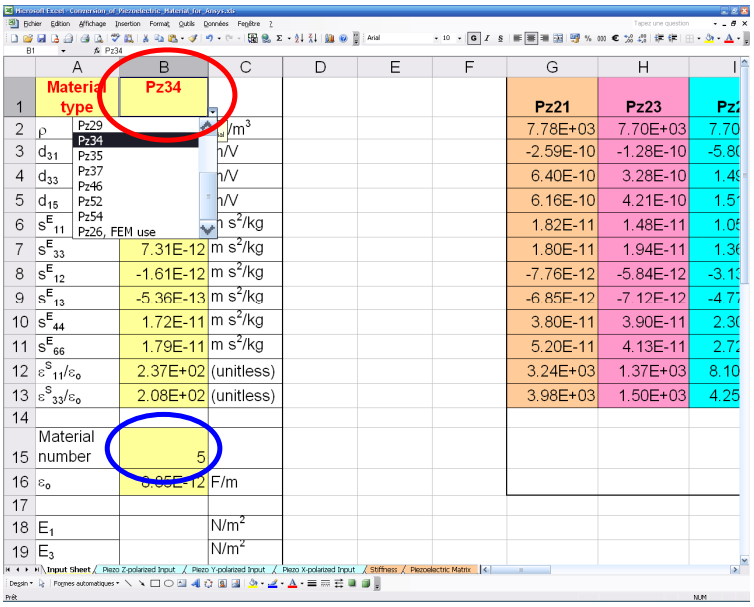
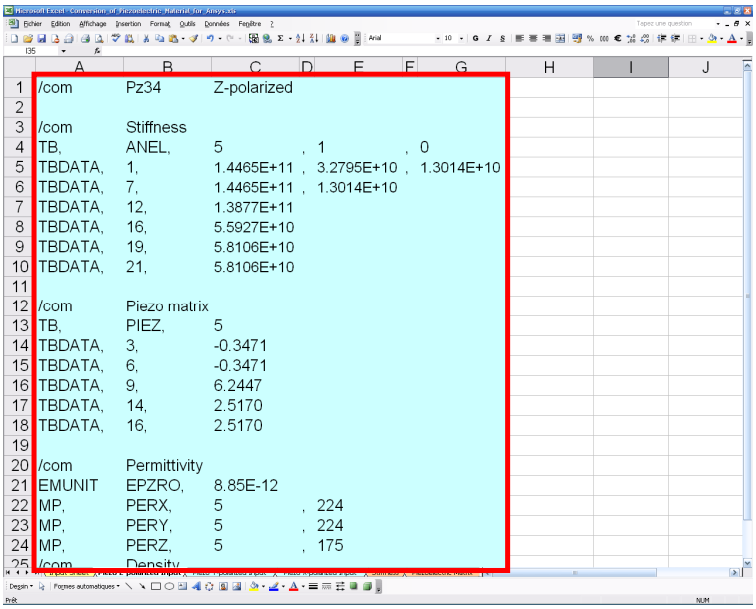
Tutorial Excel program for ANSYS piezoelectric simulation

(Extended program from S. Imaoka, Engineering consultant)
http://ansys.net/tips/Week13_TNT_Conversion_of_Piezoelectric_Material_Data.pdf

On the Input Sheet page, select the kind of ceramic by the rolling menu “material type” (red circle). Inform the material number of piezo element (blue circle). It is the only thing you need to do!

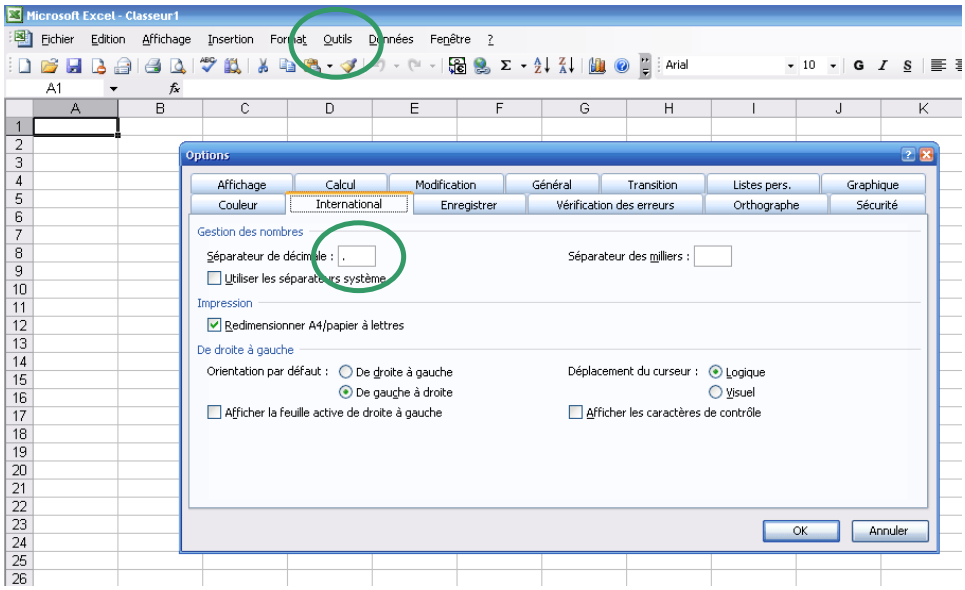


The list of ceramic materials can be extended by fulfil the parameters in the next columns (column U to DD). The 3 next pages give the ANSYS program according to the polarized axis (X, Y or Z). Just copy the blue field and directly waste it in your ANSYS File.



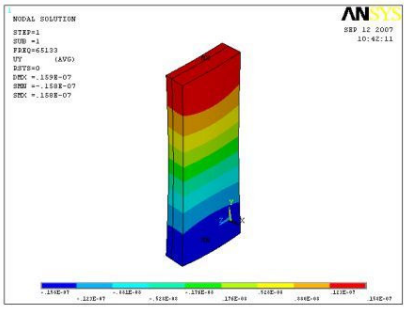
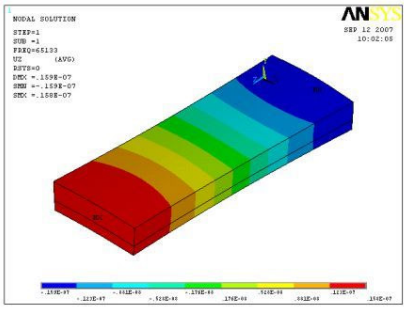
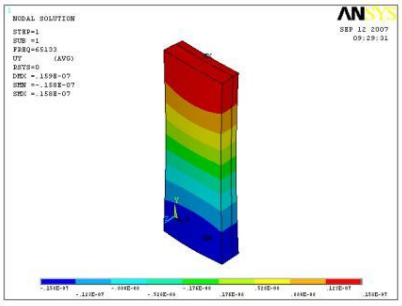
Other pages are the matrix shape fulfilled by the selected parameters (stiffness, piezoelectric, permittivity).

ⓘ Advertising: for French users, you must change the options of Excel software to have a point as decimal separation, in order to waste directly the lines code into the ansys file.
In the menu : *« Outils/Options/International/Séparateur de décimale »,* select point.



Validation

The validation of matrix transformation has been performed with a bimorph bender in elongation mode.

X polarized	Y polarized	Z polarized
		
Results Static analysis Capacitance=2.715nF Modal analysis resonance freq=65.13kHz anti-res freq.=64.416kHz kinetic energy=0.3634e-4J maximal displacement=0.391um electrical charge=-0.6839e-7C	**Results** Static analysis Capacitance=2.715nF Modal analysis resonance freq=65.13kHz anti-res freq.=64.415kHz kinetic energy=0.3693e-4J maximal displacement=0.395um electrical charge=-0.6907e-7C	**Results** Static analysis Capacitance=2.715nF Modal analysis resonance freq=65.13kHz anti-res freq.=64.415kHz kinetic energy=0.3669e-4J maximal displacement=0.393um electrical charge=-0.687e-7C

The relative error between each configuration is negligible and essentially due to the meshing precision.

Following code is about the X polarized configuration:

First file: parameters

```
!*****************************************************
!  geometrical parameters of piezo bender          *
!       (Francois Pigache 2007)                    *
!*****************************************************
/prep7
emunit,mks
!************************************
! isotropic material properties  *
!************************************
density_copper=8900
young_copper=96e9
poisson_copper=0.3
!**************************
! Main dimensions     *
!**************************

th=2e-3                 ! copper thickness
length=25e-3            ! copper length
width=10e-3             ! copper width
th_cer=1e-3             ! ceramic thickness
```

Second file: geometry, element type and meshing

```
!*****************************************************
!  design of the Bender polarized in X direction   *
!       (Francois Pigache 2007)                    *
!*****************************************************
/prep7
csys,0
BTOL,1e-6               !precision
!************************
! design blocks       *
!************************
wpoff,-th_cer,0,0
BLC4, 0,0, th_cer, length, width
wpoff,th_cer,0,0
BLC4, 0,0, th, length, width
vsel,all
vglue,all

!*****************
! element type *
!*****************
et,1,solid98,0          ! element 3D structural
KEYOPT,1,3,1
et,2,solid92
allsel

!*******************************************
! Ceramic properties
!*******************************************
/com     Pz26    X-polarized
/com     Stiffness
TB,      ANEL,   1       ,       1       ,       0
TBDATA, 1,       1.2264E+11      ,       9.9905E+10      , 9.9905E+10
TBDATA, 7,       1.6800E+11      ,       1.1035E+11
TBDATA, 12,      1.6800E+11
TBDATA, 16,      3.0126E+10
TBDATA, 19,      2.8825E+10
TBDATA, 21,      3.0126E+10

/com     Piezo matrix
TB,      PIEZ    1
TBDATA, 1,       14.6913
TBDATA, 4,       -2.8012
TBDATA, 7,       -2.8012
TBDATA, 11,      9.8568
TBDATA, 18,      9.8568

/com     Permittivity
EMUNIT, EPZRO,   8.85E-12
MP,      PERX,   1       ,       701
MP,      PERY,   1       ,       829
MP,      PERZ,   1       ,       829
/com     Density
MP,      DENS,   1       ,       7700

!*******************************************
! isotropic material properties
!*******************************************
mp,dens,2,density_copper
mp,ex,2,young_copper
mp,nuxy,2,poisson_copper

!*******************************************
! Material affiliation
!*******************************************
VSEL,all
VSEL,s,loc,x,-th_cer,0          !ceramic selection
VATT,1,,1               ! material 1 attribution

VSEL,all
VSEL,s,loc,x,0,th               !copper selection
VATT,2,,1               ! material 2 attribution

!*******************************************
!                       MESHING
!*******************************************
allsel
esize,th_cer,
vmesh,all
```

```
allsel

finish
```

Third file: static analysis

```
!*****************************************************************
Calculation of Capacitance
!*****************************************************************

/PREP7
NSEL,S,LOC,x,0
cp,1,volt,all                                   ! component n°1 ground
*get,n_ground,node,0,num,min

allsel

NSEL,S,LOC,x,-th_cer
cp,3,volt,all                                   ! component n°2 top
electrode
*get,n_supply,node,0,num,min
allsel

!*****************************
!            Loads on electrodes
!*****************************

d,n_ground,volt,0            ! Apply 0 voltage to the ground electrode
d,n_supply,volt,1          ! Apply unit voltage to top electrode
allsel,all

fini

/solu
antype,static              ! Static analysis
solve
*get,Cp,node,n_supply,rf,amps   ! use AMPS label with SOLID5
Cp = abs(Cp)               ! C = Q/V, where V = 1 Volt

FINISH

!*****************************************************************
!                                        Results
!*****************************************************************

/com, ------------------------------------------------------------------
/com,       Equivalent parameter of the piezoelement
/com,
/com,  Static primary capacitance  Cp = %Cp% F

/PREP7
*ddele,all,volt                    !delete loads
allsel,all
FINISH
```

Fourth file: modal analysis (short-circuited ceramic)

```
!*****************************************************************
! modal analysis with short-circuited ceramic
!*****************************************************************

/PREP7
NSEL,S,LOC,x,0
cp,1,volt,all                                   ! component n°1 ground
*get,n_ground,node,0,num,min

allsel
NSEL,S,LOC,x,-th_cer
cp,3,volt,all                                   ! component n°2 top
electrode
*get,n_supply,node,0,num,min

allsel

!*****************************************
!            Parameters of simulation
!*****************************************

freqstart=60000
freqstop=80000
nbremode=5

!*****************************************
!            Loads on electrodes
!*****************************************

allsel,all

d,n_ground,volt,0          ! Apply 0 voltage to the ground electrode
d,n_supply,volt,0          ! Apply 0 voltage to top electrode
ALLSEL
FINISH

/SOLU

ANTYPE,2
MSAVE,0
!*
MODOPT,LANB,nbremode
EQSLV,SPAR
MXPAND,nbremode, , ,1
LUMPM,0
PSTRES,0
!*
MODOPT,LANB,nbremode,freqstart,freqstop, ,ON

solve
finish

/POST1
SET,LIST

FINISH
```