Project 1

Data Analysis of Monte Carlo Simulation of InGAs Semiconductor Device

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EECE 5090 – Linear Systems Analysis
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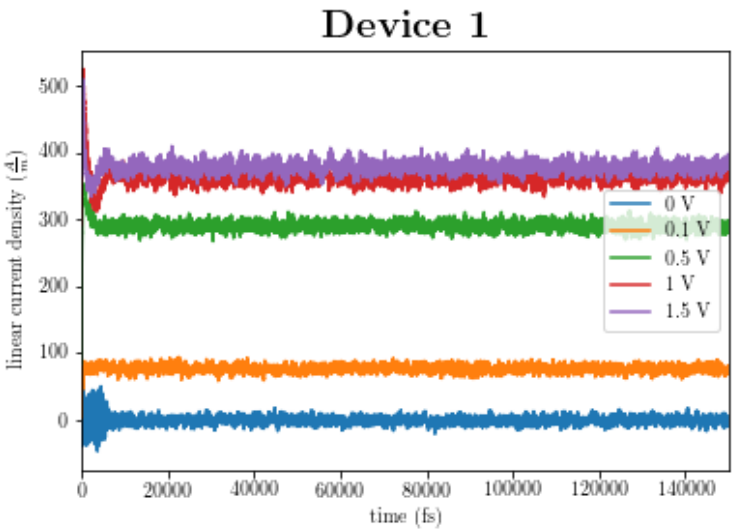
Strategy

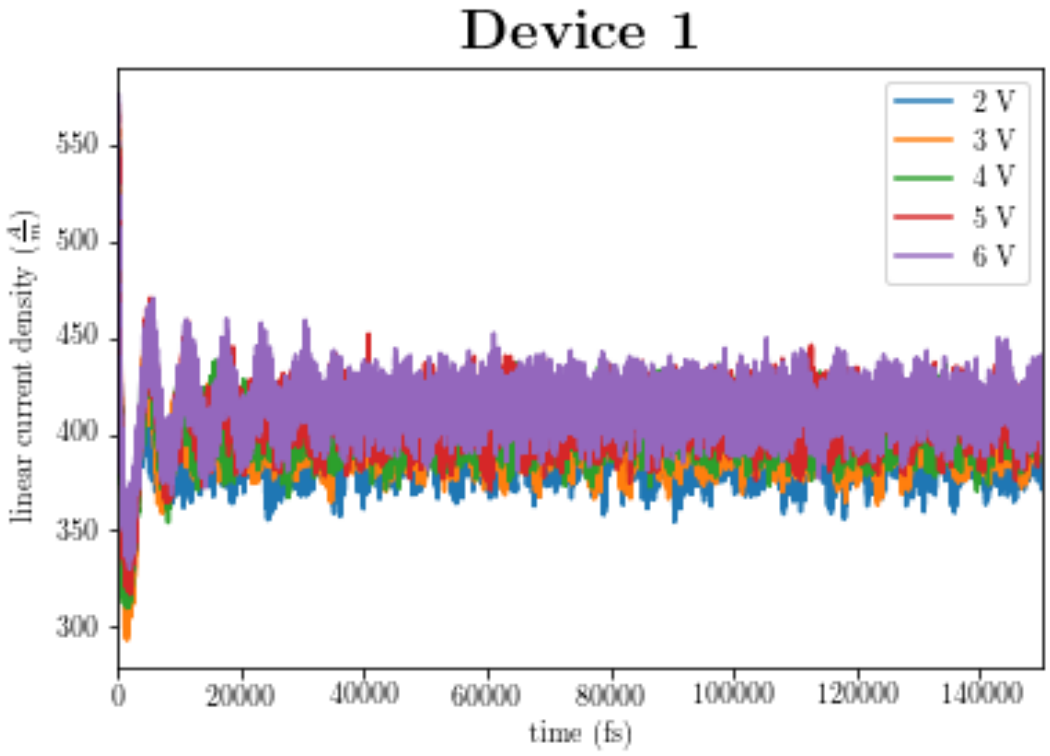
- Visual analysis
- Noise reduction – fourth-order Butterworth filter with $f_{3\text{dB}} = 500$ GHz
- Least squares fit, model function: $I = I_{ss} + Ae^{-t/\tau} cos\,(2\pi ft + \phi)$
- Analyze voltage vs steady-state current (I_{ss})

Device 1 – Visual Analysis

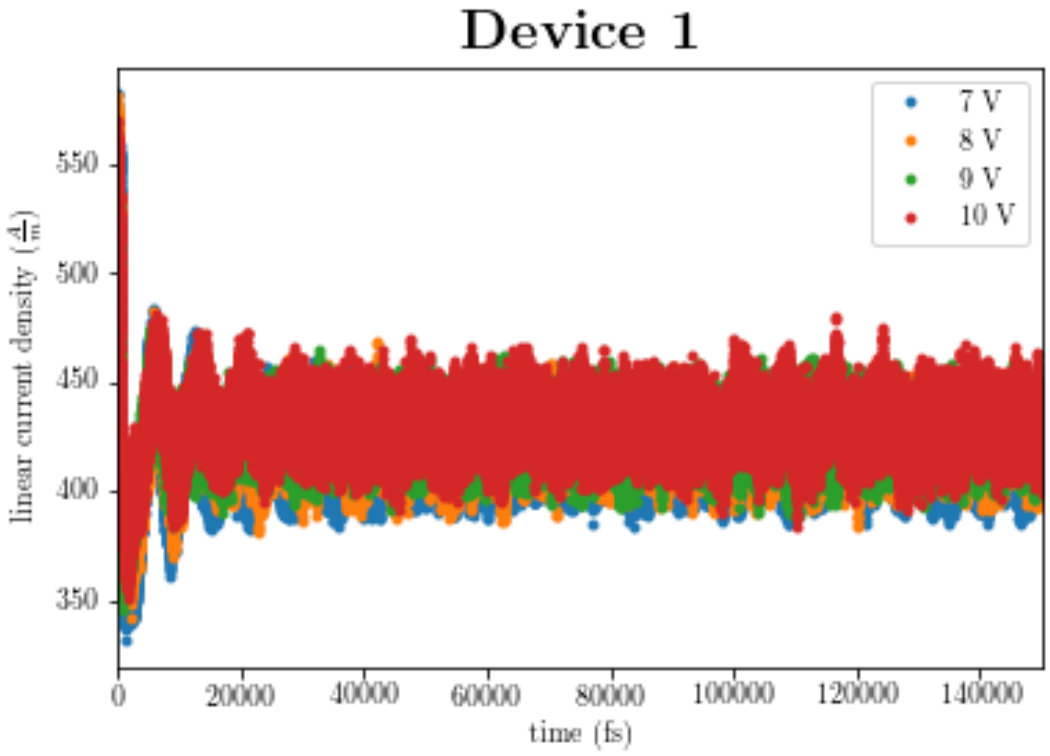


- 0 V, AWGN noise, mean $= 0\frac{\text{A}}{\text{m}}$, $\sigma = 4.72\frac{\text{A}}{\text{m}}$
- Response looks second order
- Steady-state value with decaying oscillations
- Steady-state saturation at $V \geq 1$ V

Device 1 – Visual Analysis



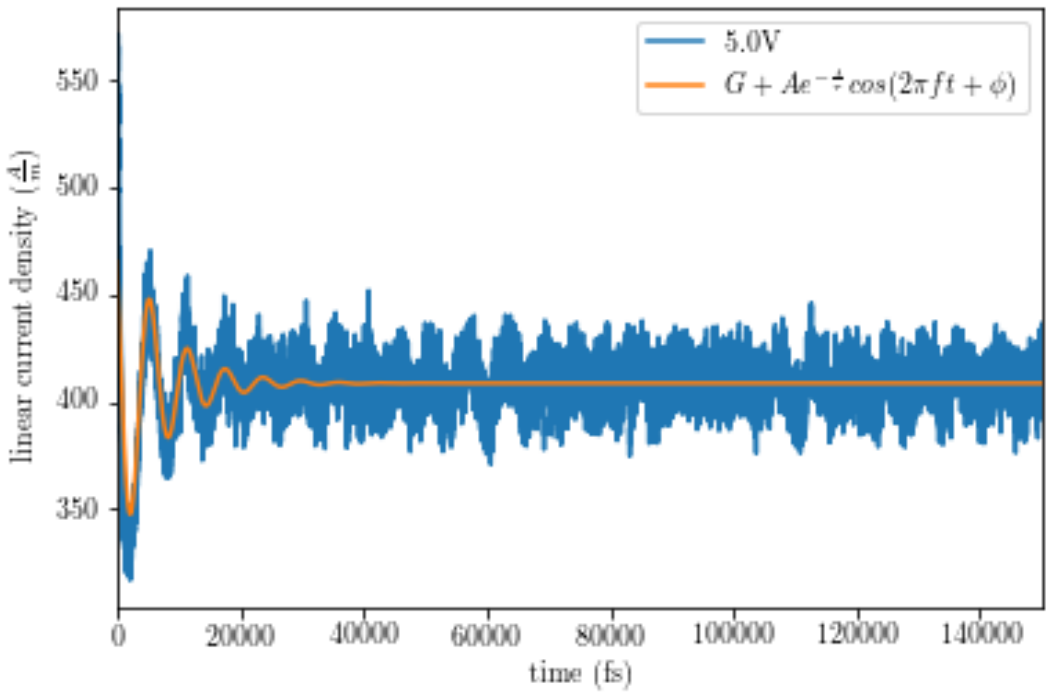
Device 1 – Visual Analysis



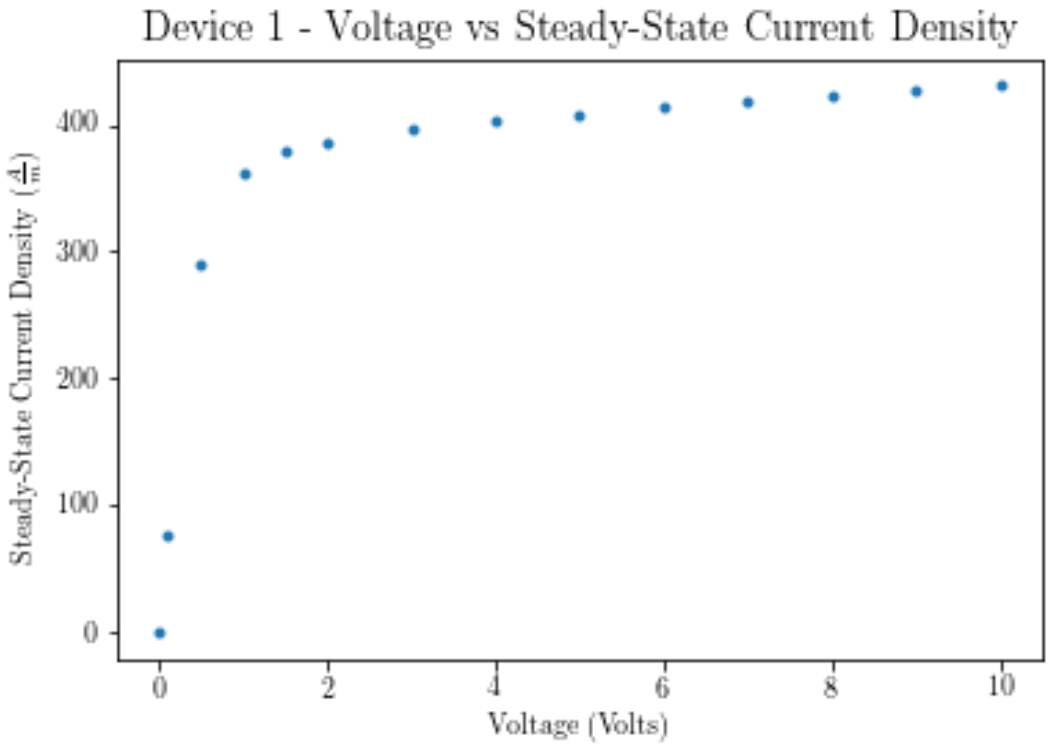
Device 1 – Least Squares Fit

Potential (V)	$I_{ss}\left(\frac{A}{m}\right)$	$A\left(\frac{A}{m}\right)$	$\tau(fs)$	$f(GHz)$	ϕ
0.0V	0.019	2.535	21485.326	23.79e	0.090
0.1V	77.114	150.177	1445.860	28.13e	14.427
0.5V	290.489	121.998	1381.979	161.2	-27.486
1.0V	362.484	69.103	4599.648	146.7	-38.298
1.5V	378.867	47.094	4530.814	152.5e	-31.200
2.0V	386.603	-50.277	3147.451	168.9	-27.532
3.0V	396.042	-109.606	3960.664	167.6	-21.091
4.0V	402.939	101.358	4759.568	163.8	0.906
5.0V	408.584	-83.844	6970.881	162.7	-21.166
6.0V	413.809	61.526	11258.244	162.8	5.544
7.0V	417.989	-68.995	10213.410	155.8	3.838
8.0V	422.669	67.139	7408.109	141.7	5.441
9.0V	427.040	60.321	5789.370	140.9	1.054
10.0V	430.729	-50.401	9899.451	138.0	-27.394

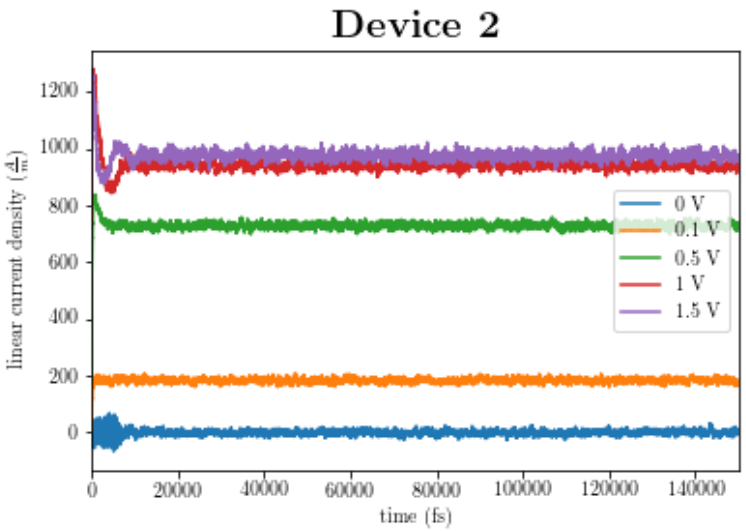
Device 1 – Least Squares Fit



Device 1 – Channel Voltage vs Steady-State Current

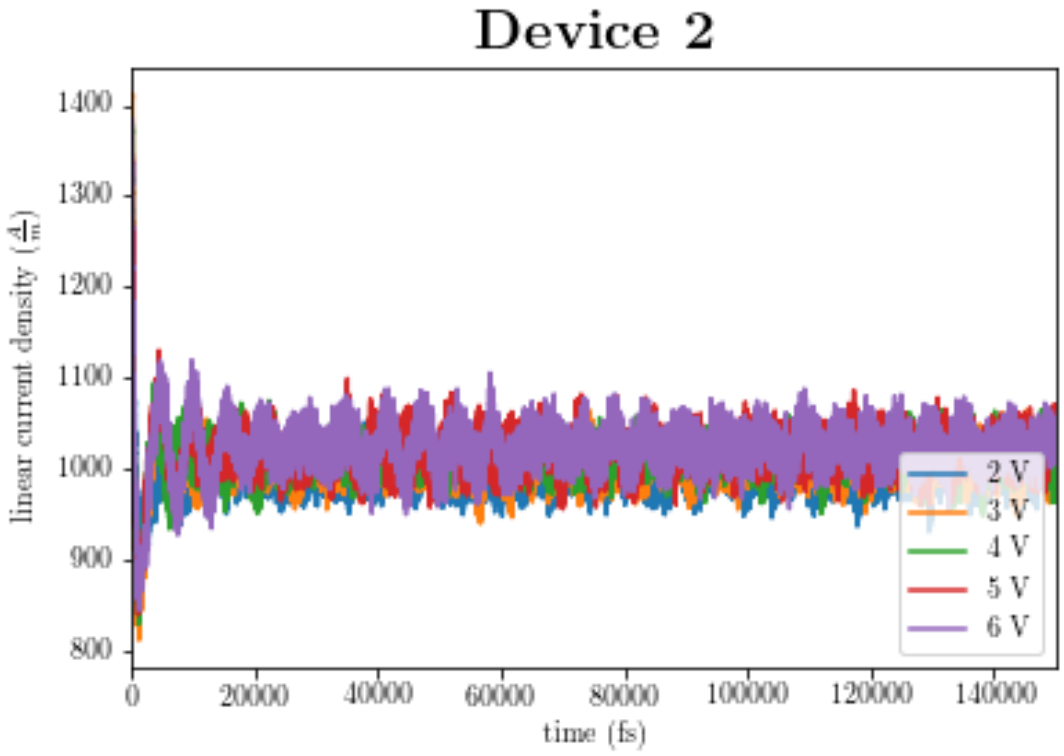


Device 2 – Visual Analysis

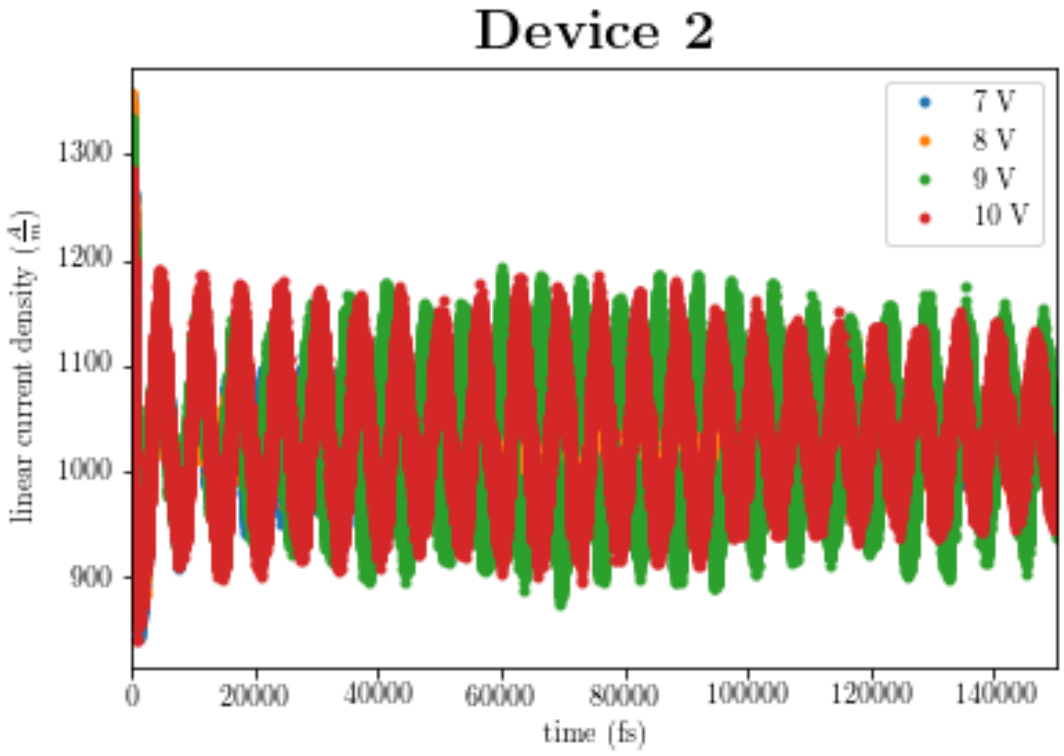


- 0 V, AWGN noise, mean $= 0\frac{\text{A}}{\text{m}}$, $\sigma = 6.95\frac{\text{A}}{\text{m}}$
- Response looks second order
- Steady-state value with decaying oscillations for $V \leq 8$ V
- Sustained oscillations for $V \geq 9$ V
- Steady-state saturation at $V \geq 1$ V

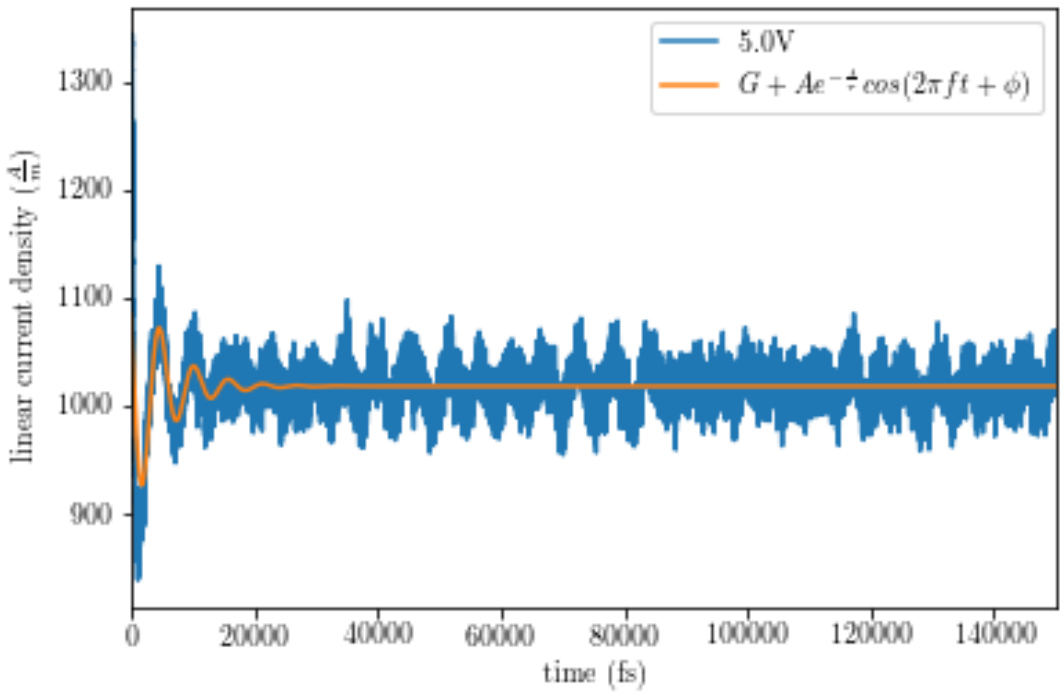
Device 2 – Visual Analysis



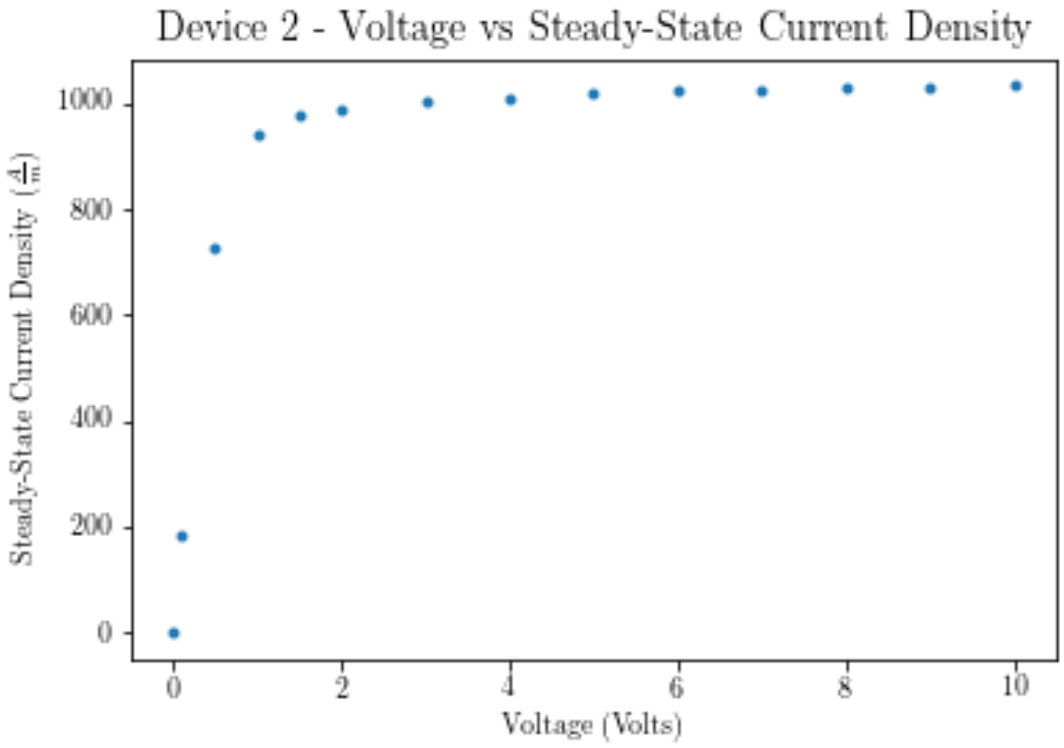
Device 2 – Visual Analysis



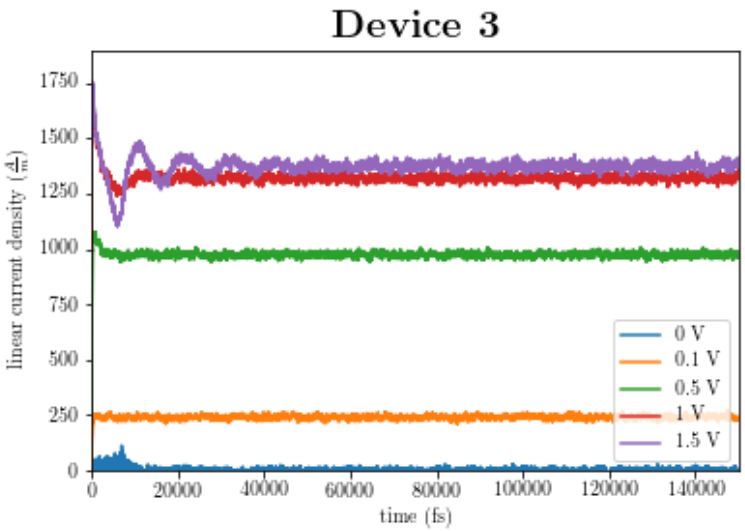
Device 2 – Least Squares Fit



Device 2 – Channel Voltage vs Steady-State Current

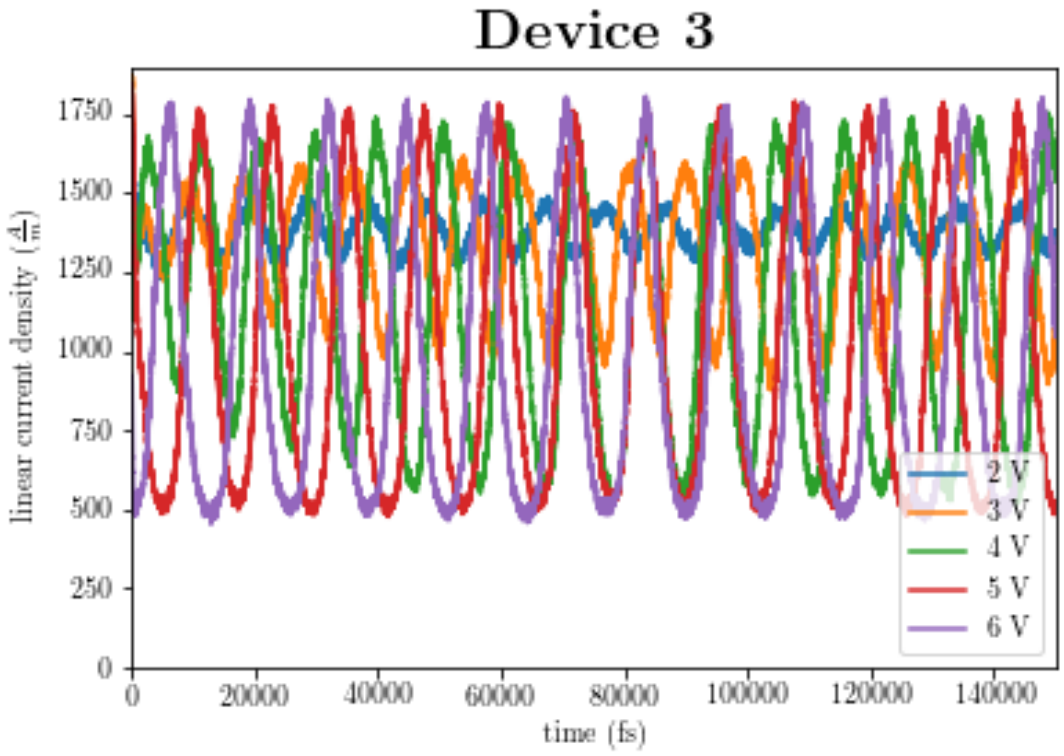


Device 3 – Visual Analysis

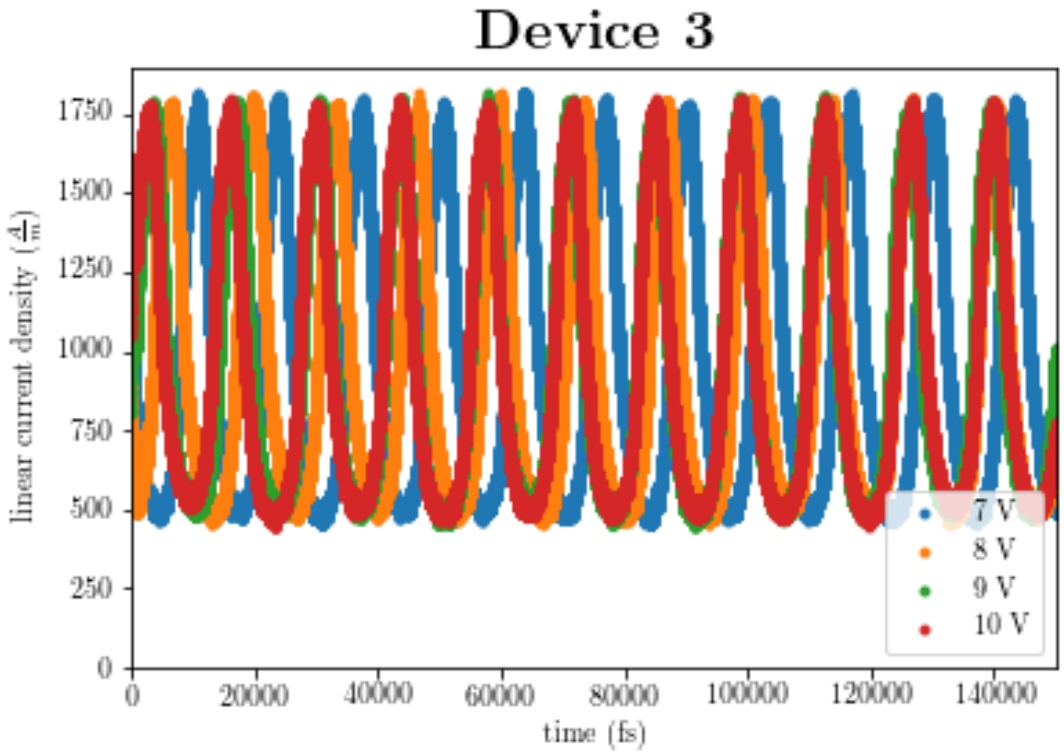


- 0 V, AWGN noise, mean $= 0\frac{\text{A}}{\text{m}}$, $\sigma = 7.77\frac{\text{A}}{\text{m}}$
- Response looks second order
- Steady-state value with decaying oscillations for $V \leq 1.5$ V
- Sustained oscillations for $V \geq 2$ V
- Steady-state saturation at $V \geq 1$ V

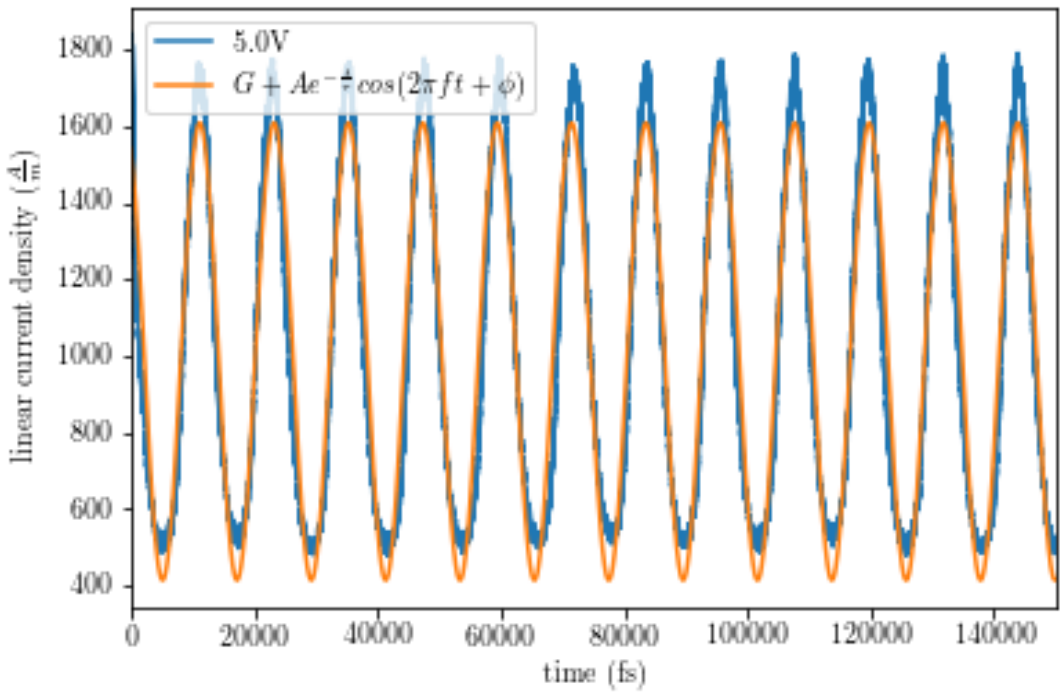
Device 3 – Visual Analysis



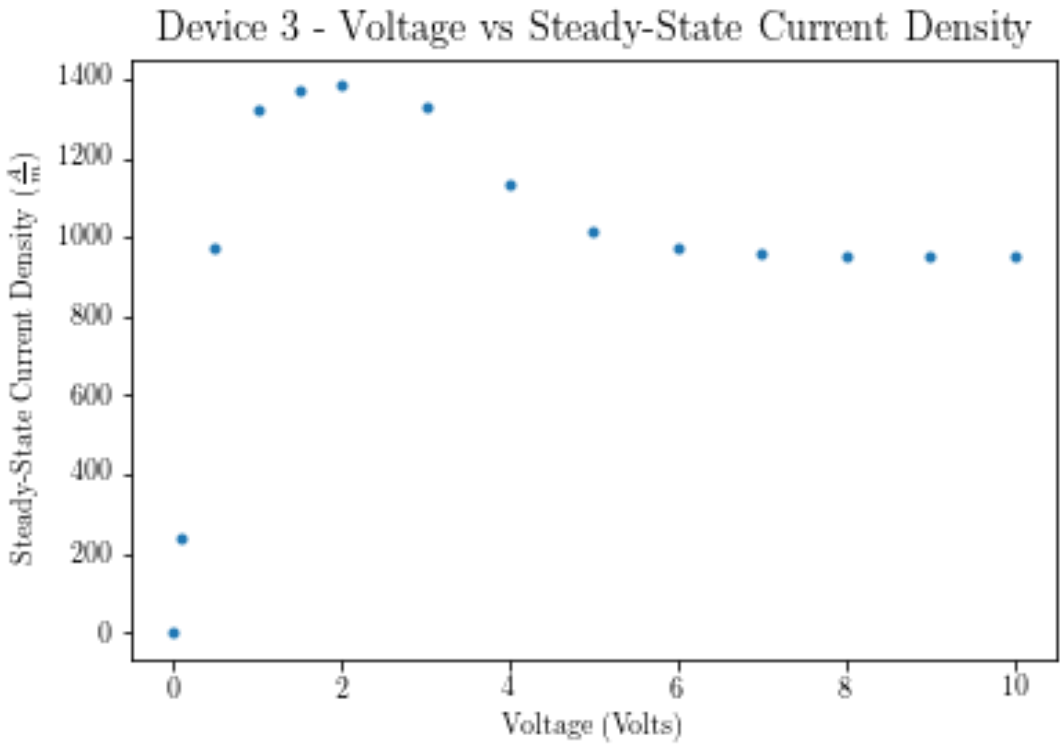
Device 3 – Visual Analysis



Device 3 – Least Squares Fit



Device 3 – Channel Voltage vs Steady-State Current



Future Work

- Model steady state current vs channel voltage curve (I_{ss} vs V)
- Analyze other fit parameters dependence on channel voltage
- Oscillations are not perfectly sinusoidal, analyze power spectrum and model with Fourier series?