Design and Implementation A Home Cnc Open Control System

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ABSTRACT

This paper presents a utilization of software KCAM4(Computer Aided Manufacture) based open architecture control system (OAC) as a computer numerical control (CNC) solution for the plotter suggested. The characteristics of the chosen OAC solution, and implementation details are briefly depicted. This work give us an ability to implementation of home CNC machine robust efficient and inexpensive (about 250 $) with multipurpose utilization output tools. The implemented machine is rugged and reliably work in all environment , the cost is very cheap comparing with that found in market, except that it has the ability of changing the output tools to make others skills like drilling and figuration.

KEYWORDS: Open Control Systems, Enhanced Machine Control, KCAM4

I.   INTRODUCTION

Numerical control (NC) systems are hardware controls in which most of functions are carried out by electronic hardware based upon digital circuit technology. Numerical Control is a technique for controlling machine tools or processes using coded command instructions. These coded command instructions are interpreted and converted by NC controller into two types of signals namely; motion control signals and miscellaneous control signals. Motion control signals are a series of electric pulse trains that are used to control the positions and the speed of the machine table and spindle, whereas miscellaneous control signals are set of ON/OFF signals to execute the spindle rotation and direction, control of coolant supply, selection of cutting tools, automatic clamping and unclamping, etc. In motion control signals, each pulse activates a motion of one basic length-unit (BLU). CNC controls are soft-wired NC systems as control functions are controlled by software programs. Alternatively, Computer Numerical Control is the numerical control system in which dedicated, stored program microprocessors are built into the control to perform basic and advanced NC functions [1]. CNC (Computer Numerical Control) is the process of manufacturing machined parts [2]. CNC technology has been one of manufacturing's major developments in the past fifty years. It not only resulted in the development of new manufacturing techniques and the achievement of higher production levels, but it also helped increase product quality and stabilized manufacturing costs [3, 4].

In the last two decades, a lot of efforts have been made in the development of open control systems for machine tools. They were recognized as a solution to machine tool and controlmanufacturers endeavors to elaborate common concepts, develop basic technologies and to produce basic components together, in order to fulfill continuous demands for higher machine toolfunctionality and flexibility, product quality and costs reduction [5].According to the IEEE, "an open system provides capabilities that enabled properly implemented applications to run on a variety of platforms from multiple vendors, interoperate with other system applications and present a consistent style of interaction with theuser " (IEEE 1003.0). This means that, Open Architecture Controller (OAC) has to be flexible in hardware and software, for all control levels, i.e. must be standardized in the sense of integration with other control systems and permit theintegration of independent application program modules, control algorithms, sensors and computer hardware developed by different manufacturers [6]. With the ability of implementation and integration of customer-specific controls by means of openinterfaces and configuration methods, their implementation is particularly important in the development of reconfigurable manufacturing systems [7]. This paper present home implementation of CNC Open loop control hard ware from the power supply to output tools with demo software KCAM4, very cheap product and effective and efficient with 0,01 percentage of error. Section two explained the essential component of this machine, in section three give us an idea about the controller of motion and I/o controller finally in fourth the conclusions and future works.

II.   CNC OVERVIEW

This paragraph present an overview of our suggestion CNC PLOTTER .Figure (1) show the general block diagram of the PLOTTER beginning from the personal computer (PC) [the controller] and ending to the motors & solenoid as output tools to execute the order.
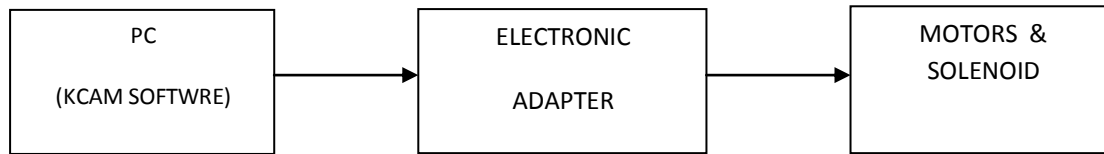

Fig.(1) overview blocks diagram CNC plotter

It is CAM (Computer Aided Manufacturing) application. KCAM 4 is designed to control CNC axes andexecution the given drawing. Typical CNC applications for KCAM 4 include routing, 3D Milling, PCB milling and drilling, and plasma Cutting. KCAM 4 is designed to read the files created by the CAD (Computer Aided Design) programs such as AutoCAD &OrCAD and control the CNC tools linked to the PC a cross parallel port (LPT).

2.1 ELECTRONICS ADAPTER

It is adapts the personal computer (PC) signal with output tools "MOTORS & SOLENOID". Figure (2) show the block diagram of the electronics adapter. In Figure (2) the electronics adapter blocks beginning from "BUFFER" to "DRIVERS" blocks. Its function is taking the digital codes and analyze it by a digital ICs then give it to the drivers to operate the stepper motors and the solenoid. The drivers are a power transistors, these transistors must be compatible with the digital ICs.
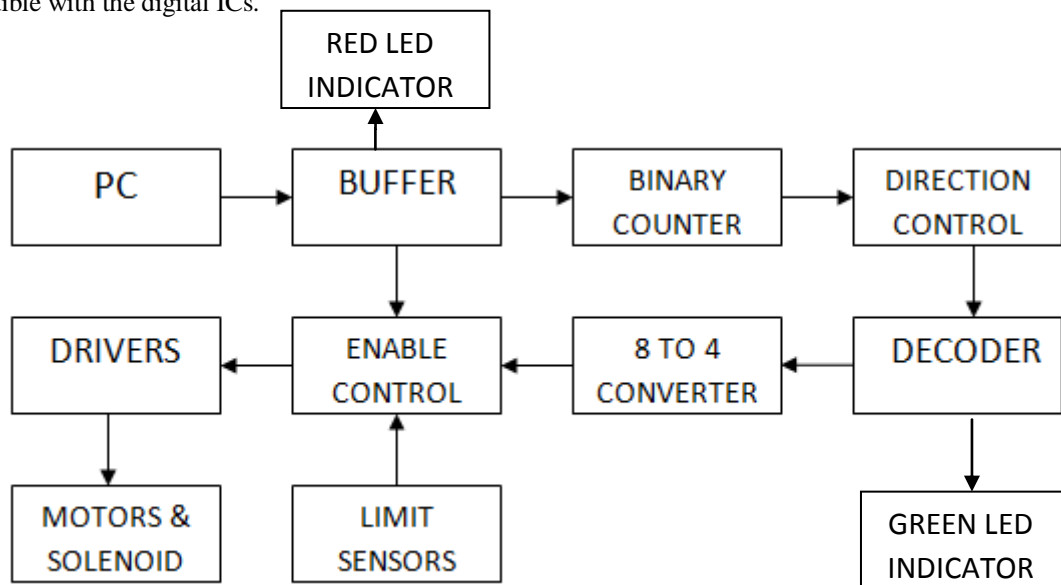

Figure (2) Block diagram electronic adapter

2.2 MOTORS & SOLENOID

In CNC machines the motors are two types: servo-motors or stepper motors .The advantage of the stepper motor it is easy to control by the computer and the disadvantage is open loop control , this is a drawback. The advantage of the servo-motor is closed loop control , meaning that the servo-motor has a feedback circuit to process the errors and the disadvantage of this type is needs more maintenance and the driver is not economical as in stepper motor driver [4, 11]. In our PLOTTER the selected motor was stepper motor , because we need a simple motion and light torque to carrying out the work. We can classify the stepper motors by sizes and the rating current .Sizes of motors such as (42mm , 50mm , 56mm , 60mm , 86mm , 106mm) , this standards , and current ranging from (1A) for size 42mm to (6A) for 106mm. Our motor choice is 42mm (size) , 1A [8, 11].

2.3 COUPLING : The coupling between the motors and the mechanical sliders is MXL pulley & belt system. This is a simplest manner to couple the motors with the mechanical parts as shown in following picture figure (3).
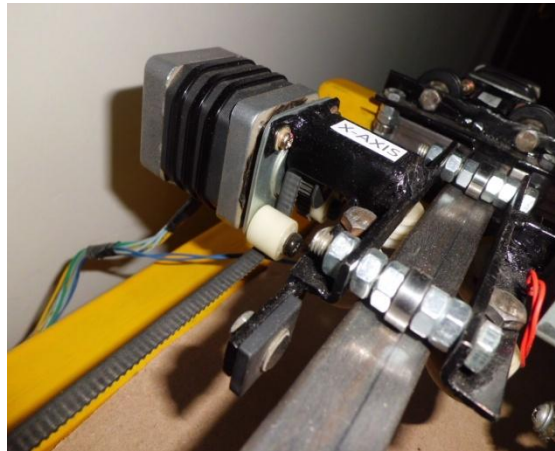

Figure (3) mechanical parts

III.   ARCHITECTURE CNC

CNC is composed from three components:

 Motion Controller ,

 Discrete I/O Controller ,

 Text-based and graphical user interfaces(GU)

3.1.motion controller

    To oriented the rotation of motor clockwise and counter clockwise by usindg directional control circuit, which can be done by changing the status of binary counter outputs. In another words, invert the output of counter binary or not.Directional control circuit can be design by a digital AND gates and NOT gates using ICs (74LS08) for AND gate and (74LS04) for NOT gate as shown in figure (4b). The buffer working to matching between two stages (the (PC) and the digital controller) and provide a security to the personal computer(PC) as shown in figure (4a), the complete of printed circuit board for digital controller shown in figure (4c).

| (a) | (b) | (c) |
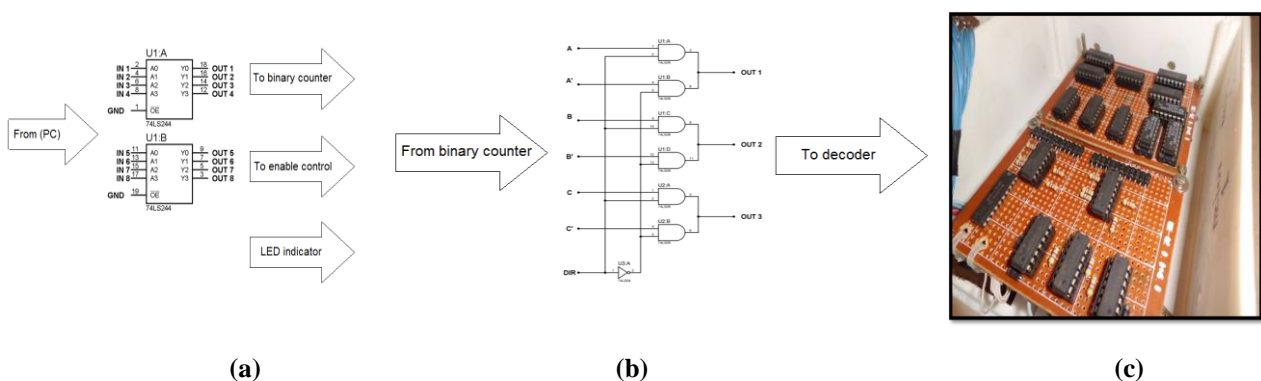
 Figure (4) (a) tri-state buffer (74LS244) (b) direction control (c) printed circuit board of digital controller

3-2 Discrete I/O cotroller

    It is very important circuit in our (CNC PLOTTER) ,its function is to prevent the stepper motor from burning. It is digital circuit that receiving two signals one from the personal computer (PC) and another from the limit sensors so be easy to taking the decision (motor enabled or not).It is consists from a simple logic gates, AND gates and NOT gates using ICs (74LS08) and (74LS04) respectively, as shown in Figure (5a).The delivered signals from the PC are enable (E) and direction (DIR) signals. The receiving signals from the limit sensors are (1) logic level and (0) logic level. Assume that the direction signal status control ,(1) logic level moving the axis in the left direction

and (0) logic level moving the axis in the right direction. When left limit sensor (LS) and right limit sensor (RS) are giving (0) at the same time, meaning that the mover moving between the sensors (LS & RS),another words, the mover don't near from any sensor and in this case the enable and direction signals coming from the (PC) and pass through the enable control circuit without interrupt from any limit sensor If the (LS) is giving (1) logic level,meaning that the mover near from the (LS) and this sensor making an interrupt case, the mover moving in the right direction only (no motor enabled in the left direction) DIR=0 only .If the (RS) is giving (1) logic level,meaning that the mover near from the (RS) and this sensor making an interrupt case,the mover moving in the left direction only (no motor enable in the right direction) DIR=1 only .The case is that the two sensors (LS & RS) giving (1) logic level at the same time, the mover don't moving in the left direction and don't moving in the right direction, this is undesired case. The output of the circuit in Figure (5a) directly connected to the input control of drivers as in Figure (5b) ,(ENABLE CONTROL) line to control on the motor activation.
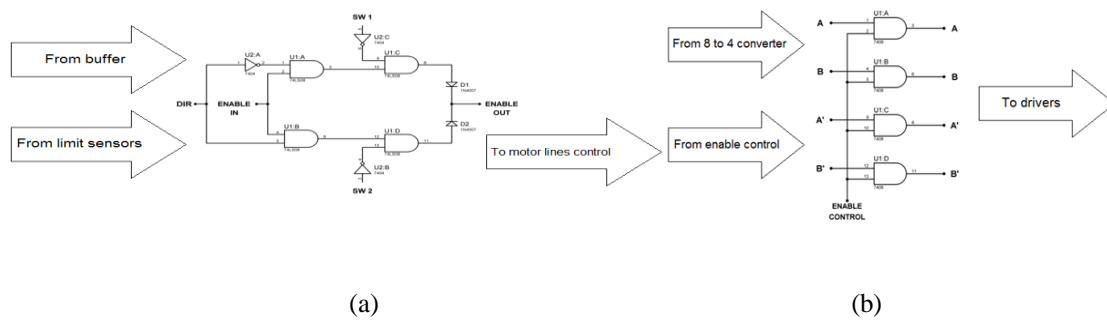
(a)   (b)

Figure (5) (a) enable control (b) motor activation

3-3 Text-based and graphical user interfaces(GU)

Import and saving option is to transfer the files from the CAD Programs to the CAM programs. Example, making a file in AutoCAD programs and saving this file as DXF R12 format in a certain location in the hard disk. In KCAM 4 importing this file from its location and the file will display in the KCAM 4 plot surface [9, 10]. Finally, turn on the machine from the panel and press on to start CNC button in automatic control mode , then the machine will operate to draw the file on the paper.At the end of the operation the plotted paper is complete, as shown in Figure (6&7).

Figure (6) final sight of controller

(a)   **(b)**
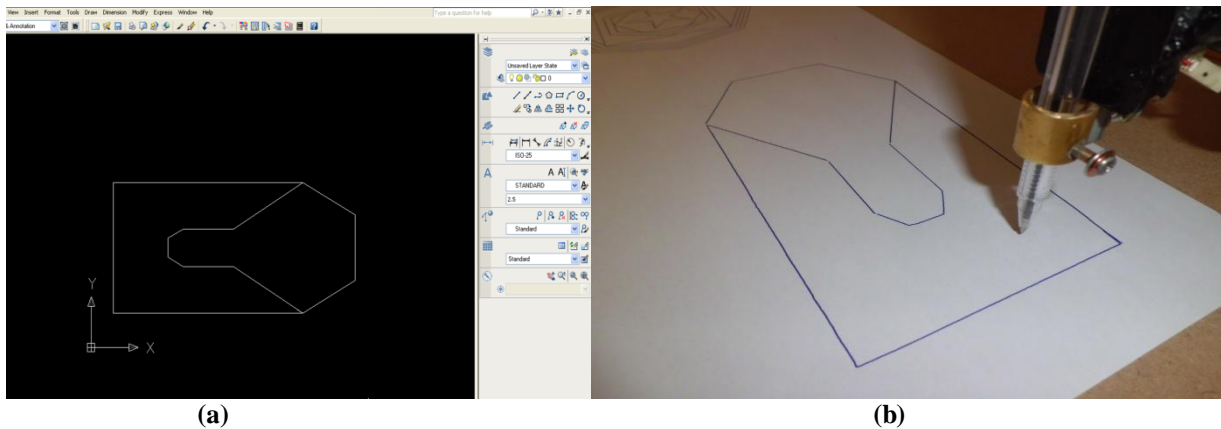
Figure(7)(a) saved file as DXF R12 format (b) executed order given.

Dimension of stepper motor 42 mm, rated current (a/phase) 1A, holding torque (0.39 N.m), rotor inertia (0.056x10^{-4} Kg.m^2) and mass (0.29 Kg) [11].

IV.   CONCLUSION

This CNC and its electronics adapter is **Homemade ,** in another words , designed and implemented with a limited abilities and **Most Economical cost (250 \$)**. The ICs in the digital controller is considered principal ICs , such as 74LS04 (Hexa-Inverter), 74LS08 (Quad AND Gates) and 74LS76 (Dual J-K Flip-Flops)….etc. Also the drive circuits are standard or simple drive. The implemented machine is rugged and reliably work in all environment , the cost is very cheap comparing with that found in market,except that it has the ability of changing the output tools to make others skills like drilling and figuration.

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