# Structured Electronic Design

EE4109
Homework 1
Design of a CS stage,
Design tasks

*Anton J.M. Montagne*

# Tasks

# Tasks

1. Design a CS stage that can drive the load (from 50 Ohm)

# Tasks

1. Design a CS stage that can drive the load
   (from 50 Ohm)

2. Design a CS stage that can be used as input stage
   (antenna length = 18cm, capacitance = 1.5pF)

# Tasks

1. Design a CS stage that can drive the load
   (from 50 Ohm)

2. Design a CS stage that can be used as input stage
   (antenna length = 18cm, capacitance = 1.5pF)

Deliver:

# Tasks

1. Design a CS stage that can drive the load
   (from 50 Ohm)

2. Design a CS stage that can be used as input stage
   (antenna length = 18cm, capacitance = 1.5pF)

Deliver:

SLiCAP generated HTML report with minimum values for the width, the length, the drain-source voltage and the drain current

# Tasks

1. Design a CS stage that can drive the load (from 50 Ohm)

2. Design a CS stage that can be used as input stage (antenna length = 18cm, capacitance = 1.5pF)

Deliver:

SLiCAP generated HTML report with minimum values for the width, the length, the drain-source voltage and the drain current

# Structured Electronic Design

EE4109
Homework 1
Design of a CS stage,
Load drive requirements

*Anton J.M. Montagne*

# Load drive requirements

# Load drive requirements

0 dBm in 50 Ohm

# Load drive requirements

0 dBm in 50 Ohm

1mW in 50 Ohm

# Load drive requirements

0 dBm in 50 Ohm

1mW in 50 Ohm

225m$V_{rms}$ in 50 Ohm

# Load drive requirements

0 dBm in 50 Ohm

1mW in 50 Ohm

225mV$_{rms}$ in 50 Ohm

Sinewave: crest factor 1.41: 320mV$_p$, 6.4mA$_p$

# Load drive requirements

## 0 dBm in 50 Ohm

1mW in 50 Ohm

225mV$_{rms}$ in 50 Ohm

Sinewave: crest factor 1.41: 320mV$_p$, 6.4mA$_p$

Noise: crest factor 3: 675mV, 13.5mA$_p$

# Load drive requirements

## 0 dBm in 50 Ohm

1mW in 50 Ohm

225m$V_{rms}$ in 50 Ohm

Sinewave: crest factor 1.41: 320m$V_p$, 6.4m$A_p$

Noise: crest factor 3: 675mV, 13.5m$A_p$

**Structured Electronic Design**

EE4109
Homework 1
Design of a CS stage,
Output stage drive requirements

*Anton J.M. Montagne*

# Output stage drive options

# Output stage drive options

No output feedback:

# Output stage drive options

No output feedback:

Output impedance of the CS stage has to be 50 Ohm

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm

Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage

Sinewave: 640m$V_p$, 6.4m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$
Noise: 1.3V$_p$, 13.5mA$_p$

# Output stage drive options

## No output feedback:

- Output impedance of the CS stage has to be 50 Ohm
- Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$

Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

- Output impedance of the amplifier approximates zero
- Insert 50 Ohm in series with the output to obtain 50 Ohm
- Output stage drives 100 Ohm with two times the voltage
  - Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$

Noise: 1.3V$_p$, 13.5mA$_p$

## Output current feedback:

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$
Noise: 1.3V$_p$, 13.5mA$_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$
Noise: 1.3V$_p$, 13.5mA$_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: $320mV_p$, $6.4mA_p$
Noise: $675mV_p$, $13.5mA_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: $640mV_p$, $6.4mA_p$
Noise: $1.3V_p$, $13.5mA_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current

Sinewave: $320mV_p$, $12.8mA_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current

Sinewave: 320m$V_p$, 12.8m$A_p$
Noise: 675m$V_p$, 27m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$
Noise: 1.3V$_p$, 13.5mA$_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320mV$_p$, 12.8mA$_p$
Noise: 675mV$_p$, 27mA$_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320m$V_p$, 12.8m$A_p$
Noise: 675m$V_p$, 27m$A_p$

## Output voltage and current feedback:

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320m$V_p$, 12.8m$A_p$
Noise: 675m$V_p$, 27m$A_p$

## Output voltage and current feedback:

Output impedance of the amplifier approximates 50 Ohm

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320m$V_p$, 12.8m$A_p$
Noise: 675m$V_p$, 27m$A_p$

## Output voltage and current feedback:

Output impedance of the amplifier approximates 50 Ohm
Output stage drives 50 Ohm with required voltage/current

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$
Noise: 1.3V$_p$, 13.5mA$_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320mV$_p$, 12.8mA$_p$
Noise: 675mV$_p$, 27mA$_p$

## Output voltage and current feedback:

Output impedance of the amplifier approximates 50 Ohm
Output stage drives 50 Ohm with required voltage/current

Sinewave: 320mV$_p$, 6.4mA$_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320m$V_p$, 12.8m$A_p$
Noise: 675m$V_p$, 27m$A_p$

## Output voltage and current feedback:

Output impedance of the amplifier approximates 50 Ohm
Output stage drives 50 Ohm with required voltage/current

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
- Ignored current drawn by feedback network

Sinewave: 640m$V_p$, 6.4m$A_p$
Noise: 1.3$V_p$, 13.5m$A_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
- Ignored voltage drop across feedback network

Sinewave: 320m$V_p$, 12.8m$A_p$
Noise: 675m$V_p$, 27m$A_p$

## Output voltage and current feedback:

Output impedance of the amplifier approximates 50 Ohm
Output stage drives 50 Ohm with required voltage/current
- Ignored voltage drop across series feedback network and current drawn by parallel feedback network

Sinewave: 320m$V_p$, 6.4m$A_p$
Noise: 675m$V_p$, 13.5m$A_p$

# Output stage drive options

## No output feedback:

Output impedance of the CS stage has to be 50 Ohm
Output stage drives 50 Ohm

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

## Only output voltage feedback:

Output impedance of the amplifier approximates zero
Insert 50 Ohm in series with the output to obtain 50 Ohm
Output stage drives 100 Ohm with two times the voltage
    Ignored current drawn by feedback network

Sinewave: 640mV$_p$, 6.4mA$_p$
Noise: 1.3V$_p$, 13.5mA$_p$

## Output current feedback:

Output impedance of the amplifier approximates infinity
Insert 50 Ohm in parallel with the output to obtain 50 Ohm
Output stage drives 25 Ohm with two times the current
    Ignored voltage drop across feedback network

Sinewave: 320mV$_p$, 12.8mA$_p$
Noise: 675mV$_p$, 27mA$_p$

## Output voltage and current feedback:

Output impedance of the amplifier approximates 50 Ohm
Output stage drives 50 Ohm with required voltage/current
    Ignored voltage drop across series feedback network
    and current drawn by parallel feedback network

Sinewave: 320mV$_p$, 6.4mA$_p$
Noise: 675mV$_p$, 13.5mA$_p$

**Structured Electronic Design**

EE4109
Homework 1
Design of a CS stage,
Driving the output stage

*Anton J.M. Montagne*

# Output stage drive conditions

# Output stage drive conditions

The CS output stage will be driven from:

# Output stage drive conditions

The CS output stage will be driven from:

Preceding stage:

# Output stage drive conditions

The CS output stage will be driven from:

Preceding stage:

Peak-peak drive voltage maximally equals the power supply voltage

# Output stage drive conditions

The CS output stage will be driven from:

Preceding stage:

Peak-peak drive voltage maximally equals the power supply voltage

$1.8V_{pp}$

# Output stage drive conditions

The CS output stage will be driven from:

Preceding stage:

Peak-peak drive voltage maximally equals the power supply voltage

$1.8V_{pp}$

Antenna:

# Output stage drive conditions

The CS output stage will be driven from:

- Preceding stage:
  - Peak-peak drive voltage maximally equals the power supply voltage
    - $1.8V_{pp}$
- Antenna:
  - Peak-peak drive voltage maximally equals the peak-peak antenna voltage

# Output stage drive conditions

The CS output stage will be driven from:

Preceding stage:

Peak-peak drive voltage maximally equals the power supply voltage

$1.8V_{pp}$

Antenna:

Peak-peak drive voltage maximally equals the peak-peak antenna voltage

$0.45 \times 0.18 = 81mV_{rms}$

# Output stage drive conditions

The CS output stage will be driven from:

- Preceding stage:
  - Peak-peak drive voltage maximally equals the power supply voltage
    - $1.8V_{pp}$
- Antenna:
  - Peak-peak drive voltage maximally equals the peak-peak antenna voltage
    - $0.45 \times 0.18 = 81mV_{rms}$
    - Sinewave: $230mV_{pp}$

# Output stage drive conditions

The CS output stage will be driven from:

- Preceding stage:
  - Peak-peak drive voltage maximally equals the power supply voltage
    - $1.8V_{pp}$
- Antenna:
  - Peak-peak drive voltage maximally equals the peak-peak antenna voltage
    - $0.45 \times 0.18 = 81mV_{rms}$
    - Sinewave: $230mV_{pp}$
    - Noise: $490mV_{pp}$

# Output stage drive conditions

The CS output stage will be driven from:

- Preceding stage:
  - Peak-peak drive voltage maximally equals the power supply voltage
    - $1.8V_{pp}$
- Antenna:
  - Peak-peak drive voltage maximally equals the peak-peak antenna voltage
    - $0.45 \times 0.18 = 81mV_{rms}$
    - Sinewave: $230mV_{pp}$
    - Noise: $490mV_{pp}$

# Structured Electronic Design

EE4109
Homework 1
Design of a CS stage,
Test benches output stage

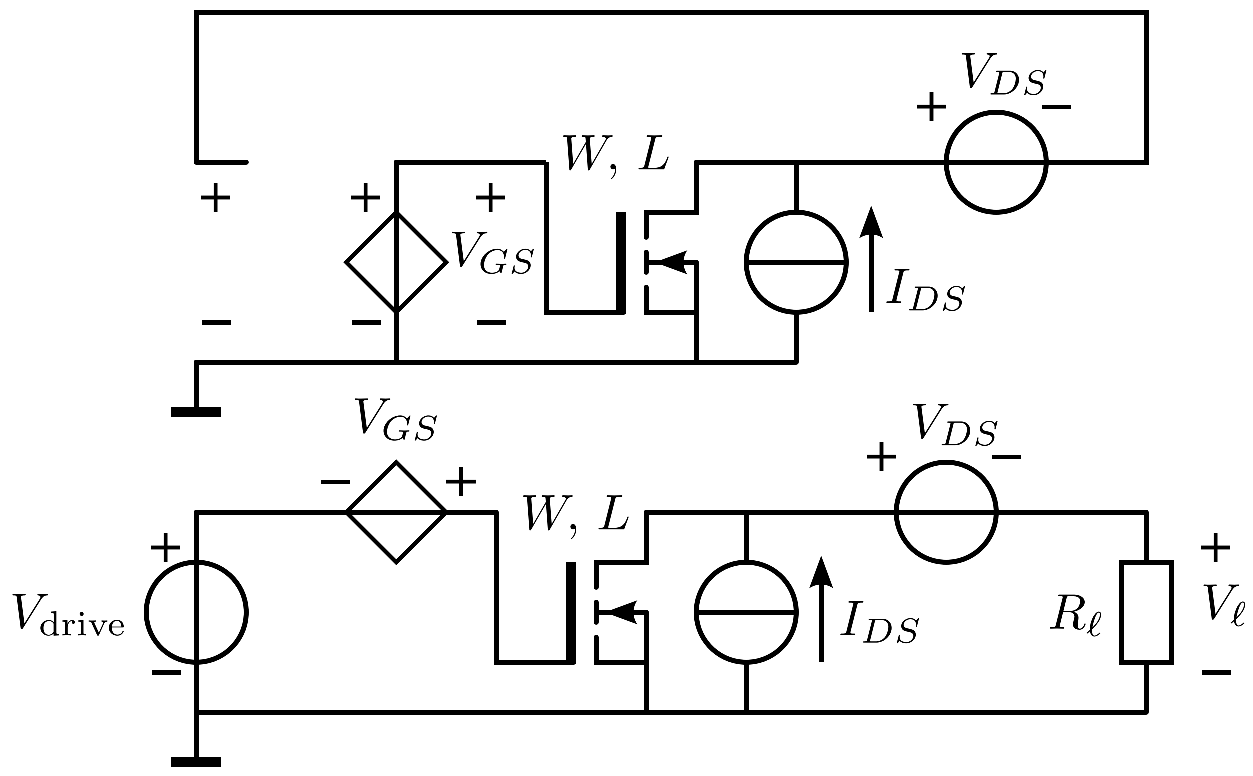
*Anton J.M. Montagne*

# Test benches output stage LTspice

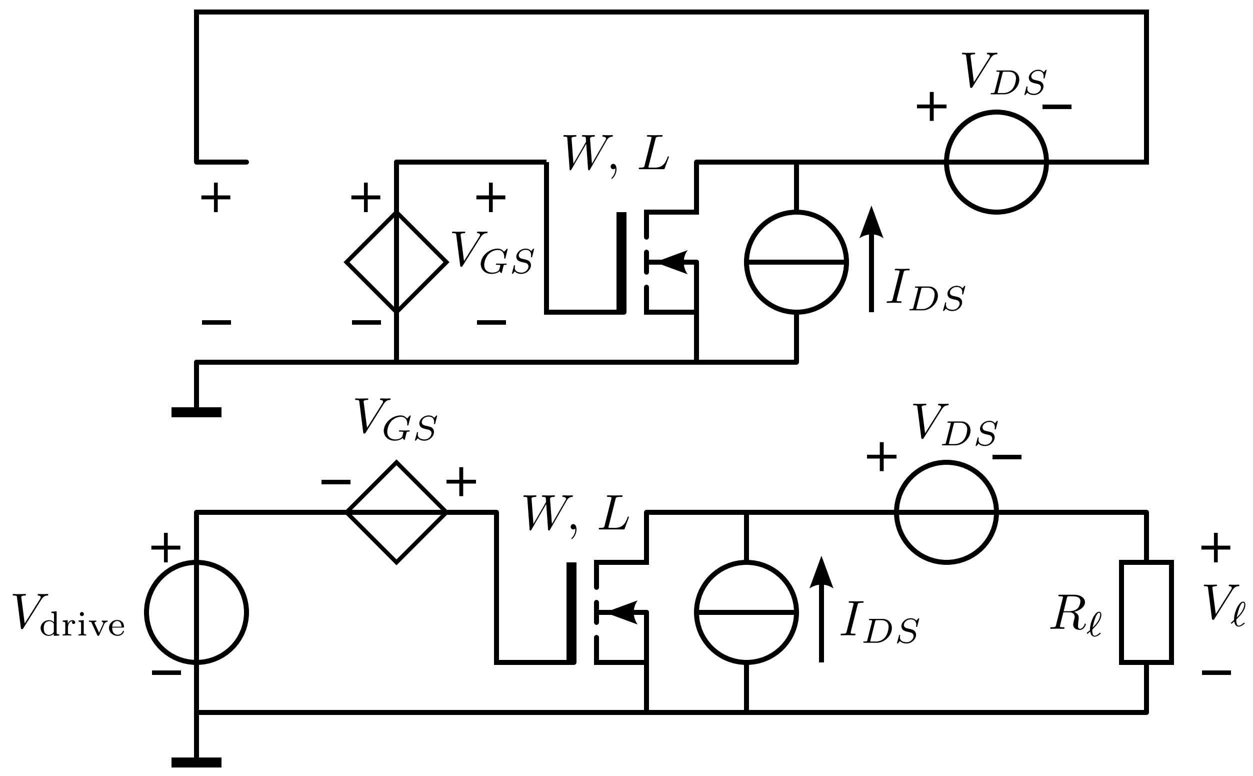
# Test benches output stage LTspice

## Indirect feedback biasing

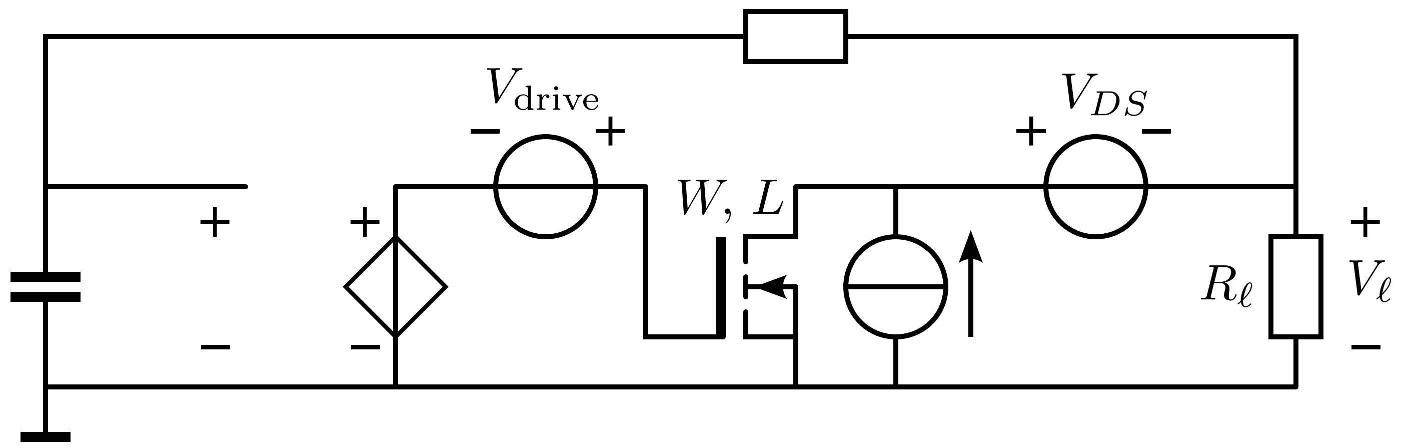


# Test benches output stage LTspice

## Indirect feedback biasing

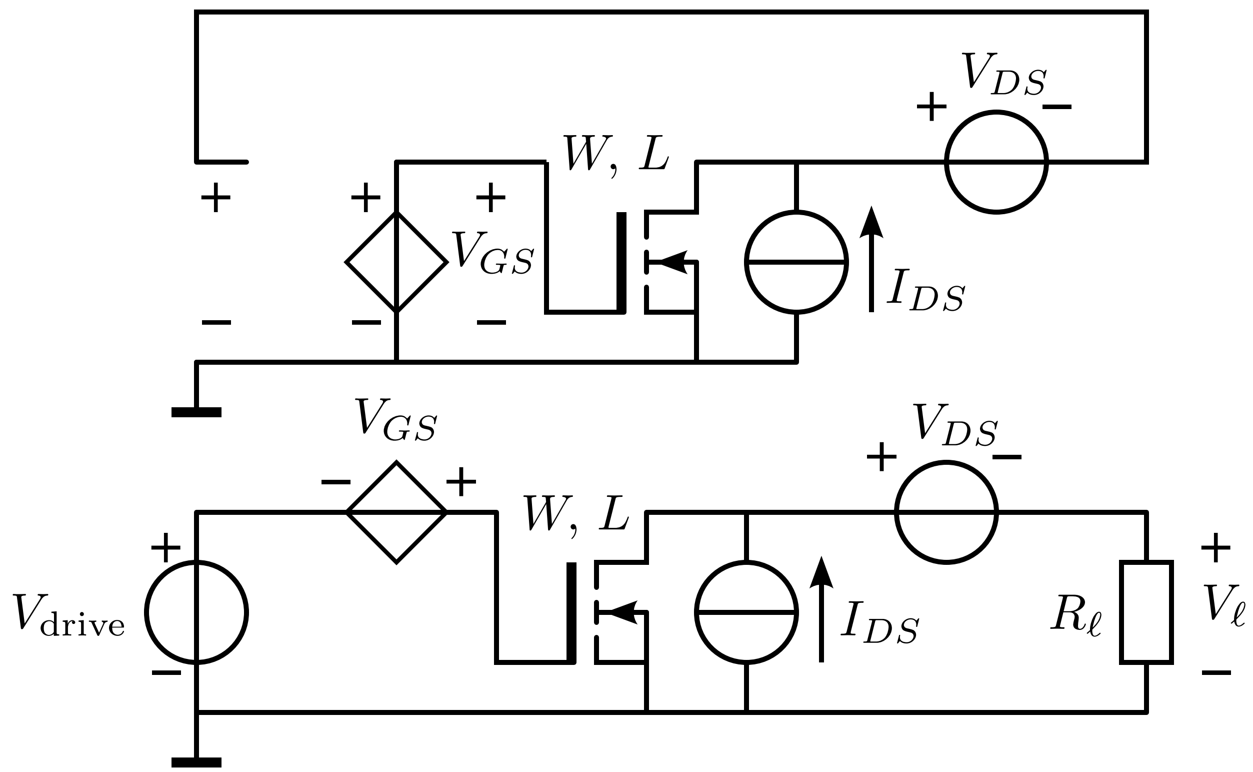



## Direct feedback biasing

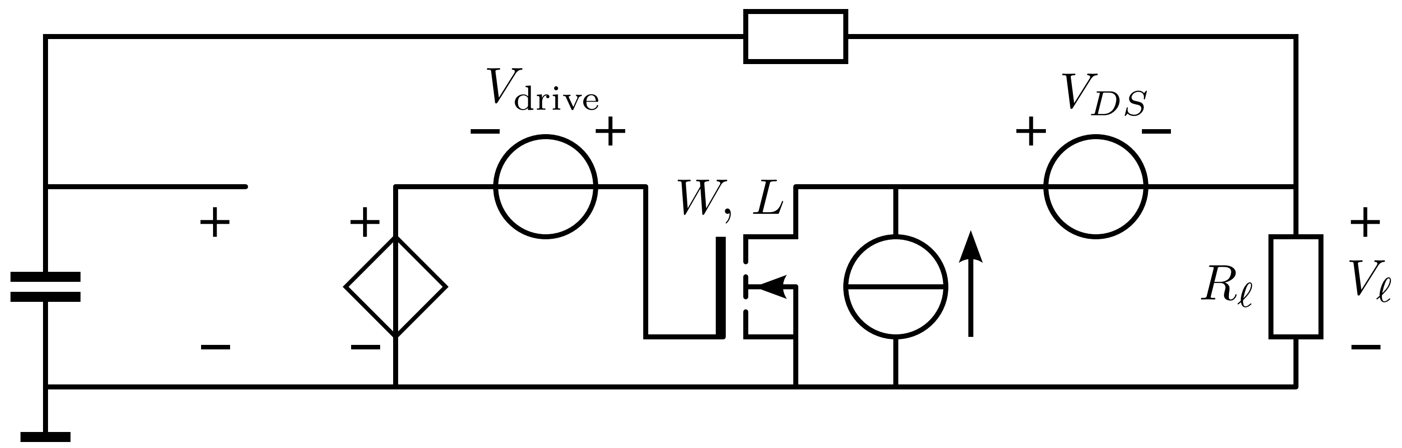


# Test benches output stage LTspice

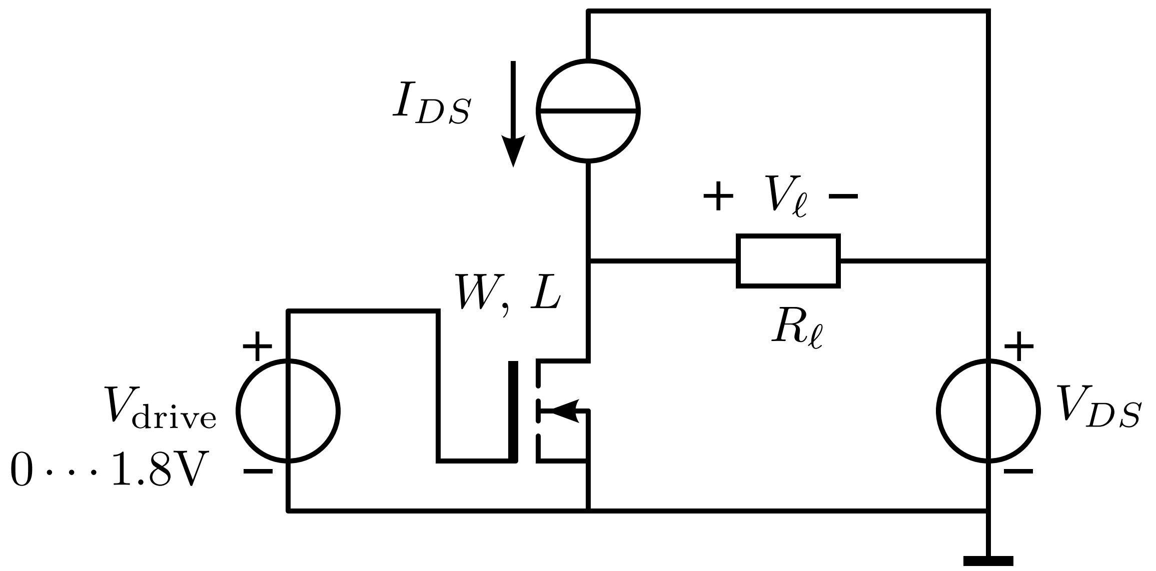
## Indirect feedback biasing




## Direct feedback biasing

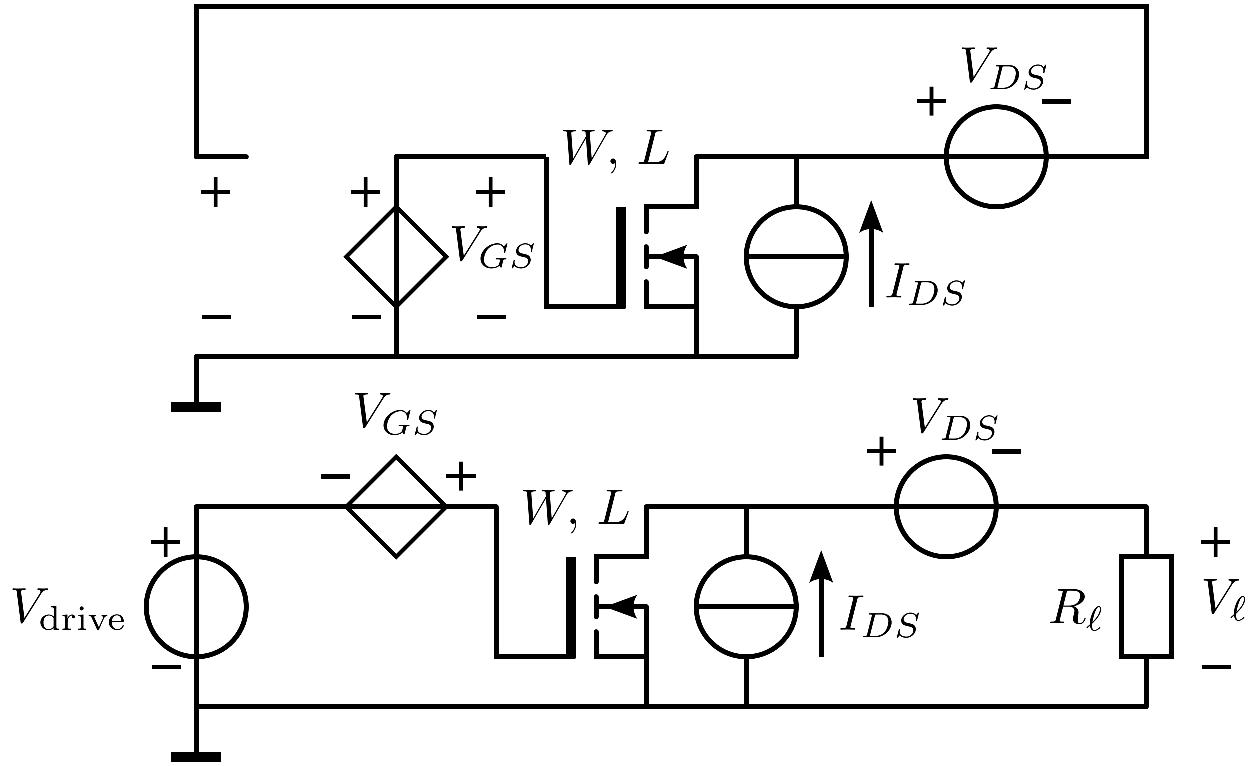



## Swept input



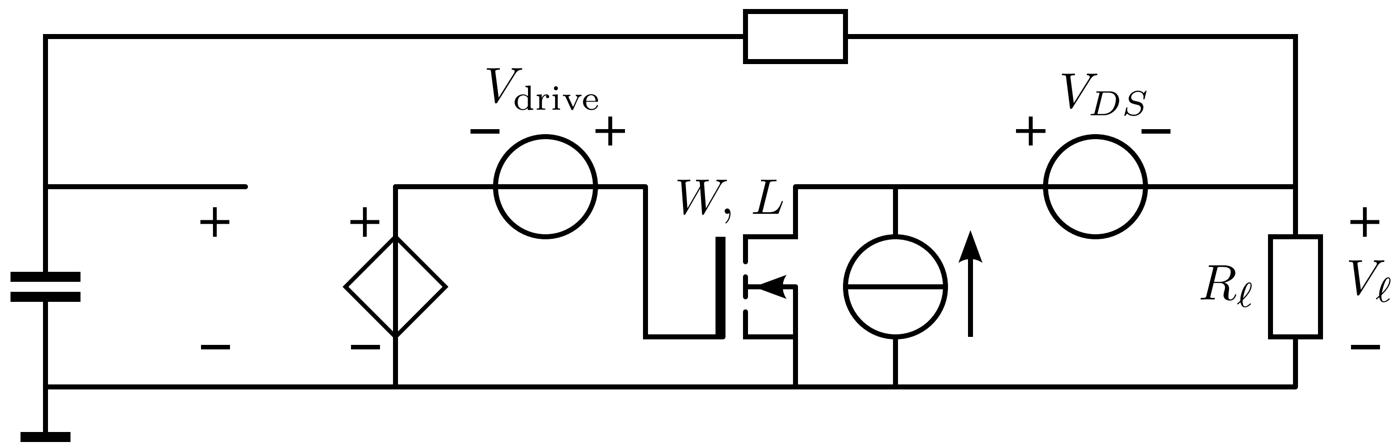
# Test benches output stage LTspice

## Indirect feedback biasing

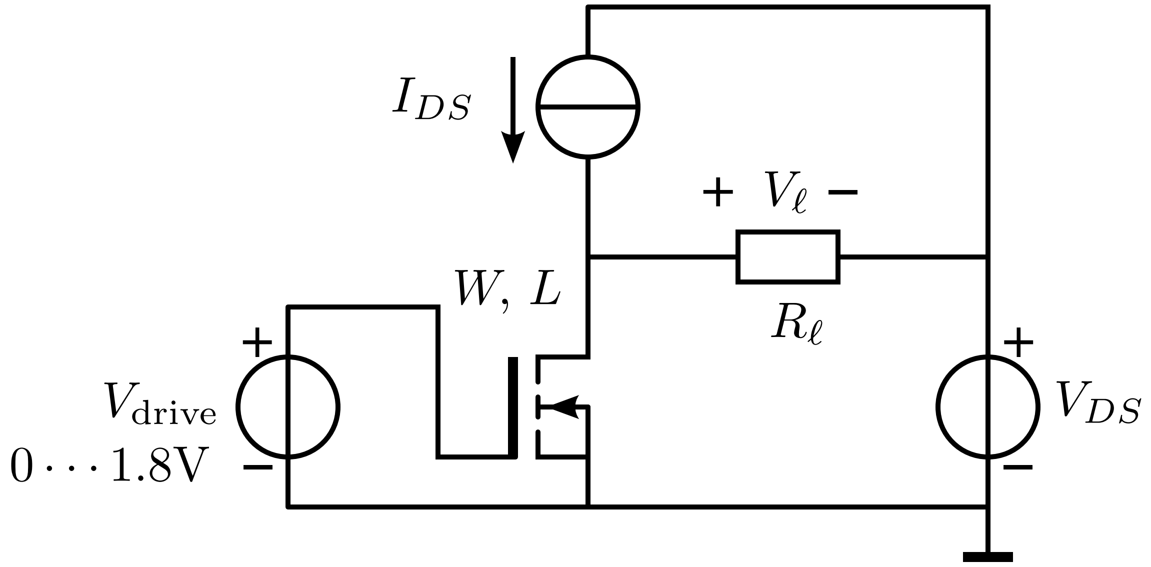



$V_{DS}$ Larger than the peak voltage drive requirement

## Direct feedback biasing

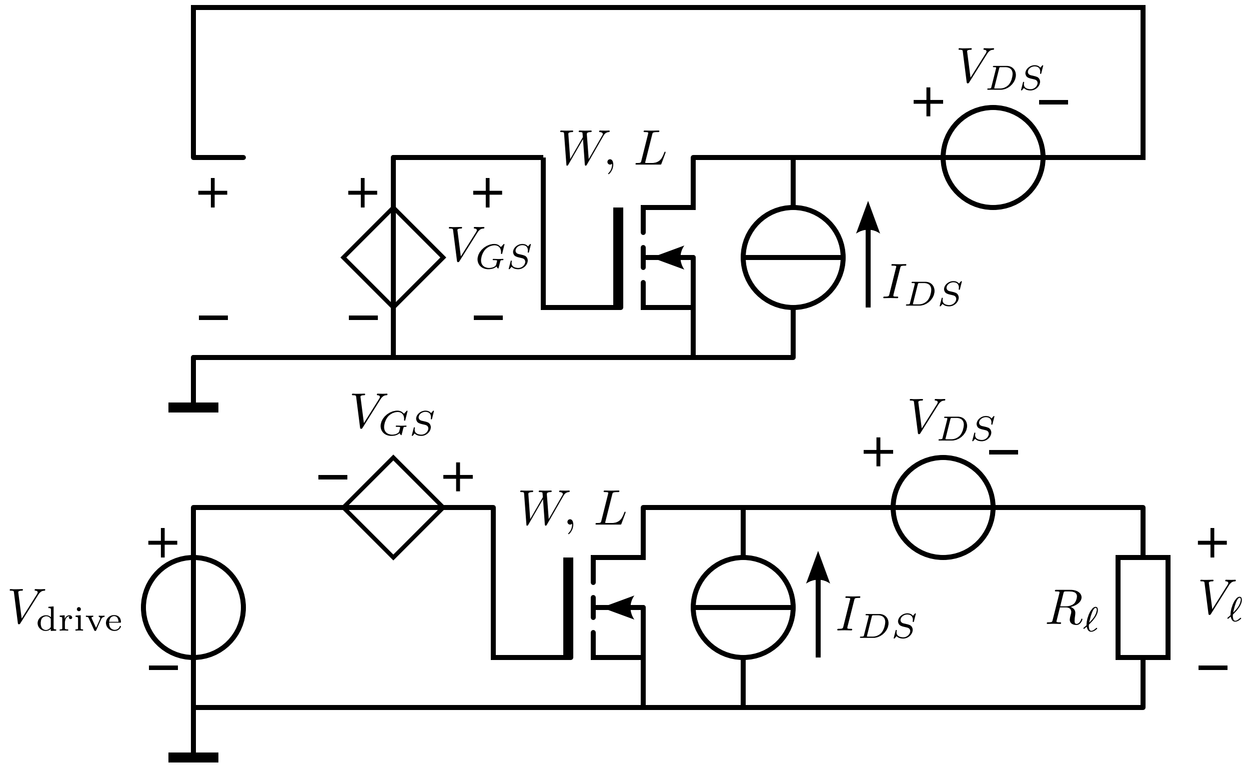



## Swept input



# Test benches output stage LTspice

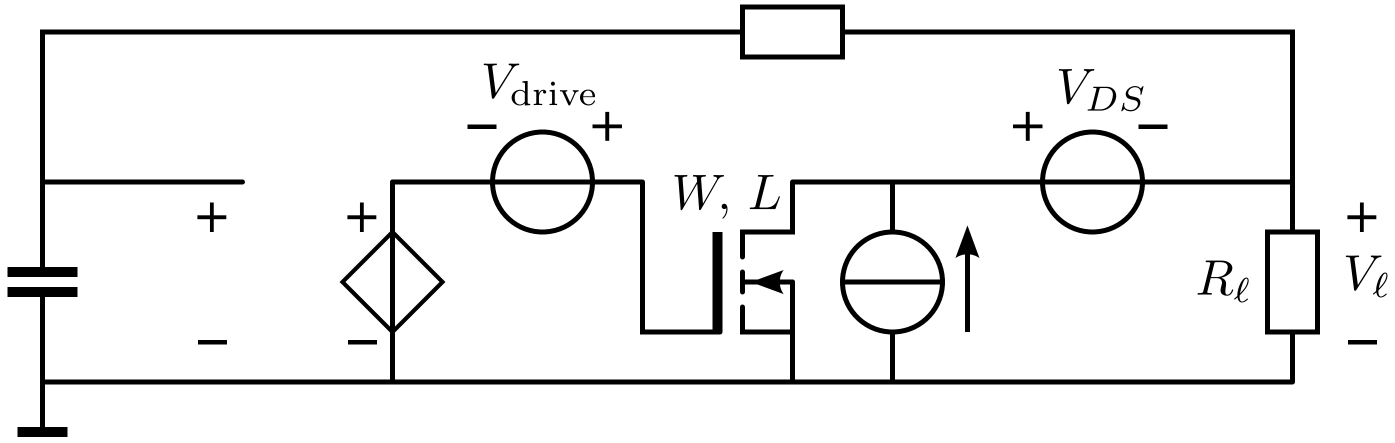
## Indirect feedback biasing



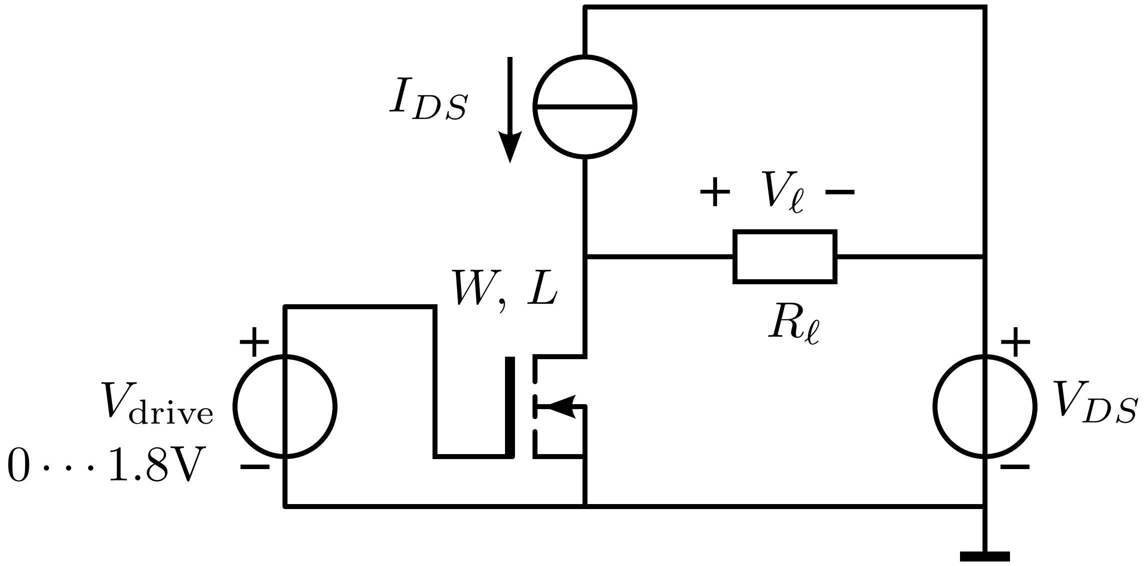

$V_{DS}$ Larger than the peak voltage drive requirement

$I_{DS}$ Larger than the peak current drive requirement

## Direct feedback biasing

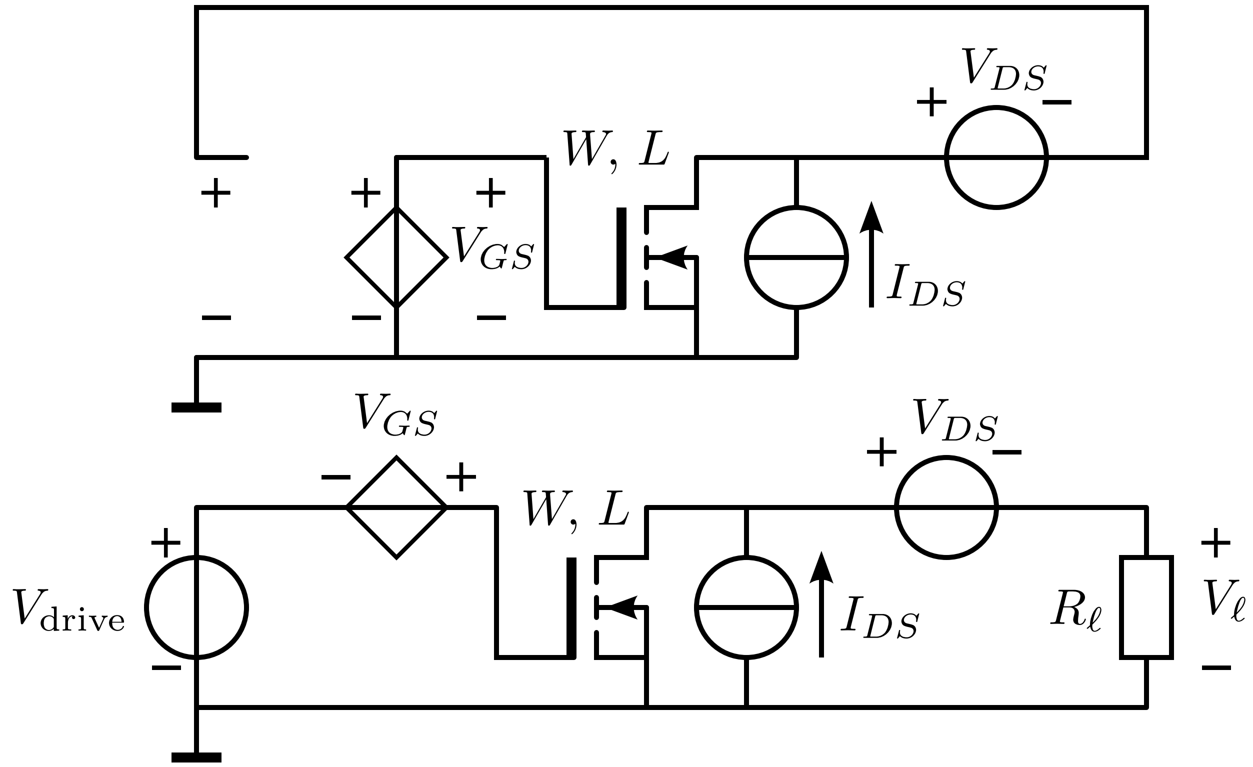



## Swept input



# Test benches output stage LTspice

## Indirect feedback biasing

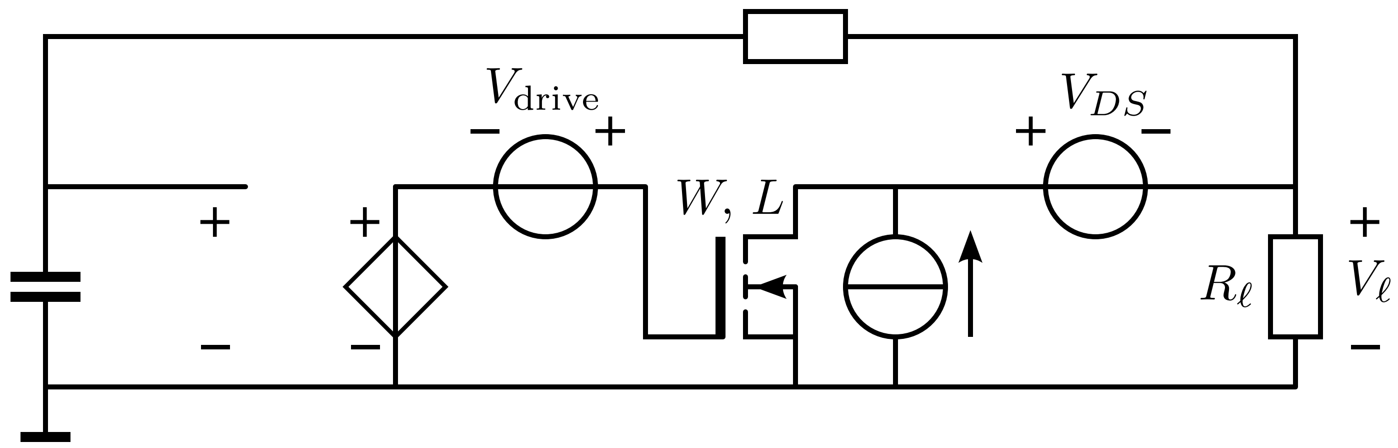



$V_{DS}$ Larger than the peak voltage drive requirement

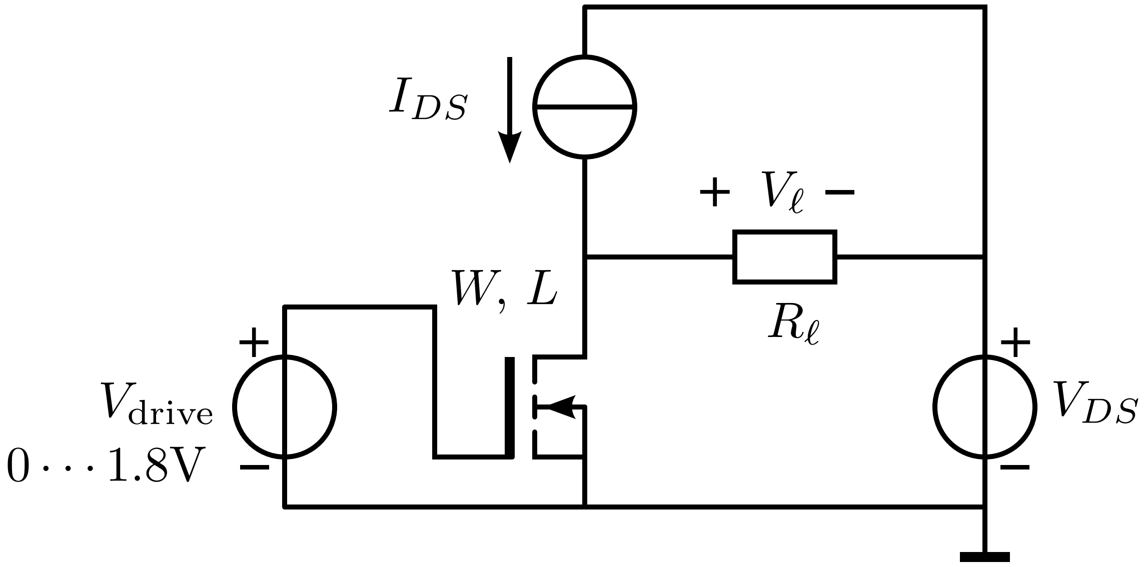
$I_{DS}$ Larger than the peak current drive requirement

$L$ Smallest value (lowest voltage drive requirement)

## Direct feedback biasing

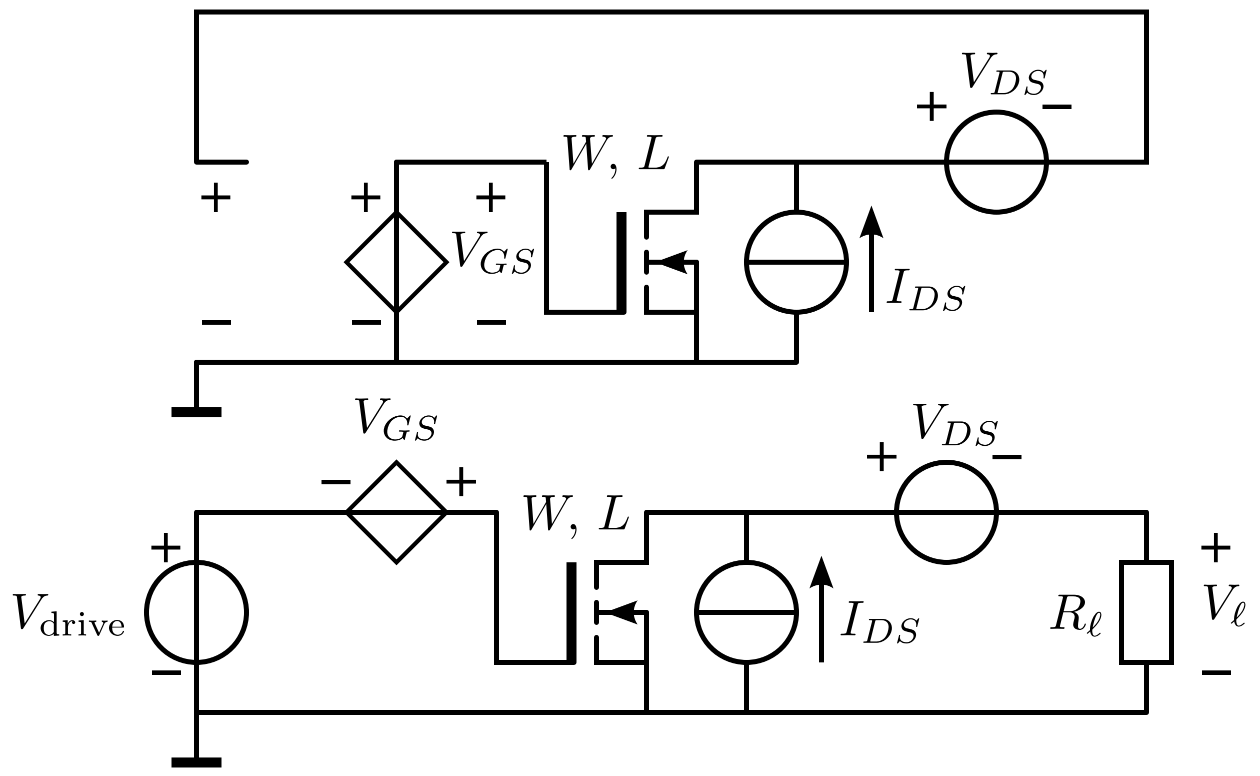



## Swept input

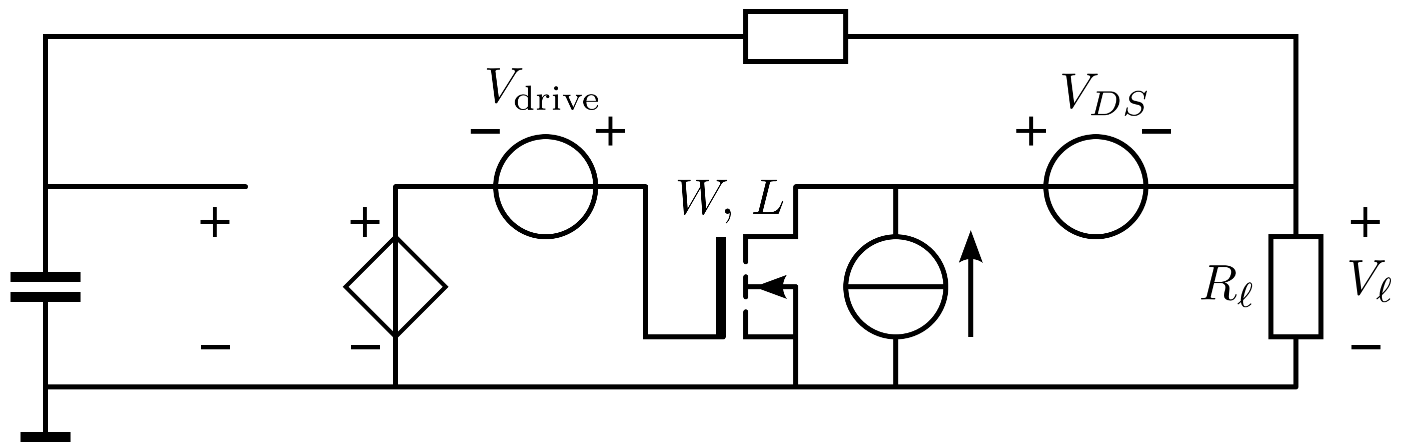


# Test benches output stage LTspice

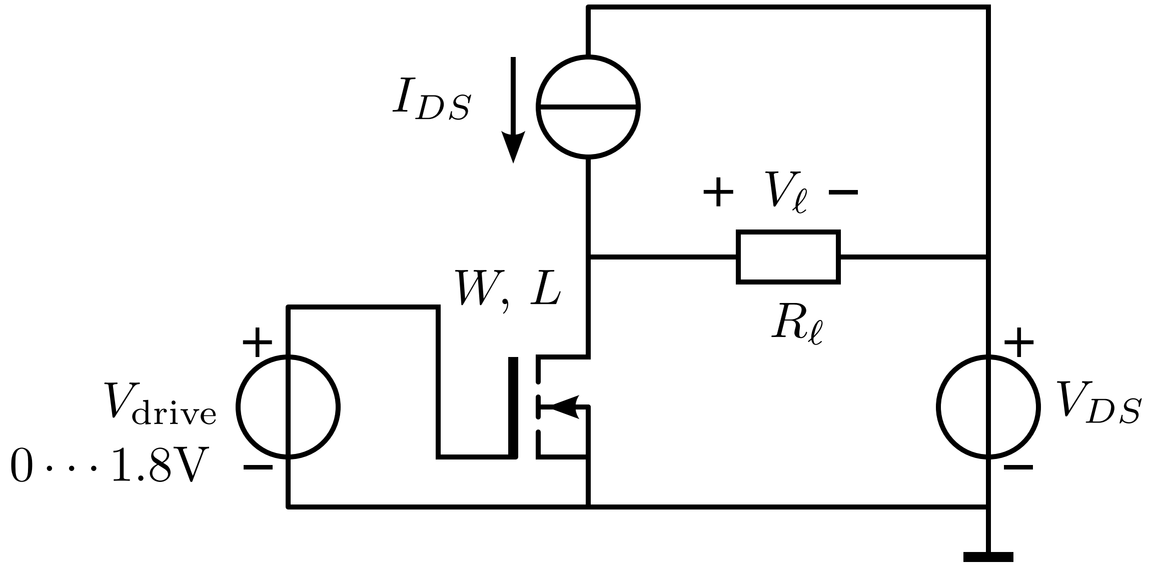
## Indirect feedback biasing




## Direct feedback biasing



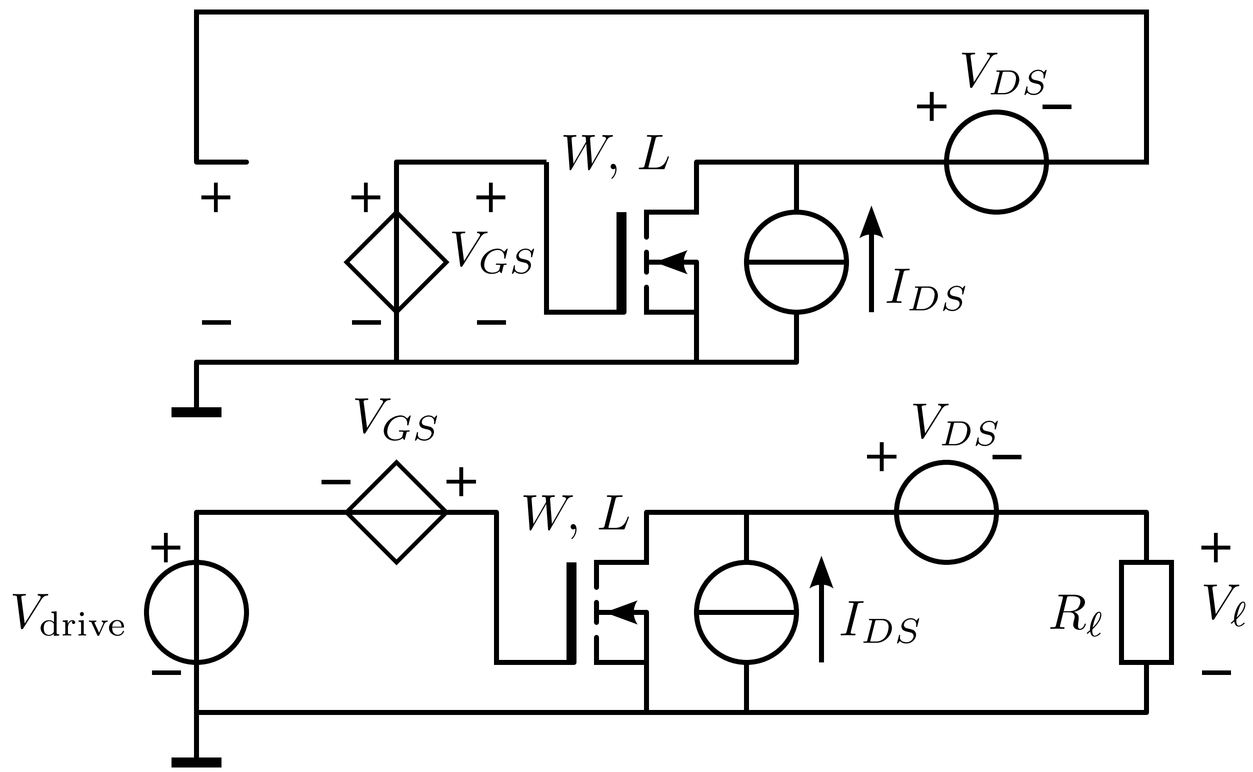

## Swept input



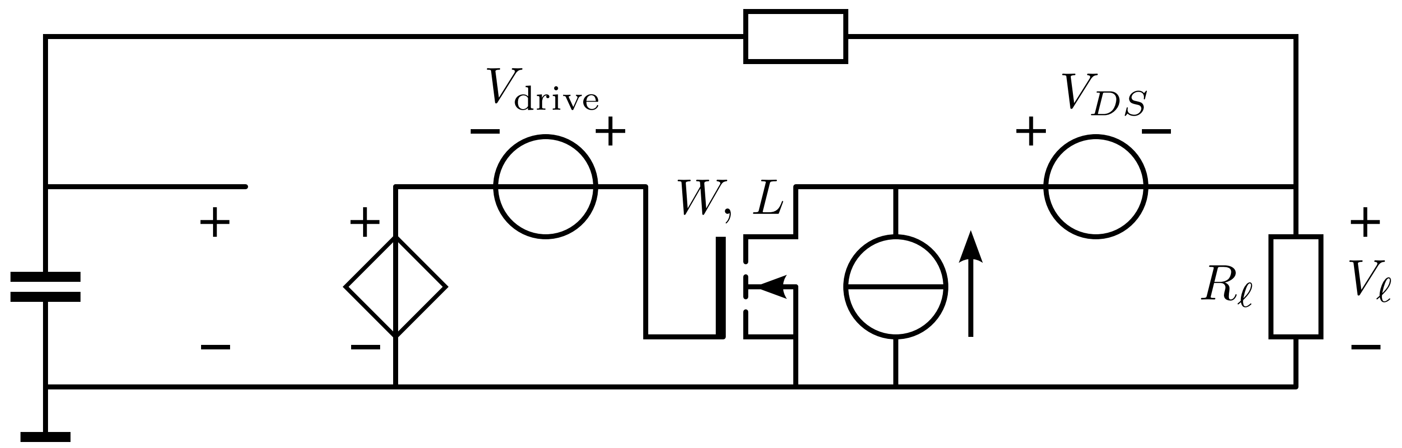

| | |
|---|---|
| $V_{DS}$ | Larger than the peak voltage drive requirement |
| $I_{DS}$ | Larger than the peak current drive requirement |
| $L$ | Smallest value (lowest voltage drive requirement) |
| $W$ | Large enough to ensure sufficiently large drive capability |

# Test benches output stage LTspice

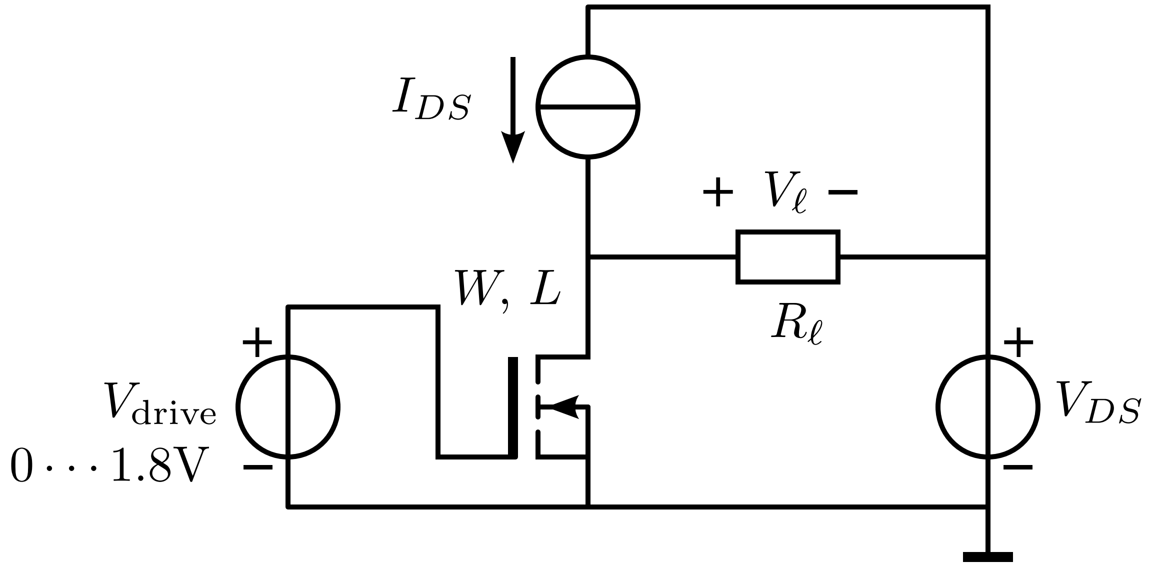
## Indirect feedback biasing




## Direct feedback biasing




## Swept input




| | |
|---|---|
| $V_{DS}$ | Larger than the peak voltage drive requirement |
| $I_{DS}$ | Larger than the peak current drive requirement |
| $L$ | Smallest value (lowest voltage drive requirement) |
| $W$ | Large enough to ensure sufficiently large drive capability |

# Structured Electronic Design

EE4109
Homework 1
Design of a CS stage,
Input stage design

*Anton J.M. Montagne*

# Design input stage noise performance: SLiCAP

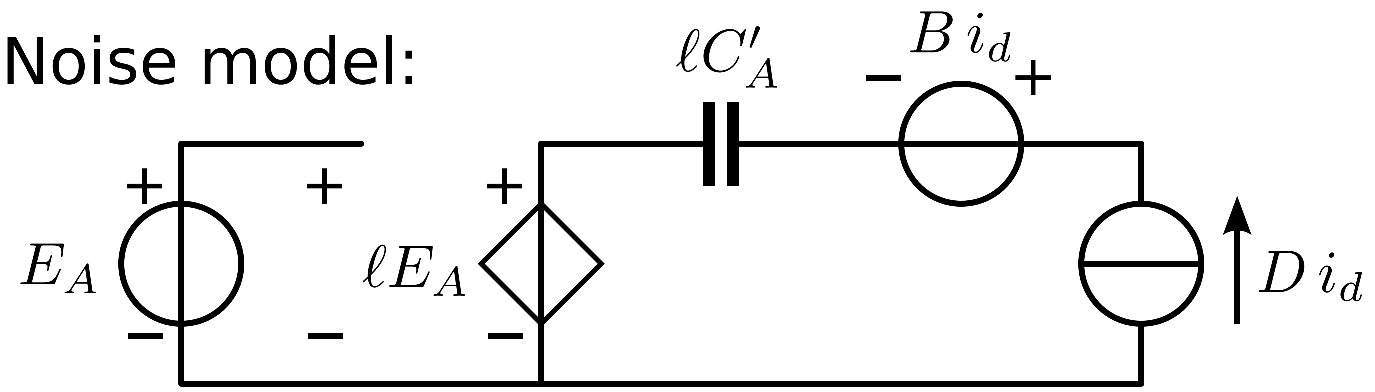
 

# Design input stage noise performance: SLiCAP

Noise model:

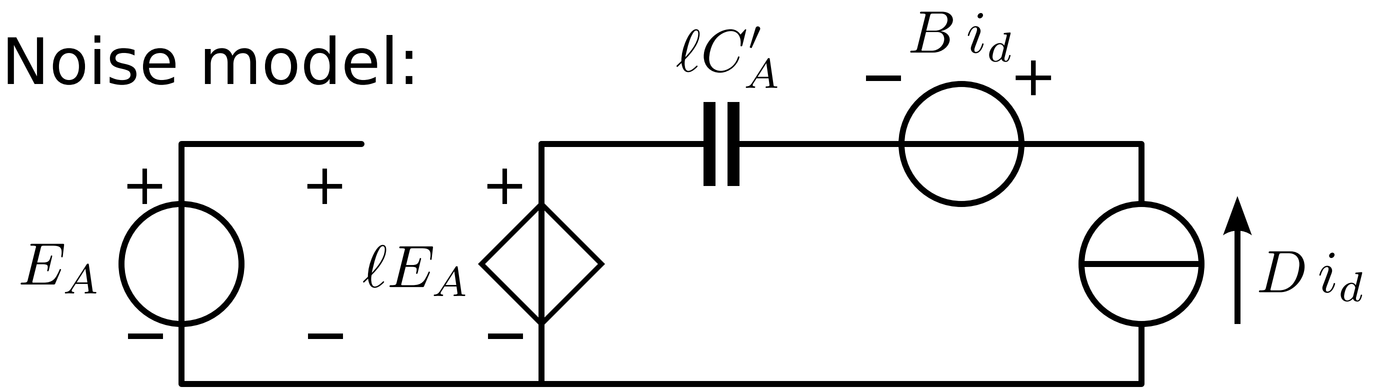
# Design input stage noise performance: SLiCAP

Noise model:



# Design input stage noise performance: SLiCAP

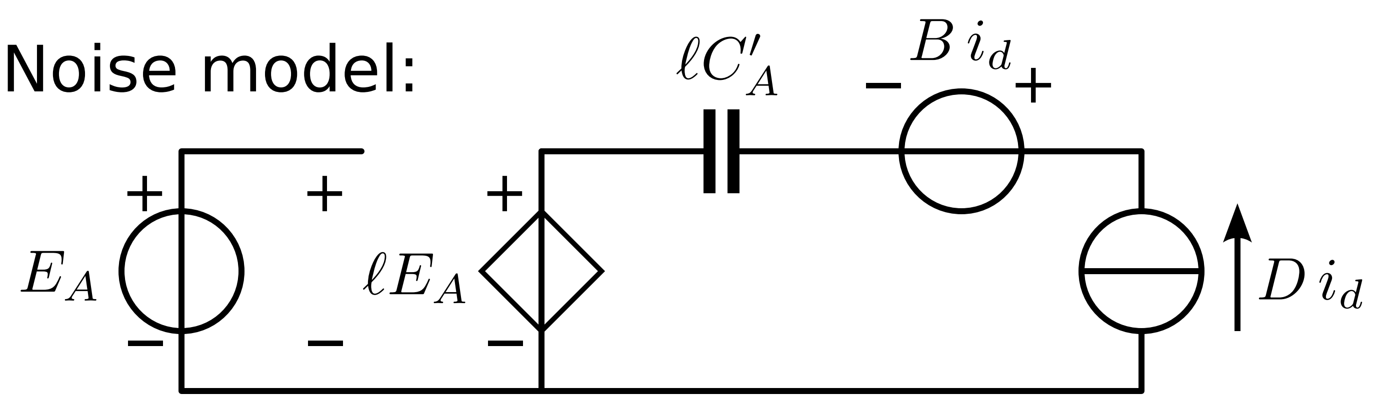
Noise model:




Given:

# Design input stage noise performance: SLiCAP

Noise model:

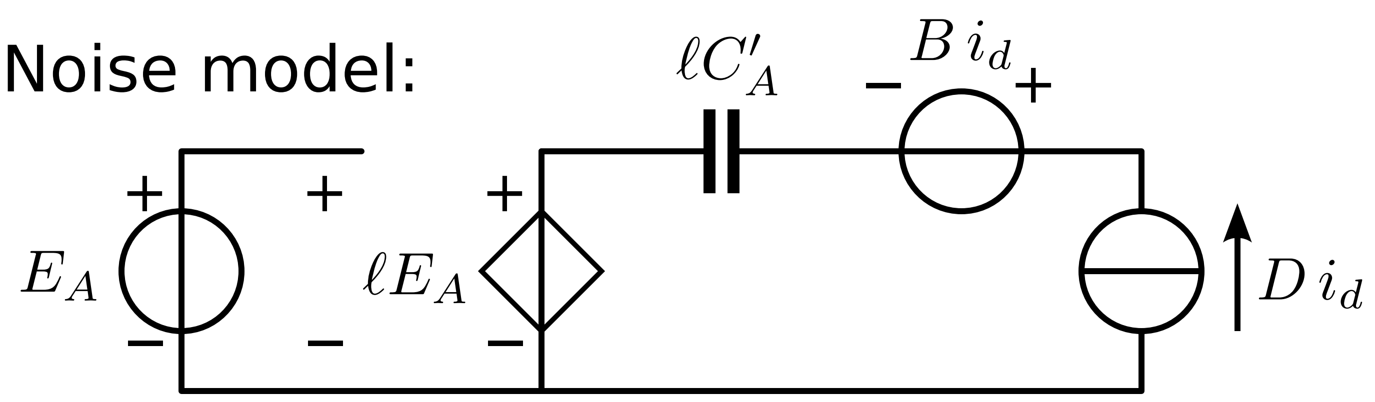



Given:

$$\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$$

# Design input stage noise performance: SLiCAP

Noise model:

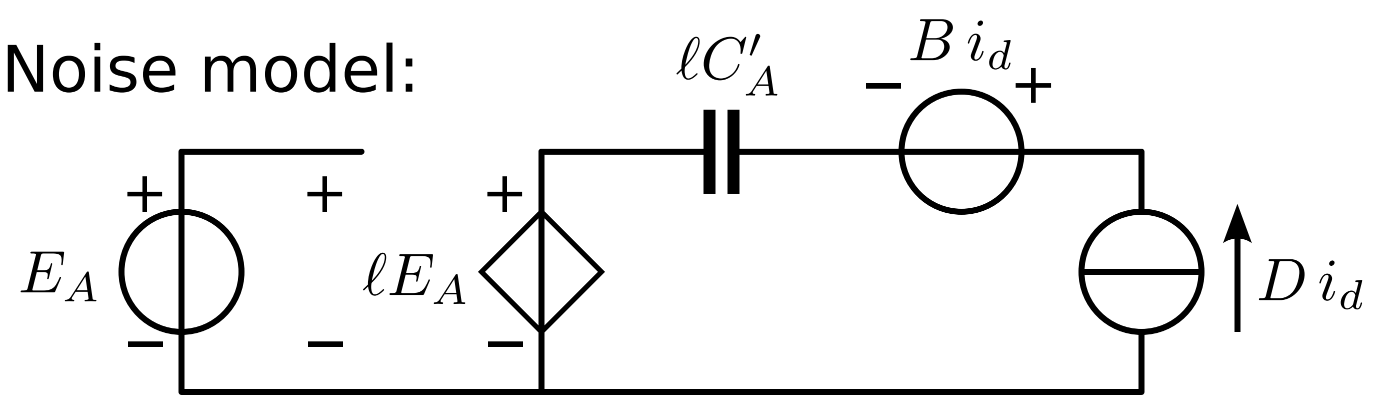



Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required:

# Design input stage noise performance: SLiCAP

Noise model:




Given:

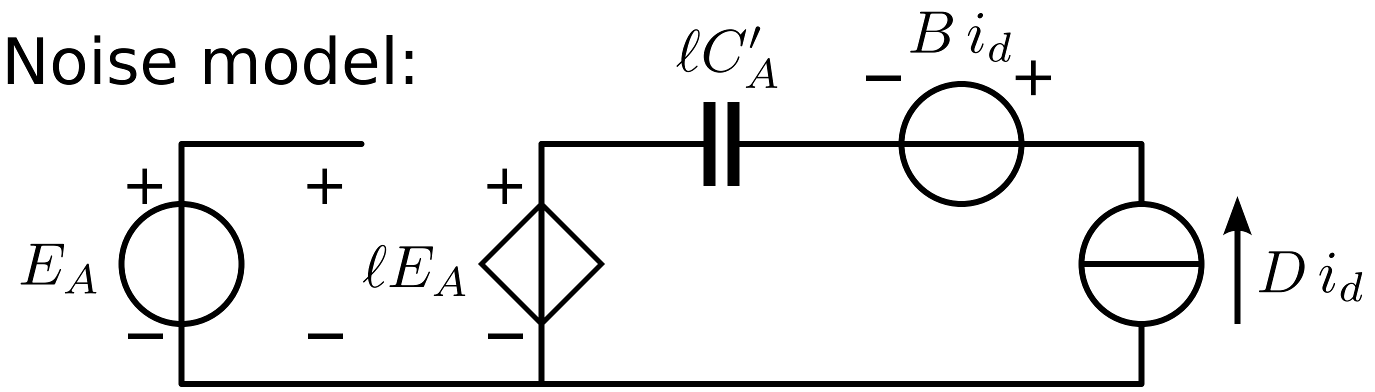
$$C'_A = 8.33 \times 10^{-12} \; [\mathrm{Fm^{-1}}]$$
$$\ell = 0.18 \; [\mathrm{m}]$$

Required:

$$S_E = 25 \times 10^{-18} \; [\mathrm{V^2 m^{-2} Hz^{-1}}]$$
$$f_\ell = 100 \times 10^3 \; [\mathrm{Hz}]$$

# Design input stage noise performance: SLiCAP

Noise model:




Given:

$$C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}]$$
$$\ell = 0.18\ [\mathrm{m}]$$

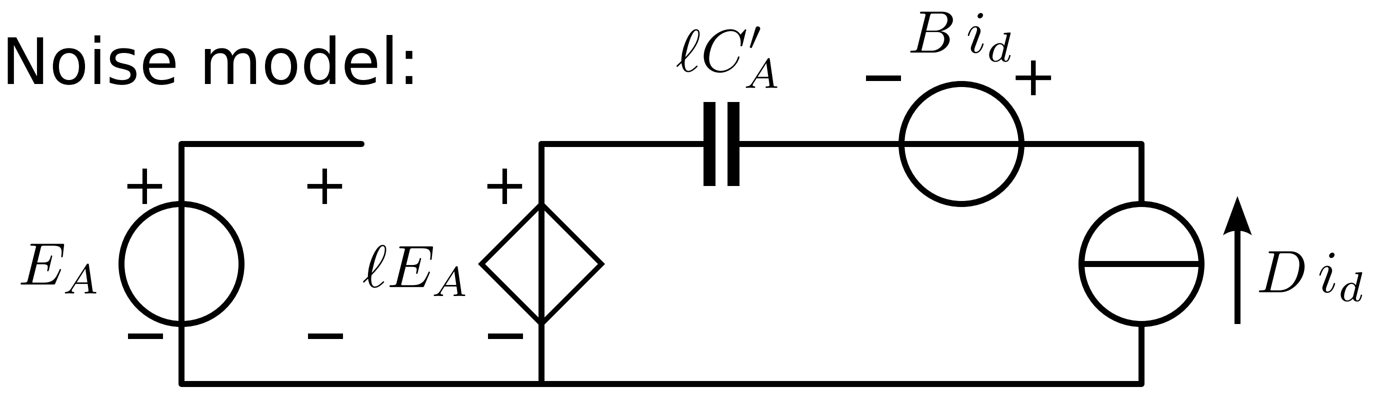
Required:

$$S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}]$$
$$f_\ell = 100 \times 10^3\ [\mathrm{Hz}]$$

Determine $I_{DS}$, $L$, $W$ based on spectrum noise floor and corner frequency 1/f noise

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\left\{ \begin{array}{l} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{array} \right.$

Required: $\left\{ \begin{array}{l} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{array} \right.$

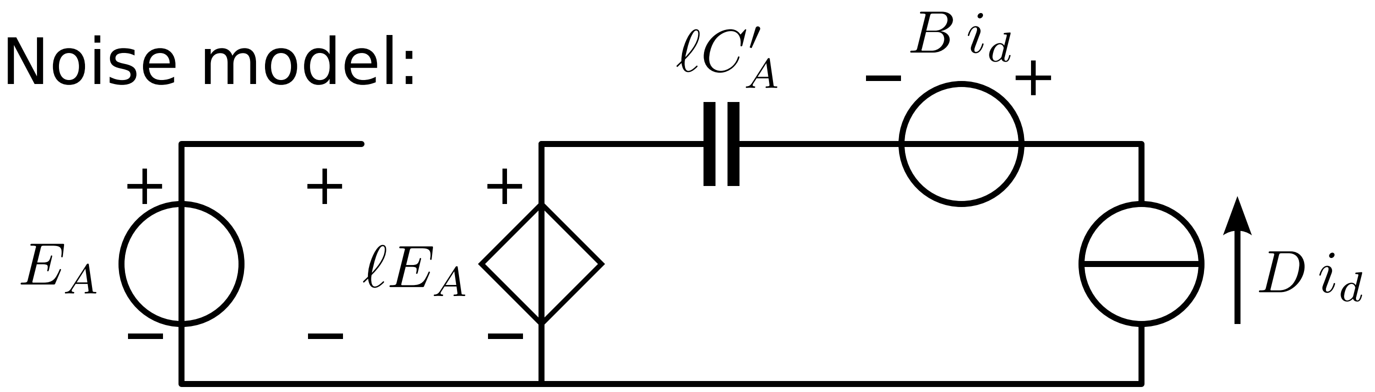
Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12} \; [\mathrm{Fm}^{-1}] \\ \ell = 0.18 \; [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18} \; [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3 \; [\mathrm{Hz}] \end{cases}$

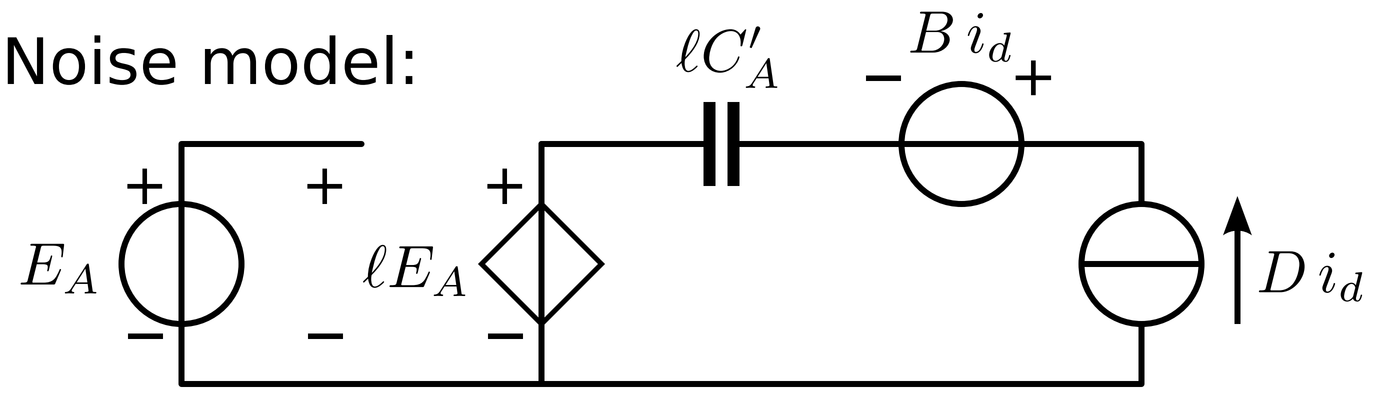
Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

# Design input stage noise performance: SLiCAP

Noise model:




Given:
$$\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm^{-1}}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$$

Required:
$$\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V^2 m^{-2} Hz^{-1}}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

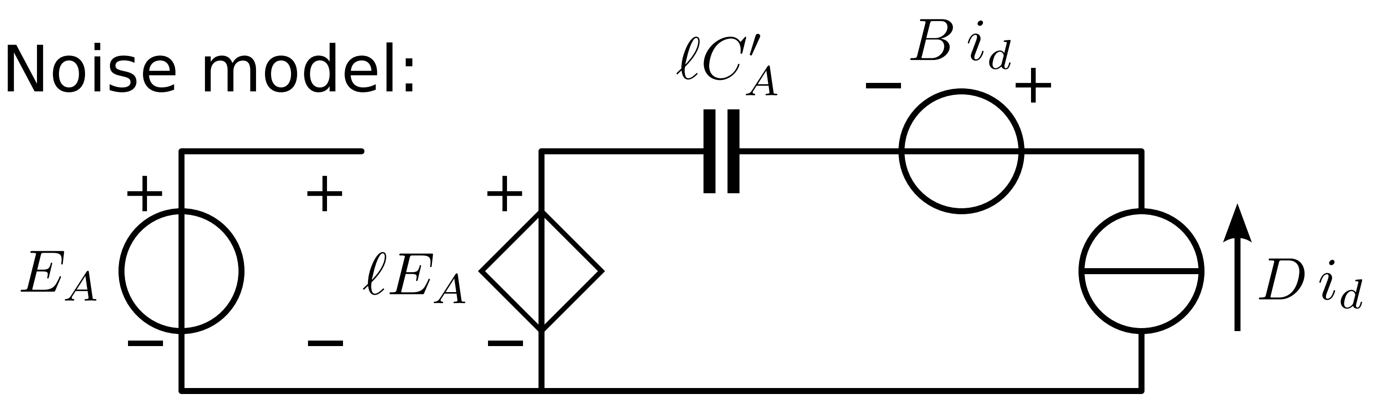
$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

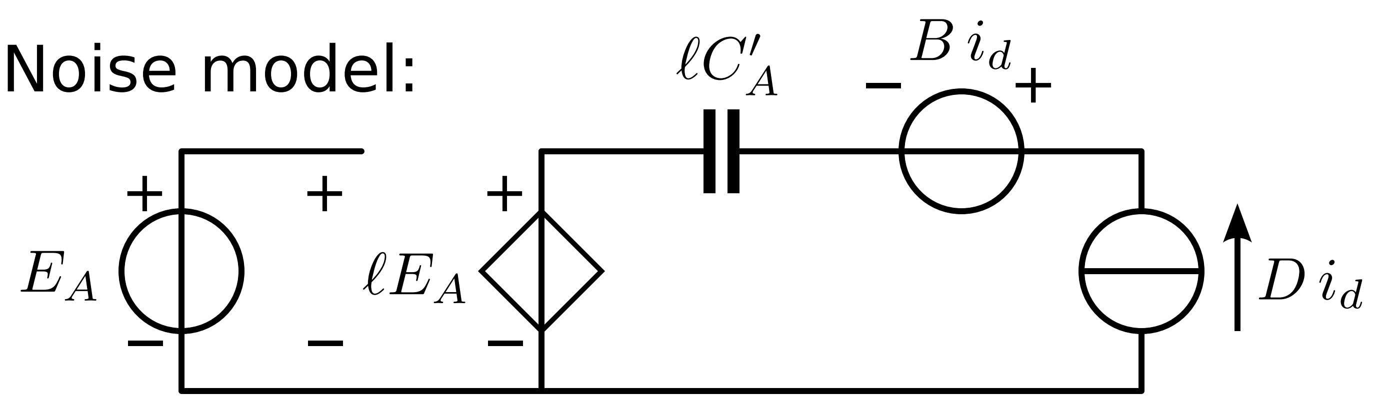
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12} \ [\mathrm{Fm}^{-1}] \\ \ell = 0.18 \ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18} \ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3 \ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 \frac{1}{f}\right)$$

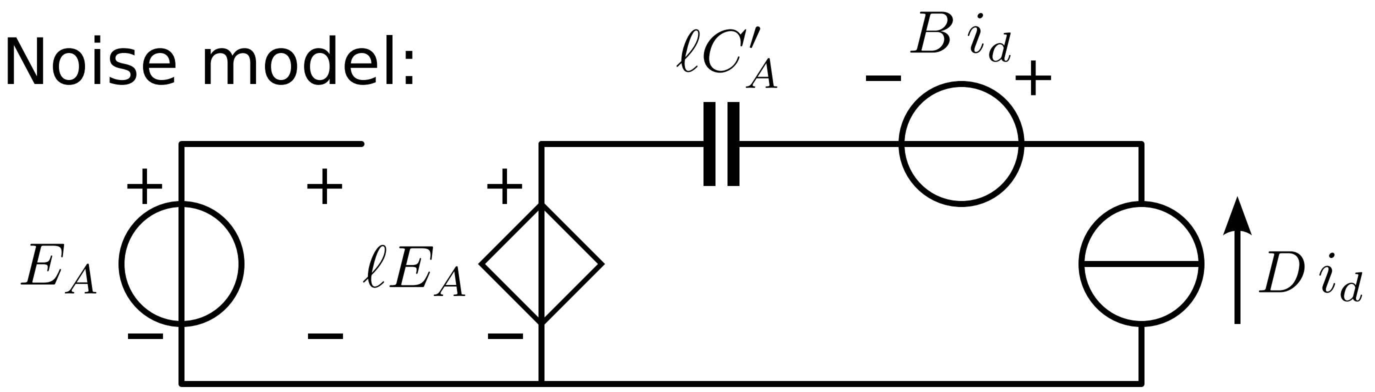
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0 \epsilon_{\mathrm{SiO_2}}}$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

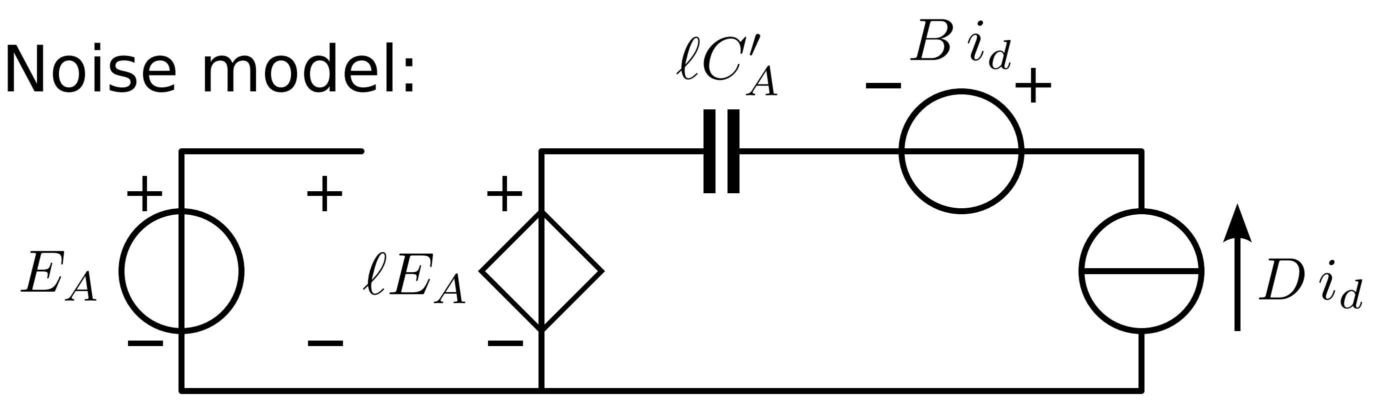
Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO_2}}}$

2. Derive requirement floor noise

# Design input stage noise performance: SLiCAP

Noise model:




Given:
$$\begin{cases} C'_A = 8.33 \times 10^{-12} \ [\mathrm{Fm^{-1}}] \\ \ell = 0.18 \ [\mathrm{m}] \end{cases}$$

Required:
$$\begin{cases} S_E = 25 \times 10^{-18} \ [\mathrm{V^2 m^{-2} Hz^{-1}}] \\ f_\ell = 100 \times 10^3 \ [\mathrm{Hz}] \end{cases}$$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

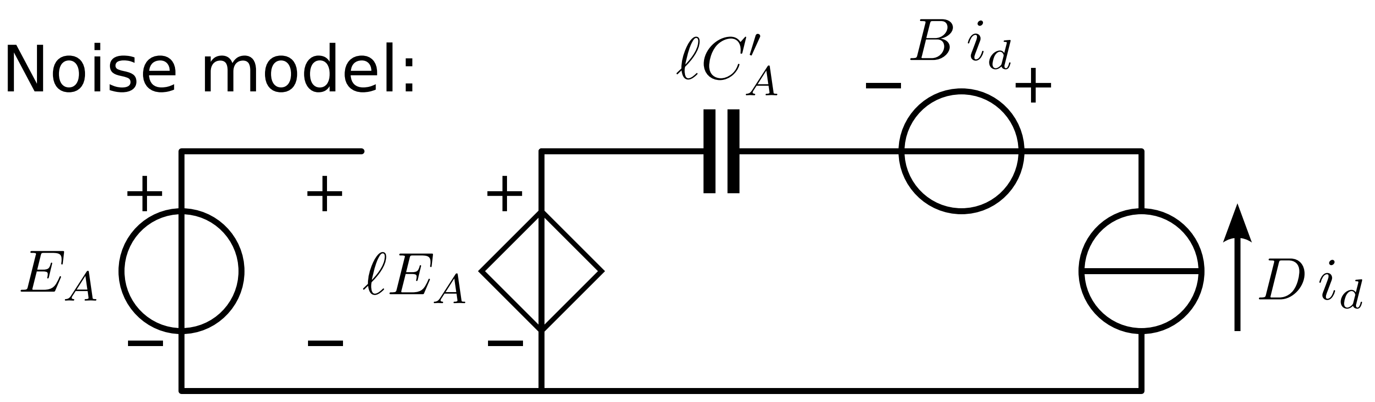
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0 \epsilon_{\mathrm{SiO_2}}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm^{-1}}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V^2m^{-2}Hz^{-1}}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

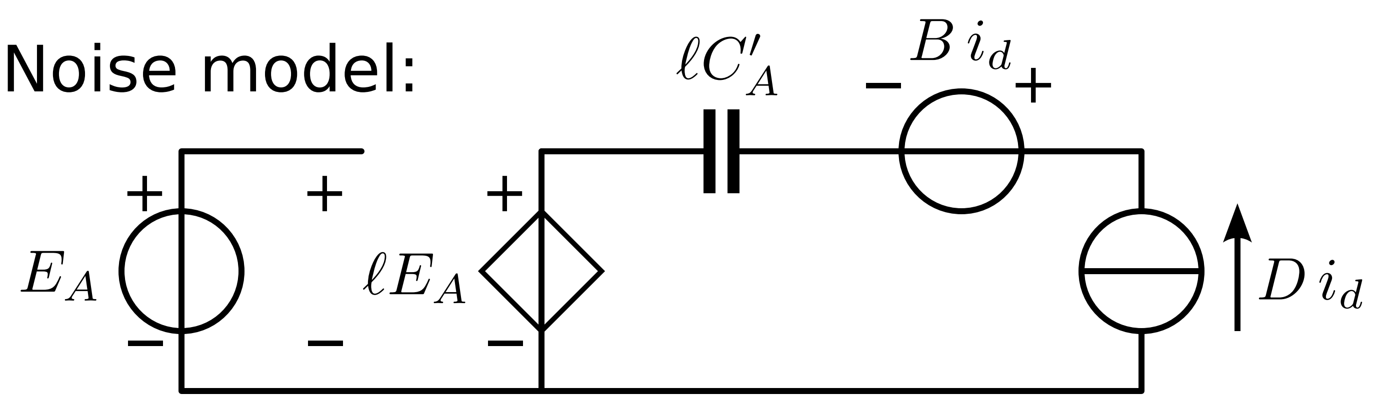
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO_2}}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm^{-1}}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V^2 m^{-2} Hz^{-1}}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

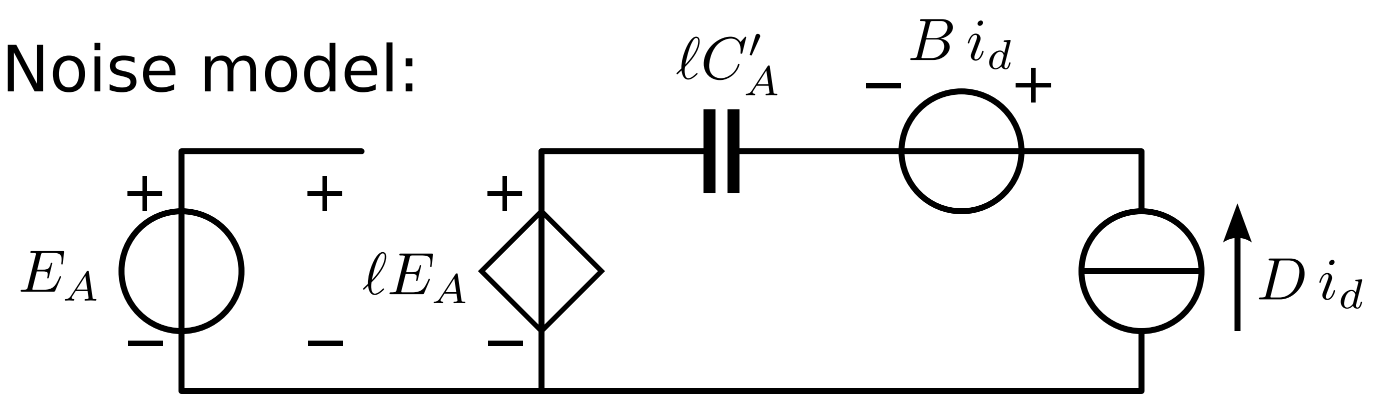
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0 \epsilon_{\mathrm{SiO_2}}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma} f_T \approx 10^{-4} f_T = 620\mathrm{kHz}$

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

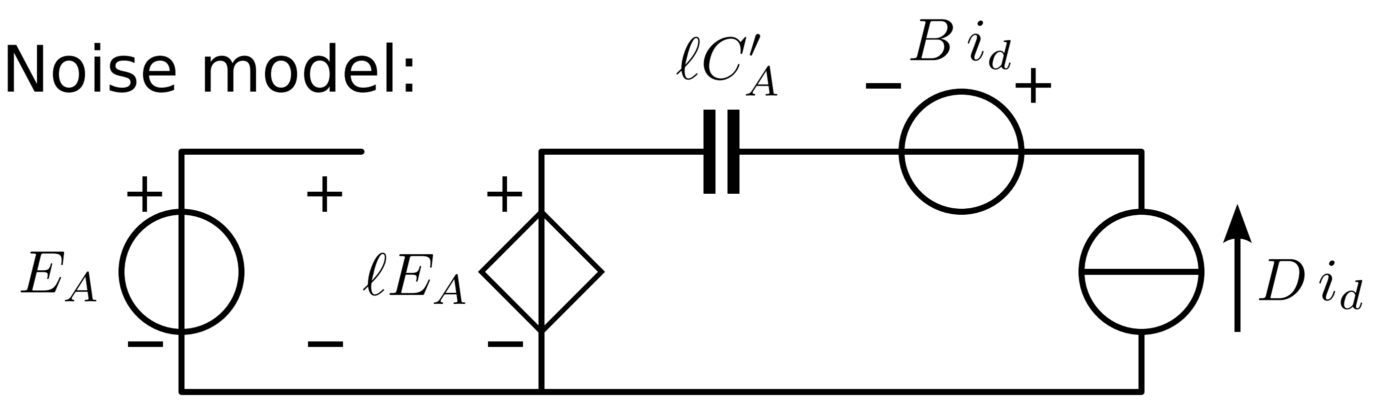
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO}_2}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma}f_T \approx 10^{-4}f_T = 620\mathrm{kHz}$ show stopper!

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

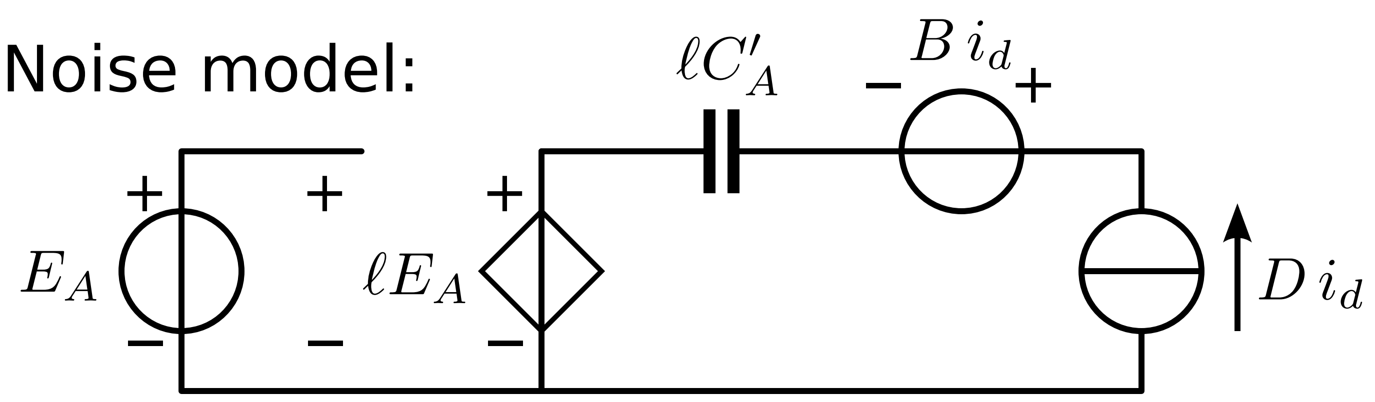
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0 \epsilon_{\mathrm{SiO}_2}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma}f_T \approx 10^{-4}f_T = 620\mathrm{kHz}$ show stopper!
5. If possible adjust drain current to obtain the correct noise floor:

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12} \ [\mathrm{Fm}^{-1}] \\ \ell = 0.18 \ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18} \ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3 \ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

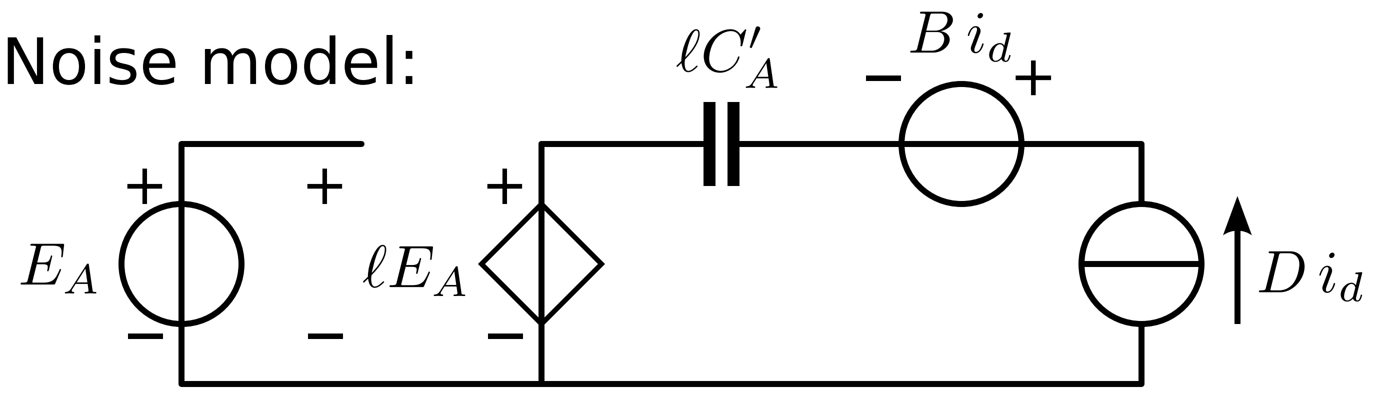
Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO}_2}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma}f_T \approx 10^{-4}f_T = 620\mathrm{kHz}$ show stopper!
5. If possible adjust drain current to obtain the correct noise floor:
   lowest current with shortest channel

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

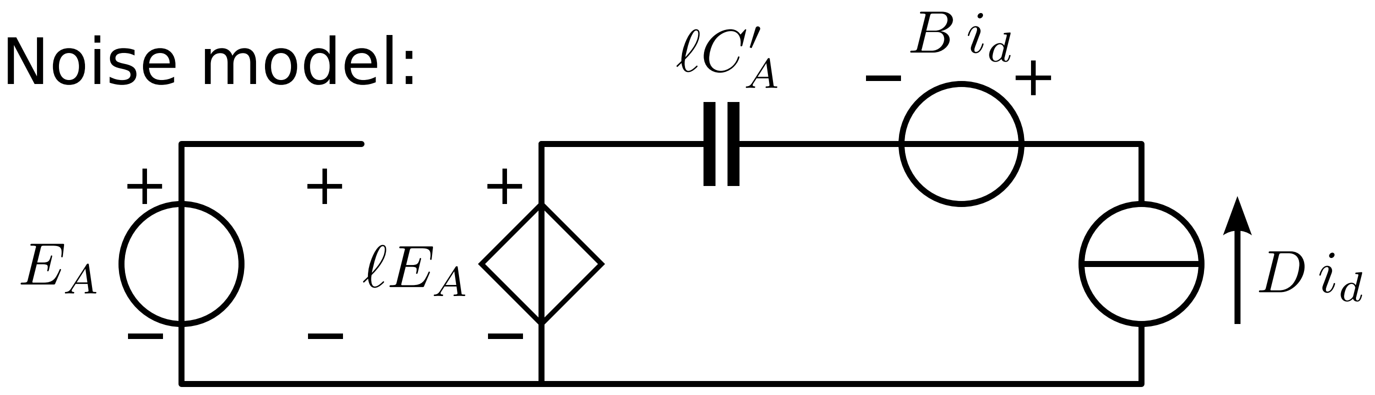
Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO_2}}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma}f_T \approx 10^{-4} f_T = 620\mathrm{kHz}$ show stopper!
5. If possible adjust drain current to obtain the correct noise floor:
   lowest current with shortest channel

Can be automated using SLiCAP!

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12} \; [\mathrm{Fm}^{-1}] \\ \ell = 0.18 \; [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18} \; [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3 \; [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF} \quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO_2}}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma}f_T \approx 10^{-4} f_T = 620\mathrm{kHz}$ show stopper!
5. If possible adjust drain current to obtain the correct noise floor:
   lowest current with shortest channel

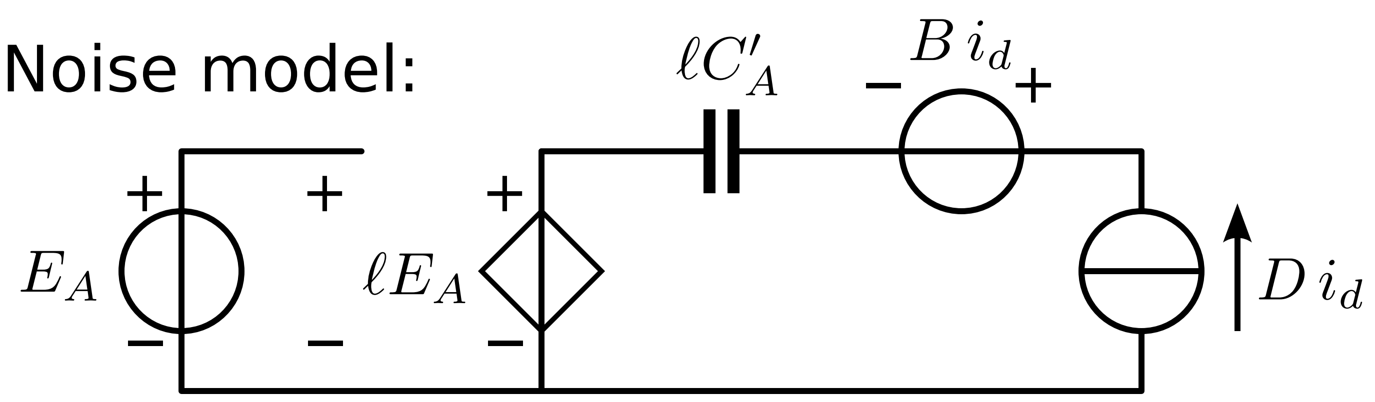
Can be automated using SLiCAP!

Demo

# Design input stage noise performance: SLiCAP

Noise model:




Given: $\begin{cases} C'_A = 8.33 \times 10^{-12}\ [\mathrm{Fm}^{-1}] \\ \ell = 0.18\ [\mathrm{m}] \end{cases}$

Required: $\begin{cases} S_E = 25 \times 10^{-18}\ [\mathrm{V}^2\mathrm{m}^{-2}\mathrm{Hz}^{-1}] \\ f_\ell = 100 \times 10^3\ [\mathrm{Hz}] \end{cases}$

Determine $I_{DS}, L, W$ based on spectrum noise floor and corner frequency 1/f noise

$$S_E = \frac{1}{\ell^2}\left(\frac{4kT\Gamma n}{g_m}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2 + \frac{2\mathrm{KF}}{3c_{iss}}\left(1+\frac{c_{iss}}{\ell C'_A}\right)^2\frac{1}{f}\right)$$

Lowest corner frequency 1/f noise if $c_{iss} = \ell C'_A$

Minimum length for given requirements and process: $\ell > 2\sqrt[3]{\frac{\mathrm{KF}}{3S_E C'_A f_\ell}}$

1. Design $c_{iss} = \ell C'_A = 1.5\mathrm{pF}$ $\quad WL \approx c_{iss}\frac{3}{2}\frac{t_{ox}}{\epsilon_0\epsilon_{\mathrm{SiO_2}}}$
2. Derive requirement floor noise $g_m = \frac{16kT\Gamma n}{\ell^2 S_E} = 58\mathrm{mS}$
3. Calculate $f_T = \frac{g_m}{2\pi c_{iss}} = 6.2\mathrm{GHz}$
4. Check $f_\ell = \mathrm{KF}\frac{\pi}{3kTn\Gamma}f_T \approx 10^{-4}f_T = 620\mathrm{kHz}$ show stopper!
5. If possible adjust drain current to obtain the correct noise floor:
   lowest current with shortest channel

Can be automated using SLiCAP!

Demo

# Structured Electronic Design

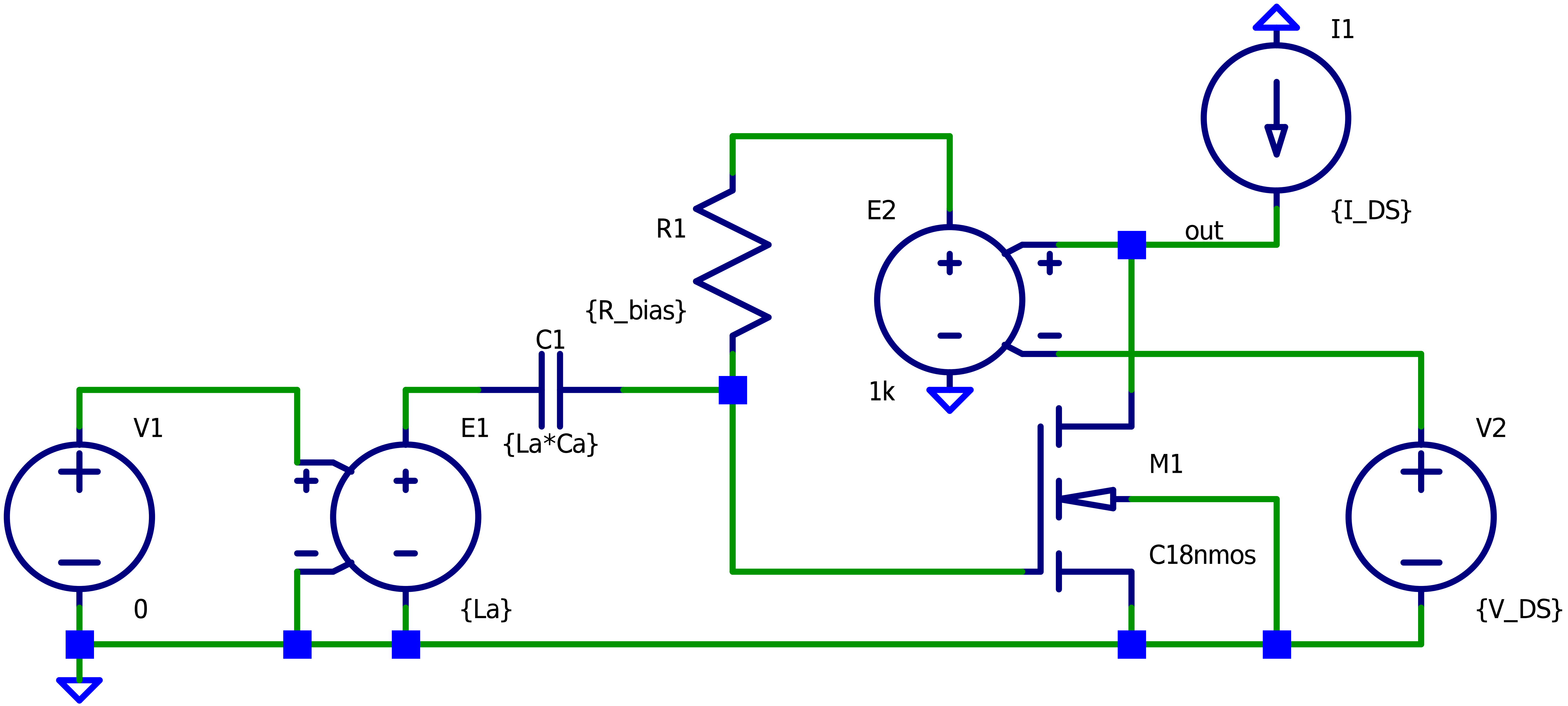
EE4109
Homework 1
Design of a CS stage,
LTspice noise test bench

*Anton J.M. Montagne*

# LTspice noise test bench

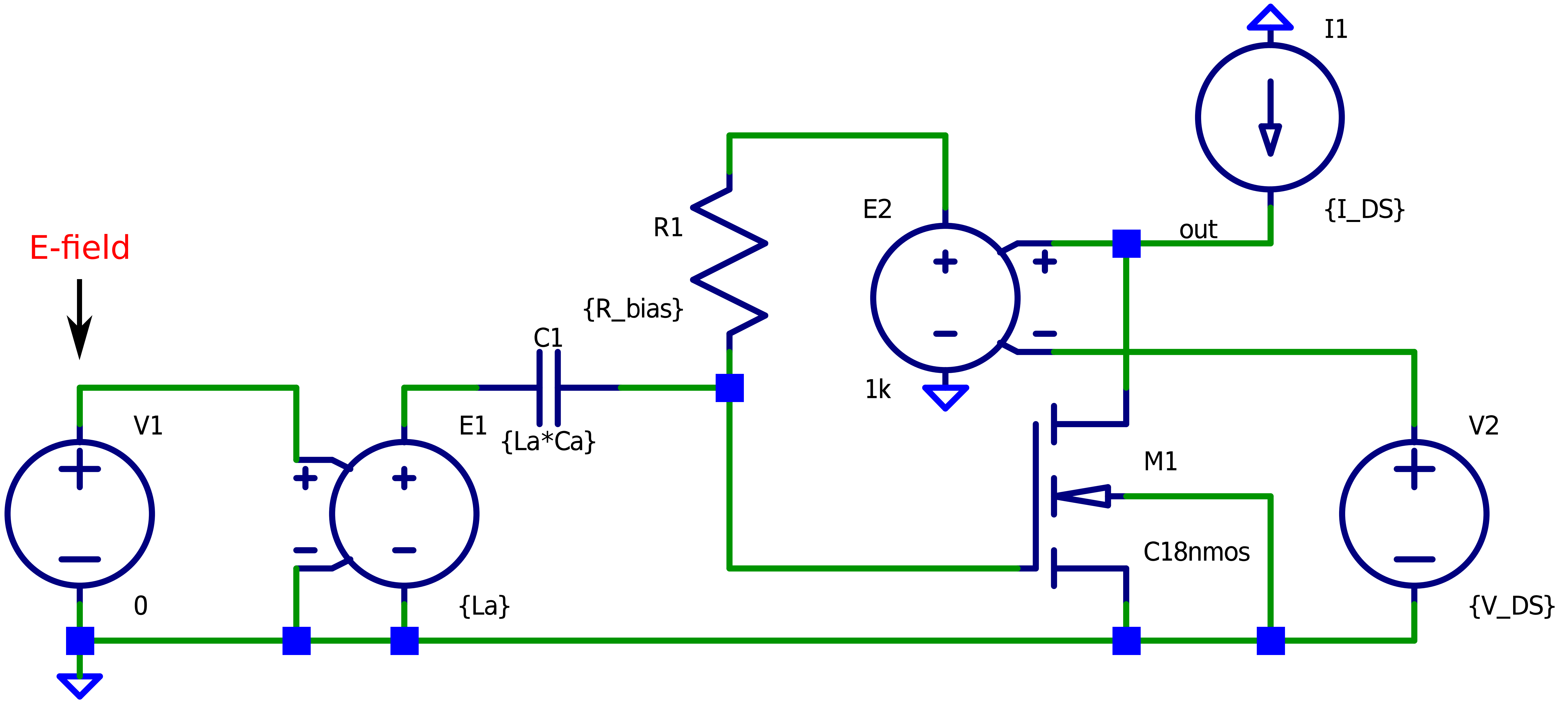
# LTspice noise test bench




.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

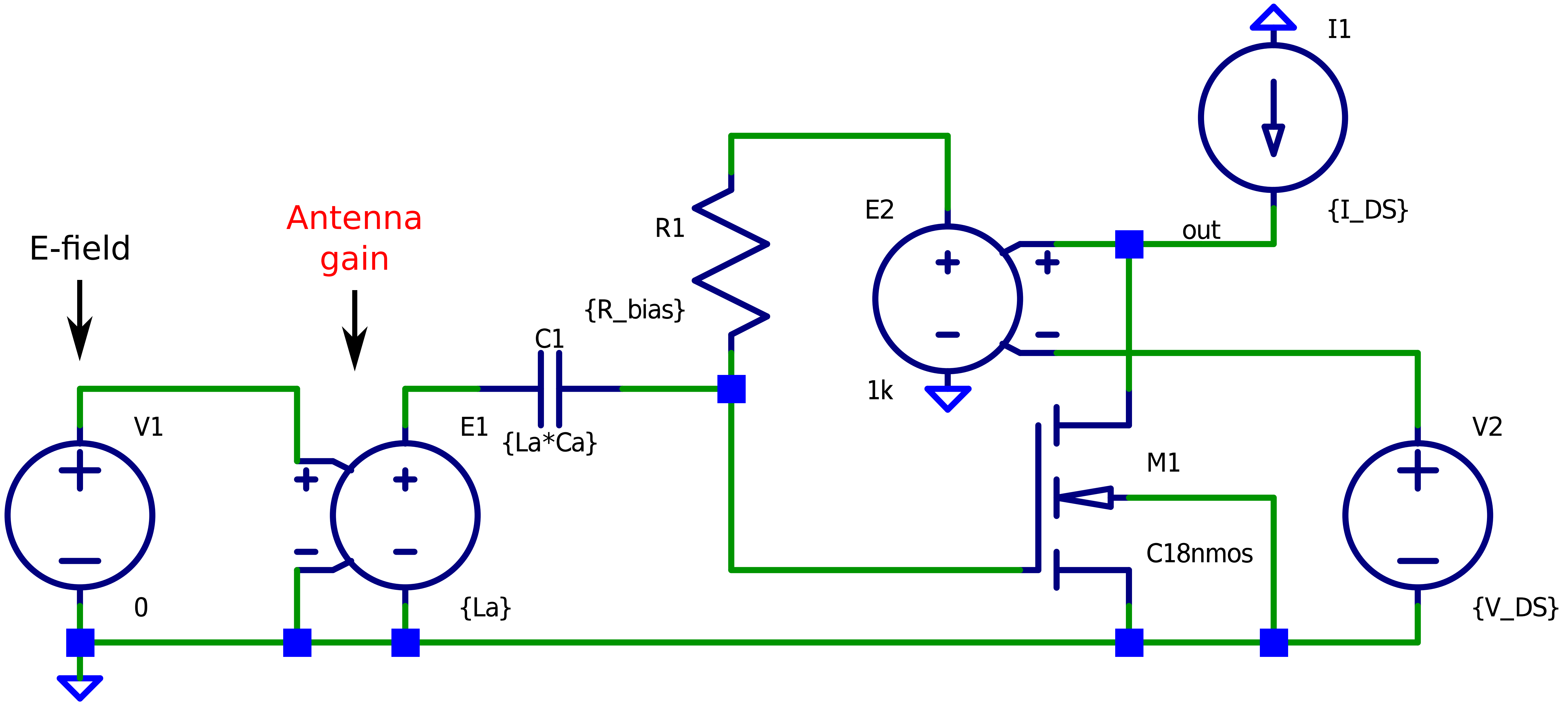
 

# LTspice noise test bench



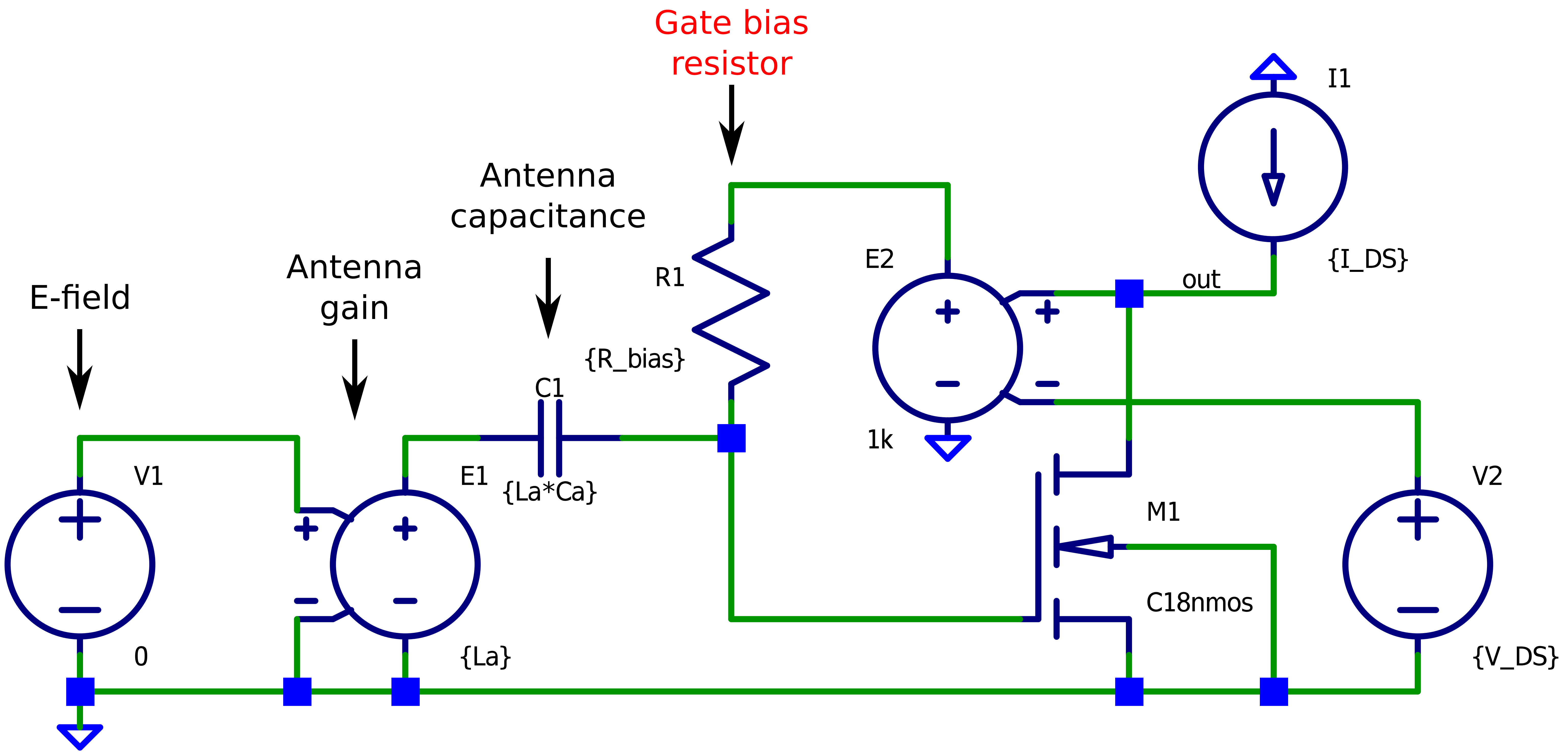

.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg



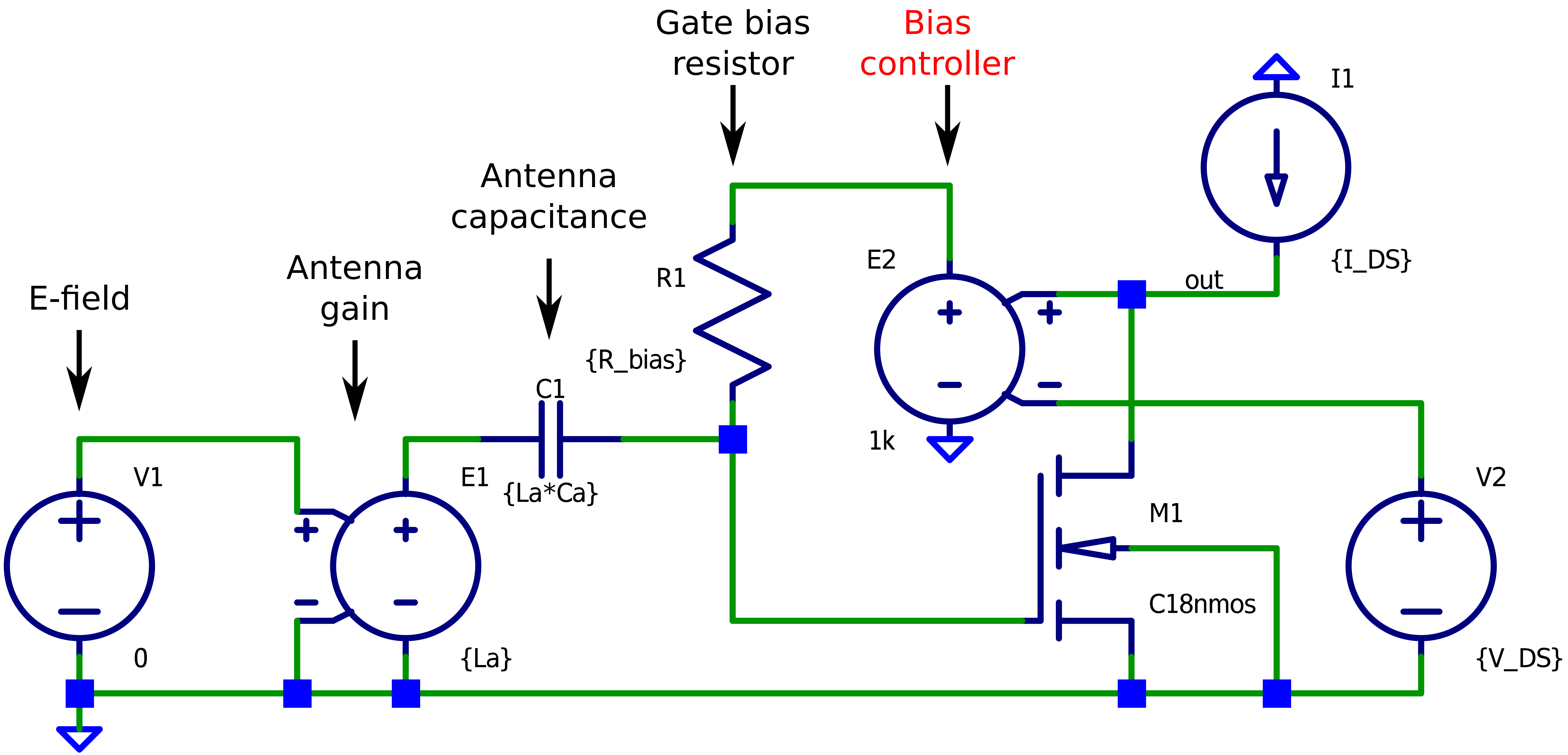

```
.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg
```

# LTspice noise test bench



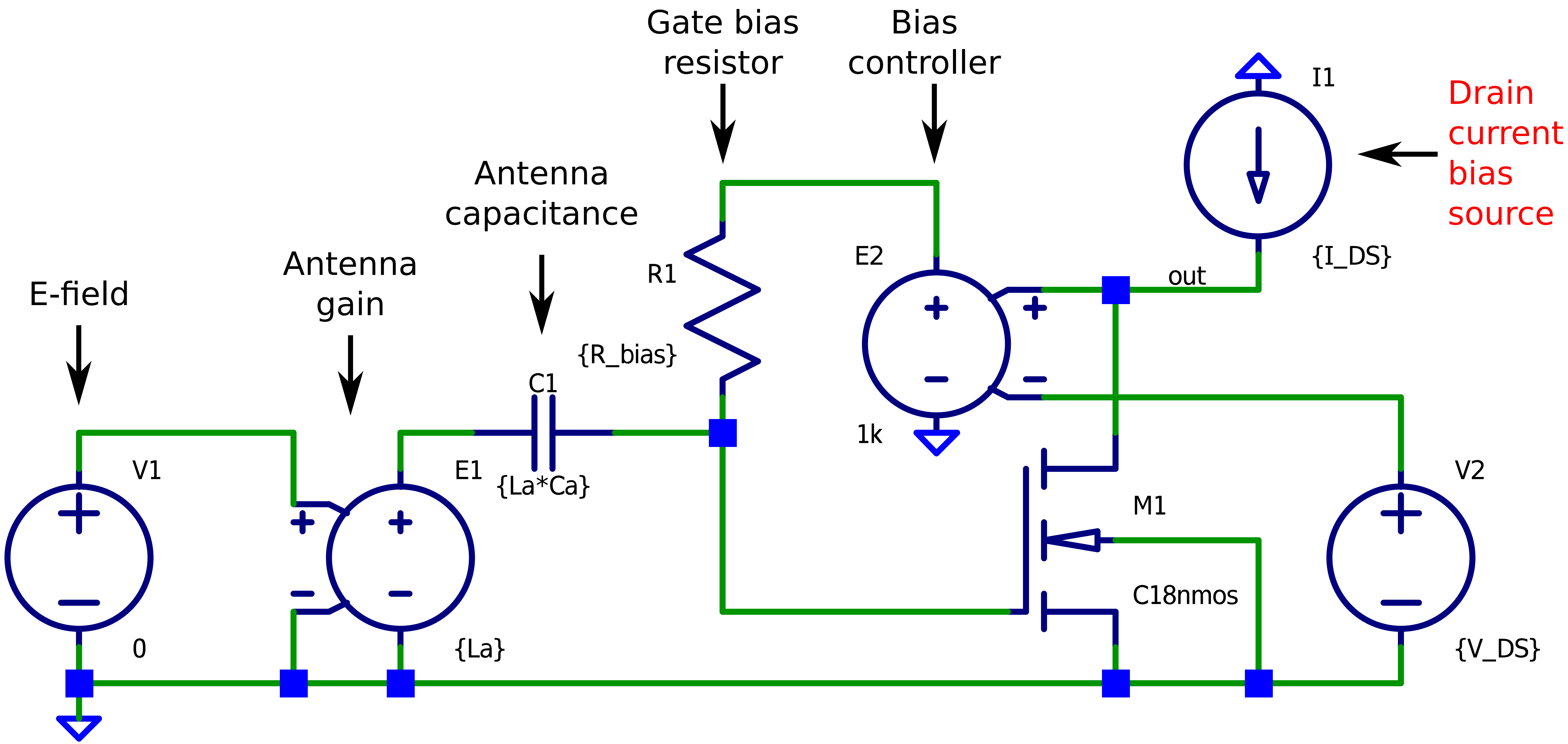

.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

# LTspice noise test bench



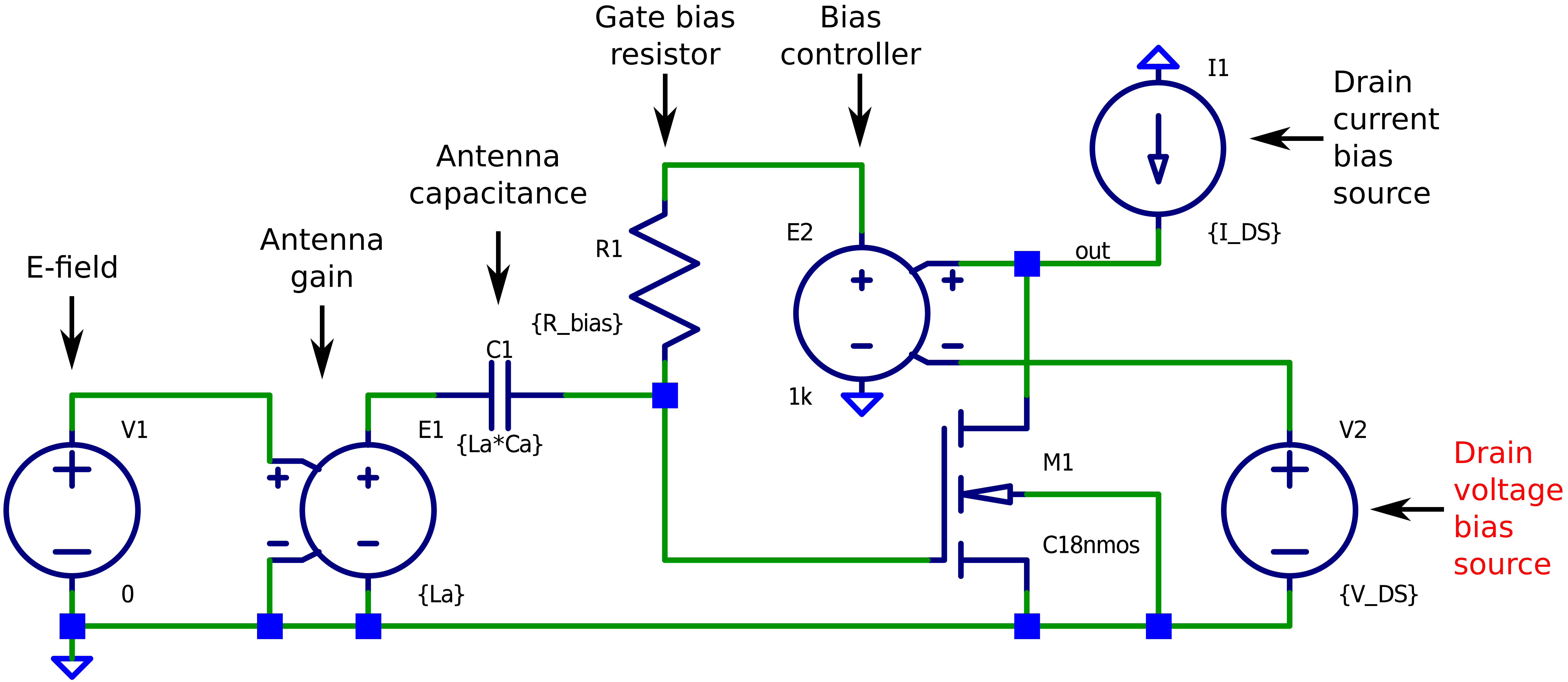

.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

# LTspice noise test bench



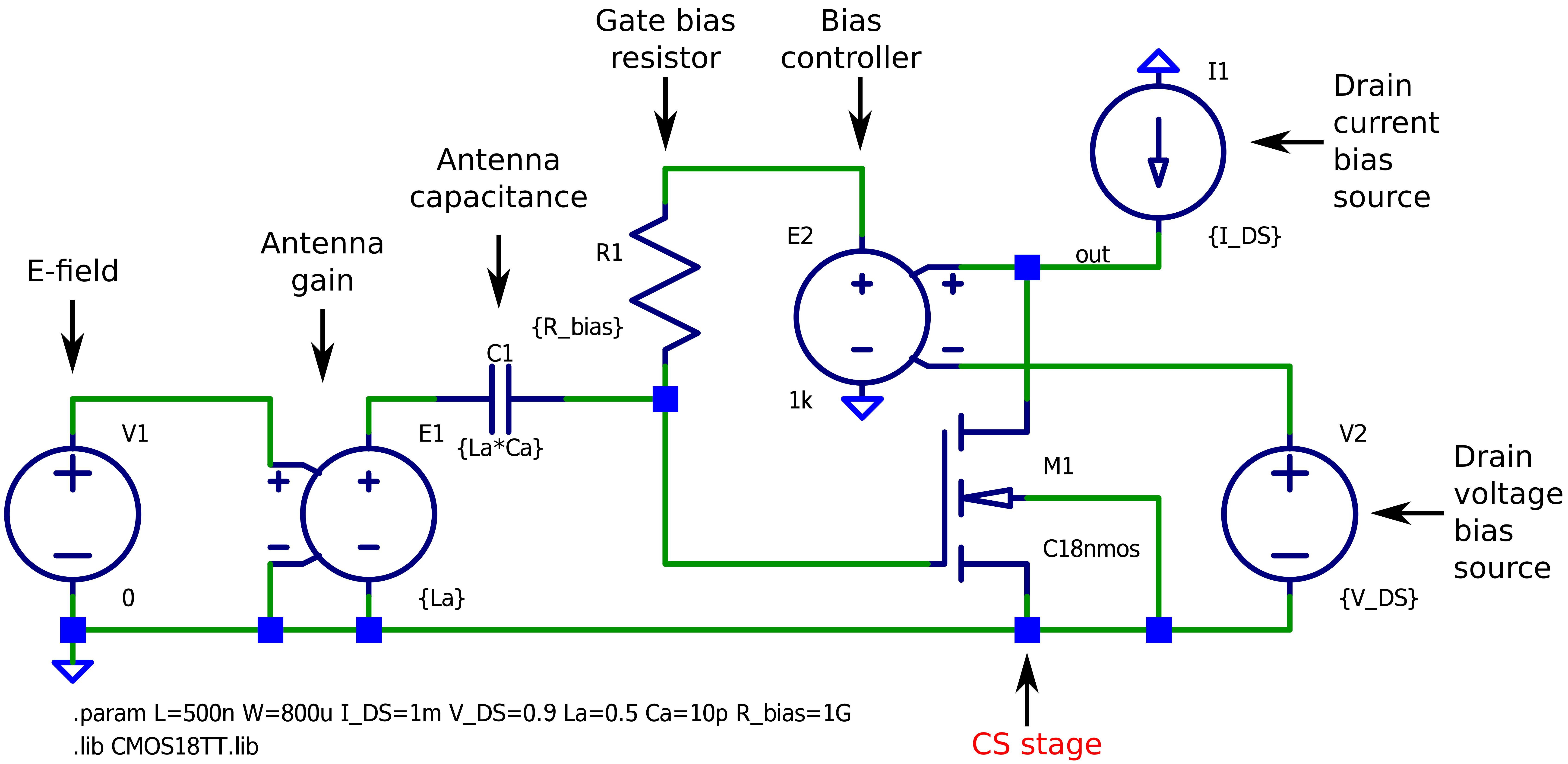

.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

# LTspice noise test bench



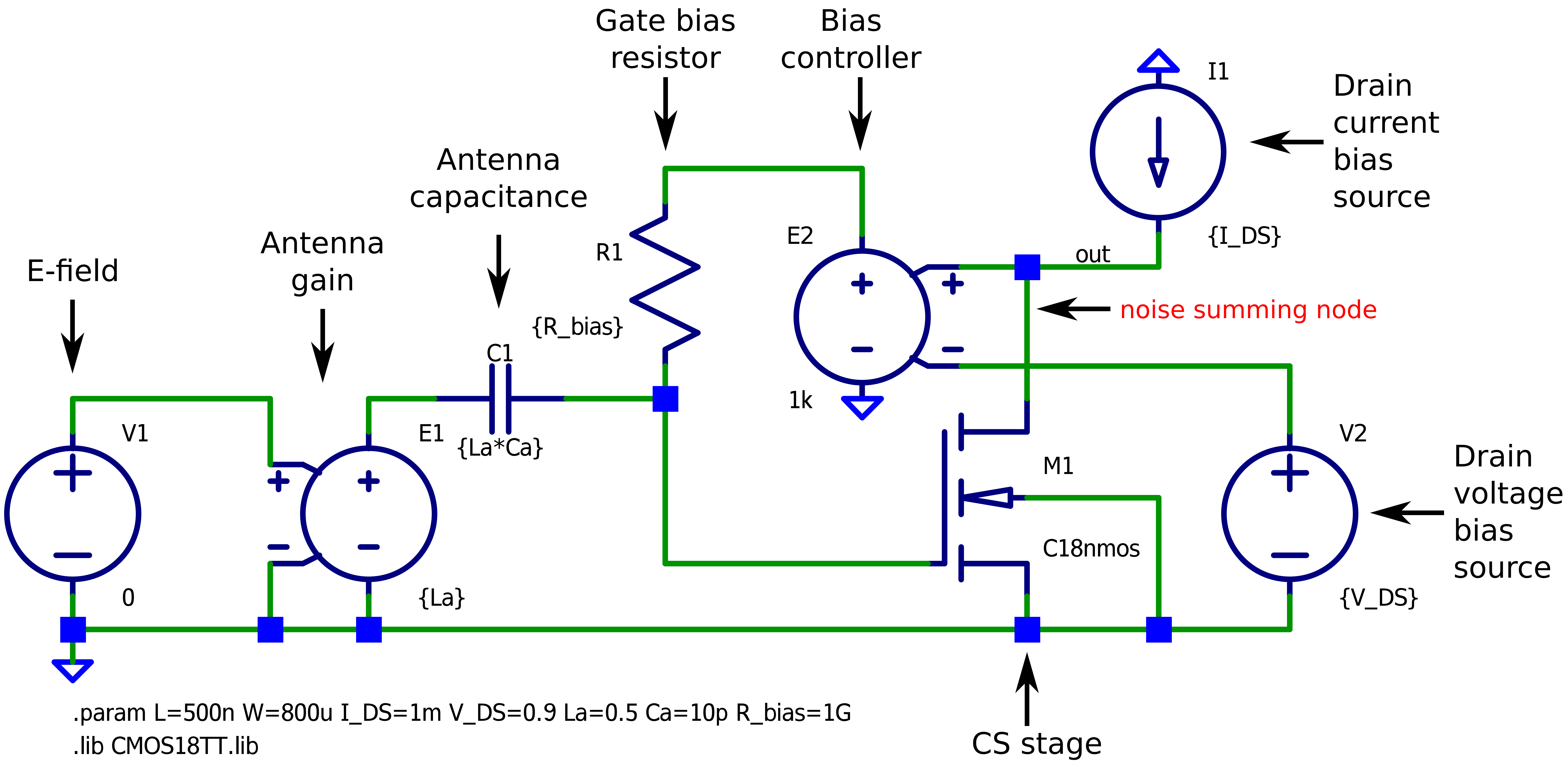

```
.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg
```

# LTspice noise test bench



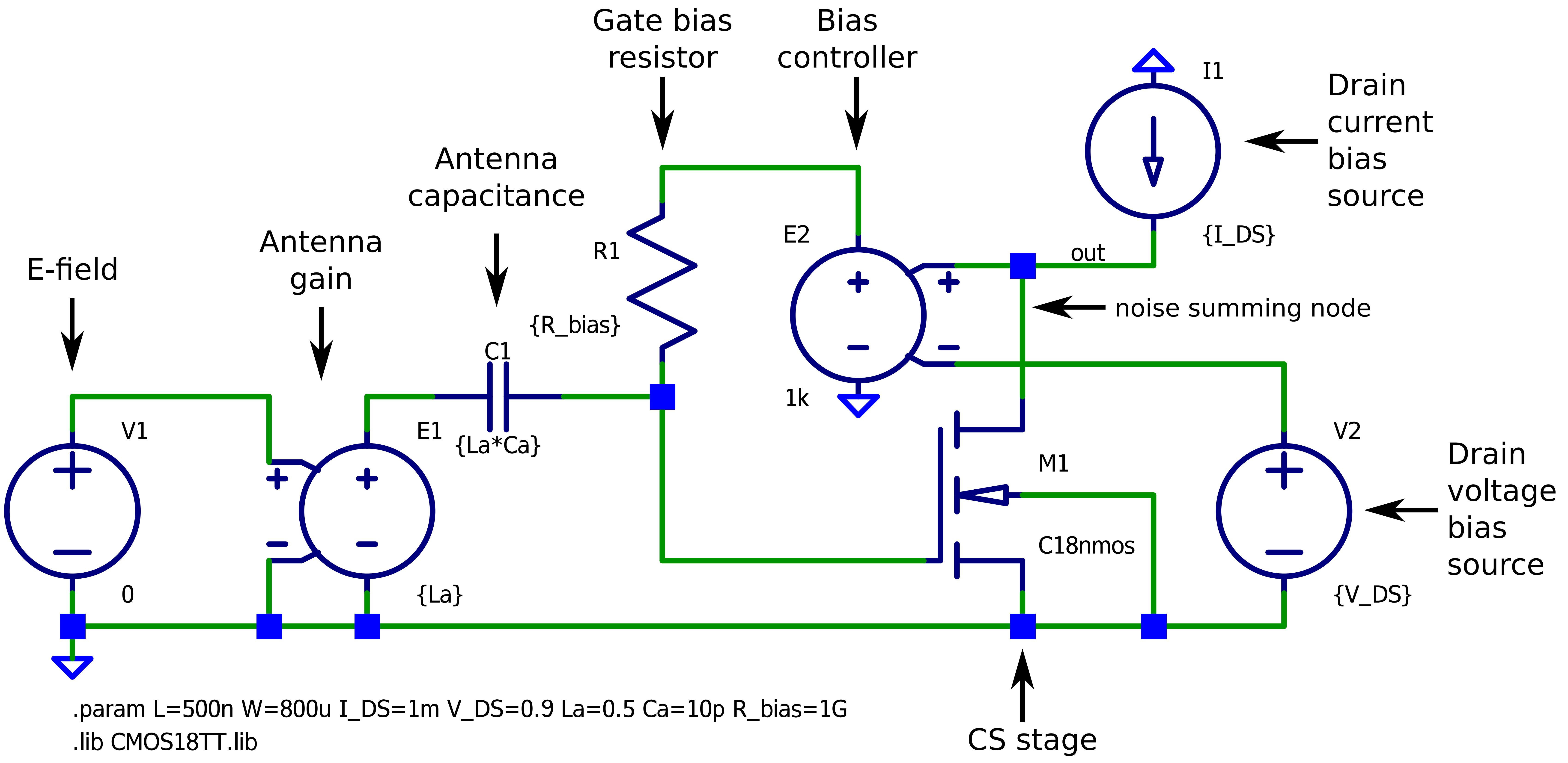

.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

# LTspice noise test bench




```
.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg
```

# LTspice noise test bench

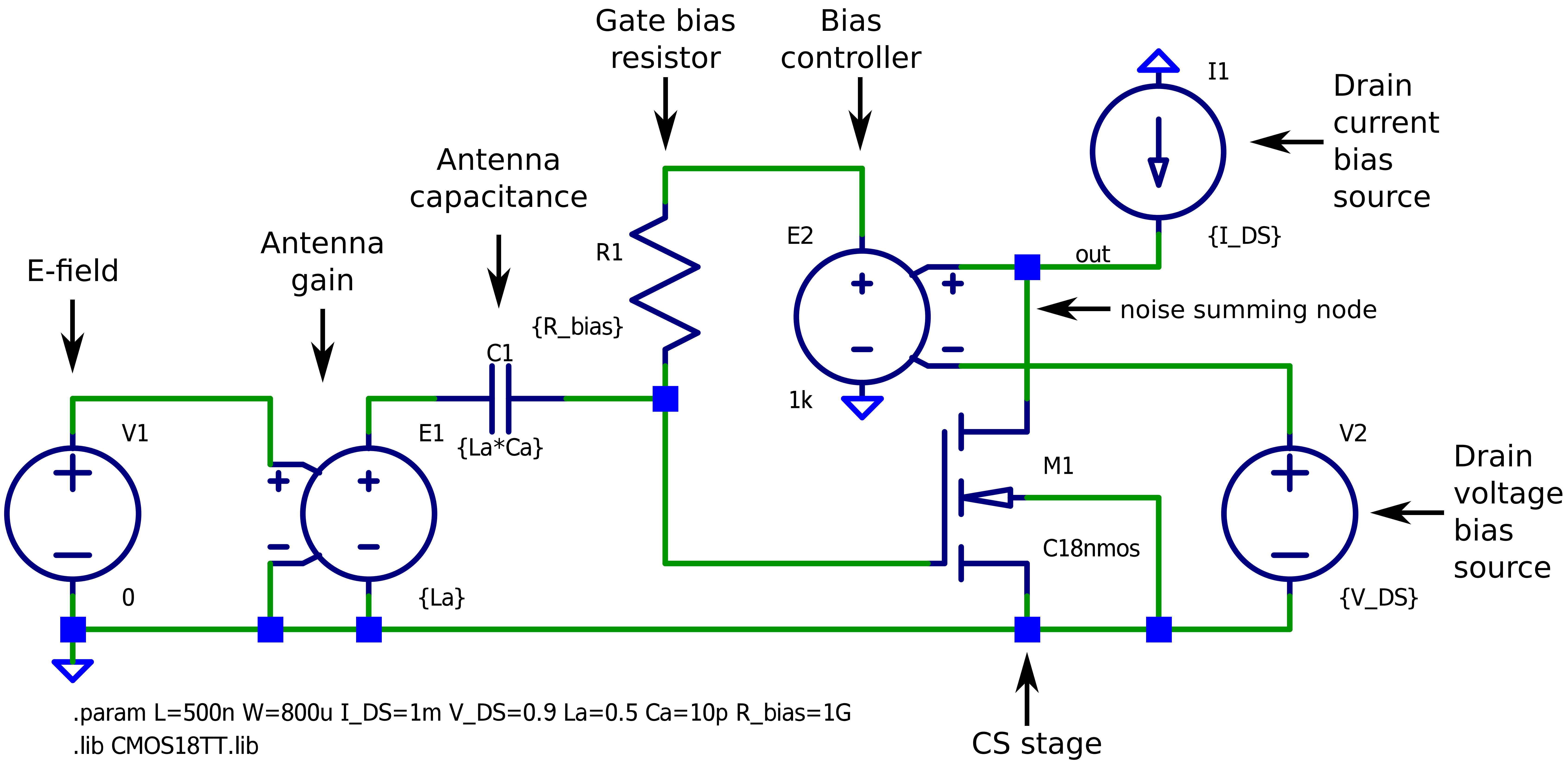



.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

Always check for correct operating point!

# LTspice noise test bench




.param L=500n W=800u I_DS=1m V_DS=0.9 La=0.5 Ca=10p R_bias=1G
.lib CMOS18TT.lib
.noise V(out) V1 dec 20 1k 100meg

Always check for correct operating point!

# Structured Electronic Design

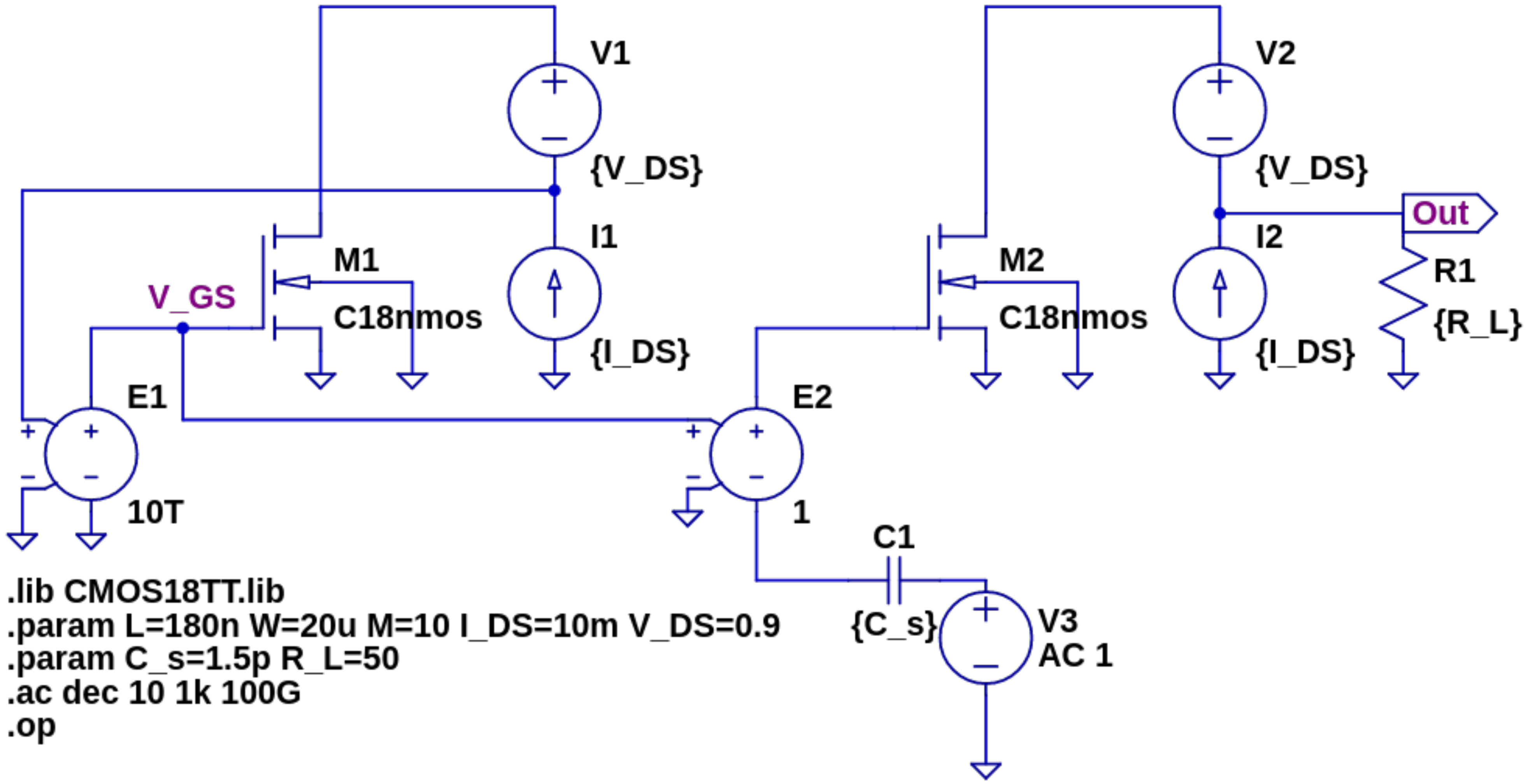
EE4109
Homework 1
Design of a CS stage,
Homework remarks

*Anton J.M. Montagne*

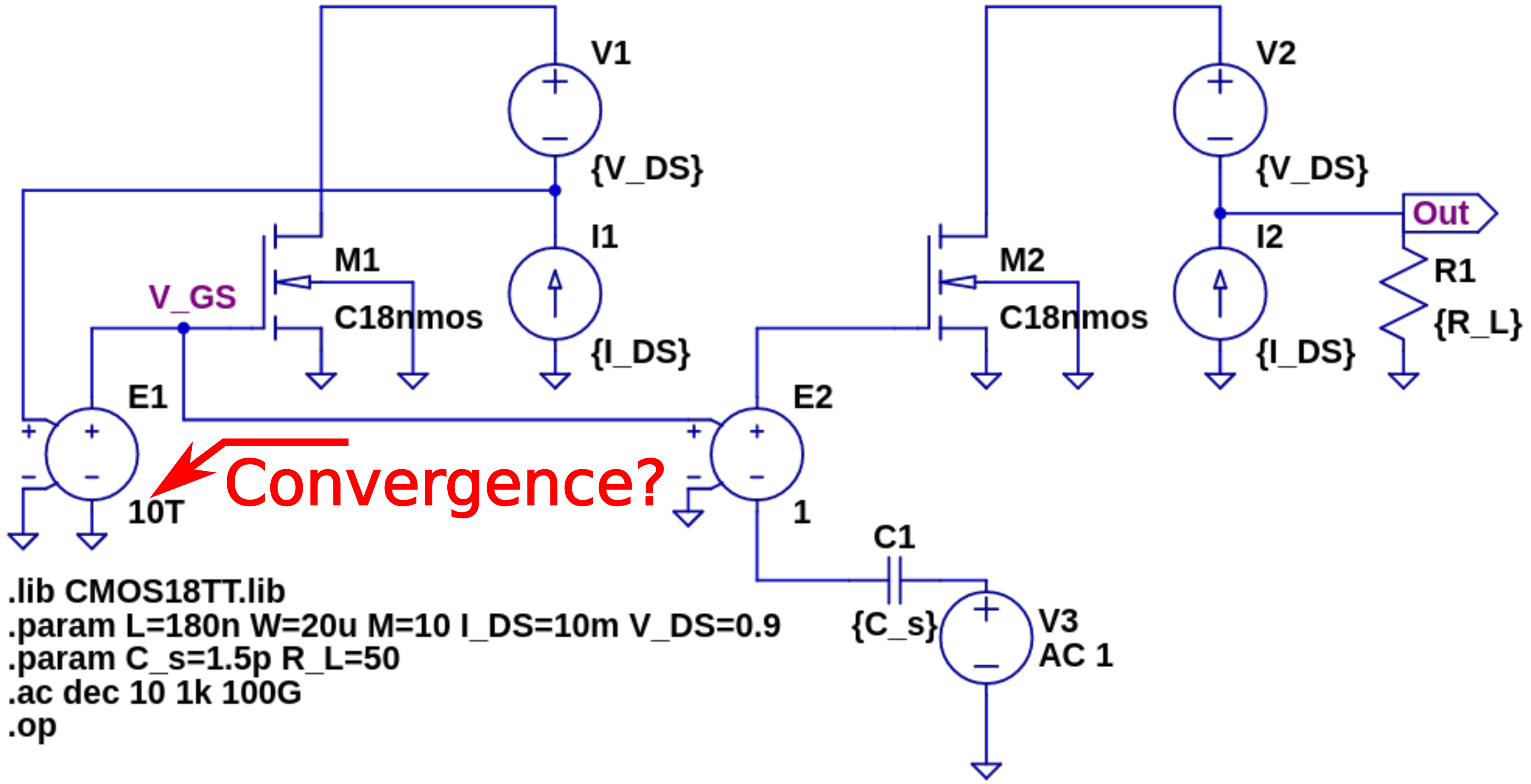
 

# Bias error

# Bias error

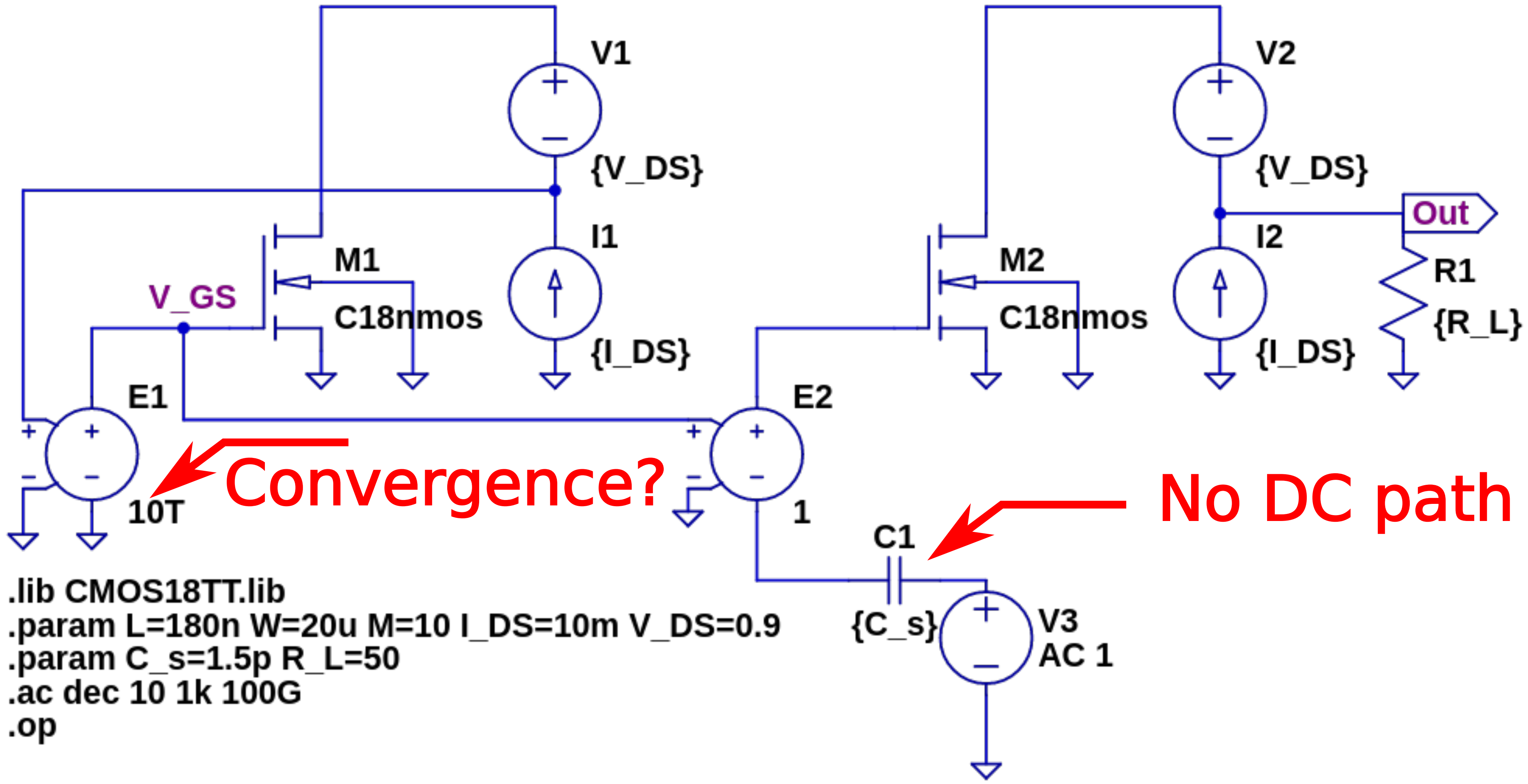

V1
{V_DS}
I1
{I_DS}
M1
C18nmos
V_GS
E1
10T
V2
{V_DS}
Out
I2
{I_DS}
R1
{R_L}
M2
C18nmos
E2
1
C1
{C_s}
V3
AC 1
.lib CMOS18TT.lib
.param L=180n W=20u M=10 I_DS=10m V_DS=0.9
.param C_s=1.5p R_L=50
.ac dec 10 1k 100G
.op

# Bias error



V1
{V_DS}
I1
{I_DS}
M1
C18nmos
V_GS
E1
10T
Convergence?
V2
{V_DS}
I2
{I_DS}
Out
R1
{R_L}
M2
C18nmos
E2
1
C1
{C_s}
V3
AC 1
.lib CMOS18TT.lib
.param L=180n W=20u M=10 I_DS=10m V_DS=0.9
.param C_s=1.5p R_L=50
.ac dec 10 1k 100G
.op

# Bias error



V1
{V_DS}
I1
{I_DS}
M1
C18nmos
V_GS
E1
10T
Convergence?
V2
{V_DS}
I2
{I_DS}
Out
R1
{R_L}
M2
C18nmos
E2
1
C1
{C_s}
V3
AC 1
No DC path
.lib CMOS18TT.lib
.param L=180n W=20u M=10 I_DS=10m V_DS=0.9
.param C_s=1.5p R_L=50
.ac dec 10 1k 100G
.op