Electrical and Electronics Circuits (4190.206A 002)

- HW #1 is due on Oct. 7, 2019 3:15pm
- Make-up class
  - There will be a make-up class today at 7pm-8:15pm in the same classroom (the class attendance won't be checked, and video recording of the class will become available at ETL)
- Tutorial session on the basic math (will be provided in Korean language only, sorry!)
  - For more information, check ETL announcement
  - All the lecture notes will be posted on ETL after each session
  - Session 1: corresponding to Appendix B Trigonometric functions and identities except B.8 and B.9
  - Session 2: derivation of $\frac{d}{dx}\cos x = -\sin x, \frac{d}{dx}\sin x = \cos x, \frac{d}{dx}e^x = e^x, \frac{d}{dx}\ln x = \frac{1}{x}, \frac{d}{dx}f\big(g(x)\big) = \left.\frac{df(y)}{dy}\right|_{y=g(x)} \cdot \frac{dg(x)}{dx}$
  - Session 3: Appendix B.8 Taylor Series, B.9 Euler Relation, and C. Complex Numbers
  - Session 4: additional exercises related to the class
- Scheduling session 1 (hopefully 1~1.5 hours)

	10/3 (Thursday)	10/4 (Friday)
7pm~		
8pm~		

- Self-attendance check

Review

- Analog-Digital Conversion
  - ADC: Analog-to-digital converter
  - DAC: Digital-to-analog converter
  - Typically input range of ADC and output range of DAC are fixed ➔ To utilize the full resolution, we need to change the scale of the analog signal ➔ voltage divider or amplifier
- MOSFET
  - Metal-Oxide Semiconductor Field-Effect Transistor
  - S model ("Switch" model): V_{GS} vs. V_T
  - SR model ("Switch Resistor" model)
  - Feature size of MOSFET and implication of Moore's law

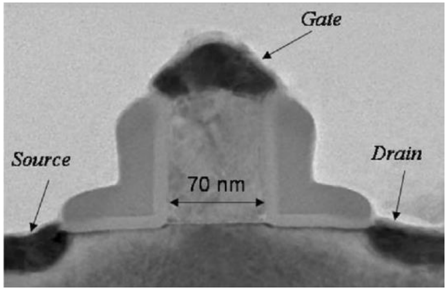
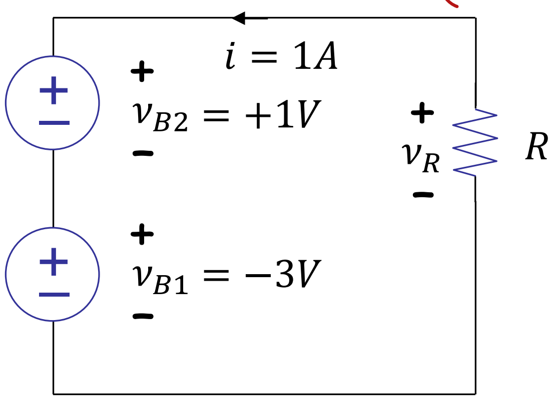


FIGURE 6.38 A cross-sectional picture of Intel's 0.13-μm generation logic transistor.

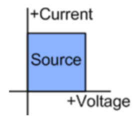
How to build / why we need amplifier?
simple.

ideal : allow any of the current

Side note for voltage source

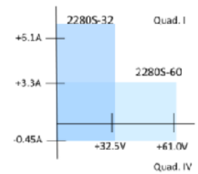


General Purpose Power Supply



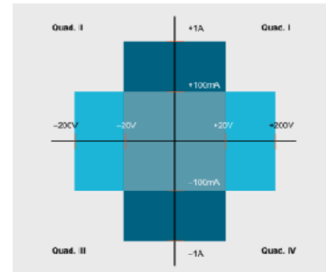
Typical power supply operates only in power quadrant one.
It cannot accept power from external source.
It cannot sink current.

Speciality Power Supply with 6.5 digit measure



Model 2280S or 2281S power supply has some current sink ability, ~450mA.
It cannot regulate the current when sinking it.

SourceMeter or SMU

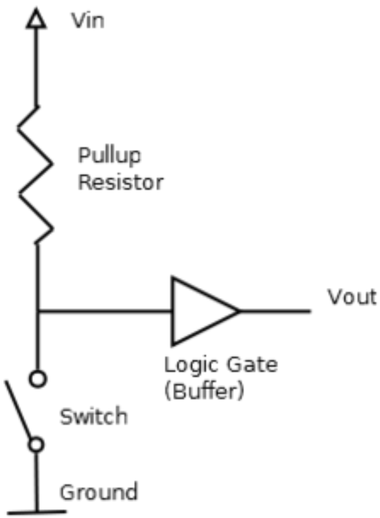


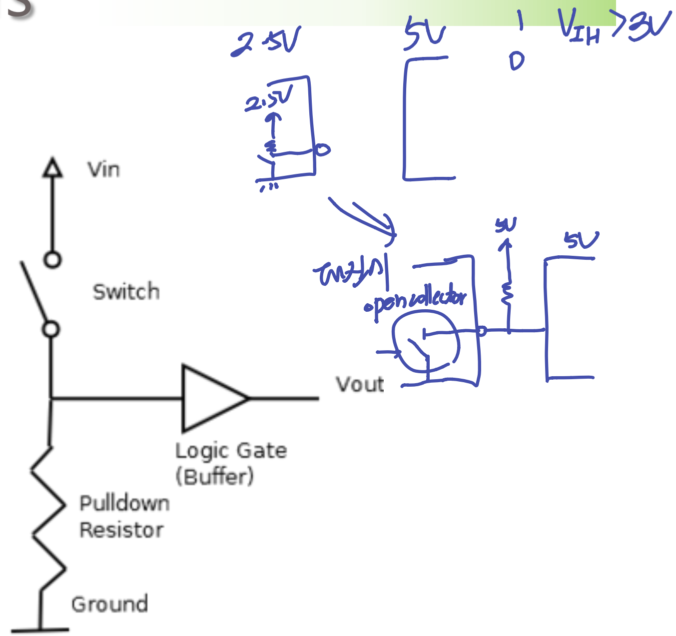
2450 power envelope.

A SourceMeter is four quadrant product.
It can accept power from external source.
It can sink current.
It can regulate how much current under both sourcing and sinking conditions.

- Counter-intuitive example
  - When $v_{B2} = +1V, v_{B1} = -3V$ and $R = 2\Omega$, the current i will be $1A$. This means current will flow backward through the voltage source with v_{B2} even though v_{B2} is positive.
  - Is this realistic?
    - That depends
    - https://electronics.stackexchange.com/questions/157302/is-current-flowing-backwards-a-bad-thing
    - In your exam, you SHOULD definitely say that it is correct.
    - Many real DC power supply does not support reverse current (called current sink).
    - https://forum.tek.com/viewtopic.php?f=183&t=141961

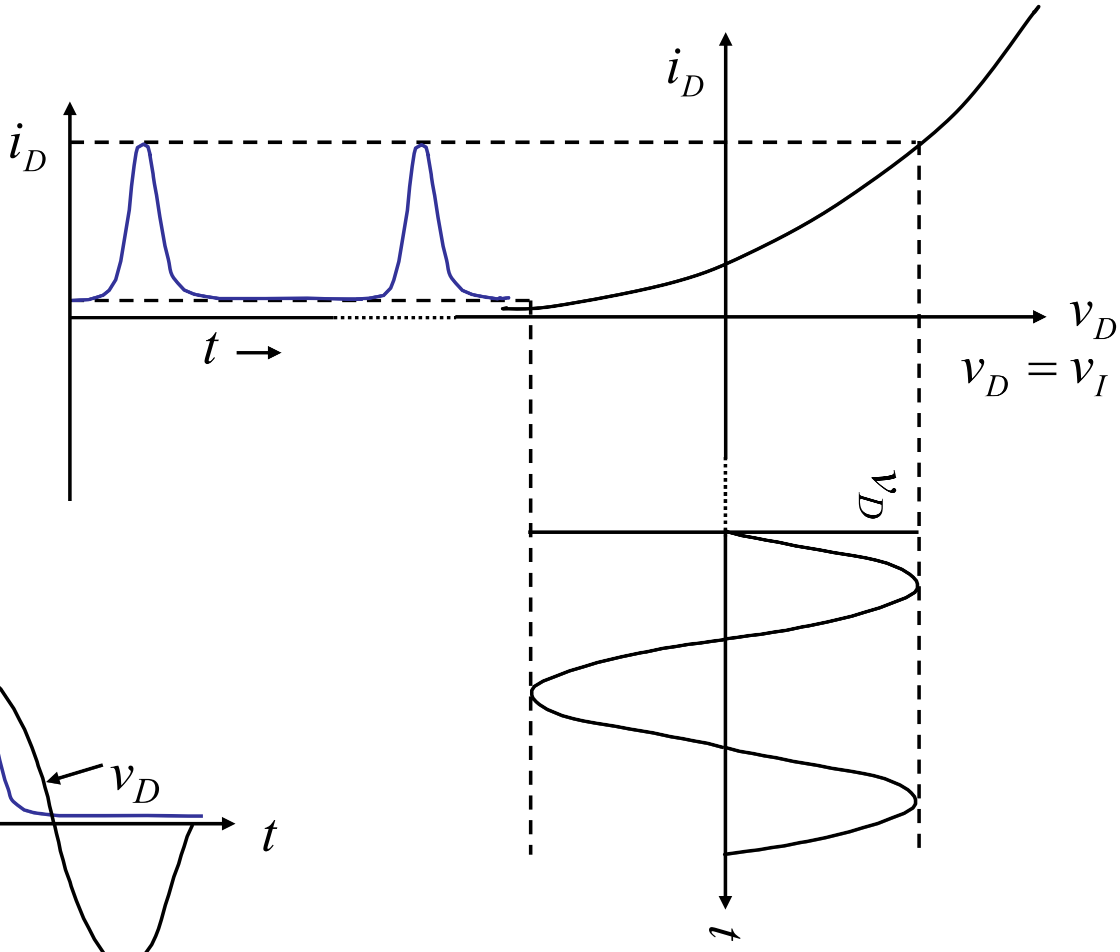
Pull-up and Pull-down Resistors

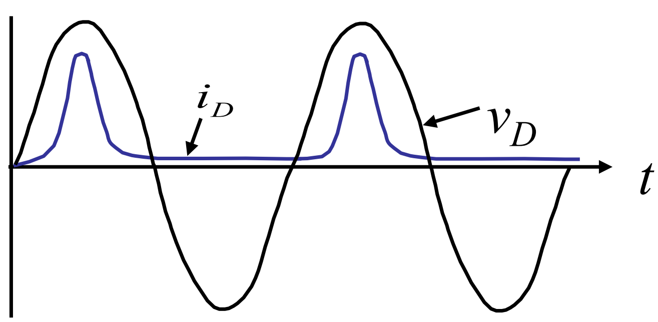




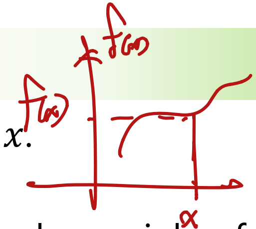
- Benefit of pull-up and pull-down interface
  - When the voltage range of the driving circuit and the receiving circuit, it can be chosen.

Incremental Analysis





Taylor expansion



- Assume that we are given some arbitrary function $f(x)$ of x.
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- Question: can we approximate this function as a some of polynomials of x? In other words,

$$f(x) = c_0 + c_1 x + c_2 x^2 + c_3 x^3 + \cdots$$

- Answer: it depends on the types of function, but for many of the functions, it is possible.

- Question: the how can we find out $c_0, c_1, c_2, c_3, \ldots$?
- Answer: by matching the values of the derivatives at $x = x_0$.

- In general, $f(x) = f(x_0) + \left.\frac{df}{dx}\right|_{x=x_0} (x - x_0) + \frac{1}{2!}\left.\frac{d^2 f}{dx^2}\right|_{x=x_0} (x - x_0)^2 + \frac{1}{3!}\left.\frac{d^3 f}{dx^3}\right|_{x=x_0} (x - x_0)^3 + \cdots$

- Example 1) at $x = 0$, $f(x) = 1 + 2x + 3x^3 = c_0 + c_1 x + c_2 x^2 + c_3 x^3 + \cdots$
- Example 2) at $x = 1$, $f(x) = 1 + 2x + 3x^3 = c_0 + c_1(x - 1) + c_2(x - 1)^2 + c_3(x - 1)^3 + \cdots$

$$i_D \approx \underbrace{f(V_D)}_{\text{constant w.r.t. } \Delta v_D} + \underbrace{\left.\frac{d\,f(v_D)}{dv_D}\right|_{v_D=V_D}}_{\substack{\text{constant w.r.t. } \Delta v_D \\ \text{slope at } V_D,\ I_D}} \cdot \Delta v_D$$

We can write

$$I_D + \Delta i_D \approx f(V_D) + \left.\frac{d\,f(v_D)}{dv_D}\right|_{v_D=V_D} \cdot \Delta v_D$$

equating DC and time-varying parts,

$$I_D = f(V_D) \longrightarrow \text{operating point}$$

$$\Delta i_D = \underbrace{\left.\frac{d\,f(v_D)}{dv_D}\right|_{v_D=V_D}}_{\text{constant w.r.t. } \Delta v_D} \cdot \Delta v_D$$

so, $\Delta i_D \propto \Delta v_D$

By notation,

$\Delta i_D = i_d$

$\Delta v_D = v_d$