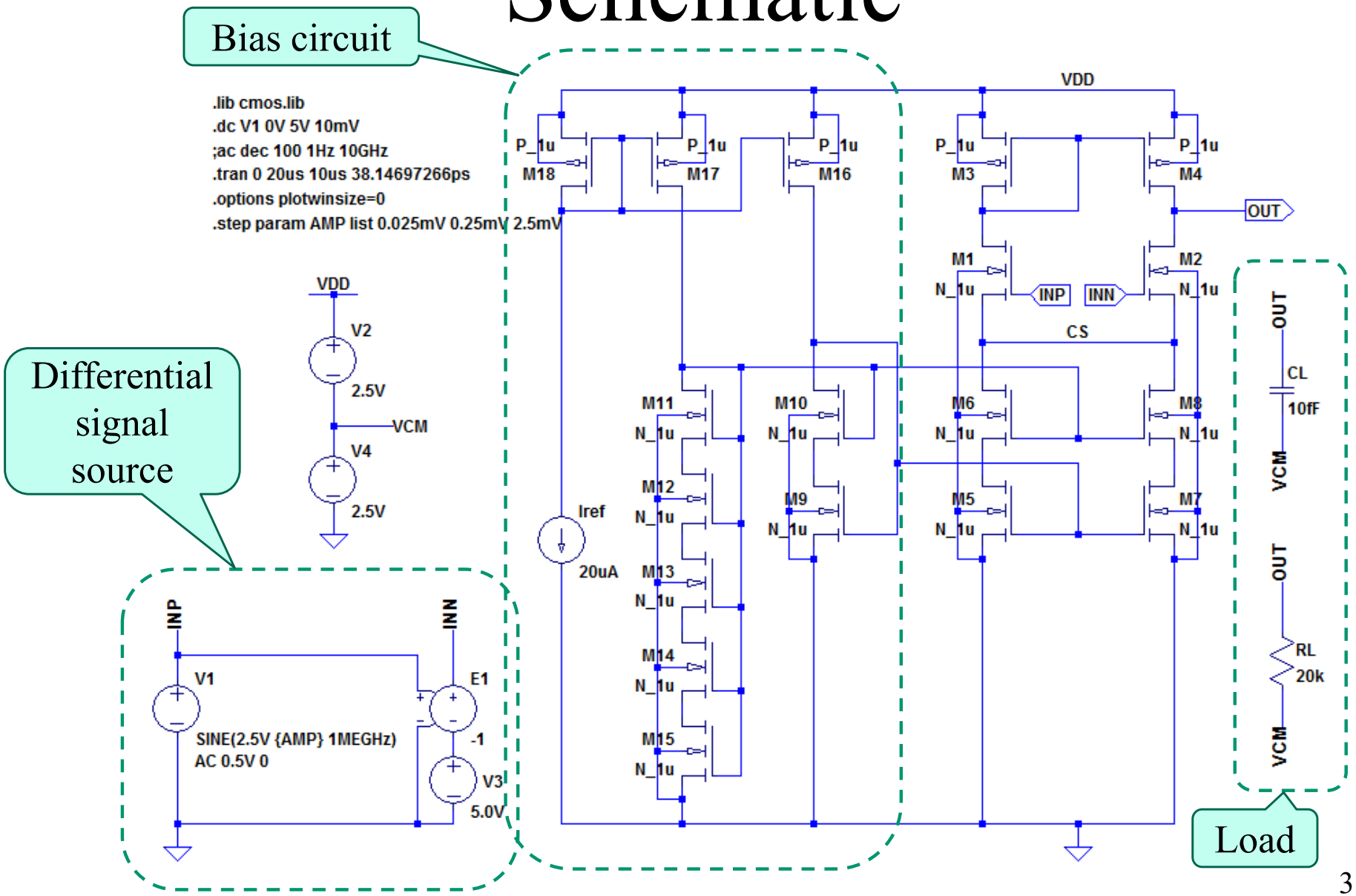
Lab. 11

# CHARACTERIZATION OF DIFFERENTIAL AMPLIFIER

# 1. DC bias and input range

- Carry out the analysis of the differential amplifier shown in the next slide. In the DC analysis, use 20 kΩ load resistor (RL) to sink and source the output current.
- Check the output voltage, the input voltage, the drain current of M1 and M2, the common source voltage V(MC).
  - Note: The input and output signal is biased by the common mode voltage VCM. Then the load resistor must be connected to VCM node.

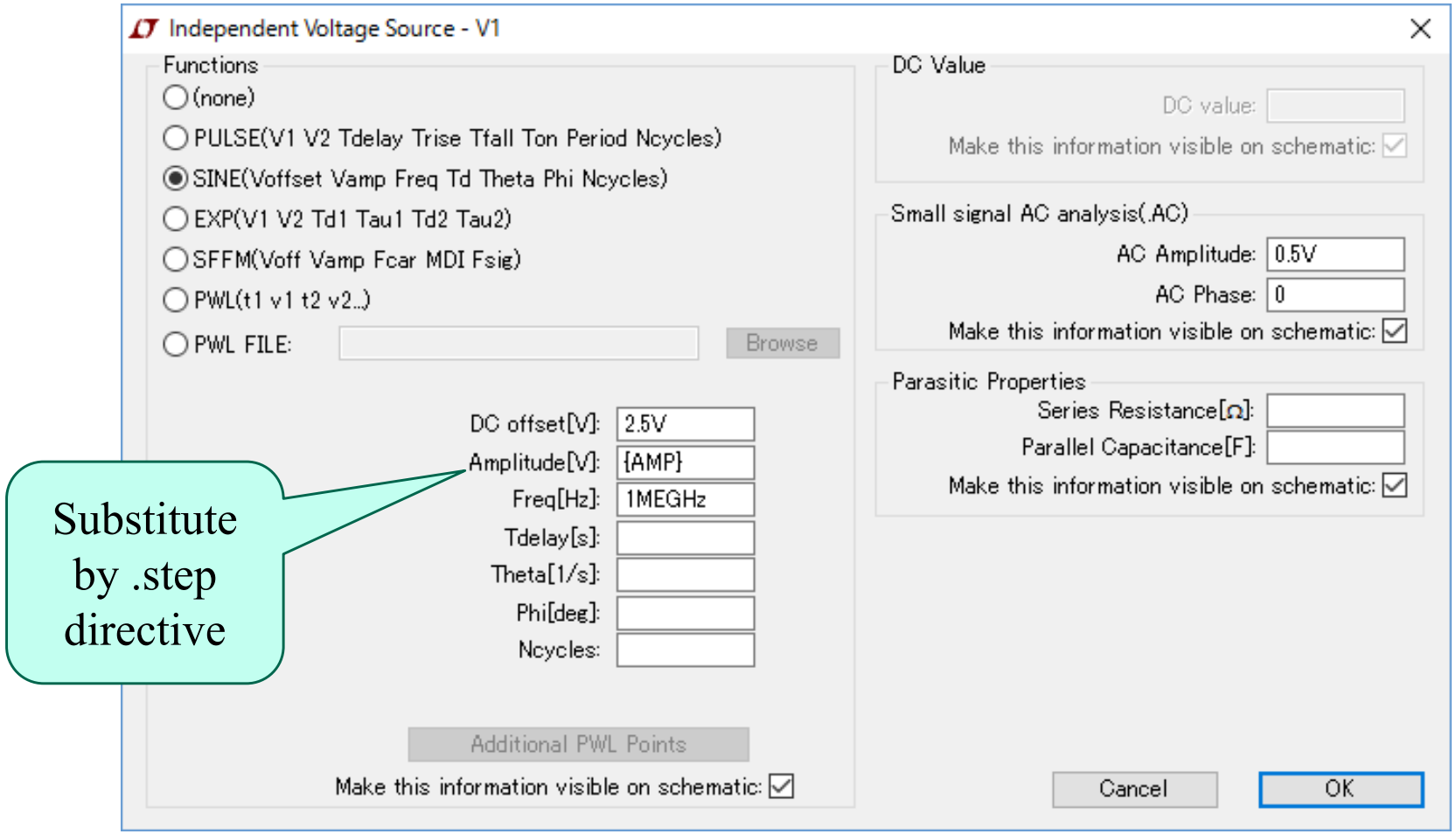
# Schematic


Bias circuit
.lib cmos.lib
.dc V1 0V 5V 10mV
;ac dec 100 1Hz 10GHz
.tran 0 20us 10us 38.14697266ps
.options plotwinsize=0
.step param AMP list 0.025mV 0.25mV 2.5mV
Differential signal source
VDD
V2
2.5V
VCM
V4
2.5V
INP
INN
V1
SINE(2.5V {AMP} 1MEGHz)
AC 0.5V 0
E1
-1
V3
5.0V
Iref
20uA
P_1u
M18
M17
M16
M3
M4
OUT
M1
M2
N_1u
INP
INN
CS
M11
M10
M6
M8
M12
M9
M5
M7
M13
M14
M15
CL
10fF
RL
20k
Load

# Parameters

| MOSFET | L(m) | W(m) | M | AD, AS($m^2$) | PD, PS(m) | W/L |
|---|---|---|---|---|---|---|
| M1, M2 | 2u | 20u | 1 | 60p | 26u | 10 |
| M3, M4 | 2u | 20u | 1 | 60p | 26u | 10 |
| M5-M15 | 2u | 10u | 1 | 30p | 16u | 5 |
| M16-M18 | 2u | 10u | 3 | 30p | 16u | 15 |

# Differential signal source



# 2. AC analysis

- Carry out the AC analysis of the differential amplifier shown in the previous page. In the AC and TRAN analysis, use the 10fF capacitive load.
- Measure the differential gain, the cut-off frequency, the unity gain frequency, and the phase margin.
  - Remove the load resistor RL or set the RL to 1TΩ, because the voltage gain is degraded by RL.
  - Set the AC magnitude of the signal source = 0.5V, that is, the amplitude of the differential signal is given at 1.0V. In an AC analysis, the distortion cannot be considered, because the analysis is carried out for the linearized small-signal equivalent circuit. Therefore, the amplitude of signal source is usually set at 1.0V for convenience to obtain the sensitivity to the input amplitude.

# 3. TRAN analysis

- Carry out the TRAN analysis of the differential amplifier shown in the previous page.
  - The amplitude of the input signal is stepped by .step param directive.
- Show the output waveform and FFT results.
  - FFT requires the large number of point in the waveform. The automatic data deletion must be suppressed by the .option directive.
  - .options plotwinsize=0
  - FFT can be applied to the $2^N$ data. Here the number of data is set to the default value (262144 = $2^{18}$). Please see the comment on the FFT setting in http://jaco.ec.t.kanazawa-u.ac.jp/edu/ec2/ltspice/26.html

# Parameter of transient analysis