB high = 183 khz	F -3dB high = 119 khz	F -3dB high = 103 khz	F -3dB high = 108 khz
Plate Dis. = 979 maw	Plate Dis. = 875 maw	Plate Dis. = 445 maw	Plate Dis. = 1.43 w
Ra Dis. = 1 w	Ra Dis. = 900 maw	Ra Dis. = 450 maw	Ra Dis. = 1.5 w
Rk = 205 ohm	Rk = 665 ohm	Rk = 523 ohm	Rk = 665 ohm
Cap Rk = 38 µf	Cap Rk = 11 µf	Cap Rk = 15 µf	Cap Rk = 12 µf

GlasView™

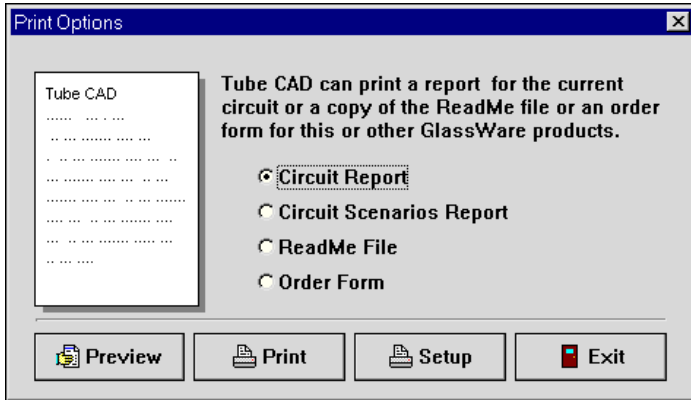
PERMANENT MEMORY SLOTS

Tube CAD stores four permanent circuit arrangements on the hard drive that can be recalled or modified at any time. To place into or recall from memory, click on the menu bar item “Circuits” and then move down to “Store Circuit Values,” from which the four memory slots can be chosen. Alternatively, at any time, just right mouse button click to bring up the speed menu, whose second and third items refer to storing and recalling circuit values.



REPORTS

Tube CAD can print a report for each of the page topics and the ReadMe.txt file for the program. In addition, an order form can be printed to order other GlassWare programs



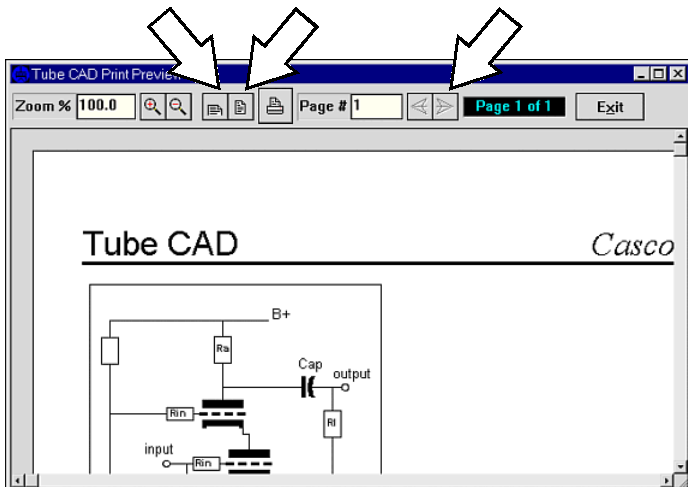
Circuit Reports

A circuit report is a snapshot of whichever circuit and variation of that circuit is currently on the screen. It lists the tube type, tube characteristics, number, circuit part values, power supply voltage, and user options, such as bypassing the cathode resistor. Additionally, it lists all the AC & DC results and calculated part values, along with a schematic of the circuit under obser-

Print Previews

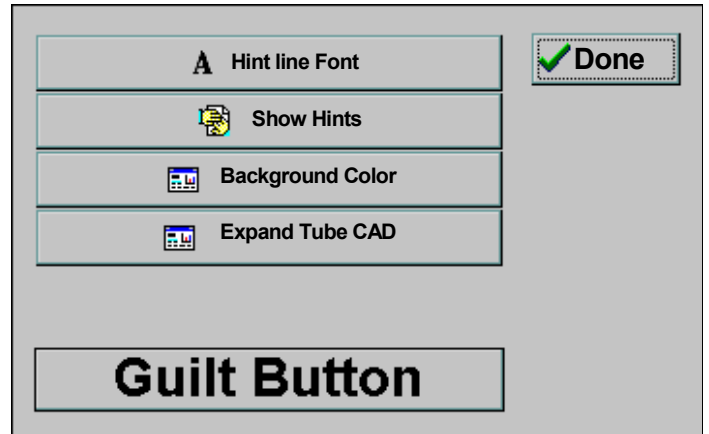
The "Print Preview" window allows you to see what the printed result will look like, depending on your printer of course. Pressing the "Preview" button brings up the print preview window, which allows you to see what you are going to print.

Press to see the entire width of the report page. Press to see the entire report page. Press these buttons to display the next or previous report page.



OPTIONS

The "Options" page allows the user to change the Tube CAD program itself. Size, fonts, color, hint balloons—all are changeable.



Hint Line Font

The hint line font, which appears in the black display box at the top of the program, can be changed to another font, size, color. Just choose an alternative font, size, color. The new font choices will be remembered the next time the program is run.

Don't Show Hint Balloons

Some user just love the hint balloons; others just hate them. Decide which group you belong to and press the "Don't show hint balloons" button to stop or start the display of hint balloon messages. This choice will be remembered the next time the program is run.

Background Color

The normally black hint line background can be changed to another color. Just choose an alternative color. This choice will be remembered the next time the program is run.

Expand Tube CAD

Unbelievably, there are people with 14 inch monitors who insist on running them at 1280 x 1024 resolution. How their eyes must ache. By pressing the "Expand Tube CAD" button, some aid can be had. Fortunately, this choice will be remembered the next time the program is run.

On the other hand, if your monitor is plenty big and you are running at a higher resolution, then try resizing the program. If there is enough room, Tube CAD will display in a fully expanded mode, which can be seen in the illustration in the introduction of this manual.

Guilt Button

Rather than spend thousands of dollars on questionable and often humiliating therapy sessions...

G L O S S A R Y

- AC** Alternating current. A flow of electricity that changes direction cyclically.
- Amp** Short for Ampere. A unit of electrical current flow. One volt across one ohm of resistance defines 1 amp of current flow. Often the amp is too large to be used conveniently in audio circuits and consequently the milliamper (ma, .001 amps) is used instead.
- Amplification Factor** a.k.a., the “mu” or “ μ ” of the triode; it is the variation in plate voltage divided by the variation in grid voltage while the plate current is held constant, for example when the plate is loaded with a constant current source. The mu of a tube sets the upper limit to the gain that is realizable from a triode in a grounded cathode amplifier circuit.
- Amplifier** An electronic circuit that creates a copy of the input signal with an increase in voltage and/or current.
- Anode** The positive electrode. In a tube it is element that receives the majority of electrons emitted by the cathode.
- Bandwidth** Usually in audio work, the range of frequencies that does not drop below -3 dB of the average gain. For most audio work this range covers 20hz to 20khz.
- Bypass Capacitor** A capacitor that is used to provide an effective AC shunting path across a circuit element—usually, a resistor. Across a cathode resistor in a Grounded Cathode or Cascode tube circuit results in greater gain and a lower Z_o , but at the cost of greater distortion.
- Capacitance** The physical property of a circuit component that permits it to store an electric charge, a potential difference, between elements within that circuit. The unit of capacitance is the farad.
- Cathode** The negative electrode. In a tube it is element that emits electrons.
- Class-A** Whether the signal swings positive or negative, *each* output device handles *all* of the output waveform.
- Class-B** *Each* output device handles *exactly half* of the output waveform.
- Class-AB** *Each* output device handles only a little *more than half* of the output waveform.
- Class-C** *Each* output device handles only a little *less than half* of the output waveform.
- DC** Direct Current. A flow of electricity proceeds continuously in one direction solely.
- Decibel** Abbreviated dB. A unit of change in amplitude. In acoustic terms it is the smallest increment that can be heard. In electrical terms it is equal to $\text{dB}=10\log P1/P2$ and $\text{dB}=20\log E1/E2$.
- Distortion** The departure of the reproduced signal from the input signal. Of course, one listener’s distortion can be another listener’s bloom, sweetness, warmth, and fluidity.
- EMF** The Electromotive Force. Unit of measurement is the volt.
- Feedback** The process of sampling a portion of the output of an amplifier and feeding it back into the circuit in a manor that will tend to correct any deviation in the output signal from the input signal other than gain.
- Filter** A frequency selective network of resistors capacitors and/or inductors that is used to tailor the frequency response of a circuit.
- Frequency Response** The range of frequencies to which a circuit or loudspeaker can respond. It is usually banded within -3dB points.
- gm** Transconductance. The measure of the change in current flow through an electronic device relative to the change in control voltage. Tubes are measured in ma / volt; solid state devices, in A/V.
- Gp** Plate Transconductance. Transconductance is the measure of the change in current flow through an electronic device relative to the change in control voltage—in this case, plate voltage.
- Gain** The relative change in voltage, current, or power to the some reference voltage, current, or power.
- Grid** The electrode structure in a vacuum tube that surrounds the cathode and through which the cathode-emitted electrons flow to the plate. It is the usual current control element of the tube.
- Ground** A circuit’s voltage reference point.
- Hertz** Abbreviated Hz. One cycle per second. A 100 Hz tone is one that has 100 cycles per second.
- Impedance** The resistance offered to the flow of alternating current.
- Inductance** The property of an electrical element that opposes any change in the existing current flow. The unit of inductance is the henry.
- Kilohertz** Abbreviated kHz. One thousand cycles per second. A 10kHz tone is one that has 10,000 cycles per second.

- Mu** A triode's amplification factor. It is a measure of the relative effectiveness of the tube's grid over the plate in controlling current flow through the tube.
- Ohm's Law** The voltage across a resistor in a DC circuit is equal to the current times the resistance. $E=IR$, $I= E/R$, $R=E/I$.
- PSRR Power Supply Rejection Ratio.** PSRR refers to the ratio of a circuit's change at its output relative to the disturbance at the power supply that caused it.
- Phase** The measure of the angular relationships between currents and voltage in an AC circuit and the angular relationships between pressures in sound waves.
- Power** The rate at which work is done. In electrical terms, the watt and the joule. In acoustic terms, the acoustical watt.
- Plate** a.k.a. anode. The positive electrode in a tube, which attracts the majority of electrons emitted by the cathode.
- Power Supply** Abbreviated PS. A circuit that supplies power to another circuit. It usually comprises a transformer, diodes, capacitors, and sometimes a choke or regulator.
- RIAA Equalization** A curve exactly the inverse of the one stored on a particular record; the combination of the two curves yields a flat output signal. It boosts the lows below 500 Hz and maintains a flat response between 500 Hz to 2121 Hz, where it falls off with a -6 dB slope. Records could have been made without pre-equalizing them, but at the cost of a greatly reduced playing time and a worse signal to noise ratio. The RIAA equalization can be achieved passively or actively through a frequency selective feedback loop.
- RMS** Abbreviated form of **Root Mean Square**, a.k.a. the effective amplitude. The conversion of a wave value of current or voltage into a value equal to the that would result in the same amount of heat generated as a DC current or voltage would into the same load. For sine waves the conversion factor is .707 the peak value; for square waves, 1; for triangle waves, .577.
- rp** The plate resistance of a vacuum tube. It is the impedance that a tube offers a change in plate voltage. It is equal to μ/gm and it is not as constant as we might like, varying as it does with voltage and current. A 12AX7 has an rp of 62k ohm; a 6DJ8, 3k ohm.
- Reactor** a.k.a. inductor, coil, choke. A device that introduces an inductive element into an circuit.
- Regulator** A circuit whose purpose is to maintain a constant output voltage in spite of variation in the power supply voltage or variations in the current drawn by the load.
- Shunt Feed** An alternative single-ended amplifier topology. An amplifier wherein the output transformer is not in series with the tube's idle current, but capacitor coupled to the plate. The idle current flows through a choke that serves as a constant current source load for the output tube.
- Single Ended** a.k.a. SE. An amplifier or circuit that uses one device (or devices in parallel) to handle all of the output signal. By necessity this entails Class A operation of the output device.
- Slew Rate** The ability of an amplifier to swing so much voltage in so much time. The voltage is measured in volts and the time is measured in micro-seconds (μs), which gives us the final "v/ μs " suffix.
- Transconductance** The measure of the change in current flow through an electronic device relative to the change in control voltage. Tubes are measured in ma / volt; solid state devices, usually, in a/v.
- Transformer** A device made up of at least two coils which usually surround a ferromagnetic core and by induction serve to transform electrical energy from one coil to the other.
- Triode** A vacuum tube with three primary elements: the cathode, which emits electrons; the grid, which surrounds the cathode and offers a large amount of control over the current flow from the cathode; the plate, which incases both the cathode and the grid and receives the flow of electrons from the cathode and, to a much lesser degree than the grid, controls the flow of current from the cathode.
- Zo** The output impedance of a circuit or amplifier.