

Lateral Si/Ge/Si PIN Photodiode

A transparent reduced-order model, generic GDS, and reproducible validation package

METHOD ESTIMATE FROM ASSUMED INPUTS. This note is not a measurement, foundry specification, or reproduction of Virod 2017 or Lischke 2021.

Why this device matters

High-speed photodetectors convert modulated telecom-band light into electrical current. Germanium provides useful absorption near 1550 nm while remaining compatible with silicon-photonics integration. Virod et al. demonstrated a lateral double Si/Ge/Si heterojunction with contacts on silicon. Lischke et al. later reported a different biconcave Ge-fin architecture. Their measured values describe separate devices and are not combined into this model.

The silicon-photonics roadmap identifies communications as a mainstream demand and notes that high-speed Ge photodiodes are native to several foundry platforms. It also identifies compact-model and process-design-kit maturity as continuing work.

What the package calculates

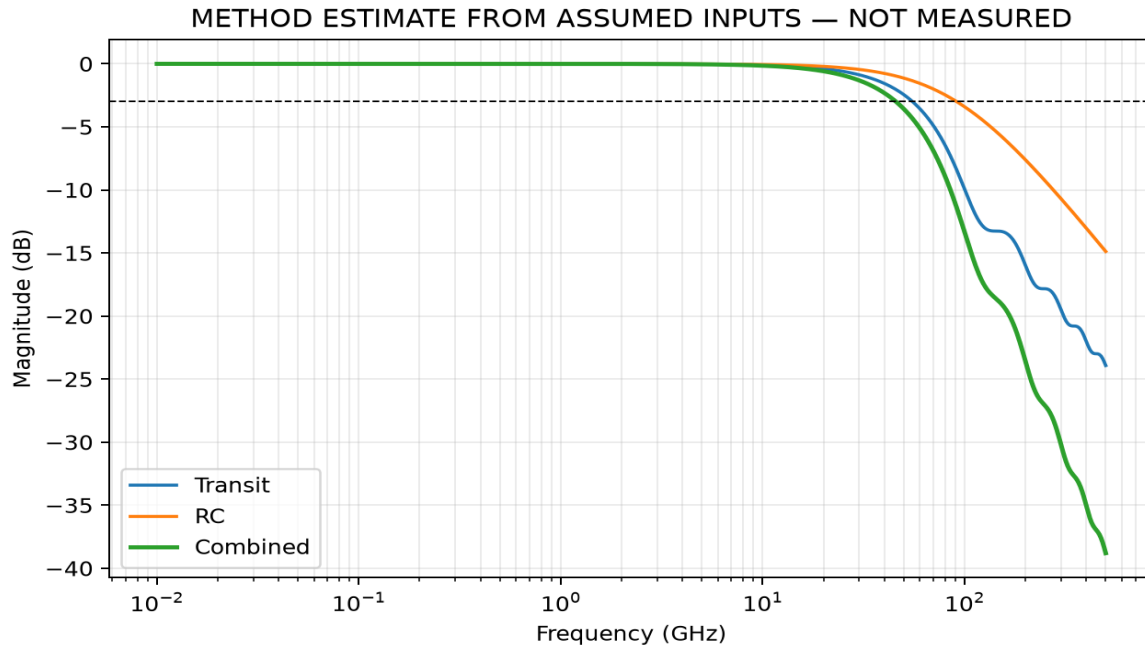
Optical	Beer-Lambert absorption from an explicitly assumed effective modal coefficient; responsivity from absorbed fraction and assumed collection efficiency.
Electrical	Parallel-plate lateral-junction capacitance plus a separate assumed parasitic; current-source RC readout through diode series resistance and instrument load.
Transit	Separate electron and hole responses from one-dimensional Ramo-Shockley integration with exact pair-charge conservation.
Noise	Optional ideal shot and Johnson terms only when a measured or process-calibrated dark current is supplied.

Nominal demonstration

Assumed / calculated quantity	Nominal value
Optical length / carrier transit width	20 μm / 0.6 μm
Assumed parasitic capacitance	15 fF
Absorbed fraction	0.909
Responsivity	1.023 A/W
Parallel-plate capacitance	2.36 fF
Transit / RC / combined 3 dB bandwidth	55.3 / 91.7 / 45.8 GHz

Because operating bias is unspecified, the transit result is a **high-field ceiling**. The calculated 45.8 GHz combined result is unrelated to Virod's measured greater-than-50 GHz value.

Calculated frequency response



The transit response, current-source RC response, and their product are normalized at DC. The banner in the figure keeps the validation level visible when the image is shared separately.

What the GDS represents

The cell `GE_PIN_LATERAL_CARTOON_VIROT_CLASS` is a top-view engineering cartoon with optical guide, rectangular Ge region, separate silicon-side p/n regions, vias, metals, and labels. Its layer numbers are project-local visualization layers. It does not encode a foundry layer map, implant dose, Ge recess or seed, silicide enclosure, GSG pads, or sign-off design rules.

Reproduce the result

Source: github.com/ShahramPhotonics/silicon-photonics-eda-portfolio/tree/7daf781590d1840bdb4bcf36d67abbee44f9eb5e/51-ge-pin-photodiode

```
git clone https://github.com/ShahramPhotonics/silicon-photonics-eda-portfolio.git cd
silicon-photonics-eda-portfolio/51-ge-pin-photodiode python -m venv .venv && source .venv/bin/activate
pip install -r requirements.txt python run_analysis.py --out results pytest -q tests
```

The release passed 15 targeted tests and the portfolio-wide verifier for all 51 projects. Checks cover analytic limits, pair-charge conservation at midpoint and edge birth, frequency roll-off, capacitance scaling, resistance and velocity sensitivity, invalid inputs, metal topology, and KLayout round trip.

Limits and next validation step

This is an educational engineering budget: not TCAD, a full-wave optical calculation, measured silicon, a PDK cell, or a tape-out-ready layout. Replace every assumed input with values from one internally consistent measured device or calibrated solver. Compare predicted responsivity and S-parameter bandwidth against that same device before changing geometry.

Primary sources

Viroi et al., *Optics Express* 25, 19487–19496 (2017), DOI 10.1364/OE.25.019487.
Lischke et al., *Nature Photonics* 15, 925–931 (2021), DOI 10.1038/s41566-021-00893-w.
Shekhar et al., *Nature Communications* 15, 751 (2024), DOI 10.1038/s41467-024-44750-0.