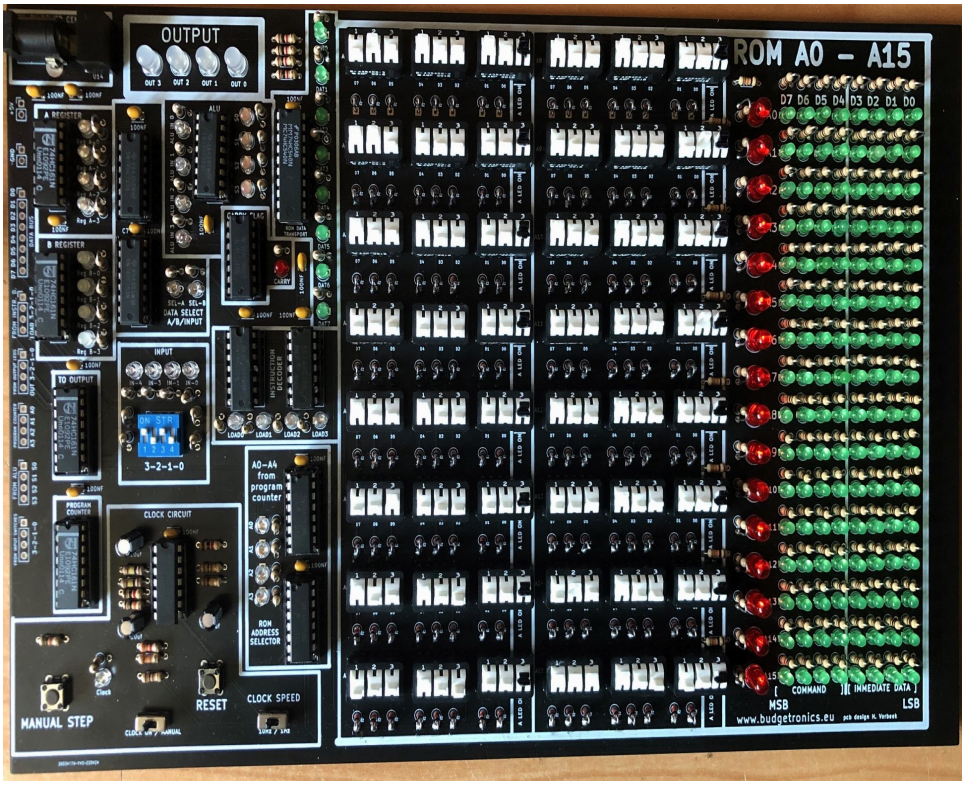
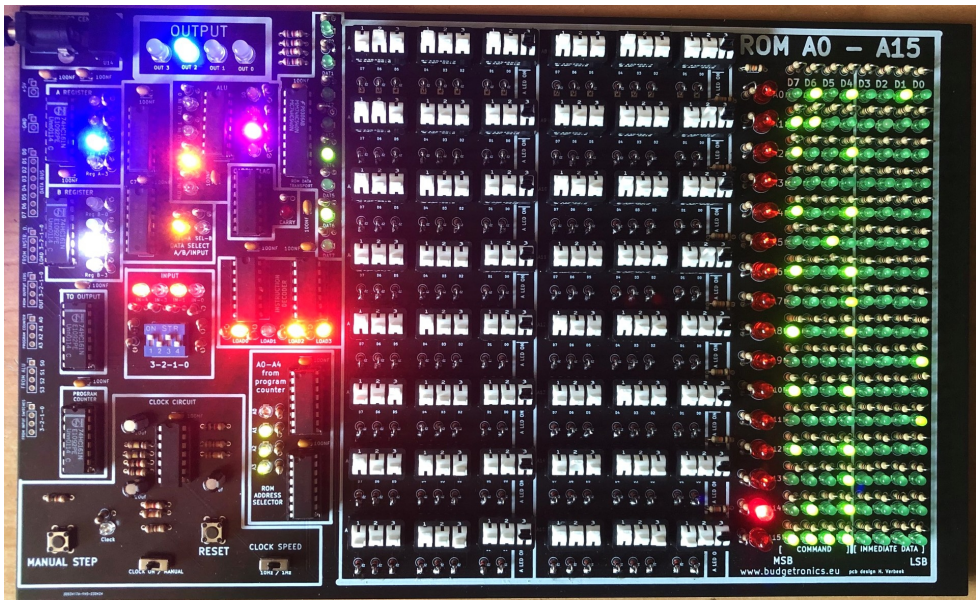
BudgeTronics

TD4 DELUXE THE SIMPLE TTL CPU

Make your own CPU and learn how computers work!





The TD4 computer deluxe building kit contains 188 LEDS, has 14 instructions, 16 Bytes of programmable ROM with switches, 2 clock speeds,step mode, 4 bits output and 4 bits input.

This building kit contains:

1x PCB
1x 74HC10 - triple 3-input NAND gate
1x 74HC14 - hex inverting scmitt trigger (used as clock generator)
1x 74HC32 - quad 2 input OR
1x 74HC74 - dual D flip-flop
2x 74HC138 - 3 to 8 line decoder
2x 74HC153 - dual 1 to 4 multiplexer
4x 74HC161 - 4 bit counter
1x 74HC283 - 4 bit binary adder with fast carry
1x 74HC540 - 3 state inverting buffer/line driver
1x 7805 voltage regulator
128x 1N4148
15x 100nf ceramic capacitor
3x 10uf electrolytic capacitor
2x 100 ohm resistor
195x 1K resistor
1x 3K3 resistor
9x 10K resistor
1x 33K resistor
3x 100K resistor
1x power socket
48x Dip switch 3x
1x DIP switch 4x
2x slide switch
2x push buttons

5mm LEDS:
4x Blue OUTPUT LEDS
16x Red ROM address LEDS

3mm LEDS:
128x Green ROM DATA LEDS
4x Blue A REGISTER LEDS
4x White B REGISTER LEDS
1x Green CLOCK LED
4x Green PROGRAM COUNTER LEDS
4x Red INPUT LEDS
2x Yellow SELECT A/B LEDS
4x Orange ALU in LEDS
4x Pink ALU out LEDS
8x Green ROM read LEDS
1x Red CARRY LED
4x Red LOAD 0 to 3 LEDS

Total 188 LEDS

SUPPLIED LED COLORS CAN BE DIFFERENT IN YOUR KIT. Colors are only an indication and just to make a difference between signals. Only make sure to set the bag of 128 LEDS apart for the ROM lights no matter what color LEDS are supplied with the kit.

Introduction

The TD4 TTL CPU is a very simple CPU to learn how computers work or just to hang on the wall to have a great blinkenlight LED display.

The TD4 computer contains 188 LEDS, has 14 instructions, 16 Bytes of programmable ROM (with switches), 2 clock speeds, step mode, 4 bits output and 4 bits input. At he left side of the PCB there are some connection available for those who somehow want to add extensions to the design.

This version of the TD4 CPU is based on the designs of Kaoru Tonami from his (in Japenese language) book "How to build a CPU", ISBN-13 : 978-4839909864. We added a lot of LEDS to this design so you can see with every program step what is happening inside this CPU. You can program it yourself with switches which sets the program in ROM. These are just simple programs but you can have a lot of fun with this simple computer. At the back of this manual you will find the complete instruction set and an example program to test the TD4. You will also find at the back the pinout of all the used IC's so you can see what connections the IC's have. We also advice those who want to learn the exact working of this computer to search Google for the datasheets of each IC to see how they work in more detail.

This is a big PCB 28,5 Cm x 18 Cm and be prepared to solder a lot of parts. <u>This is a KIT for those who have a lot of experience with soldering and have knowledge of electronics.</u> It will take some time to solder all the parts in place.

Construction (READ THIS!!!):

<u>*Before starting soldering read the construction tips first!*</u>
Because this is a big high density PCB and there are not everywhere indications of value or how to place the parts therefore we give you some tips here.

-The placing of all the IC's is clear all the numbers are on the PCB so you only have to observe the right orientation while soldering them in. IC sockets are not included but you can use them if you want.

-Take care you solder the LEDS in the right way. If you look at the PCB you see every LED connection has a <u>SQUARE and a round connection</u>. The SQUARE connection on the PCB is the <u>*negative side.*</u> All the LEDS have a long and a short pin. The <u>short pin is the Negative side</u> and the long pin is the positive side. So place the SHORT pin of the LEDS in the SQUARE holes. Please be sure you do this right because otherwise the LEDS will not light up and resoldering can damage the PCB.

-All LEDS have a 1K resistor which value is not always shown on the PCB, All the resistors you will solder upright will be 1K. These are the most resistors in the kit. The other resistors are placed flat and you can read their value on the PCB. DO NOT SOLDER RESISTORS IN THE ROM PART UNDERNEATH THE SWITCHES <u>THESE WILL BE DIODES.</u>

-In the ROM section you solder the switches and the diodes. Take care you solder the diodes in the

right way. As you can see in the pictures the black band (Cathode) of the diode faces UPWARDS. So solder the diodes exactly as shown in the pictures.

-Solder in the DIP switches and notice there are 9 switches in a row for each Byte. You only need the first 8 switches to program the ROM, the last switch, on the right, you can paint black with a marker to distinguish it from the programming switches. As shown on the picture at the top of this document. With this last switch you can turn ON or OFF the A0 to A15 LED on the right side. If the CPU runs these LEDS show what the program is executing at the moment. But you can switch this off if you want.

-the voltage regulator is placed with the metal side in line with the PCB indication so the metal side is pointing to the output LEDS.

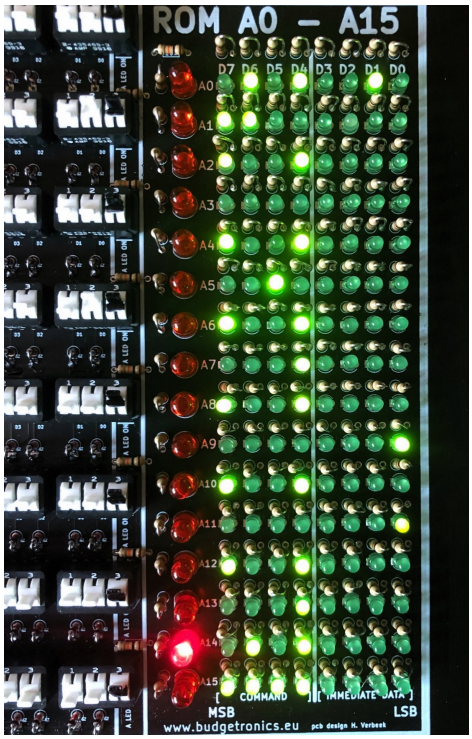
-All the other parts need no explaining it shows itself. Look at the picture of the TD4 if you are not sure about something.

TESTING AND RUNNING THE TD4

If you finished all the soldering you can test the TD4. Place all the DIP switches in the DOWNWARD position. Set Step switch on MANUAL. Use a power supply from 6-9 volts center positive and connect it.

Now test all the ROM switches and make sure all the LEDS at the right show a lighted LED. In this way you know all the ROM data will be read right. If a LED does not light up find the error and make sure it works.

Now toggle in a program with the switches until you have an image as shown in the picture below:



Place the Clock on/manual switch to Clock on and the clock speed on 1 hz for slow or 10 hz for fast. If all is well the TD4 should be running. If the TD4 does not run look for the error. Most of the times this is a soldering bridge or a bad solder connection.

If your TD4 is working you can look up the instructions as used in the above example. See the Instruction set page down here.

Instruction set:

First 4 digits from the left are commands, abcd is the chosen value, 0000 does not care.

Instructions:	Instruction format and explanation:
MOV A, Im; MOVE lm to A register	0011abcd: MOV "abcd" to A register
MOV B, Im; MOVE Im to B register	0111abcd: MOV "abcd" to B register
MOV A, B; MOVE B register to A register	00010000: MOV B register to A register
MOV B, A; MOVE A register to B register	01000000: MOV A register to B register
ADD A, Im; ADD Im to A register	0000abcd: ADD "abcd" to A register
ADD B, Im; ADD Im to B register	0101abcd: ADD "abcd" to B register
IN A; copy input port to A register	00100000: MOV input port (DIP switches) to A register
IN B; copy input port to B register	01100000: MOV input port (DIP switches) to B register
OUT Im; copy Im to output register	1011abcd: MOV "abcd" to output port (LEDS)
OUT B: copy B register to output port	10010000: MOV B register to output port (LEDS)
JNC B; Jump to value B if carry NOT 1	11000000: Jump to value in B register if carry NOT 1
JMP B; Jump to value B	11010000: Jump to value in B register
JMP Im; Jump to Im	1111abcd: Jump to "abcd"
JNC Im; Jump to Im if Carry flag is not 1	1110abcd: IF Carryflag NOT 1 Jump to "abcd"

Program examples:

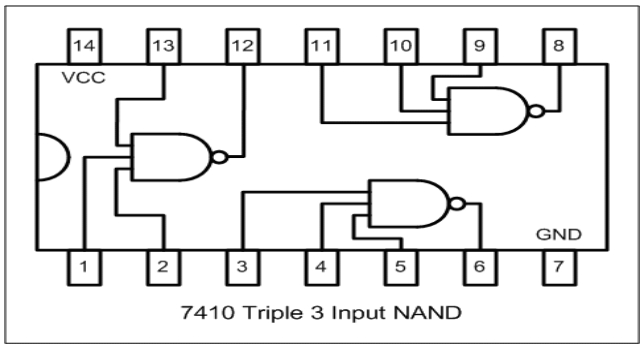
1011_0011 // 0000: OUT 0011
1011_0110 // 0001: OUT 0110
1011_1100 // 0010: OUT 1100
1011_1000 // 0011: OUT 1000
1011_1000 // 0100: OUT 1000
1011_1100 // 0101: OUT 1100
1011_0110 // 0110: OUT 0110
1011_0011 // 0111: OUT 0011
1011_0001 // 1000: OUT 0001
1111_0000 // 1001: JMP 0000
0000_0000 // 1010: NOP
0000_0000
0000_0000
0000_0000
0000_0000
0000_0000

Other example:

1011_1111 // 0000: OUT 1111
0110_0000 // 0001: IN B
1001_0000 // 0010: OUT B
1111_0001 // 0011: JMP 0001
0000_0000 // 0100: NOP

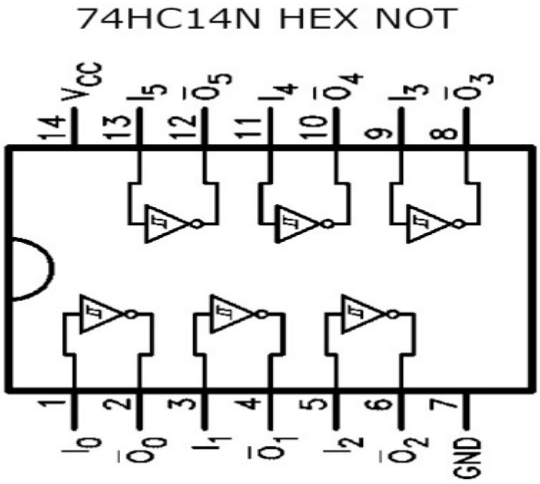
IC PINOUT CONNECTIONS

74HC10

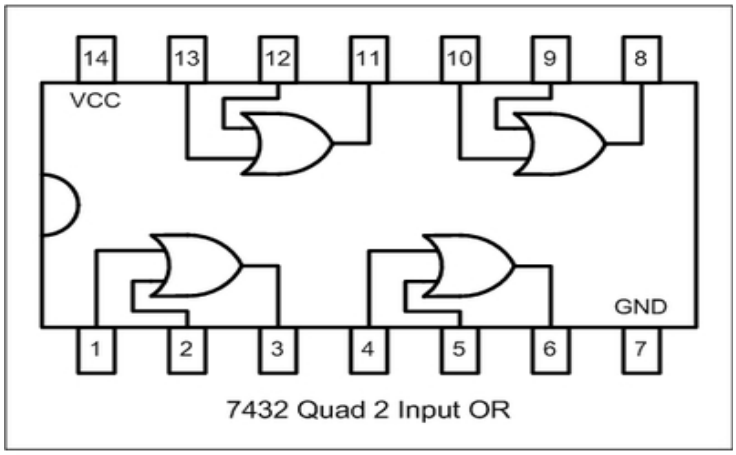


7410 Triple 3 Input NAND

74HC14

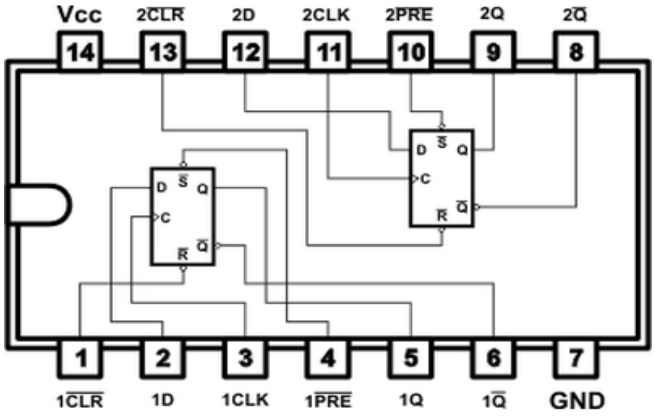


74HC32

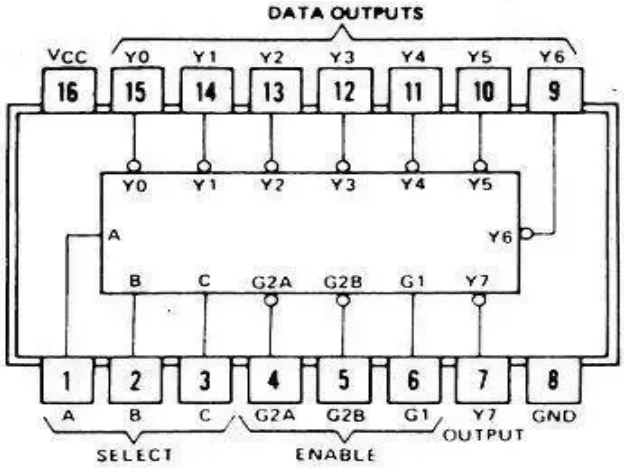


7432 Quad 2 Input OR

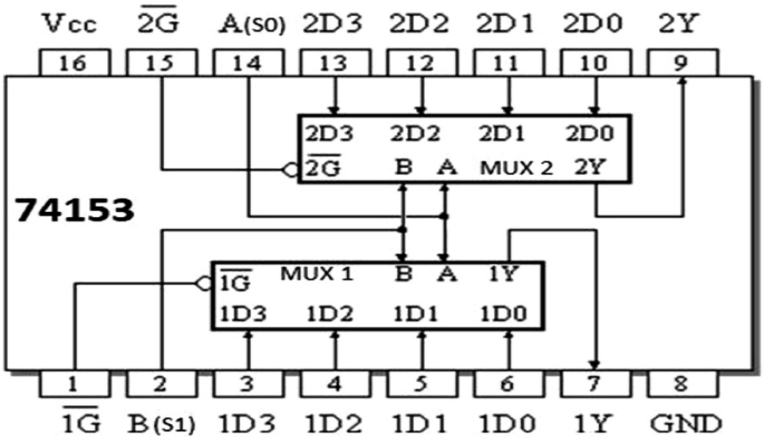
74HC74



74HC138



74HC153



74HC161

74HC/HCT161

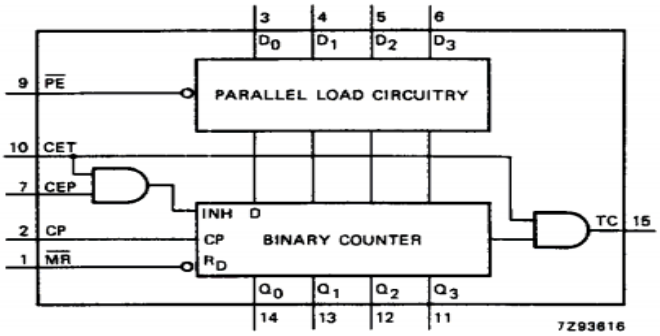
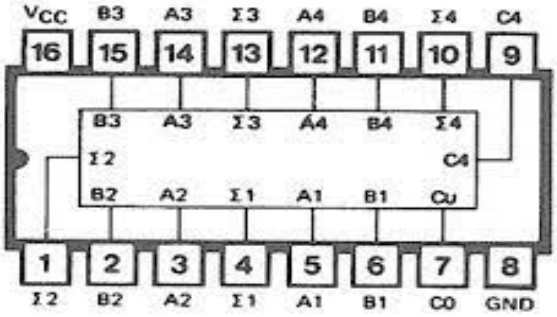


Fig.4 Functional diagram.

74HC283



74HC540