

Structured Electronic Design

Discover CMOS characteristics
with jupyter notebook

Anton J.M. Montagne

Discover CMOS characteristics

Structured Electronic Design [Running] - Oracle VM VirtualBox

Start - Jupyter Notebook - Mozilla Firefox

Jupyter Start Last Checkpoint: 11/02/2019 (autosaved) Logout

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nv. • 'Id_Vds_Plot' refers to the function which is called (this specific function creates a Id-Vds plot, in which the Vgs is stepped). • Between the brackets the parameters of this function are shown, you are free to change these parameters to your liking.

Below is a small example of how this Python - Spice interaction is often used:
(Note: you can run a cell with Python code by pressing CTRL + Enter or pressing the Run button in the navigation bar)

```
In [2]: # First we will need to import the Python - Spice interface
import spice_invoker as si

# This is the name of the Transistor Library used, this can be replaced with "CMOS18-1.lib", "CMOS18-2.lib" or
libname = "CMOS18TT.lib"

# This is the name of the transistor model to be used by Spice, for all libraries named here this is the same
modelname = "C18nmos"

# Then we can start by creating a Python - Spice interface with the above defined Library and Model!
inv = si.LTSpiceInvoker(libname, modelname)
```

```
In [3]: # We will create the plot which is used as an example above:
inv.Id_Vds_Plot(VGSmin="0", VGSmax="1.8", VGSstep="0.3", VDSmax="1.8")
```

Vds [V]	Id [A] (Vgs=0.0)	Id [A] (Vgs=0.3)	Id [A] (Vgs=0.6)	Id [A] (Vgs=0.9)	Id [A] (Vgs=1.2)	Id [A] (Vgs=1.5)	Id [A] (Vgs=1.8)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.25	0.00	0.00	0.05	0.80	1.80	3.20	4.50
0.50	0.00	0.00	0.10	1.00	2.20	3.60	5.00
0.75	0.00	0.00	0.12	1.05	2.35	3.80	5.20
1.00	0.00	0.00	0.13	1.08	2.45	3.90	5.30
1.25	0.00	0.00	0.14	1.10	2.50	3.95	5.35
1.50	0.00	0.00	0.14	1.12	2.55	4.00	5.40
1.75	0.00	0.00	0.15	1.15	2.60	4.05	5.45

```
In [4]: # Once we are done using the interface, we close it by running:
inv.clean()
```

Feel free to adjust the parameters in the 'inv.Id_Vds_Plot()' to see what happens!

If you have altered the parameters to more extreme values, you might notice weird behavior in the resulting plot. While sometimes this can represent the actual behavior of a transistor, it can also happen that this is a quirk or incompleteness of the transistor library. After all, these transistor libraries have been designed to model transistors in specific operating regions.

Exporting notebooks

It is possible to export these notebooks to a PDF file, these PDF files can then be used to hand in the exercises you have made or to share the work you have done.

Virtual Machine with Jupyter Notebook

LTspice for determination of the device characteristics

Python (matplotlib) for plotting

Jupyter Notebook user interface

Thanks to our teaching assistants

Luc Enthoven

Francesc Varkevisser

Future developments:

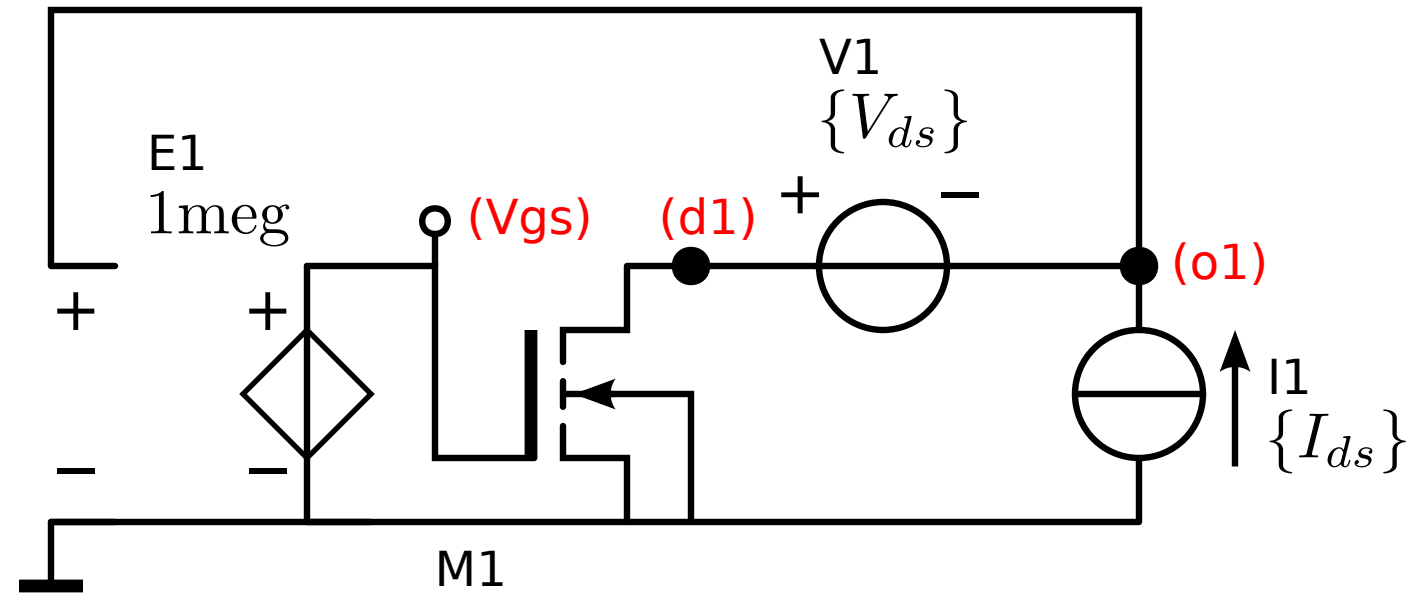
Integration in SLiCAP_python

you are invited to join the SLiCAP development team

Determination of small-signal parameters

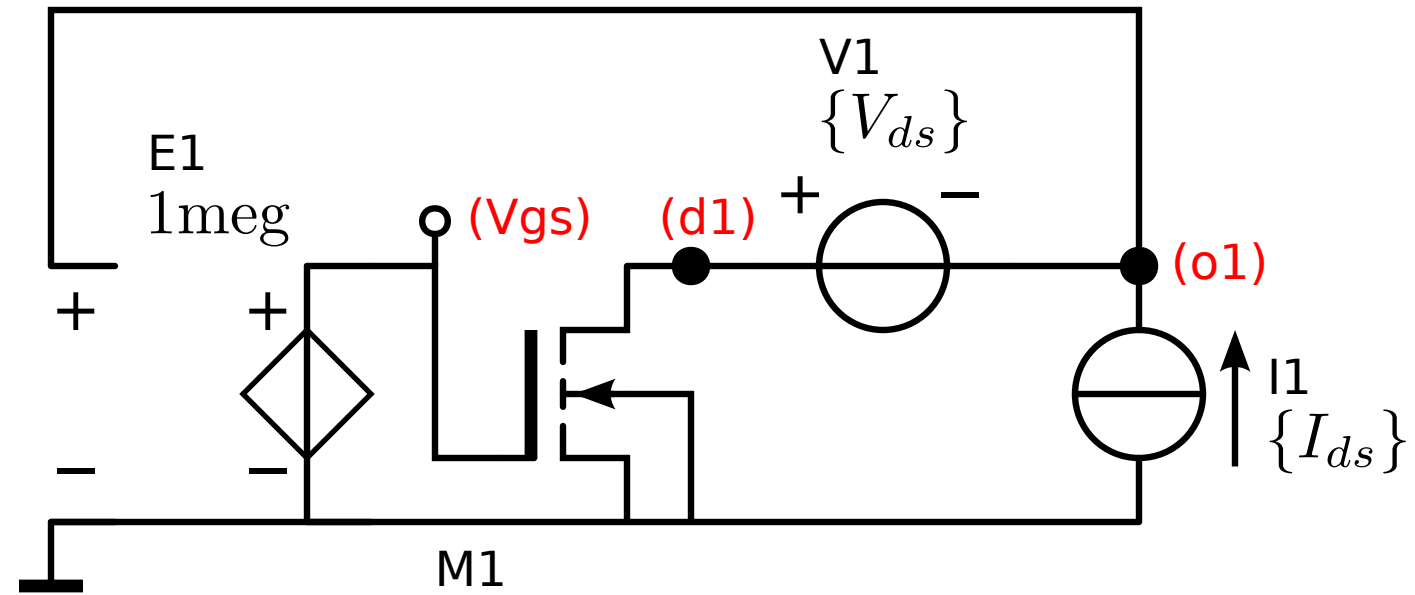
Determination of small-signal parameters

Circuit for determination of V_{gs}



Determination of small-signal parameters

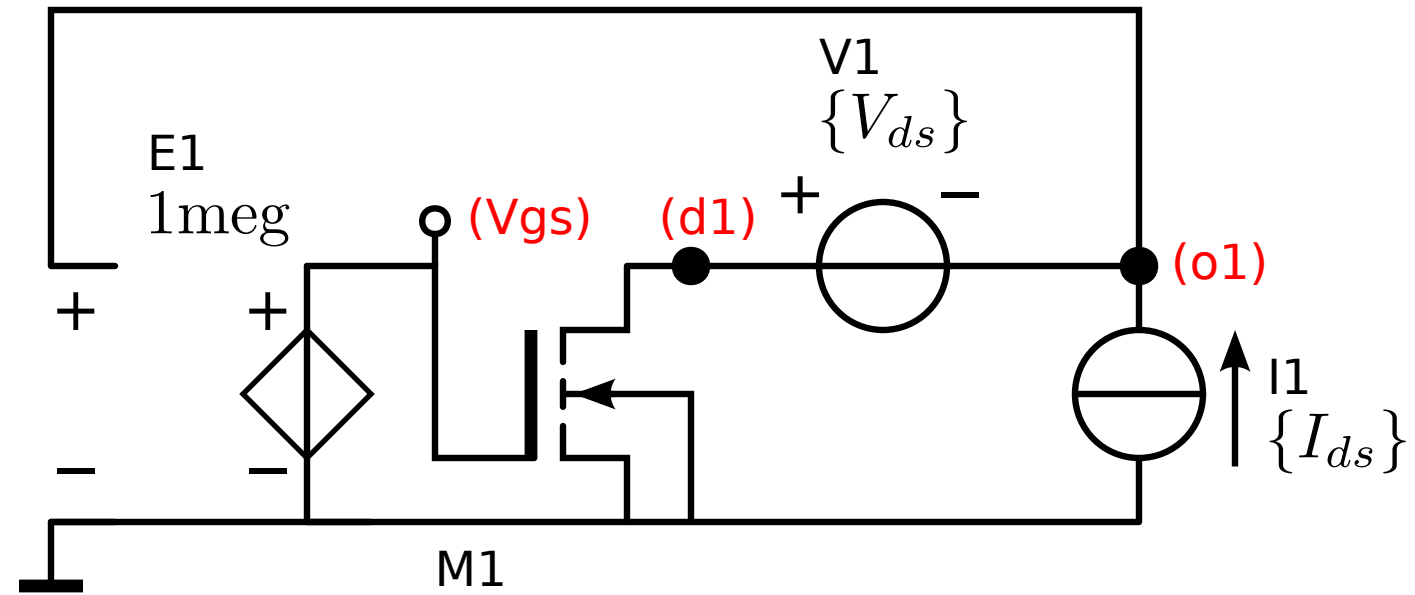
Circuit for determination of V_{gs}



Determination of Y-parameters

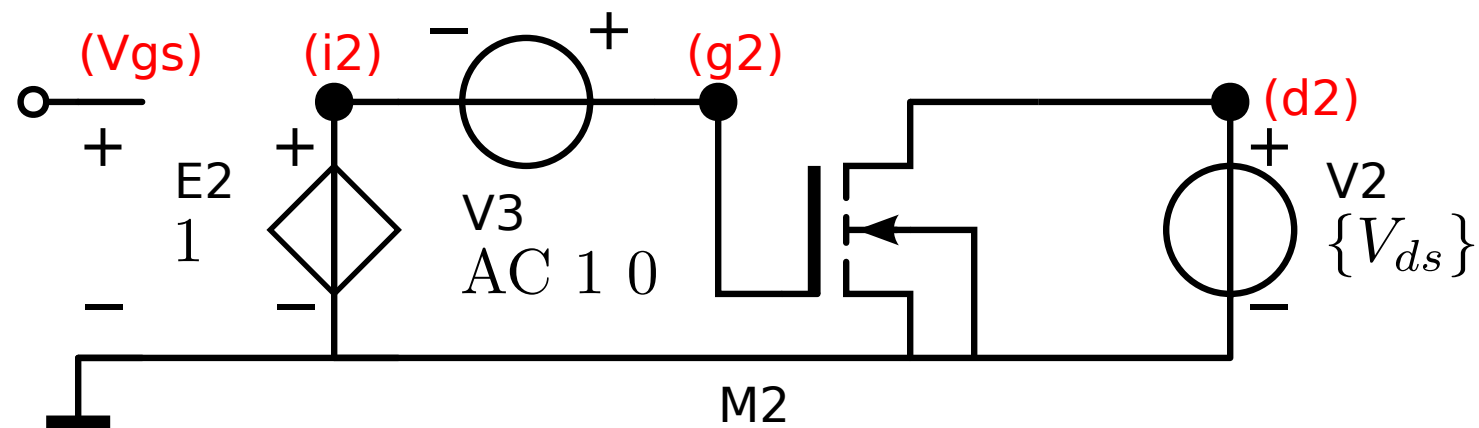
Determination of small-signal parameters

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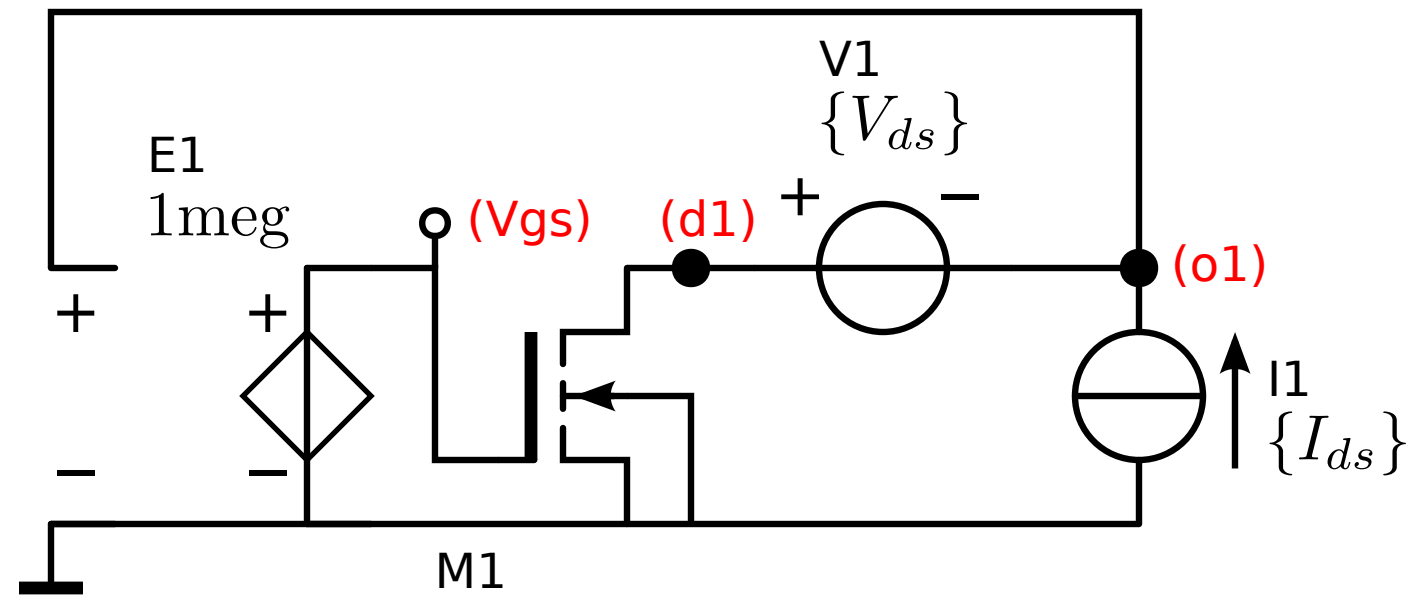
Determination of Y-parameters

Circuit for determination of Y_{11} and Y_{12}



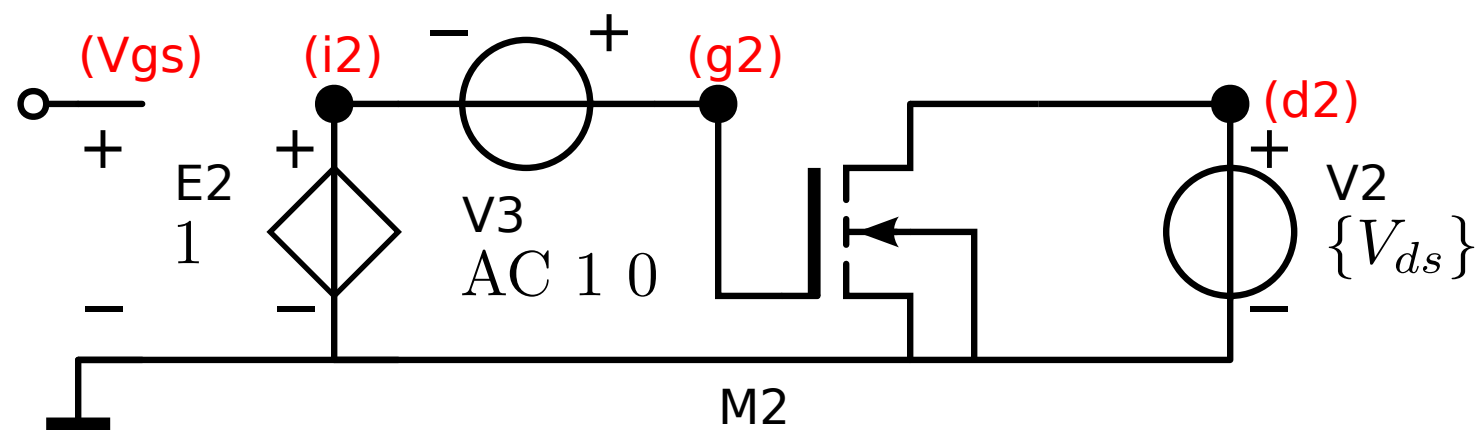
Determination of small-signal parameters

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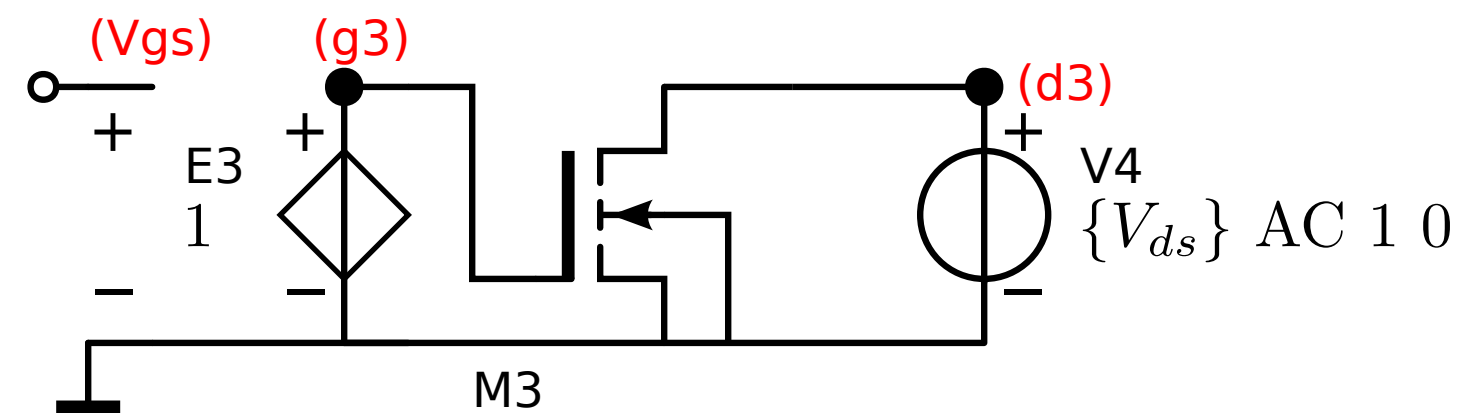


Determination of Y-parameters

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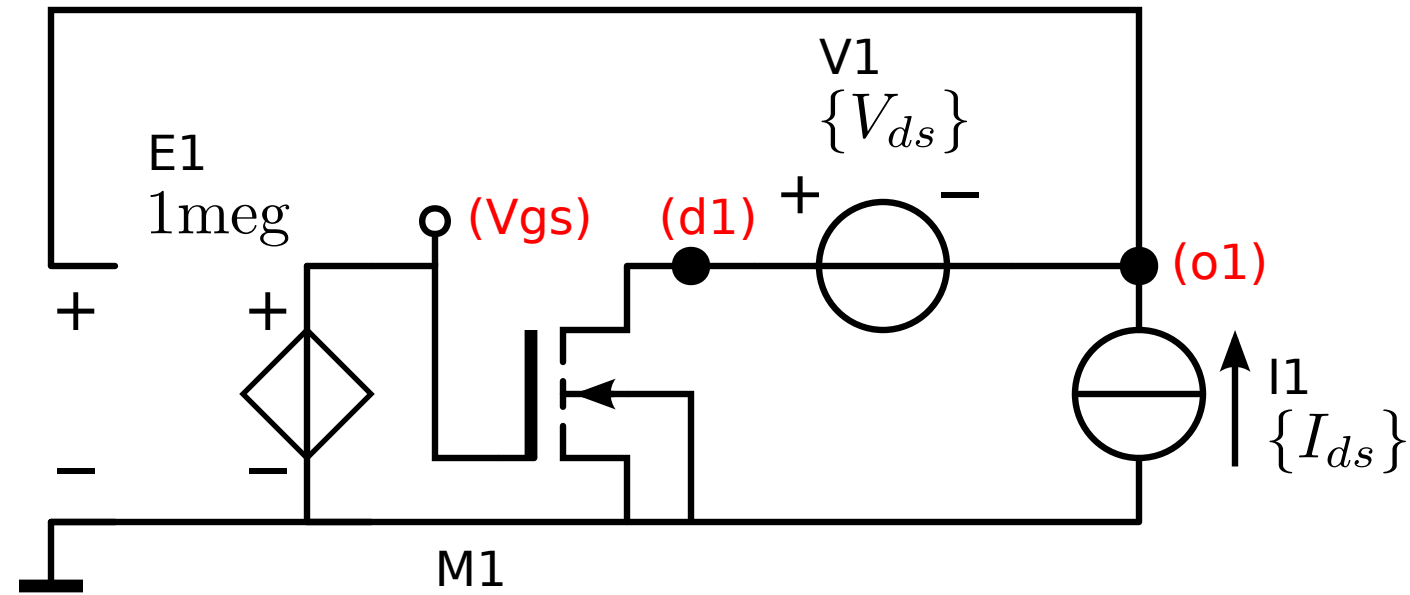
Circuit for determination of Y_{21} and Y_{22}



Determination of small-signal parameters

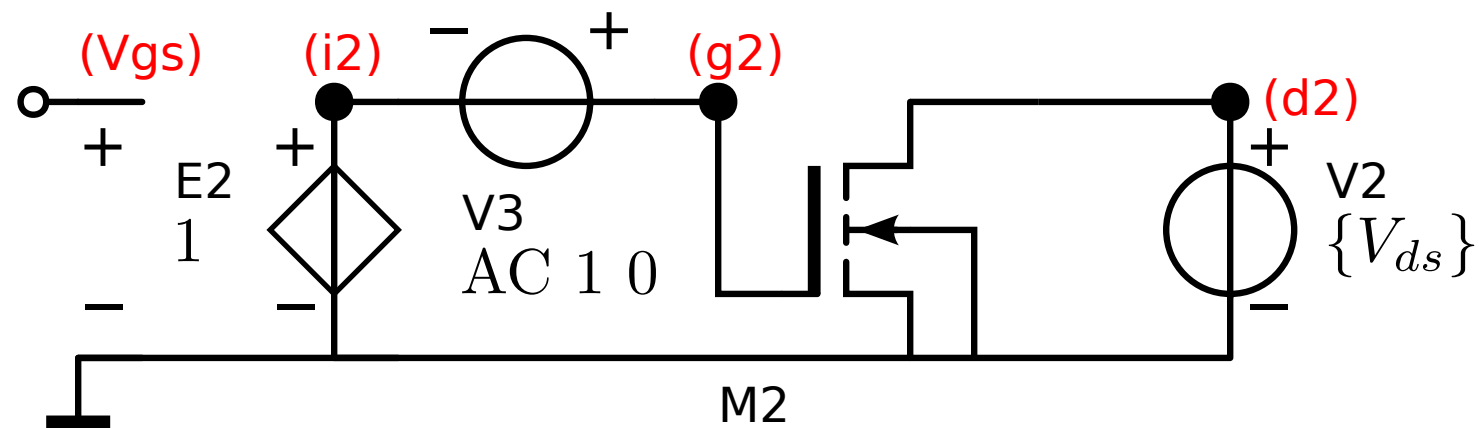
Circuit for determination of V_{gs}

$$g_m = \text{Re} [Y_{1,2}]$$

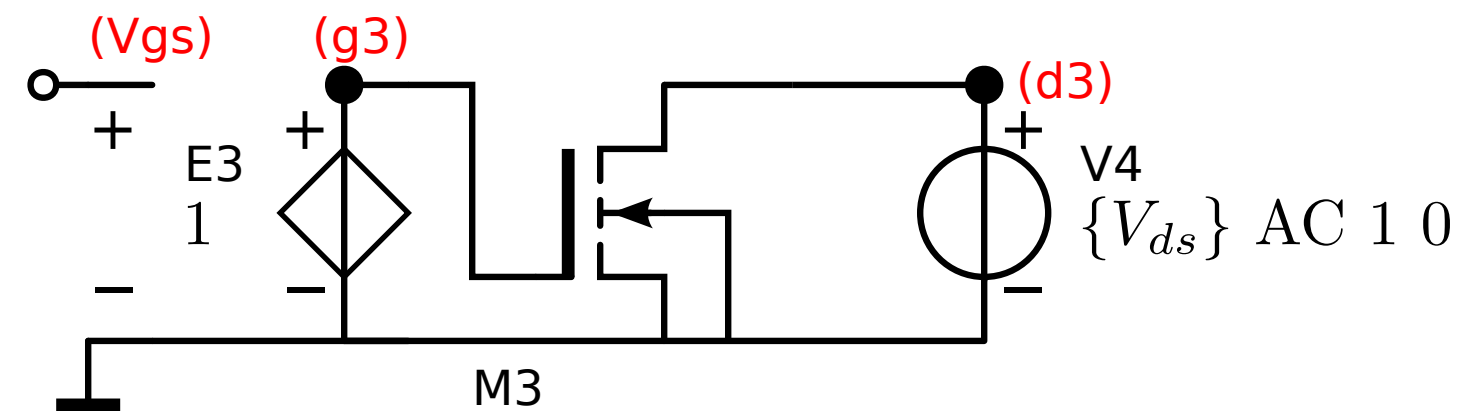


Determination of Y-parameters

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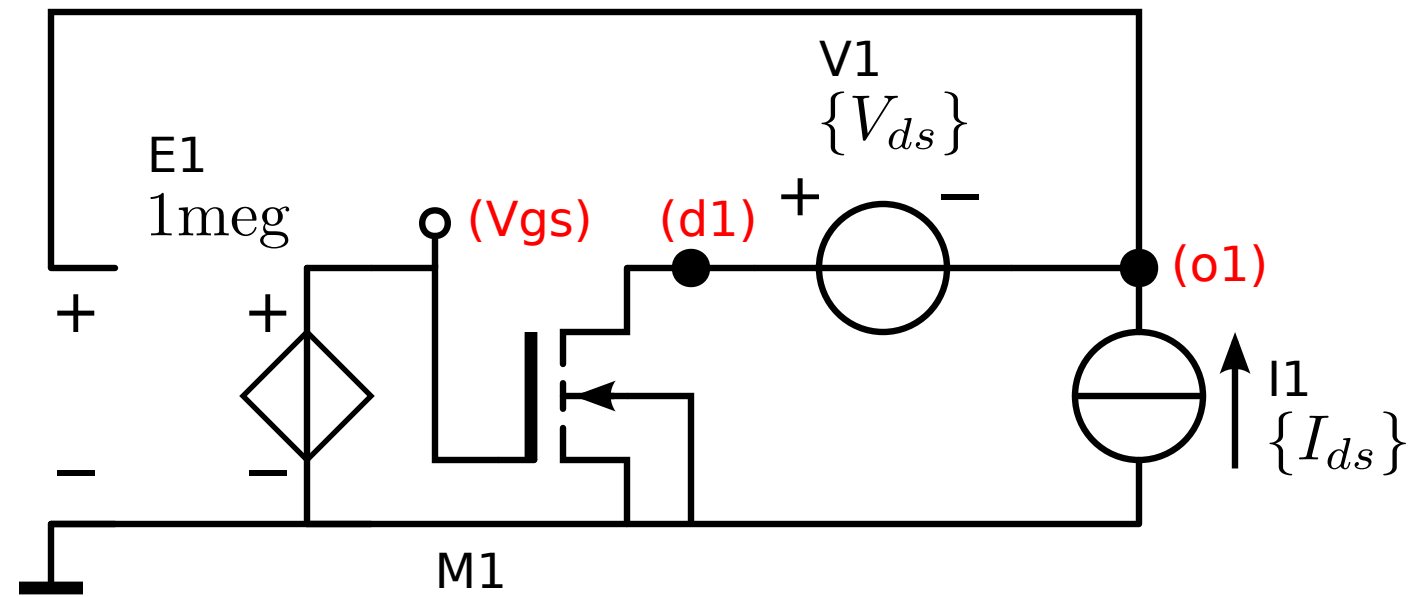


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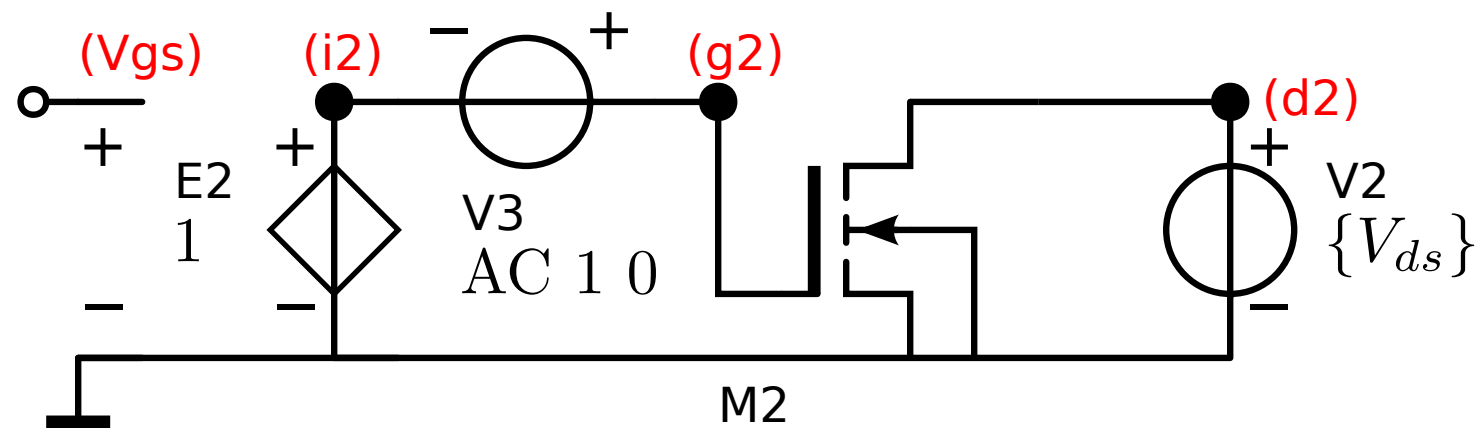


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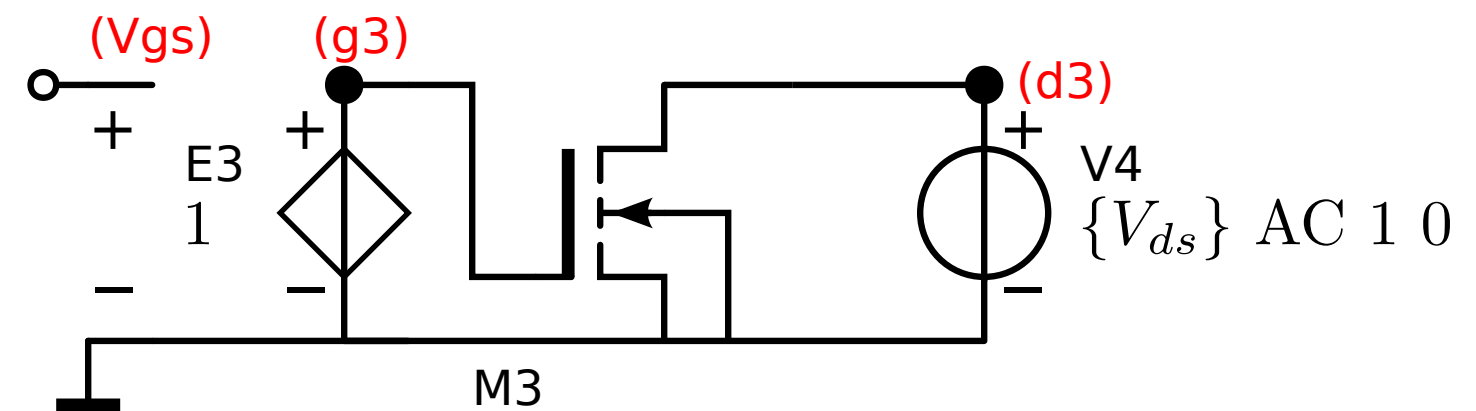
$$C_{gs} + C_{dg} = \frac{1}{2\pi f} \text{Im} [Y_{1,1}]$$

Determination of Y-parameters

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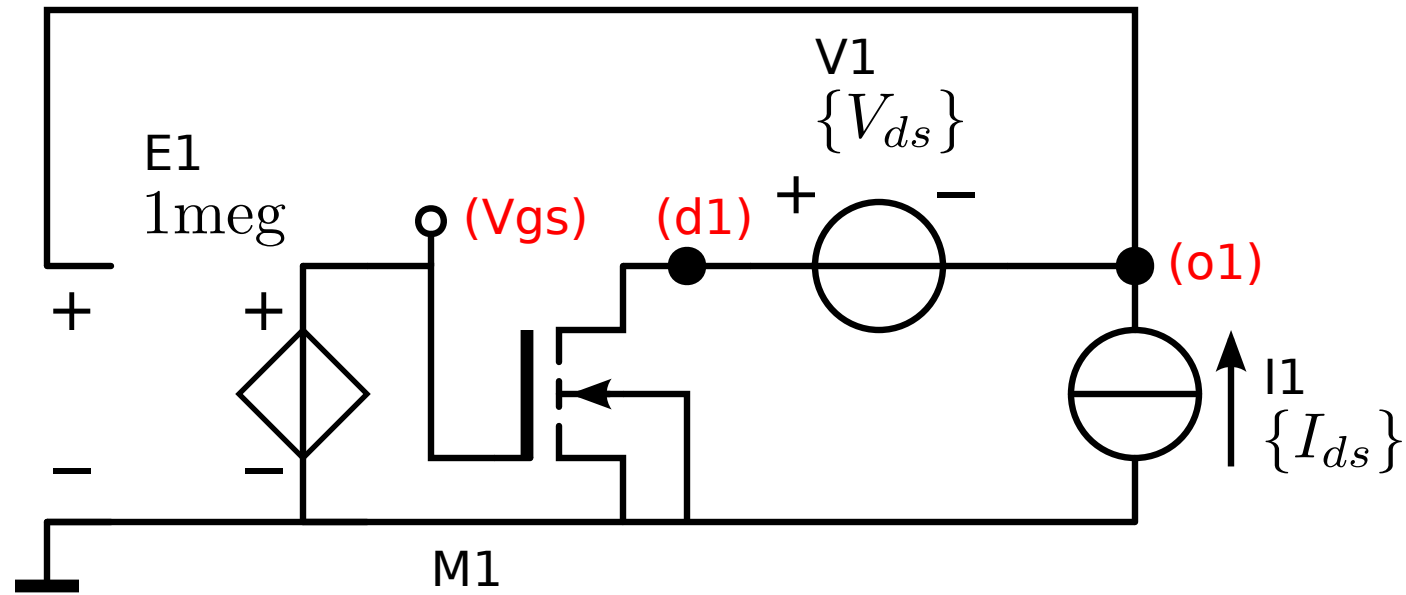


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Circuit for determination of V_{gs}



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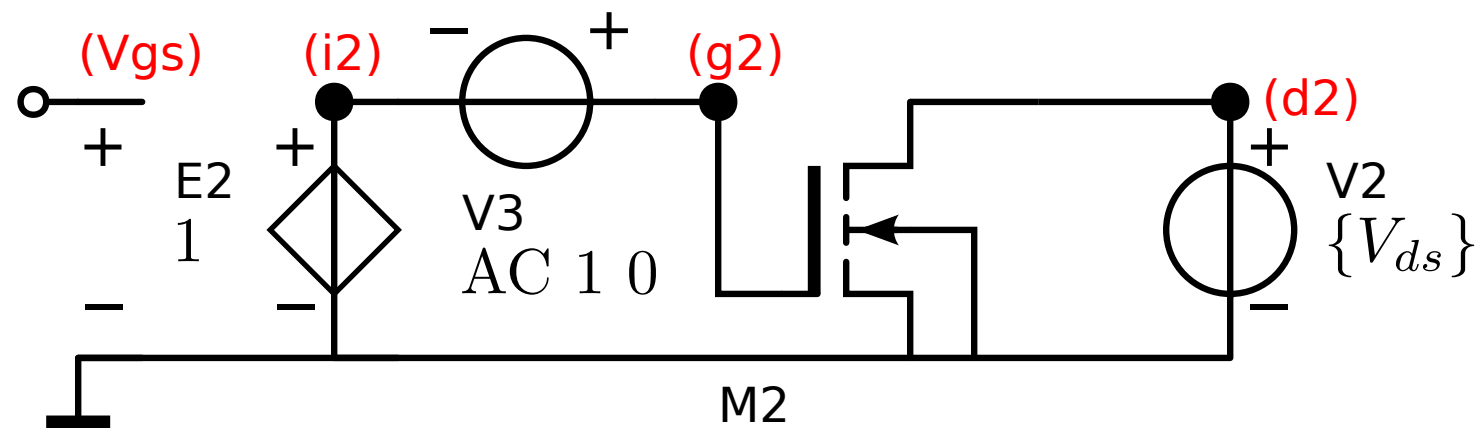
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$$C_{dg} = \frac{1}{2\pi f} \text{Im} [Y_{2,1}]$$

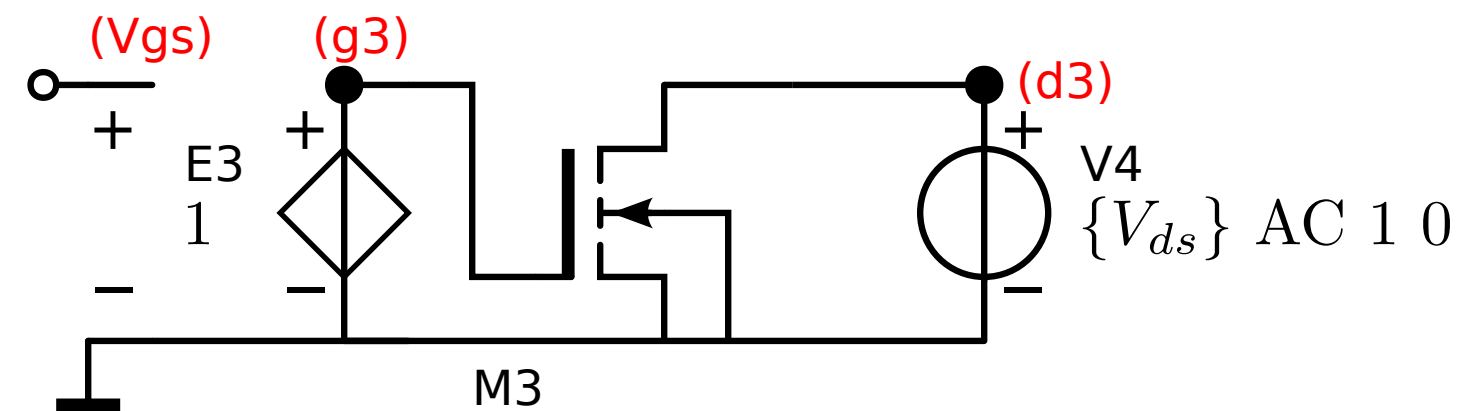
$$g_o = \text{Re} [Y_{2,2}]$$

Determination of Y-parameters

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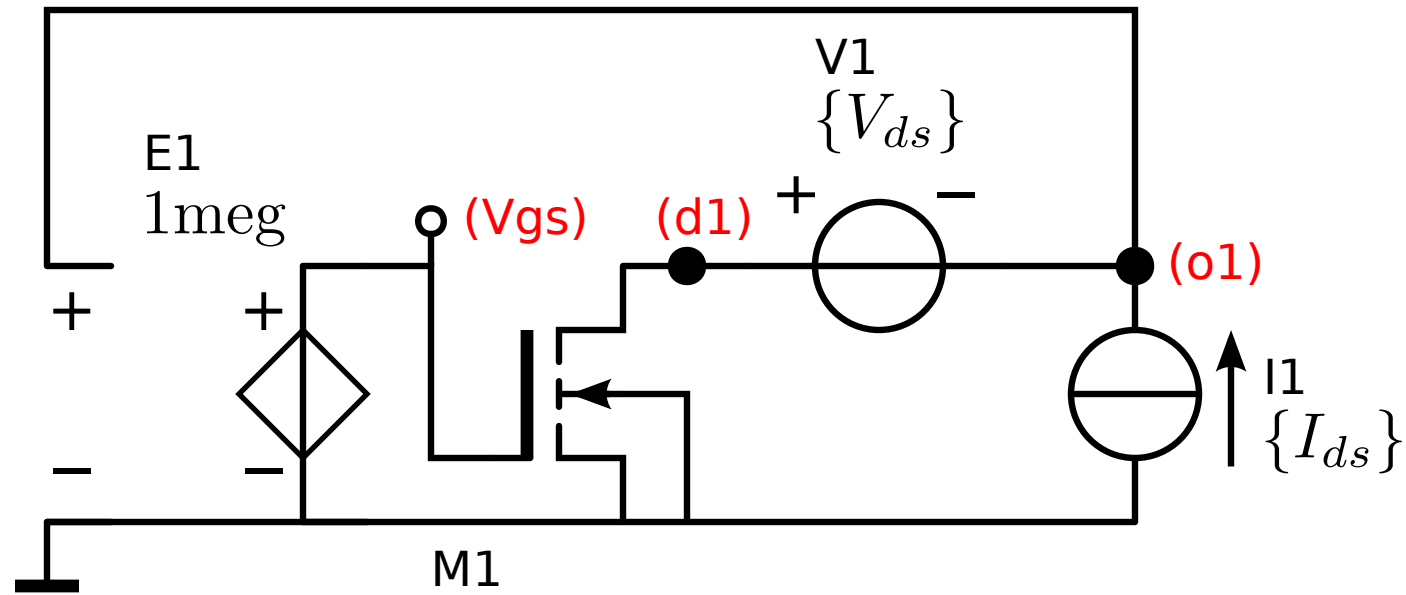


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Circuit for determination of V_{gs}



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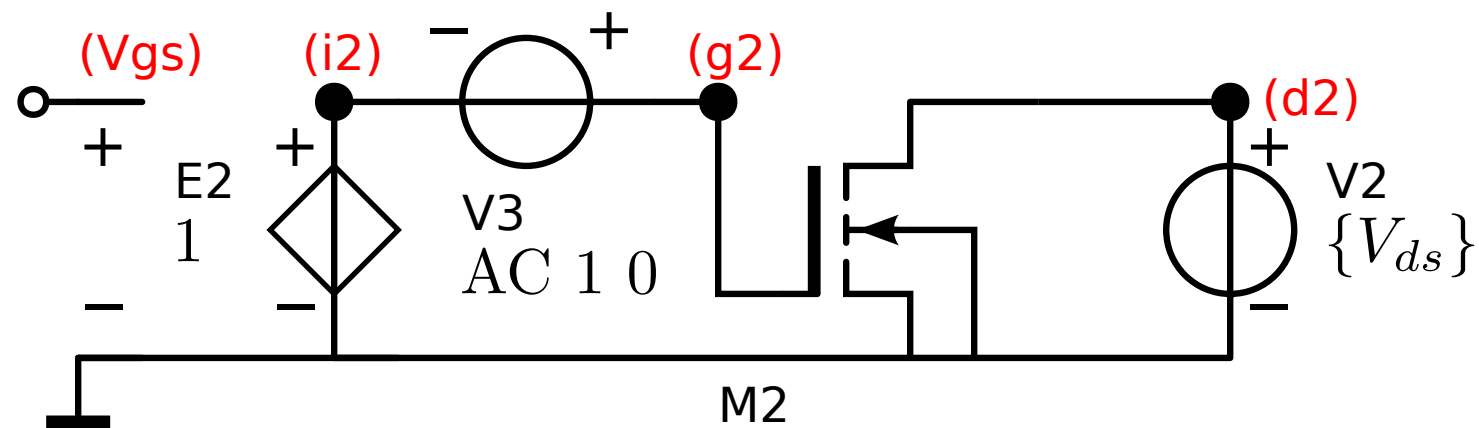
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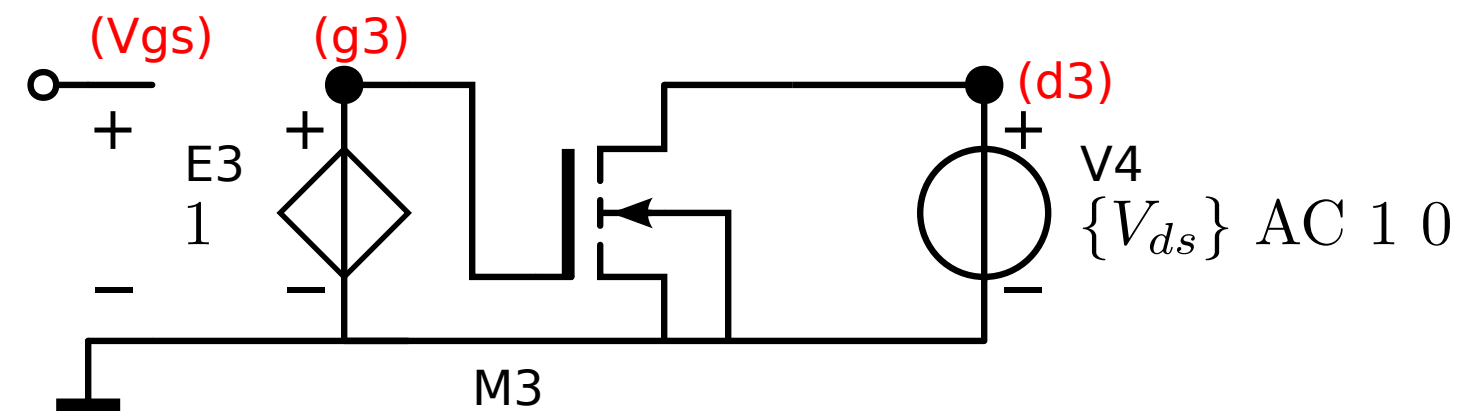
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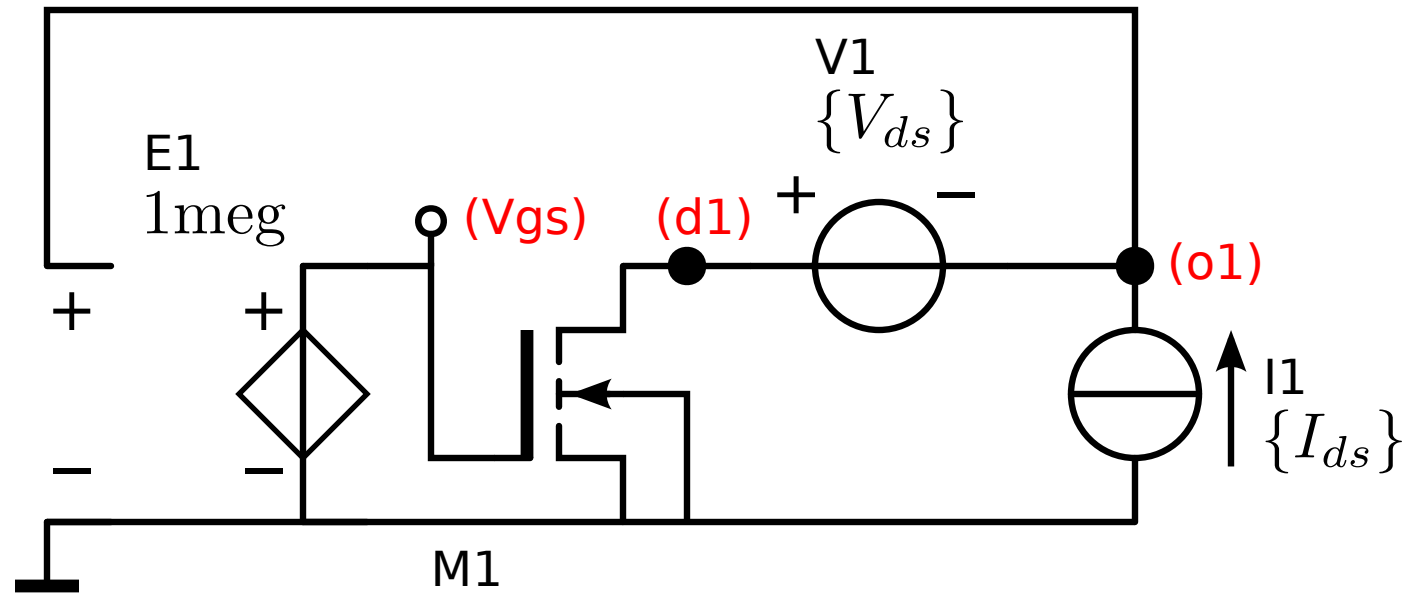


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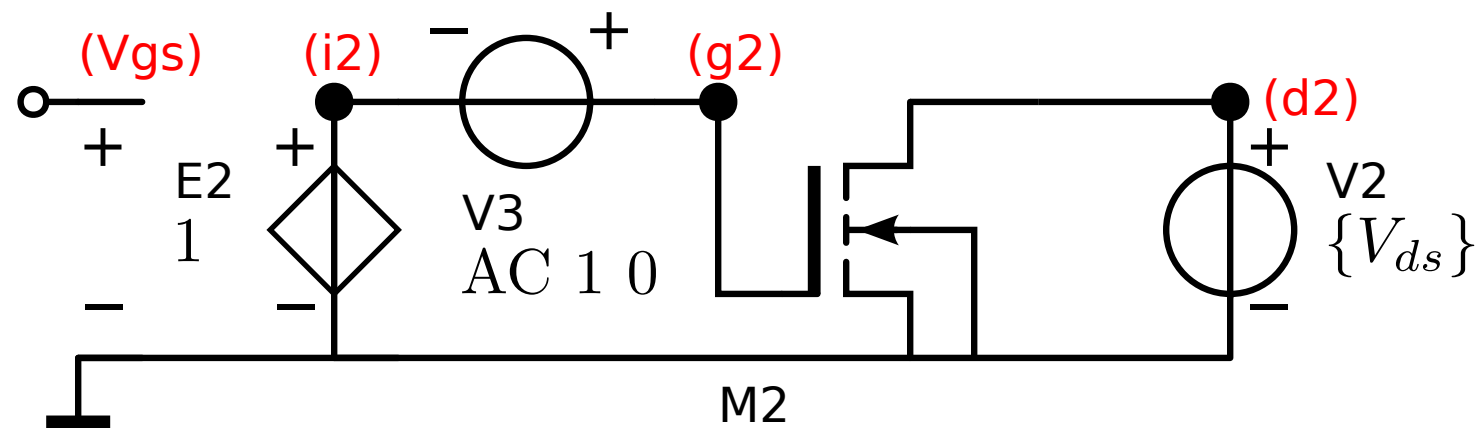
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