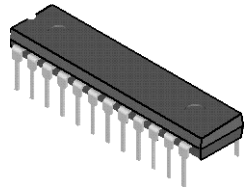

ECE380 Digital Logic

Implementation Technology:
Standard Chips and
Programmable Logic Devices

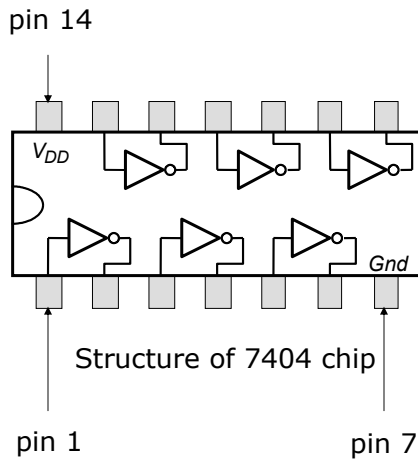
Standard chips

- A number of chips, each with a few logic gates, are commonly used for small logic circuits
- These are known as 7400-series devices because the part numbers always begin with the number 74
 - Commonly packaged in a **dual-inline package** (DIP)
 - Chips external connections are called **pins** or **leads**
 - Two pins connect **V_{DD}** and **GND** to supply power for the chip.

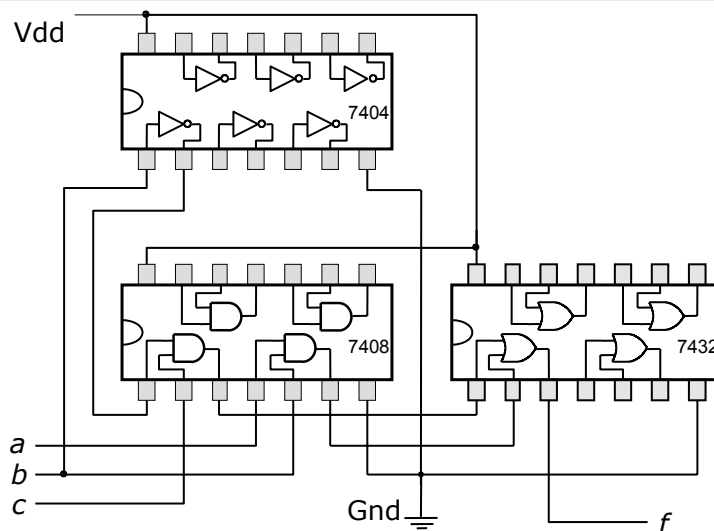
A 7400-series chip



Dual-inline package



Implementation of $f=ab+b'c$



7400-series chips

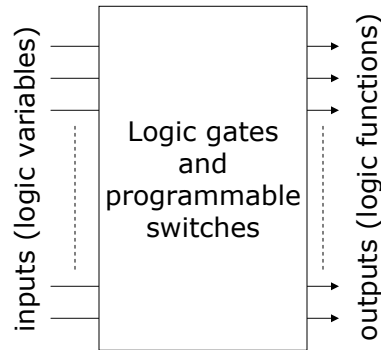
- For each specific 7400-series chip, a number of variants are fabricated with differing technologies
- For example:
 - The 74LS00 is built with a technology called transistor-transistor logic (TTL)
 - The 74HC00 is fabricated using CMOS technology
- Most popular chips in use today are the CMOS variants

Programmable logic devices

- The function provided by each 7400-series device is fixed and each chip only provides a few logic gates
 - These limitations make use of these chips inefficient for building large circuits
- It is possible to fabricate chips with a large amount of circuitry (gates) but with a structure (interconnection) that is not fixed
 - Called **programmable logic devices** (PLDs)

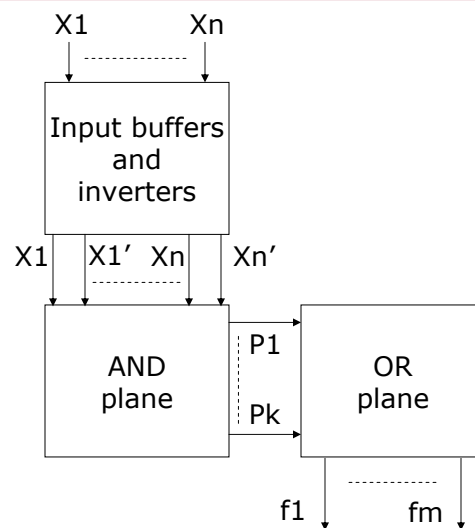
Programmable logic devices

- A PLD is a general purpose chip for implementing logic circuitry
- Contains a collection of logic circuit elements that can be customized in different ways
- Can be viewed as a black box containing logic gates and programmable switches that allow for different connections between the logic elements
- Can implement whatever logic circuit is needed – subject to limitations of the device

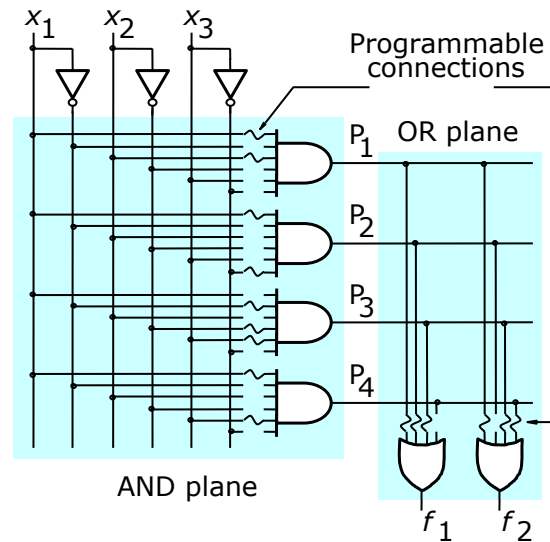


Programmable Logic Array (PLA)

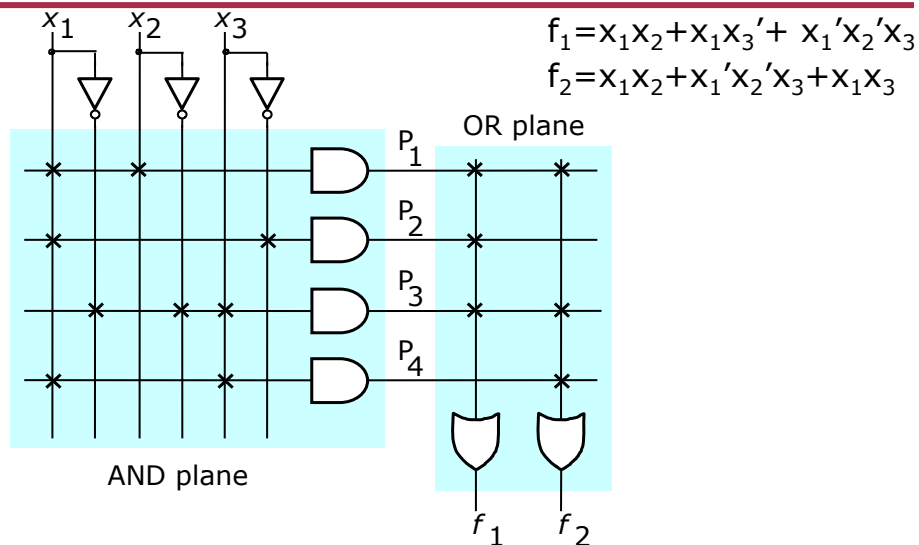
- The first PLD developed was the **programmable logic array** (PLA)
- Based on the premise that any function can be written in SOP form, a PLA consists of
 - Input buffers and inverters that provide the true and complement form for each input variable
 - A collection of AND gates, with inputs that are selectable (programmable)
 - A collection of OR gates, with inputs that are selectable (programmable)



Gate-level diagram of a PLA



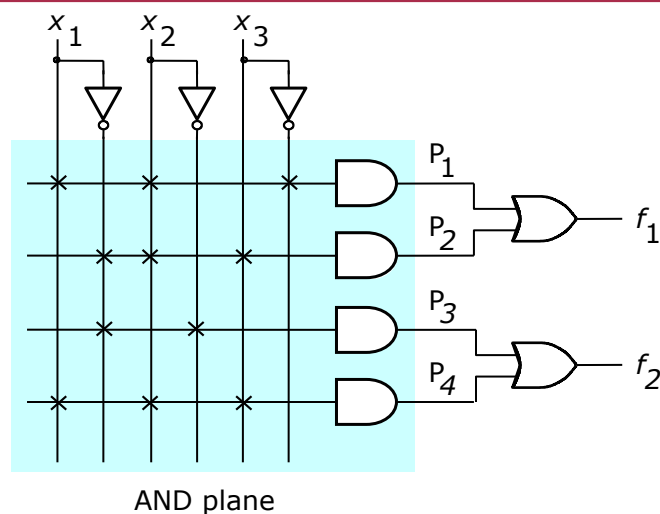
Customary schematic of a PLA



Programmable Array Logic (PAL)

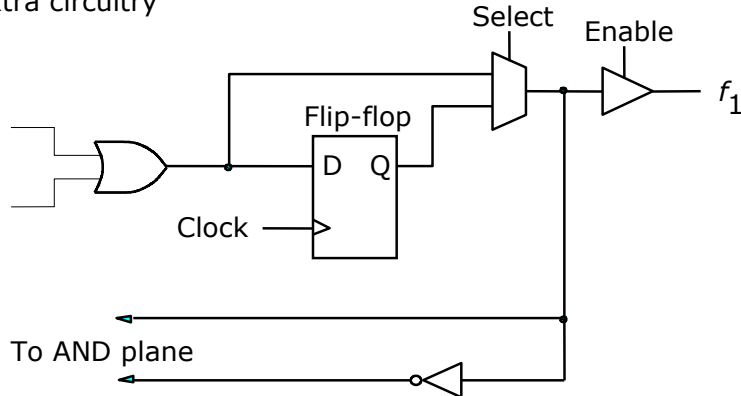
- In a PLA both the AND and the OR planes are programmable
- A simpler device with a fixed OR plane is called a programmable array logic (PAL) device
 - As PALs are easier to manufacture and can operate faster than a PLA, most practical applications using these small programmable devices use the PAL structure

An example of a PAL



Extra circuitry in a PAL

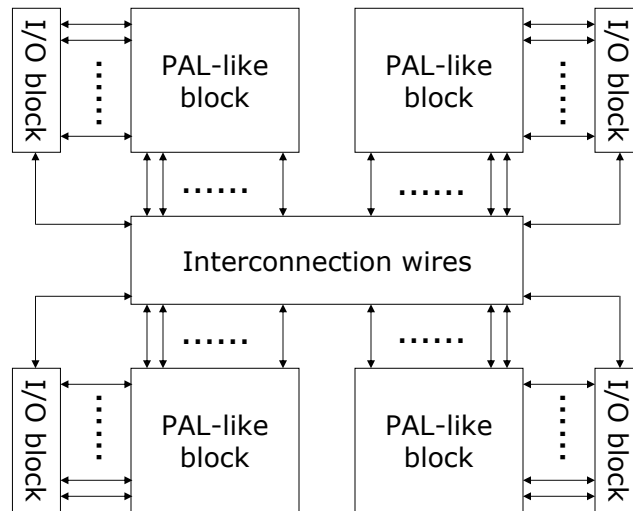
- Most actual PAL devices include extra circuitry at the output of each OR gate to provide additional functionality
- The term **macrocell** refers to the OR gate combined with the extra circuitry



Complex Programmable Logic Devices (CPLDs)

- For larger designs that single PLAs or PALs cannot accommodate, a **complex programmable logic device** (CPLD) can be utilized
- A CPLD consists of multiple circuit blocks with internal wiring to connect the blocks together and to the pins on the chip
- Each circuit block is similar to a PAL
 - PAL-like blocks
- Commercial CPLDs have from 2 to more than 100 PAL-like blocks, with 16 macrocells in each block
 - Each macrocell is the equivalent of approximately 20 gates
 - About 20,000 equivalent gates in a CPLD of 1000 macrocells
- Can construct moderately large logic circuits in a single chip

Structure of a CPLD



Field Programmable Gate Arrays

- To implement even larger circuits, it is convenient to use a different chip that has an even larger logic capacity
 - A field programmable gate array (FPGA)
- Does not contain AND and OR planes
 - Instead provides an array of **logic blocks** and interconnection wires between the logic blocks
 - Interconnection wires are arranged in horizontal and vertical **routing channels** containing wires are programmable switches
- Capable of implementing logic functions of millions of equivalent gates

Structure of an FPGA

