

Design and Implementation of Microcontroller Trainer as Interactive Media to Enhance Learning Process in Vocational Schools (Indonesia: SMK)

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Abstract

In general microcontroller trainer which is used in SMK as well as in JPTE FPTK UPI have been using personal computer (PC) on its operation and of course it was relatively expensive. Therefore, it's designed a microcontroller trainer without computer as its operating system. As a result, system can be used with less overhead project efforts because it does not need computer which is dissimilar to previous system/way (predecessor). The result of complete experiment is microcontroller trainer needs two processors, one as master (AVR ATmega 16) and the other as target processor (AT 89S51). For the output display used LCD with 20 x 4 characters, keyboard used is PS/2 type and powers are needed 220 VAC and 5 VDC.

For compiler and interfacing system used C and assembler language for AT89S51. The feature is writing directly use assembler language, program compiling, program download in microcontroller chip, running of program application, error correction in assembler language, it does not need personal computer (PC), less overhead project, easy using, I/O application is much bigger, and flexible.

Conclusions: the result of software and hardware design for microcontroller trainer which does not need computer has been success. It was done by trying some program such as running LED, key pad, push button, relay, seven segment, LCD character, counter, motor stepper, and project board. The result of opinion from teacher from around of Bandung, they are interested to the tool because it was easy, practice, and it does not need computer so it was cheap. It means that the school can do practice, without computer to operate it. The leak of tool is LCD is quite small

Keyword: Mikrokontroler Trainer, Liquid Cristal Display, Keyboard, C language, dan Assebly language.

1. Background

Microcontroller trainer is educational aid tool for learning process of microcontroller in vocational school or in certain universities or polytechnics which has electrical engineering department, instrumentation, control, and computer, even in industry automation department.

“A microcontroller trainer is described, which is intended for training of university, polytechnic and vocational-centre students in the interfacing of hardware and writing of programs in a microcontroller environment” (Habib M. Talukder and Michael Collier, 2002). Microcontroller is combination of CPU with memory and I/O which is in level of chip that produces Single Chip Microcomputer (SCM), also called as microcontroller. Microcontroller therefore can be consists of RAM, EPROM/PLASH PEROM, Input and Output (I/O), ADC, DAC, Timer, Counter, modem, clock, etc. *“A microcontroller consists of a central processor, a Read Only Memory (ROM), a Random Access Memory (RAM), an analogue/digital converter, registers and decoders all in one chip”*(Talukder dan Michael, 2002).

The equipment of microcontroller chip is depends on microcontroller type. Usually, a microprocessor is a part of Central Processing Unit (CPU) of a microcomputer, without memory, input-output, and the others equipment which is needed as a complete system. Such microprocessor in order it could be work properly needs supported ware such like Random Access Memory (RAM), Read Only Memory (ROM), and Input and Output (I/O).

There are many kinds of microcontroller type that are produced by all producer, off course, those all any kind of types have its different specification. So, many of microcontroller are incompatible one to each other, in addition it tend to get soon as obsolete. The advantages of microcontroller are quite many, it depends on application requirement. Microcontroller type which is spreading and popular among society also learned in university, polytechnic, other formal or non formal education institutes, especially in vocational schools is AT 89C51, AT 89C52, AT 89C55, AT 89S8252, AT 89S53, AT 89C2051, AT 90, AT Tiny, AT mega 8535, AVR 2313 (ATMEL). MCS-48, MCS-51, 8051, 8748, (INTEL). MC68 HC 05, 68HC08, 68HC11 and 68 RS 75 from Motorola. PIC 8 (Microchip), Z 80 (Zilog). DS80C390 (Dallas).

From those kind of microcontroller, it was divided into two type i.e.:

CISC (Complex Instruction Set Computing) type which has got more complete in instruction but less in internal facilities (AT89 has 255 instruction) and RISC (Reduced Instruction Set Computing) is much less in instruction but has got quite more internal facilities (PIC 16 F type has around 30 instructions, AVR type is about 118). The existence of microcontroller trainer which has been using in university, polytechnic, UPI, even in those kind of certain course/training center of microcontroller, according to prepared C language, bascom, etc., need to program loading into the target of IC (microcontroller) whereas in general uses loader circuit arranged in parallel or serial with computer.

Microcontroller trainer which is designed here, created such that users need not a computer or without computer facility in making program, downloading program into the target Microcontroller or practical implementation, so that consumers or students are not necessarily have computer. As a consequence, system designed reduced practical overhead, cheaper and economic, even for vocational middle schools/ technological institutions with lack of facility.

Design of this microcontroller trainer without using personal computer (PC) is the result of research grant competition in Indonesia (Directorate General of Higher Education of Indonesia).This project is a technological innovation in microcontroller trainer which still none in the public. For microcontroller or control system field of practitioner, so many benefits can be enjoyed because of this innovation.

2. Problem Faced Based Design

According to previous problem mentioned: " How designing similar microcontroller trainer without using computer (facility) but fulfilled requirements of Technological Vocational High School and Indonesia University of Education in Microcontroller experimentations?" The problem then focused on related hardware, software, interfacing and its application design.

The research is a blending of idea between technology application and pedagogical aspects which is realized in the form of microcontroller trainer as one of educational tool in area of electrical/ electronic technology.

There are three specific goals which are to be reached :

- a. Theoretical study of microcontroller stuff that can be implemented in related system which have features : flexibility in programming, can be interfaced with target of application flexibly from out/inside.
- b. As pedagogical study, where microcontroller trainer as learning facility made easy as such that can assists easily in studying microcontroller which can affect in increasing the result of learning process of microcontroller.
- c. The designed system of this microcontroller trainer without using computer as the new innovation effort and result that worth significantly for Technological Vocational High School or in Indonesia University of Education (UPI).

Benefit of the result :

- a. Realization of this microcontroller trainer as the result of research will become a pilot reference project for further trainer, especially in Jurusan Pendidikan Teknik Elektro FPTK Universitas Pendidikan Indonesia (UPI)
- b. This finding as an addition of practical equipment facility in electrical laboratory of communications and industry which will enriched our laboratory equipment notably as lack/ minim in nature. Notably here, Vocational High School of Technology (SMKT) as a biggest user of this kind of equipment.
- c. With the existence of this microcontroller trainer, students will more interested to deepen and develop the application of microcontroller because they will learn microcontroller more realistic and (in the other word) not verbal.
- d. The system designed in microcontroller learning process would be more have a meaning and can enhancing the skill of programming, in the next turn will affect to improvement in ability of leaning result.
- e. Microcontroller trainer system can be as interactive media of learning because when student makes and implements a program found as mistake, microcontroller trainer facilitated with error correction in making the program so that students will try again and again until program which is made correct.
- f. For Vocational High School of Technology (Sekolah Menengah Kejuruan Teknik) this system would more interest to be chosen and applies because this trainer considered as economic but having complete technical features and easy to be operated. With this kind of innovation can becomes a competitive consideration upon products from outside country.
- g. With the availability and usability of this microcontroller trainer hoped that learning process of microcontroller in SMKT will increase the ability of students and in the following turn will increase demand of technological human resources power from industries and society.

3. Microcontroller Trainer Design System (Journal) as Theoretical Study

Initially the system of microcontroller trainer in general is apart from and depended to computer facility to make the program needed. The previous researcher have tried this kind of efforts,

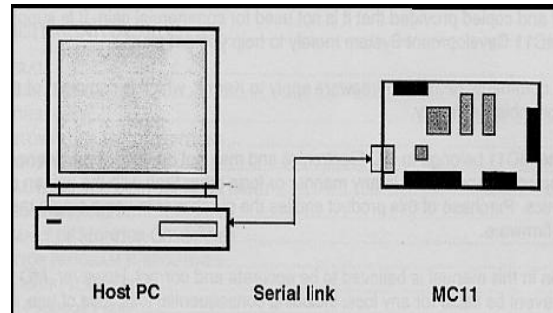


Figure 1 corelation between PC and Microconroler Trainer of 68MC11

Azad1 and Lakkaraju, had researched about microcontroller trainer which is integrated with computer (PC) described as:

'MC11 is a single board computer based on 68HC11 Microcontroller. This is a small but powerful developmental tool with an 8-bit microcontroller unit (MCU). It is designed for use as an evaluation and training aid, but may just as effectively be used as a stand-alone controller. This unit should be linked to a host PC via its serial port in order to allow the development and execution of user programs'.

The features are:

- a) MCU contains 256 bytes of RAM and 512 bytes of EEPROM;
- b) A ROM-Resident monitor program allows short user programs to be quickly assembled and debugged on a line-by-line basis. The ROM size is 8Kbyte. Longer programs may be assembled on the host PC, loaded into MC11, then run and teste under the control of a monitor program;
- c) 8-Kbyte of RAM for user programming;
- d) Two IDC connectors (Port-1 and Port-2) permiteasy interfacing to peripheral hardware. Port-1 allows direct connection to a wide range of standard target systems.
- e) An expansion port (Port-3) enables further expansion of the system.

"One of the advantages of such an educational tool is that it makes full use of its computing power by engaging in many activities simultaneously, all designed to enhance the teaching and learning processes" (Talukder and Michael, 2003).

Daniel M Castro (2003:1) mentions that: " Microcontroller based trainer is The Intelligent logic Circuits trainer" it means that the training equipment being based on microcontroller is equipment to train smart logic network. The following, Talukder and Michael (2002) designed and developed similar microcontroller trainer of SGS-THOMSON ST62XX family member ST62E10 microcontroller chip. With aims to give experience to students about techniques of :

- writing of assembly language programs
- assembling, downloading and running of programs
- programming to output characters to 7-segment displays
- programming to read key-pad characters

- generation of waveforms for display on an oscilloscope
- uses of interrupt facilities
- implementation of timing routines using the on-chip hardware timer.

The result of experiment are:

1. Allows the student to obtain LED displays by setting toggle switches to learn how the binary coded decimal and hexadecimal numbers can be represented.
2. Displays the waveforms of functions such as sine, ramp, triangle, square wave and pulse width modulation.
3. The facility to energize relays for external functional outputs, for example, switching a light, or controlling a remote switch using software.
4. The facility to connect to a personal computer for experiments to system the input and display features of the computer.
5. The facility exists to display data on the sevensegment display unit using digit select and decimal point select exists. The four-digit display unit will allow a display maximum of 9999 (base 10).
6. The use of terminal blocks as digital/analogue inputs or as digital outputs.
7. The use of the twelve-key keypad to input numeric data, which may be read by suitable software.
8. The provision of a range switch for analogue voltage inputs when converting to digital signals. This may also be used for variable frequency voltages.

The scheme of microcontroller trainer system, its equipment, will be depend on requirement of system especially related to the purpose of its learning goal in attainment of affective, cognitive, and its psychomotor domain.

4. Design of microcontroller trainer

Microcontroller trainer designed here used a series of good released by Intel, Atmel, Motorola, Dallas, Zilog etc.

The planning of block diagram as follows :

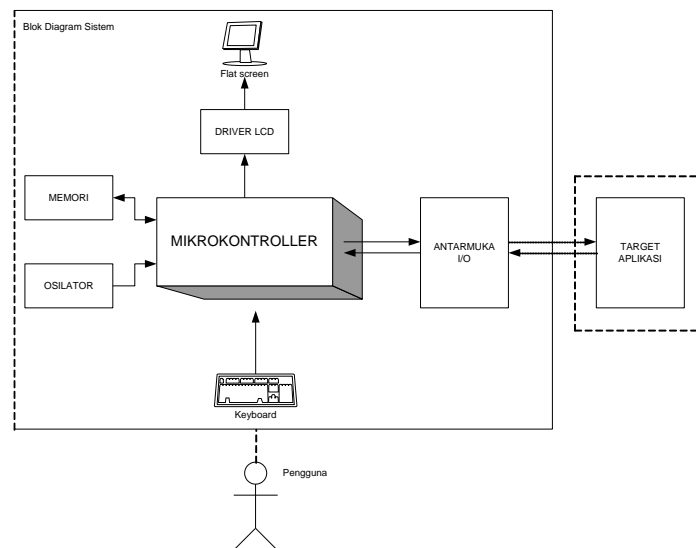


Figure 2 Model blok diagram of microcontroller trainer design

Model design of this trainer is covering of two aspects :

1. Hardware
2. Software

The general features owned as follows :

1. Direct writing of assembler program
2. Direct program compilation
3. Directly downloading program in to microcontroller chip
4. Running of program application
5. Error correction on assembler language
6. It does not need PC
7. Less overhead project
8. Easy using
9. Having expansion I/O of application
10. Flexible in/ to internal I/O application

The specification of Microcontroller trainer model hardware designed as follow :

- a. LCD character is 20x4
- b. Keyboard is PS/2 type
- c. Cristal that is used to trigger of clock is 8-16 MHz
- d. Standard LED for experiment
- e. Keypad for experiment
- f. Seven segment CA, CC and the decoder is 7447 and 7448 type
- g. Integrated circuit (ICs) as gain and driver
- h. Transistors as gain and scalar for experiment circuit
- i. DC motor or motor stepper is 9-12 volt for experiment
- j. LCD character 2x16 as experiment's trial and error
- k. Power supply uses battery of 6-9 volt, and adaptor of 5 volt

Software design as follow :

In software design, system uses C language and the compiler is Code vision AVR. It was used as :

- a. Implementation for keyboard reader,

- b. Implementation for character reader which is displayed on LCD
- c. Implementation for instruction table on Hex compiler instruction
- d. Implementation for main compiler
- e. Implementation for hex compiler
- f. Implementation for delay
- g. Implementation for hex message, etc

The scheme of hardware that has been tested on measurement as stable either on measurement of frequency clock for microcontroller or frequency clock for keyboard. Further more, according to logic level it has fulfilled logic standard conditions.

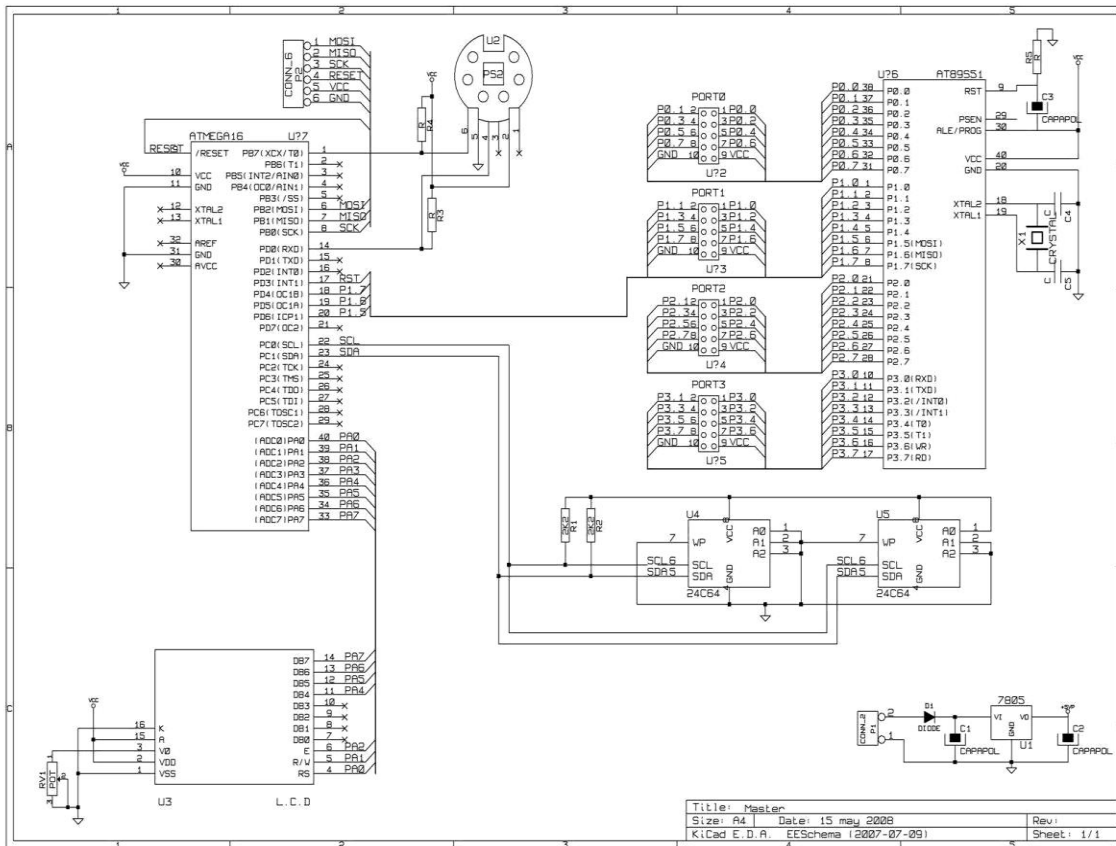
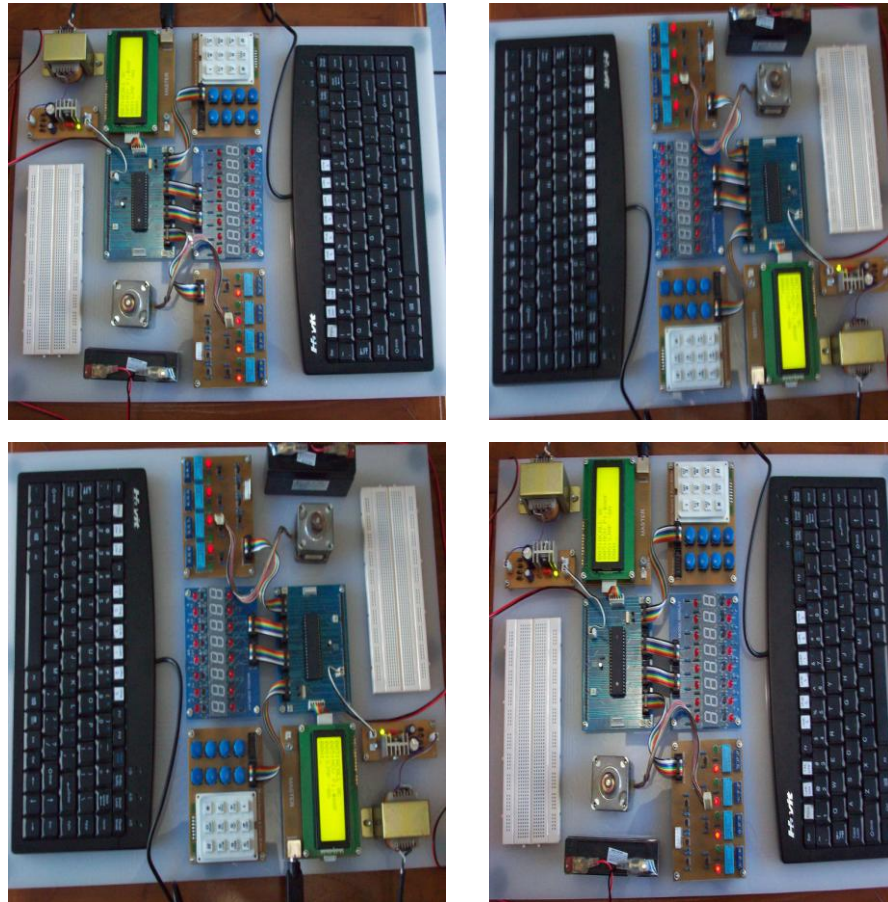


Figure 3 circuit of the result from design and research of microcontroller trainer

Below is the captures of hardware designed as complete appearance (display) viewed from top side.



Picture 4. Physical Display of Microcontroller Trainer

5. Conclusion and Suggestion

5.1 Conclusion

1. For building this system, microcontroller chosen is AVR type 16 as master with 16 kbytes of flash memory program, 1 Kbytes SRAM, 512 EEPROM, 32 bits Input/output, Timer/Counter, 10 bits ADC, 32 general registers, USART, and other parts as additional requirement.
2. As main hardware has been selected two microcontrollers. One made as processor replacing of computer function and the other one used as IC target (processor becoming target).

3. The system as a whole as the result of measurement can be mentioned as stable either based on measurement of frequency clock for microcontroller or frequency clock for keyboard, as well as logic level has fulfilled logic conditions.
4. Program applied for interfacing between keyboard with microcontroller that is C language translated into Hexadecimal format without any problem..
5. The result of research where PC dependency has been replaced by microcontroller and its software and other additional components worked as normal and optimal for doing some experiments by writing some assembly language programs.
6. Experiment modules has been tried for programmes : running lamp in the form of using LEDs, Keypad, character LCD, seven segment, Counter, stepper motor, relay, and project board.
7. Teachers all around of Bandung city, after they tried the trainer generally given response as wonder and interested because it's easy, practical, and doesn't require computer so that automatically as economic. Some SMKs which are not have computer in their laboratory give promise that they in executing laboratory experiments will use this kind microcontroller trainer.

5.2 Suggestions

Because of this experiment of design and implementation of microcontroller trainer uses with keyboard, for the future perfection suggested to be developed by using Keypad. With this way of mind, it hoped that the appearance and forms of trainer to become more interesting, small, so that looked as balance between trainer system with its input-output system.

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