PiezoInnovations

PiezoTran

Transmission Line Transducer Analysis Software

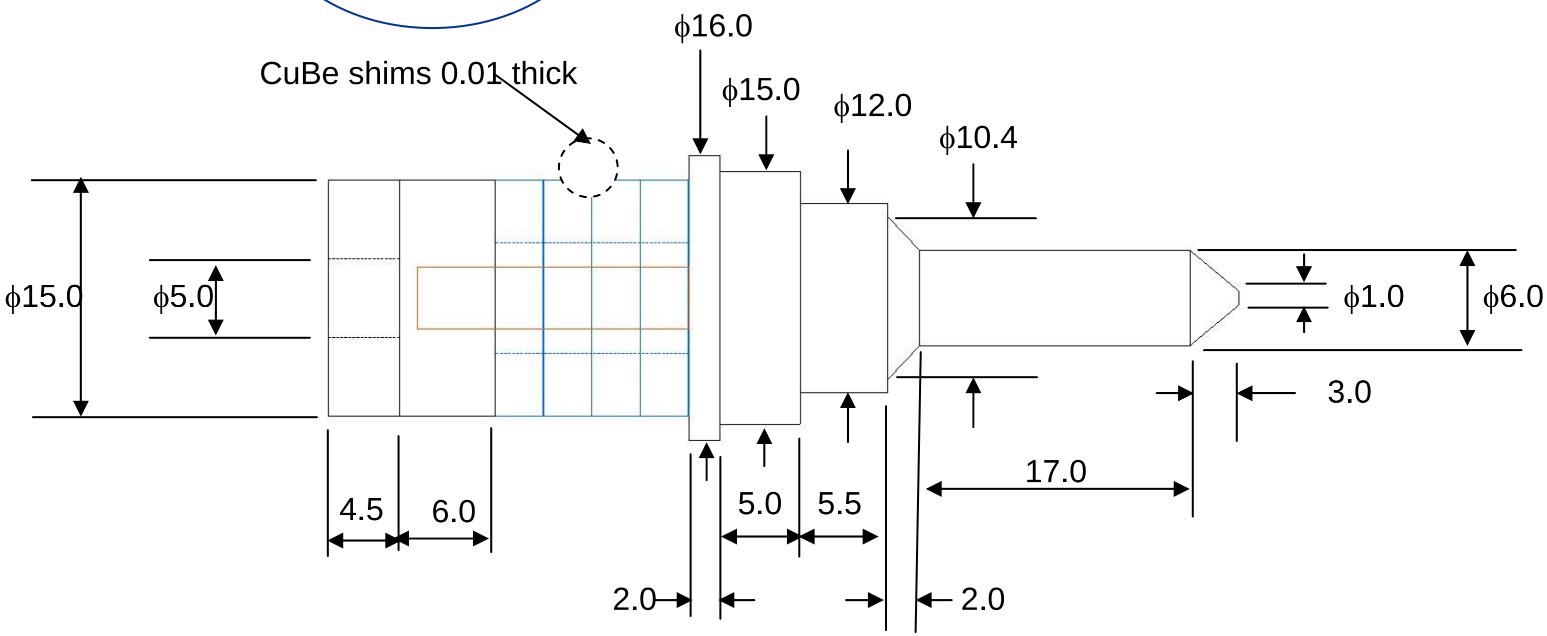
Analysis & design of piezoelectric transducers

- Material parameter variation studies
- Powerful, user-friendly & intuitive computer model
- Fine resolution displacement and stress mapping (1-D FEA)
- Impedance and admittance plots
- Sonar transducer/array analysis option including TR/volt plots

Next >

Illustrative Example

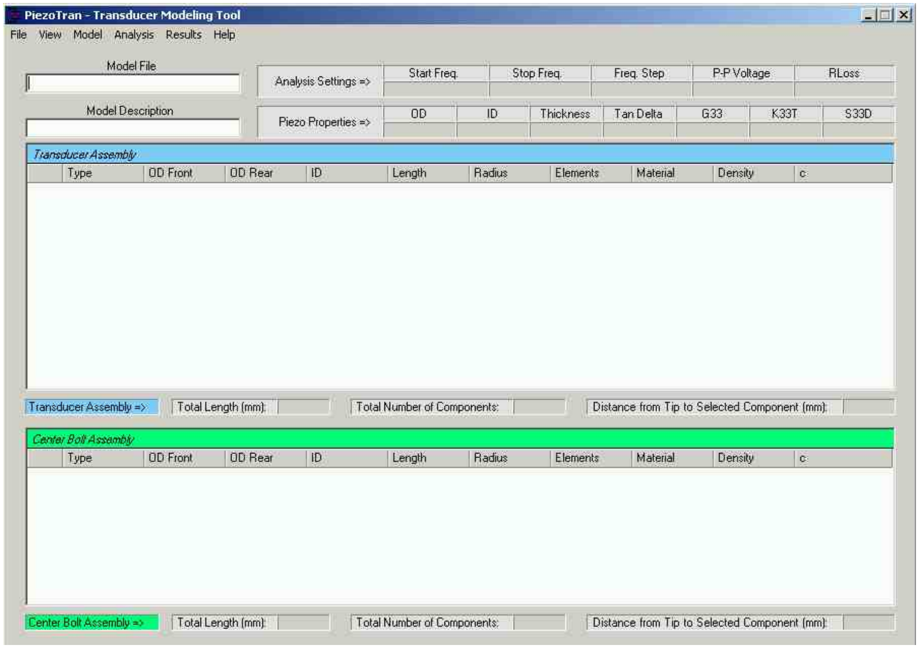
Black & Decker Buzz Ultrasonic Stain Removal



4 Navy Type I piezo rings ϕ15 X ϕ7 X 3 (shown in blue)
Steel center bolt ϕ4 X 17 (shown in red).
Aluminum alloy rear mass
Aluminum alloy front mass/horn

Starting the Program

Double click icon

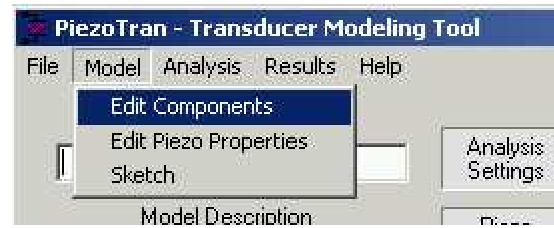


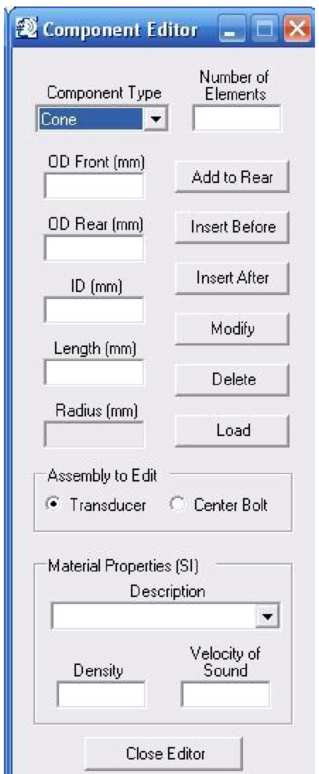
Enter a file name and description of the transducer

Input First Component

From Model menu select Edit Components

Note that it is convenient to leave this window open

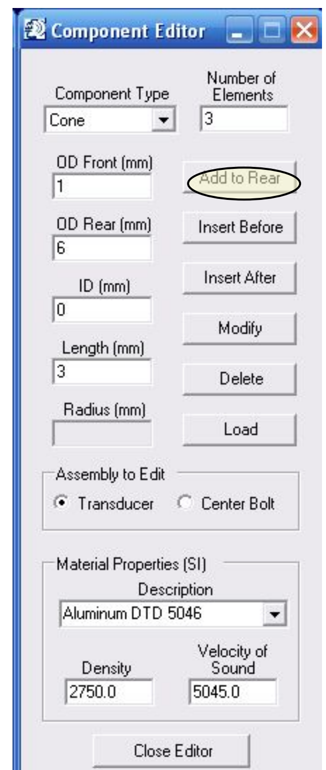




Start with the front radiating cone (Component Type) pre-selected

Pull down Materials Properties menu and select Aluminum DTD 5064

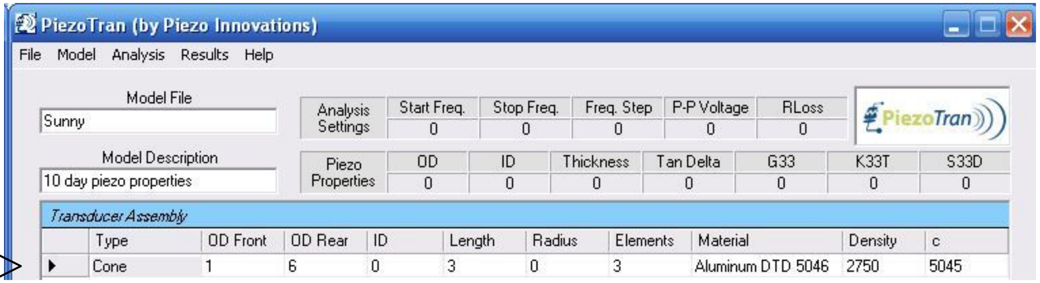
Enter OD Front = 1,
OD Rear = 6
Length = 3,
Number of Elements = 3



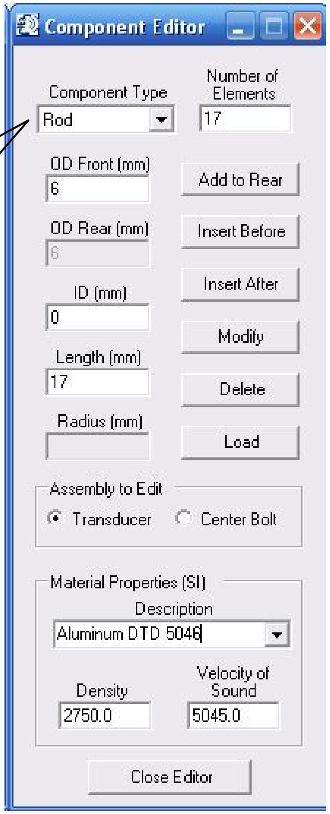
Add this component to the model by adding it to the rear of the previous component (none in this case since this is the first)

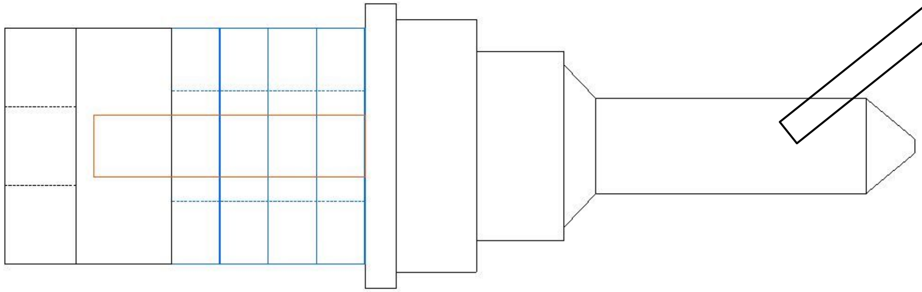
Input 2nd Component

First component is entered in model



Enter next component part by clicking in the editor window

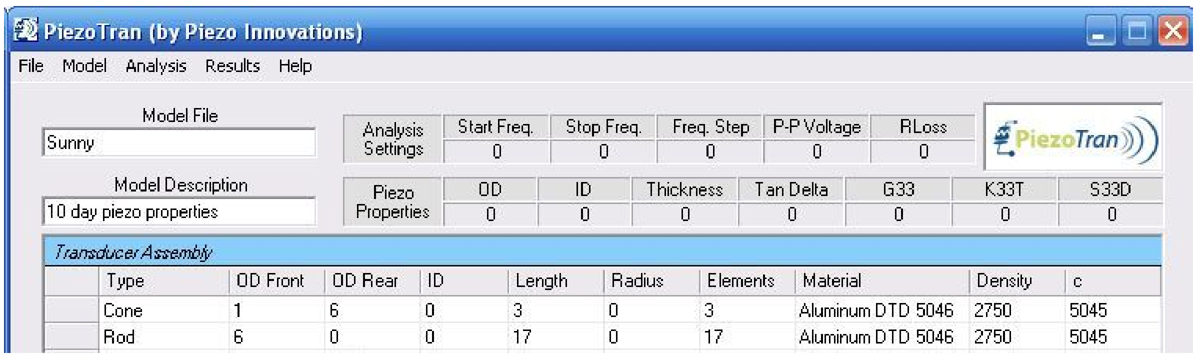




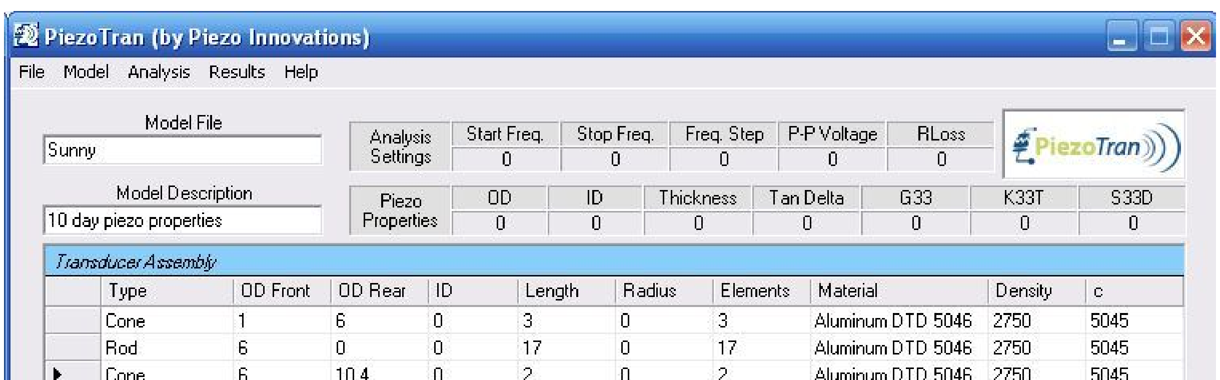
Select rod 17 elements enter dimensions and material as shown

Further Component Input

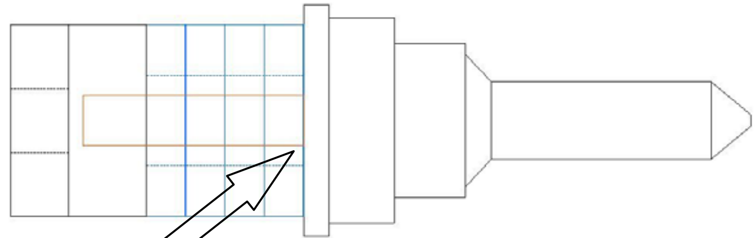
Add rod to rear of the first cone

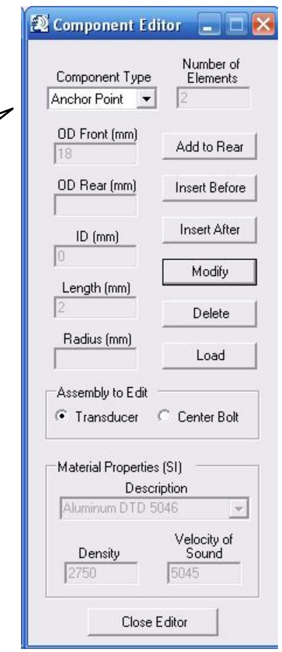


Use editor to enter the next cone and add rod to the rear of the rod



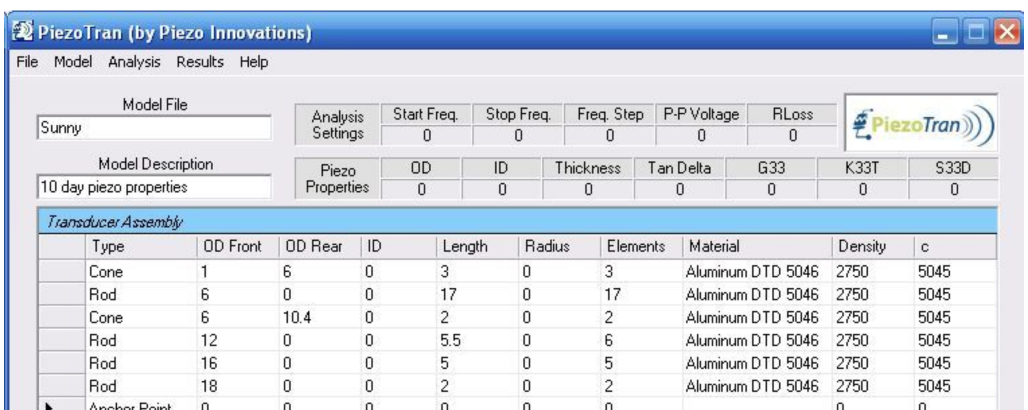
Define Bolt Anchor Point



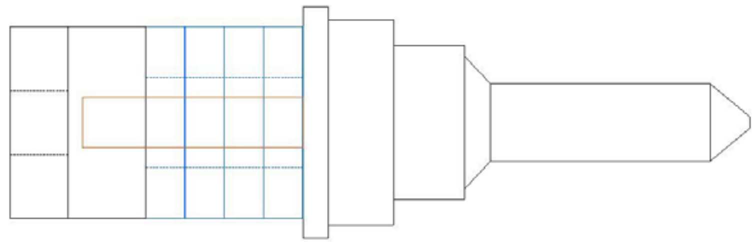


We are now at the junction between the rear face of the front mass and the front of the piezo stack.

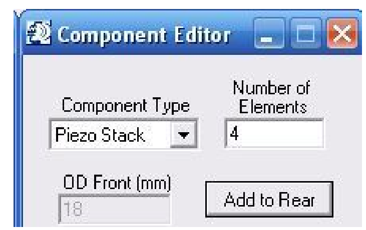
The center bolt (shown in red) is also anchored at this point by using the component editor and adding to rear of the previous rod

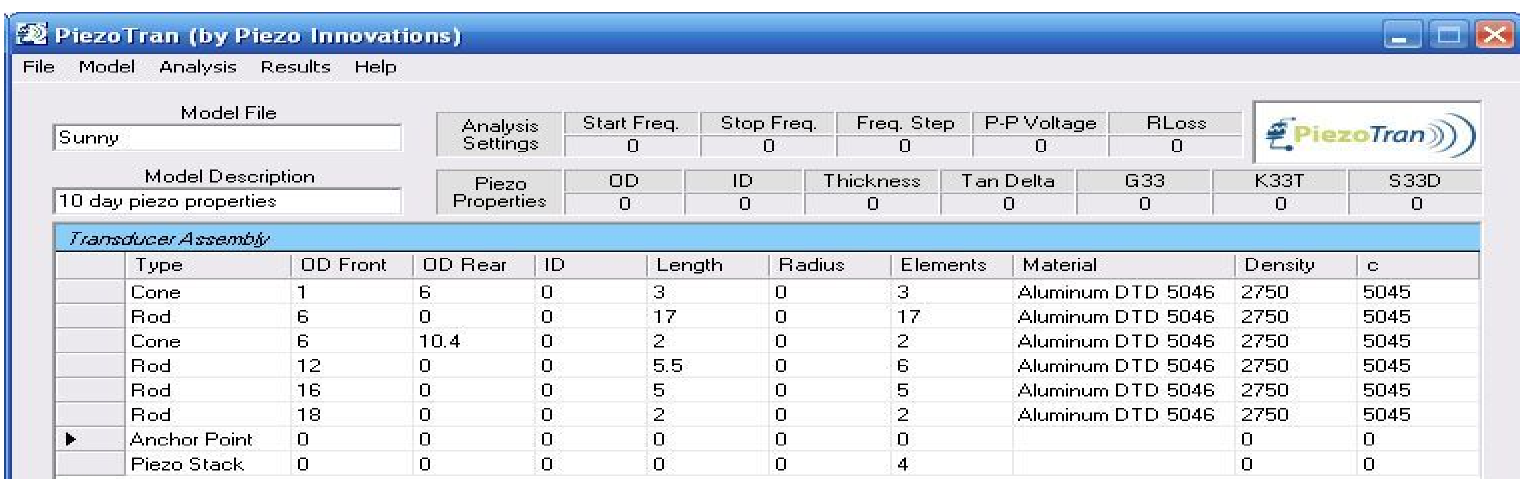


Add Piezo Stack



The 4 ring piezo stack (shown in blue) comprises the piezo elements and a beryllium copper shim electrode sandwiched between them. The complete stack including piezo, shim electrodes and joints, is treated as a single component . In the component editor, select Piezo Stack and note that the number of elements is the number of piezo rings that make up the stack.

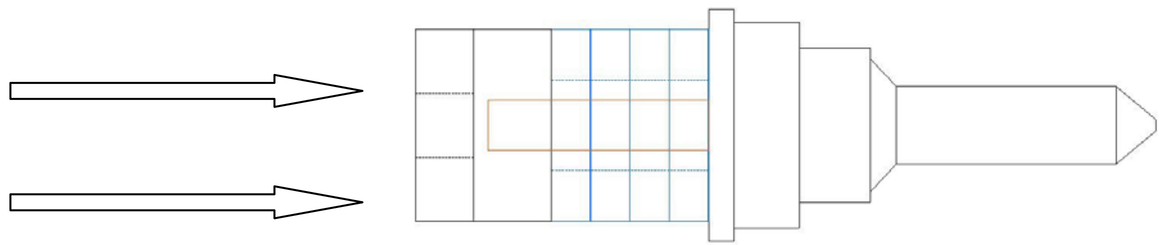


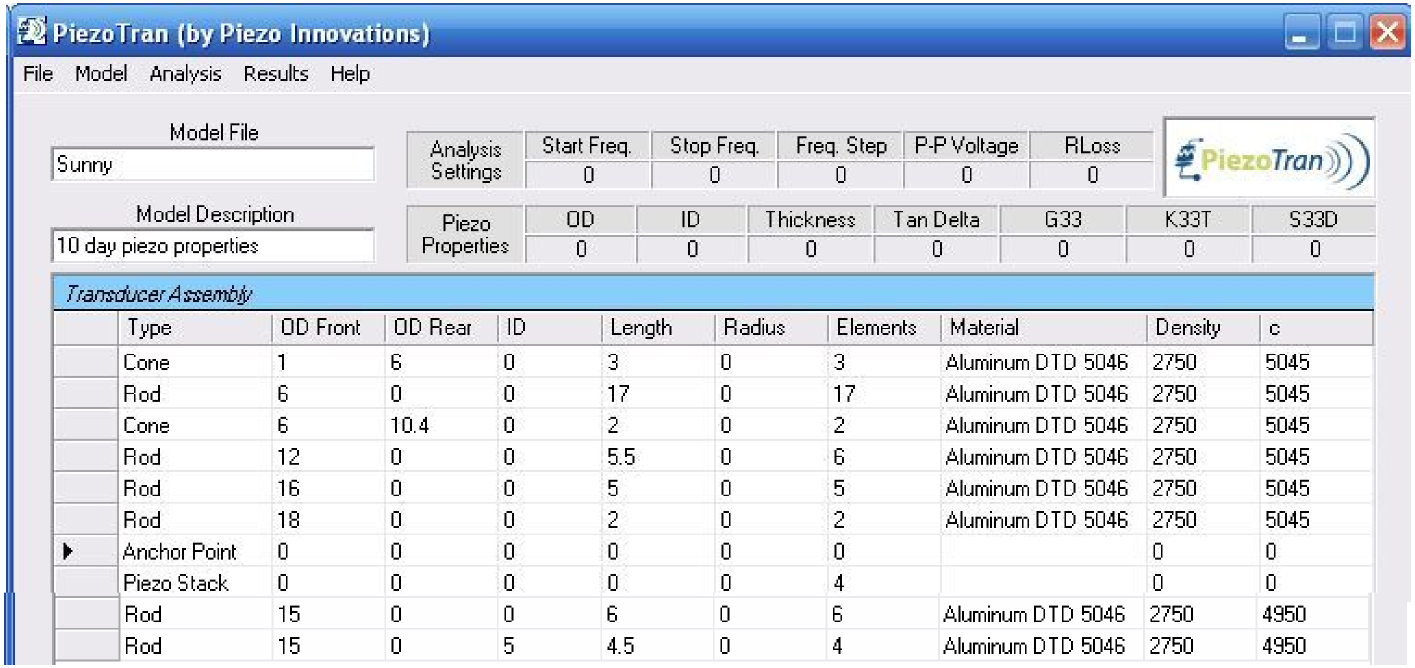


Type	OD Front	OD Rear	ID	Length	Radius	Elements	Material	Density	c
Cone	1	6	0	3	0	3	Aluminum DTD 5046	2750	5045
Rod	6	0	0	17	0	17	Aluminum DTD 5046	2750	5045
Cone	6	10.4	0	2	0	2	Aluminum DTD 5046	2750	5045
Rod	12	0	0	5.5	0	6	Aluminum DTD 5046	2750	5045
Rod	16	0	0	5	0	5	Aluminum DTD 5046	2750	5045
Rod	18	0	0	2	0	2	Aluminum DTD 5046	2750	5045
Anchor Point	0	0	0	0	0	0		0	0
Piezo Stack	0	0	0	0	0	4		0	0

Add Rear Mass

The remaining components are assembled in the same way.





PiezoTran (by Piezo Innovations)

File Model Analysis Results Help

Model File: Sunny

Model Description: 10 day piezo properties

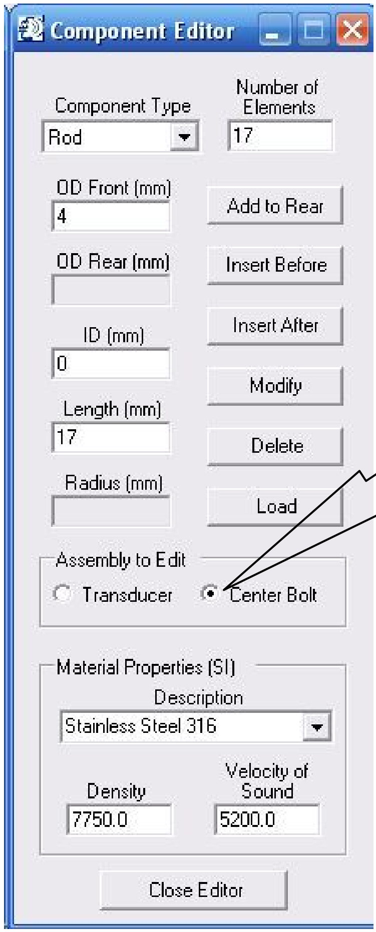
Analysis Settings	Start Freq.	Stop Freq.	Freq. Step	P-P Voltage	RLoss
	0	0	0	0	0

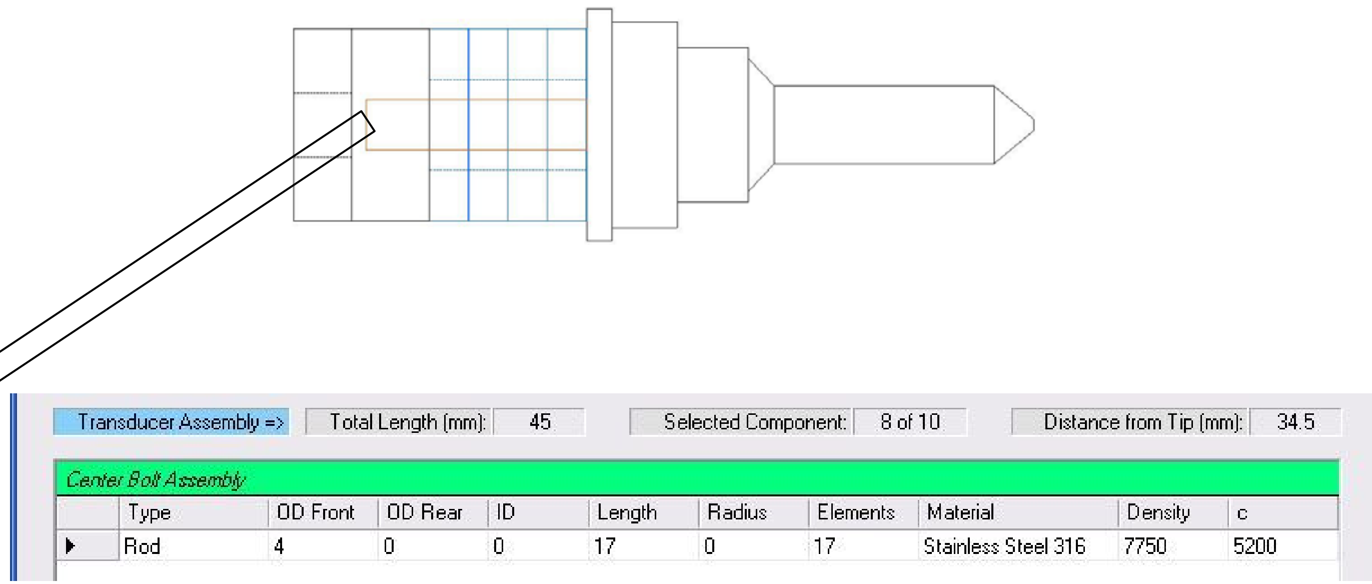
Piezo Properties	OD	ID	Thickness	Tan Delta	G33	K33T	S33D
	0	0	0	0	0	0	0

Transducer Assembly

	Type	OD Front	OD Rear	ID	Length	Radius	Elements	Material	Density	c
	Cone	1	6	0	3	0	3	Aluminum DTD 5046	2750	5045
	Rod	6	0	0	17	0	17	Aluminum DTD 5046	2750	5045
	Cone	6	10.4	0	2	0	2	Aluminum DTD 5046	2750	5045
	Rod	12	0	0	5.5	0	6	Aluminum DTD 5046	2750	5045
	Rod	16	0	0	5	0	5	Aluminum DTD 5046	2750	5045
	Rod	18	0	0	2	0	2	Aluminum DTD 5046	2750	5045
▶	Anchor Point	0	0	0	0	0	0		0	0
	Piezo Stack	0	0	0	0	0	4		0	0
	Rod	15	0	0	6	0	6	Aluminum DTD 5046	2750	4950
	Rod	15	0	5	4.5	0	4	Aluminum DTD 5046	2750	4950

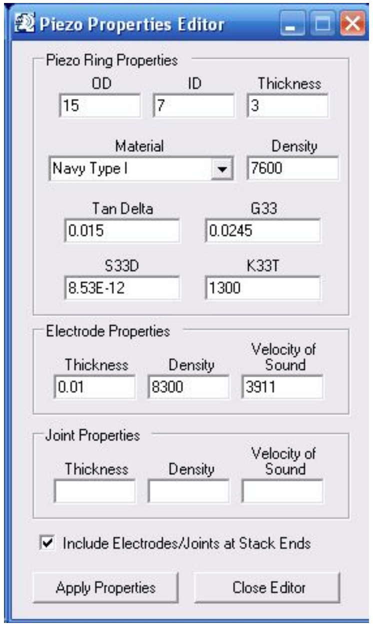
Define Center Bolt



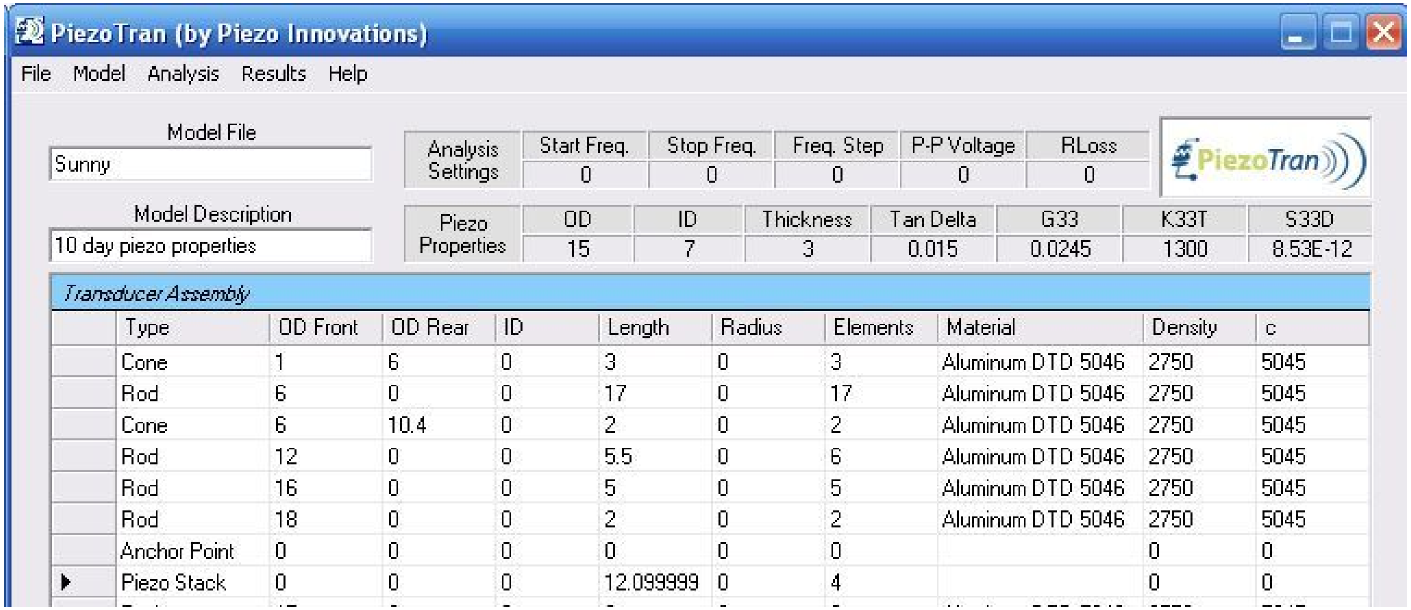


In this simplified model the bolt shank is a rod (shown in red). In a practical design conical elements would be used to model the exposed thread in the region of the anchor point in order to determine cyclic stress concentration.

Enter Piezo Properties



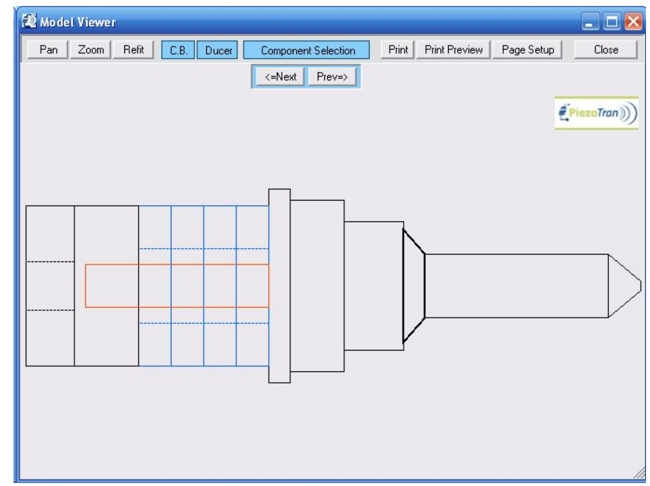
From the Model pull down menu select Edit Piezo Properties. From pull down material menu select Navy Type I. Enter piezo ring dimensions. Enter beryllium copper shim electrode properties. Initially ignore the effects of joints. After data input has been completed, select Apply Properties button and close the editor. Note that the total length of the stack components and the number of piezo rings now appear in the transducer assembly model.

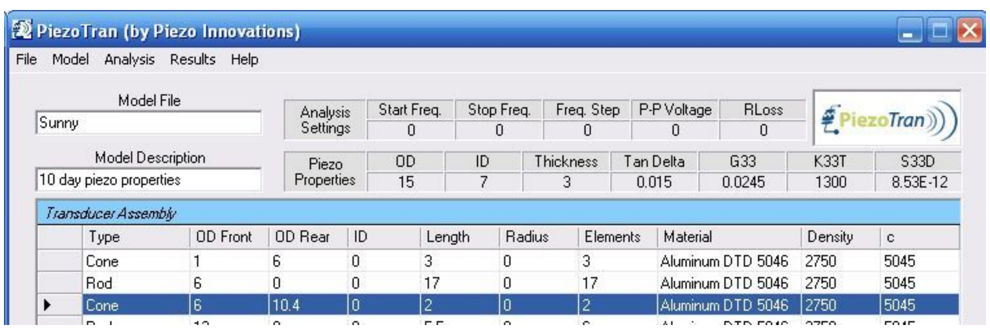


Sketch Viewer

From the Model pull down menu select Sketch.

Individual components can be identified by selecting them in the assembly script and then selecting the component highlight option in the viewer window or scrolling using Next/Prev buttons.



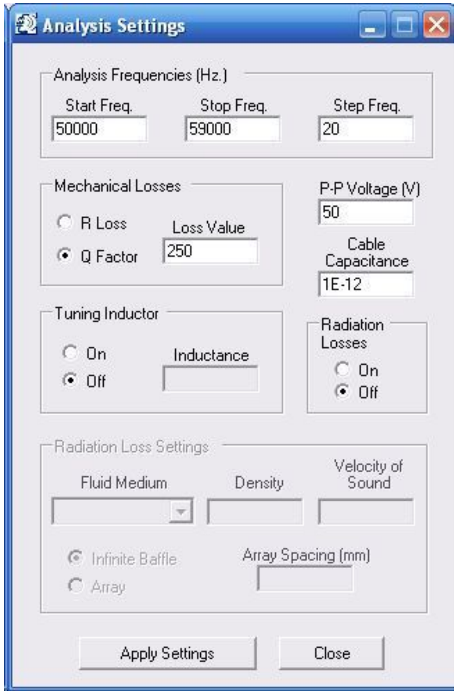


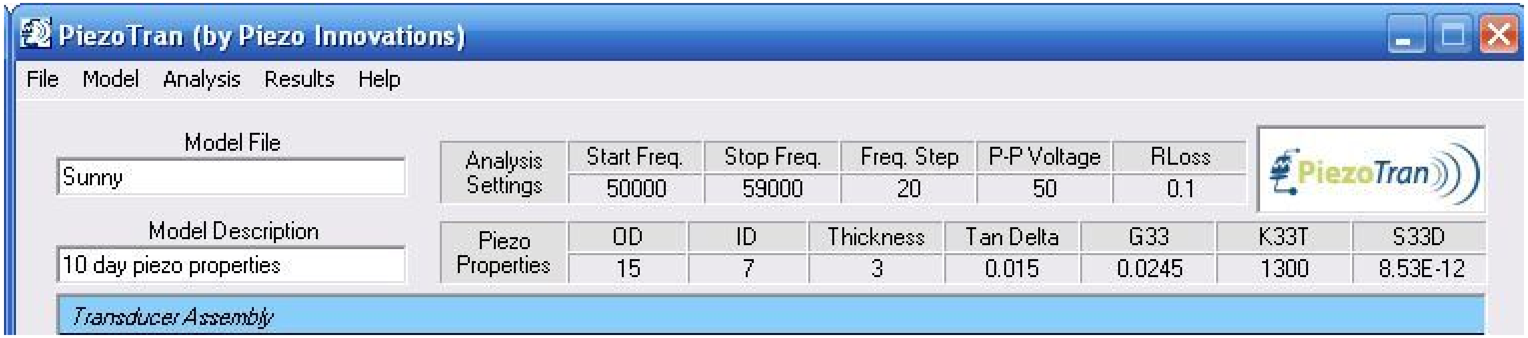
The sketch viewer is a very useful tool to check for possible errors in the text data input. It should be used prior to the analysis of the model. For convenience and clarity the transducer and center bolt can be viewed separately.

Enter Analysis Set-up

From the Analysis pull down menu select Analysis Settings. In the Earwicker model the accumulated mechanical losses (R Loss) are calculated from the mechanical acoustic efficiency by including a resistive network that is added to the radiation impedance. For the ultrasonic cleaning application the R Loss can be calculated by PiezoTran by inputting the measured value of the low power Q factor in air. Alternatively an estimated Q factor can be used (250). Since the high power radiation impedance associated with cavitation is not able to be calculated, an empirical measured Q factor should be used. Thus, for the cavitation load the Q might drop from the ‘in-air” value of 250 to 150. It would be normal practice to initially set a wide frequency sweep and large step frequency and then zoom in on the resonant mode of interest.

It is recommended that you save the data file before analyzing the model. Select the Apply Settings button followed by the Close button. From the File pull down menu select Save.





Analyzing the Model

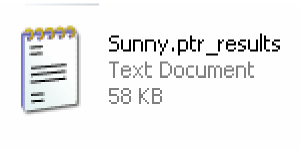
The model can be run immediately after entering all the data by selecting Analyze Model from the Analysis menu.

To start and run the model with a previously saved data file

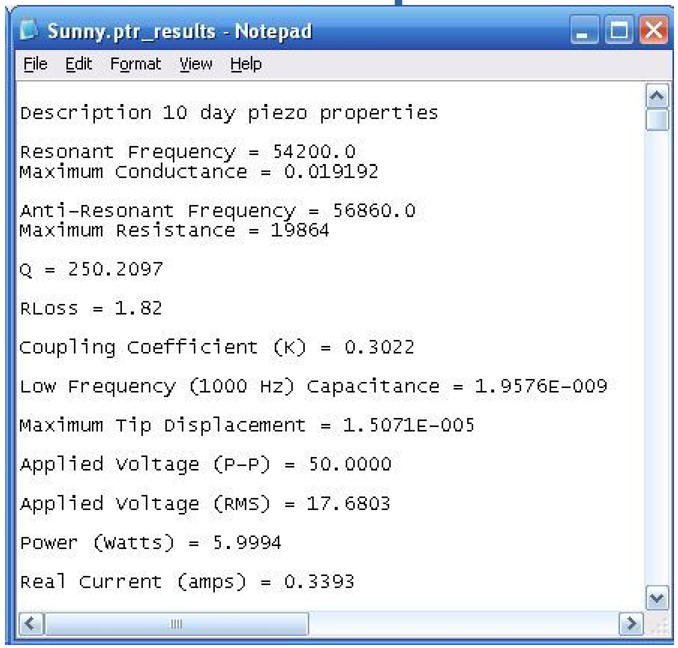
Double click icon

The input data file can also be viewed and printed in text format by adding a text extension to the file name

After analyzing the model a text results output file will be created.



Output Text File


Sunny.ptr_results - Notepad

File Edit Format View Help

Description 10 day piezo properties

Resonant Frequency = 54200.0
Maximum Conductance = 0.019192

Anti-Resonant Frequency = 56860.0
Maximum Resistance = 19864

Q = 250.2097

RLoss = 1.82

Coupling Coefficient (K) = 0.3022

Low Frequency (1000 Hz) Capacitance = 1.9576E-009

Maximum Tip Displacement = 1.5071E-005

Applied Voltage (P-P) = 50.0000

Applied Voltage (RMS) = 17.6803

Power (Watts) = 5.9994

Real Current (amps) = 0.3393

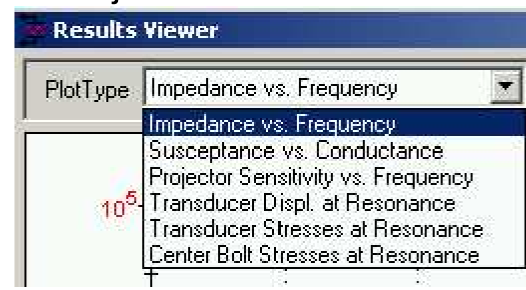
The text output file also contains tabulated data that is automatically plotted within PiezoTran. The maximum conductance is the reciprocal of the real part of the load resistance. Thus, for high Q transducers, the minimum impedance at resonance is approximately $1/G_{max}$

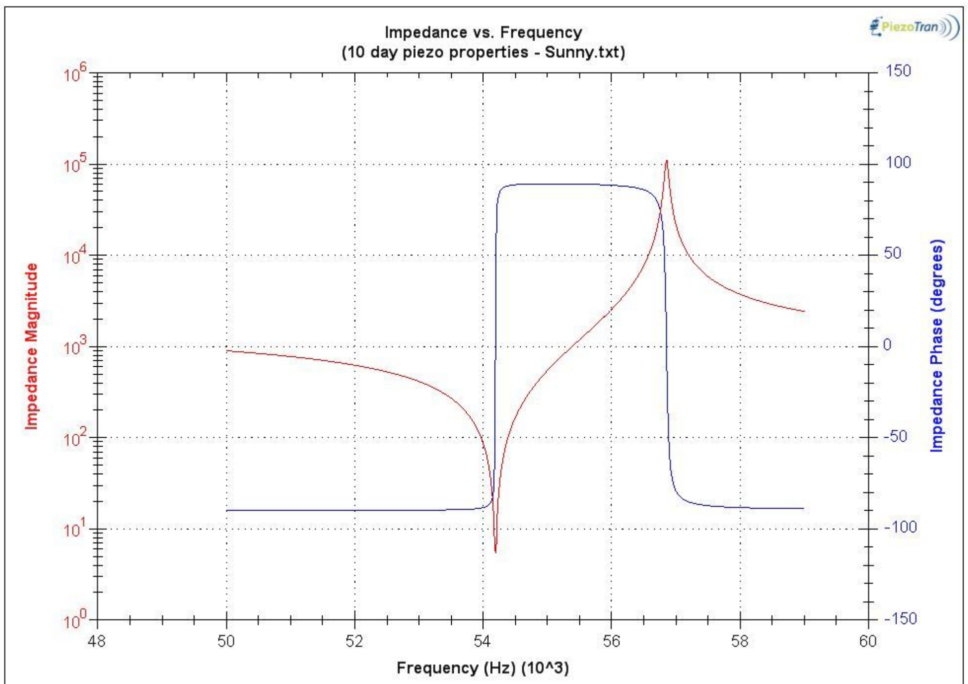
Adding a cable increases the low frequency capacitance and decreases the effective coupling coefficient.

The model assumes that constant voltage is applied and that the resonance frequency corresponds with the maximum conductance frequency. Power and current are calculated at the resonance frequency.

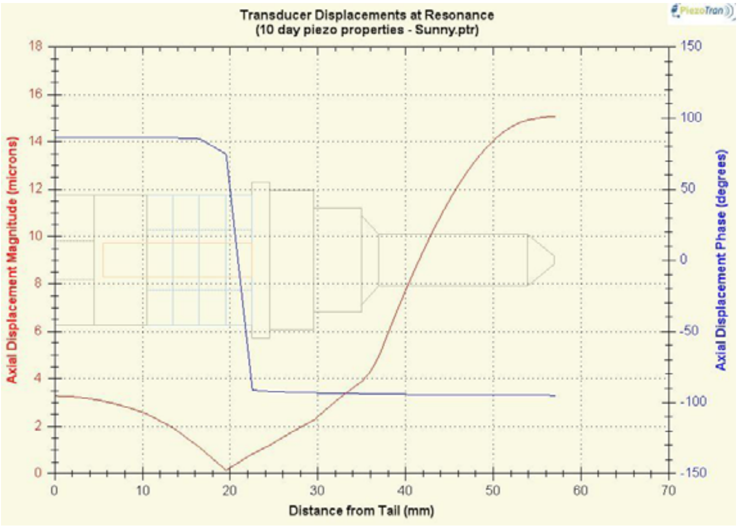
Graphical Output

Graphical output data can be viewed and printed by selecting Plots in the Results Menu. Plot options can be viewed and selected from a pull down menu in the Results Viewer. Plots of Susceptance vs. Conductance and Projector Sensitivity are applicable to sonar transducer analysis.





Output – Displacements & Stress Maps



Select Model to overlay the sketch of the transducer