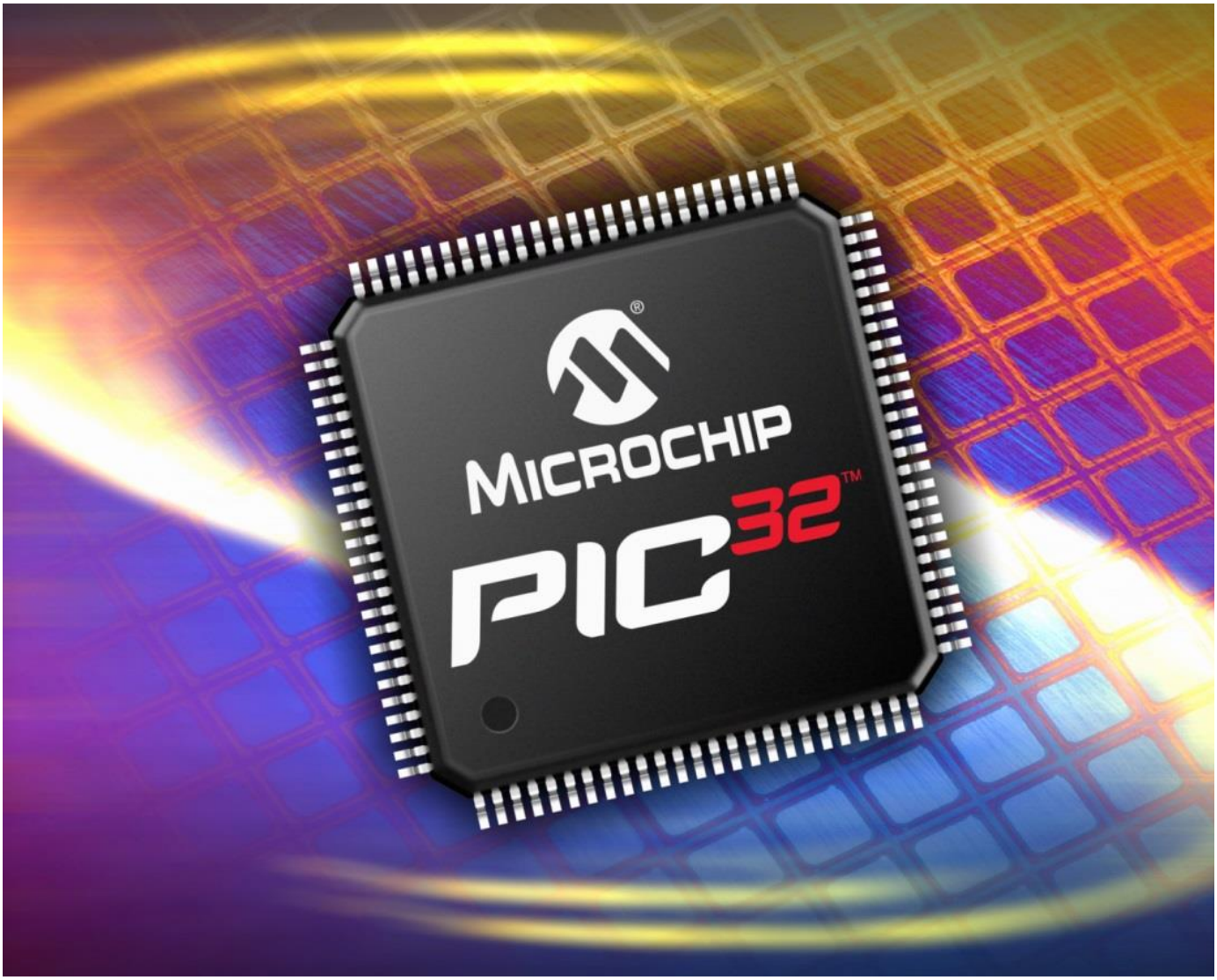

The Adventure Begins

With PIC^{32}

beti®

BETİ 32-bit PIC Trainer

Student Workbook

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Contents

Beti 32-bit PIC MCU Trainer

We implemented the PIC32MX795F512L as 32-bit MCU on our microboard. However PIC32MX5XX/6XX/7XX 32-bit MCU's have common technical specifications, that's why we tried to summarize these features. For further reading please use pdf document of Microchip's DS61156G.

1.2) High-Performance, USB, CAN and Ethernet 32-bit Flash Microcontrollers

High-Performance 32-bit RISC CPU:

- MIPS32® M4K® 32-bit core with 5-stage pipeline
- 80 MHz maximum frequency
- 1.56 DMIPS/MHz (Dhrystone 2.1) performance at zero Wait state Flash access
- Single-cycle multiply and high-performance divide unit
- MIPS16e™ mode for up to 40% smaller code size
- Two sets of 32 core register files (32-bit) to reduce interrupt latency
- Prefetch Cache module to speed execution from Flash

Microcontroller Features:

- Operating voltage range of 2.3V to 3.6V
- 64K to 512K Flash memory (plus an additional 12 KB of Boot Flash)
- 16K to 128K SRAM memory
- Pin-compatible with most PIC24/dsPIC® DSC devices
- Multiple power management modes
- Multiple interrupt vectors with individually programmable priority
- Fail-Safe Clock Monitor mode
- Configurable Watchdog Timer with on-chip Low-Power RC oscillator for reliable operation

Peripheral Features:

- Atomic SET, CLEAR and INVERT operation on select peripheral registers
- Up to 8-channels of hardware DMA with automatic data size detection

- USB 2.0-compliant full-speed device and On-The-Go (OTG) controller:
  - Dedicated DMA channels
- 10/100 Mbps Ethernet MAC with MII and RMII interface:
  - Dedicated DMA channels
- CAN module:
  - 2.0B Active with DeviceNet™ addressing support
  - Dedicated DMA channels
- 3 MHz to 25 MHz crystal oscillator
- Internal 8 MHz and 32 kHz oscillators
- Six UART modules with:
  - RS-232, RS-485 and LIN 1.2 support
  - IrDA® with on-chip hardware encoder and decoder
- Up to four SPI modules
- Up to five I2C™ modules
- Separate PLLs for CPU and USB clocks
- Parallel Master and Slave Port (PMP/PSP) with 8-bit and 16-bit data, and up to 16 address lines
- Hardware Real-Time Clock and Calendar (RTCC)
- Five 16-bit Timers/Counters (two 16-bit pairs combine to create two 32-bit timers)
- Five Capture inputs
- Five Compare/PWM outputs
- Five external interrupt pins
- High-speed I/O pins capable of toggling at up to 80 MHz
- High-current sink/source (18 mA/18 mA) on all I/O pins
- Configurable open-drain output on digital I/O pins

Debug Features:

- Two programming and debugging Interfaces:
  - 2-wire interface with unintrusive access and real-time data exchange with application
  - 4-wire MIPS® standard enhanced Joint Test Action Group (JTAG) interface
- Unintrusive hardware-based instruction trace

- IEEE Standard 1149.2 compatible (JTAG) boundary scan

Analog Features:

- Up to 16-channel, 10-bit Analog-to-Digital Converter:
  - 1 Msps conversion rate
  - Conversion available during Sleep and Idle
- Two Analog Comparators
- 5V tolerant input pins (digital pins only)

USB, Ethernet and CAN																	
Device	**Pins**	**Program Memory (KB)**	**Data Memory (KB)**	**USB**	**Ethernet**	**CAN**	**Timers/Capture/Compare**	**DMA Channels (Programmable/ Dedicated)**	**UART(2,3)**	**SPI(3)**	**I²C™(3)**	**10-bit 1 Msps ADC (Channels)**	**Comparators**	**PMP/PSP**	**JTAG**	**Trace**	**Packages(4)**
PIC32MX795F512L	100	512 + 12(1)	128	1	1	2	5/5/5	8/8	6	4	5	16	2	Yes	Yes	Yes	PT, PF, BG

Legend: PF, PT = TQFP MR = QFN BG = XBGA

Pin Diagrams (Continued)

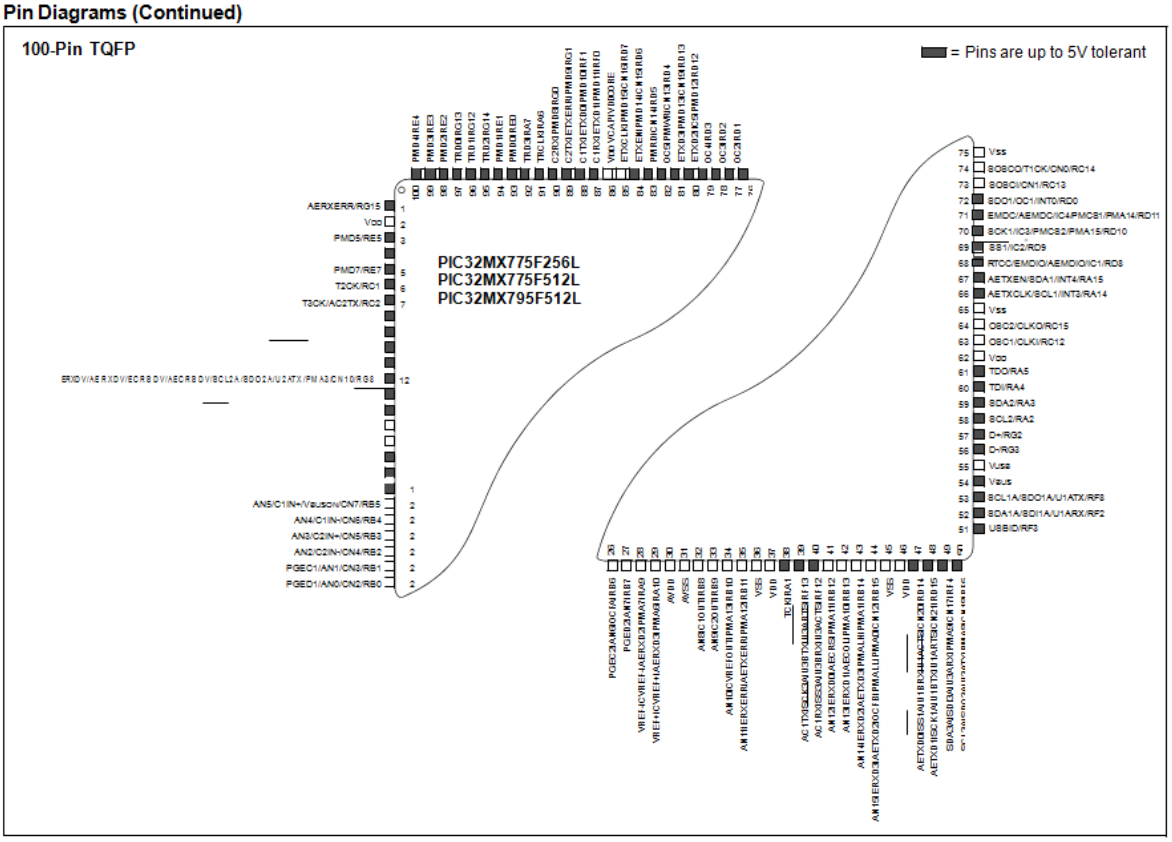

TABLE 1: PIN NAMES: PIC32MX775F256L, PIC32MX775F512L VE PIC32MX795F512L

TABLE 6: PIN NAMES: PIC32MX775F256L, PIC32MX775F512L AND PIC32MX795F512L DEVICES

Pin Number	Full Pin Name
A1	PMD4/RE4
A2	PMD3/RE3
A3	TRD0/RG13
A4	PMD0/RE0
A5	C2RX/PMD8/RG0
A6	C1TX/ETXD0/PMD10/RF1
A7	VDD
A8	VSS
A9	ETXD2/IC5/PMD12/RD12
A10	OC3/RD2
A11	OC2/RD1
B1	No Connect (NC)
B2	AERXERR/RG15
B3	PMD2/RE2
B4	PMD1/RE1
B5	TRD3/RA7
B6	C1RX/ETXD1/PMD11/RF0
B7	VCAP/VDDCORE
B8	PMRD/CN14/RD5
B9	OC4/RD3
B10	VSS
B11	SOSCO/T1CK/CN0/RC14
C1	PMD6/RE6
C2	VDD
C3	TRD1/RG12
C4	TRD2/RG14
C5	TRCLK/RA6
C6	No Connect (NC)
C7	ETXCLK/PMD15/CN16/RD7
C8	OC5/PMWR/CN13/RD4
C9	VDD
C10	SOSCI/CN1/RC13
C11	EMDC/AEMDC/IC4/PMCS1/PMA14/RD11
D1	T2CK/RC1
D2	PMD7/RE7
D3	PMD5/RE5
D4	VSS
D5	VSS
D6	No Connect (NC)
D7	ETXEN/PMD14/CN15/RD6
D8	ETXD3/PMD13/CN19/RD13
D9	SDO1/OC1/INT0/RD0
D10	No Connect (NC)
D11	SCK1/IC3/PMCS2/PMA15/RD10
E1	TSCK/SDI1/RC4
E2	T4CK/AC2RX/RC3
E3	SCL/SCK2A/U2BTX/U2ARTS/PMA5/CN8/RG6
E4	T3CK/AC2TX/RC2
E5	VDD
E6	C2TX/ETXERR/PMD9/RG1
E7	VSS

Pin Number	Full Pin Name
E8	AETXEN/SDA1/INT4/RA15
E9	RTCC/EMDIO/AEMDIO/IC1/RD8
E10	SS1/IC2/RD9
E11	AETXCLK/SCL1/INT3/RA14
F1	MCLR
F2	ERXDV/AERXDV/ECRSDV/AECRSDV/SCL2A/SDO2A/U2ATX/PMA3/CN10/RG8
F3	ERXCLK/AERXCLK/EREFCLK/AEREFCLK/SS2A/U2BRX/U2CTS/PMA2/CN11/RG9
F4	ECRS/SDA2A/SDI2A/U2ARX/PMA4/CN9/RG7
F5	VSS
F6	No Connect (NC)
F7	No Connect (NC)
F8	VDD
F9	OSC1/CLKI/RC12
F10	VSS
F11	OSC2/CLKO/RC15
G1	AERXD0/INT1/RE8
G2	AERXD1/INT2/RE9
G3	TMS/RA0
G4	No Connect (NC)
G5	VDD
G6	VSS
G7	VSS
G8	No Connect (NC)
G9	TDO/RA5
G10	SDA2/RA3
G11	TDI/RA4
H1	AN5/C1IN+/VBUSON/CN7/RB5
H2	AN4/C1IN-/CN6/RB4
H3	VSS
H4	VDD
H5	No Connect (NC)
H6	VDD
H7	No Connect (NC)
H8	VBUS
H9	VUSB
H10	D+/RG2
H11	SCL2/RA2
J1	AN3/C2IN+/CN5/RB3
J2	AN2/C2IN-/CN4/RB2
J3	PGED2/AN7/RB7
J4	AVDD
J5	AN11/ERXERR/AETXERR/PMA12/RB11
J6	TCK/RA1
J7	AN12/ERXD0/AECRS/PMA11/RB12
J8	No Connect (NC)
J9	No Connect (NC)
J10	SCL1A/SDO1A/U1ATX/RF8
J11	D-/RG3
K1	PGEC1/AN1/CN3/RB1
K2	PGED1/AN0/CN2/RB0
K3	VREF+/CVREF+/AERXD3/PMA6/RA10

TABLE 6: PIN NAMES: PIC32MX775F256L, PIC32MX775F512L AND PIC32MX795F512L DEVICES

Pin Number	Full Pin Name
K4	AN8/C1OUT/RB8
K5	No Connect (NC)
K6	AC1RX/SS3A/U3BRX/U3ACTS/RF12
K7	AN14/ERXD2/AETXD3/PMALH/PMA1/RB14
K8	VDD
K9	AETXD1/SCK1A/U1BTX/U1ARTS/CN21/RD15
K10	USBID/RF3
K11	SDA1A/SDI1A/U1ARX/RF2
L1	PGEC2/AN6/OCFA/RB6
L2	VREF+/CVREF+/AERXD2/PMA7/RA9
L3	AVDD
L4	AN9/C2OUT/RB9
L5	AN10/CVREFOUT/PMA13/RB10
L6	AC1TX/SCK3A/U3BTX/U3ARTS/RF13
L7	AN13/ERXD1/AECOL/PMA10/RB13
L8	AN15/ERXD3/AETXD2/OCFB/PMALL/PMA0/CN12/RB15
L9	AETXD0/SS1A/U1BRX/U1ACTS/CN20/RD14
L10	SDA3A/SDI3A/U3ARX/PMA9/CN17/RF4
L11	SCL3A/SDO3A/U3ATX/PMA8/CN18/RF5

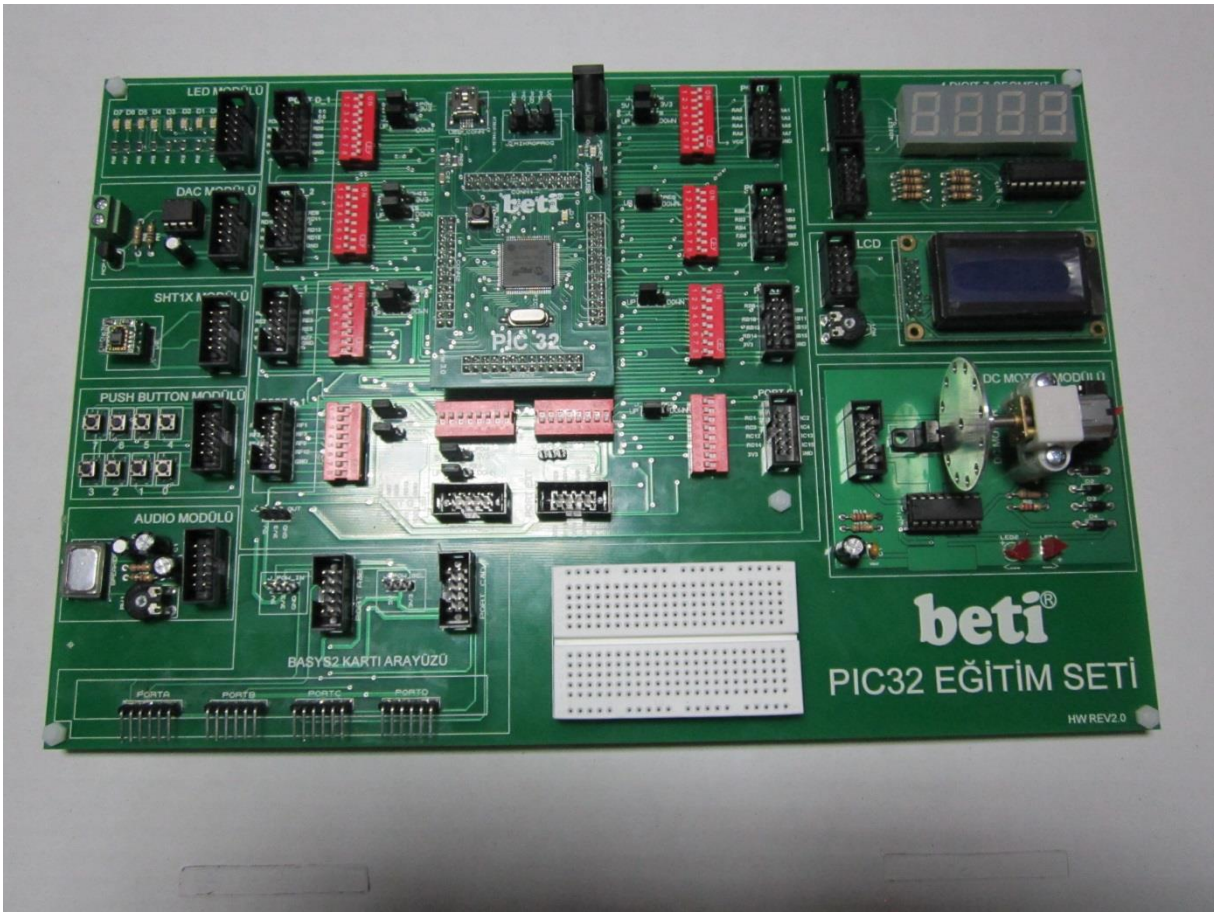

Fig.1 Beti 32-bit PIC trainer

2.1) The Topology and Technical Features of 32-bit PIC Trainer Set:

PIC32 Development Board is mainly designed to be used with the **BETI PIC32 microboard**.

Moreover, there are four 6-pin connectors at the bottom left of the PCB. That interface is completely compatible with the **BASYS2 FPGA board of Digilent Inc.**

In addition to that, **any other specific intelligent boards can be easily connected** to the development board with the help of that interface.

The development board supports different above mentioned architectures including FPGA and PIC32 MCUs.

Properties of the BETI PIC32 microboard:

- ✓ Microchip **PIC32MX795F512L** 32-bit MCU
- ✓ Comes with the **bootloader**
- ✓ **In circuit serial programming** connector
- ✓ On-Board **reset circuit**
- ✓ On-Board **crystal oscillator**
- ✓ Can be used as a **standalone** device
- ✓ Comes with **USB Cable**

The **8 on-board modules** give you chance to build your prototype **by saving your money and time.**

Overview of the on-board application modules:

- **8x LEDs,**
- **8x TAC Switches,**
- **2x8 Character LCD,**
- **4-Digit 7-Segment LED Display,**
- **DC Motor Encoder,**
- **Sht1x Temperature and Humidity Sensor,**
- **12-bit serial DAC module,**
- **Audio module.**

These on-board modules can be easily examined with the **example codes which are written in mikroC for PIC32 MCUs and VHDL for FPGAs.**

3.1) On-board application modules:

3.1.1) 8xLEDs

Purpose

1) To demonstrate 32-bit MCU IC; interfacing to an external LED display,

2) To provide an opportunity to write a number of output programs,

3) To show the students LED shift-right or shift-left with the help of MCU controlled; as well as various LED on times while shifting.

Materials Required

(1) Beti 32-bit PIC Trainer,
(1) on-board 8xLED Display module.

The first experiment is 8xLEDs, which are designed by SMD LEDs. By this experiment student are assigned to realize shifting of LED lights.

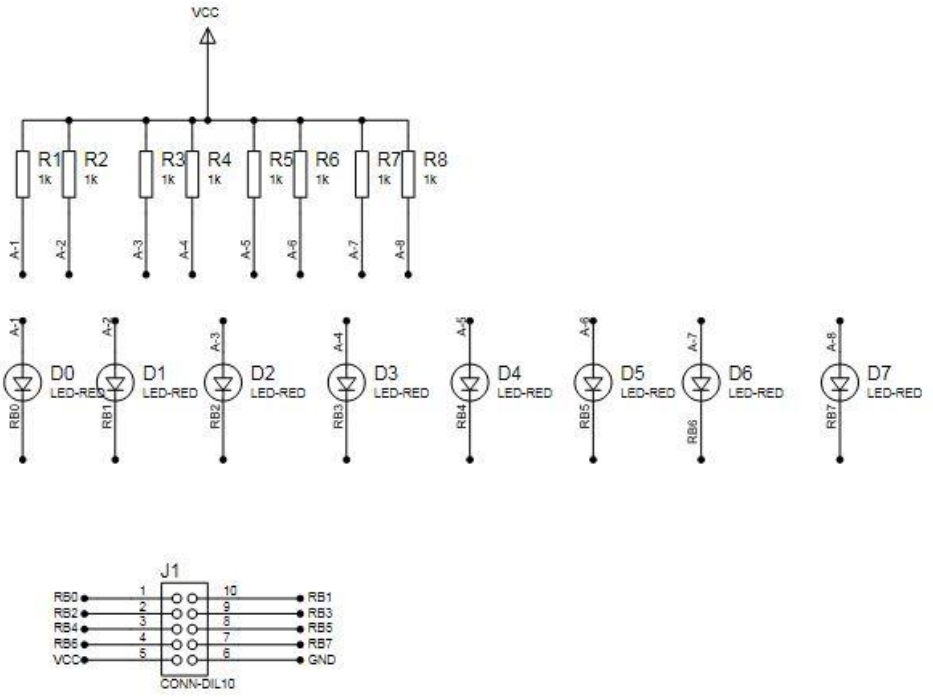

Fig.2 on-board 8xLED Display

3.1.2) DAC (Digital-to-Analog-Converter) Module

Purpose

1) By the help of Digital/Analog converter circuit (DAC) and 32-bit MCU IC; data communication is realized,

2) To show the students how to realize coding for Microchip's MCP4921; 12-bit Serial DAC IC and with the help of MCU/DAC interface to realize Digital/Analog conversions,

3) With the help of MCU controlled DAC; to develop Waveform Generation; ramp, triangular, square waveform generation.

Materials Required

(1) Beti 32-bit PIC Trainer,
(1) MCP4921; SPI DAC module,
(1) Oscilloscope.

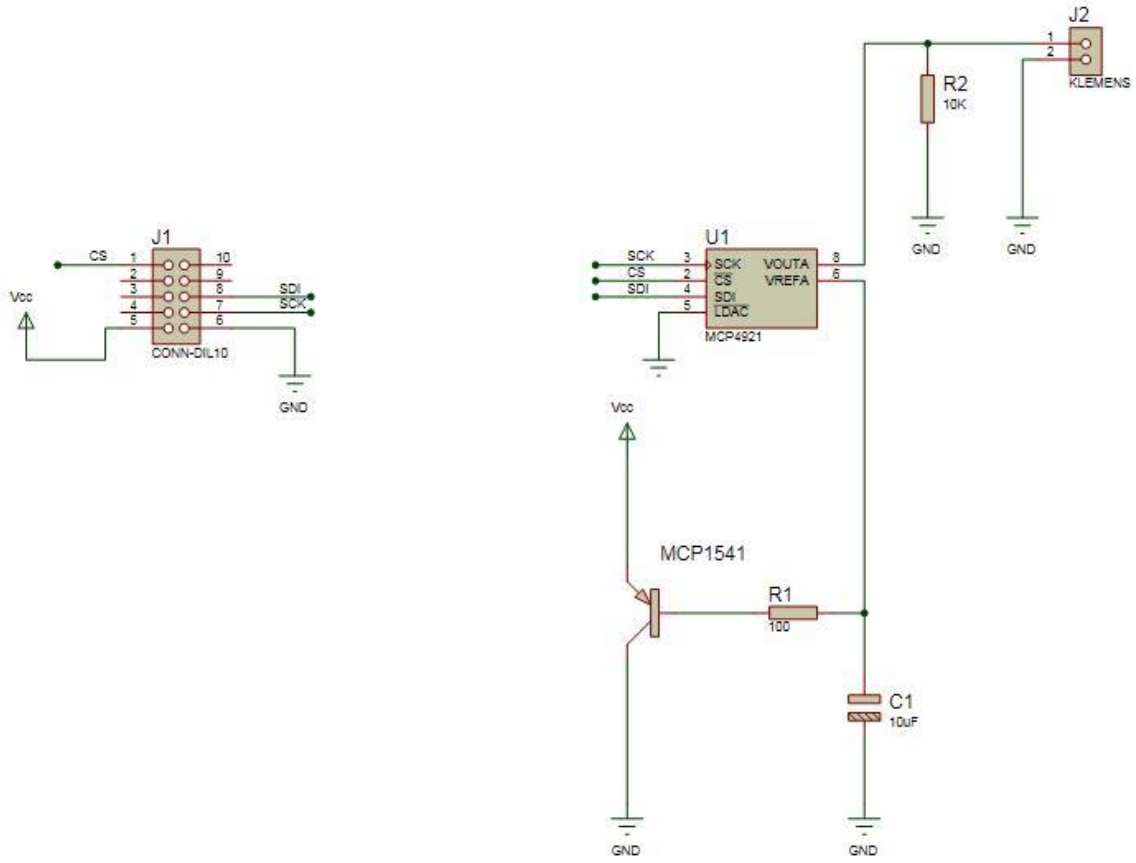

Fig.3 on-board 12-bit serial DAC

3.1.3) SHT1x Humidity and Temperature Sensor

Purpose

1) To know more closely Sensiron company product IC type Humidity and Temperature Sensor ,
2) With the help of on-board SHT1x Humidity and Temperature Sensor to demonstrate with 32-bit PIC Trainer how to measure ambient temperature and humidity,
3) To show the students how to display on 8-character LCD continuously measured ambient Humidity and Temperature.

Materials Required

(1) Beti 32-bit PIC Trainer,
(2) SHT1x Humidity and Temperature Sensor .

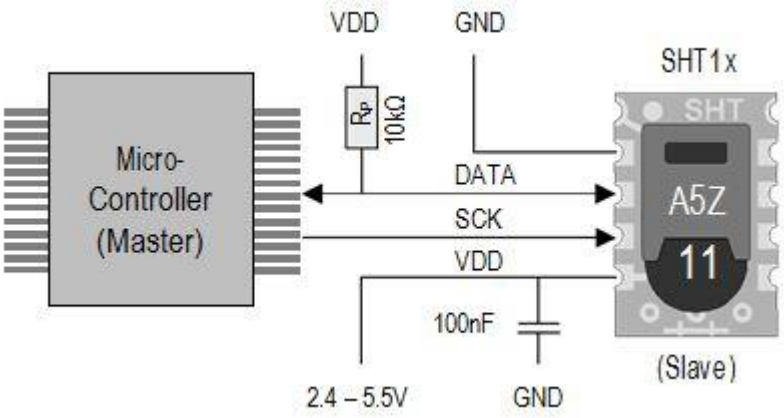

Fig.4 on-board SHT1x Block Diagram

Interfacing of SHT1x to 32-bit PIC Trainer is realized with a similar Serial Interface to I2C which is by interfacing and timing signals very good explained in SHT1x Datasheet pdf, Version 4.0-July 2008.

Pin	Name	Comment
1	GND	Ground
2	DATA	Serial Data, bidirectional
3	SCK	Serial Clock, input only
4	VDD	Source Voltage
NC	NC	Must be left unconnected

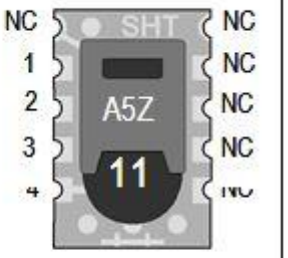

Table 1: SHT1x pin assignment, NC remain floating.

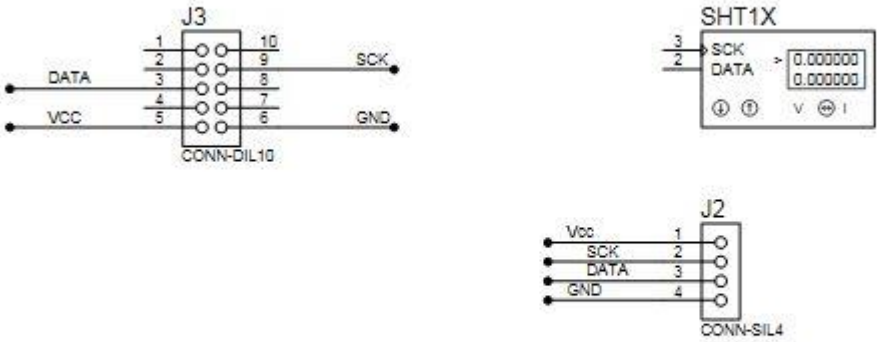

Fig.5 on-board SHT1x Interfacing to 32-bit PIC Trainer

3.1.4) 8xTAC Switches

Purpose

1) To demonstrate 32-bit MCU IC; interfacing to an external input 8xTAC switches,
2) To provide an opportunity to write a number of input programs,
3) To show the students writing codes for various input functions; like switch controlled LEDs or switch controlled songs.

Materials Required

(1) Beti 32-bit PIC Trainer,
(1) on-board 8xTAC Switch module.

The fourth experiment is 8xTAC switches, which are also designed by SMD. By this experiment student are assigned to realize several input functions.

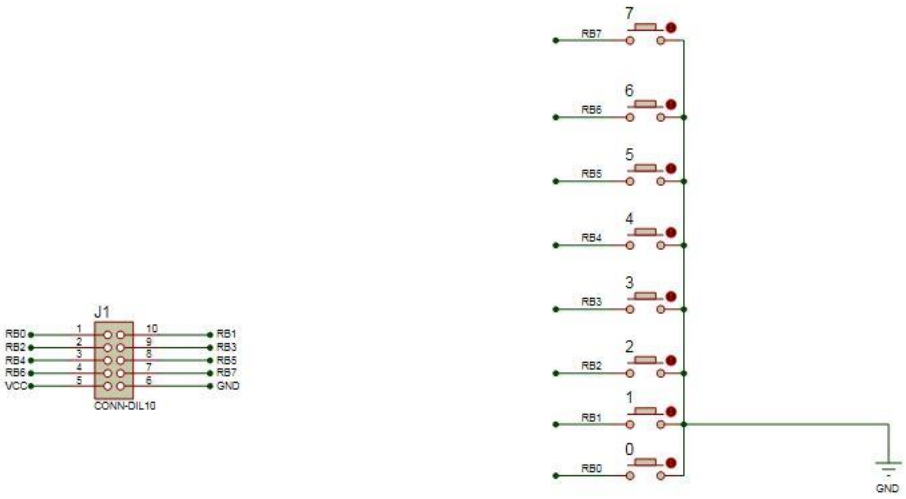

Fig.6 on-board 8x TAC switch Interfacing to 32-bit PIC Trainer

3.1.5) Audio Module

Purpose

1) To know more closely LM386 Audio Amplifier IC ,
2) With the help of on-board Audio Module to demonstrate with 32-bit PIC Trainer how to create audio music,
3) To show the students how to display different audio songs with the help of 8xTAC switches.

Materials Required

(1) Beti 32-bit PIC Trainer,
(2) Audio Module .

The LM386 is an audio amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200. We used gain 20, and a very special speaker 8 Ohm, 300Hz~20 kHz, with the dimesions 15.00mm L x 11.00mm W; produced by Knowles Company; with Digikey Part No: 423-1171-ND.

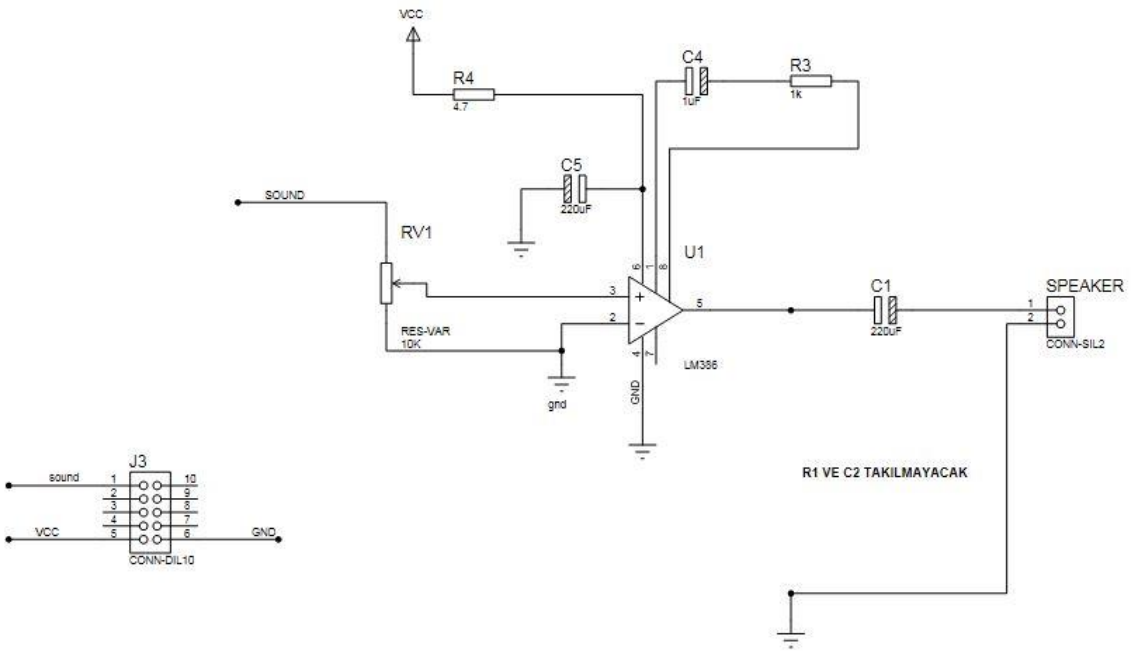

Fig.7 on-board Audio Module interfaced to the BETİ 32-bit PIC Trainer

3.1.6) 4-Digit 7-Segment Display

Purpose

1) To show the students how to multiplex 4-digit 7-segment LED Display to the 32-bit PIC Trainer ,
2) To show how different refresh rates effect the display, demonstrate the effect of using different display on times.

Materials Required

(1) Beti 32-bit PIC Trainer,
(2) 4-digit 7-Segment Display.

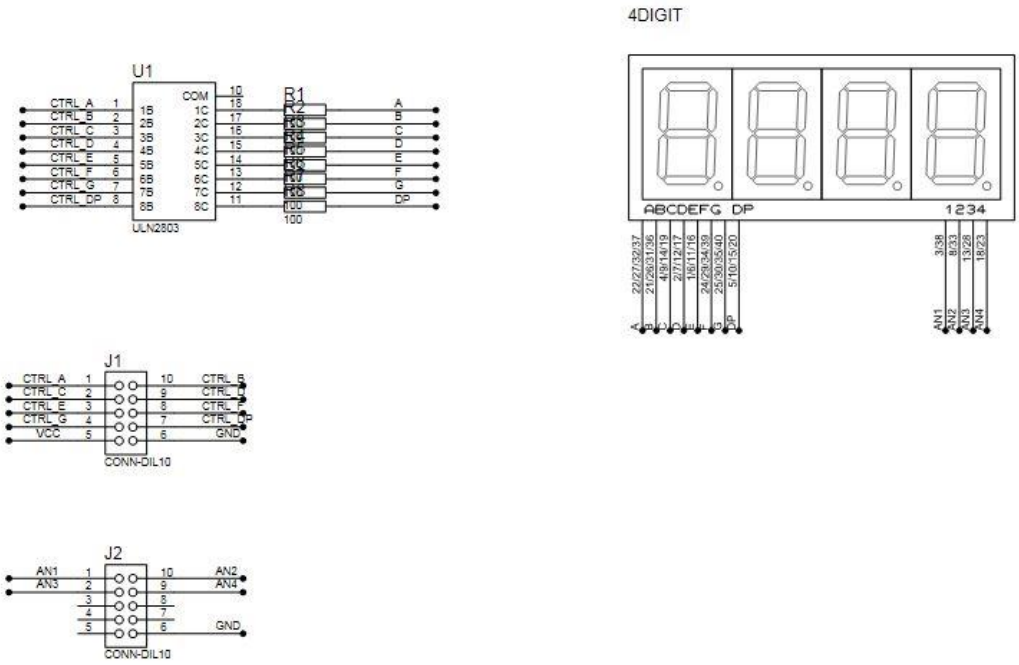

Fig.8 on-board 4-Digit 7-Segment LED Display module interfaced to the BETİ 32-bit PIC Trainer

3.1.7) 8-character LCD Display

Purpose

1) To show the students how to multiplex 4-digit 7-segment LED Display to the 32-bit PIC Trainer ,
2) To show how different refresh rates effect the display, demonstrate the effect of using different display on times.

Materials Required

(1) Beti 32-bit PIC Trainer,
(2) 8-Character LCD Display.

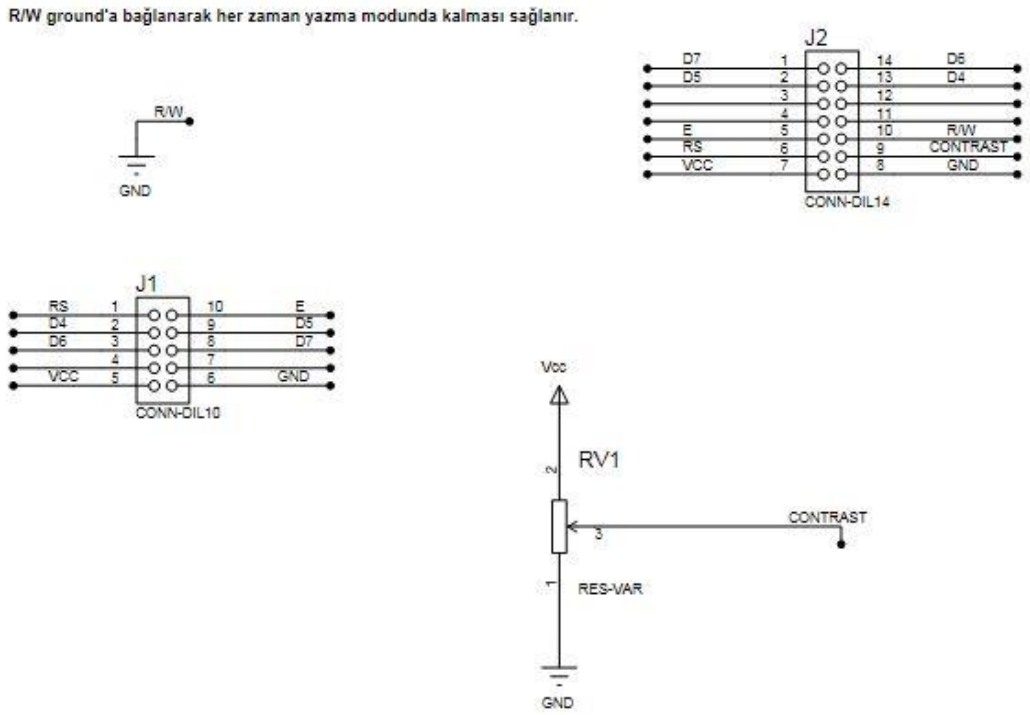

Fig.9 on-board 8-Character LCD Display module interfaced to the BETİ 32-bit PIC Trainer

3.1.8) DC Motor-Encoder

Purpose

1) To exhibit the construction of a DC Motor speed control circuit and measure motor speed using a 32-bit PIC MCU controlled optical-interrupter circuit ,
2) To show the calculation of motor rpm from motor speed data provided by the Beti 32-bit PIC MCU Trainer.

Materials Required

(1) Beti 32-bit PIC Trainer,
(2) DC Motor-Encoder.

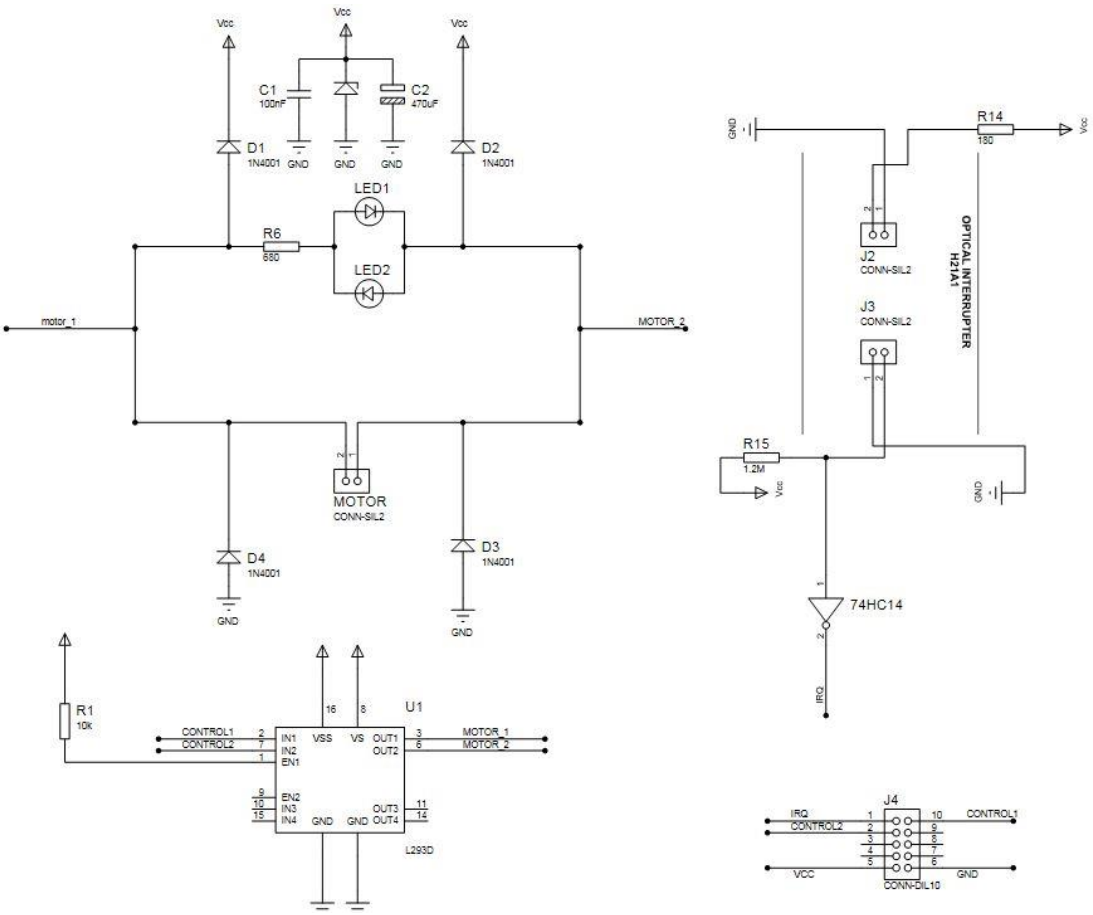

Fig.10 on-board DC Motor-Encoder Module interfaced to the BETİ 32-bit PIC Trainer

3.1.9) Digilent Basys2 FPGA Card Interface

Purpose

1) To realize the communication with the Basys2 FPGA card and 32-bit PIC MCU ,
2) To show the students how FPGA card I/O can be interfaced to the Beti 32-bit PIC MCU and vice versa.

Materials Required

(1) Beti 32-bit PIC Trainer,
(2) Digilent Basys2 FPGA Card Interface.

There are four 6-pin connectors at the bottom left of the PCB. That interface is completely compatible with the **BASYS2 FPGA board of Digilent Inc.**

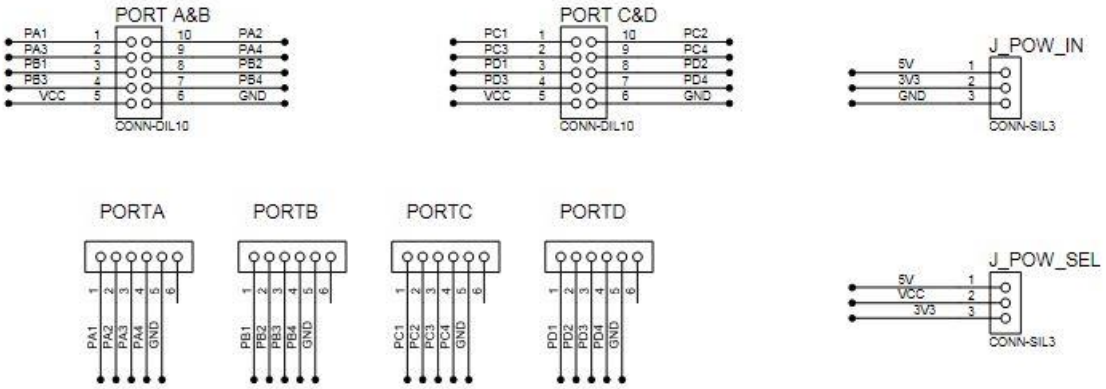

Fig.11 on-board Digilent Basys2 FPGA Card Module interfaced to the BETİ 32-bit PIC Trainer

4.1) Additional Circuitry related to Beti PIC-32 microboard, pull-up's and ports used:

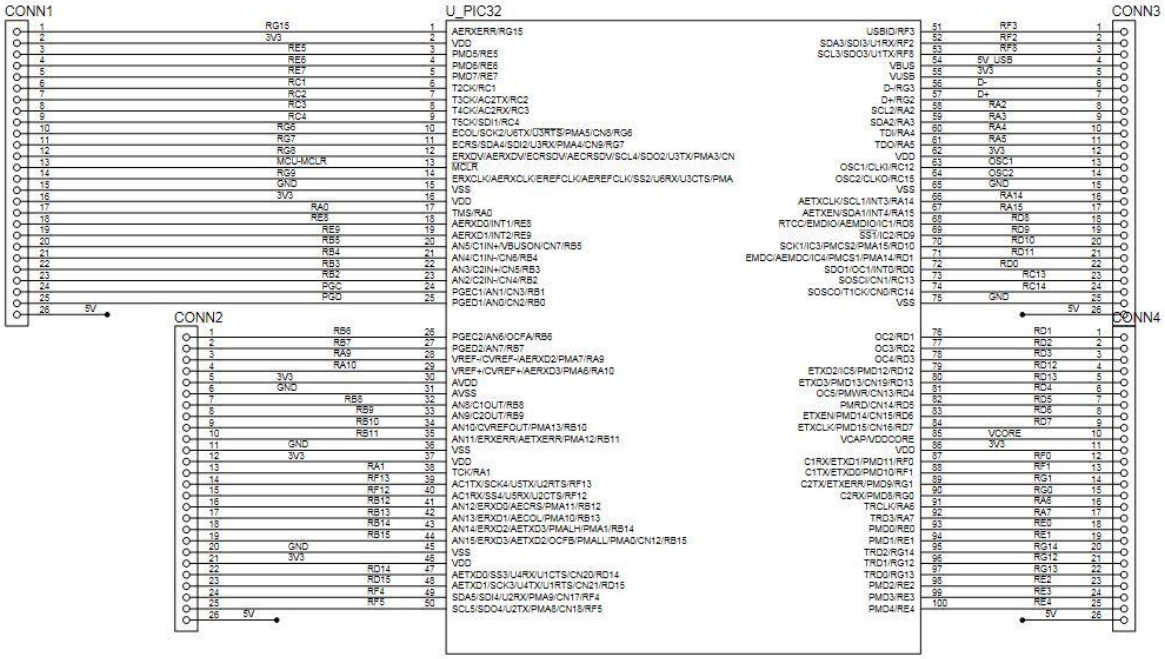

Fig.12 microboard of the BETİ 32-bit PIC Trainer

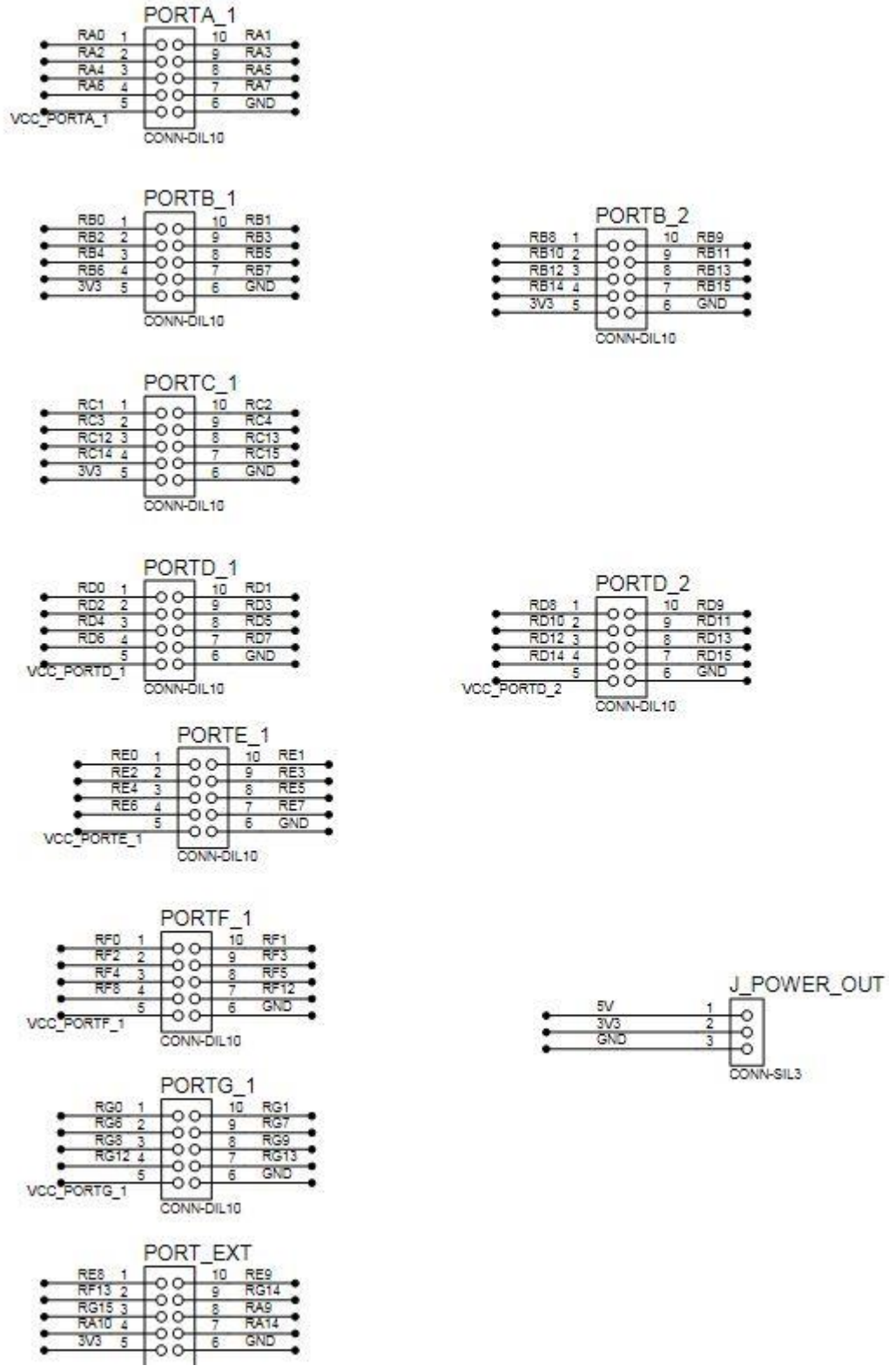

Fig.13 Port’s used in the BETİ 32-bit PIC Trainer

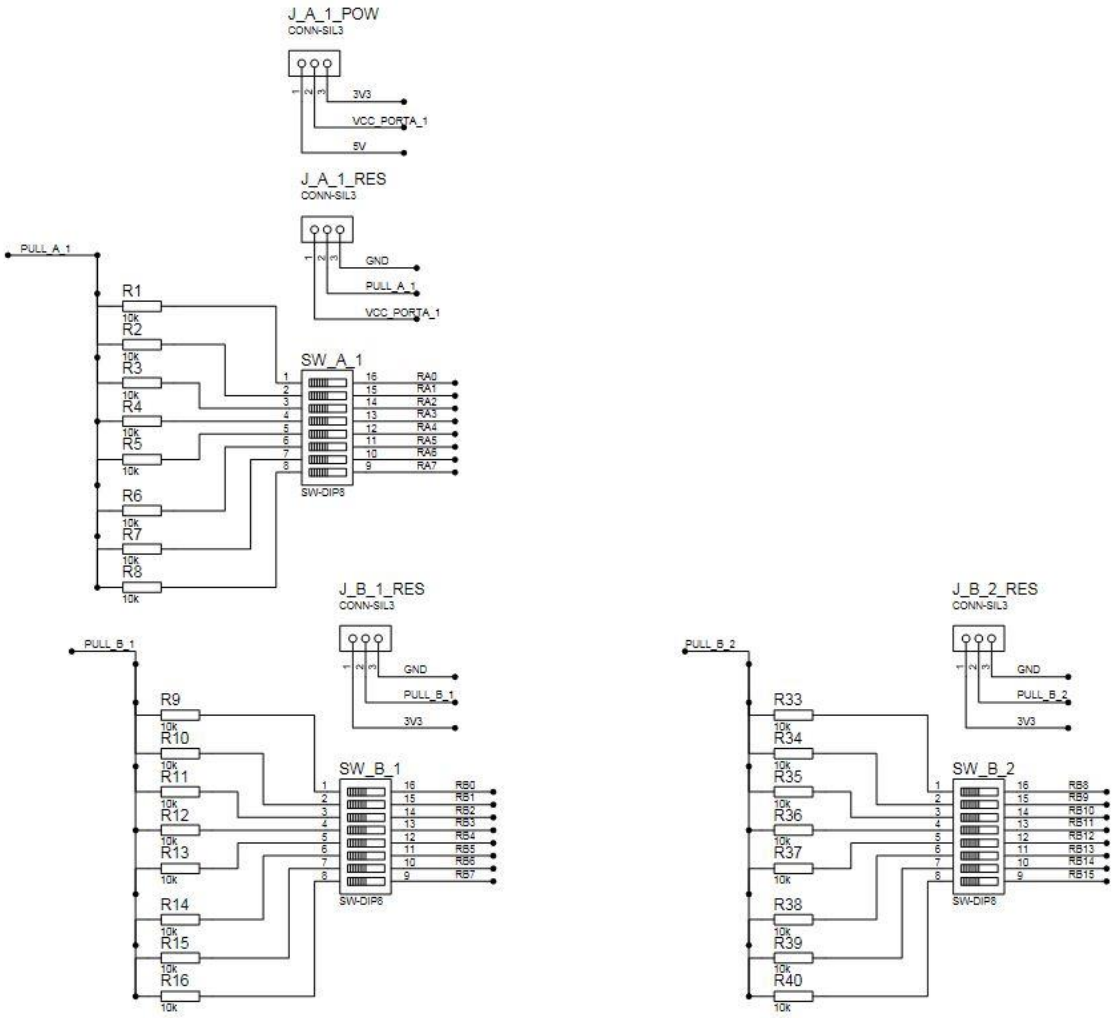

Fig.14 Port pull-up's&pull-down's used in the motherboard of the BETİ 32-bit PIC Trainer

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