

Lab. 07

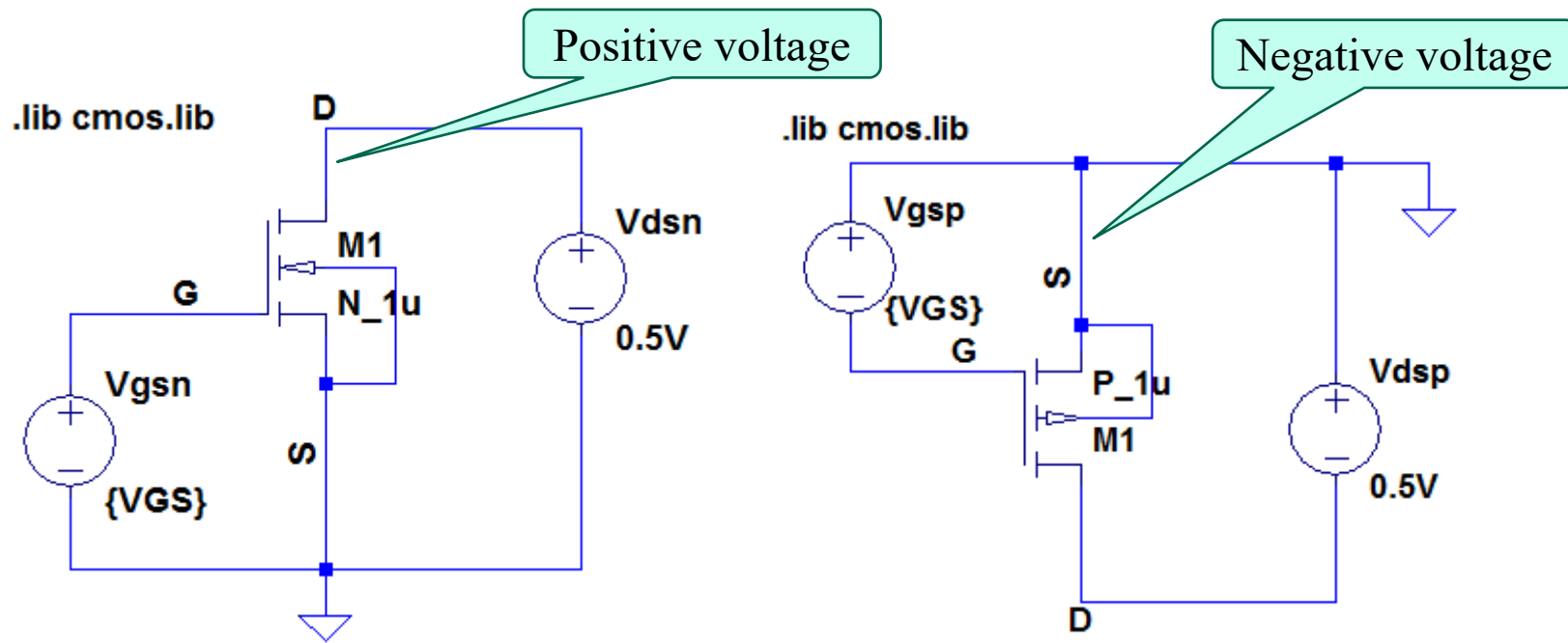
SUMMARY OF MOSFET CHARACTERISTICS

1. DC parameters of MOSFET

1. Estimate the DC parameters of MOSFET N_1u, P_1u by the circuit simulation.

<i>MOSFET model</i>	<i>N_1u</i>	<i>P_1u</i>	<i>Remarks</i>
L [m]	2u	2u	Gate length
W/L	10	10	Gate width/L
AD [m ²]	60p	60p	Area of drain
AS [m ²]	60p	60p	Area of source
PD [m]	26u	26u	Periphery of drain
PS [m]	26u	26u	Periphery of source
Multiplier	1	1	Number of fingers
V _{DS} [V]	0 – 5.0	0 – 5.0	
V _{GS} [V]	0 – 5.0	0 – 5.0	
V _T [V]			
K _p =μC _{OX} [A/V ²]			@ Δ _{OV} = 0.2 [V]
			@ Δ _{OV} = 0.4 [V]
λ [V ⁻¹]			@ Δ _{OV} = 0.2 [V]
			@ Δ _{OV} = 0.4 [V]

Measuring circuits



For n-ch MOSFET

For p-ch MOSFET

MOSFET properties

For n-ch MOSFET

Monolithic MOSFET - M1

Model Name:	N_1u	OK
Length(L):	2u	Cancel
Width(W):	20u	
Drain Area(AD):	60p	
Source Area(AS):	60p	
Drain Perimeter(PD):	26u	
Source Perimeter(PS):	26u	
No. Parallel Devices(M):	1	

N_1u l=2u w=20u ad=60p as=60p pd=26u ps=26u m=1

For p-ch MOSFET

Monolithic MOSFET - M2

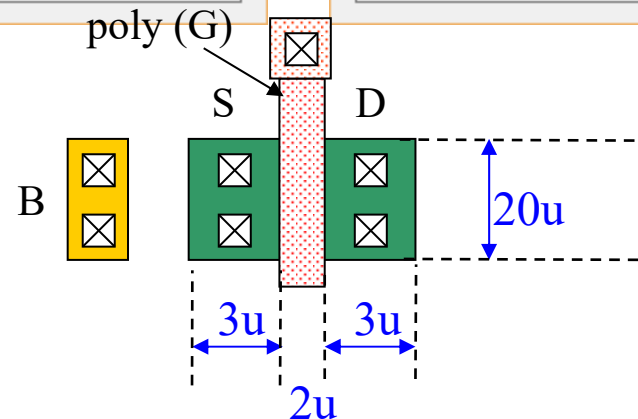
Model Name:	P_1u	OK
Length(L):	2u	Cancel
Width(W):	20u	
Drain Area(AD):	60p	
Source Area(AS):	60p	
Drain Perimeter(PD):	26u	
Source Perimeter(PS):	26u	
No. Parallel Devices(M):	1	

P_1u l=2u w=20u ad=60p as=60p pd=26u ps=26u m=1

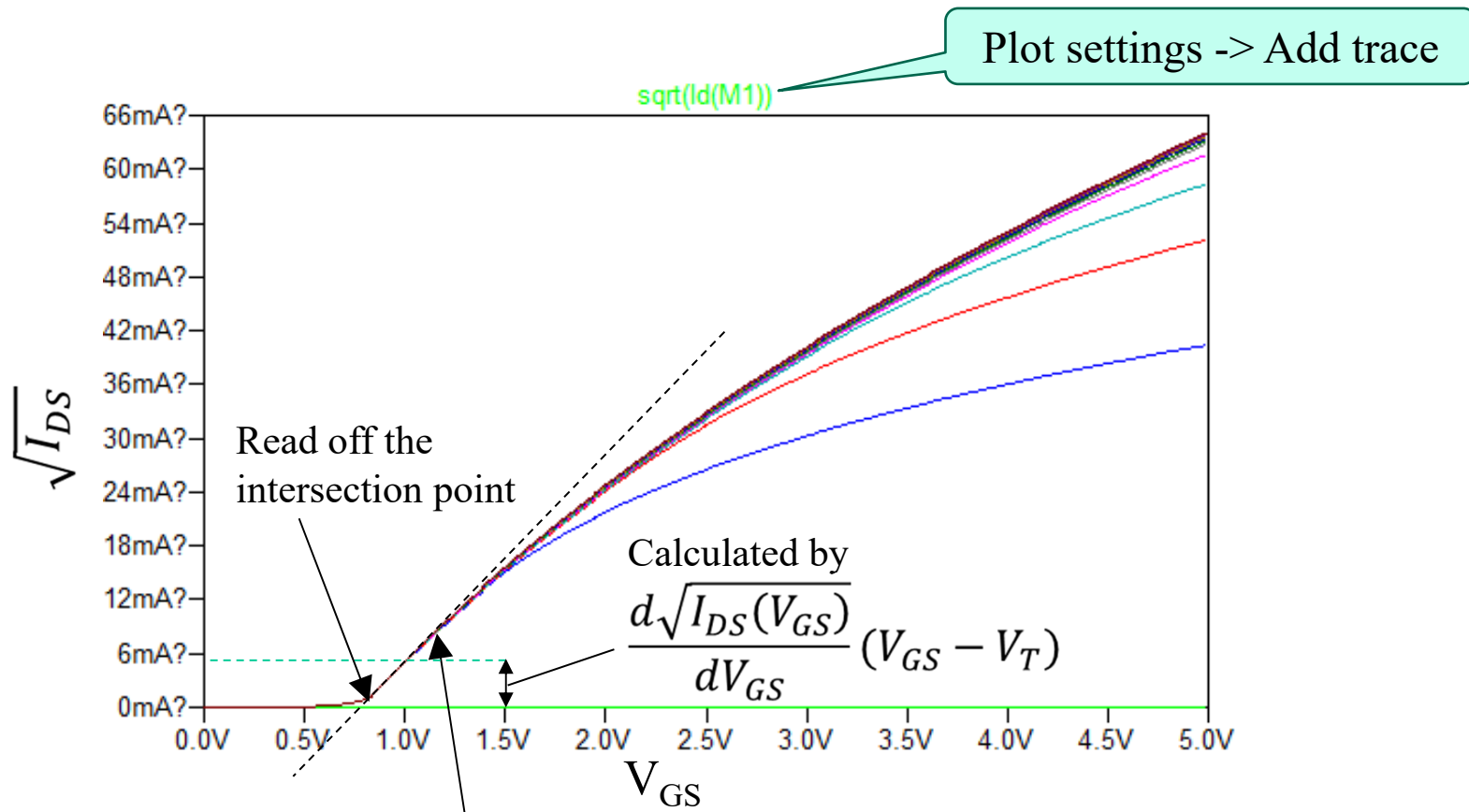
Drain area

Drain perimeter

Multiplier



Estimation of V_T from the plot



Find the linear region in neighborhood of the threshold.

[Note] You can estimate from the V_T for $g_m - V_{GS}$ characteristic too.

Estimation of V_T by .meas directive

```
.param VGS=0V
```

```
.dc Vgsn 0V 5V 0.001V
```

Read command for the expression

```
.meas dc VTN find V(G)-sqrt(Id(M1))/(d(sqrt(Id(M1)))/d(V(G))) when Vgsn=1.0V
```

Type of analysis

Label of the result

Expression of V_T
(See last slide)

Measurement condition

- Procedure to read the results
 1. Click the graph window
 2. Menu bar: View – SPICE Error Log
 3. Read the calculation result of V_T ($V_{dsn} = 0.5V$ in saturation region)

Estimation of $K_p(\mu C_{OX})$ by .meas

```
.param VGS=0V
```

```
.param VTN=0.777V
```

Set the parameter V_T at the estimated value

```
.step param VOV list 0.2V 0.4V
```

Step the parameter Δ_{ov} at 0.2V and 0.4V

```
.dc Vgsn 0V 5V 0.001V
```

```
.meas dc KP find  $2 * Id(M1) / 10 / VOV ** 2$  when Vgsn=VTN+VOV
```

Expression of μC_{OX} (See Ch.3)

Measurement condition

Estimation of λ by .meas

```
.param VTN=0.777V
```

```
.step param VOV list 0.2V 0.4V
```

```
.param VGS=VTN+VOV
```

```
.dc Vdsn 0V 5V 0.001V
```

```
.meas dc LAMBDA find 1/(Id(M1))*d(Id(M1))/d(V(D)) when Vdsn=VOV
```

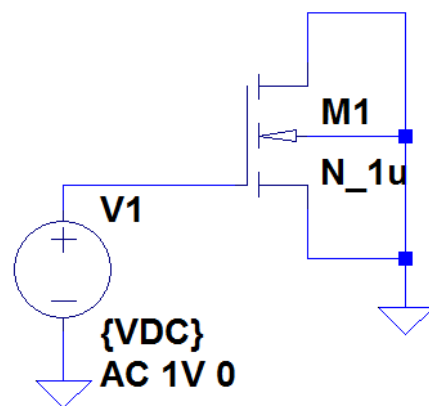
Set the parameter
of V_{GS}

Set the measurement condition of
 $V_{DS} = \Delta_{OV}$

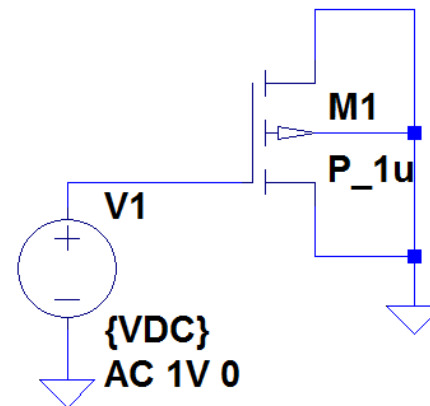
Expression of LAMBDA
parameter (See Ch.3)

2. AC parameters of MOSFET

1. Simulate the C-V characteristics of MOSFET N_1u, P_1u with the circuit simulator. Take account of the serial resistance in the C-V measurement circuits. The MOSFET properties are same as the circuit of I-V characteristic (Slide 4).

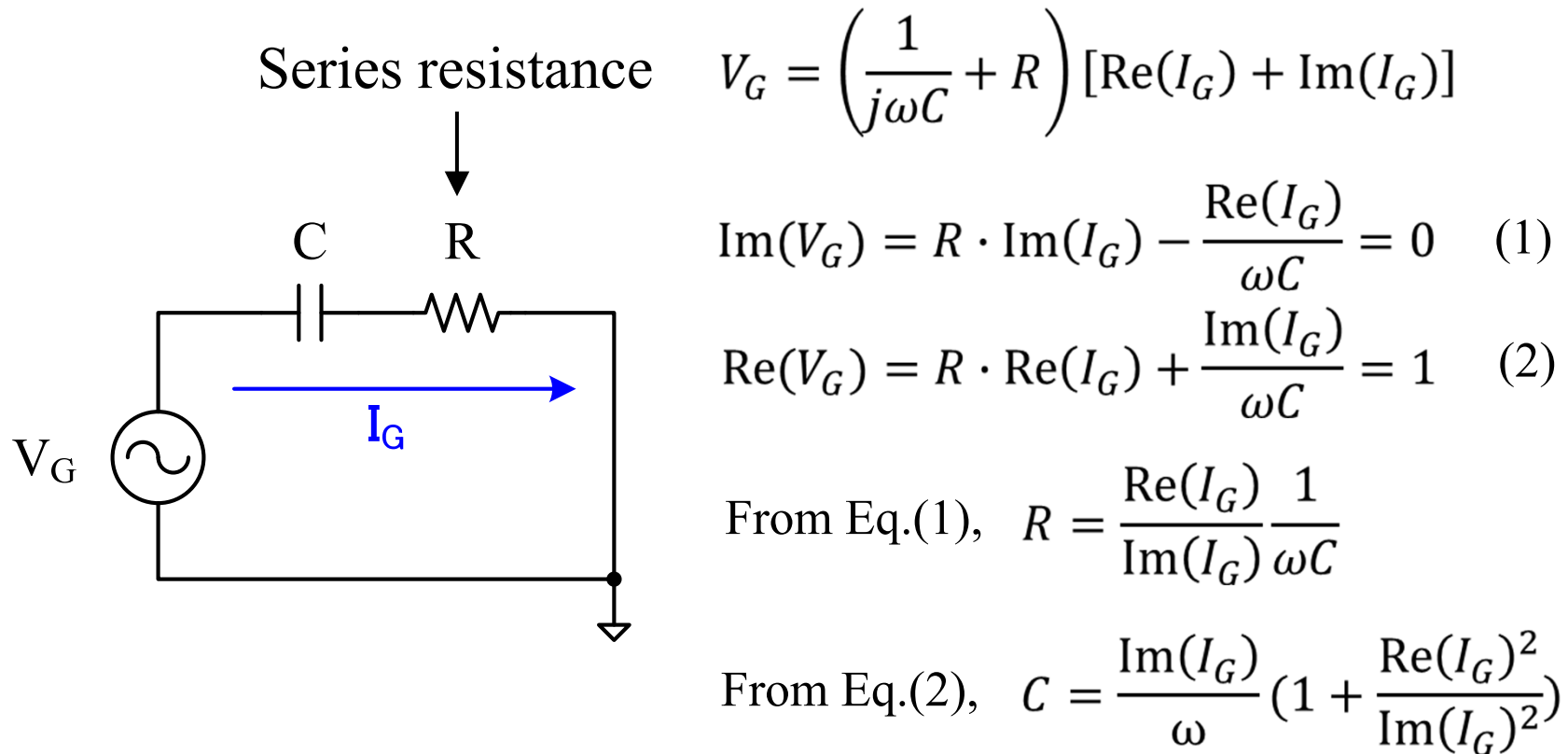


For n-ch MOSFET



For p-ch MOSFET

Cancelation technique of the series resistance



Example of .meas directive for the C-V measurement

```
.ac dec 101 1 100MEG  
.lib cmos.lib  
.step param VDC -1.5V 1.5V 0.01V  
{.meas ac CGS find  
Im(Ig(M1))/(2*pi*frequency)*(1+Re(Ig(M1))**2/Im(Ig(M1))**2) at 1MEG
```

A small-signal capacitance in semiconductors is defined as an AC property.

Built-in constant of π .

Don't insert a linefeed in the .meas directive.

Measurement frequency. The capacitance in the semiconductor depends on the measurement frequency.