



EStat

Finite-element Electrostatics

Field Precision

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PO Box 13595

Albuquerque, New Mexico 87192 U.S.A.

Telephone: 505-220-3975

FAX: 505-294-0222

E Mail: techinfo@fieldp.com

Internet: <http://www.fieldp.com>

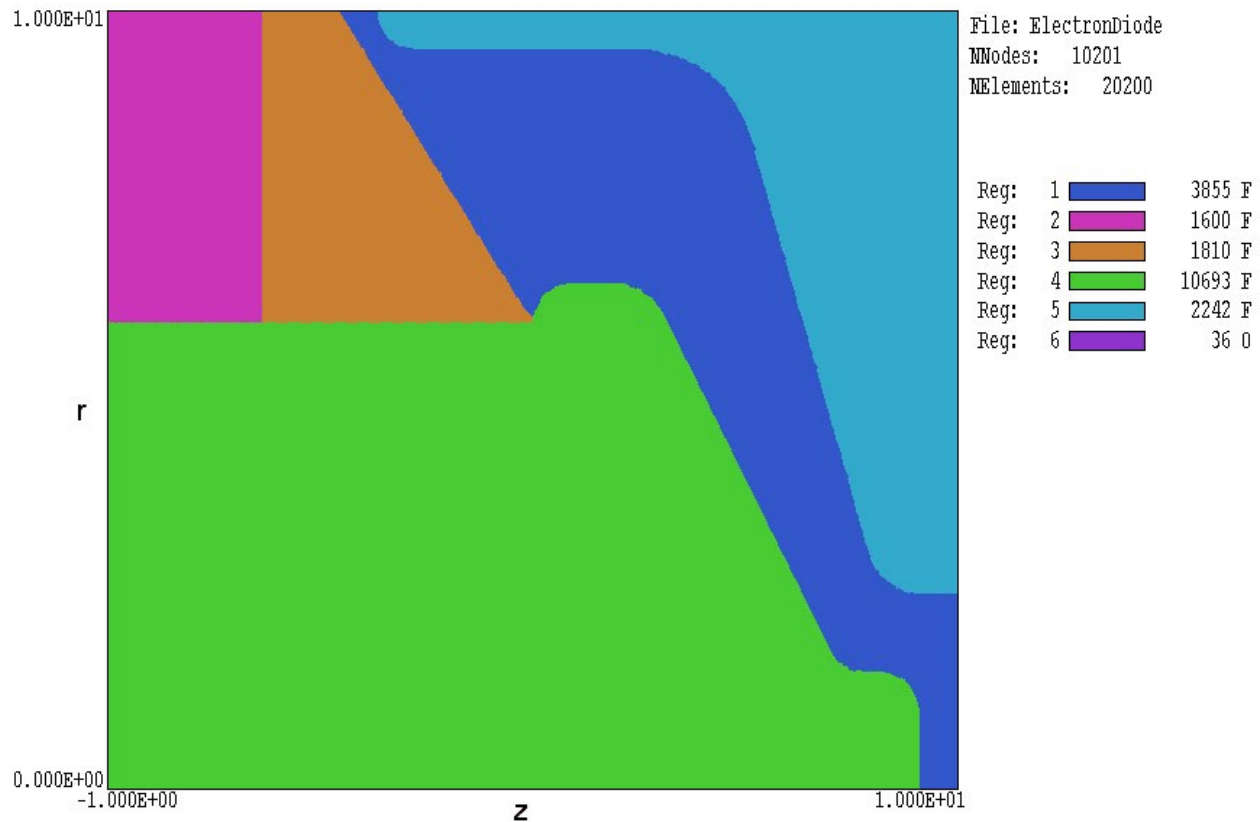


Figure 2. Geometry of the electron diode example. Region 1: Vacuum. Region 2: deionized water, Region 3: epoxy insulator. Region 4: high-voltage center-conductor. Region 5: shaped portion of vacuum chamber wall. Region 6 (not shown): other sections of upper and right-hand grounded boundaries.

Walkthrough example

We shall consider the *ElectronDiode* example from Section 5.2 of the **Mesh** manual to illustrate a complete electrostatic solution. Figure 2 shows the geometry of the cylindrical system with dimensions in inches. A voltage pulse from a coaxial water-filled transmission line is transferred through a vacuum insulator to an intense electron-beam load. The 100 ns voltage pulse is long enough to ensure that the electrostatic solution provides a good approximation but short enough so that the effects of conductivity in the water can be ignored. Three files (supplied in the example library) are required for the solution:

- `ElectronDiode.MIN` – the input file for **Mesh** that describes the geometry of system. The **Mesh** manual describes the file format and the use of the Drawing Editor to prepare the geometric specifications.
- `ElectronDiode.EIN` – the command script to control **EStat**.

- `ElectronDiode.SCR` – a script to control an automatic **VEStat** analysis session to find capacitance of the output region and the electric field distribution on the anode plate.

To begin, copy the three files to a working directory. If you are using **TC**, the working directory should correspond to the *Data folder* (i.e., `\Tricomp\Buffer`). Run **Mesh** then process and save the mesh following the instructions in the **Mesh** manual. The program creates the files `ElectronDiode.MLS` and `ElectronDiode.MOU`. The first file is a listing of run information that you can usually ignore if there are no problems. The second file describes the mesh – it is a listing of node coordinates and region numbers associated with nodes and elements. Like all **TriComp** files, `ElectronDiode.MOU` is in ASCII format so you can inspect it with a text editor or transfer the information to your own programs.

Next, run **EStat** from **TC**. We shall inspect the command script before starting the solution. In the *File* menu pick *Edit input files*. In the dialog, pick `ElectronDiode.EIN` and click *OK*.. (If the file does not appear in the list, check that you have copied it correctly to the *Data folder* listed in **TC**.) The file has the following content:

```
* File ElectronDiode.EIN
Set DUnit 39.37
Set Geometry Cylin
Region 1 Epsi 1.0
Region 2 Epsi 81.0
Region 3 Epsi 2.7
Region 4 Potential -500.0E3
Region 5 Potential 0.0E3
Region 6 Potential 0.0E3
ENDFILE
```

The first command informs the program that the dimensions in `ElectronDiode.MOU` are in inches. The second command specifies that the geometry has cylindrical symmetry. The remaining commands set the properties of the dielectrics and electrodes in Fig. 2. The regions have the following associations: 1) high vacuum, 2) de-ionized water, 3) epoxy insulator 4) high-voltage center-conductor and 5) shaped portion of the grounded vacuum chamber wall. Region 6 is an open region (node assignment only) that does not appear in the element plot of Fig. 2. The region consists of the portions of the grounded upper and right-hand boundaries that are not part of Region 5.

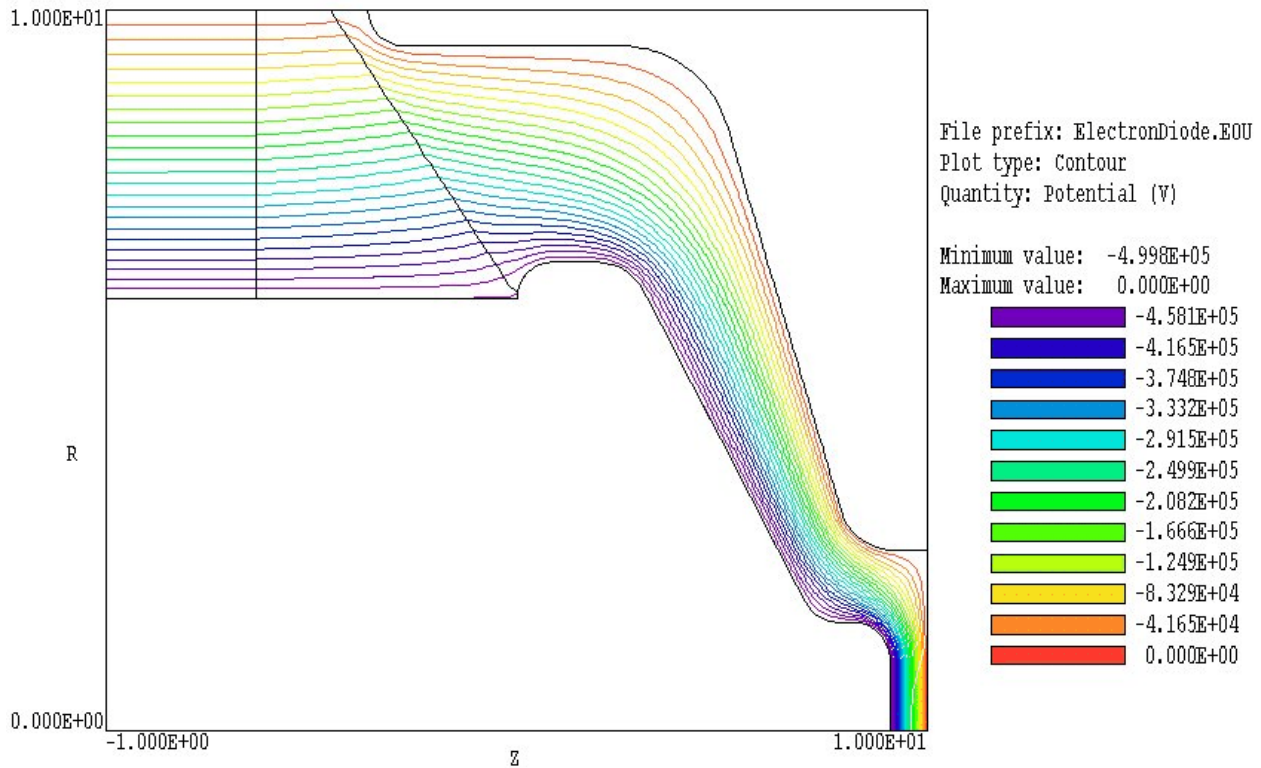


Figure 3. Equipotential contours in the full solution volume - *ElectronDiode* example.

In the *Run* menu, pick *Start run*. In the dialog, choose *ElectronDiode.EIN* and click *OK*. The electrostatic solution starts immediately and takes a second or two to complete. **EStat** creates two new files: *ElectronDiode.ELS* is a listing of run information that is useful if there are problems in the solution. The file *ElectronDiode.EOU* is the main output file that contains full information on the mesh as well as values of the electrostatic potential ϕ at each node. Section 16 describes the file format.

The **VEStat** post-processor uses the information in *ElectronDiode.EOU* to create plots and to perform quantitative analyses. Run **VEStat** from **TC** and pick *Load solution file* in the *File* menu. Choose *ElectronDiode.EOU* in the dialog and click *OK*. The program loads the solution information and creates the default equipotential plot of Figure 3. You can experiment with the program capabilities to create a wide variety of plots. For example, Figure 4 shows variations of electric field amplitude $|\mathbf{E}|$ in the vacuum insulator region.

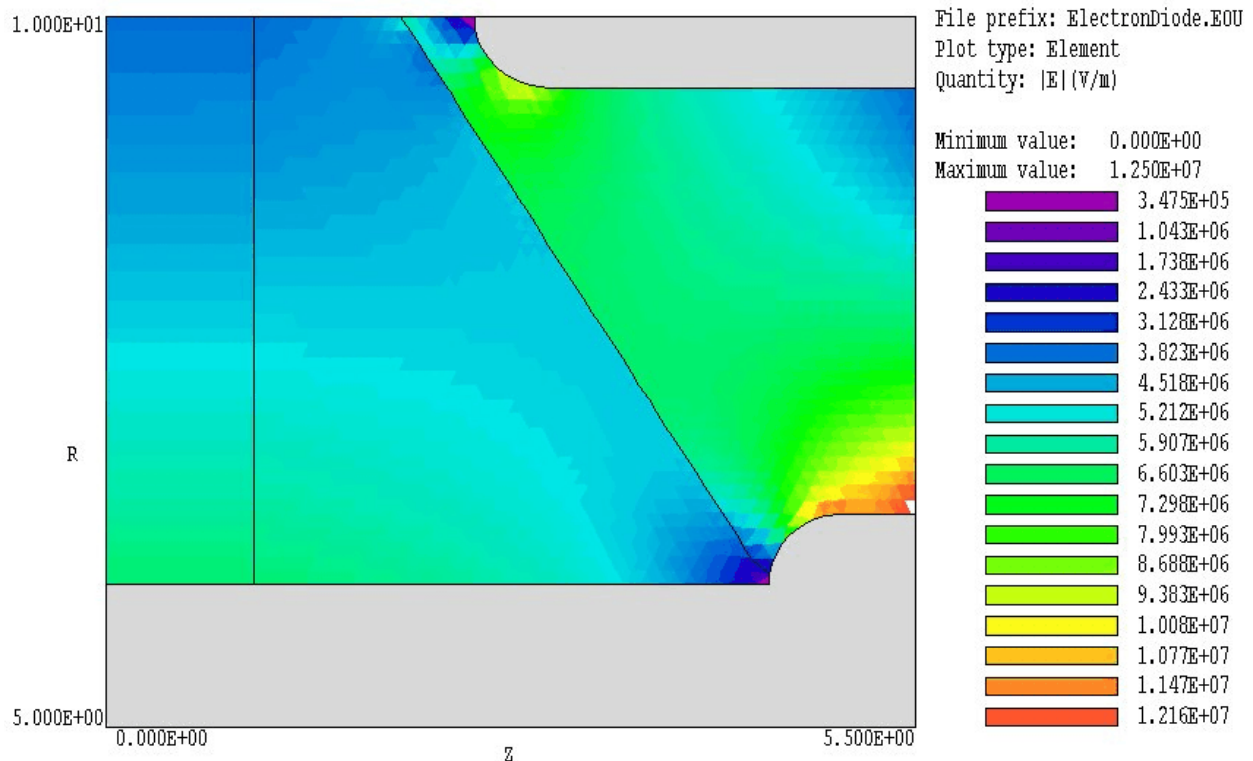


Figure 4. Variation of $|E|$ in the region of the vacuum insulator – *ElectronDiode* example.

To complete the session, we shall run a script that performs automatic calculations. To inspect the file content, click on *Edit script* in the *File* menu and pick the file `ElectronDiode.SRC`. The file has the following content:

```

INPUT ElectronDiode.EOU
OUTPUT ElectronDiode
VOLUMEINT
NSCAN 25
SCAN 9.9999 0.0000 9.9999 2.5000
ENDFILE

```

The first command ensures that the file `ElectronDiode.EOU` is loaded while the second command opens the data listing file `ElectronDiode.DAT`. The *VolumeInt* command initiates automatic volume integrals of electrostatic field energy. The *Scan* command writes a set of 25 data lines listing the potential and electric field components over the anode plane. The following is an excerpt from the listing:

```

--- Volume Integrals ---
Energy: 6.359E+01 J
Power: 7.182E+12 W
Epeak: 4.820E+07 V/m
ZPeak: 9.491E+00
RPeak: 1.242E+00

```

Integrals by region						
NReg	Volume (m3)	Energy (J)	Power (W)	PeakE (V/m)	PeakZ	PeakR
1	1.372E-02	5.545E+00	6.263E+11	4.820E+07	9.491E+00	1.242E+00
2	6.590E-03	5.602E+01	6.327E+12	6.365E+06	-9.381E-01	6.033E+00
3	7.073E-03	2.027E+00	2.289E+11	6.358E+06	1.022E+00	6.067E+00
4	1.583E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5	1.342E-02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

The field energy U_e in Region 1 (the vacuum diode) is 5.545 joules. Using the formula $U_e = CV^2/2$ and taking $V = 5.0 \times 10^5$, the capacitance of the diode region is approximately 44.36 pF.