

I-STEM Software Request - Guide Approval Form

User Details

- Name of Researcher: Anuj Kumar
- User Type: ☐ Ph.D. Scholar ☐ Postdoctoral Researcher ☐ Bachelor's ☒ Masters
- Institution Name : SCNS Jawaharlal Nehru University.
- Institutional Contact No: 8875682396
- Research Topic: Retinal implants

Software Request Details

- Software Name: COM SOL
- Justification for Software Request: [Provide detailed explanation of how the software supports your research objectives]

Guide/Supervisor Approval

I, Dr. Sandeep Kumar (Guide/Supervisor Name),

- Confirm that the above-mentioned researcher is affiliated with our institution
- Have reviewed the software request and its relevance to the researcher's academic work
- Approve the software request for research purposes

Approval Confirmation

- I approve the software request
- The software aligns with the researcher's research objectives
- The request meets the institutional research guidelines

Guide/Supervisor Signature: [Signature]

Date: 28/11/2025

Official Stamp/Seal: [Space for Institutional Stamp]



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Important Notes

- This form must be signed and scanned
- The scanned copy must be uploaded with the software request
- Electronic signatures are acceptable if from an official institutional email

Title:

Design and Simulation of a Novel Electrode Geometry for Improved Electric Field Confinement in Retinal Prostheses

Objective:

To design and optimize a new retinal stimulating electrode with reduced electric field spread and enhanced confinement using COMSOL Multiphysics simulations, improving stimulation precision and visual resolution.

Background and Motivation:

Degenerative retinal diseases such as Retinitis Pigmentosa and Age-related Macular Degeneration lead to loss of photoreceptor function. Retinal prostheses restore partial vision by electrically stimulating the remaining neurons.

Previous simulation studies (*Son et al.*, “*Effects on Retinal Stimulation of the Geometry and the Insertion Location of Penetrating Electrodes*”) demonstrated that 3D penetrating electrodes—particularly the Penetrating Electrode with Insulating Wall (PEIW)—offer improved electric field confinement compared to conventional designs.

However, further enhancement of confinement and reduction of unintended current spread are essential for achieving higher visual resolution and energy efficiency. This proposal aims to explore modified electrode geometries that outperform existing PEIW designs in confinement and directionality of stimulation.

Methodology (Using COMSOL Multiphysics):

1. Model Setup:

- Build a 3D multilayer retinal model (Vitreous Body, NFL, GCL, INL, OPL, ONL, RPE) with realistic conductivity values.
- Recreate baseline electrode geometries: Cylindrical Electrode (CE), Penetrating Electrode (PE), and PEIW for validation.

2. Proposed Design Exploration:

- Modify PEIW design by varying parameters such as **insulating wall thickness, taper angle, and tip curvature**.
- Introduce new variants (e.g., shielded sidewalls, tapered insulating collars) to enhance lateral and vertical field confinement.

3. Simulation Procedure:

- Use **Electric Currents (EC)** physics interface in COMSOL.

- Apply monopolar stimulation (50–200 nA) and compute potential distribution in retinal layers.
- Visualize equipotential contours and quantify field confinement in vertical and lateral directions.

4. Analysis Metrics:

- Evaluate confinement factor (potential drop-off distance $\Delta V/\Delta x$).
- Compare potential decay and activation zones across electrode geometries and insertion depths.

Expected Outcome:

- Identification of an optimized electrode geometry with **superior electric field confinement** compared to the standard PEIW.
- Establishment of design guidelines for **high-resolution, low-power retinal prosthesis electrodes**.
- Generation of validated simulation data for potential experimental follow-up and publication.

Software Modules Required:

- **COMSOL Multiphysics (Core)**
- **AC/DC Module** (for electric currents and electrostatic simulations)
- **Optimization Module** (for parametric geometry tuning and performance analysis)

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