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Digital Circuits Design

Faculty of Automatic Control, Electronics and Computer Science, Informatics, Bachelor Degree

Lecture 1

Digital IC Parameters – part 1

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Parameters – part 1

Program:

(today)

- Parameter groups
- Functional parameters
- Dynamic parameters

(next week)

- Static parameters
- Operational conditions parameters
- Clock asynchronism, example values

Parameters – part 1

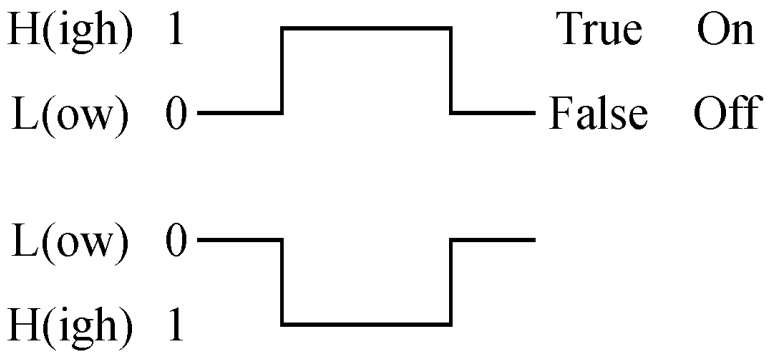
- Properties of digital IC are described by external parameters
  - Proper choice of IC
  - Optimal properties utilisation
- Digital IC’s production
  - Large series, constant proces
  - Various applications
  - Various conditions
- Full exchangeability rule
  - An IC can be replaced with another one of the same type without influence on device operation
  - No preselection of IC’s is necessary

Parameters – part 1

- Parameter groups
  - Functional parameters
    - Describe functional IC properties
  - Dynamic parameters
    - Time dependencies
  - Static parameters
    - Voltage levels, current values, cooperation conditions
  - Parameters describing IC operating conditions
    - E.g., power supply, temperature, humidity, etc.

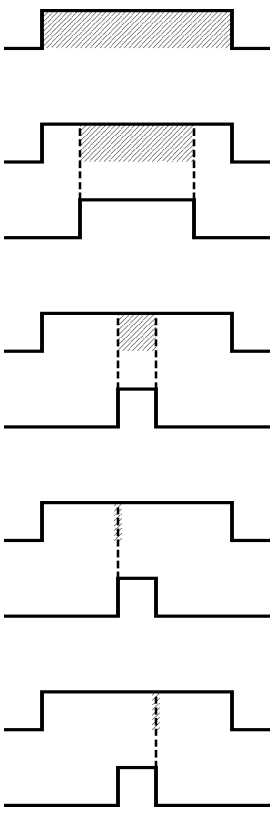
Parameters – part 1

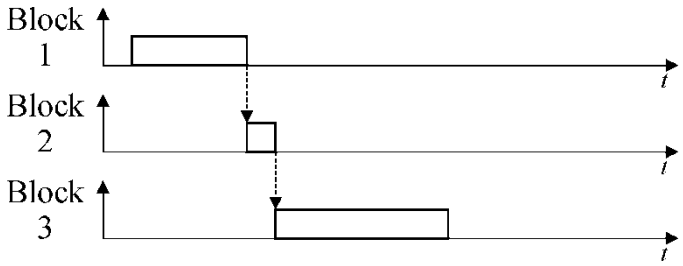
- Functional parameters
  - Logic, arithmetic function of IC
  - Logic convention must be accepted first
    - Positive convention – most of digital IC's
      - TTL
      - CMOS
    - Negative convention
      - RS-232
      - ECL

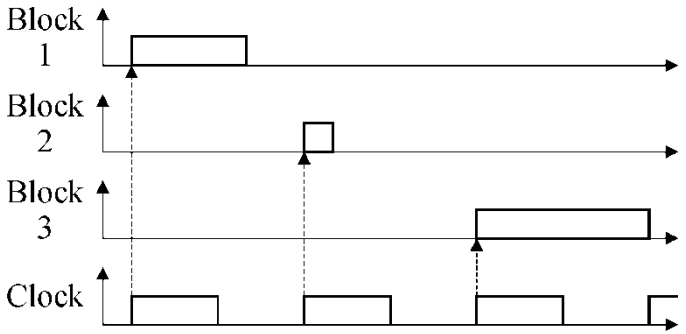


Parameters – part 1

- Inputs influence on each other and on the circuit
  - Inputs:
    - Information (data to be processed; syn/asyn)
    - Control (function to be performend; syn/asyn)
    - Synchronisation (clock)
  - Signal synchronism
    - Asynchronous – signal influences all the time it's active
    - Synchronous – signal influences only at the moments specified by clock
  - Device synchronism
    - Asynchronous – once a block finishes its task, the next one can start immediately
    - Synchronous – the next block can start a tast only at the moment specified by clock

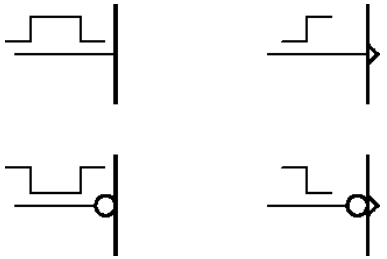




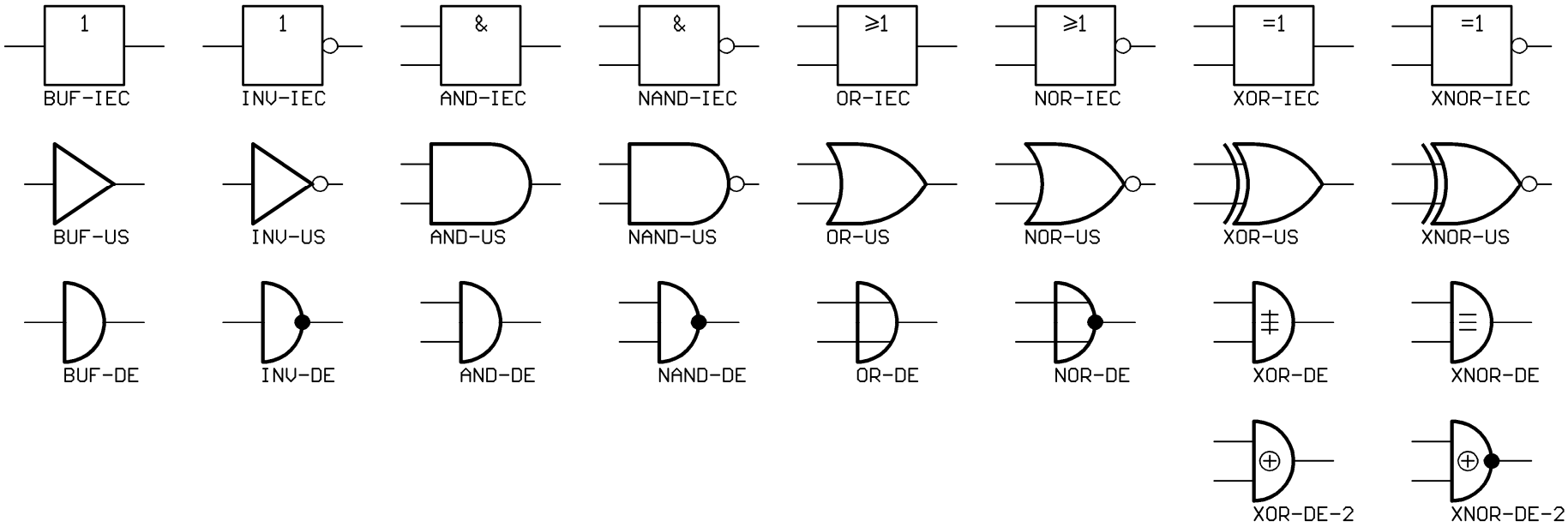


Parameters – part 1

- Inputs influence on the circuit
  - Level sensitive
  - Edge/sequence of edges sensitive
- Input/output marking on the diagram

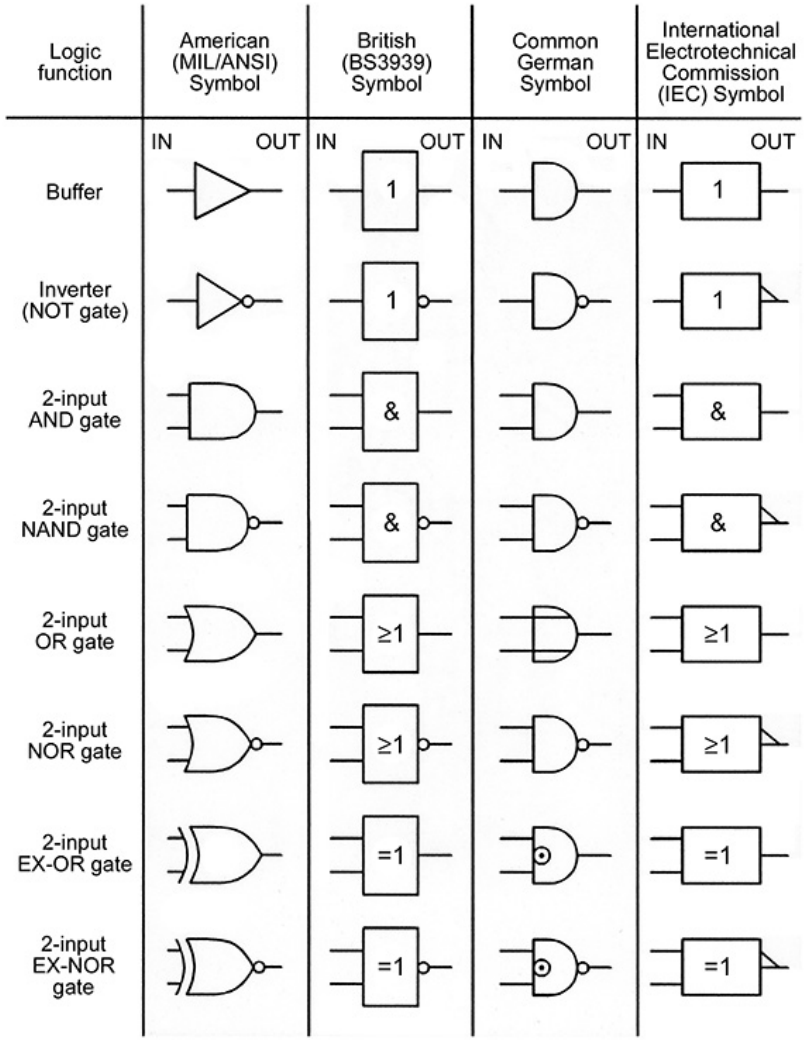


- Gates and other elements symbols
  - Few different standards



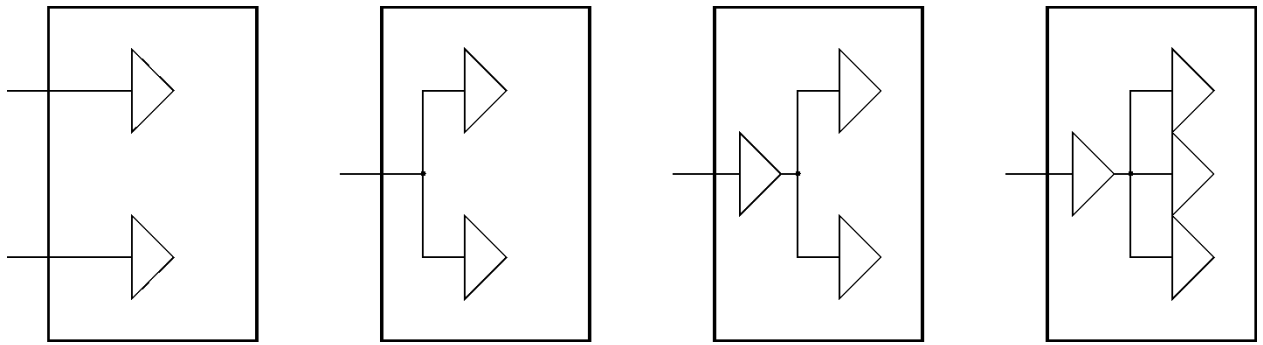
Parameters – part 1

– Gates and other elements symbols



Parameters – part 1

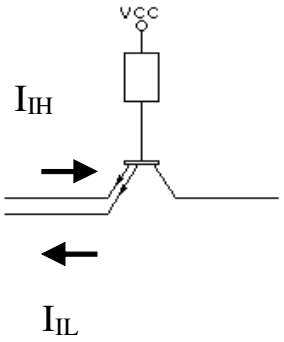
- Unit load:
  - Load caused by a single input of a standard logic gate in a given technology
  - Makes sense only if all the elements belong to the same family
  - If an input controls more internal signals, the load is a multiple of the unit load



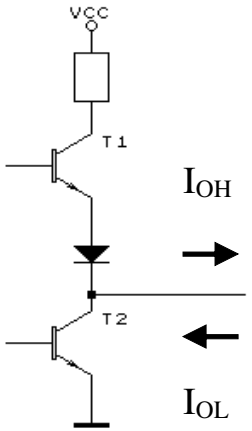
- Outputs
  - Load (logic gain) – numer of inputs of IC belonging to the given family, that can be driven by the output without exceeding/violating its parameters
  - Typical logic gain = few to over a dozen
  - Output types
  - Possibility of output connecting

Parameters – part 1

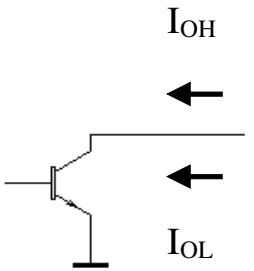
- Inputs and outputs



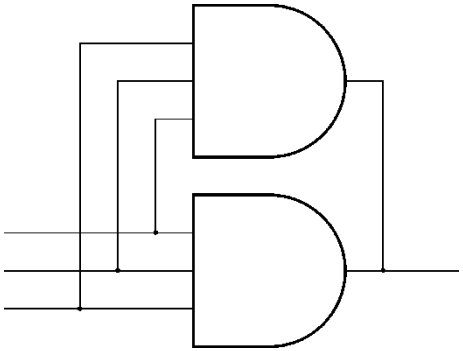
input



totem-pole output

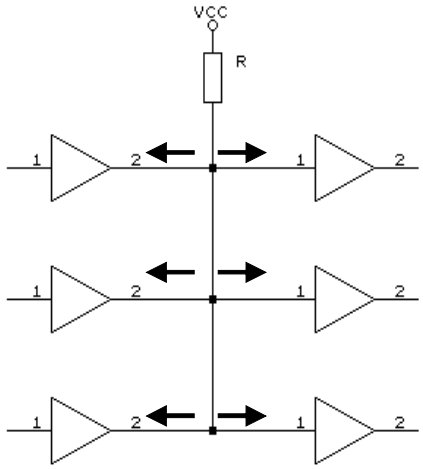


open-collector output

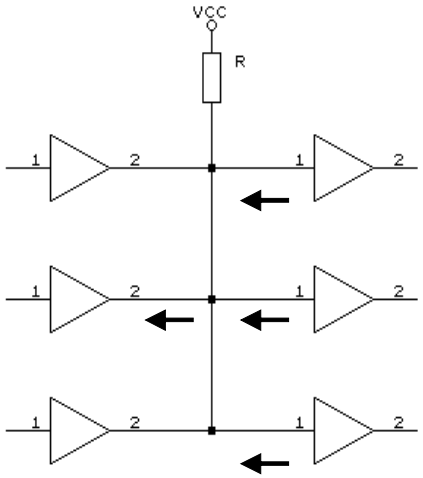


Parameters – part 1

- Resistor value calculation for open-collector outputs



High state



Low state

$$R_{max} = \frac{V_{CC} - \max(U_{OHmin}, U_{IHmin})}{\sum I_{OHmax} + \sum I_{IHmax}}.$$

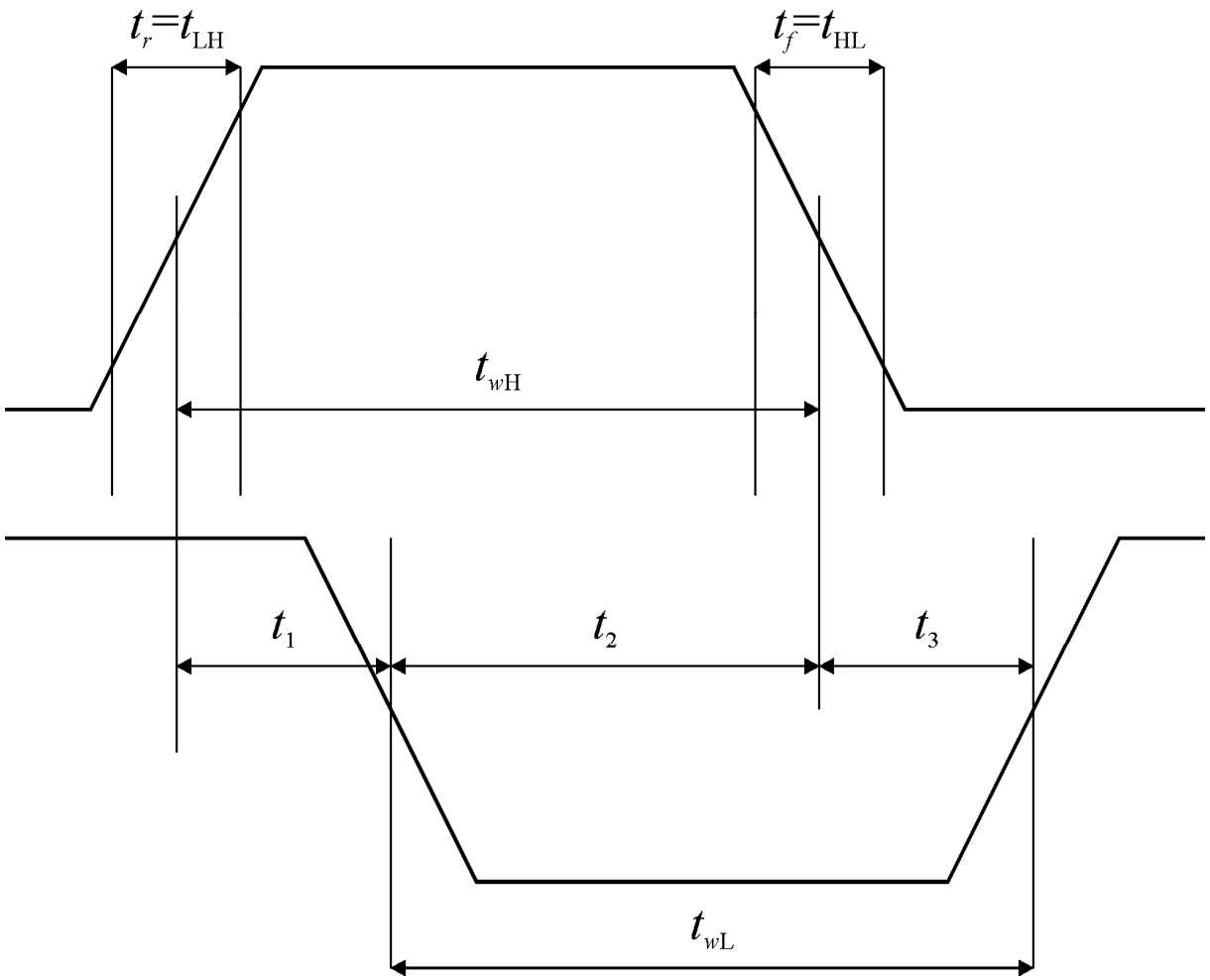
$$R_{min} = \frac{V_{CC} - \min(U_{OLmax})}{\min(I_{OLmax}) - \sum I_{ILmax}}.$$

Parameters – part 1

- Dynamic parameters
  - Dependencies between input and output signals
    - Corresponding to inputs → determine input driving conditions
    - Relations between inputs and outputs → determine circuit switching speed
  - Non-uniform production, various operating conditions → value ranges rather than exact values
  - Often only min, max and typical (e.g., average) values are given
  - „time rise" (t_r) and „time fall" (t_f) measured between:
    - 10% and 90% of amplitude
    - 20% and 80% of amplitude
    - Some constant U_a and U_b
  - Time between two edges measure between:
    - 50% to 50% of amplitude
    - Some constant U_c,
    - Switching threshold voltage

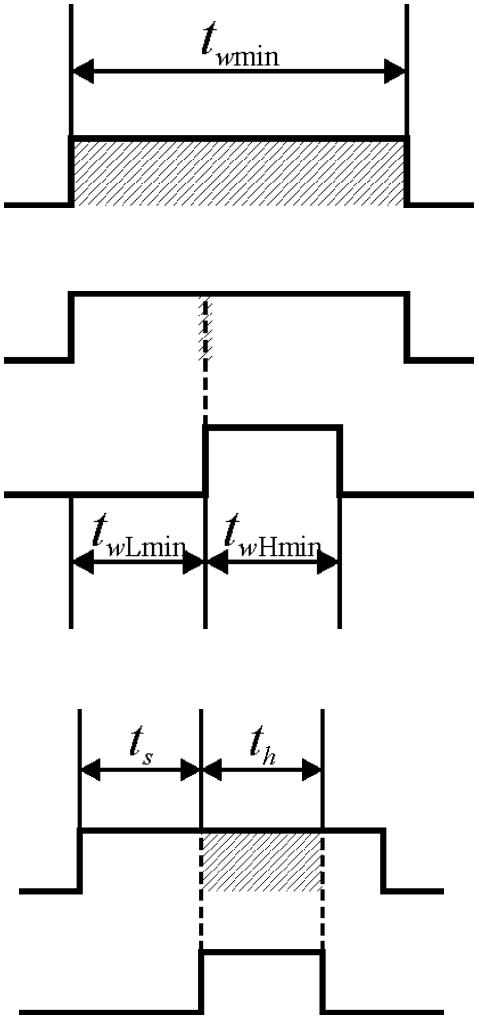
Parameters – part 1

- An illustration of dynamic parameters



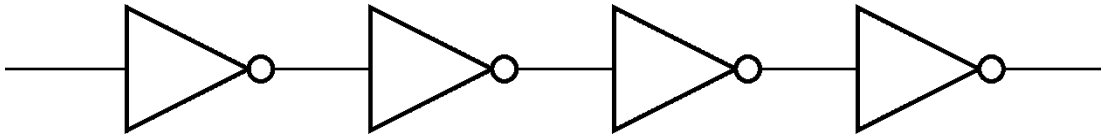
Parameters – part 1

- About dynamic parameters
  - Syn/asyn level sensitive input
    - $t_{w\text{min}}$
  - Edge synchronising input
    - $t_{w\text{Lmin}}$ (before edge),
    - $t_{w\text{Hmin}}$ (after edge),
    - $t_{r\text{max}}$, $t_{f\text{max}}$ (max edge duration)
  - Synchronous level sensitive input → t_s („time set”), t_h („time hold”)
  - Synchronisation input (clock) → f_{max} (*de facto* minimal frequency guaranteed)



Parameters – part 1

- Propagation time – from input signal change to the effect visible at the output signal
  - Usually only max value → guaranteed not to be exceeded
  - sometimes typical value → the value we can hope for (not guaranteed)
  - Very rarely min value → not necessary for digital system design (except some really special cases…)



$$\Delta t \in \left\langle \sum t_{p_{min}} \ldots \sum t_{p_{max}} \right\rangle$$