



DEPARTMENT OF COMPUTER SYSTEM ENGINEERING

Digital Integrated Circuits - ENCS333

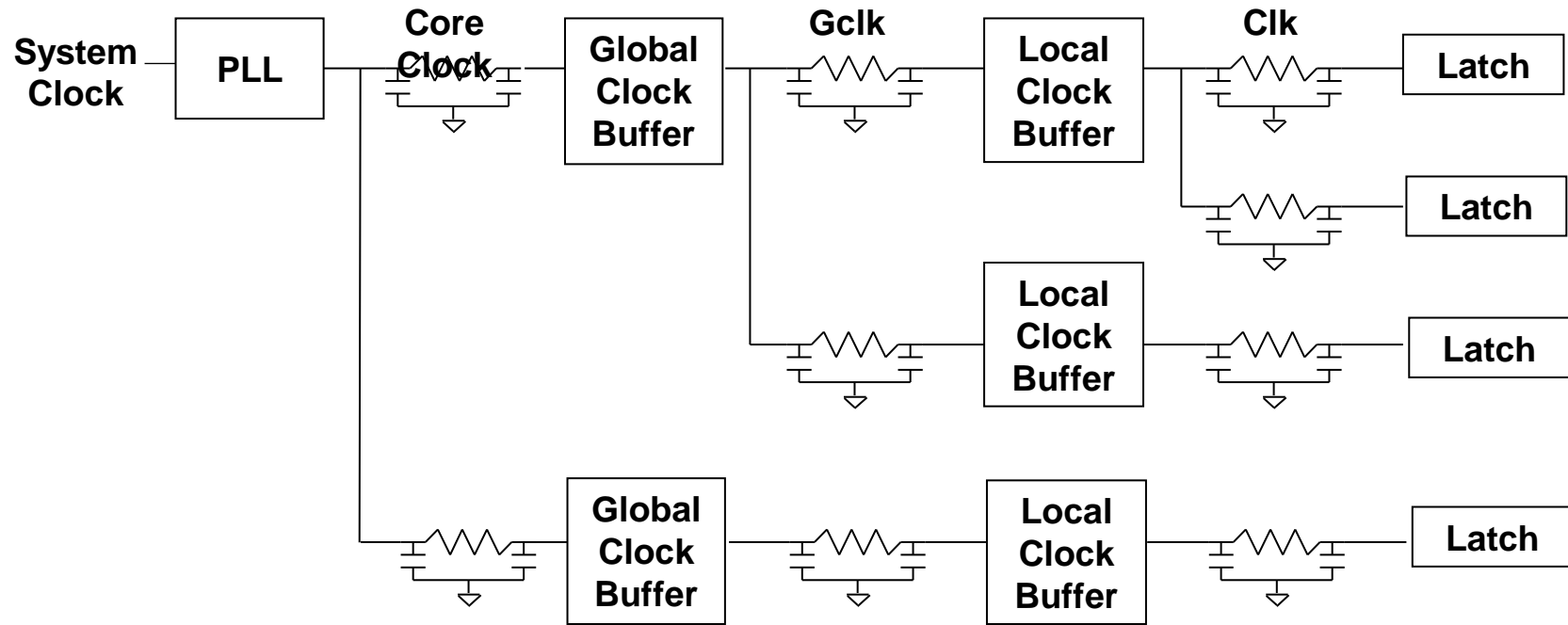
Dr. Khader Mohammad
Lecture #14

Clock Distribution

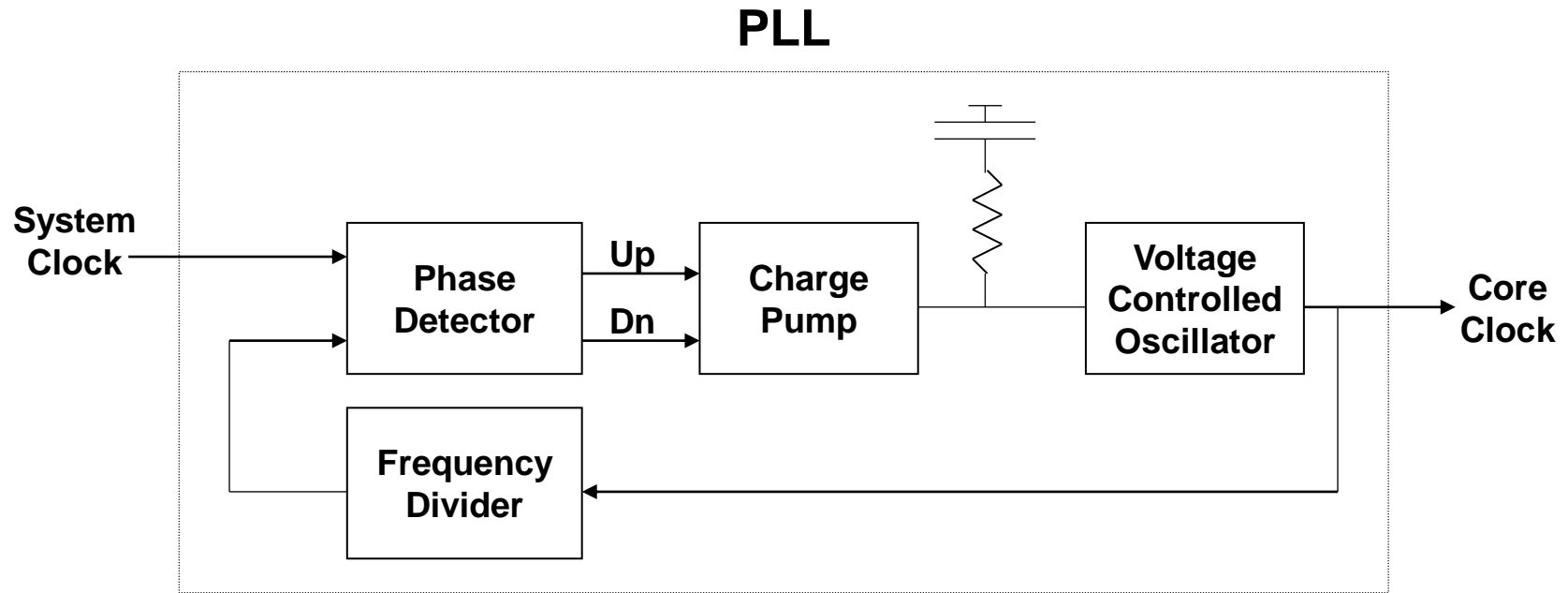
Digital Integrated Circuits

Course topics and Schedule	
	Subject
1	Introduction to Digital Integrated Circuits Design
2	Semiconductor material: pn-junction, NMOS, PMOS
3	IC Manufacturing and Design Metrics CMOS
4	Transistor Devices and Logic Design The CMOS inverter
5	Combinational logic structures
6	Layout of an Inverter and basic gates
7	Static CMOS Logic
8	Dynamic Logic
9	Sequential logic gates; Latches and Flip-Flops
10	Summary : Device modeling parameterization from I-V curves.
11	Interconnect: R, L and C - Wire modeling
12	Parasitic Capacitance Estimation
13	Timing
14	Power dissipation;
15	Clock Distribution
16	Arithmetic building blocks
17	Memories and array structures
	Final & Project discussion

Clock Distribution Tree



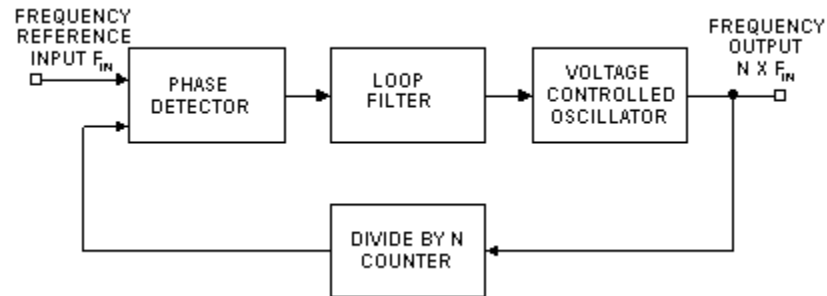
Phase Locked Loop (PLL)



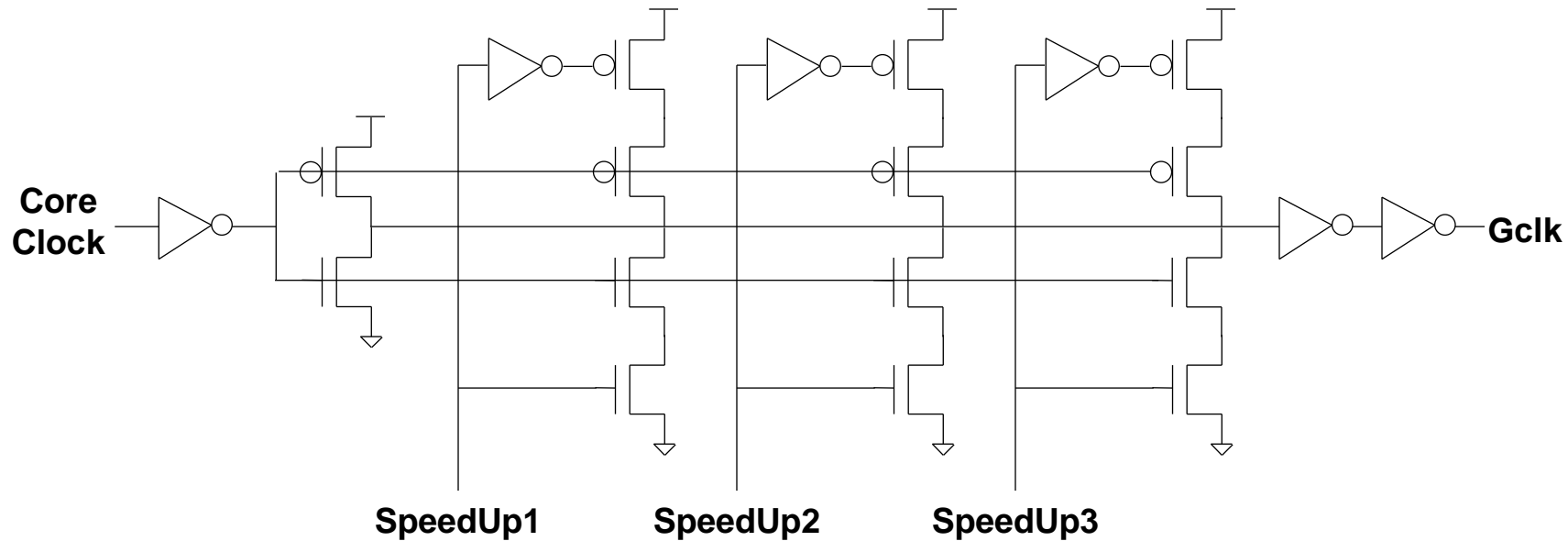
- PLLs produce an on-chip core clock at a multiple of the off-chip system clock.

PLL Overview

- PLLs
 - Typically there are two PLLs on a chip
 - IOPLL and COREPLL
 - IOPLL gets an external “x_{in}clk” and generates the address clock (2x) and data clock (4x)
 - These clocks are only used in the PADs
 - COREPLL takes the IOPLL output as reference and generates the core clock for entire chip

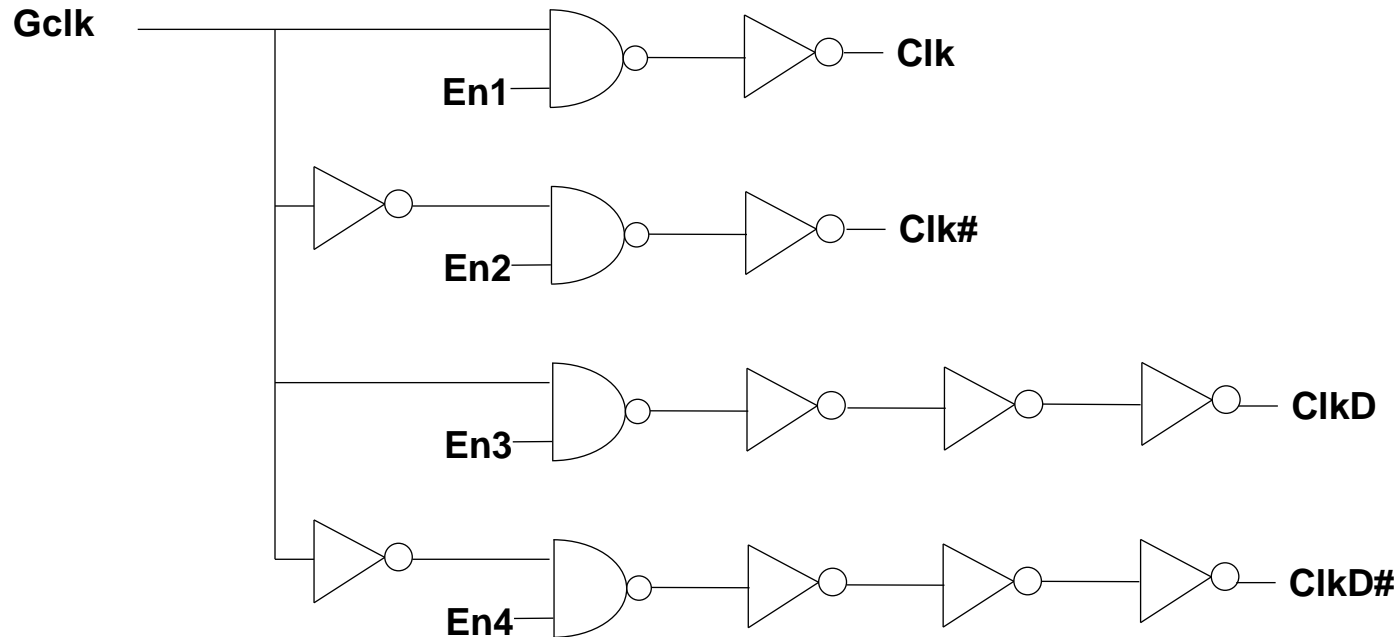


Global Clock Buffer



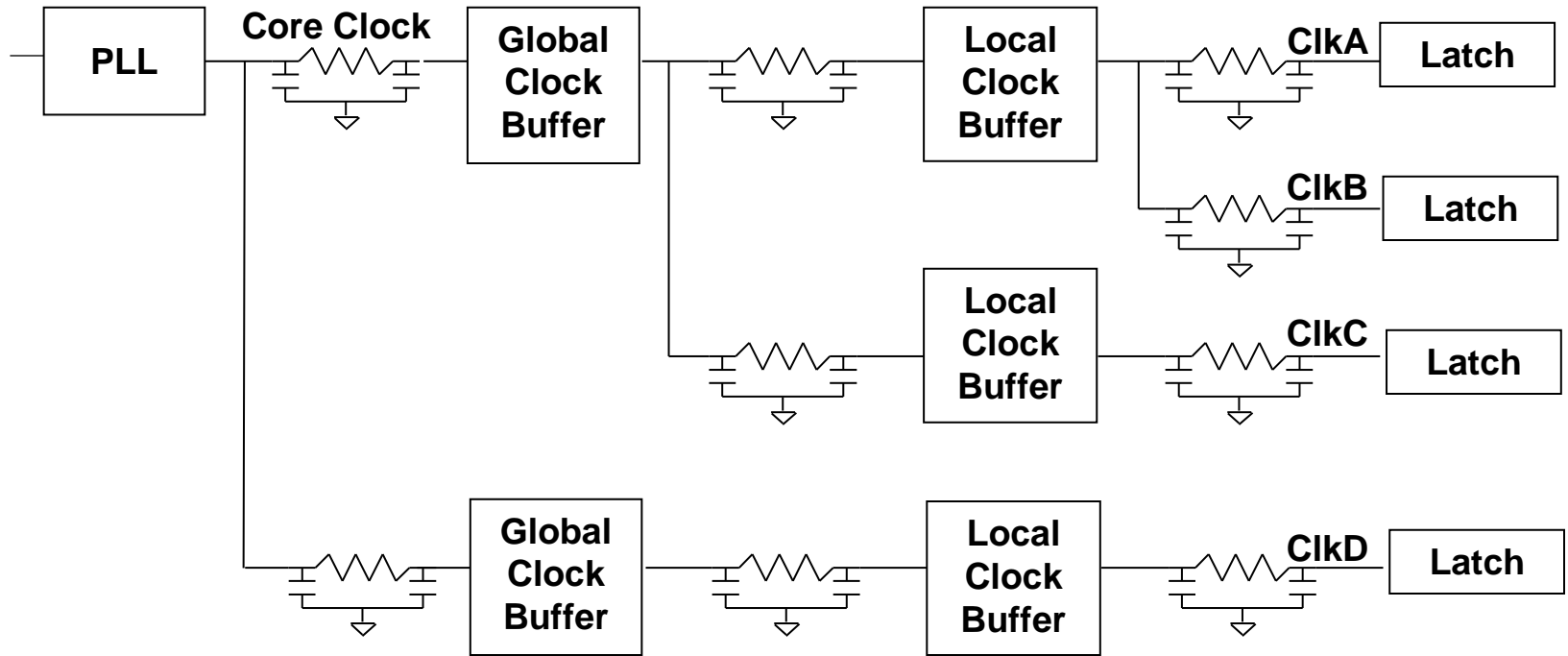
- Global clock buffers can use variable delay to compensate for RC mismatches across a die

Local Clock Buffers (LCBs)

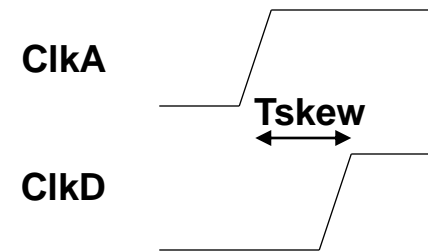


- Local Clock Buffers Support:
 - Clock gating for power reduction
 - Intentional clock skew insertion for timing optimization

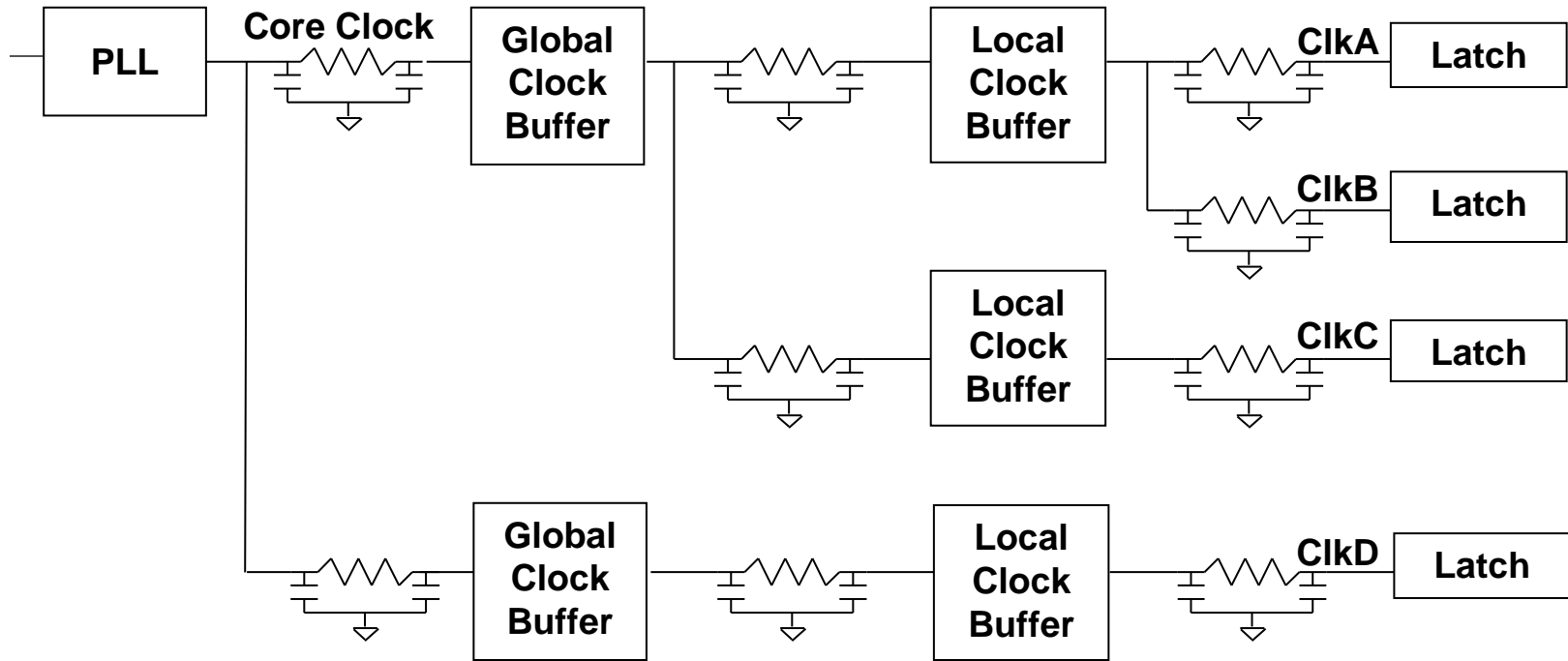
Clock Skew



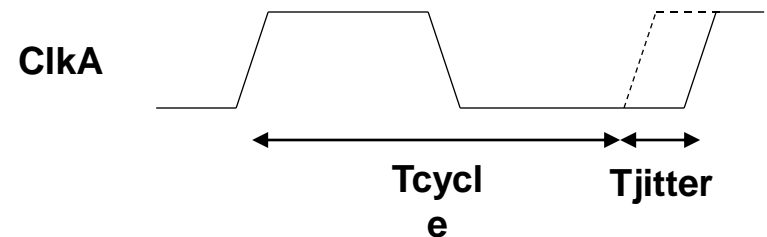
- A single transition of the core clock does not arrive at all sequentials at the same time.



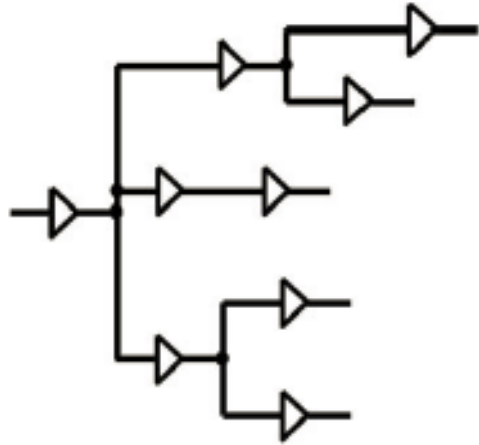
Clock Jitter



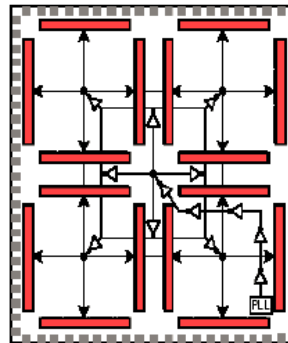
- Clock frequency at any point in the clock tree is not constant.



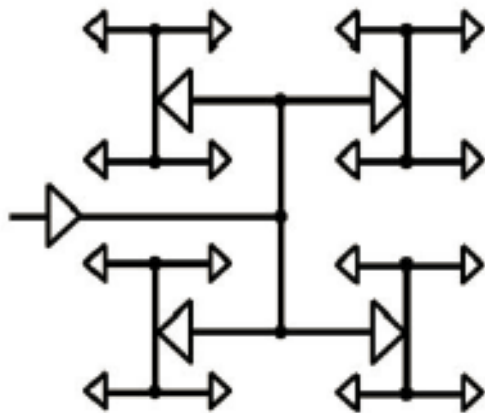
Variations of tree distribution networks



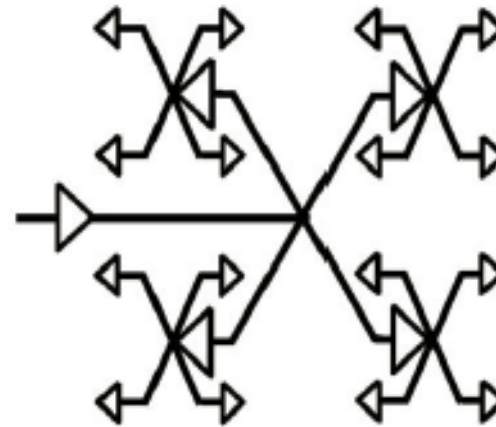
Tree



X-Tree



H-Tree



Tapered H-Tree