1 Circuit Model

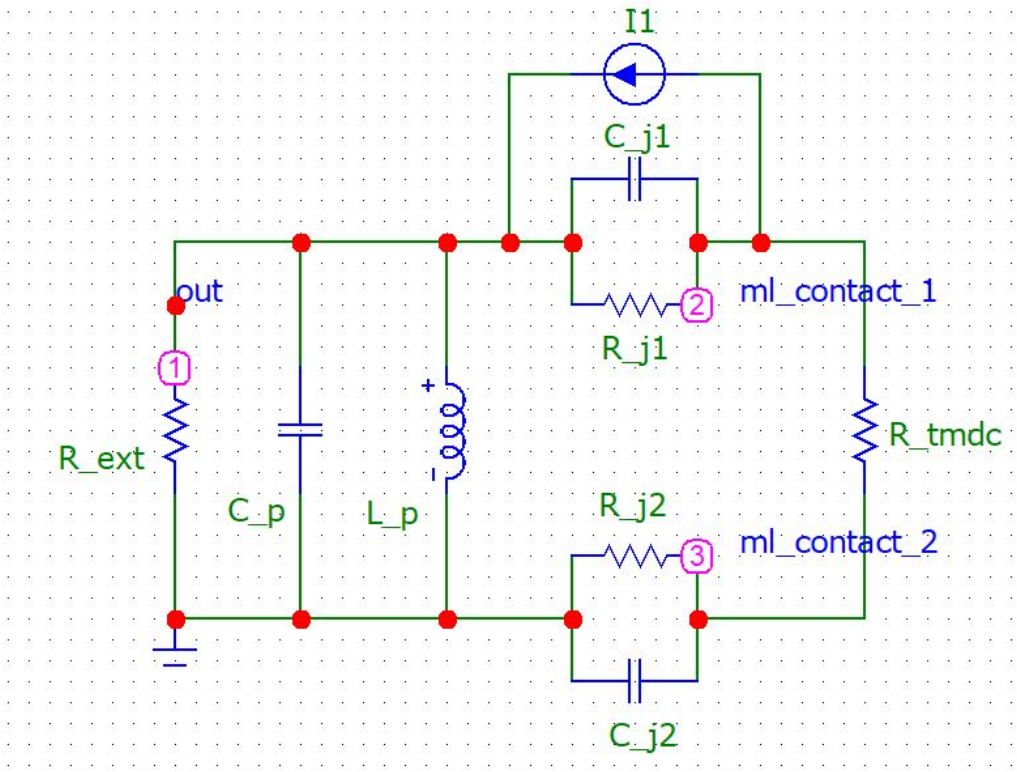


Figure 1: Lumped element circuit

- R_{ext}: External resistance, dominated by lock-in amplifier
- C_p: Parasitic capacitance at the metal-TMDC contact
- L_p: Parasitic inductance →
- $R_{j_{1/2}}$: Junction resistance of the metal-TMDC contact
- $C_{j_{1/2}}$: Junction capacitance of the metal-TMDC contact
- R_{tmdc}: intrinsic channel resistance of the TMDC monolayer/hetereostructure
- I_1: Pulsed rectangular current source representing photocurrent
- Measurement nodes are *out* and *ground*

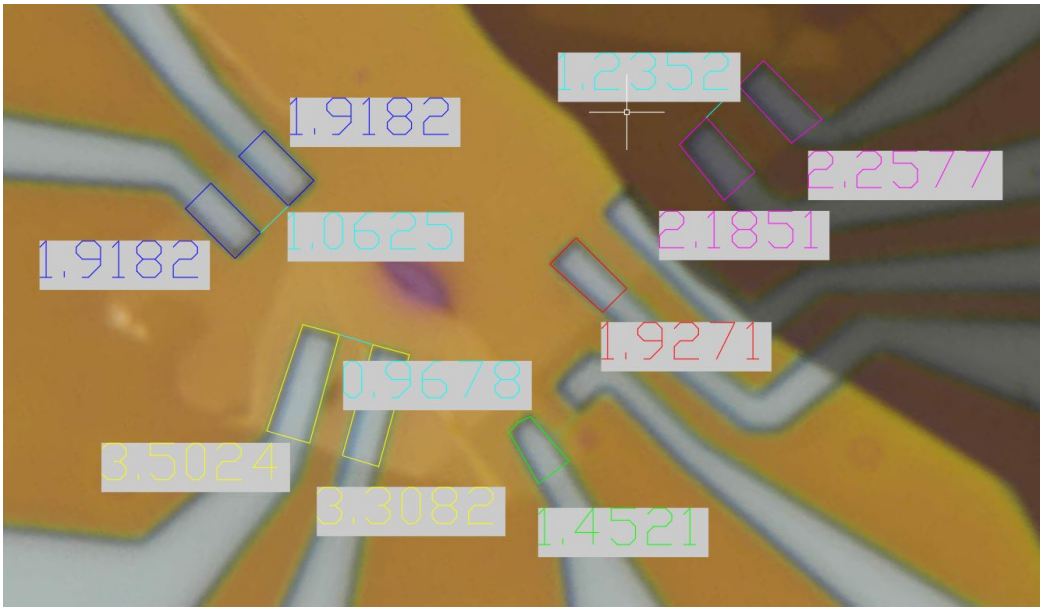


Figure 2: Sample with contact areas and channel length

2 Parameter Ranges

Channel length for all electrodes $\approx 1\mu m$

R_{ext}**:** open circuit $\approx 10M\Omega$, short circuit $\approx 1k\Omega$

C_p**:**

- Wang et.al. assume contact layer thickness of $\approx 50nm$ and therefore $10^{-17}F/\mu m$. The most influential parameter, so large range
  $\Rightarrow$ **range:** 10^{-18}-10^{-5}F

L_p**:** **range:** 10^{-8}-10^{-5}H

$R_{j_{1/2}}$**:**

- MoS_2-Au: 10^3-$10^4\Omega\mu m$ as in Wang et.al, $10^5\Omega\mu m$ as in Jo et.al., 10^2-$10^6\Omega\mu m$ in Allain et.al., also see Kappera et.al.
  $\Rightarrow$ **range:** 10^3-$10^6\Omega$

$C_{j_{1/2}}$:

- MoS_2-Au: Wang et.al. assume contact layer thickness of $\approx 50nm$ and therefore $10^{-17}F/\mu m$
  $\Rightarrow$ **range:** 10^{-18}-10^{-12}F

R_{tmdc}:

- MoS_2: $\approx 150k\Omega\mu m$ as in Wang et.al.
  $\Rightarrow$ **range:** 10^3-$10^6\Omega$

f_{pulse}:

- chopper timescale: assuming constant laser signal, only using chopper frequency for the current source:
  range: 10^1-10^4Hz
- laser timescale: looking at probable high frequency effects within one chopper period, assuming laser frequency for current source:
  $f_{laser} = 80{\cdot}10^6$Hz

3 Simulation Results

Varied parameters: $C_p, C_j, R_j, R_{tmdc}, L_p$:

- Chopper frequency timescale, f_{ch} $\approx 10^1$-10^4Hz: fine frequency sweep at one simulation per order of magnitude of the respective parameter
- Laser pulse frequency timescale, f_{ch} $\approx 10^7$Hz: fine parameter sweep at fixed frequency

Each for the open circuit ($R_{ext} \approx 10{\cdot}10^6$) and short circuit ($R_{ext} \approx 1{\cdot}10^3$).

Summary On the chopper timescale, for $C_p > 10^{-7}$, the parasitic capacitance strongly dominates all other parameters and causes a drop in frequency response at $f_{ch} > 10^6$, which is independent of other parameters. Looking at the laser timescale, $C_p > 10^{-15}$ strongly dampens the signal, approaching zero for $C_p > 10^{-10}$. The open circuit is about three orders of magnitude more sensitive to this effect than the short circuit.

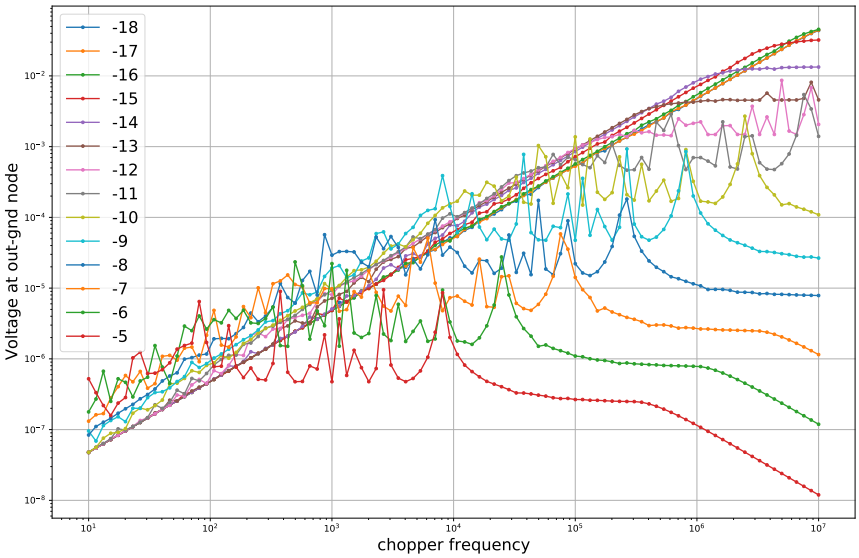


Figure 3: open circuit, chopper timescale: C_p variation from 10^{-18} to 10^{-5} F, a potentially problematic low pass filter shows for $C_j > 10^{-8}$

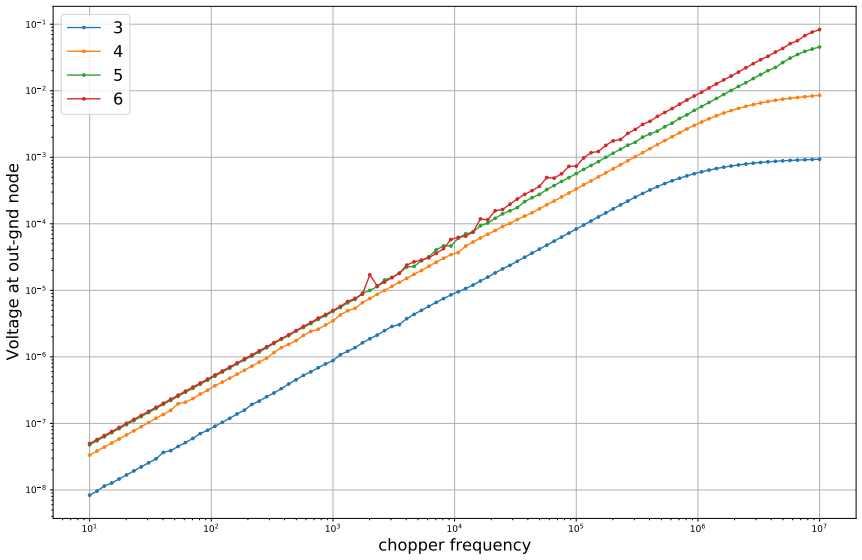


Figure 4: open circuit, chopper timescale: R_j variation from 10^3 to $10^6\Omega$

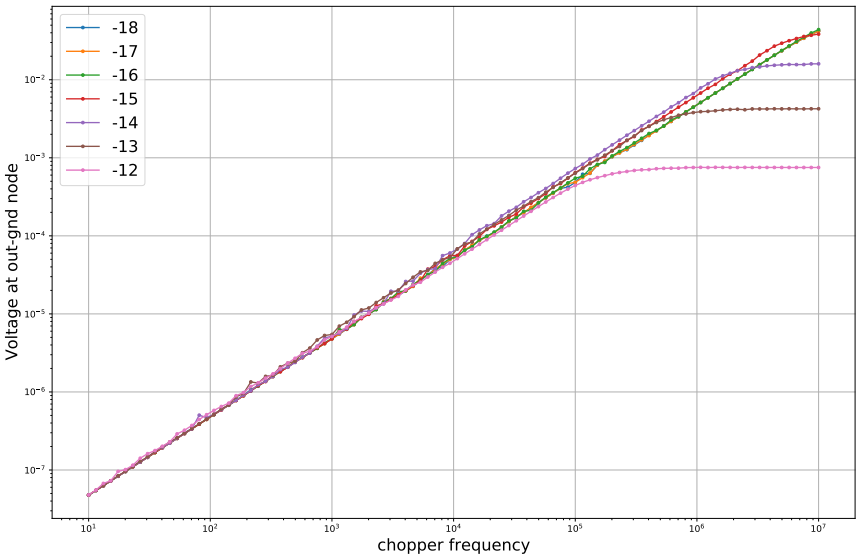


Figure 5: open circuit, chopper timescale: C_j variation at C_p =10^{-18}

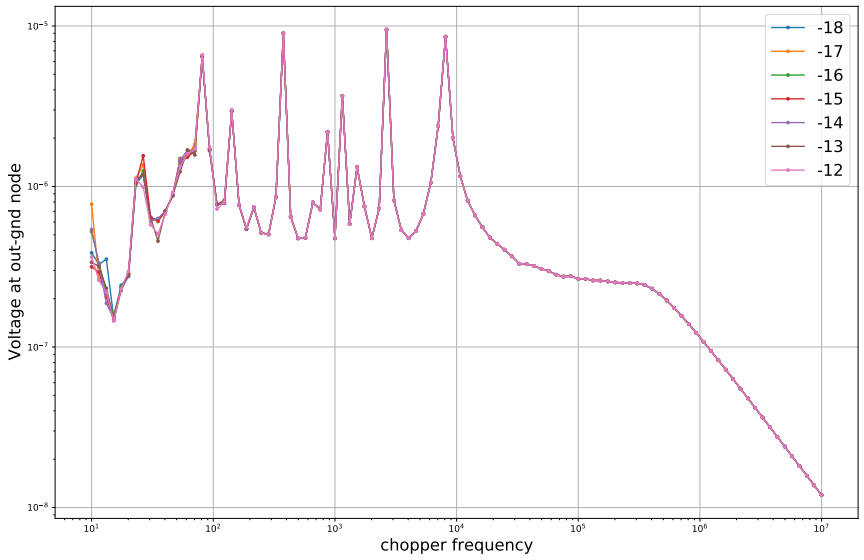
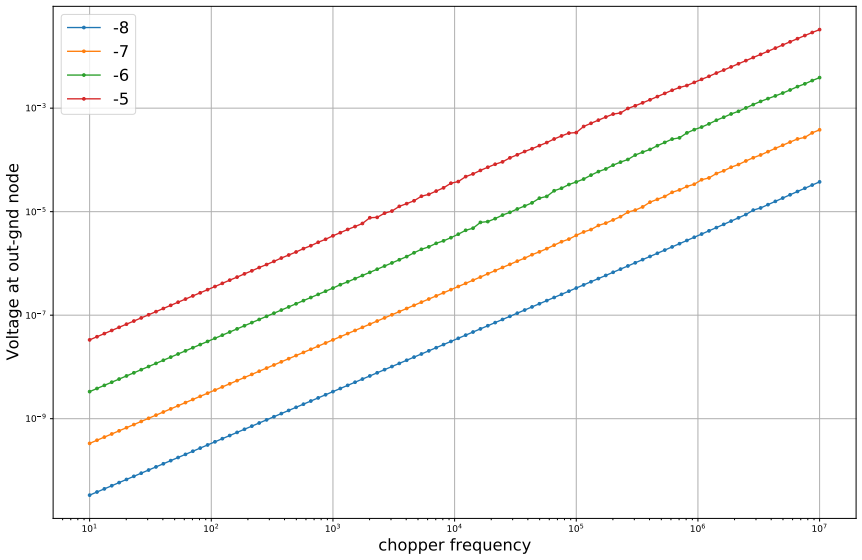


Figure 6: open circuit, chopper timescale: C_j variation at C_p =10^{-5}



]

Figure 7: open circuit, chopper timescale: L_p variation at C_p =10^{-18}

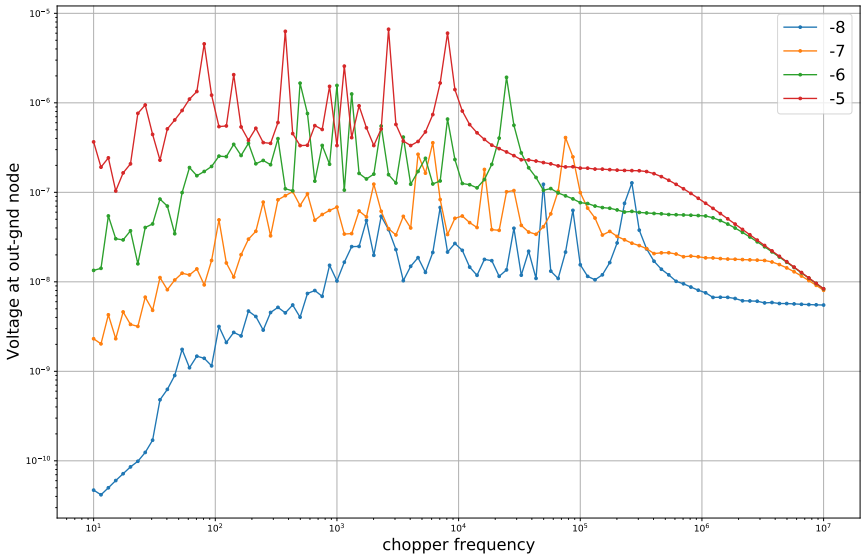


Figure 8: open circuit, chopper timescale: L_p variation at C_p =10^{-5}

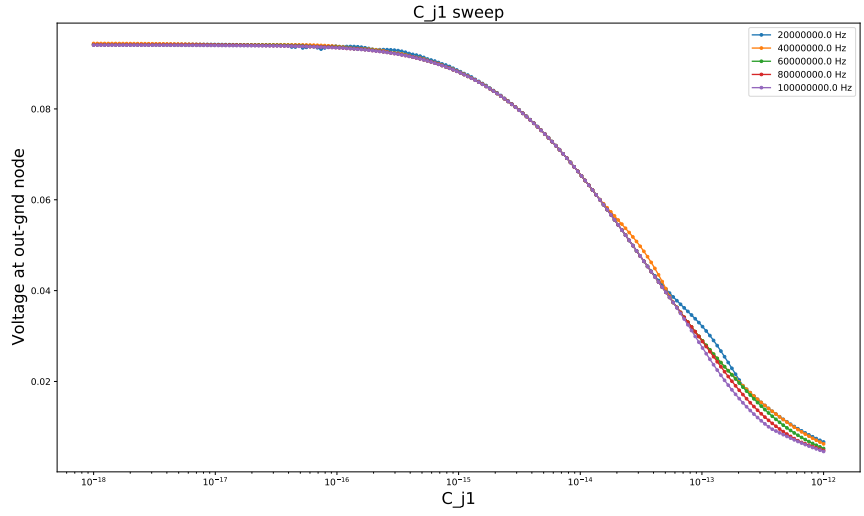


Figure 9: open circuit, laser timescale: C_j sweep

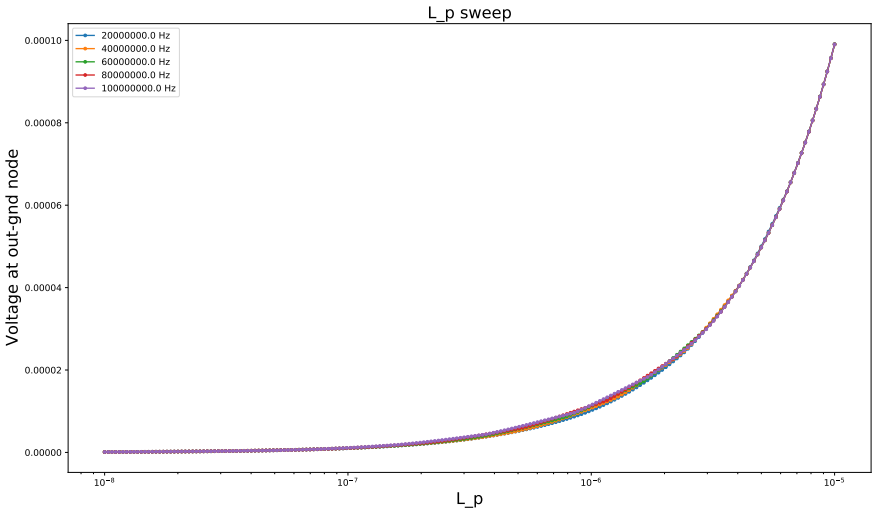


Figure 10: open circuit, laser timescale: L_p sweep

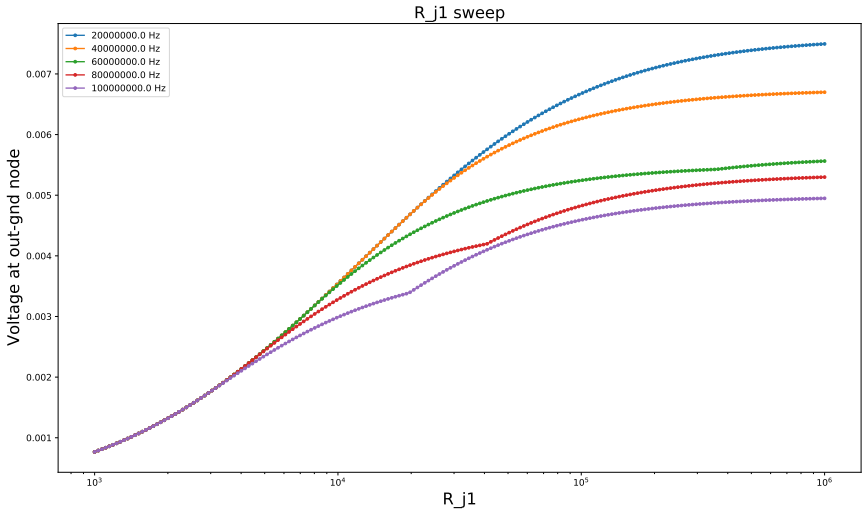


Figure 11: open circuit, laser timescale: R_j sweep

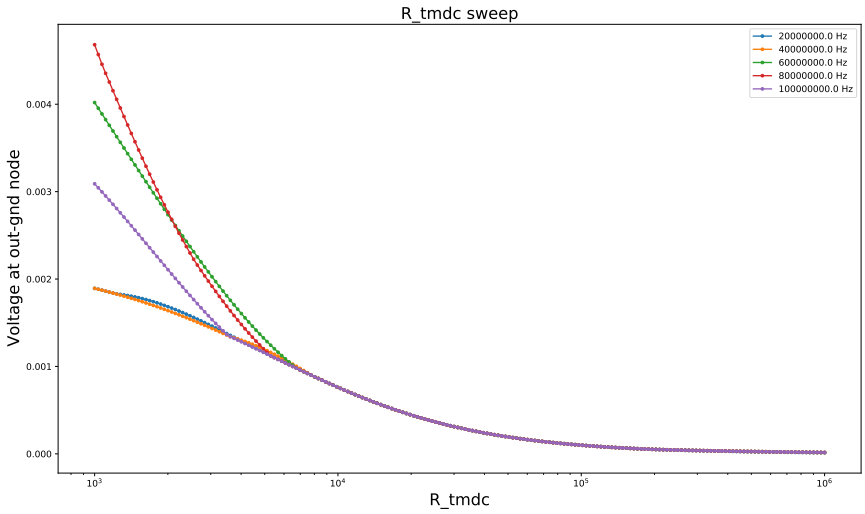


Figure 12: open circuit, laser timescale: R_{tmdc} sweep

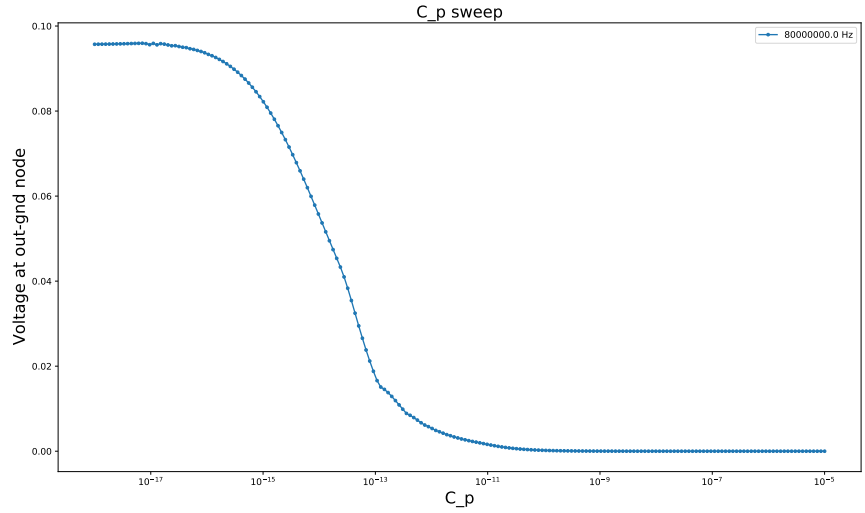


Figure 13: open circuit, laser timescale: C_p sweep

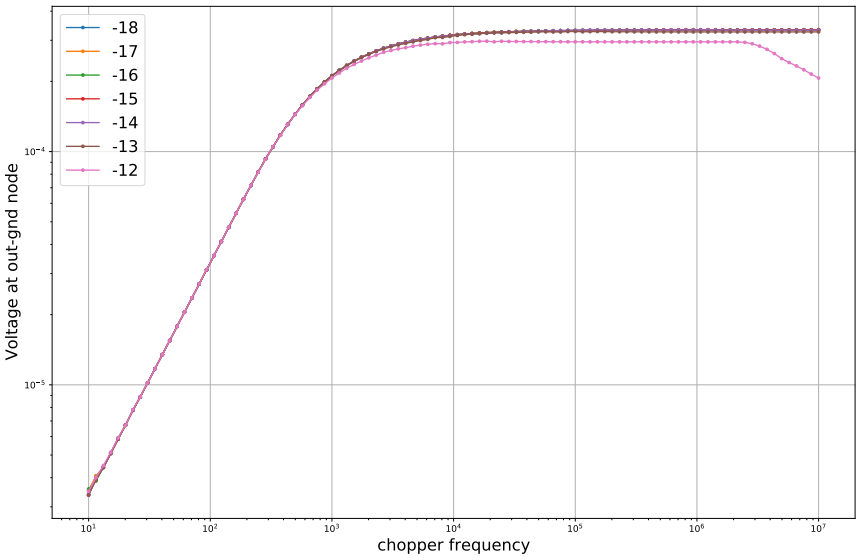


Figure 14: short circuit, chopper timescale: C_j variation at C_p =10^{-18}

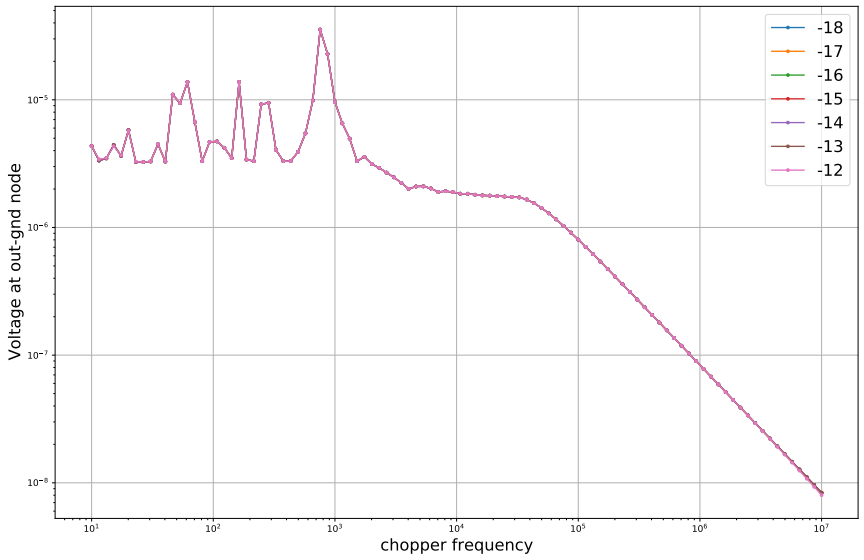


Figure 15: short circuit, chopper timescale: C_j variation at C_p =10^{-5}

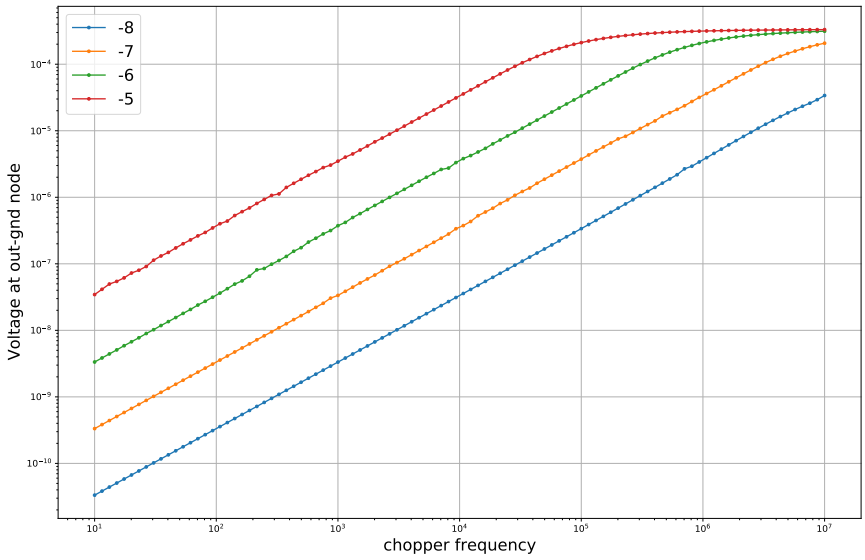


Figure 16: short circuit, chopper timescale: L_p variation at C_p =10^{-18}

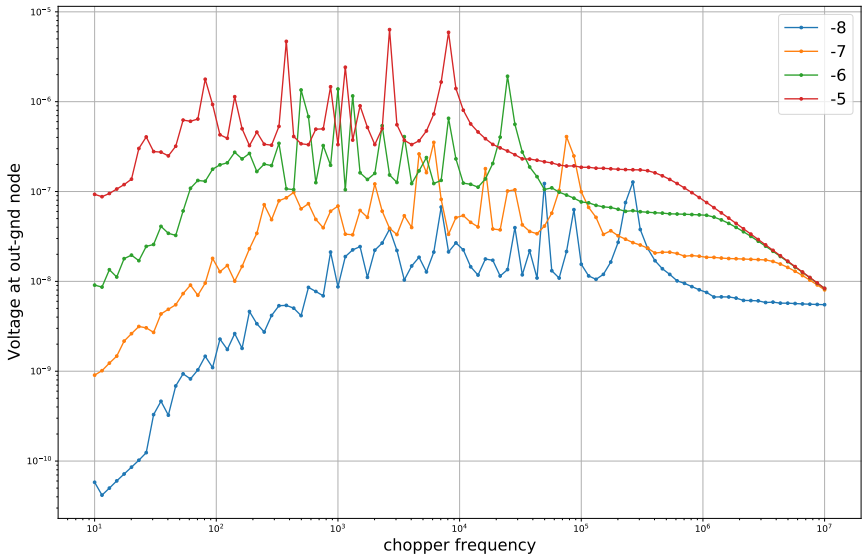


Figure 17: short circuit, chopper timescale: L_p variation at C_p =10^{-5}

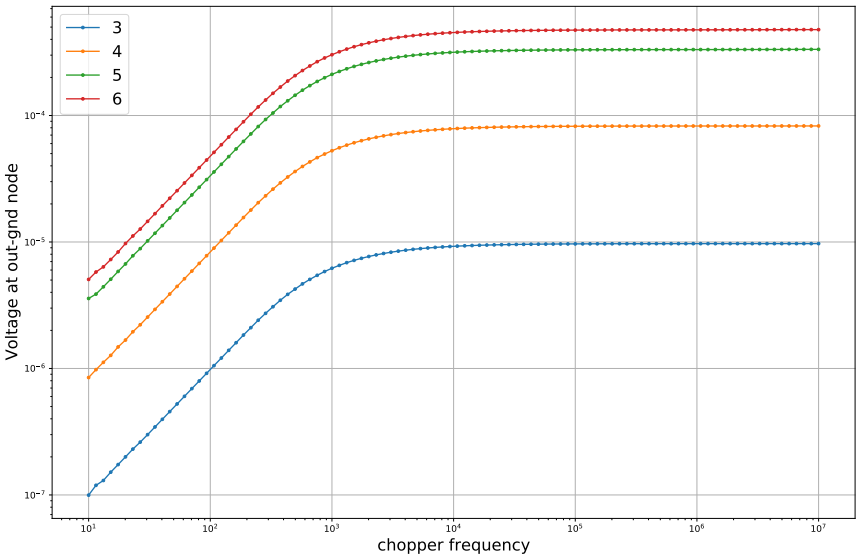


Figure 18: short circuit, chopper timescale: R_j variation at C_p =10^{-18}

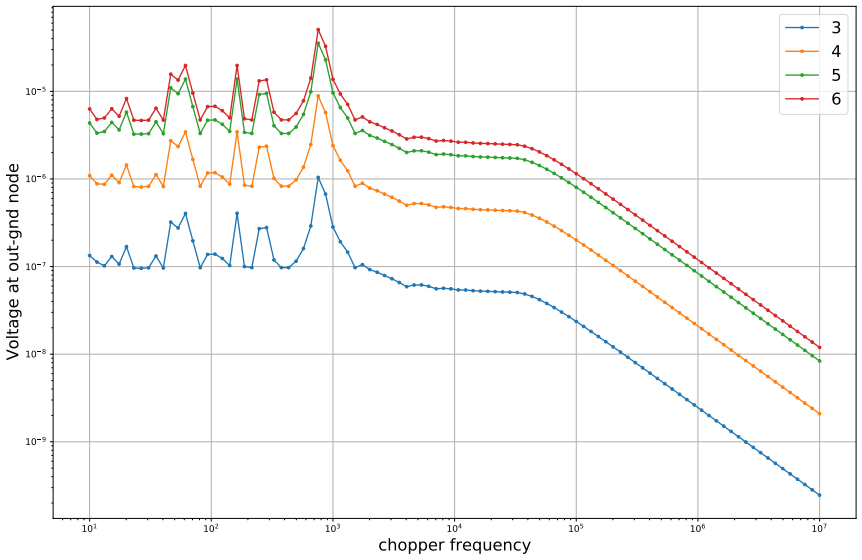


Figure 19: short circuit, chopper timescale: R_j variation at C_p =10^{-5}

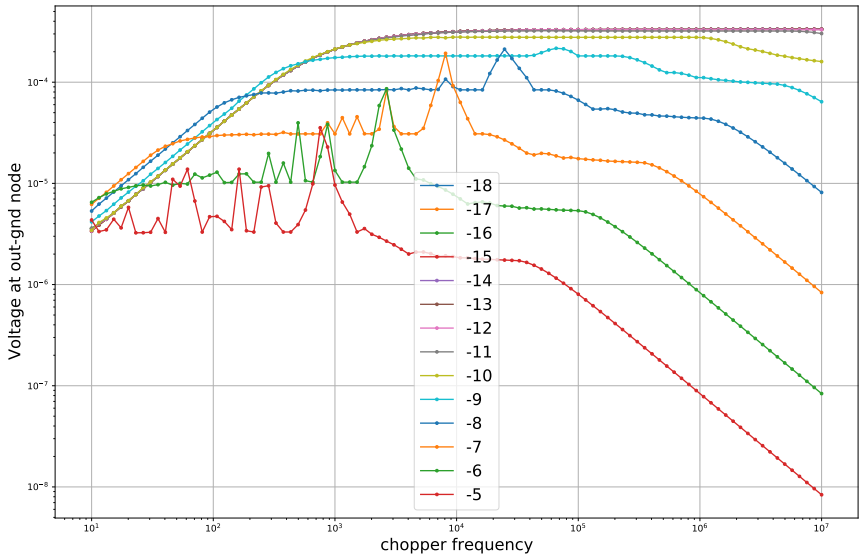


Figure 20: short circuit, chopper timescale: C_p variation

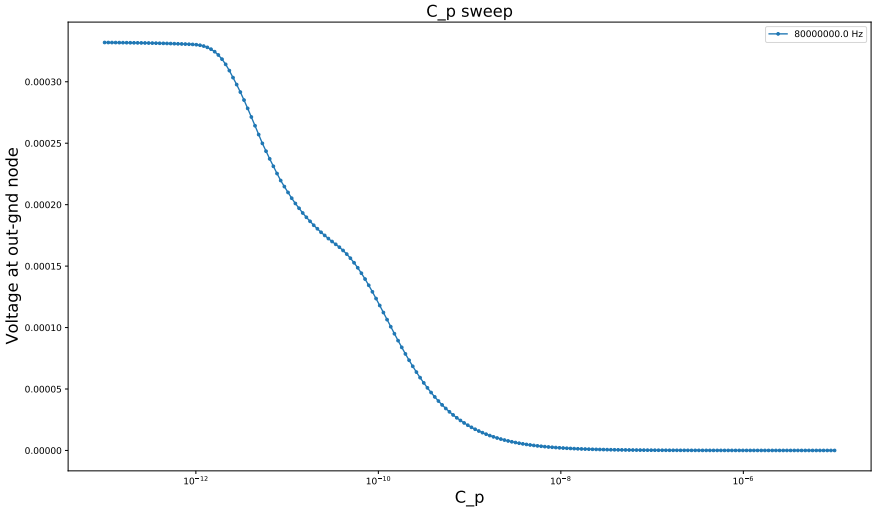


Figure 21: short circuit, laser timescale: C_p sweep

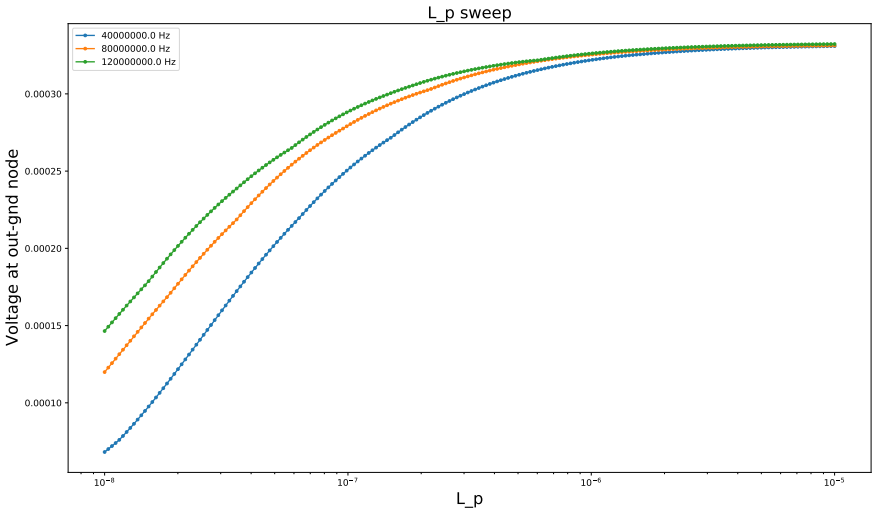


Figure 22: short circuit, laser timescale: L_p sweep

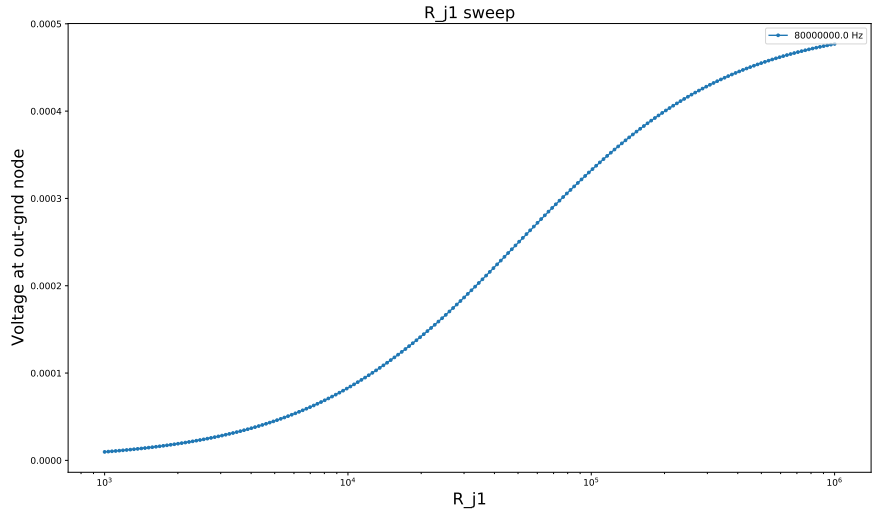


Figure 23: short circuit, laser timescale: R_j sweep

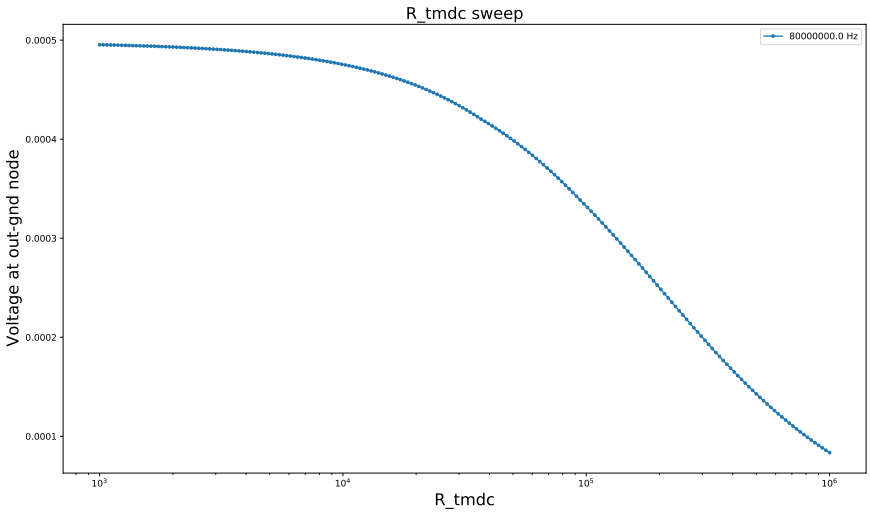


Figure 24: short circuit, laser timescale: R_{tmdc} sweep

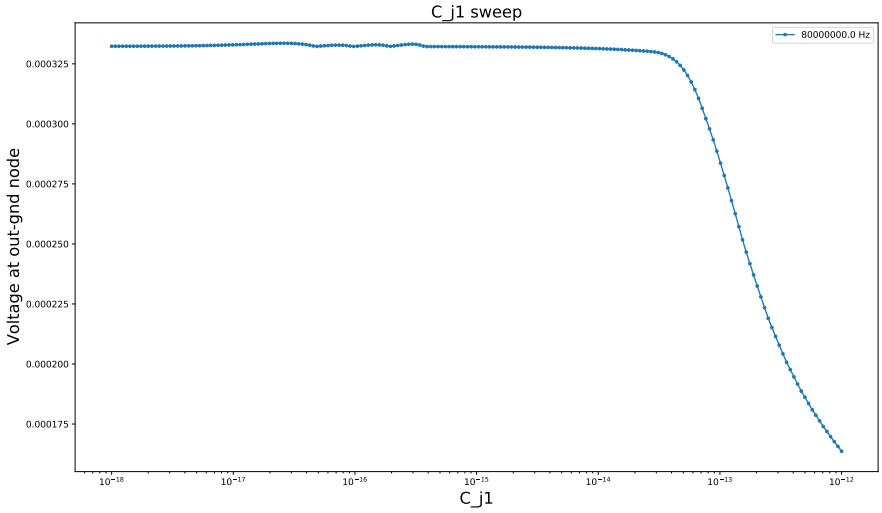


Figure 25: short circuit, laser timescale: C_j sweep