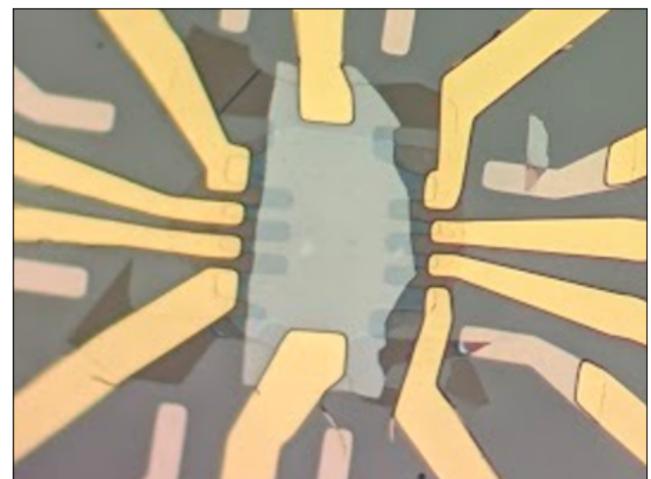
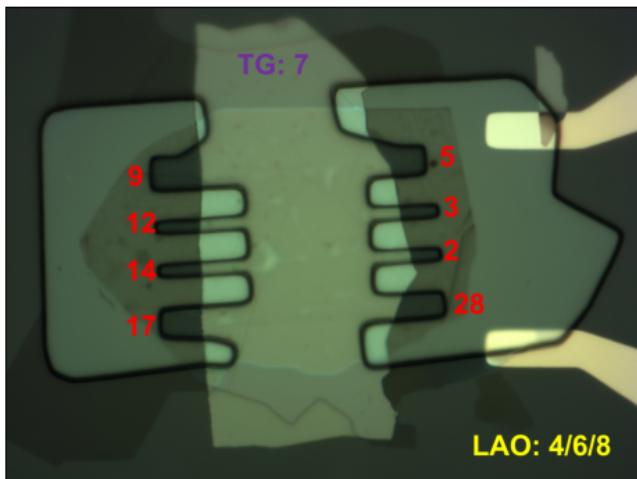


In all data analysis, \hat{x} follows the current direction (i.e. source \rightarrow drain), \hat{z} goes into the picture (i.e. top gate \rightarrow STO), and $\hat{y} = \hat{z} \times \hat{x}$. B is along the \hat{z} -axis. With my convention, R_{xy} must be positive (negative) in electron (hole) side under $B > 0$.

0. Device Layout



1. "01 - Initial test/" ($B = 0, 10\text{mV}+100\text{kOhm}, 13\text{Hz}$)

Fig. 1a SA40379A.20221115.000006.tdms (S/D = 17/9, $V_1/V_2 = 14/12$, V_{tg} from +5V to -5V)

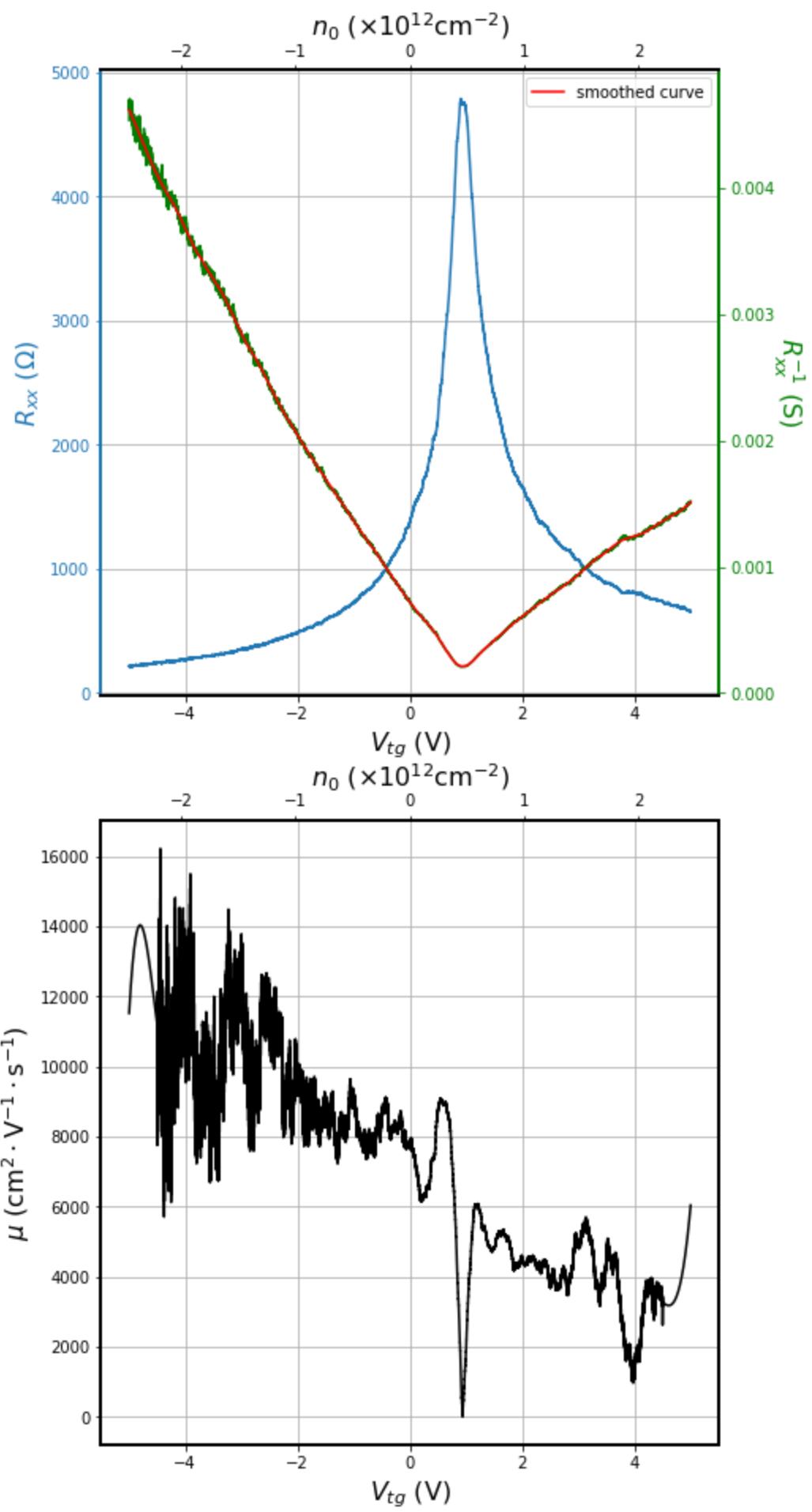


Fig. 1b SA40379A.20221115.000007.tdms (S/D = 17/9, $V_1/V_2 = 14/12$, V_{tg} from -5V to +5V)

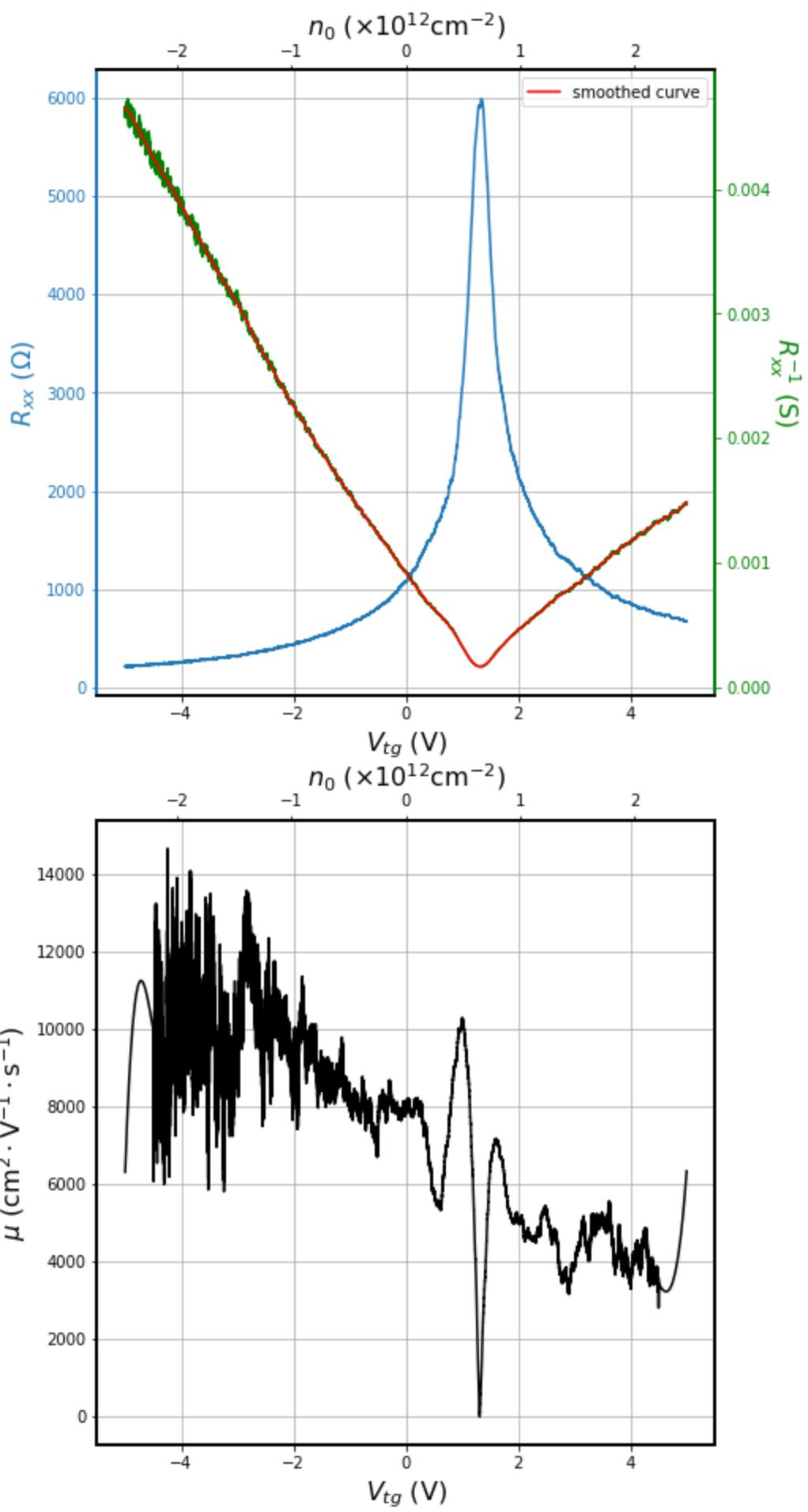


Fig. 1c SA40379A.20221115.000008.tdms (S/D = 17/9, $V_1/V_2 = 14/12$, V_{tg} from +5V to -5V)

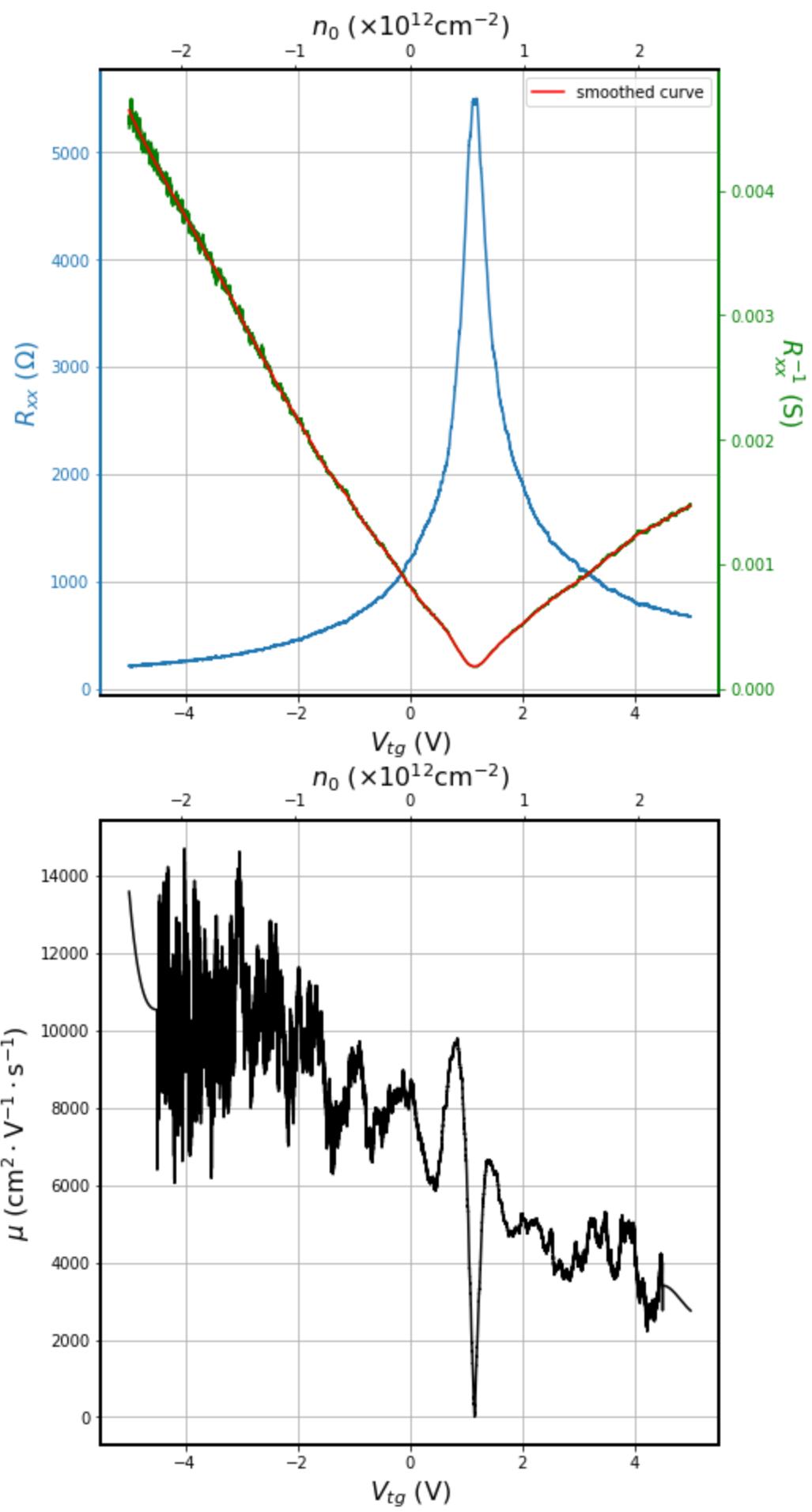
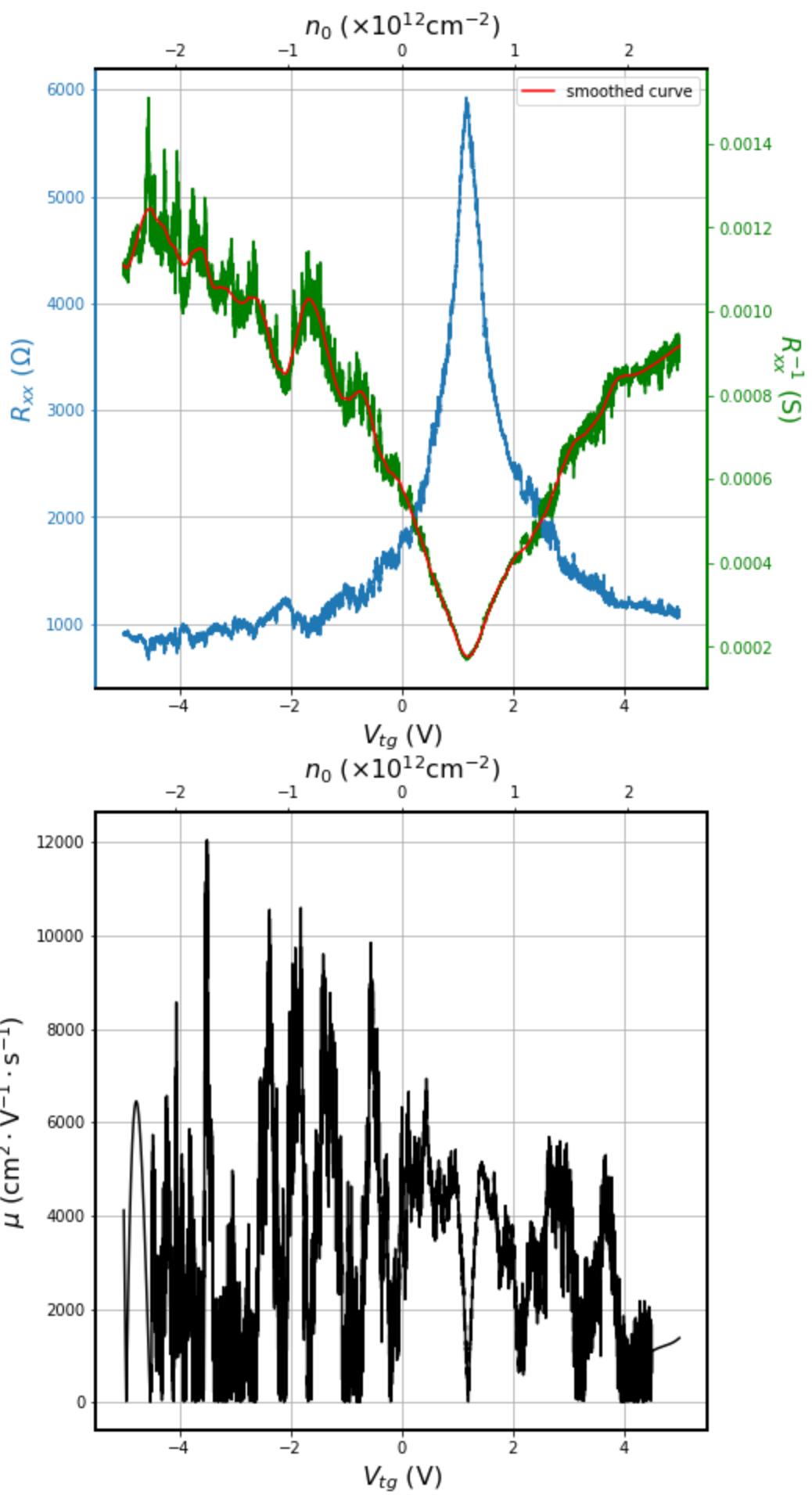


Fig. 1d SA40379A.20221115.000009.tdms (S/D = 28/5, $V_1/V_2 = 2/3$, V_{tg} from -5V to +5V)



2. "02 - Ramp B from 0 to 18T/" ($V_{tg} = +5\text{V}$,

10mV+100kOhm, 13Hz)

Out[7]:

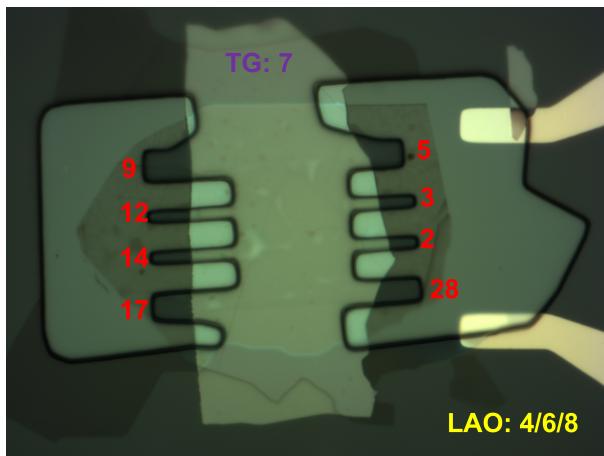
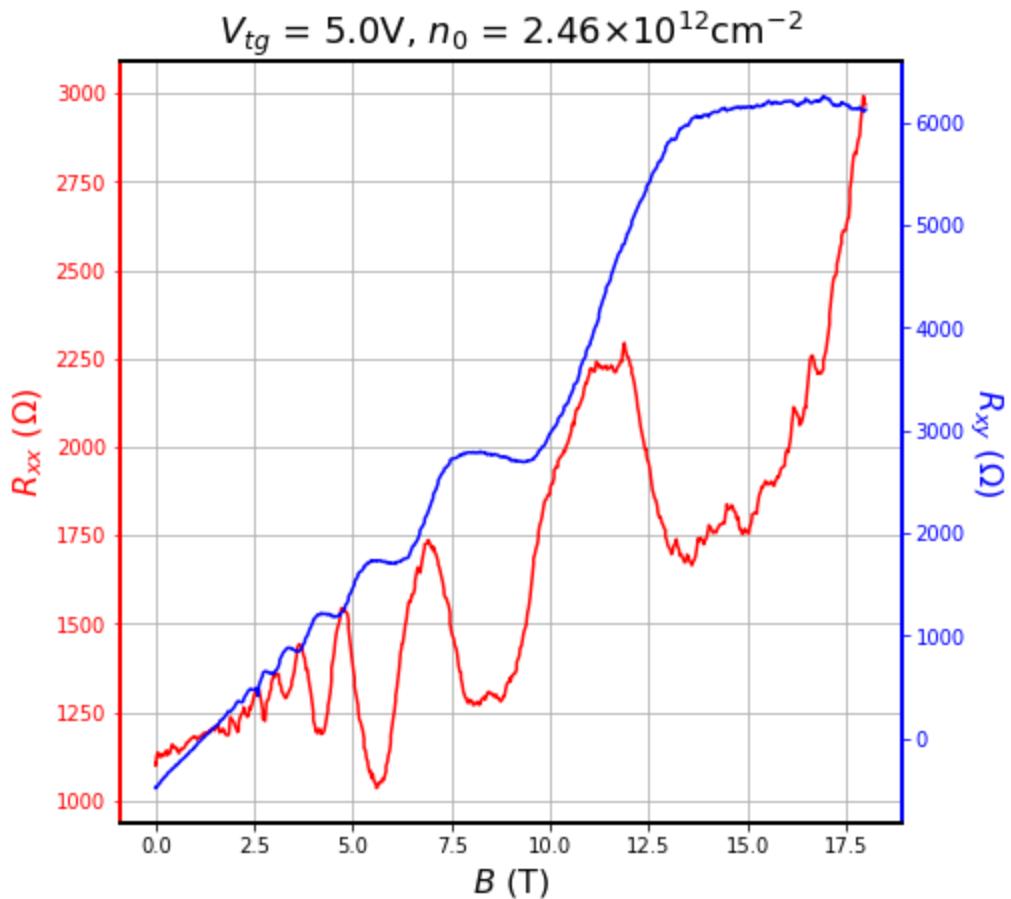


Fig. 2a SA40379A.20221115.000009.tdms (S/D = 28/5, B from 0 to 18T)
plot R_{xx} (2-3) and R_{xy} (3-12) together



3. "03 - Vsg sweep at 18T/" (B = 18T, 10mV+100kOhm, 13Hz)

Out[9]:

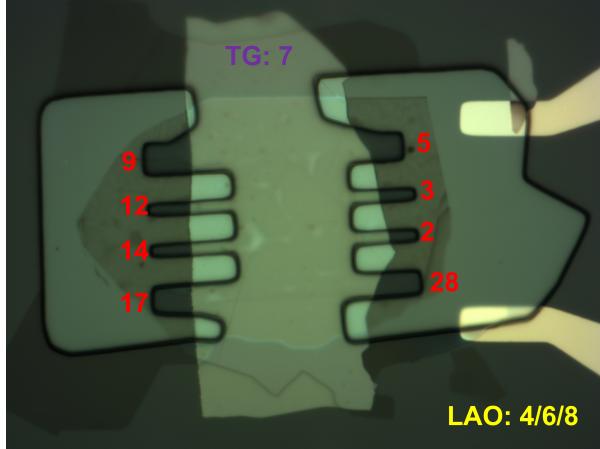


Fig. 3a SA40379A.20221115.000000.tdms ($S/D = 28/5$, V_{tg} from +5V to -5V)
plot R_{xx} (2-3) and R_{xy} (3-12) together

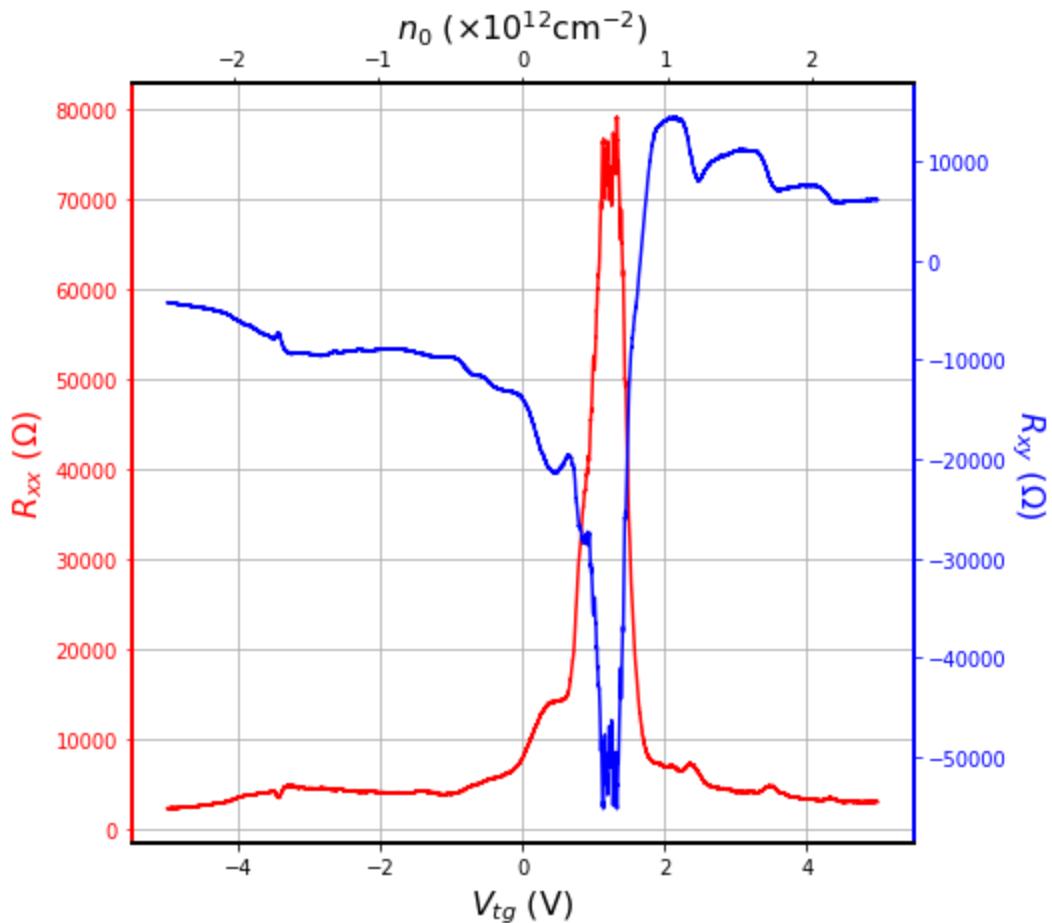
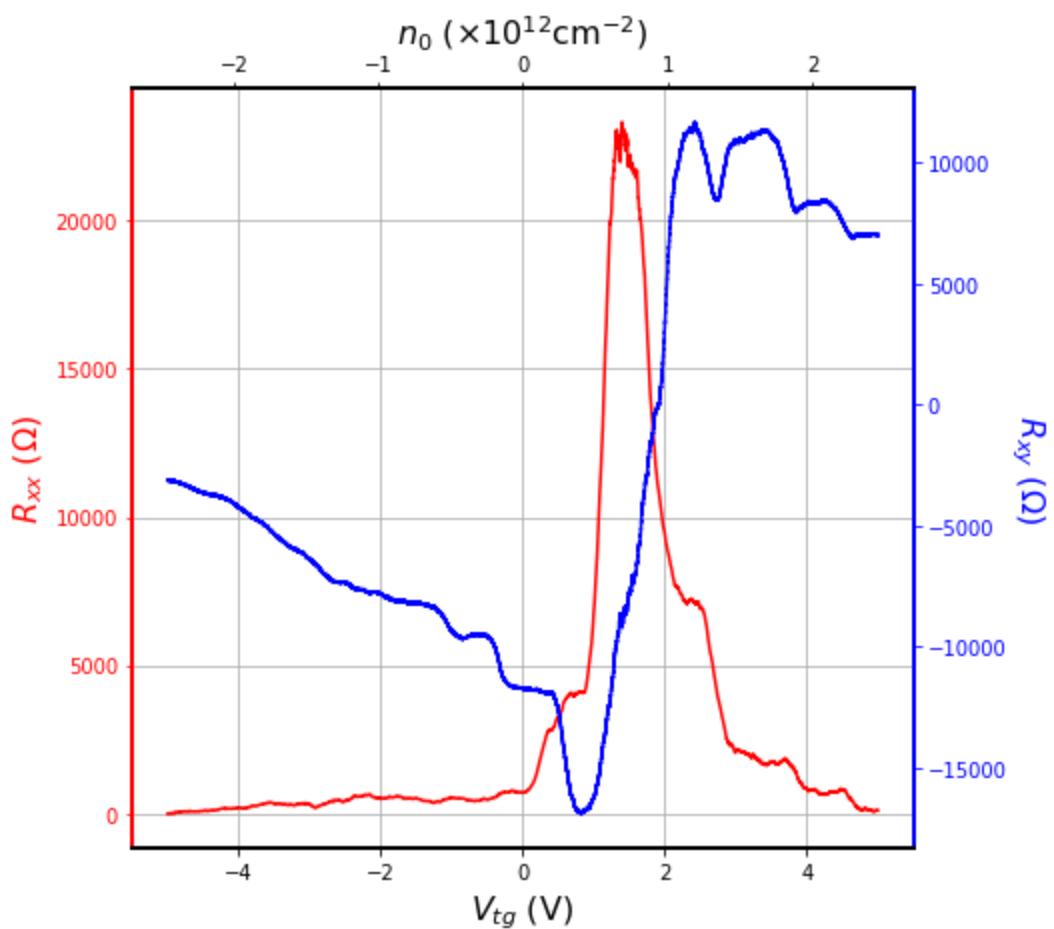
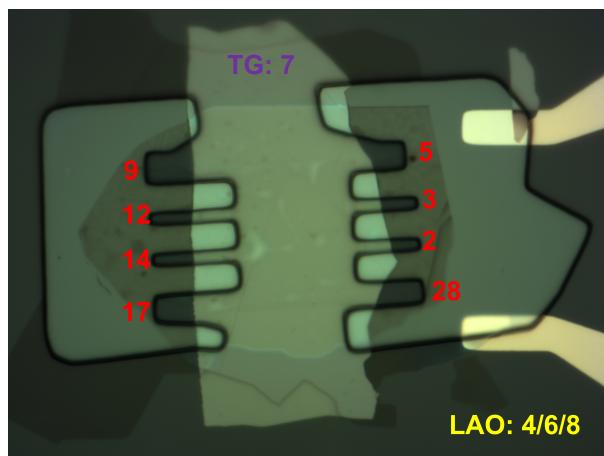


Fig. 3b SA40379A.20221115.000001.tdms ($S/D = 17/9$, $V_1/V_2 = 14/12$, V_{tg} from -5V to +5V)
plot R_{xx} (14-12) and R_{xy} (2-14) together



4. "04 - B sweep V_{tg} sweep/" (S/D = 28/5, 10mV+100kOhm, 13Hz)

Out[12]:



SA40379A.20221115.000000.tdms to ...000095.tdms (S/D = 28/5, V_{tg} slow from +5V to -5V and fast back to +5V, B from +18T to -1T, step size 0.2T)

Note: len(data) = 16120, from +5 to -5V corresponds to 0-15600 (i.e. data[15600] = data at -5V)

Fig. 4a four-terminal resistance between 2 and 3

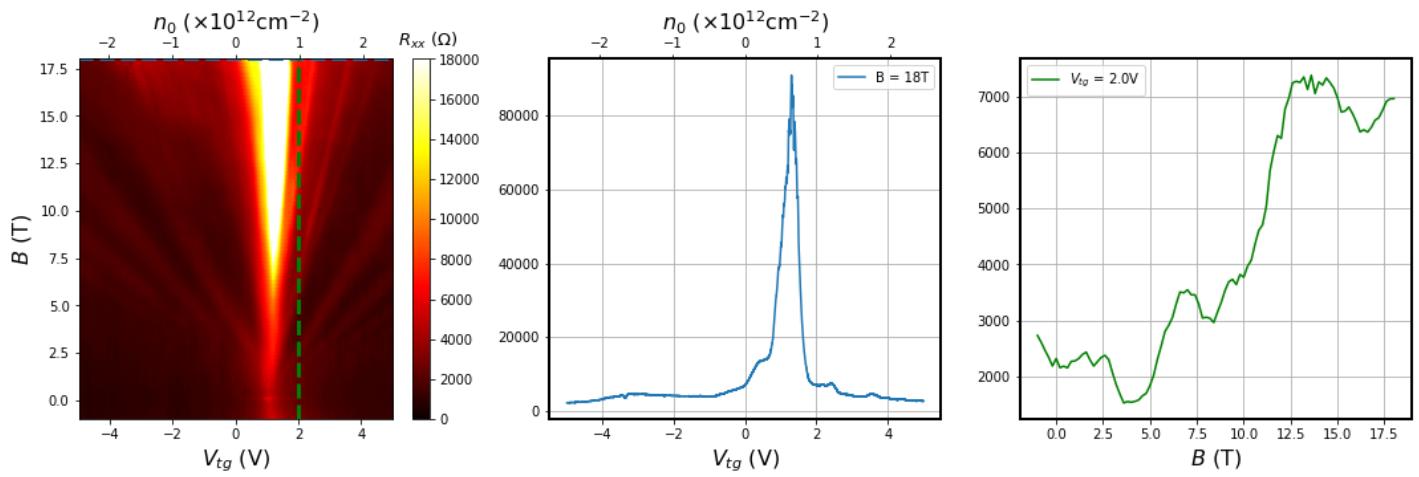


Fig. 4b four-terminal resistance between 14 and 12

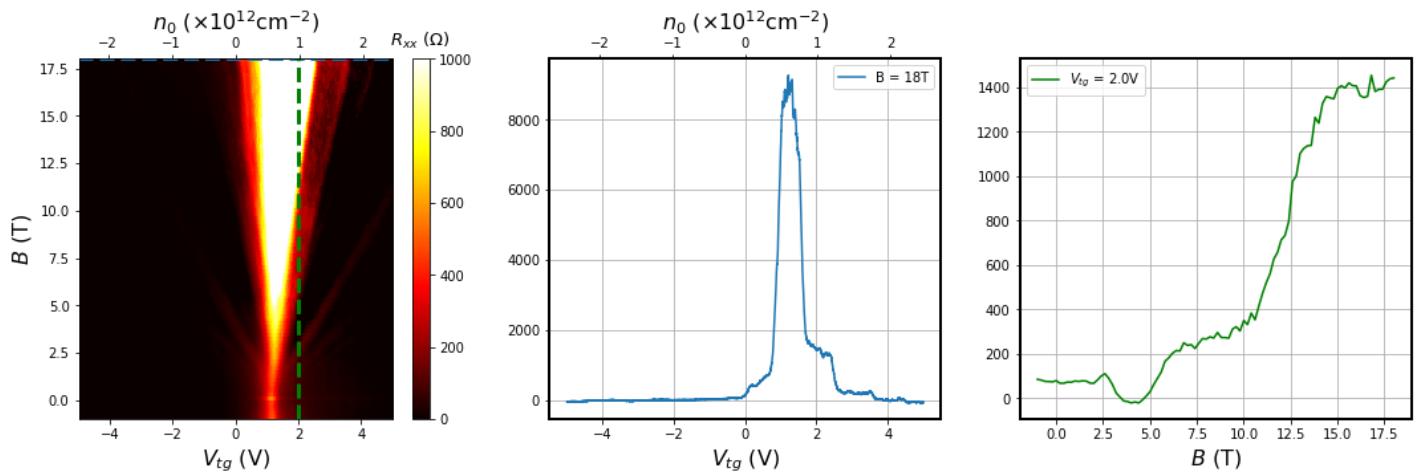


Fig. 4c four-terminal resistance between 2 and 14

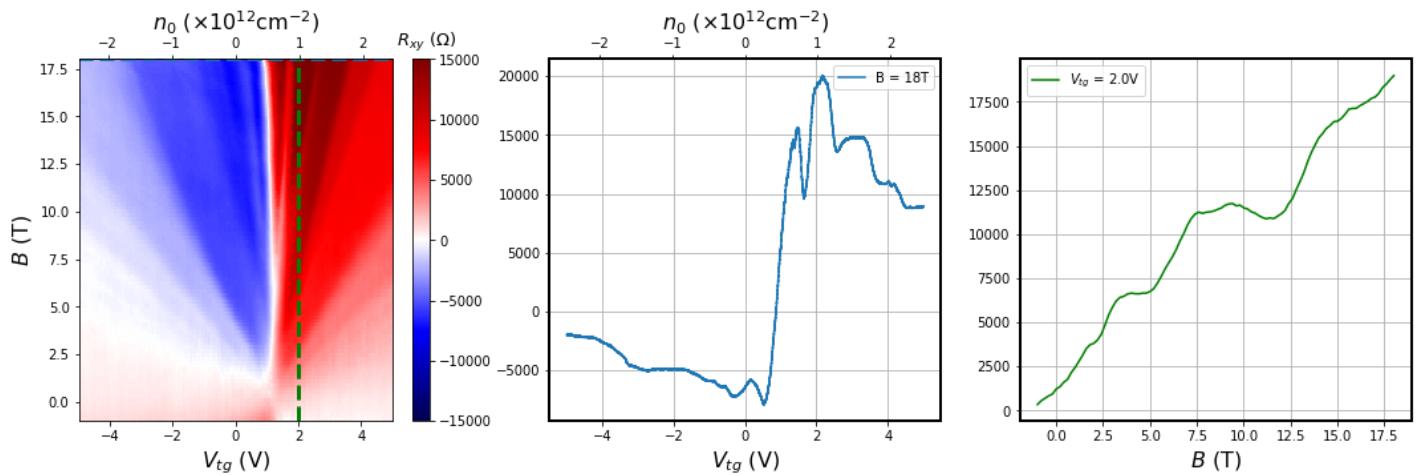


Fig. 4d four-terminal resistance between 3 and 12

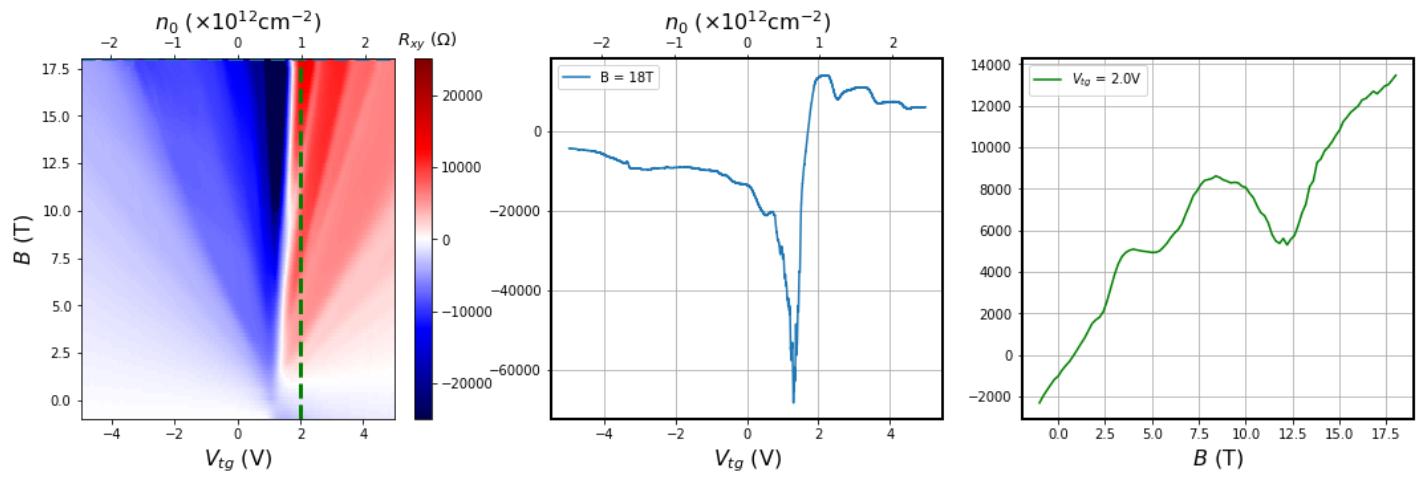
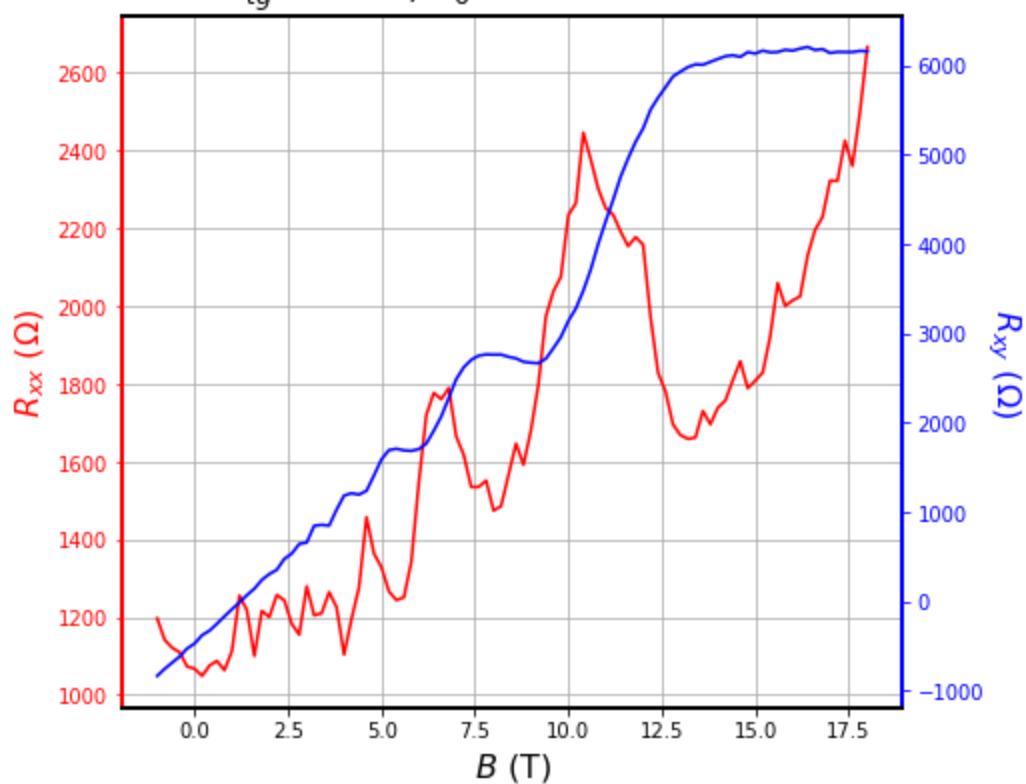
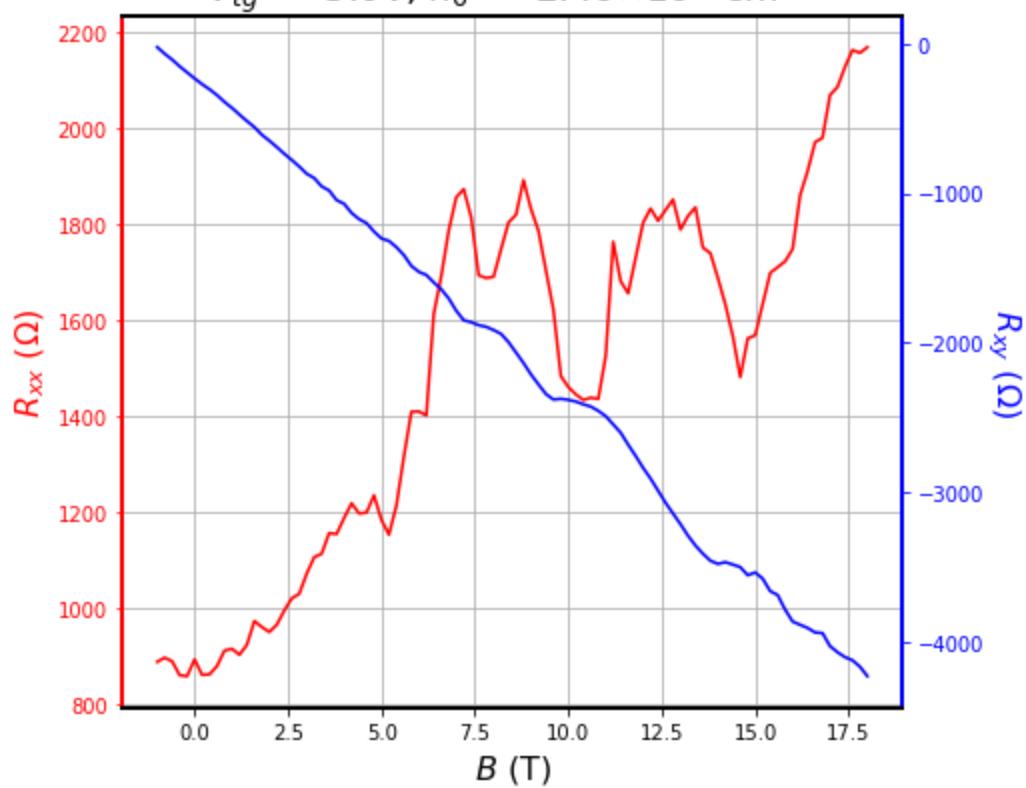


Fig. 4e plot linecuts of R_{xx} (2-3) and R_{xy} (3-12) at fixed V_{tg} together

$$V_{tg} = 5.0\text{V}, n_0 = 2.46 \times 10^{12}\text{cm}^{-2}$$



$$V_{tg} = -5.0\text{V}, n_0 = -2.46 \times 10^{12}\text{cm}^{-2}$$



5. "05 - Ramp B from 0 to -18T/" ($V_{tg} = +5\text{V}$, 10mV+100kOhm, 13Hz)

Out[19]:

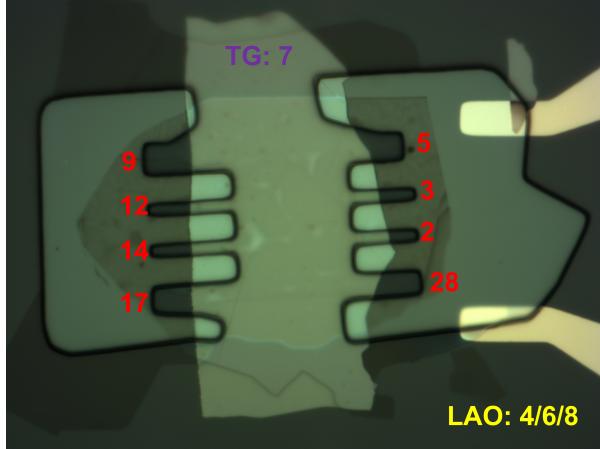
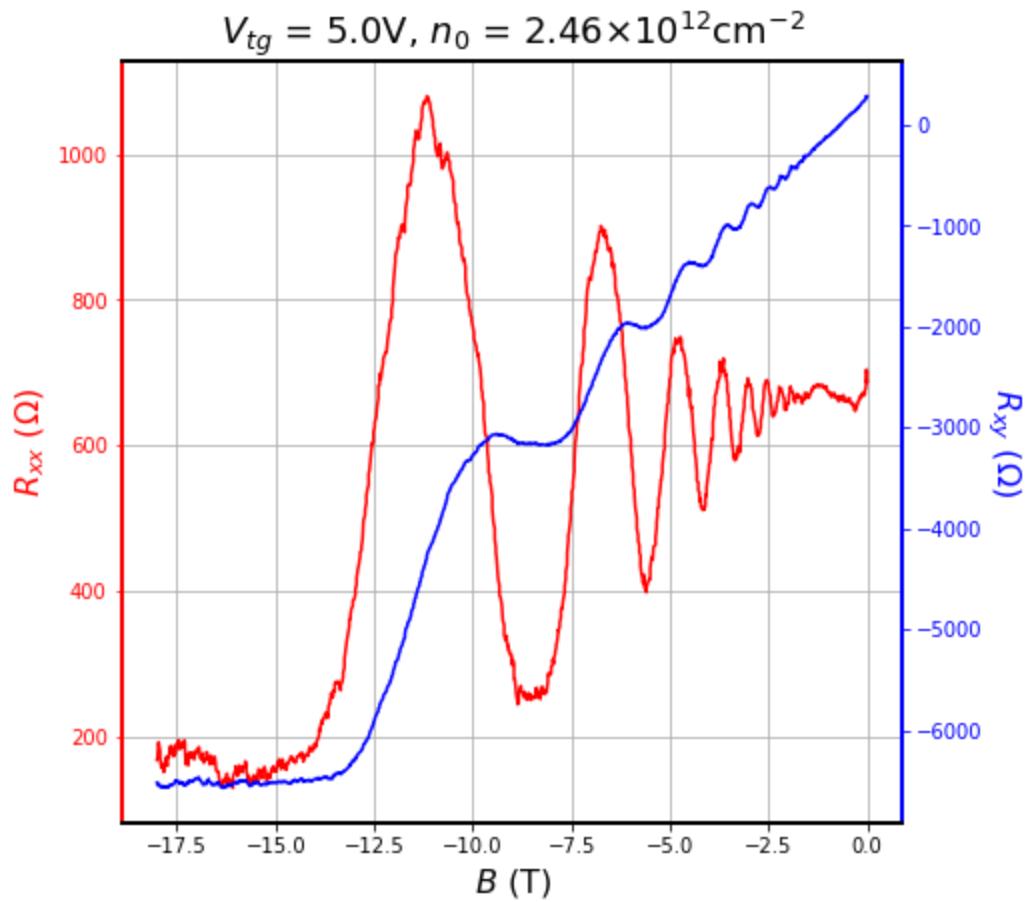
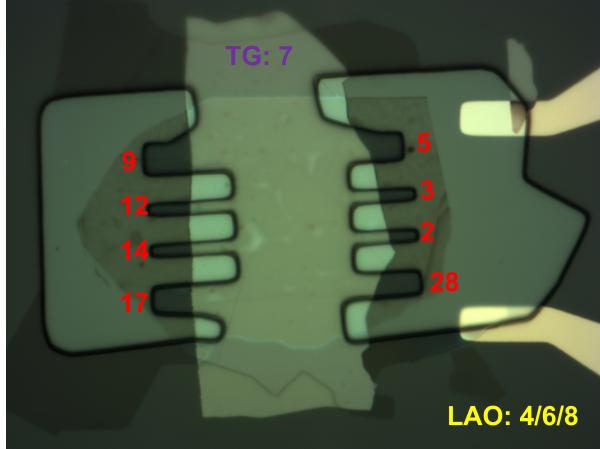


Fig. 5a SA40379A.20221115.000000.tdms (S/D = 17/9, B from 0 to -18T)
plot R_{xx} (2-3) and R_{xy} (3-12) together



6. "06 - B sweep Vtg sweep/" (S/D = 17/9, 10mV+100kOhm, 13Hz)

Out[21]:



SA40379A.20221115.000000.tdms to ...000180.tdms (S/D = 17/9, V_{tg} slow from +5V to -5V and fast back to +5V, B from -18T to +18T, step size 0.2T)

Note: len(data) = 10920, from +5 to -5V corresponds to 0-10400 (i.e. data[10400] = data at -5V)

Fig. 6a four-terminal resistance between 14 and 12

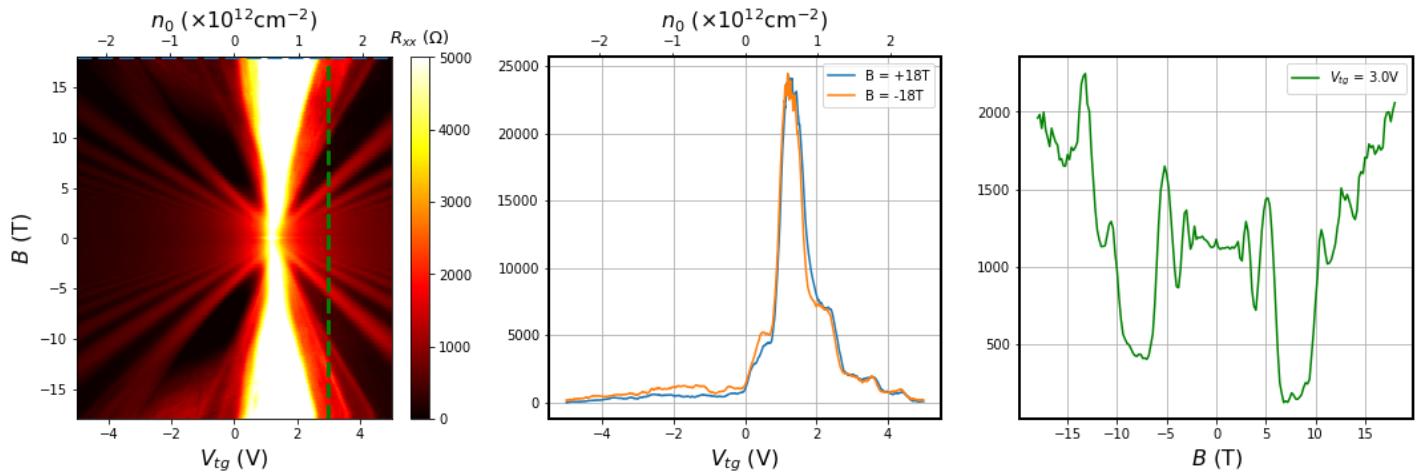


Fig. 6b four-terminal resistance between 2 and 3

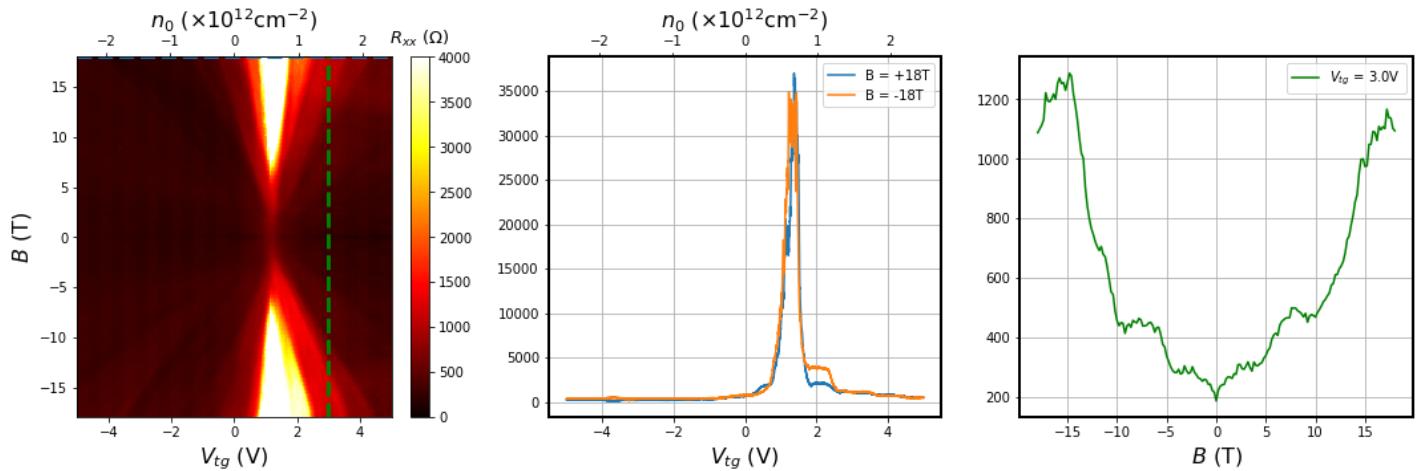


Fig. 6c four-terminal resistance between 2 and 14

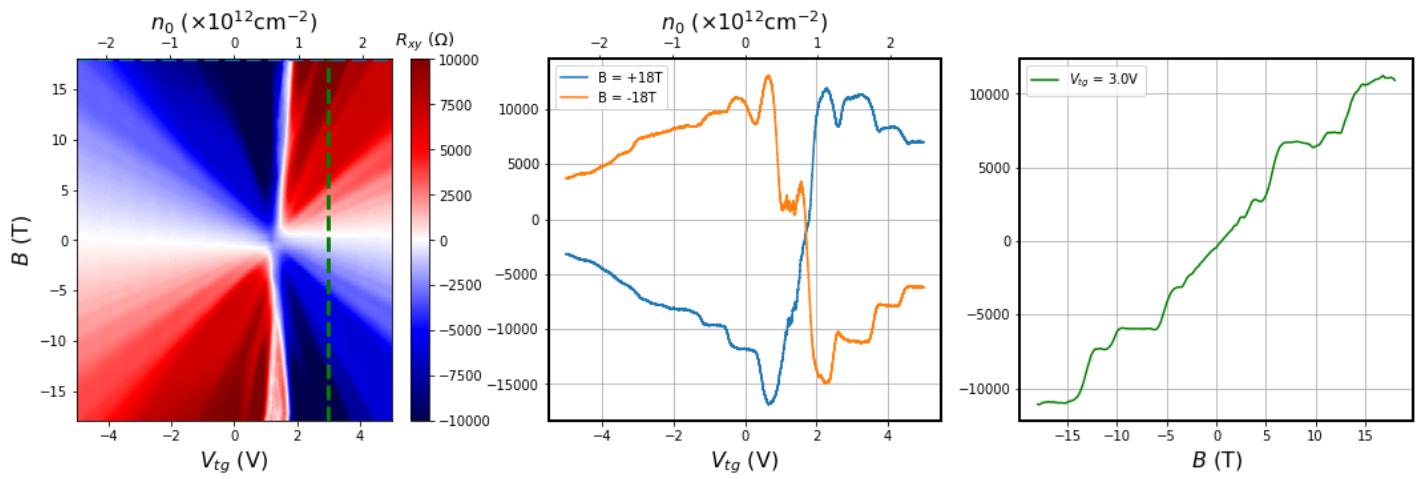


Fig. 6d four-terminal resistance between 3 and 12

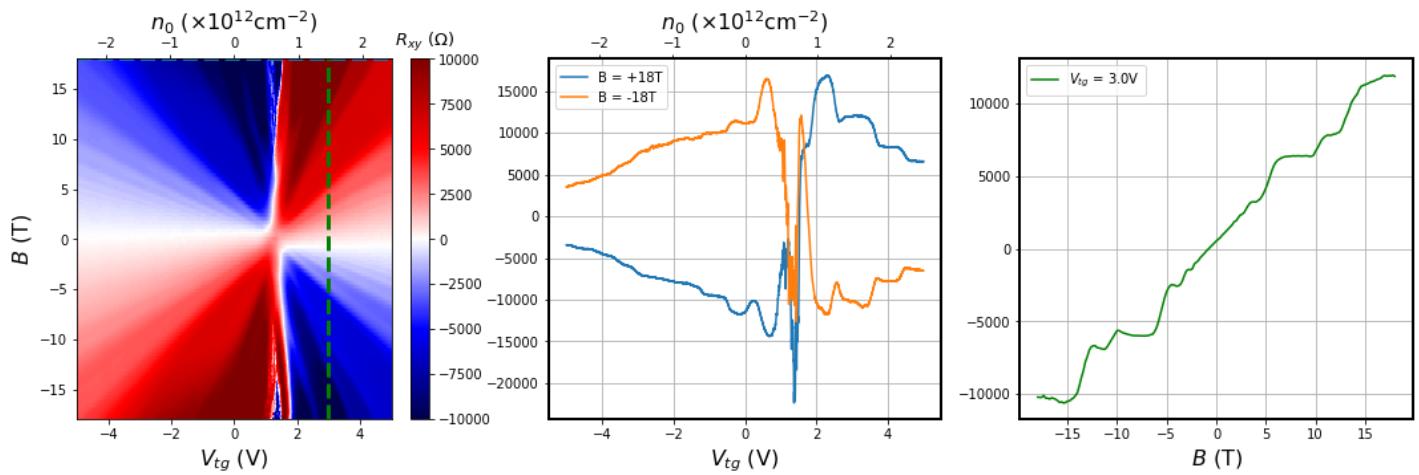
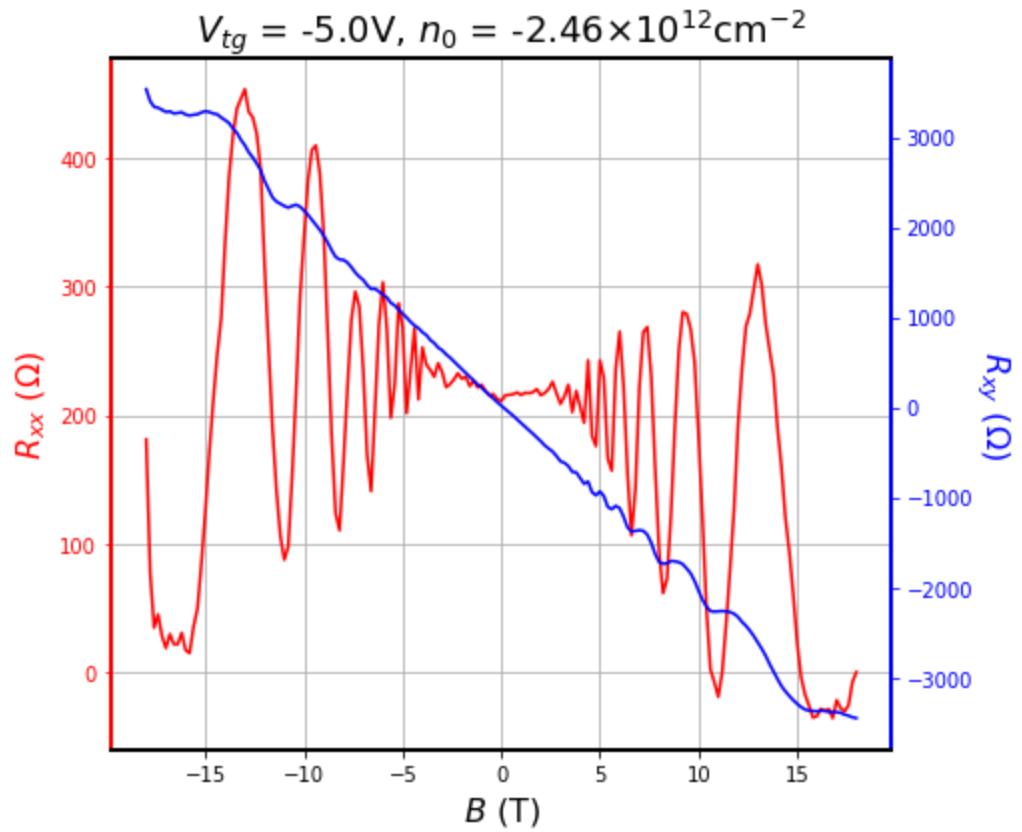
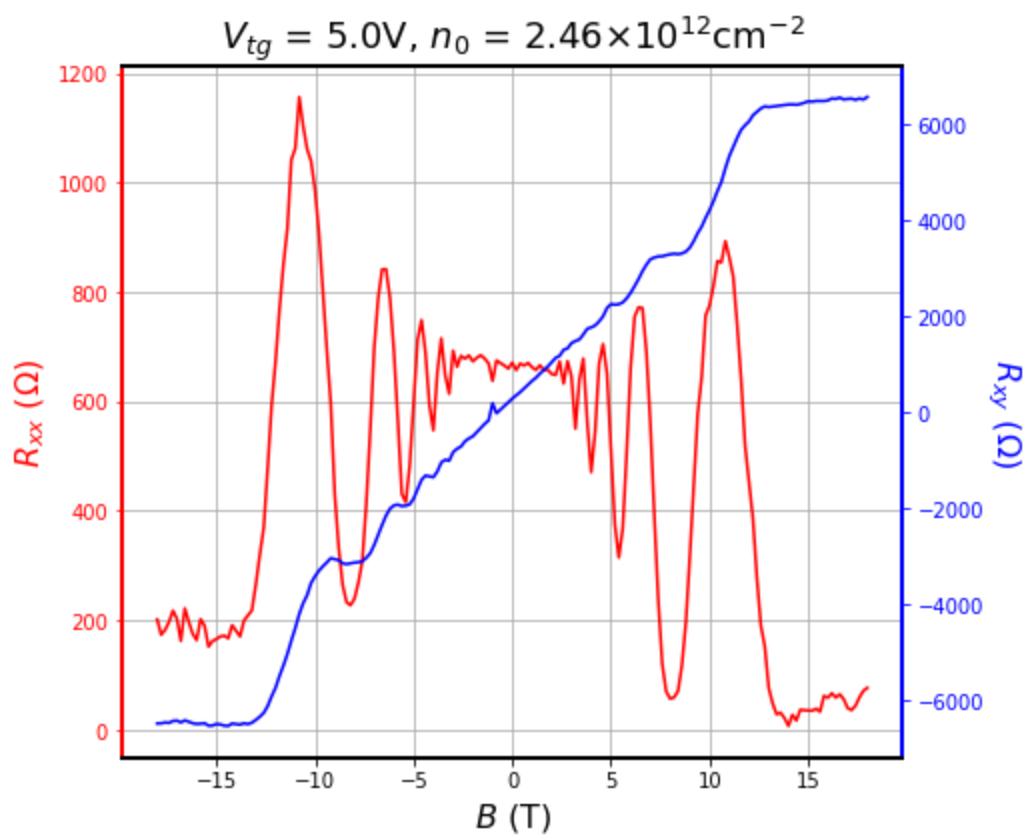


Fig. 6e plot linecuts of R_{xx} (14-12) and R_{xy} (3-12) at fixed V_{tg} together



(Anti-)symmetrization: $\rho_{xx}(B) = \frac{R_{xx}(B) + R_{xx}(-B)}{2}$,

$$\rho_{xy}(B) = \frac{R_{xy}(B) - R_{xy}(-B)}{2}$$

Fig. 6f post-symmetrization: four-terminal resistance between 14 and 12

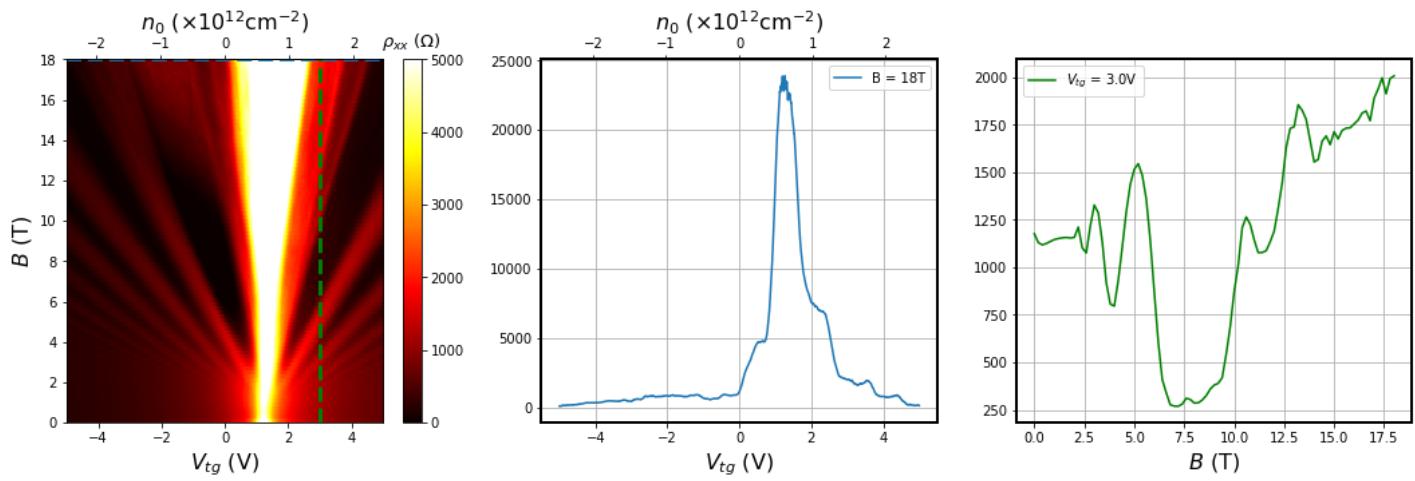


Fig. 6g post-symmetrization: four-terminal resistance between 2 and 3

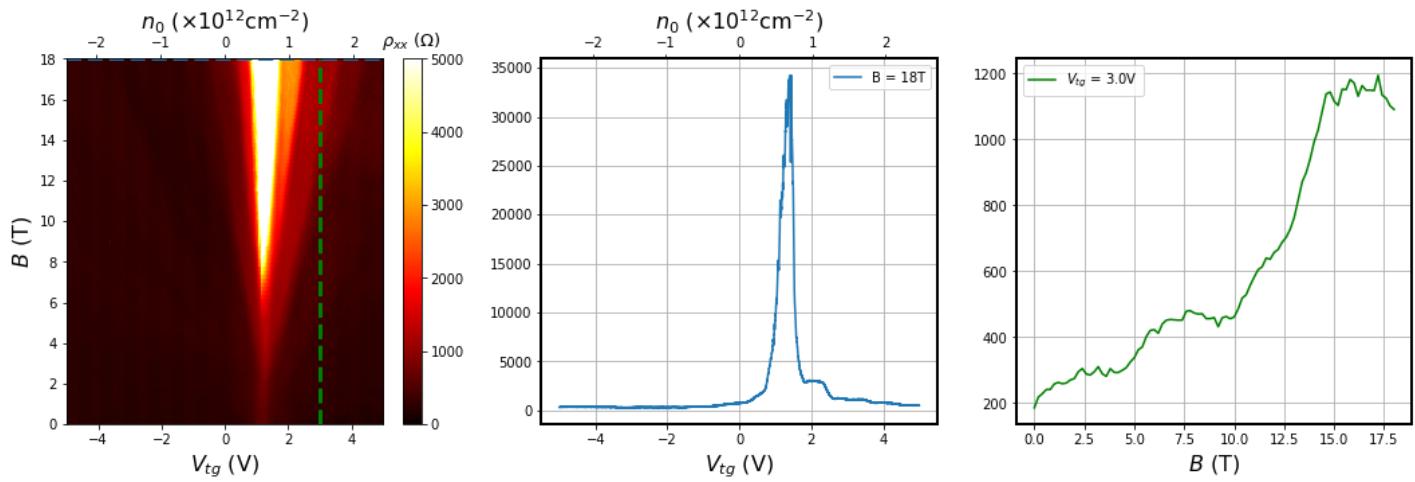


Fig. 6h post-symmetrization: four-terminal resistance between 2 and 14

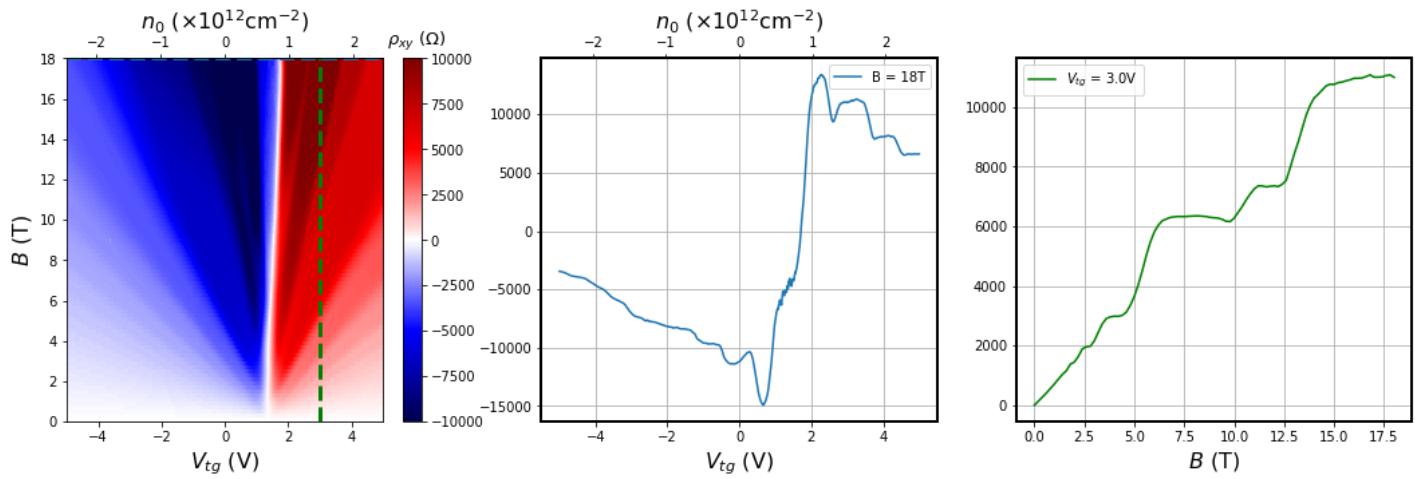


Fig. 6i post-symmetrization: four-terminal resistance between 3 and 12

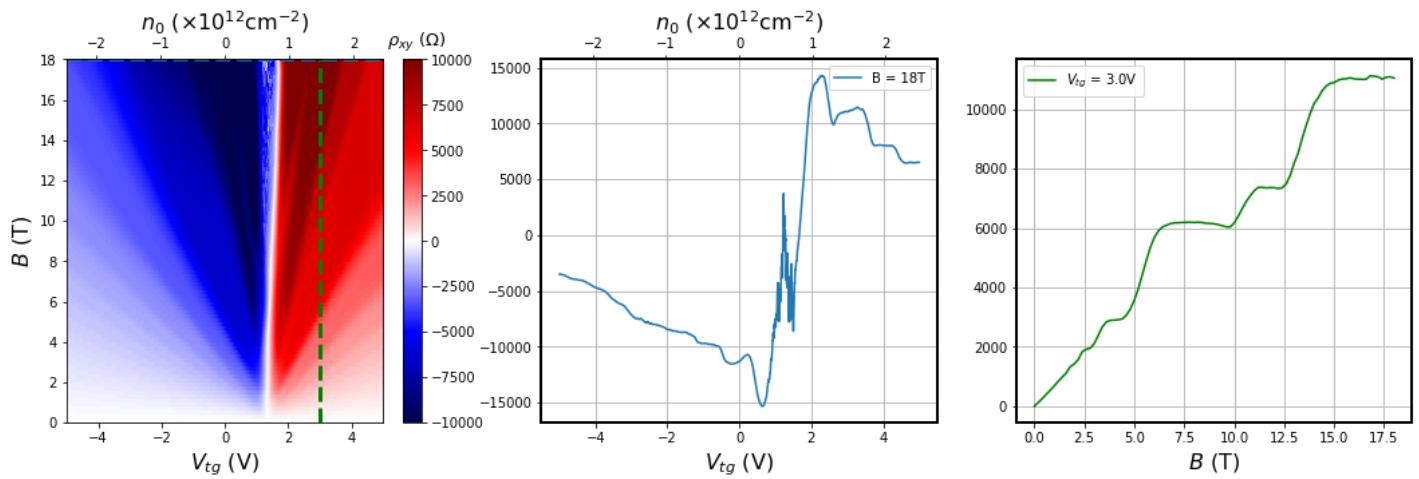
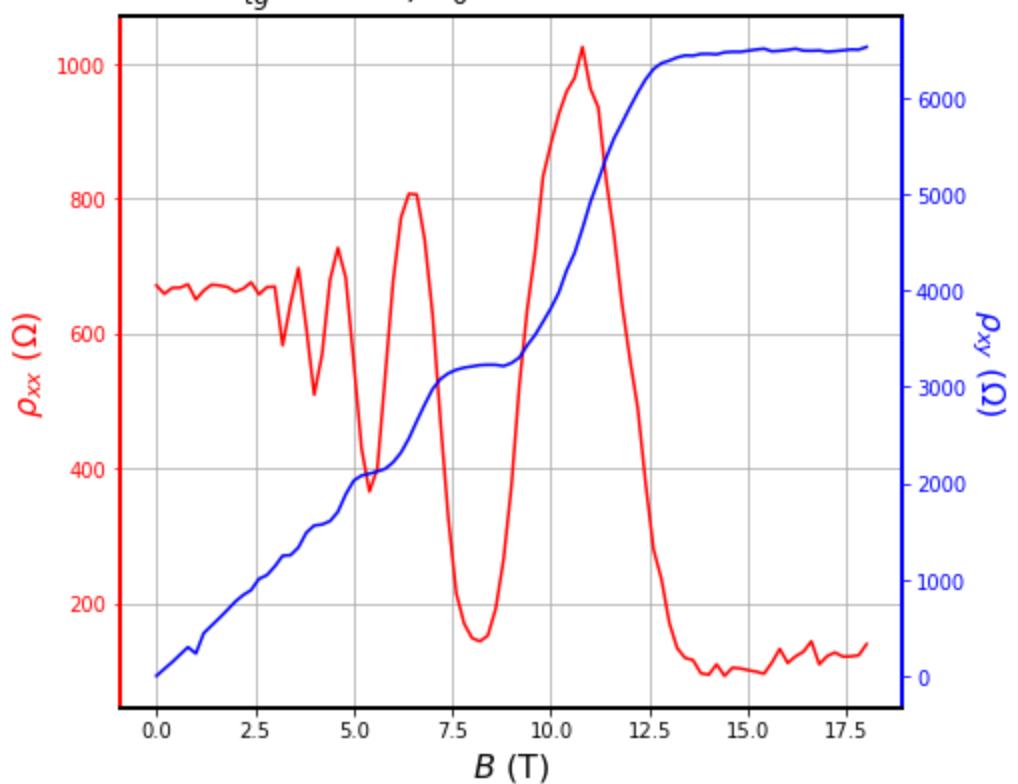
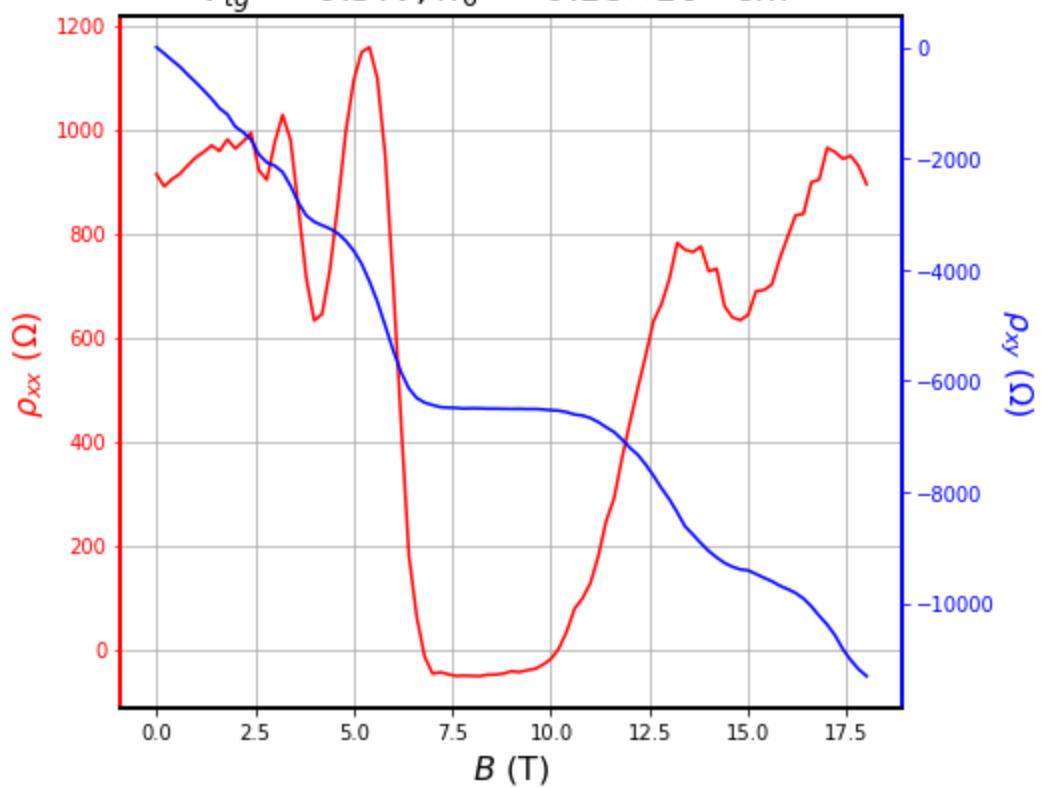


Fig. 6j post-symmetrization: plot linecuts of ρ_{xx} (14-12) and ρ_{xy} (3-12) at fixed V_{tg} together

$$V_{tg} = 5.0V, n_0 = 2.46 \times 10^{12} \text{cm}^{-2}$$



$$V_{tg} = -0.37V, n_0 = -0.18 \times 10^{12} \text{cm}^{-2}$$



7. "07 - Ramp B from 18 T to 0T/" ($V_{tg} = +5V$, 10mV+100kOhm, 13Hz)

Out[33]:

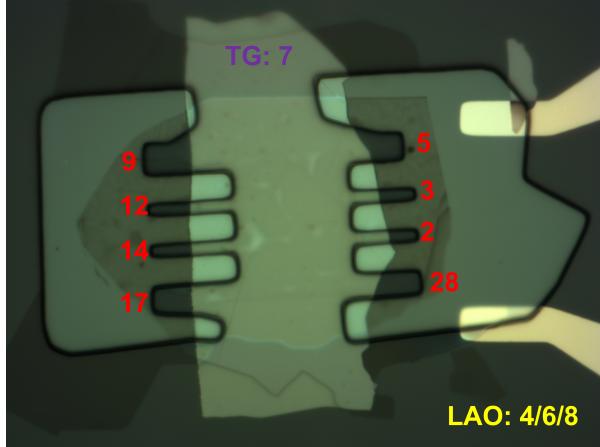
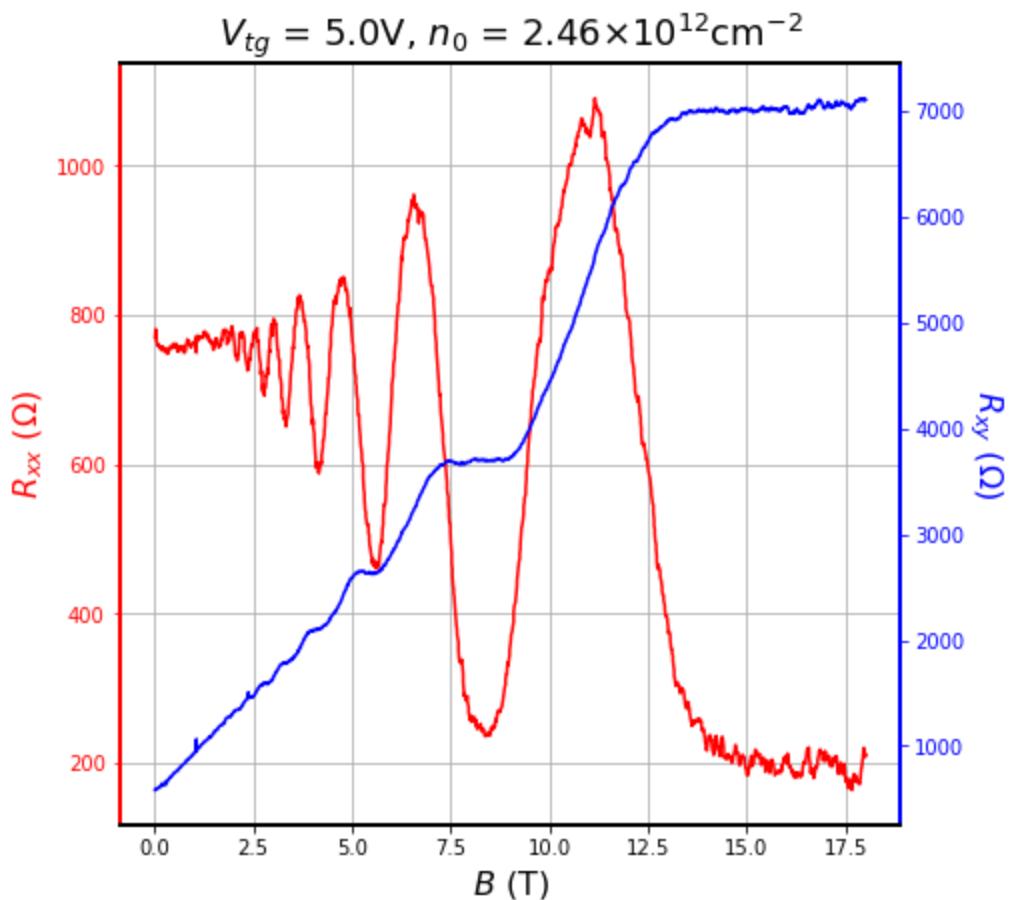


Fig. 7a SA40379A.20221115.000000.tdms (S/D = 9/17, B from 18T to 0)
plot R_{xx} (12-14) and R_{xy} (12-3) together



8. "08 - test/" is an empty folder.

Note that 4 is now a STO lead (no longer LAO) starting from here.

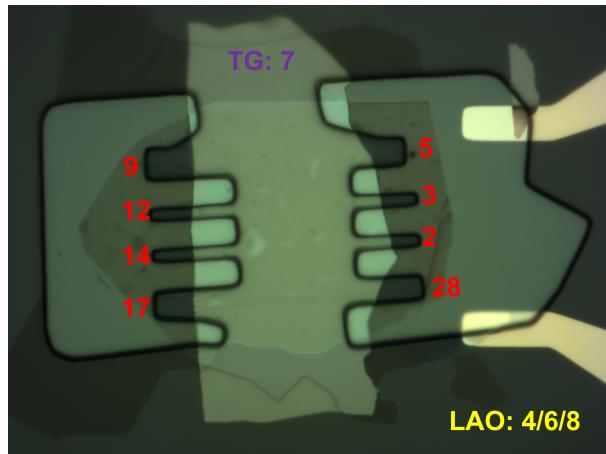
9. "09 - Vbg test/" (10mV+100kOhm, 13Hz)

9. "09 - Vbg test Vtg/" (10mV+100kOhm, 13Hz)

We explored and set the range of a dual-gate scan (V_{tg} , V_{STO}): (-5V, -25V) to (+5V, +25V). I feel no need to show these exploratory sweeps.

10. "10 - Vbg sweep Vtg sweep BOT/" ($B = 0$, 10mV+100kOhm, 13Hz)

Out[35]:



SA40379A.20221115.000000.tdms to ...000200.tdms (S/D = 17/9, V_{tg} slow from +5V to -5V and fast back to +5V, V_{STO} from +25V to -25V, step size 0.25V)

Note: len(data) = 8840, from +5 to -5V corresponds to 0-8320 (i.e. data[8320] = data at -5V)

Fig. 10a four-terminal resistance between 14 and 12

