# Mini Project: Programmable Logic Device (PLD)
# Photocopying (Xerox) Machine

## A.    Objectives

The objectives of this laboratory are to introduce the students to:
- The development of a PLD device
- A simple Hardware Description Language

## B.    Materials

Breadboard
ATMEL 22V10                                             - 1 unit
ETS-5000 Digital Training kit
Wellon or Hi-Lo ALL-11 Universal Programmer & Tester
WinCUPL 5.0 Software
Handouts:
*"WinCUPL user manual"*
*"ATMEL22V10 Data Sheet"*
*"How to use Hi-Lo Programmer"*
*"How to use Wellon Programmer"*          As an appendix in your Lab Book
*"How to use Win CUPL 5"*

## C.    Mini Project : Photocopying (Xerox) Machine

### Background

*Read the appendix in your lab book to familiarize yourself with the WinCUPL compiler and the universal programmer. If you need any help please ask your lecturer or the teaching assistants.*

This mini project will implement 3 different components on a single ATMEL device, those components are

1. Count Up Counter
2. Comparator
3. Clock Disabler

### Problem:

User will initially enter amount of copies, the counter will count the number of copies that has been photocopied. The machine will stop once the required number of copies produced.

**Proposed Solution:**

A block diagram of a component required is shown in Figure1. Three core components are counter, comparator and clock disabler. Counter will determine the number of copies that has been made while the comparator will determine whether the required number of copies has been met. Once the number of copies has been met, the clock disabler will disable the clock and stop the counter from counting. The machine will display the required number of copies and the amount that has been produced.

To implement this, the user has to key in the required number of copies by using 2 switches, which allow the required number from 0 to 3 (don't ask me why so few, if you can produce a zillion copies by using the kit in the lab then I will give you an A+ for this subject). He/she will reset the counter (assuming pressing a START button), the counter will count and its output will be compared with the value of the switches, if the value is not the same it will continue counting up. A signal will be generated to stop the counting if the output of the counter has the same value as the digital value of the switches.
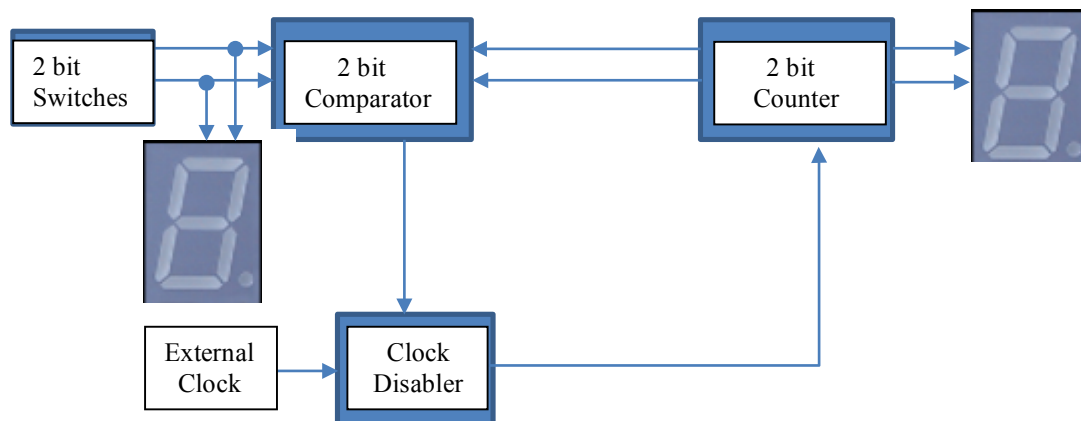


Figure 1. A block diagram of a complete system

**Components & Requirement:**

✓ **Switches:** to set the required no of copies

✓ **Counter:** to count the number of copies that has been made

✓ **Comparator:** to compare the number of copies required with the number of copies produced

✓ **Clock Disabler:** to stop the operation of the counter

*If Copies produced  < Required Copies, Counter will count up*
      *Else*
           *Counter will stop counting*

**Implementation**

All the components are implemented as a WinCUPL code that will be programmed into ATMEL.

### Switches

Use switches provided by the ETS 5000 Digital training kit

### Clock Disabler

The counter will count if there it arrives at edge of the clock signal. We want to eliminate that edge when we want to stop the counting and allow it when we want the counter to keep on counting.

```
/* *************** INPUT PINS ********************/
PIN 10 = startPrt              ; /*   Start Printing */

/**** Function Clock Enabler ********************/
clkEn = startPrt;
```

### Counter

Counter is a count up 2 bit counter that was controlled by the clock.

```
/** 2 bits count up saturated counter **/
/** Define state counter     **/
field countP = [Q1..0];
$define s0 'b'00
$define s1 'b'01
$define s2 'b'10
$define s3 'b'11

/** Define Asynchronous input: asynchronous input Active High  ** /
countP.sp = preset;
countP.ar = reset;

/** State Counter Sequence       **/
sequence countP {
present s0 default  next s1;          /** 0 --> 1 **/
present s1 default  next s2;          /** 1 --> 2 **/
present s2 default  next s3;          /** 2 --> 3 **/
present s3 default  next s3;          /** 3 --> 3 **/
}
```

Figure 2: WinCUPL code for 2 bit counter

### Comparator

A comparator is a combinational circuit that can be designed using *XNOR* gate. Figure 3 shows a 2 bit equality Comparator, you need to modify this circuit to suit the requirement of your design.
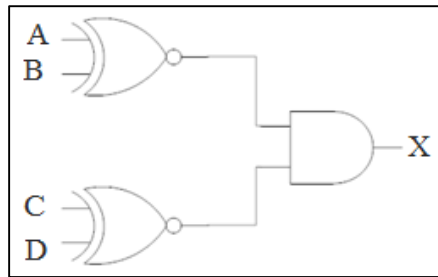
Figure 3. 2bits Equality Comparator

The circuit in Figure 3 can be translated to a WinCUPL code as follows

```
/** 2 bit comparator **/
X = !(A $ B)&!(C $ D);
```

## D. The FULL code & Circuit Implementation

```
Name      Xerox2Bnew ;
PartNo    00 ;
Date      07/12/2017 ;
Revision  01 ;
Designer  Engineer ;
Company   UTM ;
Assembly  None ;
Location   ;
Device    G22V10 ;

/* ************** INPUT PINS ********************/
PIN  1   =    clk                ; /*        clock    */
PIN  2   =    reset              ; /*        reset    */
PIN  3   =    preset             ; /*       preset    */
PIN  4   =    a0                 ; /*  Comparator A   */
PIN  5   =    a1                 ; /*                 */
PIN  7   =    b0                 ; /*   Comparator B  */
PIN  8   =    b1                 ; /*                 */
PIN  10  =    startPrt           ; /*   Start Printing */

/* ************** OUTPUT PINS ********************/
PIN  17  =    diffCmp            ; /* XOR (A B not equal HIGH)  */
PIN  18  =    sameCmp            ; /* XNOR (A B equal HIGH)    */
PIN  21  =    q0                 ; /*  output counter        */
PIN  22  =    q1                 ; /*  output counter        */

/***** Function Comparator*********************/
sameCmp = !(a0$b0)&!(a1$b1);
diffCmp = !sameCmp ;

/**** Function Clock Enabler ******************/
clkEn=startPrt & diffCmp;

/*** Function Counter 2 Bit UP ****************/
field count =[q1..0];
$define s0 'b' 00
$define s1 'b' 01
$define s2 'b' 10
```

```
$define s3 'b' 11

count.ar=reset;          /* connect reg AR to reset (Asyn Mode)     */
count.sp=preset;         /* connect reg AR to preset (Syn Mode)     */

sequence count{
      present s0 if clkEn next s1;
            default next s0;
      present s1 if clkEn next s2;
            default next s1;
      present s2 if clkEn next s3;
            default next s2;
      present s3 if clkEn next s3;
            default next s3;
}
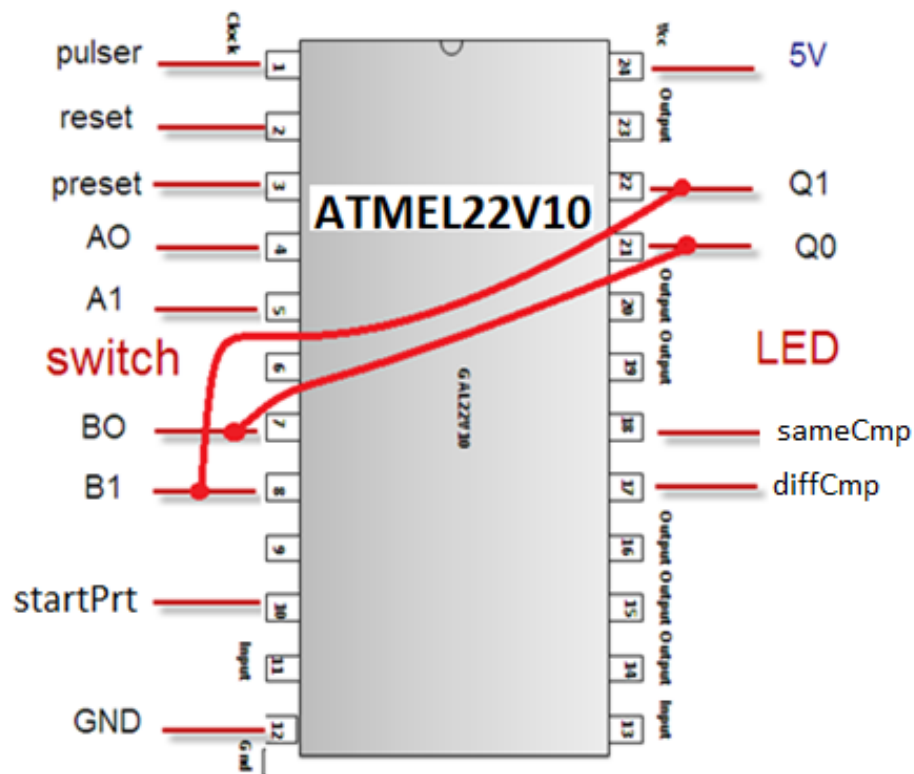```

**Circuit implementation on ETS5000 Training kit**



Figure 6. 2 Bit Xerox Machine

**E.     The Practical Work**

1. a) Type your code using WinCUPL.
   b)  Compile the program. The compiler will generate .JED (jedec) file.

c) Burn the .JED file to ATMEL22V10D using a Wellon or HiLo programmer in the lab

d) Test the circuit by using a Digital Training Kit.
  i. Connect the Vcc and GND
  ii. Connect Clock pin to a pulser switch
  iii. Connect switches input to a toggle switch
  iv. Monitor the logic value of the switches and the output of the counter by connecting it to the 7 segment display (digital display on the kit)
  v. ***ATMEL22V10 is a CMOS device, handle with care***. Flip Mode selector switch to CMOS. If your counter miss a counting sequence you can try to flip the switch to TTL

2. You must bring your source code (.PLD) and a jedec file (.JED) in electronic form to the lab before lab begins.

**COMPARATOR Testing steps:**

a. Set the number of required copies by flipping the switch (eg: $A_1A_0 = 10$ ; 2 copies)

b. Set different value of $B_1B_0$ and compare the value in $A_1A_0$ . What is the value of L and H.

| $A_1$ | $A_0$ | $B_1$ | $B_0$ | diffCmp | sameCmp |
|-------|-------|-------|-------|---------|---------|
| 1 | 0 | 0 | 0 | | |
| | | 0 | 1 | | |
| | | 1 | 0 | | |
| | | 1 | 1 | | |

**COUNTER Testing steps:**

a. Set the Asynchronous/Synchronous pin switch input to the correct setting. Make sure the initial output of the counter in ZERO.

b. Press the pulser switch, it will increment the counter ($00 \rightarrow 01 \rightarrow 10$)

c. Counter output equals comparator will change as count up counter.

**F: PROJECT Part I**

1.  Extend the 2-bits Xerox Machine to 3-bits Xerox Machine.
2. Do the following:

   a)   Change the 2-bits up counter from Figure 4 to 3-bits up counter
   b)   Using Figure 5 as a guide design for a 3 bits comparator and write the equation
        into your winCUPL code.
        *Hint: "if find too many product terms, DeMorgan might be your best friend"*
   **c)**  Make sure th clock disable is connected to the correct function.

   (** *You can choose the pin to be assigned to each variable by referring to
   ATMEL22V10 manual.*)
3. **Test your circuit on ETS5000 Training kit**
4. **Demo Session with Q&A**


**G: Project PART 2**

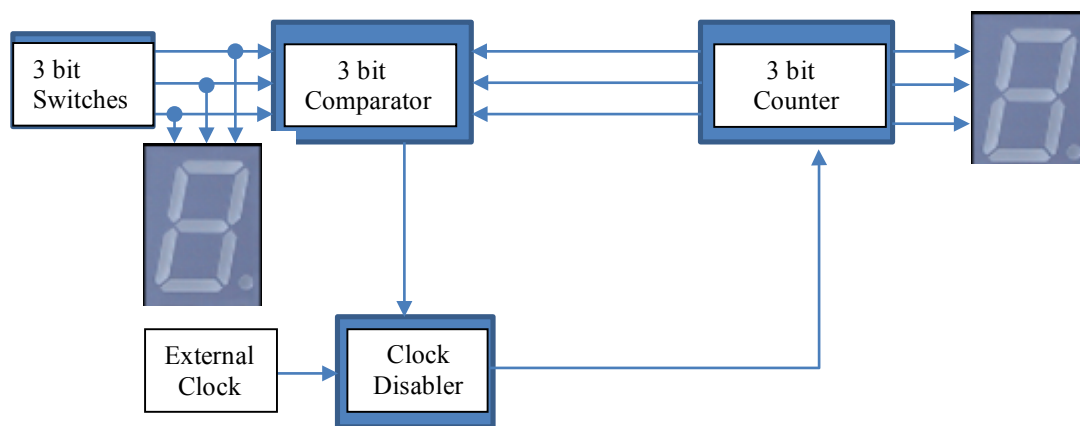**Enhanced Design Features Using Deeds Software**



Figure 7. A block diagram of a complete system

1.  Add more components with different functions (features) to the existing circuit in
    Figure 7 using components that you have learnt in this course (especially components
    discussed in Chapter 6). You can have a look at a real photocopy machine to get ideas
    or come up with a new function to enhanced the current photocopy machine.

    Your design must be unique and you can discuss it with your lecturer.

2.  Simulate your enhanced circuit design using DEEDS software.
3.  Prepare a report. Refer to the report requirement.