



Electronics project

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Sec: 2

BN: 30

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Question 1:

the models that I have chosen

PMOS



default values

```
.MODEL MINT PMOS(Vto=-1.66 Kp=1.3807e-01 Nfs=1000000000000 Eta=0
+ Level=3 L=1e-4 W=1e-4 Gamma=0 Phi=0.6 Is=1e-24
+ Js=0 Pb=0.8 Cj=0 Cjsw=0 Cgso=0 Cgdo=0 Cgbo=0
+ Tox=1e-07 Xj=0
+ U0=600 Vmax=3000)
*+ U0=600 Vmax=1000)
.MODEL DBD D(Bv=63.00 Ibv=2.00E-06 Rs=1E-6 Is=1.48118796889277e-15
+ N=1 M=0.33 VJ=0.53 Fc=0.5 Cjo=1.144e-11 Tt=1.85e-08)
```

NMOS



default values

```
.MODEL MINT NMOS(Vto=1.975 Kp=1.0 Nfs=300000000000000 Eta=1000
+ Level=3 L=1e-4 W=1e-4 Gamma=0 Phi=0.6 Is=1e-24
+ Js=0 Pb=0.8 Cj=0 Cjsw=0 Cgso=0 Cgdo=0 Cgbo=0
+ Tox=1e-07 Xj=0
+ U0=600 Vmax=1000)
.MODEL DBD D(Bv=80.00 Ibv=1.00E-05 Rs=1E-6 Is=5e-15
+ N=1 M=0.5 VJ=0.5 Fc=0.5 Cjo=9.64e-12 Tt=3e-08)
```

Analytical Solution

in multisim $k_p(\text{Transconductance parameter}) = \mu_{ox}$

$$V_{thP} = -1.66 \text{ V}$$

$$K_P = 1.3807 \times 10^{-1} \text{ A/V}^2$$

$$L_P = 100 \times 10^{-6}$$

$$\left\{ \begin{array}{l} V_{thN} = 1.975 \text{ V} \\ K_N = 1 \text{ A/V}^2 \\ L_N = 100 \times 10^{-6} \end{array} \right.$$

$$V_M = \frac{V_{DD} - |V_{thP}| + \sqrt{a} V_{thN}}{1 + \sqrt{a}}$$

$$5.5 = \frac{12 - 1.66 + 1.975\sqrt{a}}{1 + \sqrt{a}}$$

$$10.34 + 1.975\sqrt{a} = 5.5 + 5.5\sqrt{a}$$

$$3.825\sqrt{a} = 4.84$$

$$\sqrt{a} = \frac{968}{705}$$

$$a = \left(\frac{968}{705} \right)^2$$

$$a = \frac{K_N \frac{W_N}{L_N}}{K_P \frac{W_P}{L_P}}$$

$$\left(\frac{968}{705} \right)^2 = \frac{W_N}{1.3807 \times 10^{-1} W_P}$$

$$W_N = 0.2602985839 W_P$$

$$\text{let } W_P = 291.5 \times 10^{-6} \text{ m}$$

$$\therefore W_N = 75.87703721 \times 10^{-6} \text{ m}$$

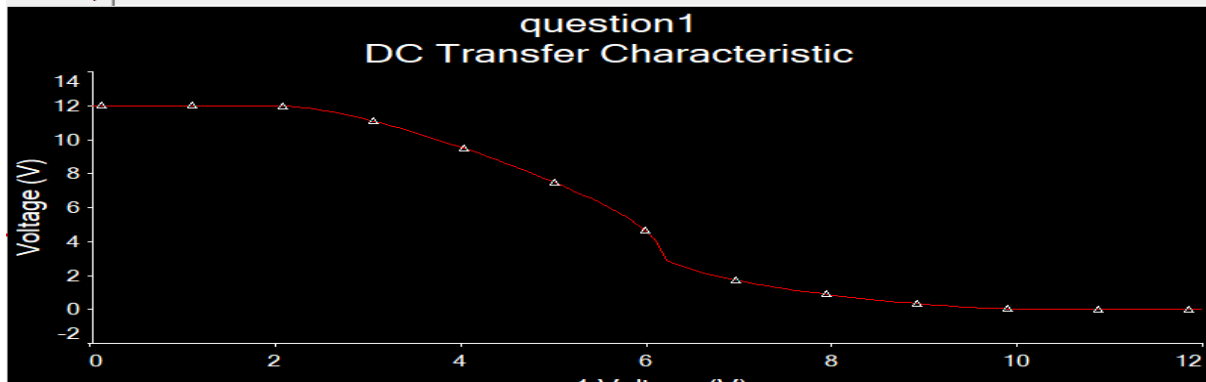
Why did I choose $w_p=291.5e-6$ m ?
at the beginning i assumed $w_p=250e-6$
trials

trial 1

$w_p=250e-6$

$w_n=65.07464598e-6$

$v_{out}=6.24v$



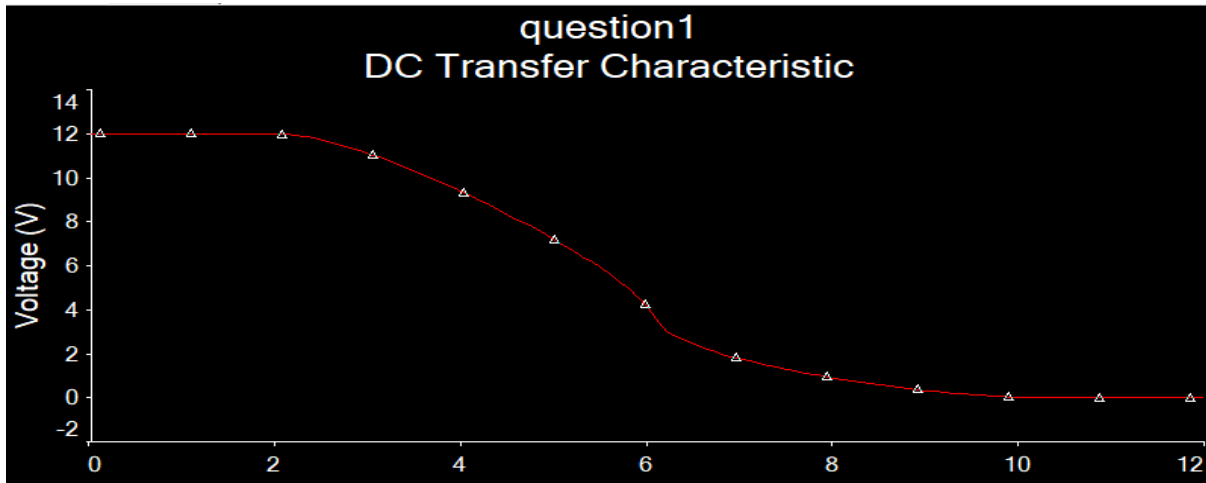
trial 2

try to increase it

$w_p=270e-6$

$w_n=70.28061765e-6$

$v_{out}=5.88v$



trial 3

try to increase it

$w_p=290e-6$

$w_n=75.48658933e-6$

$v_{out}=5.52v$ it is to close to 5.5v

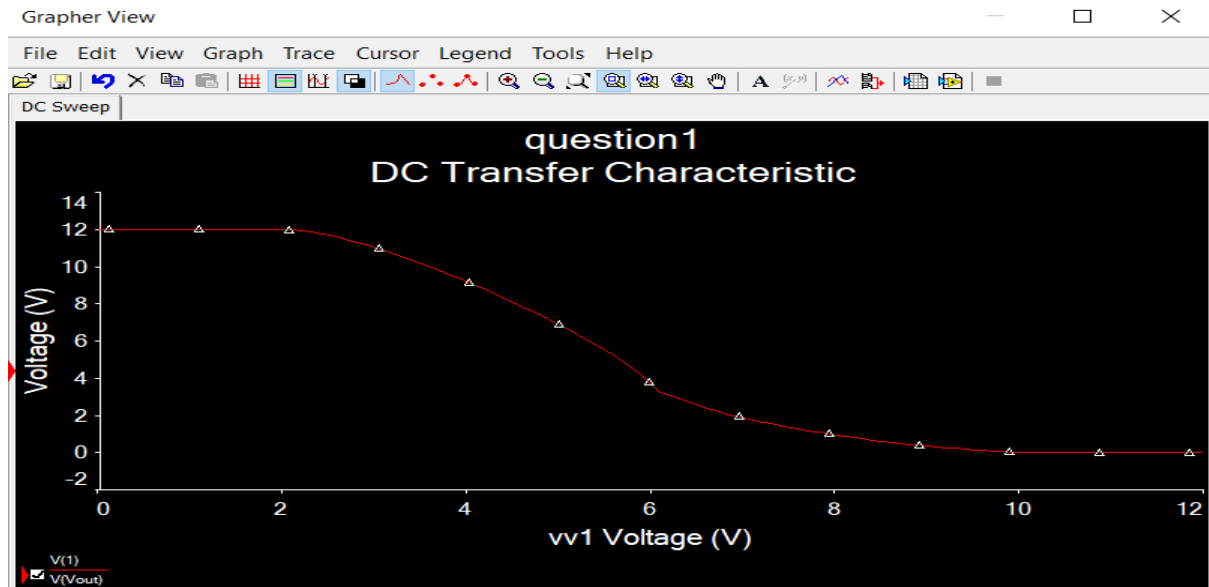
last trial

try to increase it by very small value

$w_p=291.5e-6$

$w_n=75.87703721e-6$

$v_{out}=5.5v$ it is exactly 5.5



Results

what i noticed during assuming the values of w_p and from dc characteristics

I started with $w_p=250e-6$ and got $v_{out}=6.24v$ i noticed that when I increased w_p

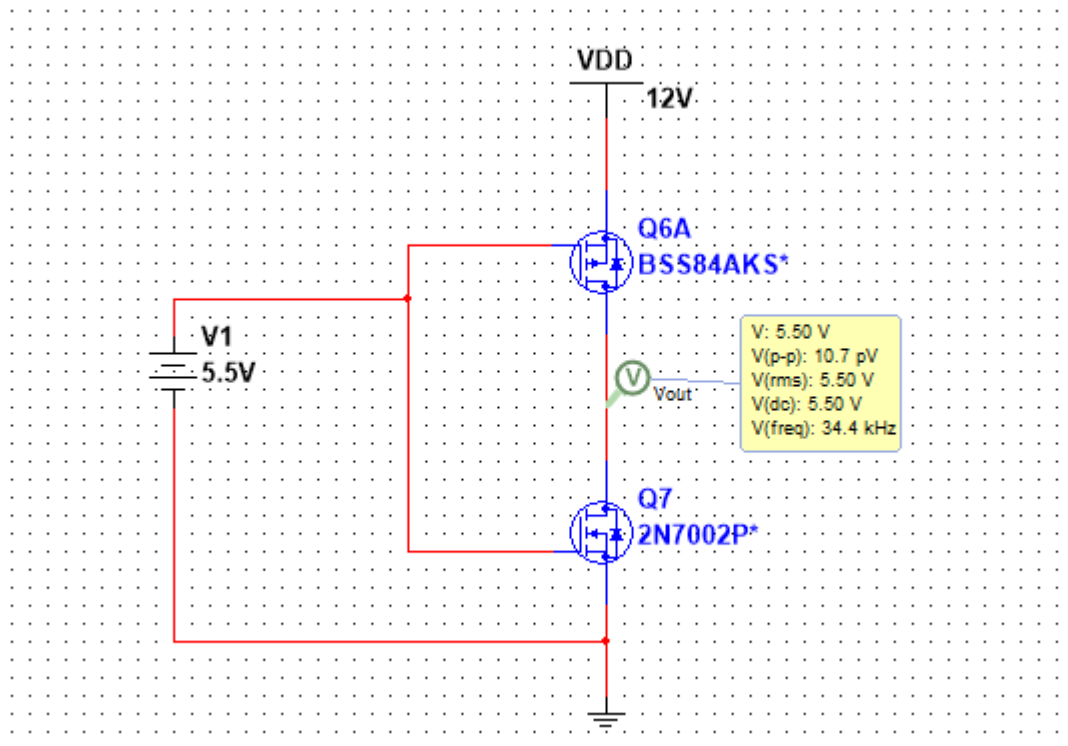
and getting w_n from ratio I found that the value of v_{out} is going to reach 5.5

so I kepted increasing w_p till I found a value that makes $v_{out}=5.5v$

the value is $w_p=291.5e-6m$

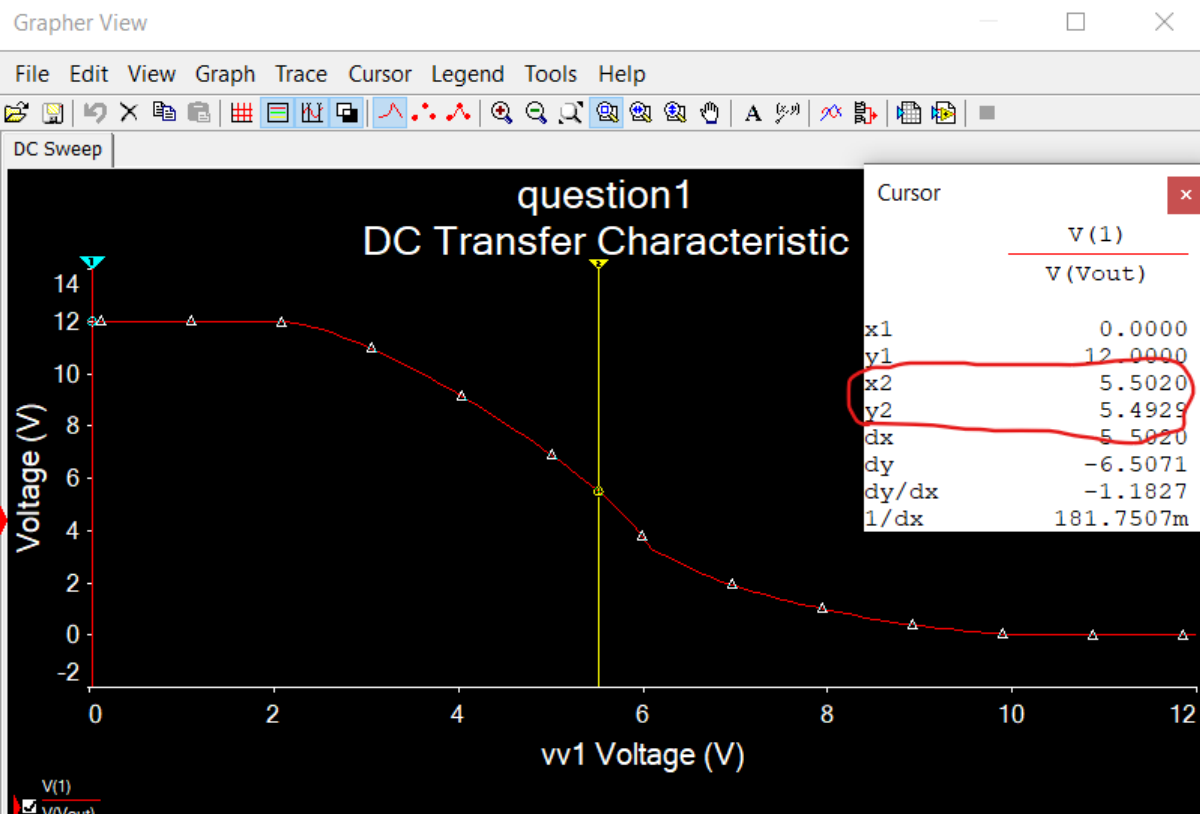
and getting w_n from ratio $w_n= 75.87703721e-6$

by substitution of this values in the model



I get that $v_{out}=5.5$ which is the trip point

Dc static characteristics

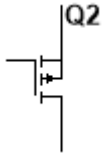


Question 2:

the models that I have chosen

PMOS

i choose the model



it has a $v_{th}=0$ so i sets its values according to the model

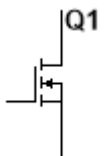


default values

```
.MODEL MINT PMOS (Vto=-1.9033423414524 Kp=3.7372e-01
```

NMOS

i choose the model



default values

it has a $v_{th}=0$ so i sets its values according to the model



```
.MODEL MINT NMOS (Vto=1.9 Kp=0.95 1
```

why i choose MOS_P and MOS_N (virtual model) and setting its values by the modeles BSH201 and 2N7002BK (real model) because while using real model in simulation i get this message

Simulation Error



A simulation error has occurred. Would you like to run the Convergence Assistant to attempt to resolve this problem automatically?

Yes

No

so i used MOS_N and MOS_P and setting its values by real values this message always appears while using real model in this ex

Analytical solution

in multisim $k_p(\text{Transconductance parameter}) = u_{cox}$

$$V_{thp} = -1.9033423414524 \text{ V}$$

$$V_{pox} = K_p = 3.7372 \times 10^{-1} \text{ A/V}^2$$

$$L_p = 100 \times 10^{-6} \text{ m}$$

$$T_{PLH} = R_{onp} C_L \left[\frac{2|V_{thp}|}{V_{DD} - |V_{thp}|} + \ln\left(3 - 4 \frac{|V_{thp}|}{V_{DD}}\right) \right]$$

$$70 \times 10^{-15} = R_{onp} (1 \times 10^{-12}) \left[\frac{2 \times 1.9033423414524}{12 - 1.9033414524} + \ln\left(3 - 4 \frac{1.9033423414524}{12}\right) \right]$$

$$R_{onp} = 0.05654117264 \text{ } \Omega$$

$$R_{onp} = \frac{1}{K_p \frac{W_p}{L_p} (V_{DD} - |V_{thp}|)}$$

$$0.05654117264 = \frac{1}{3.7372 \times 10^{-1} \frac{W_p}{100 \times 10^{-6}} (12 - 1.9033423414524)}$$

$$W_p = 468.717 \times 10^{-6} \text{ m}$$

$$V_{thN} = 1.9 \text{ V}$$

$$V_{NGS} = V_{thN} = 0.95 \text{ A/V}^2$$

$$I_N = 100 \times 10^{-6}$$

$$T_{PHL} = R_{thN} C_L \left[\frac{2 V_{thN}}{V_{DD} - V_{thN}} + \ln \left(3 - 4 \frac{V_{thN}}{V_{DD}} \right) \right]$$

$$70 \times 10^{-15} = R_{thN} (1 \times 10^{-12}) \left[\frac{2(1.9)}{12 - 1.9} + \ln \left(3 - 4 \frac{1.9}{12} \right) \right]$$

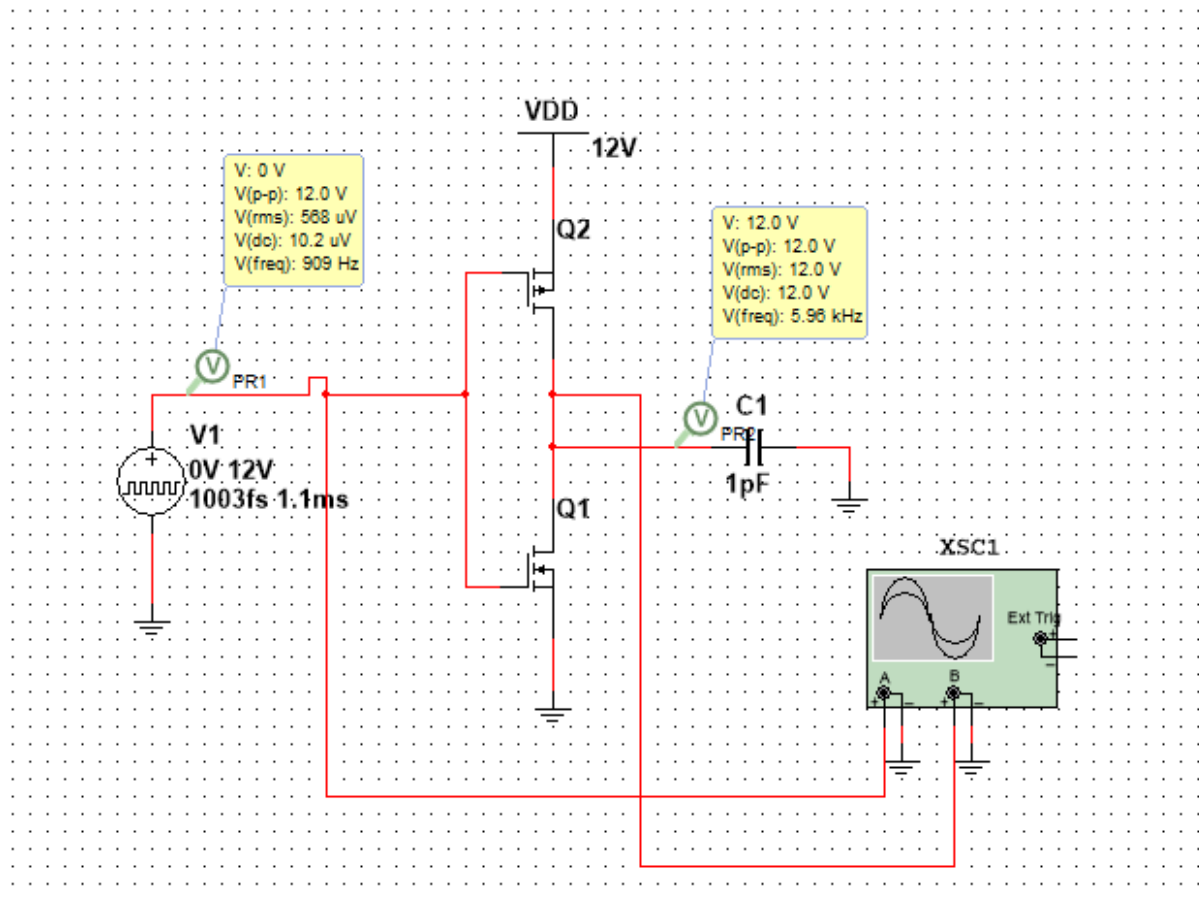
$$R_{thN} = 0.05655559679$$

$$R_{thN} = \frac{1}{K_n \frac{W}{L}_n (V_{DD} - V_{thn})}$$

$$0.05655559679 = \frac{1}{0.95 \frac{W_N}{100 \times 10^{-6}} (12 - 1.9)}$$

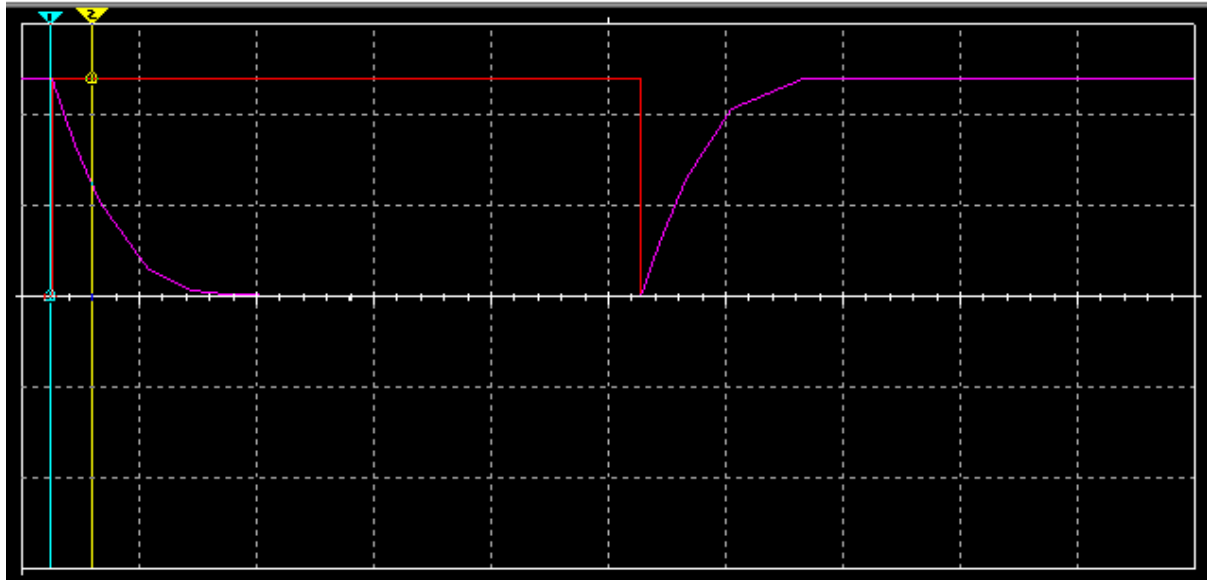
$$W_N = 184.28 \times 10^{-6} \text{ m}$$

Design



TpHL

Oscilloscope-XSC1



	Time	Channel_A	Channel_B
T1	48.387 fs	0.000 V	12.000 V
T2	119.355 fs	12.000 V	6.223 V
T2-T1	70.968 fs	12.000 V	-5.777 V

Reverse

Save

Ext. trigger ☐

Timebase

Scale: 200 fs/Div

X pos.(Div): 0

Channel A

Scale: 5 V/Div

Y pos.(Div): 0

Channel B

Scale: 5 V/Div

Y pos.(Div): 0

Trigger

Edge: ☐ F ☐ L ☒ A ☐ B ☐ Ext

Level: 0 V

Single Normal Auto None

Y/T Add B/A A/B

AC 0 DC

AC 0 DC -

TpLH

Oscilloscope-XSC1

