JX-2148
LPC2148 ARM7-32 bit Microcontroller Education board

1. Kit Contents

In standard package of JX-2148 board include:

1. JX-2148 Education board x 1
2. CX-232 serial port cable x 1
3. AWG #22 wire jumper, 7cm. length x 10
4. Documentation x 1
5. CD-ROM x 1

To run this education board you’ll need: DC adaptor +6Vdc 500mA (maximum +9Vdc)

2. JX-2148 board features

- LPC2148 microcontrollers are based on a 32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high-speed flash memory 512 kB. A 128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at the maximum clock rate

- Standard JTAG connector

- USB 2.0 Full Speed Interface (USB connectortype B). JX-2148 board provides a USB interface connector that interfaces ot the on-chip USB peripheral of the LPC2148 device. You may configure the board as self-powered or USB powered device.

- Dual Serial Ports. JX-2148 provides standard DB9 connectors for both of the LPC214x's serial ports. UART-0 for communication and support In-System Programming (ISP), UART-1 for serial communication and select to connect ESD-02 Bluetooth module (optional) by jumpers.

- SD/MMC socket. The JX-2148 provides one SPI module to interface SD/MMC memory socket.
- A PS/2 jack for interface Keyboard or Mouse.
- 2 of push-button switches with resistor pull-up.
- 2 of LED indicator
- Analog Voltage Control for ADC Input. JX-2148 provides an adjustable analog voltage source for testing the A/D converter feature of the LPC2148.
- A small buzzer for sound experiment
- Mini-breadboard 170 points contact.
- 32kHz crystal and +3V battery backup for real-time clock system within MCU.
- +3.3V on-board regulator for MCU and +5V for PS/2 circuit.
- Polarity voltage protection.

3. System requirements

To use the JX-2148 Education Board, the following item must be prepared:

- An IBM-compatible PC with port of the following:
  - one unused USB ports to test USB experiment
  - at least one unused RS-232 port for In-System Flash Programming via Serial Interface. If have two better, because can download and test communication both.
- Install Windows XP Operating System
- Install µVision3 or Keil ARM tool kit evaluation version. Download at www.keil.com
- Install LPC2000 In-system programming utility software from Philips. Download at www.philips.com and search by keyword “Microcontroller ARM7”.
- USB to RS-232 serial port converter. In case the computer does not provide RS-232 port. (Suggest UCON-232. See detail at www.inexglobal.com)
- DC adaptor +9V 500mA recommended.
- A serial cable, 9-pin male to 9-pin female, 1.8 m length, wired one-to-one. In case using both UART in same time. CX-232 cable from INEX recommended
- ESD-02 Bluetooth module if need to make wireless communication.
- PS/2 Keyboard if need to make PS/2 keyboard interface experiment.
- PS/2 Mouse if need to make PS/2 mouse interface experiment.
- USB cable, AB type not over 3m. length for testing USB interface.
4. JX-2148 board layout

The figure 1 illustration shows the important interface and hardware components of the JX-2148 board.
5. JX-2148 operation

The operation of JX-2148 board has 3 main sections following:

1. LPC2148 microcontroller unit
2. Power supply
3. Input/Output circuit

**Microcontroller unit** consists of Philips's LPC2148 and 2 of clock oscillator circuit; 12MHz main clock oscillator and 32.768kHz for real-time clock. The full schematic can see in the figure 2.

**Power supply** of JX-2148 has 2 regulator. One is +3.3V. It receives +6 to +16V from external DC adaptor. The 3.3V regulated circuit supplies to the microcontroller unit and many I/O devices. Another one is +5V for supply PS/2 circuit.

**Many I/O devices** are installed on the JX-2148 board. Includes LED, Push-button switches, Variable resistor for A/D converter circuit, Two of RS-232 serial port interface, PS/2 jack, MMC/SD socket, USB port interface, JTAG interface for many debugger such as ULINK from Keil or Olimex JTAG adaptor or Wiggler from Macraigor, ESD-02 Bluetooth connector, Free I/O microcontroller port and a Mini-breadboard 180 points for construction the experimental circuit.

6. JX-2148 circuit description

The complete schematic of the JX-2148 board shows in the figure 2. The main device is Philips's LPC2148 ARM7 microcontroller. LPC2148 is assigned to connect many I/O devices as:

- P0.00/TxD0 and P0.01/RxD0 are connected to RS-232 serial port interface at UART0
- P0.02/SCL0 and P0.03/SDA0 are connected with I²C bus or Two wire interface (TWI)
- P0.04 to P0.07 are connected SPI bus
- P0.08/TxD1, P0.09/RxD1, P0.10 and P0.11 are connected with serial port interface circuit; UART1 and ESD-02 Bluetooth module connector. User can select by jumpers. P0.10 pin is connected with CTS pin and P0.11 is connected with RTS pin. See the figure 3.
Figure 2  JX-2148 board schematic diagram
P0.12 and P0.13 are connected to buzzer.

P0.15 and P0.16 are connected with PS/2 jack. P0.15 is data pin and P0.16 is clock pin.

P0.17 to P0.20 are SSP module port. They are connected with MMC/SD socket.

P0.21 and P0.22 are connected with LED in active low.

P0.25 is D/A output of D/A converter module in LPC2148.

P0.28 and P0.29 are connected push-button switches with pull-up resistors.

P0.30 is connected with 10kΩ variable resistor for testing A/D converter module.

P0.31 is used to control USB port interfacing and connected with REDY connection indicator circuit.

P1.16 to P1.23 are free port.
P1.24 and P1.25 are connected MMC/SD socket to testing card insertion.

P1.26 to P1.31 are assigned as JTAG interface.

**In-system flash programming of JX-2148 will work via UART0 module. SW3 is ISP mode switch. Must press this switch to enter ISP mode.**

LPC2148 has each of SPI (Serial Peripheral Interface) and SSP (Synchronous Serial Port) module. The SSP module can work in SPI mode. On JX-2148 board define SSP to connect with MMC/SD card interface. The SPI module (SPI0) will reserve to connect additional SPI peripheral.

In A/D converter demonstration, on JX-2148 board provides one POT or variable resistor is connected at P0.30 ready to test with programming.

In testing simple I/O port, the JX-2148 board provides 2 of LED that connected with P0.21 and P0.22. About input device, provides 2 of push-button switch to connect with P0.28 and P0.29. Two port pins P0.12 and P0.13 are connected with buzzer to sound generator.

PS/2 interface need +5V. LM2931-5.0 IC is regulator +5V IC. It receive input voltage from main DC adaptor.

USB interface use USBD+ and USBD- pin. They are connected limited current protection resistor. Port 0.23/VBUS is connected with +5V from USB port connector. Interface controlling port is function of P0.31 port pin. In connection must control this pin to logic “0”. Thus, user can control the USB connections via software.

**REF jumper**: use to select the reference voltage of A/D converter module. Normally connected with +3.3V. If need to use external reference voltage, user can do very easy step. Remove jumper out and connect the external reference voltage with middle pin of REF jumper.

**DEBUG EN. jumper**: Select to enable debugging via JTAG connector.
7. Software Development tools:

7.1 Keil µVision3 evaluation version

The JX-2148 board can develop with any software development such as WinARM with Eclipse IDE or Keil µVision3. However in this documentation will suggest Keil µVision3 evaluation version. Developers can purchase the full version from www.keil.com.

The limitation of Keil µVision3 evaluation version is:

- Programs that generate more than 16K Bytes of object code will not compile, assemble, or link.
- The evaluation tools create Symbolic Output Format when the RealView compiler is selected. Fully licensed tools generate standard ELF/DWARF files.
- The debugger supports programs that are 16K Bytes or smaller.
- The RealView Linker does not accept scatter-loading description files for sophisticated memory layouts.
- The RealView Linker restricts the base address for code/constanats to 0xXX000000, 0xXX800000, or 0x00080000 where XX is 00, 01, ..., FF. This allows memory start address like 0x00000000 and 0x12800000.
- It is not possible to generate position independent code or data. The RealView C/C++ Compiler does not generate a listing file.
- The CARM compiler, assembler, and linker are limited to 16K Bytes of object code. Source code may be of any size.
- The GNU ARM tools (compiler, assembler, and so on) that are provided are not limited or restricted in any way.

7.1.1 Download

All steps are introduced in this document can change anytime depend on the owner website.

(1) Enter to Keil webpage by type URL as www.keil.com following the figure 4. See Software header and select Evaluation Software.
(2) After that Evaluation Software page will appear following the figure 5. Select ARM Evaluation Software.

Figure 4 Keil’s homepage

Figure 5 Evaluation Software webpage for download. Select ARM Evaluation Software.
(3) Developers must register before download following the figure 6. After complete, click Submit button to confirmation.

![Figure 6 Evaluation Software Registration form.](image)

(4) Download webpage will appear following the figure 7. Click at RVMDK300A.EXE file. Its size is 50MB approximation.

![Figure 7 ARM Evaluation Software Download webpage](image)
(5) Saving file dialog box will appear following the figure 8. Click **Save** button and define path and folder for saving file. After that downloading will begin and shows status following the figure 9.

7.1.2 Installation Keil µVision3 and Preparation

(1) After download complete, double-click at the installation file. The first installation window will appear following the figure 10. Click **Next** button.

![Figure 8: Saving file dialog box.](image1)

![Figure 9: Download software status](image2)

![Figure 10: The First Keil µVision3 installation window](image3)
(2) Enter to License Agreement window following the figure 11. Click at box of message “I agree to all the terms of the preceding License Agreement”. Click Next button.

![License Agreement window](image1)

Figure 11 License Agreement window of Keil µVision3

(3) Folder Selection window will appear. Suggest to install into Keil folder following the figure 12.

![Folder Selection window](image2)

Figure 12 Folder Selection window of Keil µVision3
(4) The Customer Information window will appear following the figure 13. Must to put the user information in the blank box. Click Next button.

![Customer Information Window](image)

**Figure 13** Customer Information window.

(5) Installation software will start and shows status following the figure 14.

![Setup Status Window](image)

**Figure 14** Setup status window shows the installation status.
(6) After installation complete, the window in figure 15 will appear. Click **Finish** button to ending installation.

![Figure 15](image1.png)

**Figure 15** Completed installation window

(7) Run Keil µVision3 program. The main program window will be show following the figure 16.

![Figure 16](image2.png)

**Figure 16** The main window of Keil µVision3
(8) Enter Project → Component, Environment, Book... menu following the figure 17.

Figure 17 Shows the selection Project → Component, Environment, Book...

(9) Component, Environment, Book window will appear. At Select ARM Development Tools menu, select Use Keil CARM Compiler to select compiler as Keil CARM following the figure 18. After that developers can develop their own softwares.

Figure 18 Shows the selection Keil CARM compiler to program development preparation.
7.2 Philips LPC 2000 Flash utility

The Philips LPC 2000 Flash utility provides In-System Flash Programming (ISP) support for Intel HEX files. The Philips LPC 2000 Flash Utility connects the PC’s COM port to the serial port UART0 of the J X-2148 Education board. The installation program for this utility is included on the INEX J X-2148 CD-ROM or may be downloaded from the Philips Web Site. The LPC 2000 Flash Utility may be run as a stand-alone utility or as an external tool from within the mVision IDE. The version of LPC 2000 Flash utility can support LPC 2148 is V2.2.3 or higher.

The normal installation file name of Philips LPC 2000 Flash utility is Philips Flash Utility Installation.exe. Double-click that file. Accept all confirmation until installation complete.

8. Develop programs

This sections introduce you to the Keil development tools, and take you through the process using them with the J X-2148 board. You’ll learn how to use mVision to create, compile, download, and run a program on this board.

Developing programs for the J X-2148 board is easy. The process is:

1) Creating Application Programs using the µVision IDE and the Keil, GNU or ARM ADS C Compiler.

2) Download the program to the on-chip Flash of the J X-2148 Board.

8.1 Building C project file

1) Run Keil µVision3. The main window will appear following the figure 19. If have any project opened, can close by select menu Project → Close Project

2) Build new project. Enter menu Project → New Project..following the figure 20.

3) The Create New Project window will appear. Set path of project file, from example set to c:\ following the figure 21. Make new folder for storing project file in name led.
Figure 19 Shows the main window of Kei\textsubscript{u}Vision3

Figure 20 Shows the selection to make the new project.

Figure 21 Shows the Create New Project window for making the new project.
(4) Enter to led folder. Define the filename as led following the figure 22. Click **Save** button to next step.

![Create New Project](image)

**Figure 22** Define the project filename to led at Create New Project window.

(5) The **Select Device for Target** window will appear following the figure 23 for selection microcontroller from Manufacturer listing.

![Select Device for Target](image)

**Figure 23** Shows the Select Device for Target window for microcontroller selection.
(6) Select the manufacturer in Data base header to Phillips and select LPC2148. At Description header is on the right, shows the detail and properties of selected microcontroller following the figure 24. Click OK button to next step.

![Select Device for Target 'Target 1'](image1)

**Figure 24** Shows the selection of Philips LPC2148

(7) After that you will see the dialog box ask about copying LPC2100 Startup code into your project following the figure 25. Click No button for denying. Developers can copy the Startup code that store in INEX’s JX-2148 CD-ROM to this project later.

![Copy Philips LPC2100 Startup Code to Project Folder and Add File to Project?](image2)

**Figure 25** Asking about copy Startup Code to project.
(8) The project Workspace will appear following the figure 26.

Figure 26 The Project Workspace window

(9) For more comfortable, copy the start up file includes main.c and Startup.s from keil_2148_system folder in CD-ROM (or download from www.inexglobal.com; this start up file INEX modify for support all developers) to path of project. In this example is C:\led following the figure 27.

Figure 27 Shows the copying main.c and Startup.s file from keil_2148_system folder in CD-ROM to led Projectd
(10) Click at + sign front the Target1 project for preparing to add main.c and Startup.s file. These file will be the system files for developing the programs in the future. Then, found Source group 1 file, click right button of mouse for select Add Files to Groups instruction to add main.c and Startup.s file into this project following the figure 28.

![Figure 28 Adding file main.c and Startup.s into the project.](image)

(11) The Add Files to Groups window will appear. Select path in Look in: box to led project path; c:\led. Select File of type as All Files(*.*) for watching all files and can select Startup.s file following the figure 29.

![Figure 29 Shows the Add Files to Groups window to adding files.](image)
(12) Press Ctrl key and hold it. Click to select main.c and Startup.s file for adding files into the project. After that click **Add** button once. Both files will add into this project following the figure 30. Click **Close** button to next step.

![Image](image1.png)

**Figure 30** Shows adding file main.c and Startup.s into the project.

(13) Double-click at main.c file at **Project Workspace window**. The editing window will appear. This window is called **template**. Include **init** function to initialize the program operation relate with clock oscillator and PLL (Phase Lock Loop) within LPC2148. The main program will declare below. See the figure 31.

![Image](image2.png)

**Figure 31** Shows the main.c file that adding into project.
(14) Write the program addition from main program. The contents of program can show in the figure 32.

```
void main()
{
    long i;
    init();   // Initialize the system
    SCS = 0x03;  // select the "fast" version of the I/O ports
    FILEDIR |= 0x00400000;
    while(1)
    {
        FILEPIN ^= 0x00400000;
        for (i = 0; i < 1000000; i++);
    }
}
```

**Figure 32** Shows the C program that writes into main program.

(15) Set the project’s option to make the target file. Click **Option for Target** button at Tool bar following the figure 33. The steps of setting include:

**Figure 33** Shows position of Option for Target button at Tool Bar
(15.1) The **Option for Target window** will appear following the figure 34.

Select **Output** tab.

![Select Output tab](image)

**Figure 34** Shows the Option for Target window

(15.2) Click the listing following the figure 35.

- Select **Create HEX file** for making *led.hex* file after compile.
- Select **HEX format**: as **HEX-386**

After that click **OK** button.

![Select parameter](image)

**Figure 35** Parameter setting in Output tab of Option for Target window
(16) Compile project by select **Project → Build Target** or press **F7** key following the figure 36. The result is **led.hex** for downloading to MCU later.

Compiling result will show in text format at Output Window bottom section of main window following the figure 37. If compile complete, **led.hex** file will generate and store in same folder of project. In this example is **C:\led**.

If developers would like to open the old project for develop continue, select at menu bar **Project → Open Project** and select path that store the previous project. The project file has ***.uv2** file. See the figure 38 for example.

**Figure 36** Compiling the program by select at Project → Build Target

**Figure 37** Compiling result at Output window

**Figure 38** Select the previous file to edit or develop
8.2 Download programs and test

After compile the program, from example the result file is led.hex. Next step is downloading hex file to LPC2148 microcontroller and run it. Developers can check the operation at P0.22 LED. The downloading procedure is:

1. Apply the supply voltage to JX-2148 board. Turn-on POWER switch.
2. Connect download cable to the JX-2148 board and Serial port of computer.
3. Open the LPC2000 Flash Utility software. The main window will appear following the figure 39.

![LPC2000 Flash Utility](image)

**Figure 39** Main window of the LPC2000 Flash Utility

4. In the first time, developers must set some parameter before.
   - At Device box set as:
     - **Device** select to LPC2148
     - **XTAL Freq. [kHz]** set to 12000 (12MHz)
   - At Communication box set as:
     - **Connected To Port** select the serial port is connected
     - **Use Baud Rate** set baudrate 9,600 bps is default.
Figure 40 Shows the complete connection message at the status bar

(5) Set the JX-2148 board to ISP mode by press ISP SWITCH (its shaft will down) following press RESET switch once.

(6) At the main window of LPC2000 Flash Utility. Click at Manual Reset button once following click Read Device ID once too. If the connection is correct, status bar at left down corner will show message Read Part ID Successfully following the figure 40

If connection fail, the warning window will appear following the figure 41. Click Read Device ID button again and see the result. May be back to do in step 5 and 6 again.

Figure 41 Warning message about connection failed
(7) If connection complete, click at Browse button in Filename of Flash Programming. Select `led.hex` in path `c:\led\led.hex`. Next, click **Upload to Flash button** to download. After downloading complete the message **File Upload Successfully Completed** will show at the status bar.

(8) Developers can test the program by press ISP switch again to RUN mode (The switch’s shaft will release) and press RESET switch once. Observe the operation.

*LED at P0.22 blink continuous.*