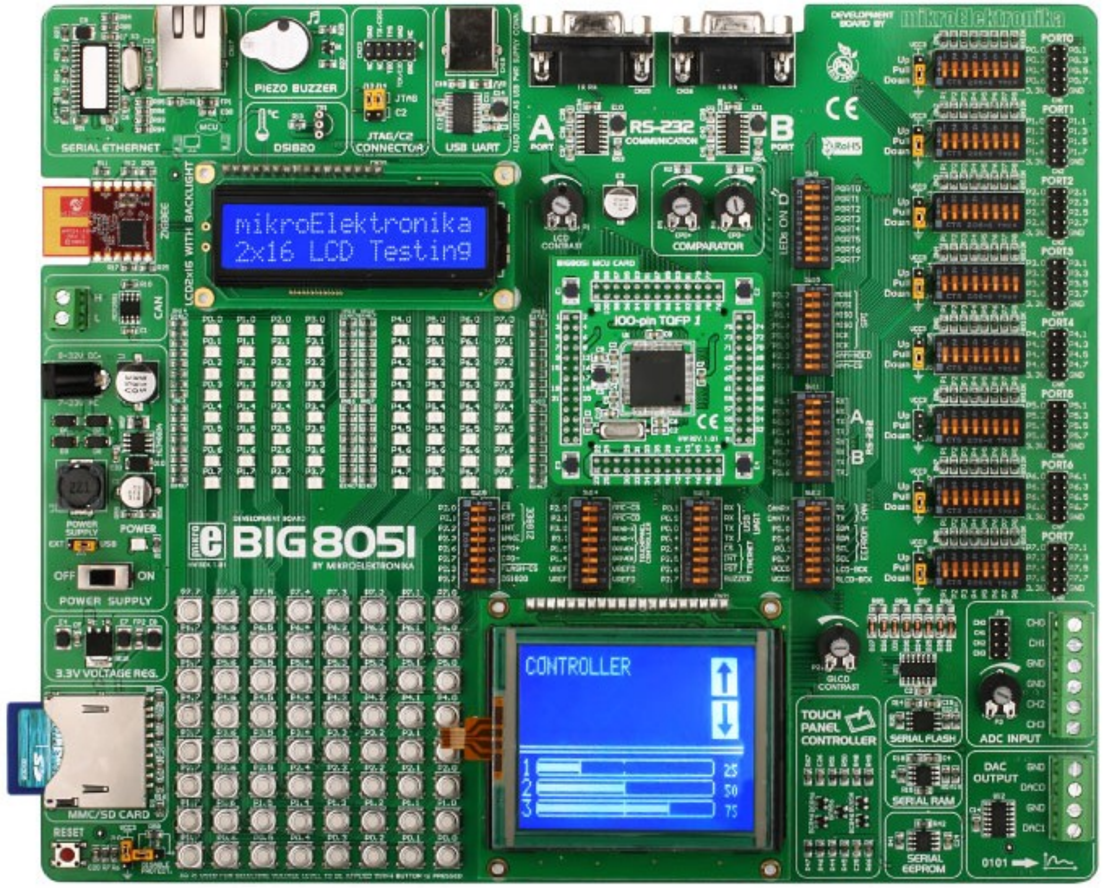
User Manual



BIG 8051

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Added resources from the works of: James Kelly and David Cain, Computer Engineering Elizabethtown College

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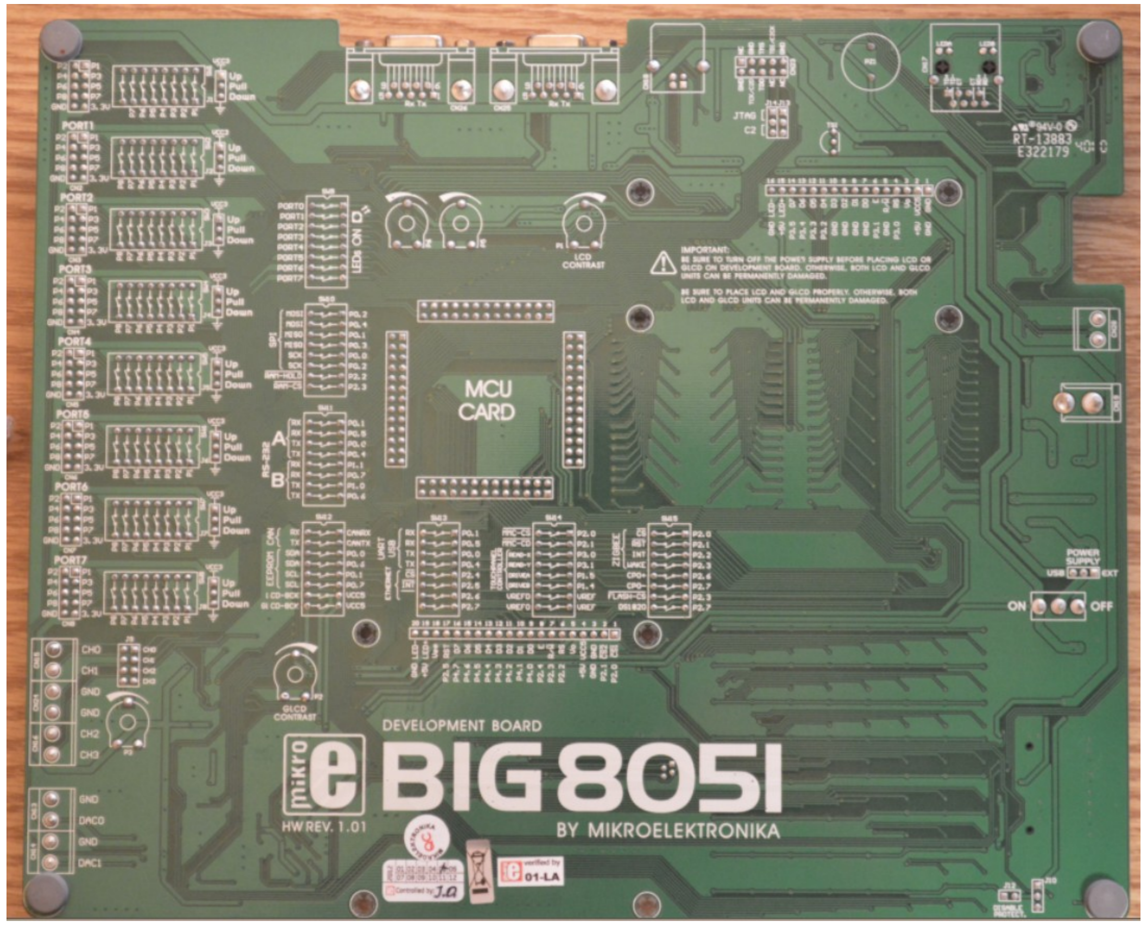
General information

The BIG 8051 development system provides a development environment for programming and experimenting with 8051 microcontrollers.

Inside the box

- Development System: BIG8051
- CD: Product CD
- USB Cable
- 128x64 graphic LCD display
- 2x16 alphanumeric LCD display
- Piezo buzzer
- CAN
- ZigBee



Back of BIG8051 development system

System Specification

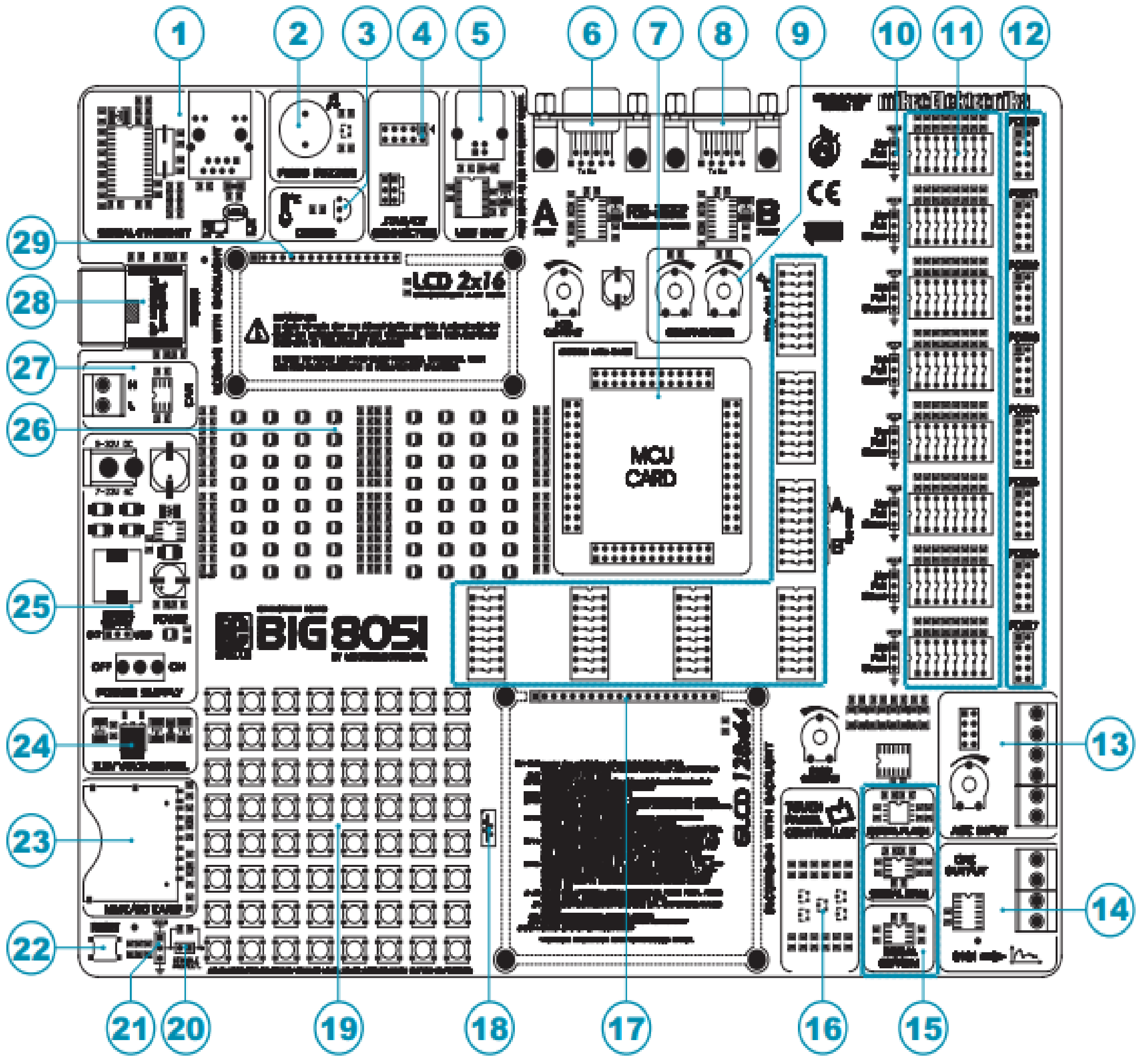
- **Power Supply:** over AC/DC connector / USB Cable (5V DC)
- **Power Consumption:** 50mA (with all modules off)
- **Dimensions:** 26.5 x 22 cm
- **Weight:** 420g

Features

- Full-featured development system for 8051
- Analog to digital conversion of voltage signal
- CAN communication module

Key Features

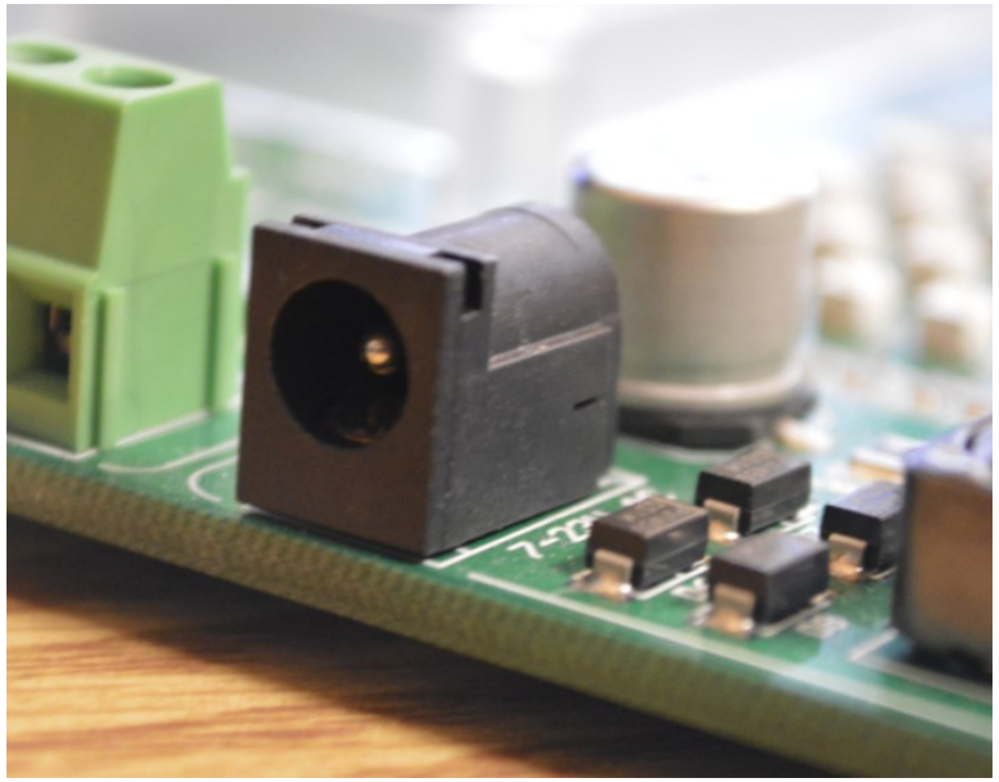
1. Ethernet module
2. Piezo buzzer
3. Connector for temperature sensor
4. Connector for programmer
5. USB UART module (USB power supply connector)
6. RS-232B module
7. Connector for MCU card
8. RS232B module
9. Comparator
10. Jumpers used to select pull-up/pull-down resistors
11. DIP switches used to turn on pull-up/pull-down resistors
12. I/O ports
13. A/D converter inputs
14. D/A converter outputs
15. Memory modules
16. Touch panel controller
17. Connector for GLCD display
18. Connector for touch panel
19. Push buttons
20. Jumper used to shorten protective resistor
21. Jumper used to select push buttons' logic state
22. Reset button
23. Connector for MMC/SD cards
24. 3.3 V voltage regulator
25. Power supply module
26. LEDs
27. CAN module
28. ZigBee module
29. Connector for LCD display



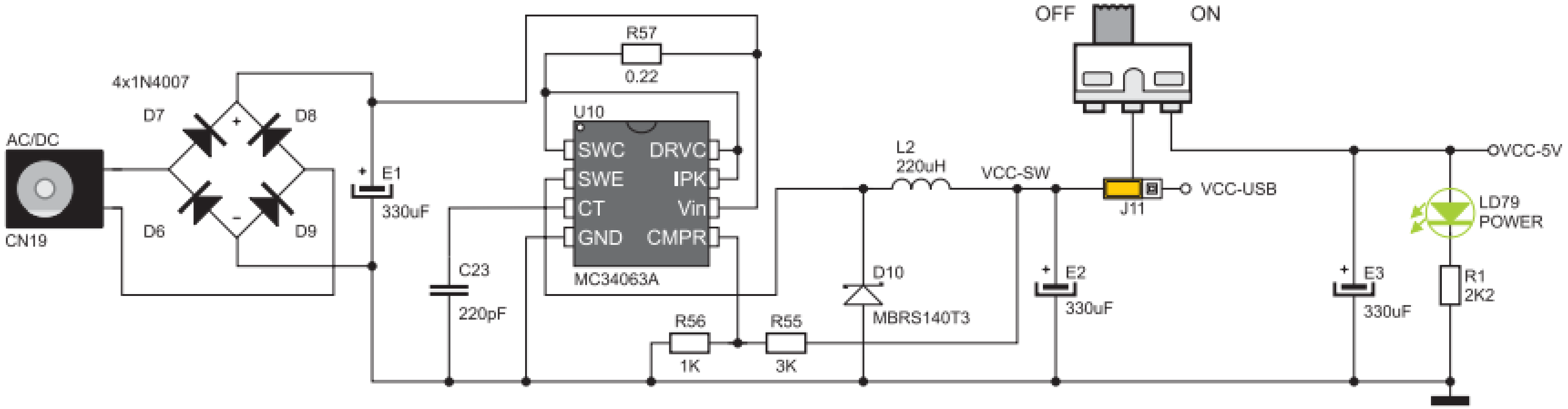
BIG8051 Board overview[1]

Connecting to power supply

To power the development system on, we have to provide power supply voltage over AC/DC connector CN18. Before you turn the system on, it is necessary to place jumper J11 in the EXT position. Next, set the switch marked POWER SUPPLY to the ON position. As soon as the development system now powers on, a green LED labelled POWER will automatically illuminate.



Power Supply connector



Power supply module connections schematic

C8051F040 microcontroller

The BIG8051 system has a 100-pin microcontroller C8051F040 in TQFP package. Today over fifty companies produce variations of the 8051. Several of these companies have over fifty variations of this system. To bring things into context, over 100 million 8051's are sold each year. Our microcontroller appears to be soldered on the MCU card.

Originally, 8051 belongs to the MCS-51 family of microcontrollers. MCS-51 was developed by Intel but other manufacturers are second sources of this family. The MCS-51, now commonly referred to as the 8051 is a Harvard architecture, consisting of physically separate storage and signal pathways for instructions and data. Today, most processors implement such separate signal pathways for performance reasons. The original MCS-51 featured 8-bit ALU, registers, and data busses. The following table shows the features of the MCS-51 and the BIG8051:

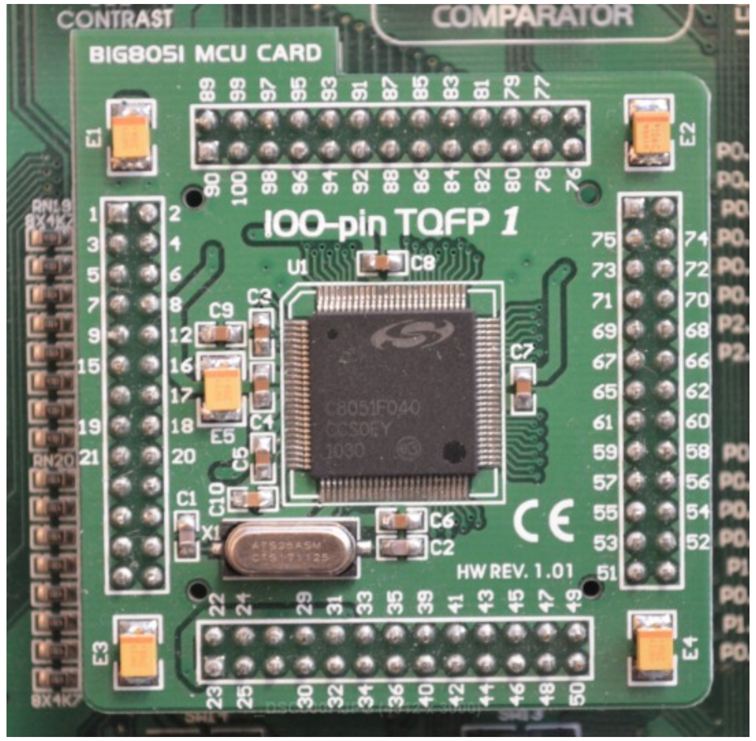
MCS-51

- 4K bytes internal ROM
- 128 bytes internal RAM
- Four 8-bit I/O ports
- Two 16-bit timers
- Serial interface
- 64K external code memory space
- 64K external data memory space
- 210 bit-addressable locations

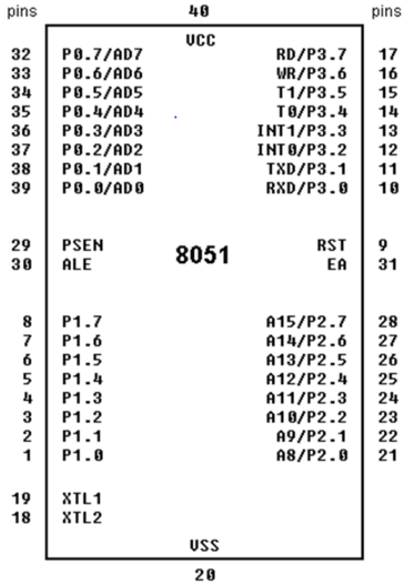
BIG8051

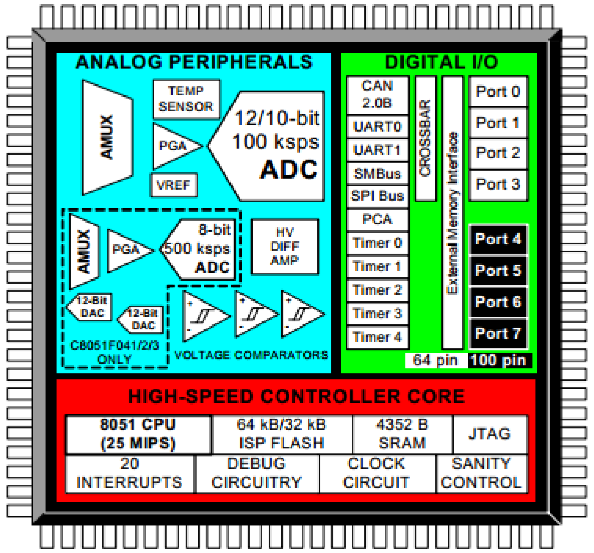
- Pipelined instruction architecture executes 70% of instruction set in 1 or 2 system clocks
- Up to 25 MIPS throughout with 25MHz clock
- 4352 bytes internal RAM
- 64kB Flash; in-system programmable 512-byte sectors
- BOSCH Controller Area Network (CAN 2.0B), hardware SMBus™ (I2C™ Compatible), SPI™, and two UART serial ports available concurrently
- Internal calibrated programmable oscillator: 3 to 24.5 MHz; etc.

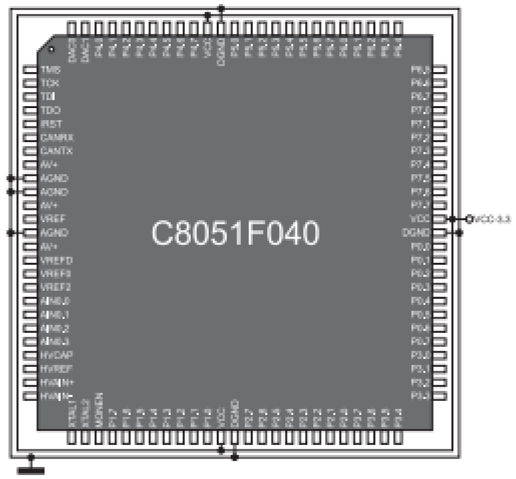
The microcontroller can be replaced with another one if desired, but it is important to make sure that they are compatible with the pinouts. "1-wire serial communication enables data to be transferred over one single communication line, while the process itself is under control of the *master* microcontroller. The advantage of this communication is that only one microcontroller pin is used. All *slave* devices have unique ID code, which enables the *master* device to easily identify all devices sharing the same communication bus



Microcontroller 8051F040





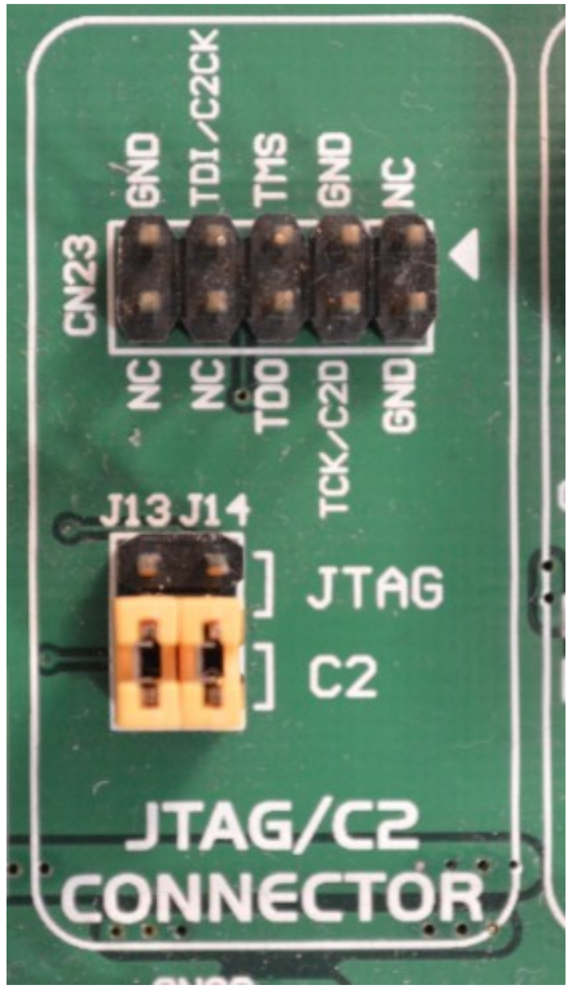


Pinout [3]

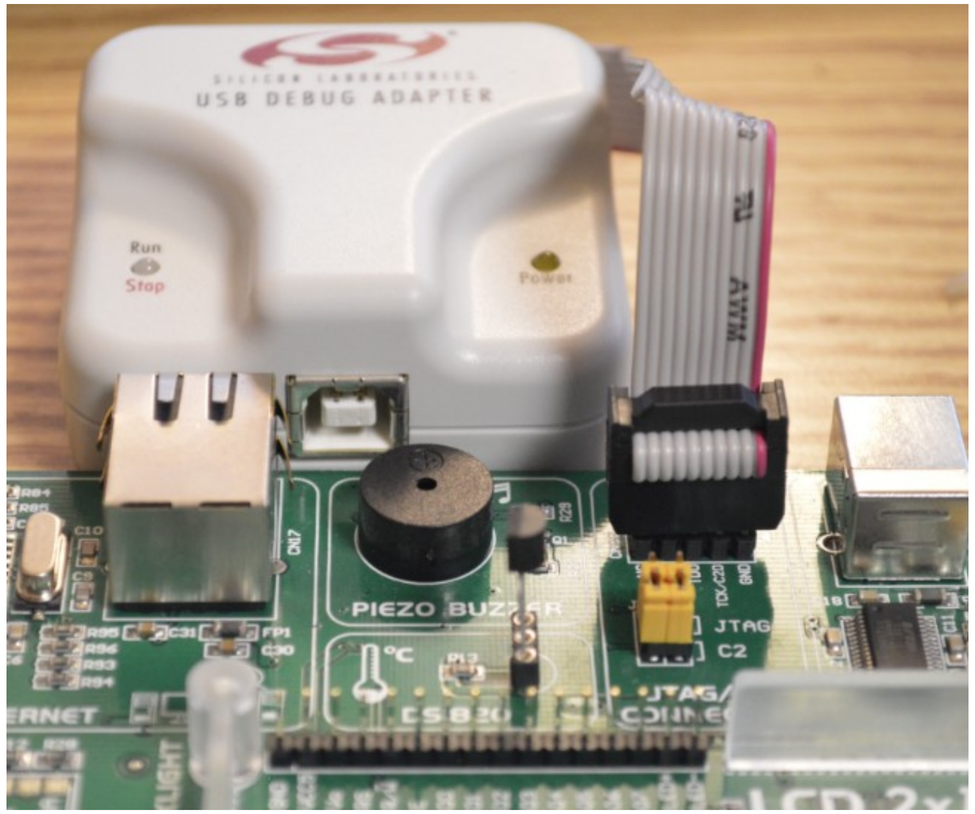
Programming microcontroller

The C8051F040 microcontroller must be programmed using a USB DEBUG ADAPTER which is provided with the box. It is always a good practice to make sure that the power is turned on, the USB DEBUG ADAPTER is connected to the development system through the cable as shown(CN23).

JTAG programmer USB DEBUG ADAPTER



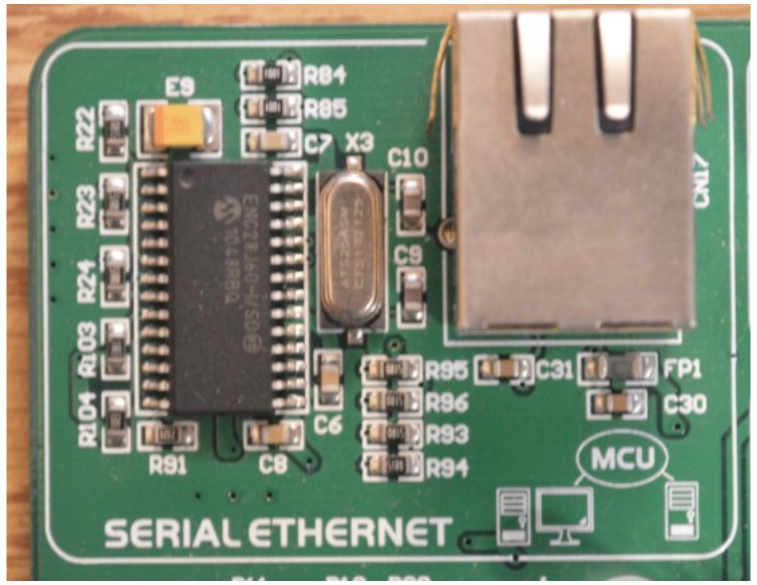
Connector for programmer



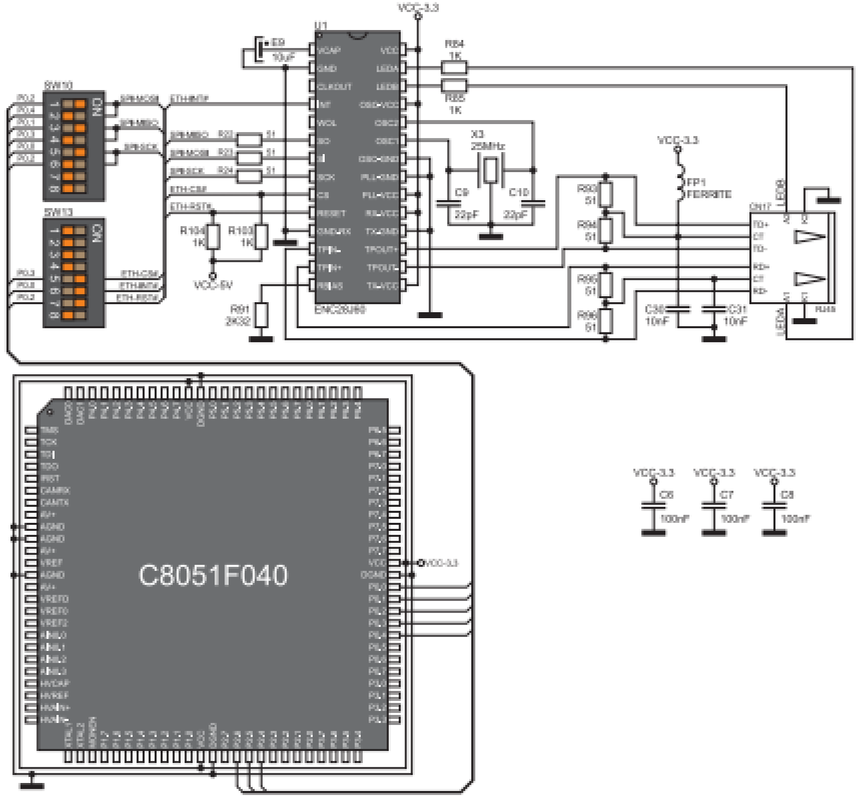
Connecting JTAG Programmer

Ethernet module

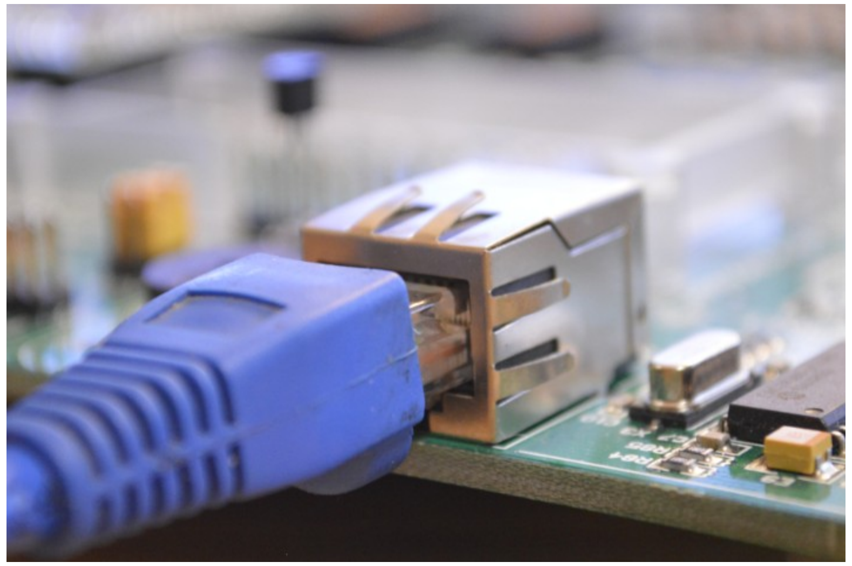
The Ethernet module lets us access the LAN network via the connector (RJ45). Using Serial Peripheral Interface, this module can communicate with the microcontroller.



Ethernet module



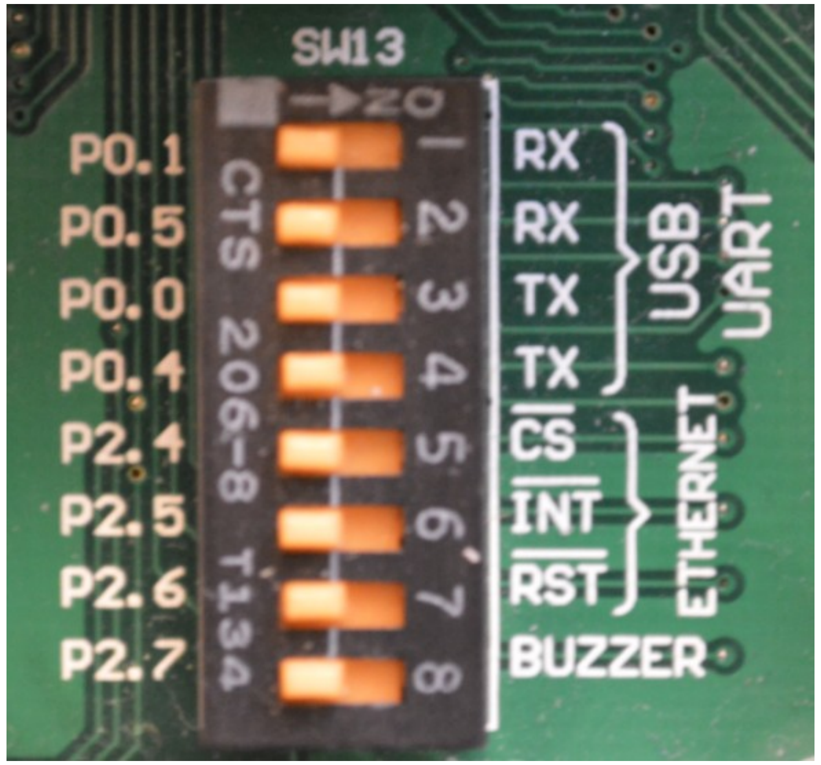
Ethernet module connection schematic [4]



Connecting Ethernet cable

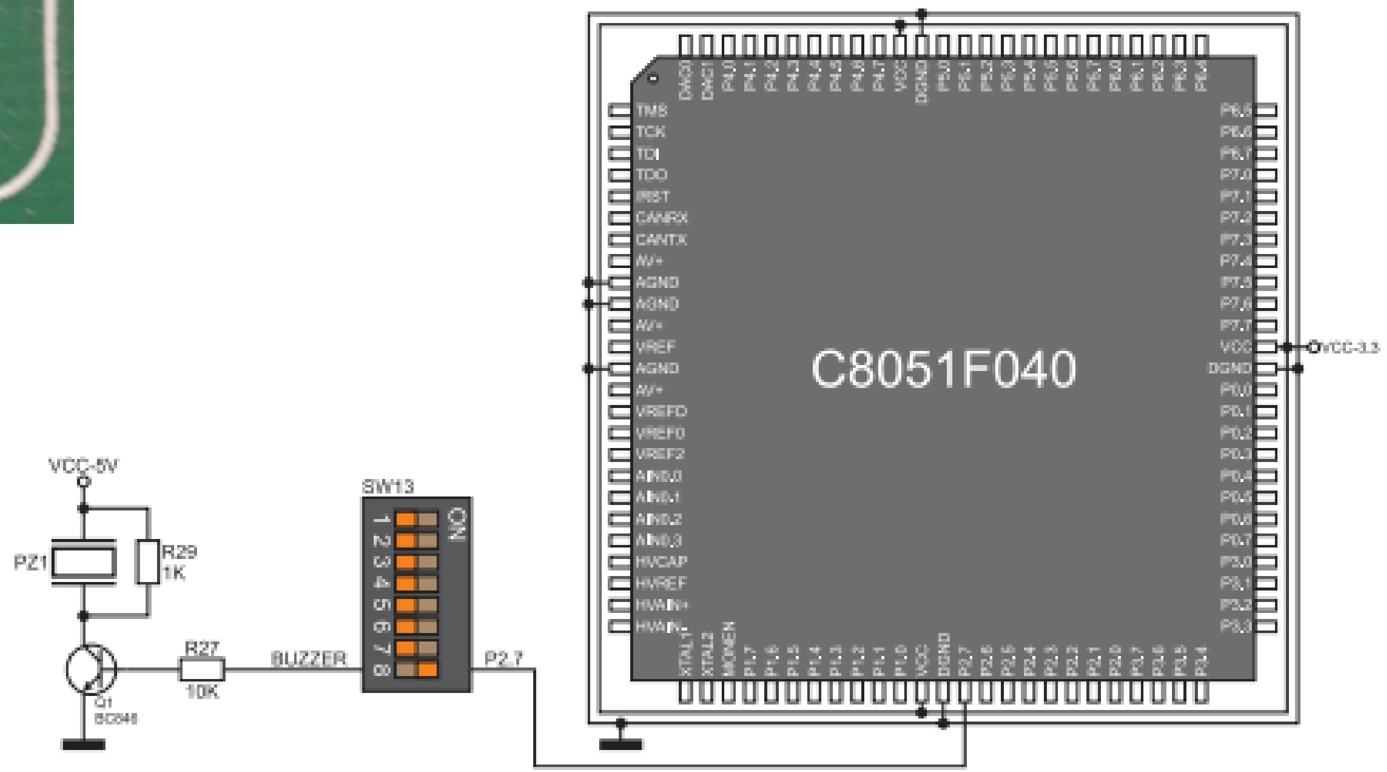
Piezo Buzzer

Piezo buzzers are used for making beeps, tones, and alerts. To use, one pin has to be connected to the ground (in schematic) and the other pin to a square wave out from a timer or microcontroller. For the loudest tones, stay around 4KHz. This buzzer gives the BIG8051 development system the ability to emit audio signals. Best performance for our Piezo buzzer can be achieved with frequencies between 2KHz and 4KHz. To make a connection between the piezo buzzer and the microcontroller, it is necessary to set switch 8 on the DIP switch SW13 to the ON position . The figure currently shows it in off position.



Piezo buzzer connected to the microcontroller

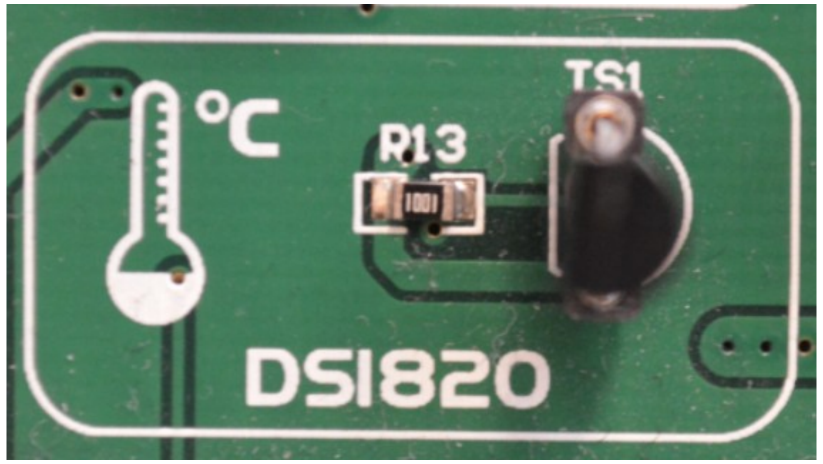
Piezo buzzer



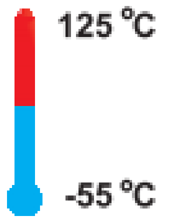
Piezo buzzer and connection schematic [5]

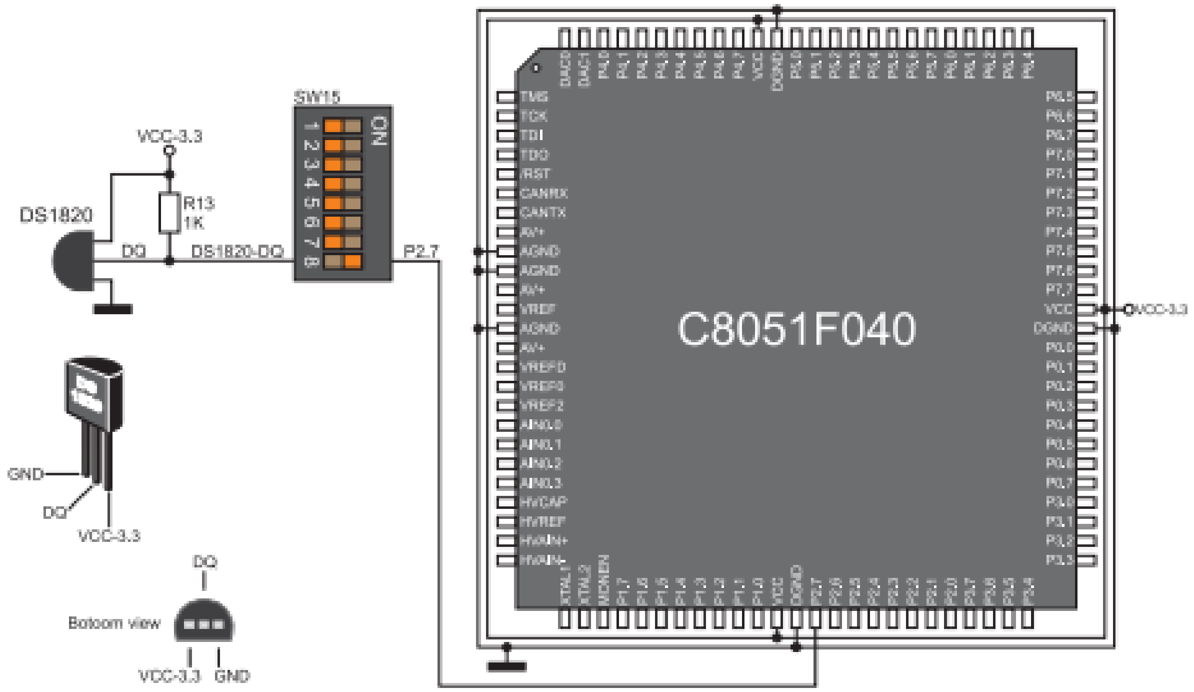
Temperature sensor

Our BIG8051 development system comes with a DS1820 temperature sensor that uses 1-wire communication as mentioned earlier. It can be used to measure temperature in the range between –55 degrees Celsius to 125 degree Celsius with an accuracy of +/-0.5 degrees Celsius. The sensor can convert temperature with 9-bit resolution and takes a maximum of 750ms. The communication between this module and the microcontroller is achieved via pin P2.7 as shown in the diagram. To establish a connection between them, it is necessary to set switch 8 on the DIP switch SW15 to the ON position.

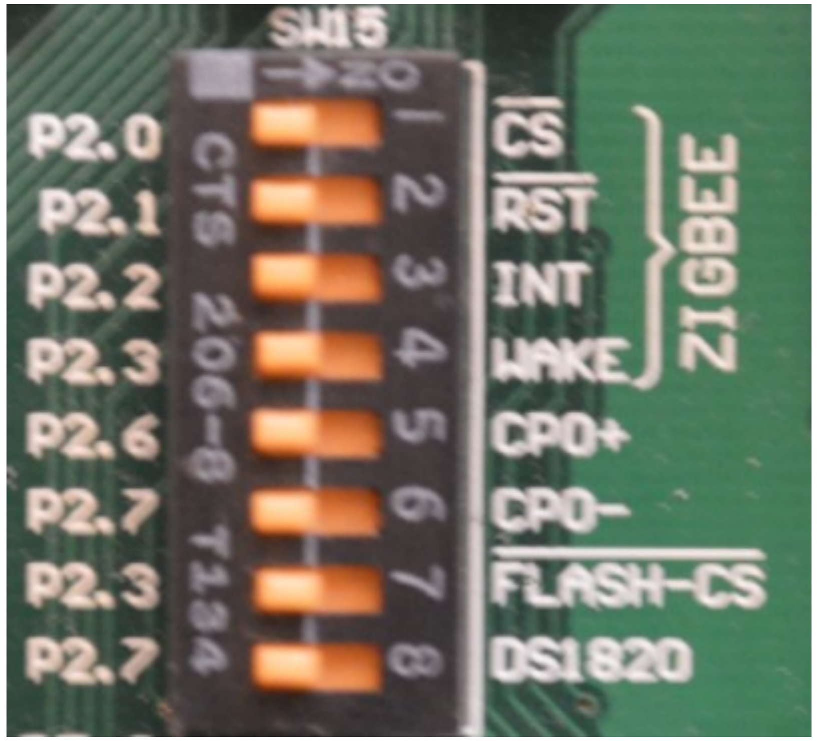


DS1820 temperature sensor connected. Make sure that the rounded side of the DS1820 matches the half circle on board





DS1820 and microcontroller connection schematic [6]

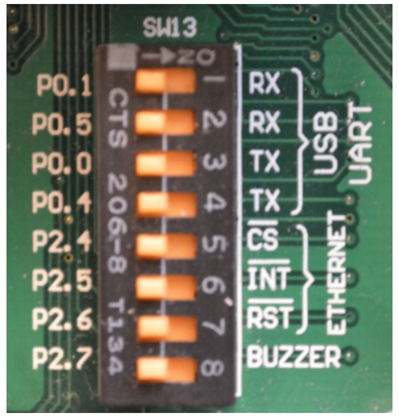


Switch 8 on the DIP switch SW15 is set to OFF at the moment. To connect DS1820, set pin P2.7 to ON

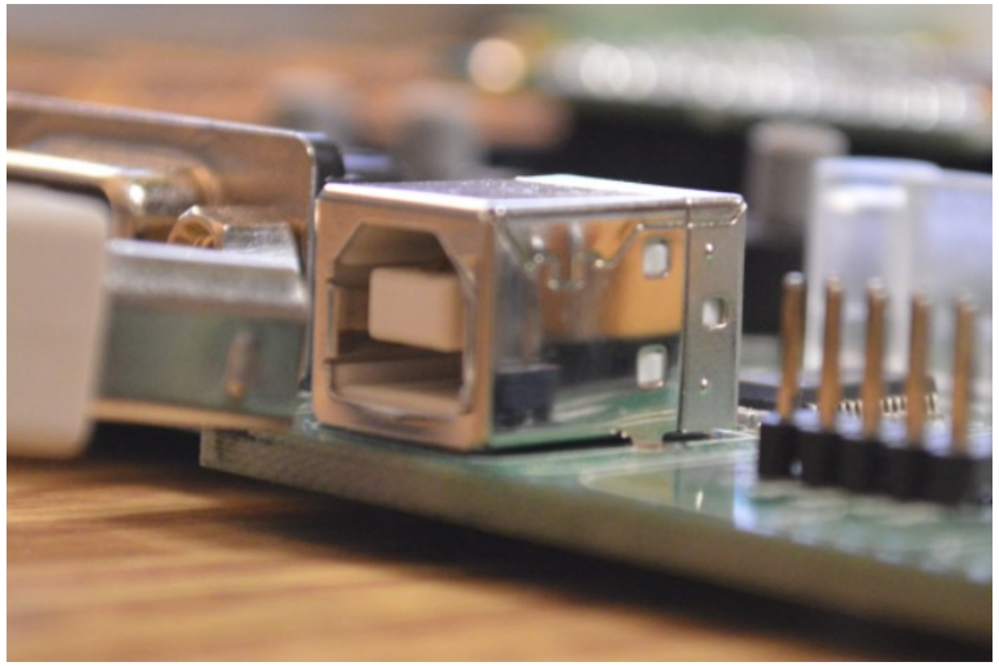
USB UART module

The USB UART module is used to connect the microcontroller to an external USB device. To establish connection between the microcontroller and the USB UART module, it is important to set switches 1 and 3 (optionally 2 and 4) to the ON position.

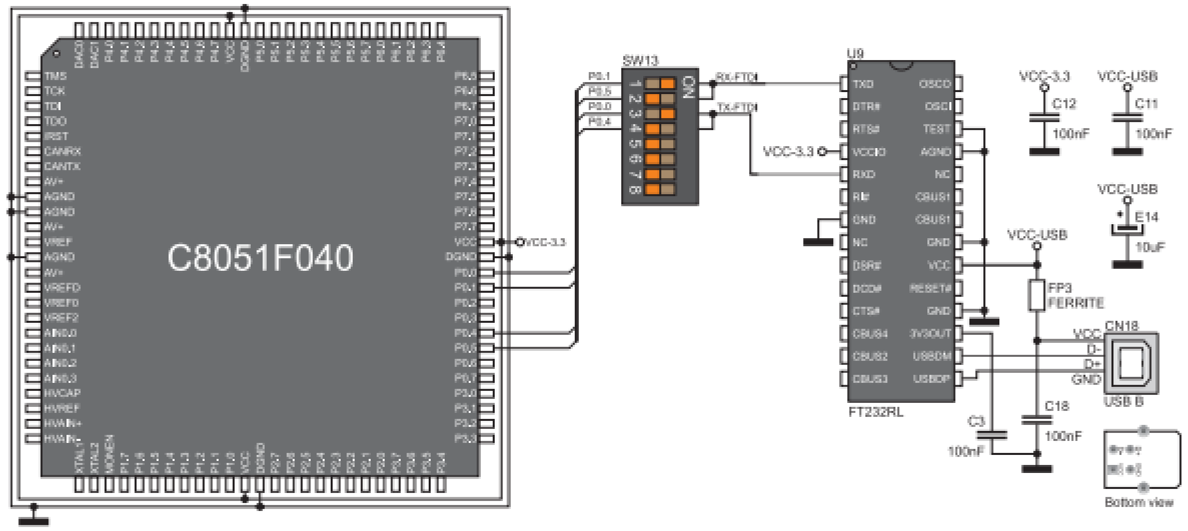
The BIG8051 can also use this module to power itself. To achieve this, it is necessary to set the switch position of jumper J11 (found on the power module) from EXT to USB.



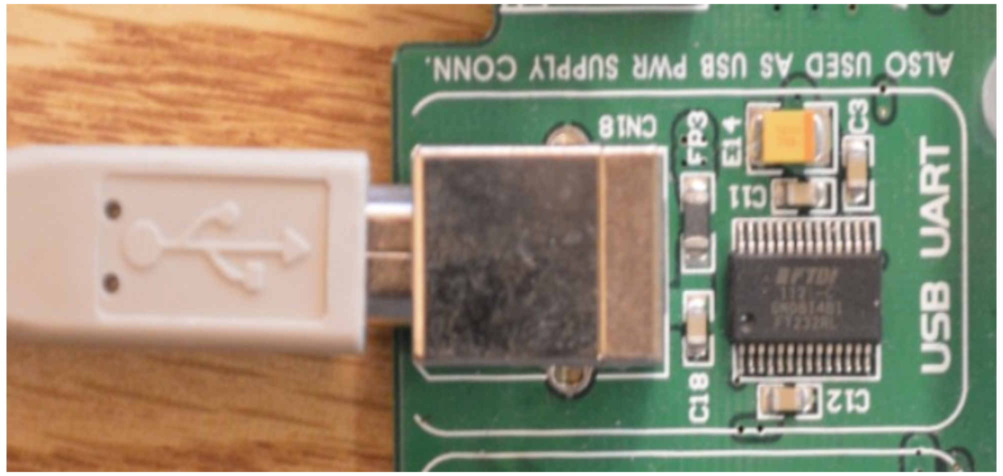
SW13



Connecting USB cable



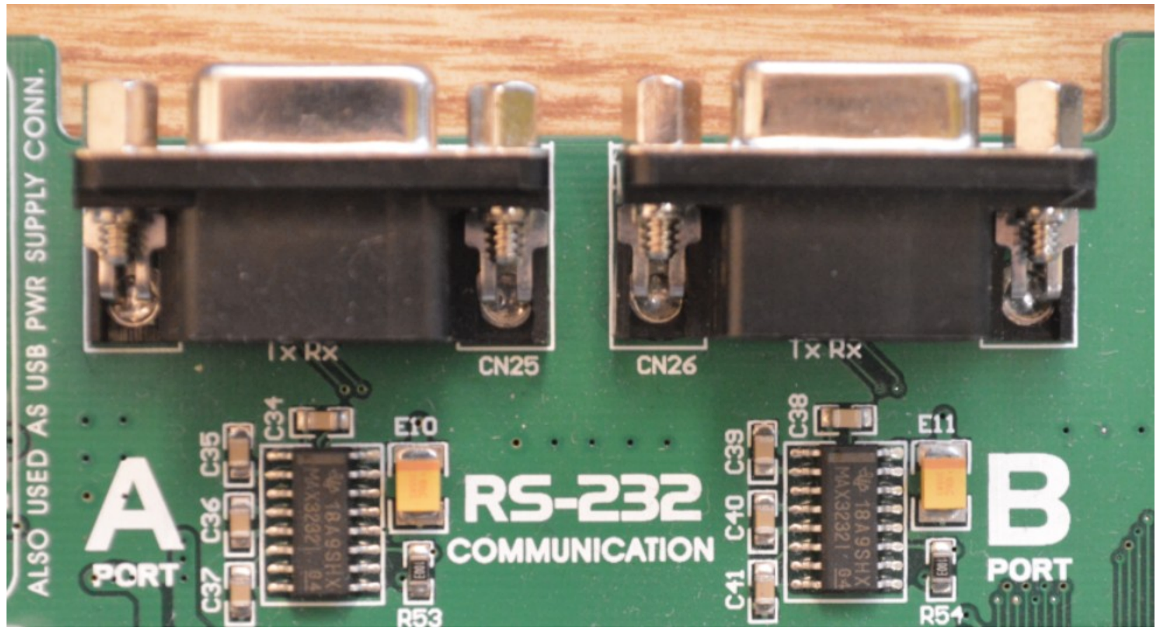
USB connector and microcontroller connection schematic [7]



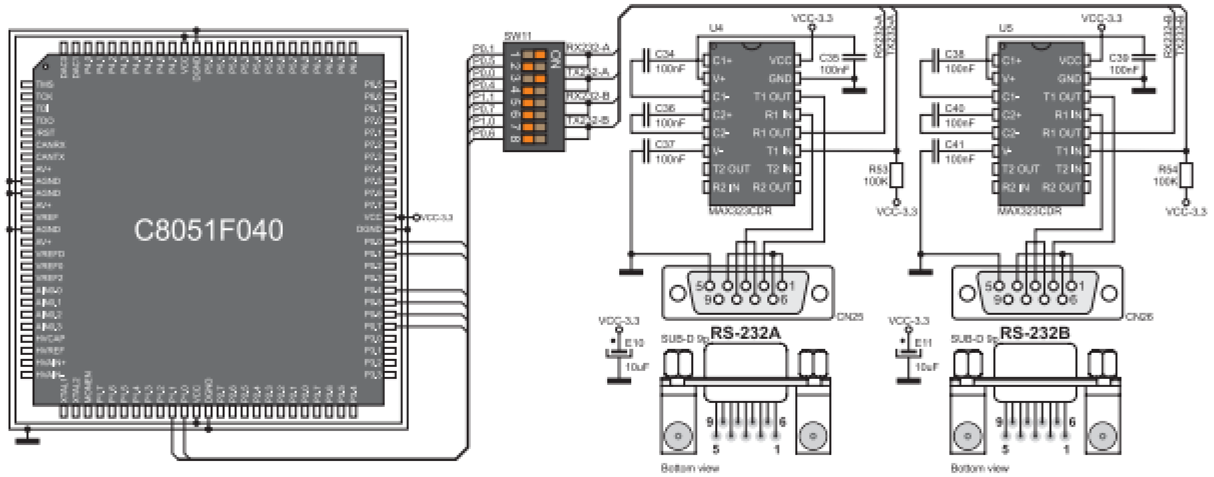
USB UART module

RS-232 modules

The RS-232 modules allow the development system to communicate to external devices in compliance with the RS-232 standard. The two RS modules in the BIG8051 can operate separately. To connect, switches 1 and 3 (optionally 2 and 4) on DIP switch SW11 should be set to the ON position.



RS-232 module



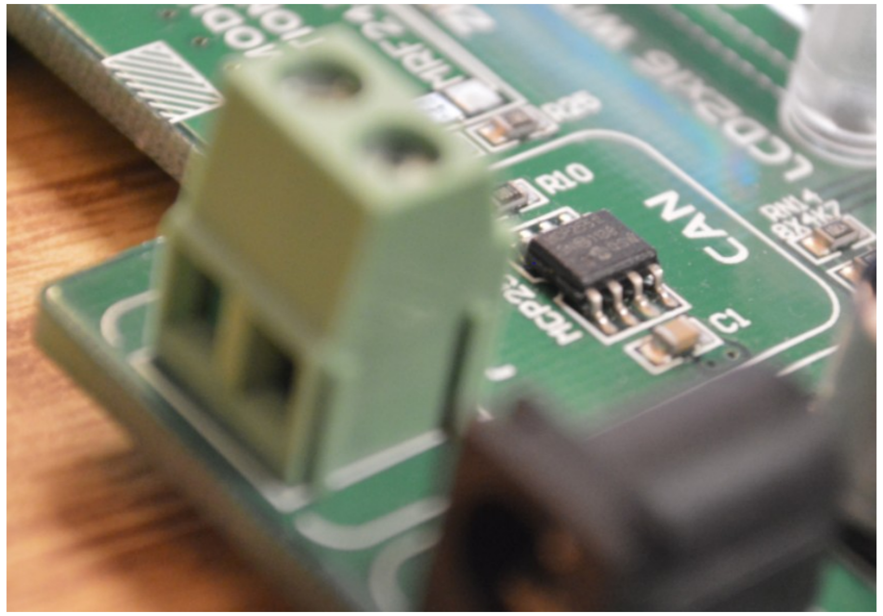
RS-232 module connection schematic [8]

CAN module

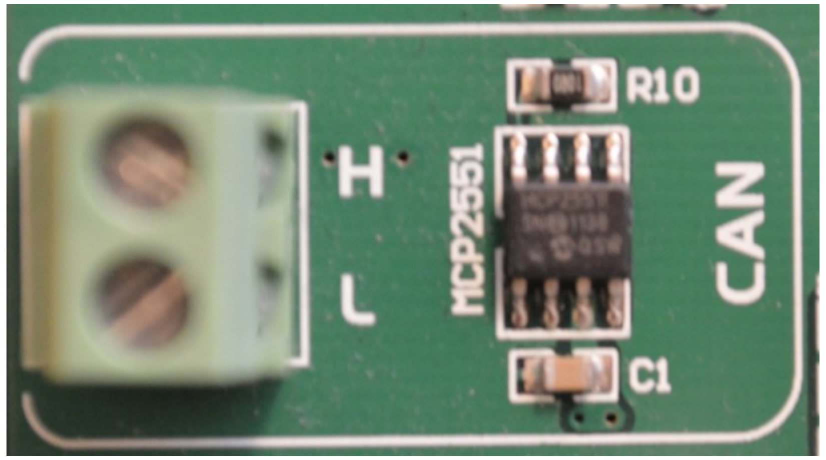
Controller Area Network (CAN) is a communication standard primarily intended for use in the automotive industry. It is used when microcontrollers and devices need to communicate with each other in applications without a host computer. The modern automobile may have as many as 70 electric control units for various subsystems. Typically the biggest processor is the engine control unit. Others are used for transmission, airbags, ABS, cruise control, electric power steering, audio systems, power windows, doors, mirrors, etc. Some of these form independent subsystems, but communications among others are essential. A subsystem may need to control actuators or receive feedback from sensors. The CAN standard was devised to fill this need.

Each CAN node is able to send and receive messages, but not simultaneously. The devices that are usually connected by a CAN network are typically sensors, actuators, and other control devices. The host processor decides what the received messages mean and what messages it wants to transmit. Sensors, actuators and control devices can be connected to the host processor. CAN controller stores the receives serial bits from the bus until an entire message is available, which can then be fetched by the host processer, usually by the CAN controller triggering an interrupt. For sending, the host processor sends the transmit messages to a CAN controller, which transmits the bits serially onto the bus when the bus is free.

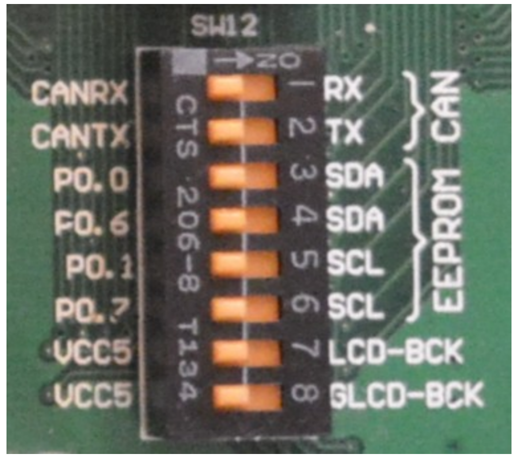
To establish connection between this module and the microcontroller, it is necessary to set the switches 1 and 2 on the DIP switch SW12 to the ON position.



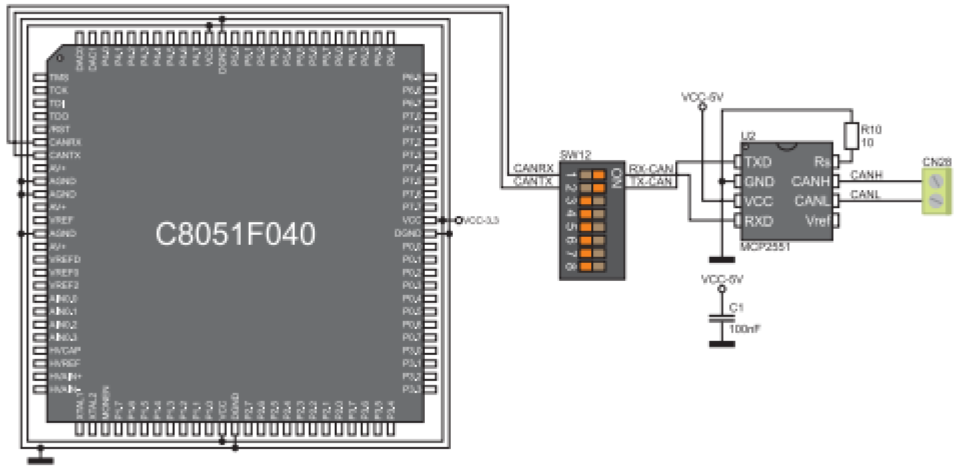
CAN module connector



CAN module



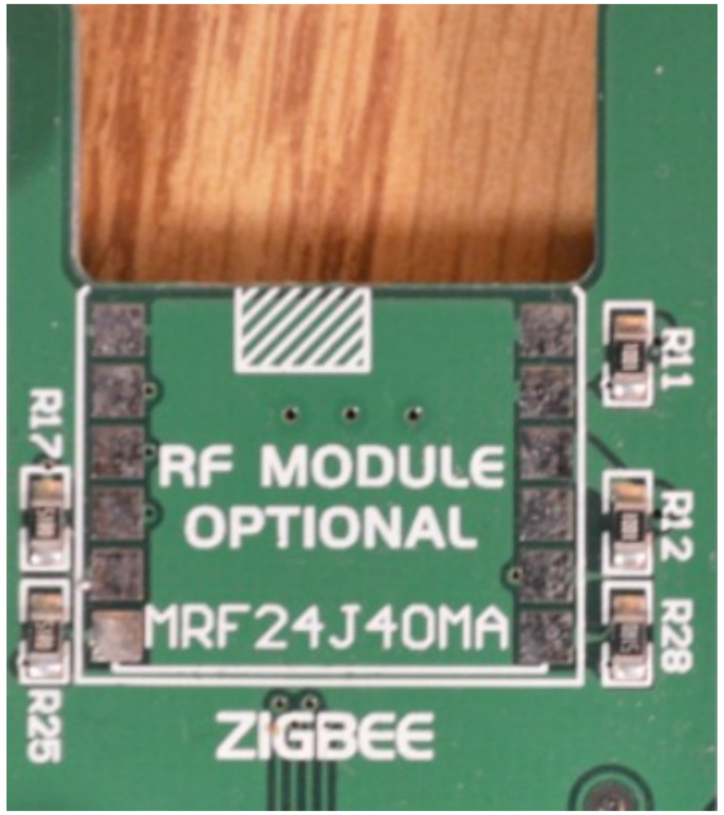
SW12



CAN module and microcontroller connection schematic [9]

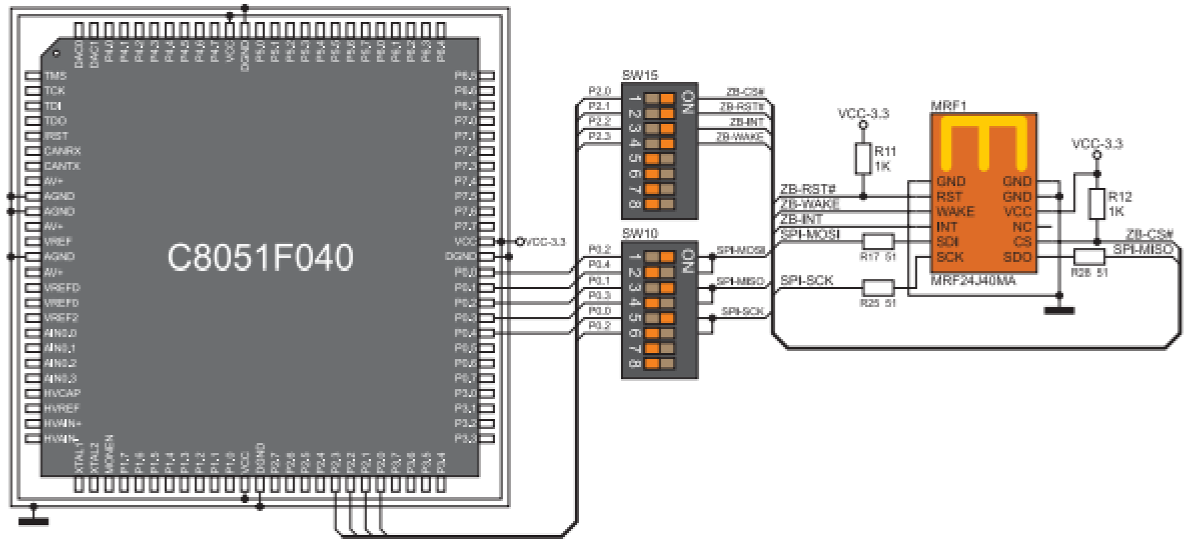
ZigBee module

The BIG805 enables you to connect the ZigBee module that is used for wireless communication. The module communicates with the microcontroller with the standard SPI protocols. It is necessary to set switches 1,3 and 5 on the DIP switch SW10, as well as the switches 1,2,3 and 4 on the DIP switch SW15 to the ON position for functionality.



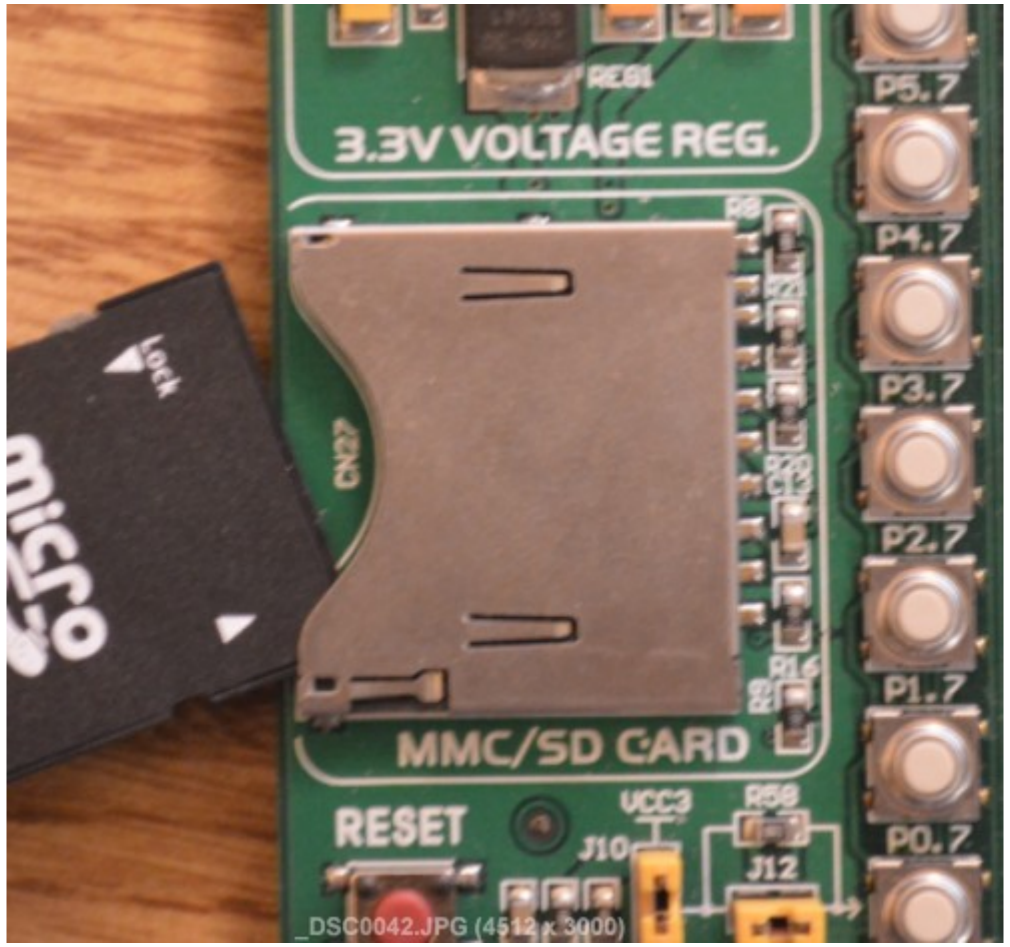
At the moment, our boards do not have any RF module attached to it. However, the MRF24J40MA ZigBee module can be connected to the development system. This module can be used as an ideal solution for wireless sensor networks, home automation, building automation, and consumer applications. The features of this particular radio transceiver module are:

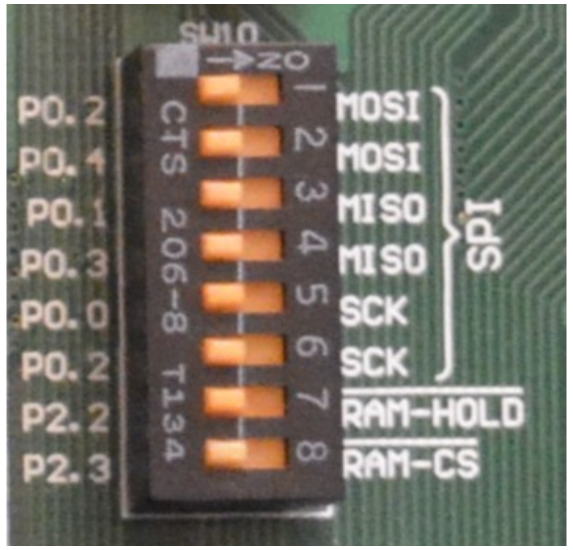
- 2.4 GHz IEEE 8-2.15.4 Transceiver module supports ZigBee™, MiWi™, and MiWi P2P protocols
- Integrated PCB Antenna with simple four-wire SPI interface to PIC microcontroller
- Low current consumption

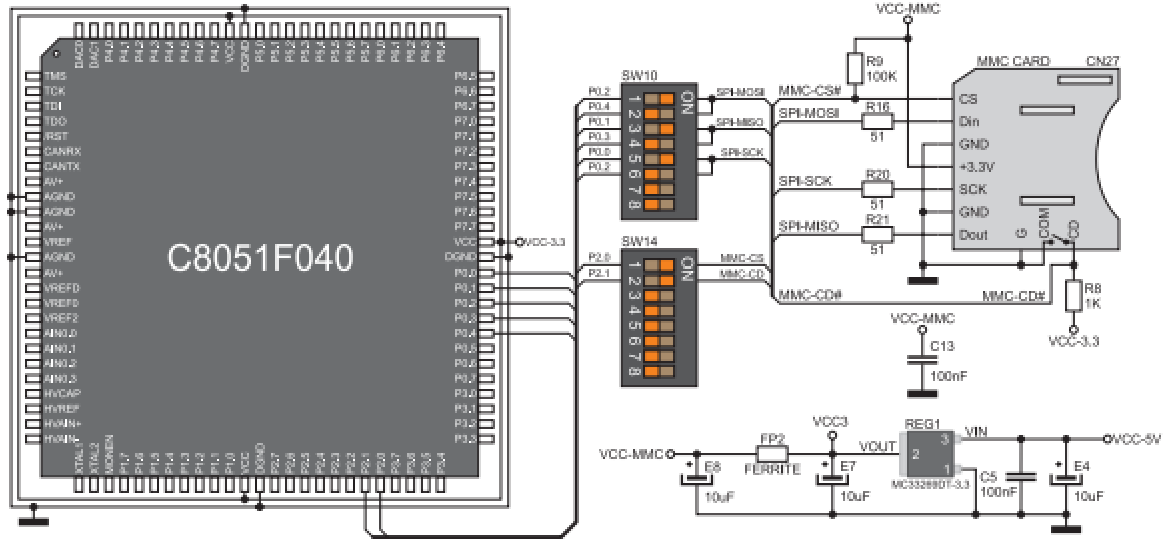


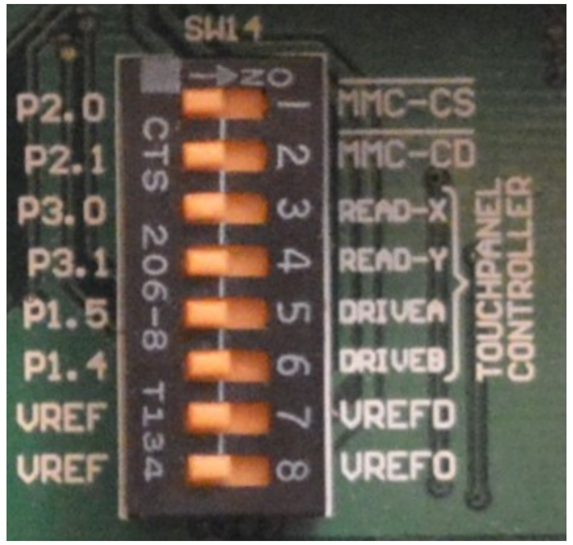
MMC/SD connector

The development system is able to read memory cards due to the on-board MMC/SD connector. The module uses microcontroller pins for serial communication. To connect this module, it is necessary to set switches 1,3 and 5 (optionally 2,4, and 6) on the DIP switch SW10, as well as switches 1 and 2 on the DIP switch SW14 to the ON position.



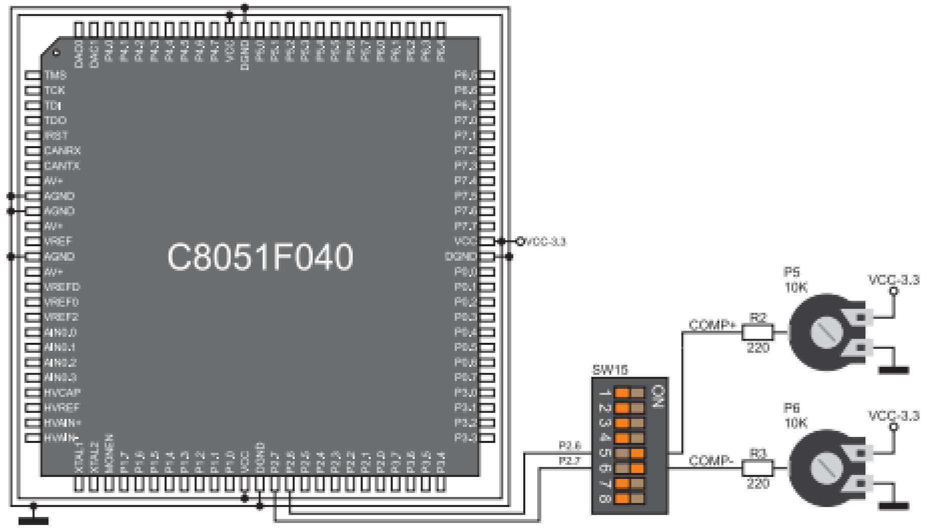


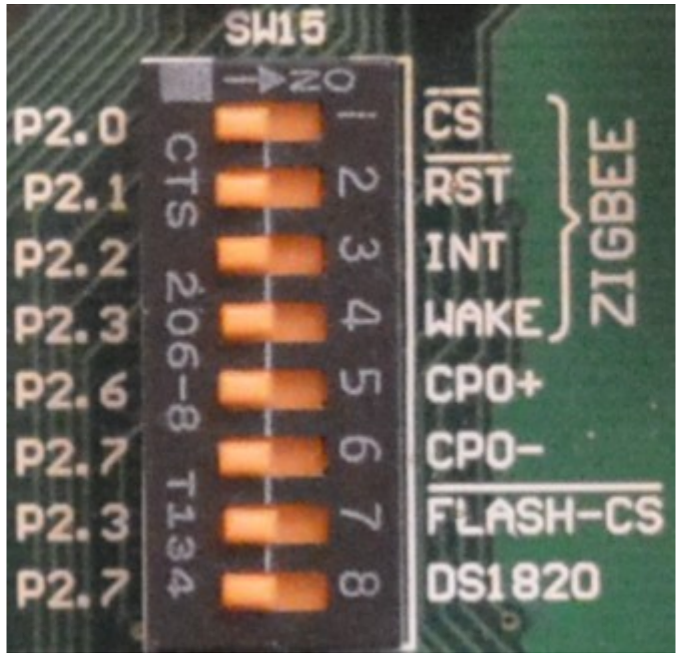




Comparator

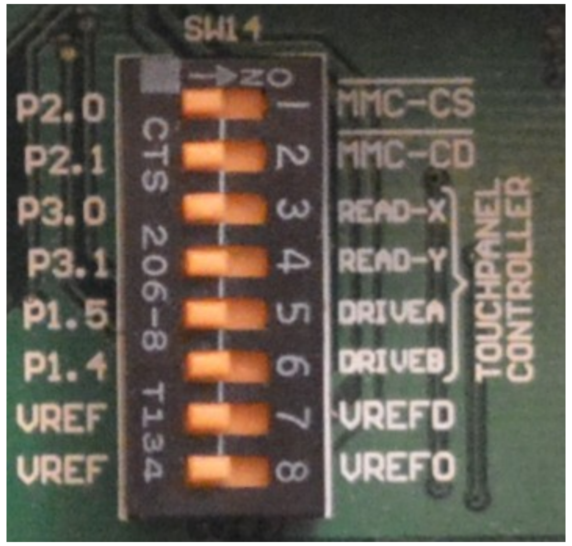
The BIG8051 can compare voltage levels due to a comparator built into the microcontroller. Voltage signals are supplied via potentiometers P5 and P6. To enable voltage signals, set switches 5 and 6 on DIP switch SW15 to the ON position.

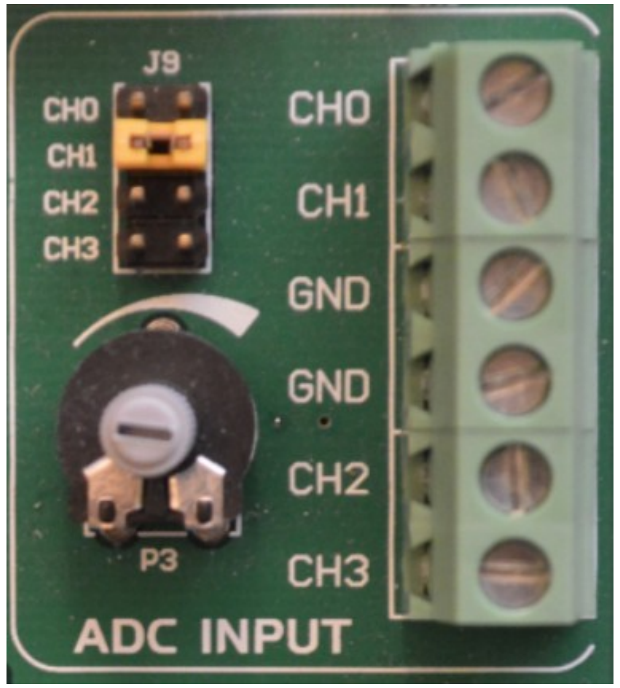


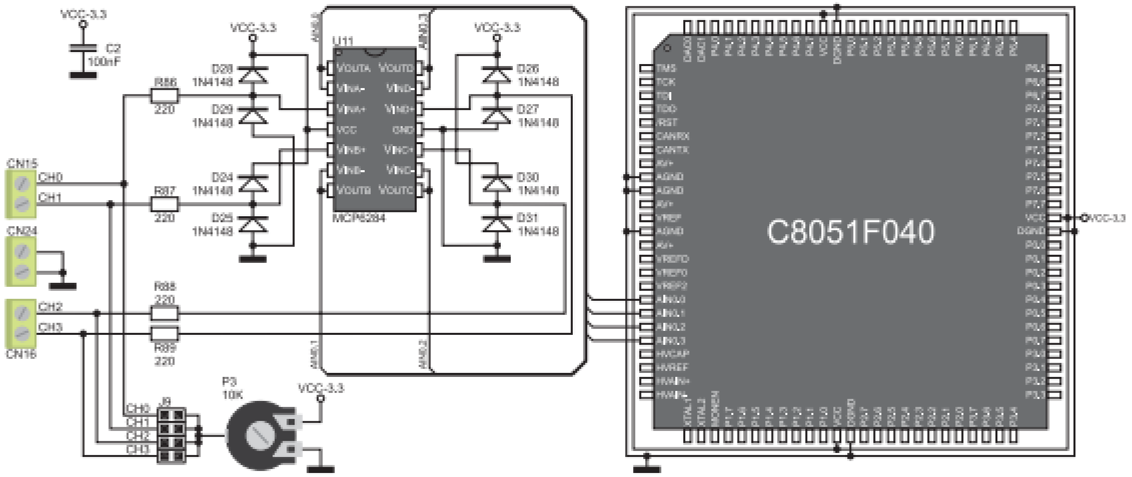


ADC module

The ADC module is used to convert an analog voltage level into the appropriate 12-bit digital value. The analog voltage signal is supplied via screw terminals CH0, CH1, CH2, and CH3. The ADC module is built-in into the microcontroller. The voltage supplied from the VREF pin is used as a voltage reference. In order to use this voltage, switch 8 on the DIP SW14 should be set to the ON position.

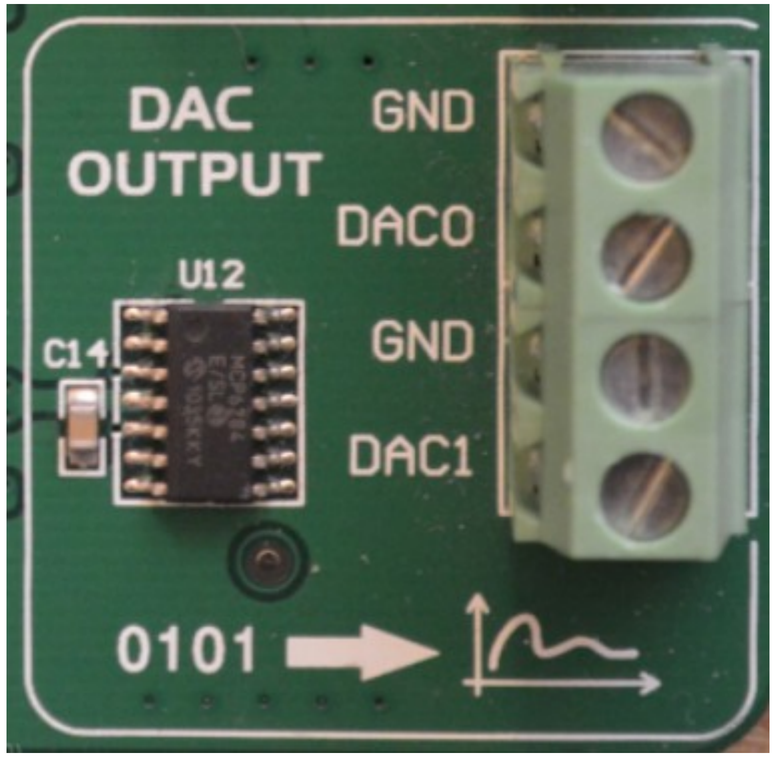


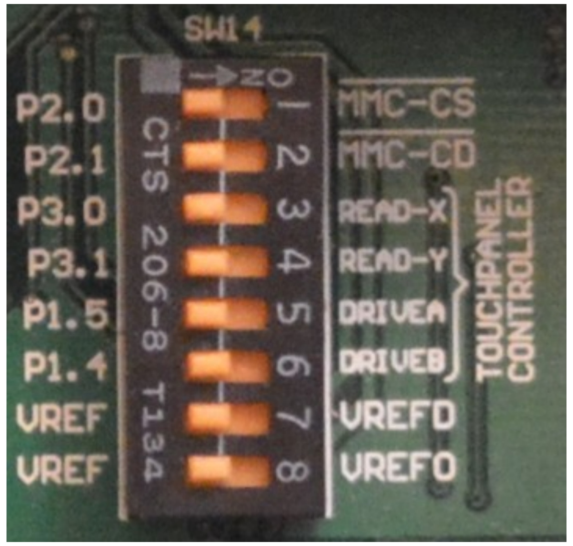


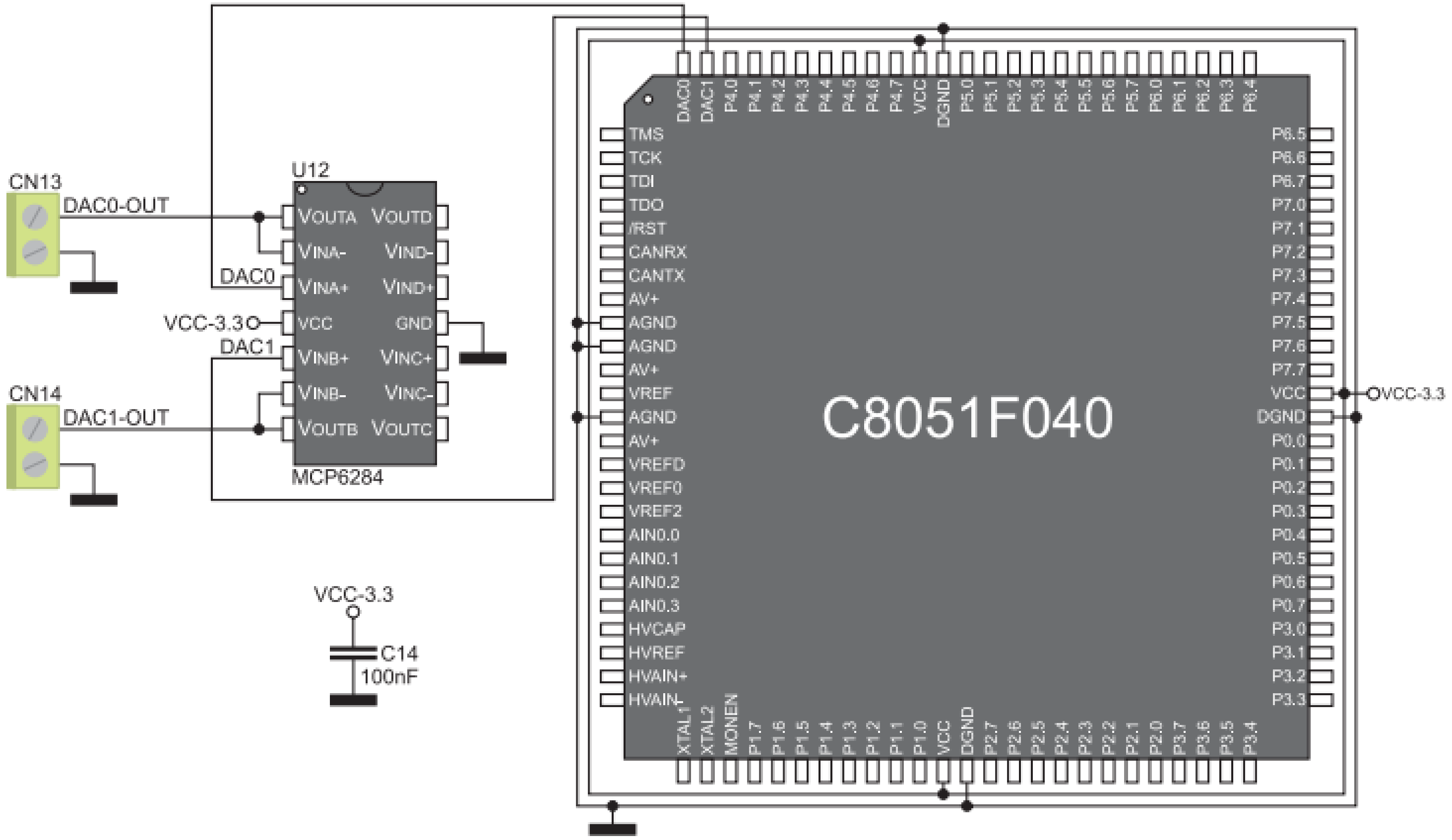


DAC module

. The DAC module attached to the development system can be used to convert 12-bit digital values into appropriate analog voltage values. The output analog voltage signals is delivered via screw terminals DAC0, and DAC1. Like the ADC module, this module also uses the VREF pin on the microcontroller as a voltage reference. To use this voltage, switch 7 on DIP switch SW14 should be set to the ON position.







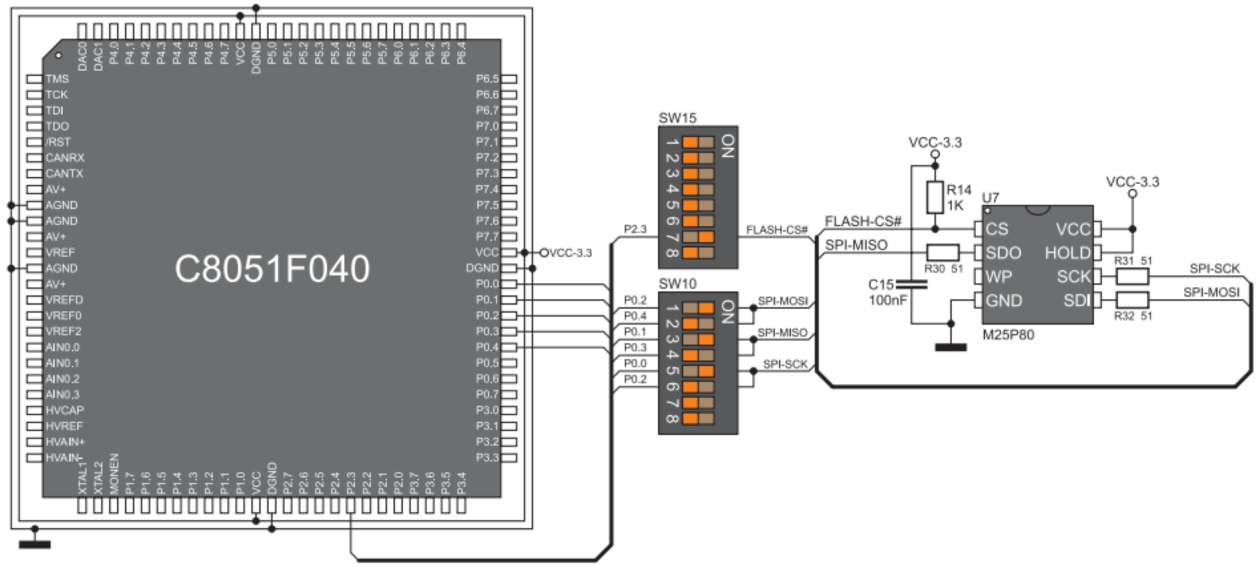
Memory modules

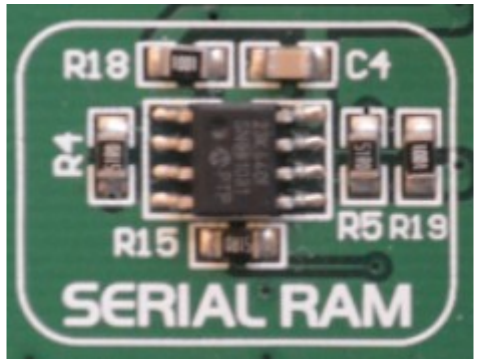
The BIG8051 comes with Flash, RAM and EEPROM memory modules. This allows the microcontroller to expand its memory space.

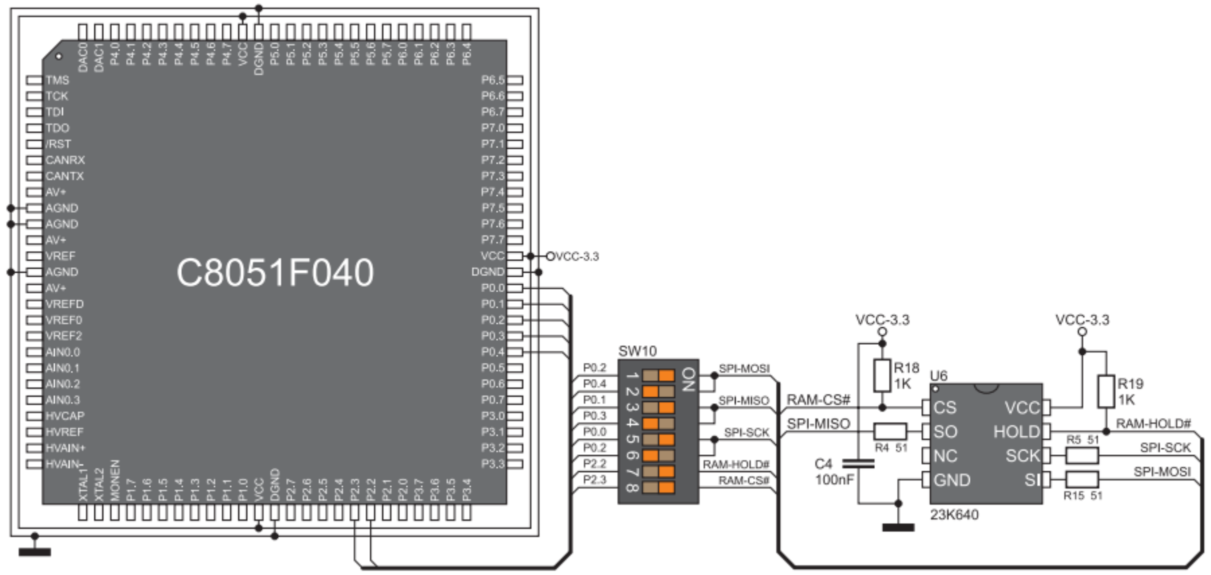
The Flash module lets the microcontroller to use an additional 8Mbit flash memory via SPI. To establish connection between the Flash module and the microcontroller, switches 1, 3, and 5 (optionally 2, 4, and 6) on the DIP switch SW10, as well as switch 7 on the DIP switch SW15 to the ON position.

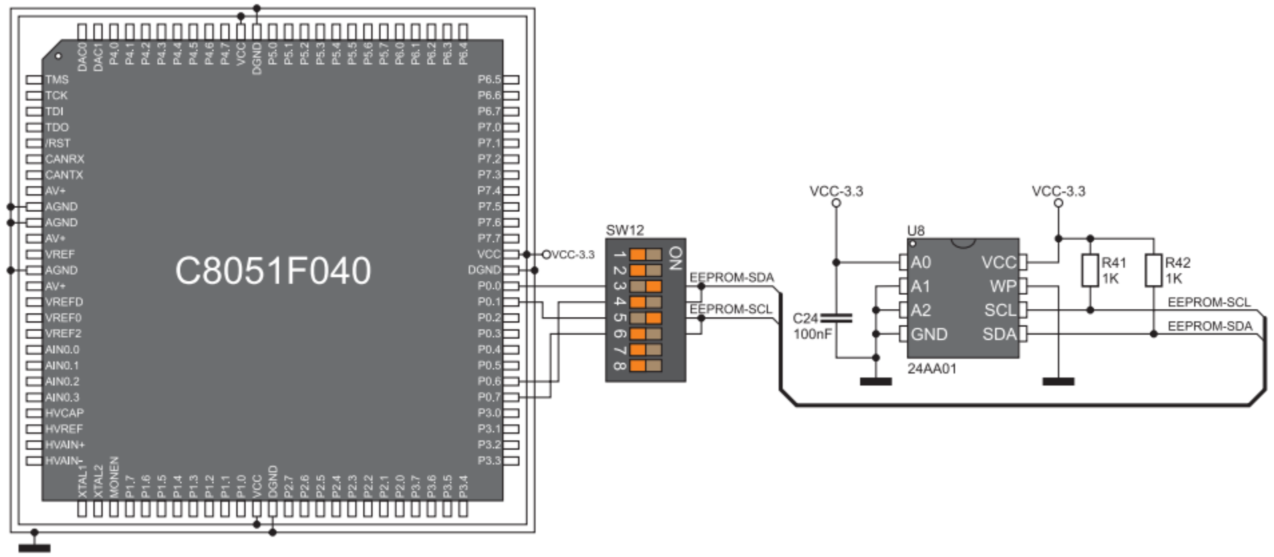
The RAM module enables the microcontroller to use an additional 64Kbit RAM memory via SPI. To enable this connection between the module and the microcontroller, it is necessary to set switches 1,3,5,7 and 8 (optionally 2,4,6) on the DIP switch SW10 to the ON position.

EEPROM module enables the microcontroller to use an additional 1Kbit EEPROM memory via I2C serial connection. Set switches 3 and 5 (optionally 4 and 6) on the DIP switch SW12 to the ON position.





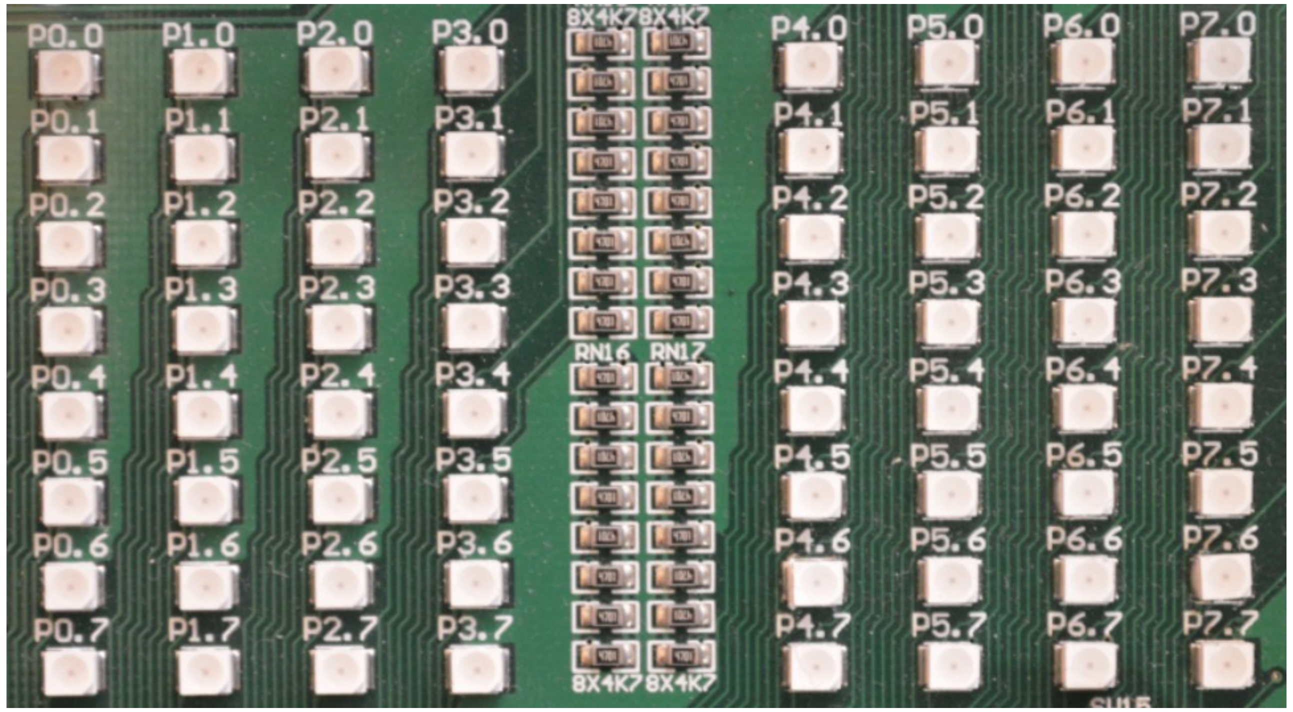


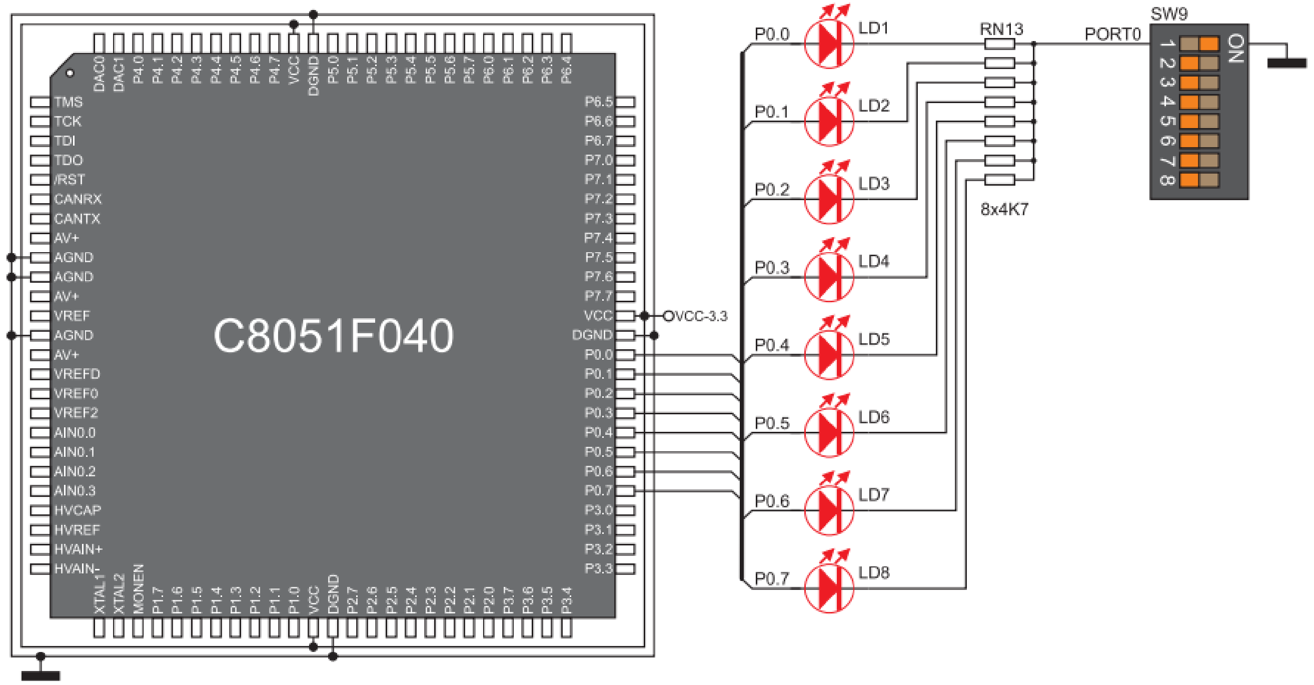


LEDs

There are a total of 64 LEDs on the development board and can be used to visually indicate the state of each microcontroller I/O pin. When active, an LED indicates that a logic 1 is present on that particular pin. To enable LEDs to illuminate, it is necessary to select the appropriate port using DIP switch SW9.

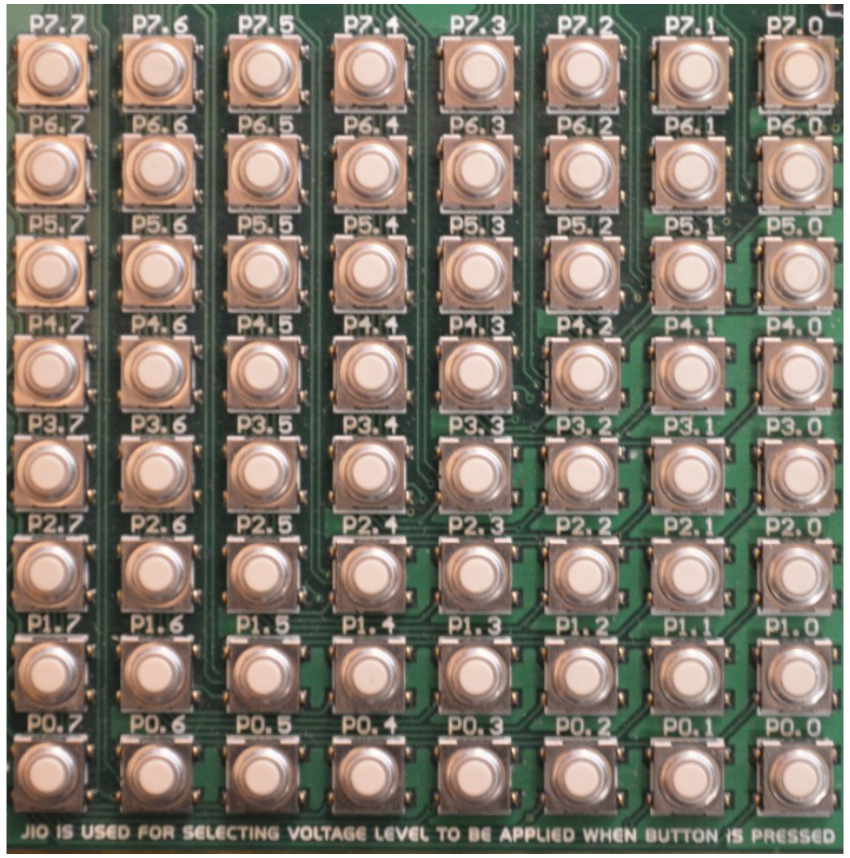
There are 8 available ports labelled PORT0 through PORT7.

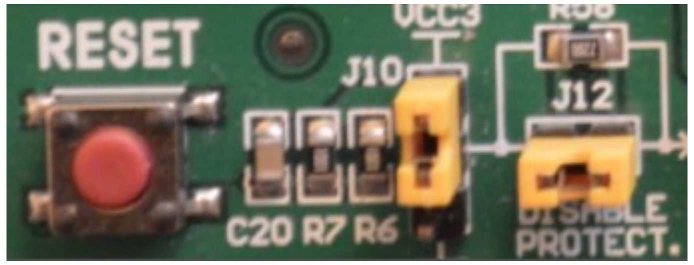


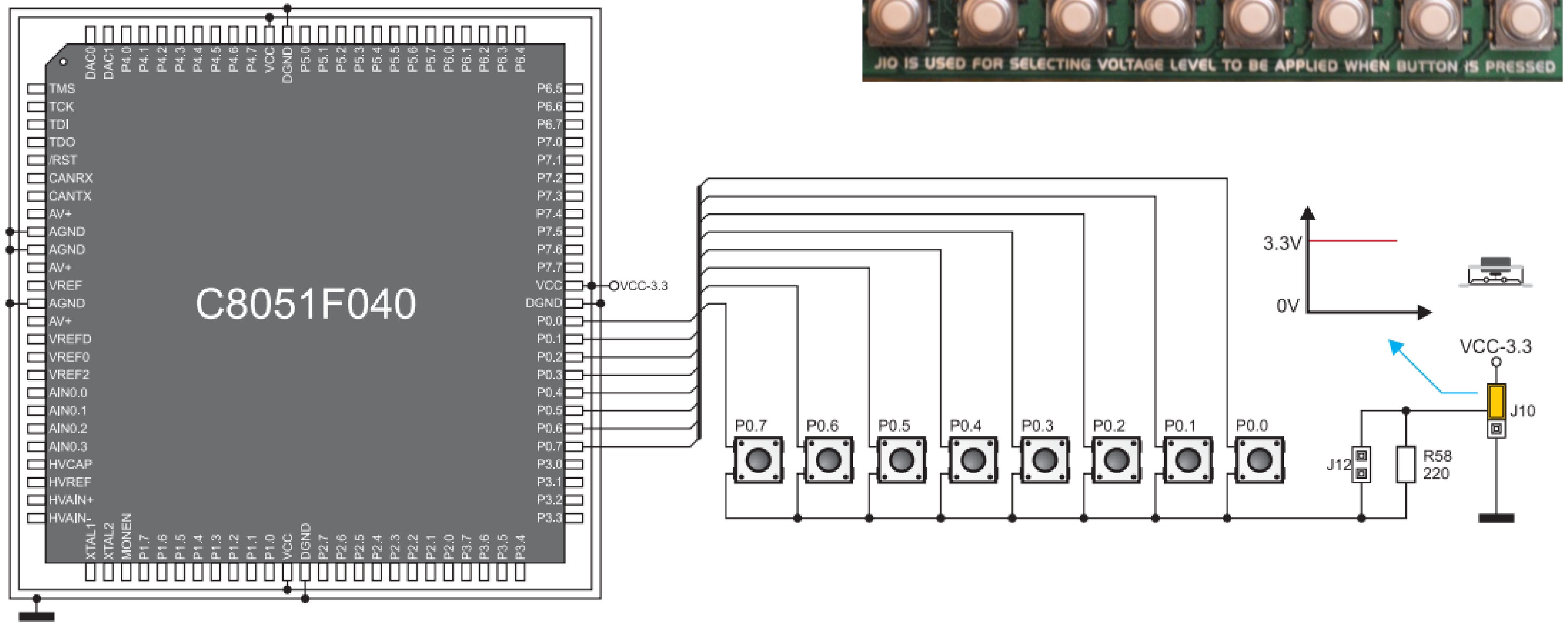


Push buttons

The provided push buttons on the development board can be used to change the logic state of all the microcontroller input pins. Jumper J10 is used to determine the logic state to be supplied on the appropriate microcontroller pin by pressing a push button. On the lower left side of the push buttons, a RESET button can be found to reset the microcontroller.


P7.7
P7.6
P7.5
P7.4
P7.3
P7.2
P7.1
P7.0
P0.7
P0.6
P0.5
P0.4
P0.3
P0.2
P0.1
P0.0
J10 IS USED FOR SELECTING VOLTAGE LEVEL TO BE APPLIED WHEN BUTTON IS PRESSED

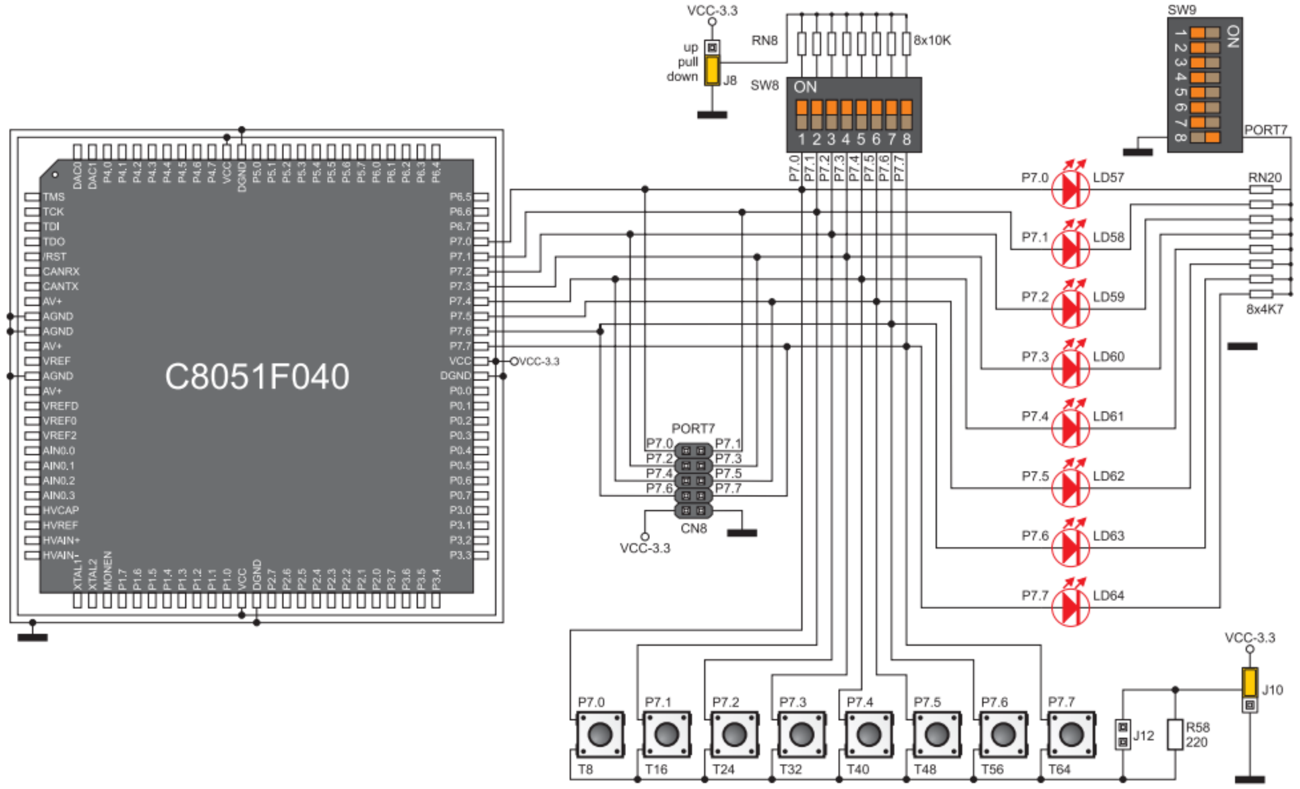


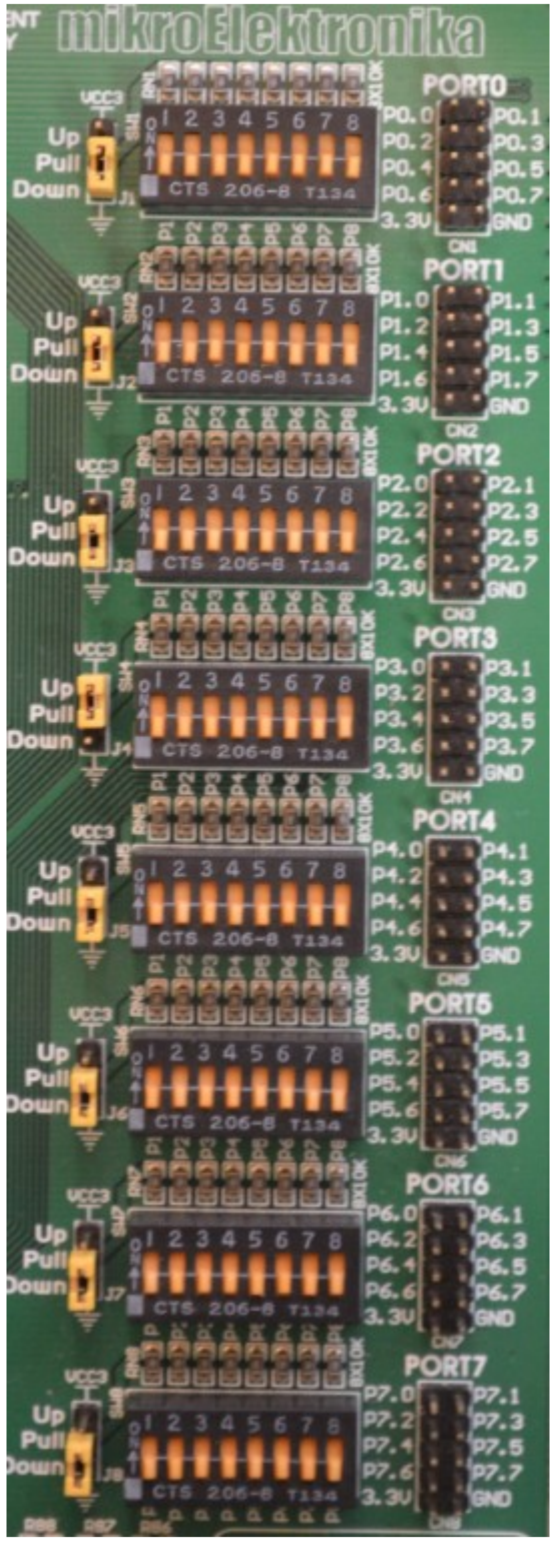


Input / Output ports

The BIG8051 has 10-pin connectors lined to the microcontroller I/O ports. Due to DIP switches SW1-SW8, every connector pin can be connected to one pull-up/pull-down resistor. It depends on the position of jumpers J1-J8 to control this aspect.

The pull-up resistor ensures that the signal will be a valid logic level if external devices are connected. A pull up resistor weakly "pulls" the voltage of the wire it is connected to towards its voltage source level when the other components on the line are inactive. A pull-down resistor works the same way but is connected to ground. It holds the logic signal near zero volts when no other device is connected.





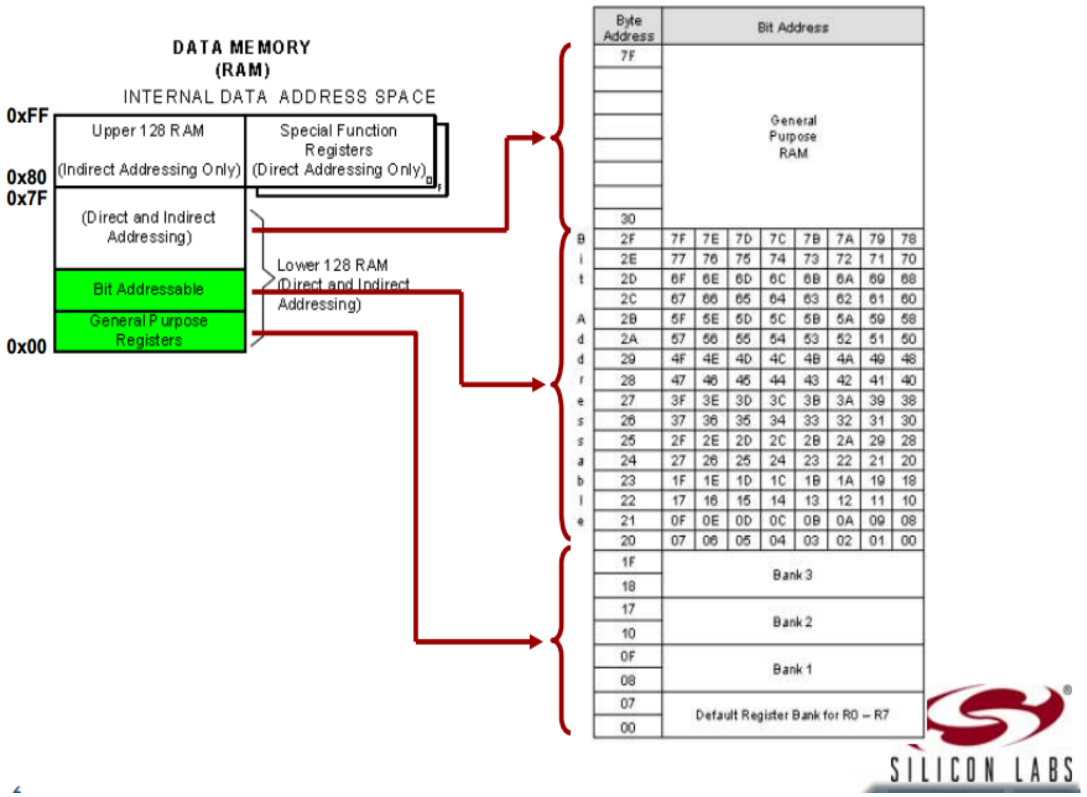
8051 Assembly Introduction

A computer instruction is made up of an operation code (op-code) followed by either zero, one, or two bytes of operands.

The op-code identifies the type of operation to be performed while the operands identify the source and destination of the data

If the instruction is associated with more than one operand, the format is always:

Instruction Destination, Source

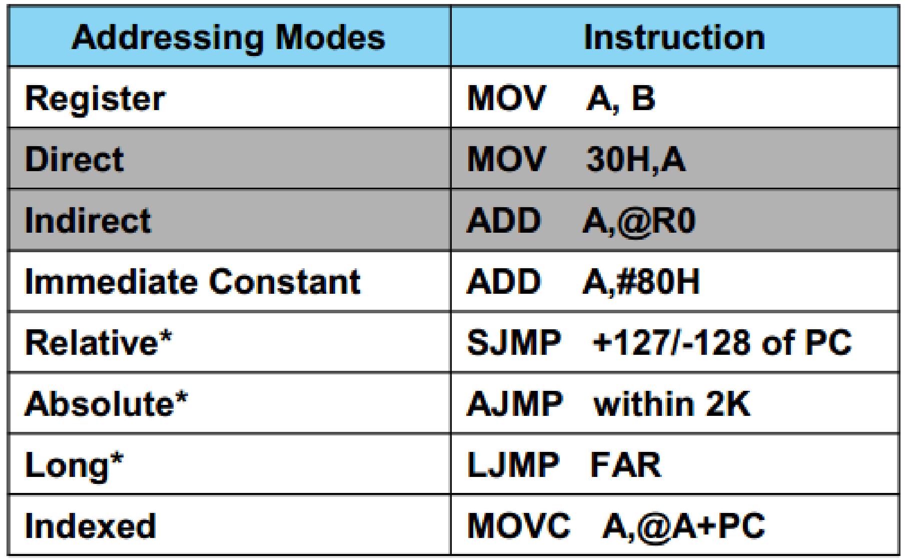

DATA MEMORY
(RAM)
INTERNAL DATA ADDRESS SPACE
0xFF
0x80
0x7F
0x00
Upper 128 RAM
(Indirect Addressing Only)
Special Function Registers
(Direct Addressing Only)
(Direct and Indirect Addressing)
Bit Addressable
General Purpose Registers
Lower 128 RAM
(Direct and Indirect Addressing)
Bit Addressable
SILICON LABS

Byte Address	Bit Address							
7F	General Purpose RAM							
30								
2F	7F	7E	7D	7C	7B	7A	79	78
2E	77	76	75	74	73	72	71	70
2D	6F	6E	6D	6C	6B	6A	69	68
2C	67	66	65	64	63	62	61	60
2B	5F	5E	5D	5C	5B	5A	59	58
2A	57	56	55	54	53	52	51	50
29	4F	4E	4D	4C	4B	4A	49	48
28	47	46	45	44	43	42	41	40
27	3F	3E	3D	3C	3B	3A	39	38
26	37	36	35	34	33	32	31	30
25	2F	2E	2D	2C	2B	2A	29	28
24	27	26	25	24	23	22	21	20
23	1F	1E	1D	1C	1B	1A	19	18
22	17	16	15	14	13	12	11	10
21	0F	0E	0D	0C	0B	0A	09	08
20	07	06	05	04	03	02	01	00
1F	Bank 3							
18								
17	Bank 2							
10								
0F	Bank 1							
08								
07	Default Register Bank for R0 – R7							
00								

The memory map of the C8051 if the lower data RAM area. Addresses 0x00 through 0X1F are banked registers R0-R7. The active bank is controlled via bits in the Program Status Word. From the PSW, we can conclude that the bit addressable memory located from 0x20 through 0x2F which provides 128 bits of bit addressable memory. The upper portion is used general purpose RAM ad can be accessed by any addressing mode (direct or indirect)

Special function registers (SFRs) have been added to the C8051 to that of the standard 8051 for enhanced peripherals. Upper data memory and SFR memory share the same address space but are accessed via different addressing modes (direct vs. indirect). The SFR portion can be accessed via ***direct addressing*** only.

There are eight modes of addressing available on the C805. The different addressing modes determine how the operand byte mentioned earlier to be selected.



Addressing Modes	Instruction
Register	MOV A, B
Direct	MOV 30H,A
Indirect	ADD A,@R0
Immediate Constant	ADD A,#80H
Relative*	SJMP +127/-128 of PC
Absolute*	AJMP within 2K
Long*	LJMP FAR
Indexed	MOVC A,@A+PC

The direct and indirect addressing modes are used to distinguish between the SFR space and data memory space.

Register Addressing

In CPU registers are used to store information temporarily. That information can be in the form of bytes of data to be processed or some address pointing to a data to be fetched. In 8051 there is only one data type: 8 bits. With an 8 bit data registers, any data more than 8-bit should be divided into 8 bit chunks before being processed.

The most widely used registers of 8051 are A (accumulator), R0, R1, R2, R3, R4, R5, R6, R7, DPTR (data pointer), PC (program counter). A register is used for all arithmetic and logic operations. These registers are divided into two groups:

- General purpose registers
- Special purpose registers

The register addressing instruction involves information transfer between registers

Example:

- MOV R0, A
- MOV A,#51H
- MOV R1,#0FFH
- MOV R2, #3BH

The first instruction above transfers the accumulator content into the R0 register. The register bank (Bank 0,1,2 or 3) must be specified prior to this instruction.

⇒ # signifies that it is a number and not a byte address
⇒ ‘H’ symbolizes that it is a hexadecimal number. Similarly if we write a binary number it should end with ‘B’
⇒ The ‘0’ in the third instruction in 0FFH symbolizes that the ‘F’ is a hex number and not a letter. This is always necessary if we are writing any hex numbers. It should always start with a 0.
⇒ All the register should be assumed to be of 1 byte unless otherwise mentioned.

Now to transfer contents of R1 to lets say, R6, the following code should do the trick:

```
MOV          R6,R1 ; copy contents of R1 to T6
```

DIRECT ADDRESSING:

This mode allows you to specify the operand by giving its actual memory address (typically specified in hex format) or by giving its abbreviated name. It is also used for SFR accesses.

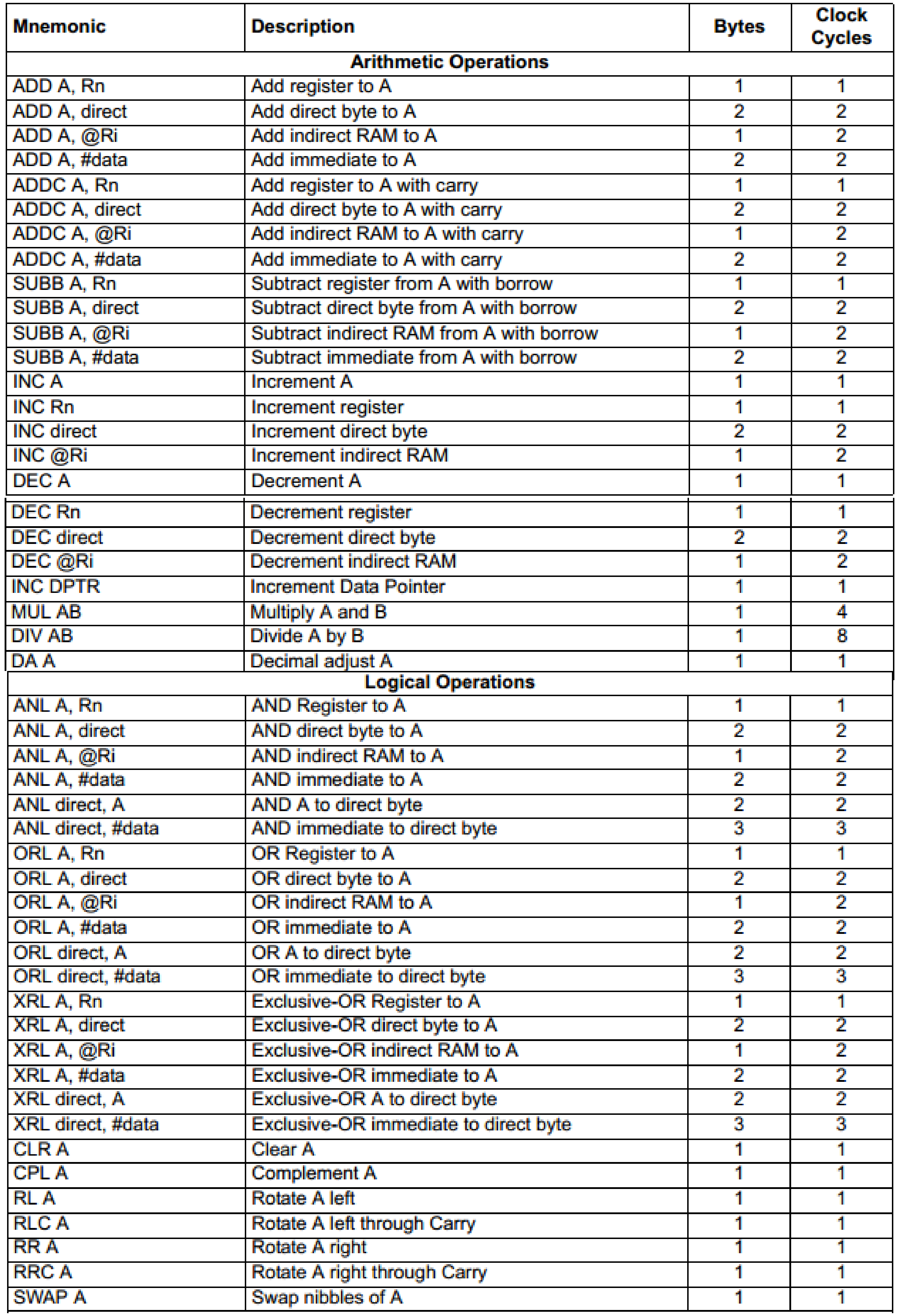
INDIRECT ADDRESSING:

In the indirect addressing mode, a register is used to hold the effective address of the operand. This register, which holds the address, is called the pointer register and is said to point to the operand. Only registers R0, R1 and DPTR can be used as pointer registers. DPTR is useful in accessing operands which are in the external memory.

The 8051 microcontroller instructions are divided among five functional groups

1. Arithmetic
2. Logical
3. Data transfer
4. Boolean variable
5. Program branching

Instruction Set Sum-



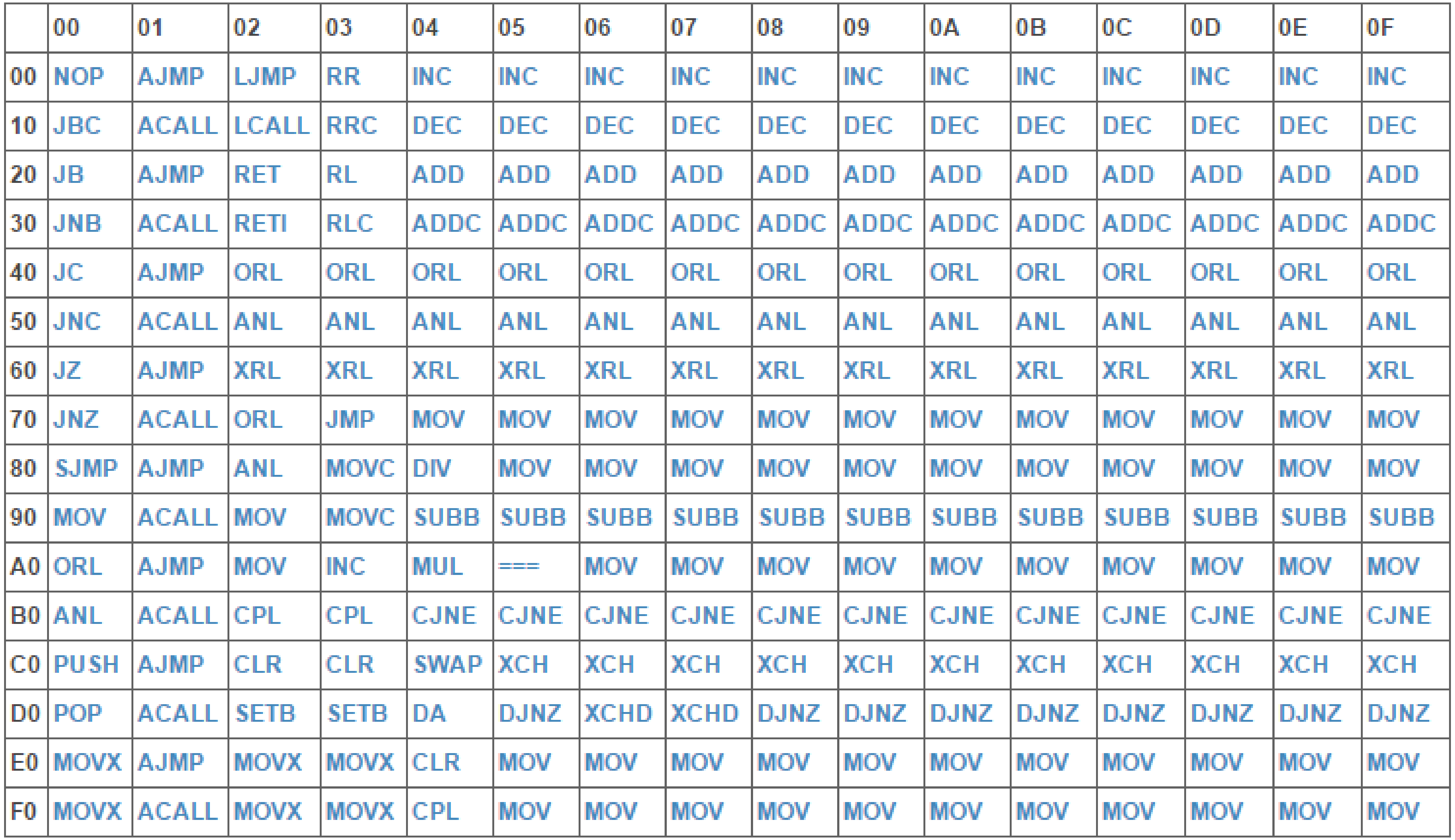
Mnemonic	Description	Bytes	Clock Cycles
Arithmetic Operations			
ADD A, Rn	Add register to A	1	1
ADD A, direct	Add direct byte to A	2	2
ADD A, @Ri	Add indirect RAM to A	1	2
ADD A, #data	Add immediate to A	2	2
ADDC A, Rn	Add register to A with carry	1	1
ADDC A, direct	Add direct byte to A with carry	2	2
ADDC A, @Ri	Add indirect RAM to A with carry	1	2
ADDC A, #data	Add immediate to A with carry	2	2
SUBB A, Rn	Subtract register from A with borrow	1	1
SUBB A, direct	Subtract direct byte from A with borrow	2	2
SUBB A, @Ri	Subtract indirect RAM from A with borrow	1	2
SUBB A, #data	Subtract immediate from A with borrow	2	2
INC A	Increment A	1	1
INC Rn	Increment register	1	1
INC direct	Increment direct byte	2	2
INC @Ri	Increment indirect RAM	1	2
DEC A	Decrement A	1	1
DEC Rn	Decrement register	1	1
DEC direct	Decrement direct byte	2	2
DEC @Ri	Decrement indirect RAM	1	2
INC DPTR	Increment Data Pointer	1	1
MUL AB	Multiply A and B	1	4
DIV AB	Divide A by B	1	8
DA A	Decimal adjust A	1	1
Logical Operations			
ANL A, Rn	AND Register to A	1	1
ANL A, direct	AND direct byte to A	2	2
ANL A, @Ri	AND indirect RAM to A	1	2
ANL A, #data	AND immediate to A	2	2
ANL direct, A	AND A to direct byte	2	2
ANL direct, #data	AND immediate to direct byte	3	3
ORL A, Rn	OR Register to A	1	1
ORL A, direct	OR direct byte to A	2	2
ORL A, @Ri	OR indirect RAM to A	1	2
ORL A, #data	OR immediate to A	2	2
ORL direct, A	OR A to direct byte	2	2
ORL direct, #data	OR immediate to direct byte	3	3
XRL A, Rn	Exclusive-OR Register to A	1	1
XRL A, direct	Exclusive-OR direct byte to A	2	2
XRL A, @Ri	Exclusive-OR indirect RAM to A	1	2
XRL A, #data	Exclusive-OR immediate to A	2	2
XRL direct, A	Exclusive-OR A to direct byte	2	2
XRL direct, #data	Exclusive-OR immediate to direct byte	3	3
CLR A	Clear A	1	1
CPL A	Complement A	1	1
RL A	Rotate A left	1	1
RLC A	Rotate A left through Carry	1	1
RR A	Rotate A right	1	1
RRC A	Rotate A right through Carry	1	1
SWAP A	Swap nibbles of A	1	1

Instruction Set Summary (cont.)

Data Transfer			
MOV A, Rn	Move Register to A	1	1
MOV A, direct	Move direct byte to A	2	2
MOV A, @Ri	Move indirect RAM to A	1	2
MOV A, #data	Move immediate to A	2	2
MOV Rn, A	Move A to Register	1	1
MOV Rn, direct	Move direct byte to Register	2	2
MOV Rn, #data	Move immediate to Register	2	2
MOV direct, A	Move A to direct byte	2	2
MOV direct, Rn	Move Register to direct byte	2	2
MOV direct, direct	Move direct byte to direct byte	3	3
MOV direct, @Ri	Move indirect RAM to direct byte	2	2
MOV direct, #data	Move immediate to direct byte	3	3
MOV @Ri, A	Move A to indirect RAM	1	2
MOV @Ri, direct	Move direct byte to indirect RAM	2	2
MOV @Ri, #data	Move immediate to indirect RAM	2	2
MOV DPTR, #data16	Load DPTR with 16-bit constant	3	3
MOVC A, @A+DPTR	Move code byte relative DPTR to A	1	3
MOVC A, @A+PC	Move code byte relative PC to A	1	3
MOVX A, @Ri	Move external data (8-bit address) to A	1	3
MOVX @Ri, A	Move A to external data (8-bit address)	1	3
MOVX A, @DPTR	Move external data (16-bit address) to A	1	3
MOVX @DPTR, A	Move A to external data (16-bit address)	1	3
PUSH direct	Push direct byte onto stack	2	2
POP direct	Pop direct byte from stack	2	2
XCH A, Rn	Exchange Register with A	1	1
XCH A, direct	Exchange direct byte with A	2	2
XCH A, @Ri	Exchange indirect RAM with A	1	2
XCHD A, @Ri	Exchange low nibble of indirect RAM with A	1	2

Boolean Manipulation			
CLR C	Clear Carry	1	1
CLR bit	Clear direct bit	2	2
SETB C	Set Carry	1	1
SETB bit	Set direct bit	2	2
CPL C	Complement Carry	1	1
CPL bit	Complement direct bit	2	2
ANL C, bit	AND direct bit to Carry	2	2
ANL C, /bit	AND complement of direct bit to Carry	2	2
ORL C, bit	OR direct bit to carry	2	2
ORL C, /bit	OR complement of direct bit to Carry	2	2
MOV C, bit	Move direct bit to Carry	2	2
MOV bit, C	Move Carry to direct bit	2	2
JC rel	Jump if Carry is set	2	2/3
JNC rel	Jump if Carry is not set	2	2/3
JB bit, rel	Jump if direct bit is set	3	3/4
JNB bit, rel	Jump if direct bit is not set	3	3/4
JBC bit, rel	Jump if direct bit is set and clear bit	3	3/4
Program Branching			
ACALL addr11	Absolute subroutine call	2	3
LCALL addr16	Long subroutine call	3	4
RET	Return from subroutine	1	5
RETI	Return from interrupt	1	5
AJMP addr11	Absolute jump	2	3
LJMP addr16	Long jump	3	4
SJMP rel	Short jump (relative address)	2	3
JMP @A+DPTR	Jump indirect relative to DPTR	1	3
JZ rel	Jump if A equals zero	2	2/3
JNZ rel	Jump if A does not equal zero	2	2/3
CJNE A, direct, rel	Compare direct byte to A and jump if not equal	3	3/4
CJNE A, #data, rel	Compare immediate to A and jump if not equal	3	3/4
CJNE Rn, #data, rel	Compare immediate to Register and jump if not equal	3	3/4
CJNE @Ri, #data, rel	Compare immediate to indirect and jump if not equal	3	4/5
DJNZ Rn, rel	Decrement Register and jump if not zero	2	2/3
DJNZ direct, rel	Decrement direct byte and jump if not zero	3	3/4
NOP	No operation	1	1

Instructions by opcode



	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
00	NOP	AJMP	LJMP	RR	INC	INC	INC	INC	INC	INC	INC	INC	INC	INC	INC	INC
10	JBC	ACALL	LCALL	RRC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC	DEC
20	JB	AJMP	RET	RL	ADD	ADD	ADD	ADD	ADD	ADD	ADD	ADD	ADD	ADD	ADD	ADD
30	JNB	ACALL	RETI	RLC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC	ADDC
40	JC	AJMP	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL	ORL
50	JNC	ACALL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL	ANL
60	JZ	AJMP	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL	XRL
70	JNZ	ACALL	ORL	JMP	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV
80	SJMP	AJMP	ANL	MOVC	DIV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV
90	MOV	ACALL	MOV	MOVC	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB	SUBB
A0	ORL	AJMP	MOV	INC	MUL	===	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV
B0	ANL	ACALL	CPL	CPL	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE	CJNE
C0	PUSH	AJMP	CLR	CLR	SWAP	XCH	XCH	XCH	XCH	XCH	XCH	XCH	XCH	XCH	XCH	XCH
D0	POP	ACALL	SETB	SETB	DA	DJNZ	XCHD	XCHD	DJNZ	DJNZ	DJNZ	DJNZ	DJNZ	DJNZ	DJNZ	DJNZ
E0	MOVX	AJMP	MOVX	MOVX	CLR	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV
F0	MOVX	ACALL	MOVX	MOVX	CPL	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV	MOV

Writing your first Program

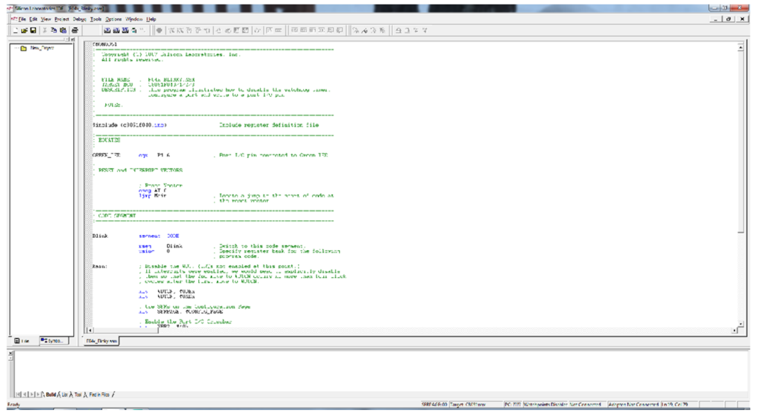
Download Silicon Laboratories IDE. Follow the link for the download:

- https://www.silabs.com/products/mcu/Pages/8-bit-microcontroller-software.aspx

Next, download an assembler. The recommended assembler is: Keil uVision5

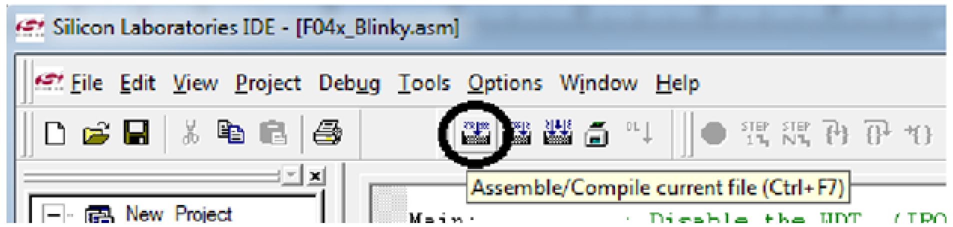
- http://www.keil.com/c51/

After both the installers are downloaded, install the software and run the IDE first. Then proceed to write your program in assembly language

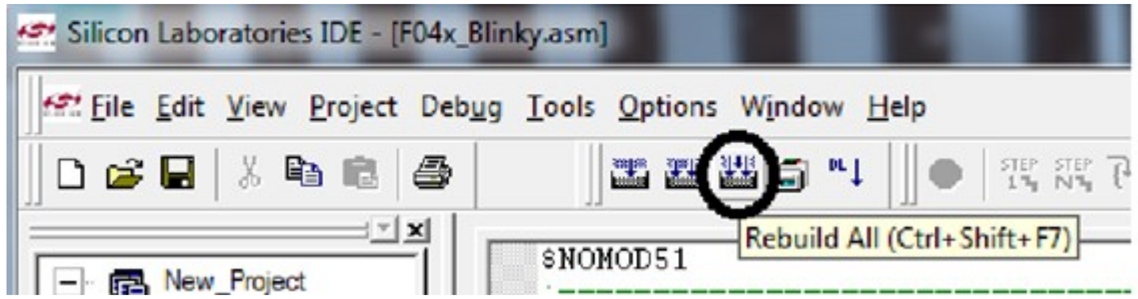


Assembling your Code

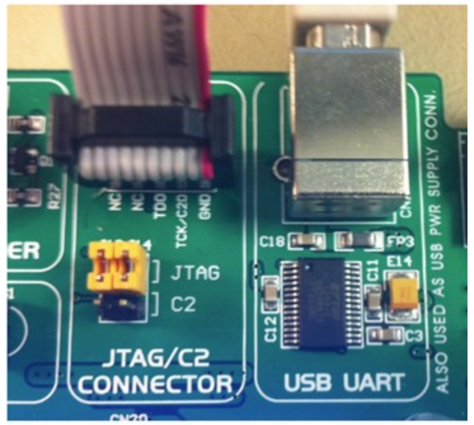
After completing your code, click the assemble button as shown:


Silicon Laboratories IDE - [F04x_Blinky.asm]
File Edit View Project Debug Tools Options Window Help
Assemble/Compile current file (Ctrl+F7)
New_Project
Main: ; Disable the WDT (IRQ

Next, you may be prompted to find an assembler. Browse for the assembler (Keil uVision 5) installed earlier. Click rebuild all as shown:

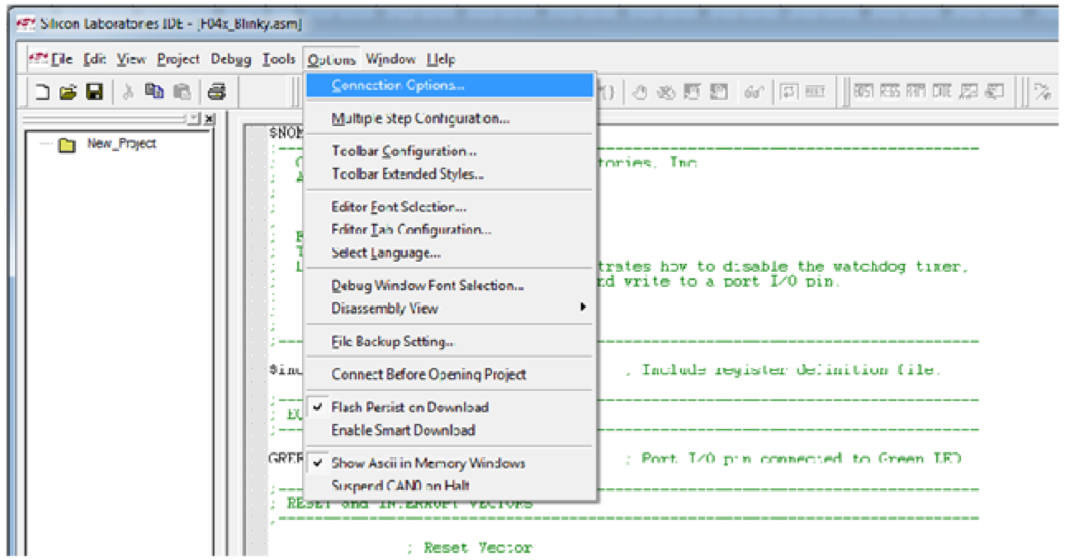

Silicon Laboratories IDE - [F04x_Blinky.asm]
File Edit View Project Debug Tools Options Window Help
Rebuild All (Ctrl+Shift+F7)
$NOMOD51
New_Project

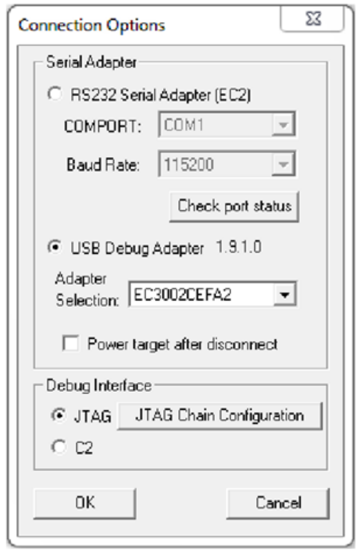
Connecting the IDE with the Development Board



Before establishing connection between the development board and the IDE, power on the system as instructed earlier. The jumpers J13 and J14 should be in the JTAG position.

- Click options and then select Connection Options from the drop down:
- In the Collection Options Dialog Box, select configuration as shown:
- Click Connect to establish connection:


Silicon Laboratories IDE - [F04x_Blinky.asm]
File Edit View Project Debug Tools Options Window Help
Connection Options...
Multiple Step Configuration...
Toolbar Configuration...
Toolbar Extended Styles...
Editor Font Selection...
Editor Tab Configuration...
Select Language...
Debug Window Font Selection...
Disassembly View
File Backup Setting...
Connect Before Opening Project
✓ Flash Persist on Download
Enable Smart Download
✓ Show Ascii in Memory Windows
Suspend CAN0 on Halt
New_Project


Connection Options

Serial Adapter

○ RS232 Serial Adapter (EC2)

COMPORT: COM1

Baud Rate: 115200

● USB Debug Adapter 1.9.1.0

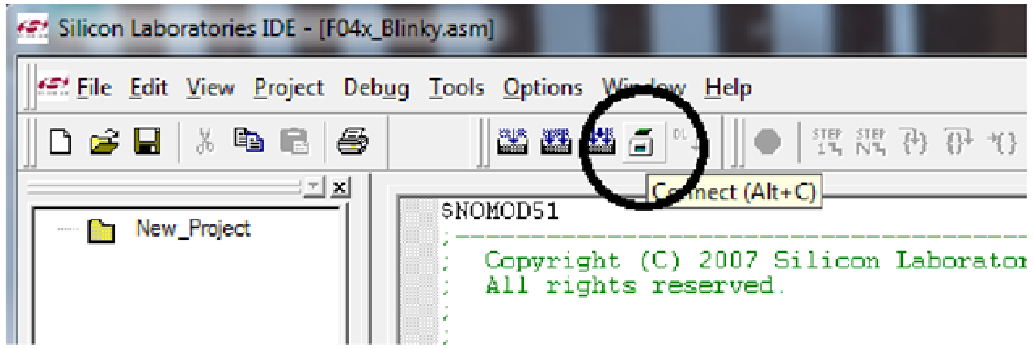
Adapter Selection: EC3002CEFA2

□ Power target after disconnect

Debug Interface

● JTAG

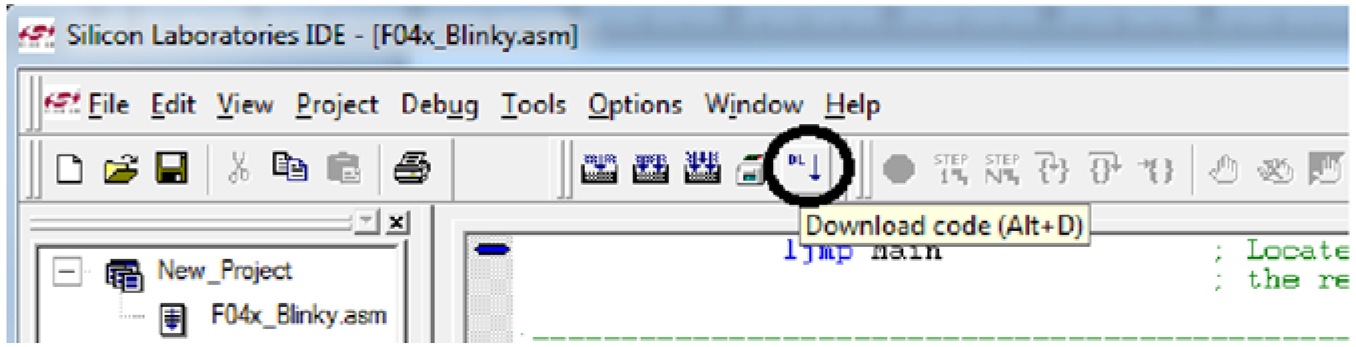
○ C2


Silicon Laboratories IDE - [F04x_Blinky.asm]
File Edit View Project Debug Tools Options Window Help
Connect (Alt+C)
New_Project

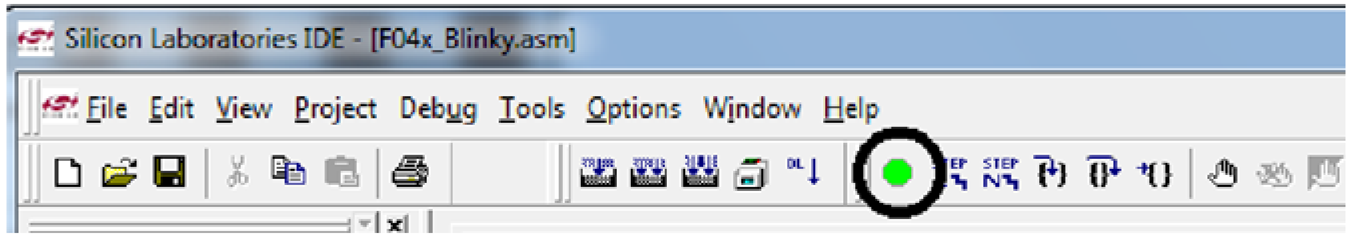
```
$NOMOD51
;-----------------------------------------
;   Copyright (C) 2007 Silicon Laborator
;   All rights reserved.
```

Downloading and Running Code on 8051

- Click Download after connection has been established successfully
- Then click the Go button as shown
- Observe results on board


Silicon Laboratories IDE - [F04x_Blinky.asm]
File Edit View Project Debug Tools Options Window Help
Download code (Alt+D)
New_Project
F04x_Blinky.asm

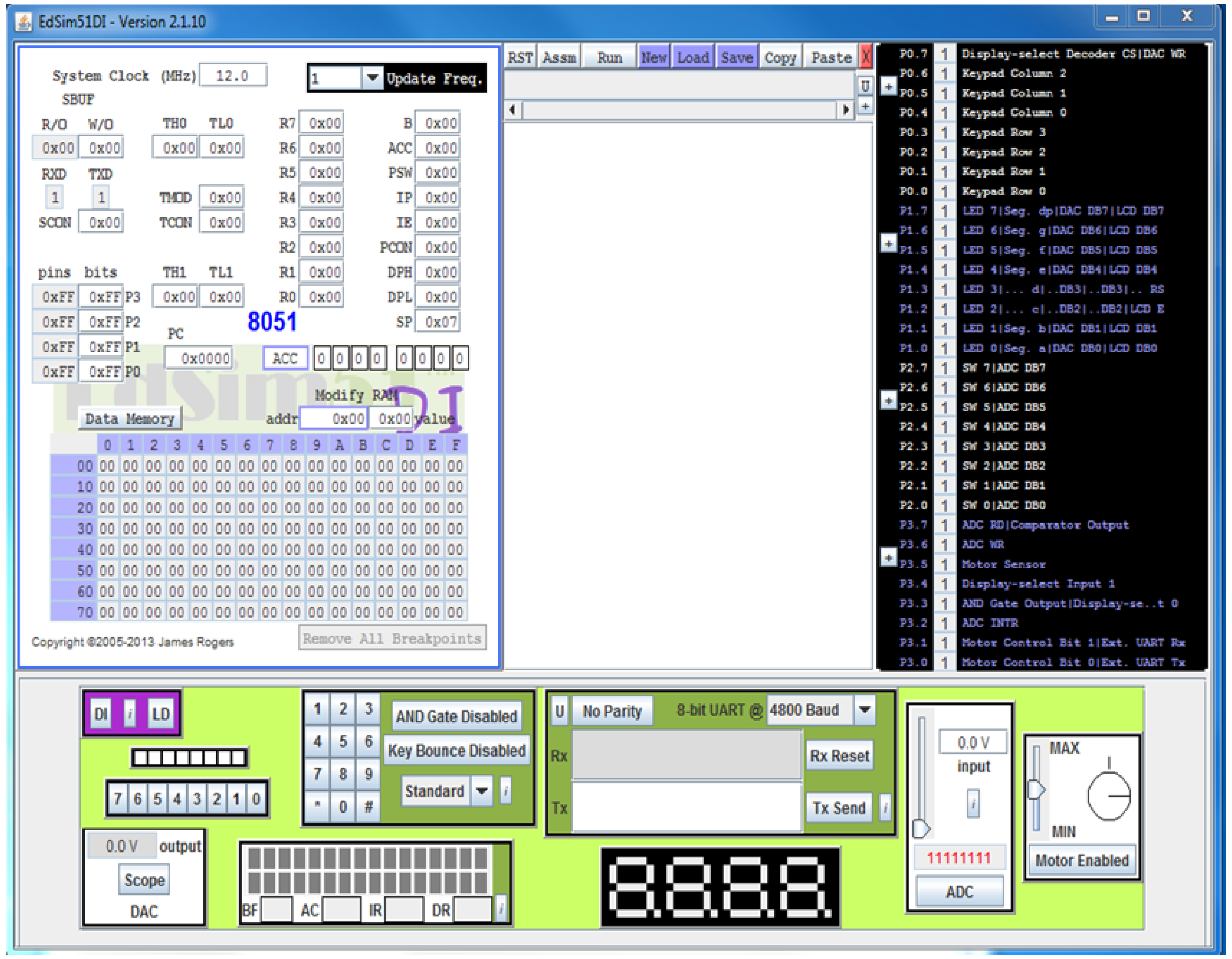
```
ljmp main                               ; Locate
                                        ; the re
```


Silicon Laboratories IDE - [F04x_Blinky.asm]
File Edit View Project Debug Tools Options Window Help

How to set up the 8051 Simulator

1) Make sure you have Java installed, you can download it at: http://java.com/en/download/index.jsp
2) Run the installer you downloaded and make sure to uncheck installing the Ask Toolbar
3) Download http://www.edsim51.com/8051simulator/edsim51di.zip . If the software has been updated since this writing, the newer version can be downloaded at http://www.edsim51.com/
4) Unzip the file
5) Inside edsim51di folder, run edsim51di.jar

- In the middle window are your main controls where you will be able to write and execute your code
- The bottom window allows you to manipulate virtual inputs to the 8051, and see outputs on its various LCDs and LEDs
- On the left is a representation of what is stored in the memory and registers of your 8051
  - Note: To clear some of these requires closing and re-opening the simulator
- In the black box on the right you'll find a reference for how to access various "hardware" elements of the simulated 8051, such as switches and LEDs, and whether currently sees a logic 1 or 0

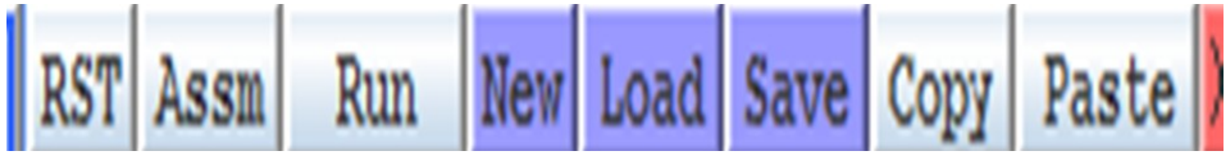


```
System Clock (MHz) 12.0
SBUF
R/O 0x00   W/O 0x00
RXD 1   TXD 1
SCON 0x00
TH0 0x00   TL0 0x00
TMOD 0x00
TCON 0x00
TH1 0x00   TL1 0x00
PC 0x0000
R7 0x00   R6 0x00   R5 0x00   R4 0x00
R3 0x00   R2 0x00   R1 0x00   R0 0x00
B 0x00   ACC 0x00   PSW 0x00   IP 0x00   IE 0x00
PCON 0x00   DPH 0x00   DPL 0x00   SP 0x07
pins  bits
0xFF  0xFF P3
0xFF  0xFF P2
0xFF  0xFF P1
0xFF  0xFF P0
addr 0x00   0x00 value
```

```
P0.7  1  Display-select Decoder CS|DAC WR
P0.6  1  Keypad Column 2
P0.5  1  Keypad Column 1
P0.4  1  Keypad Column 0
P0.3  1  Keypad Row 3
P0.2  1  Keypad Row 2
P0.1  1  Keypad Row 1
P0.0  1  Keypad Row 0
P1.7  1  LED 7|Seg. dp|DAC DB7|LCD DB7
P1.6  1  LED 6|Seg. g|DAC DB6|LCD DB6
P1.5  1  LED 5|Seg. f|DAC DB5|LCD DB5
P1.4  1  LED 4|Seg. e|DAC DB4|LCD DB4
P1.3  1  LED 3|... d|..DB3|..DB3|.. RS
P1.2  1  LED 2|... c|..DB2|..DB2|LCD E
P1.1  1  LED 1|Seg. b|DAC DB1|LCD DB1
P1.0  1  LED 0|Seg. a|DAC DB0|LCD DB0
P2.7  1  SW 7|ADC DB7
P2.6  1  SW 6|ADC DB6
P2.5  1  SW 5|ADC DB5
P2.4  1  SW 4|ADC DB4
P2.3  1  SW 3|ADC DB3
P2.2  1  SW 2|ADC DB2
P2.1  1  SW 1|ADC DB1
P2.0  1  SW 0|ADC DB0
P3.7  1  ADC RD|Comparator Output
P3.6  1  ADC WR
P3.5  1  Motor Sensor
P3.4  1  Display-select Input 1
P3.3  1  AND Gate Output|Display-se..t 0
P3.2  1  ADC INTR
P3.1  1  Motor Control Bit 1|Ext. UART Rx
P3.0  1  Motor Control Bit 0|Ext. UART Tx
```

```
    0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
10 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
20 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
30 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
40 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
50 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
60 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
70 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

Coding the Simulator



1) Above the assembly code window, you will see the toolbar depicted below. Either select “New” to begin a new assembly or “Load” to import an existing one
2) Once a program has been written or loaded, select either “Assm” or “Run” to execute it. If the simulator identifies any errors in the code, the program will not run, and a message will appear indicating where the problem originated
   - “Assm” is used to manually step through the code and observe the individual steps. Once it has been clicked, the button will change to “Step” and must be pressed repeatedly to advance the program one line of code at a time
   - “Run” will run the program all the way to the end without stopping. At any point, the user may pause the program by clicking the button again.
3) If you wish to stop the program from running entirely, select “RST”. This will end the program and allow you to make modifications or simply begin the program again
4) When finished, you can save your code as a **.asm** by clicking save, which will allow you to import your work at a later time

Sample Code:

1) A simple program to display binary values from 0 to 255 on the LEDs (note, since the simulator considers logic 0 to be ‘lit’ for the LEDs, the program must decrement instead of increment)

```
main:
       DEC P1 ;decrement instead of increment because logic 0 lights the LEDs
JMP main
```

2) A Program to mirror the 8 push buttons onto the corresponding LEDs

```
main:
       MOV P1, P2 ;move values on buttons into the LEDs
JMP main
```

Simulation Video (Amir & Buxton)

https://youtu.be/x5dIODI726U

Sample Project (Cain & Kelly)

Below is a fully functional program that may be run on the simulator. The program is designed to control the water level in a bucket used as part of a hydroponic garden. Switches 1, 2 and 3 on the board serve as stand ins for a trio of float sensors that will activate when the water level reaches a set height. The first four LEDs on the board correspond to the four devices that the system needs to control. LED 0 represents the input valve, LED 1 represents an aerator that needs to run for 5 seconds each time a switch is flipped for the first time. LEDs 3 and 4 represent the drain valve that will allow the water out (3), and a light that is required to be turned on while the bucket empties (4). Recall that, as with the earlier example programs, logic 0 is required to “light” the LEDs, so CLR is used to light them instead of SETB.3

```
main:
       JNB F0, initialize ; F0 is a flag that is set when initialization has been run once
       SETB P1.1 ; ensure that the aerator is off
       JB P0.3, drain ;ifP0.3 is set, the bucket has finished filling and should begin to drain
       CLR P1.0 ; Begin filling the bucket
       JNB P2.3, Switch3 ; is the third switch tripped? (note that the last switch must be the first checked so as to not get stuck)
       JNB P2.2, Switch2 ; Is the second switch tripped?
       JNB P2.1, Switch1 ;Is the first switch tripped?
       JMP main ; continuously loop

Switch1:
       JB P0.0, main ; If this function has been executed before return to main
       SETB P0.0 ; set as flag that this function has been executed
       JMP aerate ; jump if this is the first time the switch read as pressed

Switch2:
       JB P0.1, main  ; If this function has been executed before return to main
       SETB P0.1 ; set as flag that this function has been executed
       JMP aerate ; jump if this is the first time the switch read as pressed

Switch3:
       JB P0.2, main ; If this function has been executed before return to main
       SETB P0.2 ; set as flag that this function has been executed
       SETB P0.3 ; set to indicate that bucket is full
       JMP aerate ; jump if this is the first time the switch read as pressed

aerate:
       SETB P1.0 ; stop filling
       CLR P1.1 ; start aerator
       JMP delay ; jump to delay

delay:
       MOV R0,#20 ; set loop count to 20
       JMP countdown ; jump to countdown


countdown:
       DEC R0 ; Decrement R0
    DJNZ R0,countdown ; keep looping until R0 hits 0
       JMP main ; return to main

drain:
       CLR P1.2 ; open drain valve
       CLR P1.3 ; turn on light
       JNB P2.1, drain      ; keep looping until the water drops below the first sensor
       SETB P1.2 ; close drain valve
       SETB P1.3 ; turn off light
       JMP initialize ; Reset the flags so the program can restart automatically

initialize: ; This functions sets flags to ensure certain functions are only run once (aerate once per switch,  drain once)
       CLR P0.0 ; This will be set when the first sensor is tripped
       CLR P0.1 ; This will be set when the second sensor is tripped
       CLR P0.2 ; This will be set when the third sensor is tripped
       CLR P0.3 ; This will be set after the third switch is tripped to confirm that the bucket is full
       SETB F0 ; Set to confirm that this function has been run once
       JMP main ; return to main
```

Disclaimer

This manual was prepared strictly for academic use. All the information gathered here have been collected via research and aimed to guide any student to start using the BIG 8051 microcontroller. All the pictures of the development system were taken by Sajid Amir and should not be copied.

References:

- http://www.mikroe.com/downloads/get/1460/big8051_manual_v100.pdf
- http://www.silabs.com/Support%20Documents/Software/8051_Instruction_Set.pdf
- http://www.botskool.com/tutorials/electronics/8051/introduction-8051-assembly-language-programming?page=1
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