

User's Manual

TK-78K0R/KG3+UZ

ZigBee™-ready

Wireless Network Evaluation Board

Using the UZ2400 RF chip

and the 78K0R/KG3 Microcontroller

Tutorial

Date published: March 2009

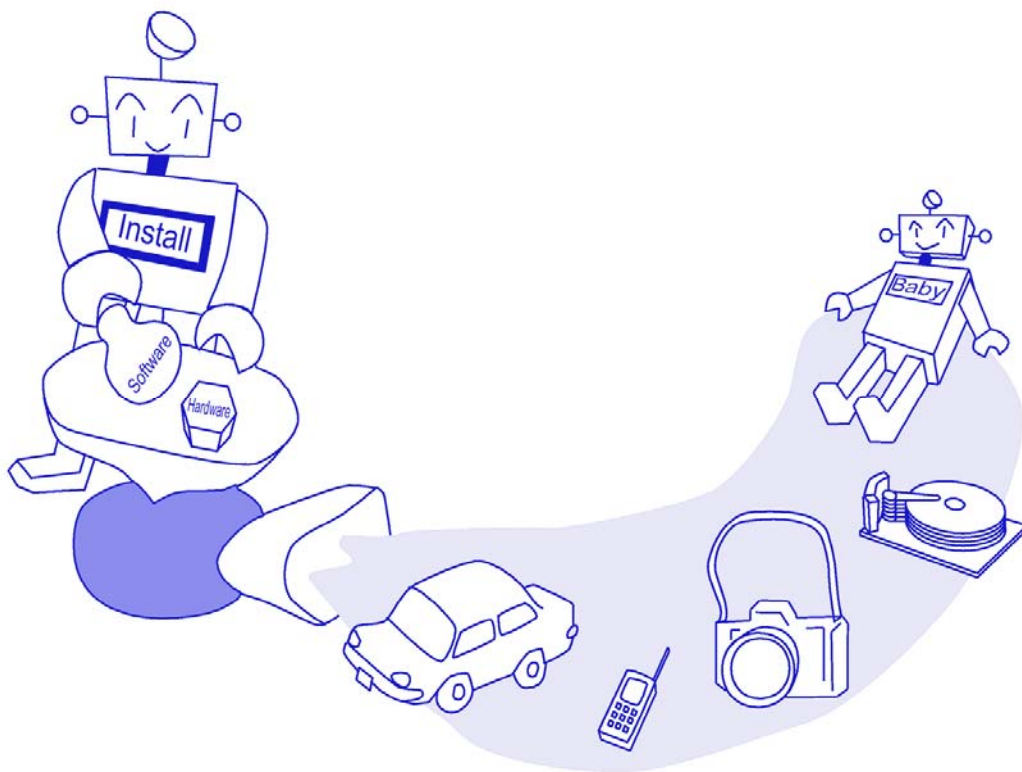
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Welcome to the world of TK-78K0R/KG3+UZ.

You are now being navigated to the design environment of the 78K0R microcontroller for developing wireless network applications. Please follow the tutorial step by step.



[NOTES]

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[CAUTION]

This equipment should be handled like a CMOS semiconductor device. The user must take all precautions to avoid build-up of static electricity while working with this equipment. All test and measurement tool including the workbench must be grounded. The user/operator must be grounded using the wrist strap. The connectors and/or device pins should not be touched with bare hands.

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1 Introduction

| | |
|---------------|---|
| Target Reader | Software development engineers who wish to become familiar with the development environment of the 78K0R microcontrollers. It is assumed that the readers have been familiar with basics of microcontrollers, C and assembler languages, and the Windows™ operating system. |
| Purpose | For readers to become familiar with the design environment and the application examples of wireless networks. |
| Overview | This manual consists of the following contents Chapter 1 Introductions → Overview of this manual Chapter 2 Preparations → Introduction of soft tools, and sample programs and installation Chapter 3 Experiences → Guide to the basic operations of PM + and the integrated debugger using sample programs. Chapter 4 IEEE 802.15.4 MAC Sample Programs → Learn sample programs, which utilize the MAC library Chapter 5 Mode Setting of the Board → Explanation of switch setting. |
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2 Preparations

This chapter introduces the development environment and describes how to install the sample programs. The sample program can be tested on this hardware platform of the evaluation kit.

2.1 Development Tools, Sample Programs, and the MAC Library

This section outlines the development tools, sample programs and the MAC library used in this tutorial.

2.1.1 Integrated Development Environment PM + V6.30

This is a project manager, where you work for editing the source code, compiling it, and initiating the debugger. The project manager works on MS Windows 2000 or XP.

2.1.2 Device file DF781188 V3.00

A device file contains an MCU specific information. It instructs the development tools what kind of an MCU the tools shall work for.

2.1.3 C Compiler CC78K0R W1.20 : Code size limited version

This is a free compiler for the 78K0R microcontrollers. The object code size is limited to 64 Kbytes. It works on MS Windows 2000 or XP.

2.1.4 Assembler RA78K0R W1.10 : Code size limited version

This is a free assembler for the 78K0R microcontrollers. The object code size is limited to 64 Kbytes. It works on MS Windows 2000 or XP. The RA78K0R Assembler Package contains Structured Assembler Preprocessor, Assembler, Linker, Object Converter, Librarian, and List Converter.

2.1.5 78K0R integrated debugger ID78K0R-QB V3.40

The Integrated Debugger ID78K0R-QB offers a debug environment on your PC, where the MS Windows 2000 or XP runs, if the TK board is connected to the PC with USB. The USB I/F accesses to the OCD, On Chip Debug, interface on the microcontroller.

2.1.6 78K0R Starter Kit Setting

If you forget about the security ID or if you set “Does not erases data of flash memory in case of failures in enabling on-chip debugging”, you can erase the flash memory by using this starter kit.

2.1.7 USB driver

This is a software driver for PC to access to the USB interface of the TK-78K0R/KG3+UZ board.

2.1.8 The RF Test Program

The RF Test Program is used in [chapter 3 Experiences].

The RF Test Program is provided in the form of the C source codes.

If you wish to tailor the RF Test Program to meet your specific needs, you can edit the source code, re-compile it with debug build to generate a load module file, then, start the debugger to load the tailored execution code on to the microcontroller for further debugging on the project manager PM +.

Alternatively, if debugging is not required, you can make a release build to achieve a new hex file, on the project manager PM +.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0R/KG3+UZ board in a radio anechoic chamber.

2.1.9 IEEE 802.15.4 MAC Library

The IEEE 802.15.4 MAC Library offers an executable object-code library of the MAC stack specified in the IEEE 802.15.4. Please refer to the MAC Library manual for further details.

2.1.10 The MAC Sample Program1 : Text Chat Program

The MAC Sample program 1 is developed to provide with a simple example to construct a star network utilizing the IEEE 802.15.4 PHY/MAC standard.

The MAC Sample Program 1 offers,

- 1). Designation of a network coordinator in a star configuration
- 2). Text chat between a coordinator and an end device

To use the MAC Sample Program 1, you need to prepare at least two PC with a USB interface and two TK-78K0R/KG3+UZ boards.

The MAC Sample Program 1 is provided in the form of the C source codes.

If you wish to tailor the sample program to meet your specific needs, you can edit the source code, re-compile it with debug build to generate a load module file, then, start the debugger to load the tailored execution code on to the microcontroller for further debugging on the project manager PM +.

However, because the USB connection to instruct operation to the program is occupied for the debugging purpose, alternatively, you can make a release build to achieve a new hex file, on the project manager PM +.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0R/KG3+UZ board in a radio anechoic chamber.

2.1.11 The MAC Sample Program2 : LED Control

The MAC Sample program 2 is developed to provide with another simple example to construct a star network utilizing the IEEE 802.15.4 PHY/MAC standard.

The MAC Sample Program 2 offers,

- 1). Designation of a network coordinator in a star configuration
- 2). LEDs on the coordinator board indicate which switch on which end device is pressed.

To use the MAC Sample Program 2, you need to prepare one PC with a USB interface and two TK-78K0R/KG3+UZ boards or more boards, up to 5.

The MAC Sample Program 2 is provided in the form of the C source codes.

If you wish to tailor the sample program to meet your specific needs, you can edit the source code, re-compile it with debug build to generate a load module file, then, start the debugger to load the tailored execution code on to the microcontroller for further debugging on the project manager PM +. However, because the USB connection is occupied for the debugging interface, the USB connection is not available for applications. Alternatively, you may make a release build to achieve a new hex file, on the project manager PM +.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0R/KG3+UZ board in a radio anechoic chamber.

2.2 Installation of Software Development Tools

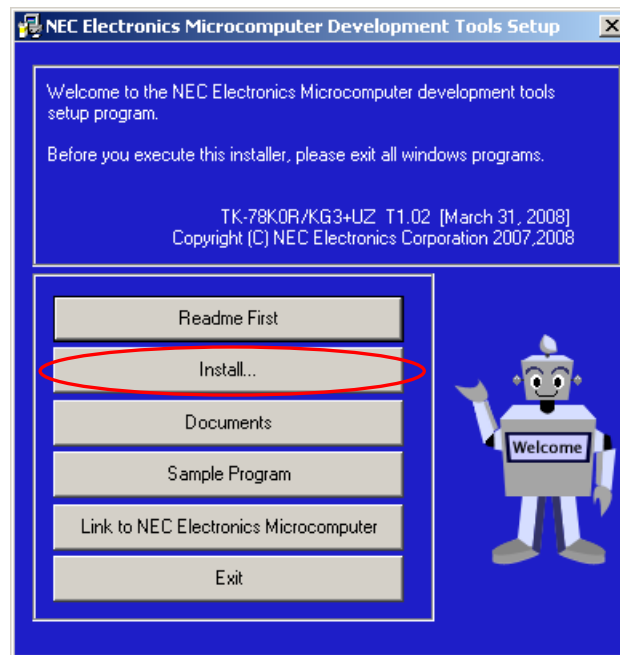
2.2.1 Start-up of the installation CD-ROM

The attached CD-ROM contains Development Tools, documents and sample software.

You can install it using an installer.

2.2.2 Installation of the software development tools.

Please insert the CD-ROM in the drive. The installer will show up automatically. If it does not start automatically, please initiate it by double clicking the SETUP.EXE.



<1> Readme First

The contents of the CD-ROM, and some notes are available. Please read it at first.

<2> Install...

Click "Install" to start installation of development tools. For details, please refer to the next section.

<3> Documents

Manuals of development tools and the evaluation kit are available in PDF files.

When this button is clicked, the WWW browser will start. Adobe® Acrobat® Reader is available in the CD-ROM.

<4> Sample Program

Click this button to start the WWW browser for the sample program and the tutorial.

<5> Link to NEC Electronics Microcontrollers

Click this button to start the WWW browser display the link to the NEC Electronics Microcontroller web site
(http://www.necel.com/micro/index_e.html)

The NEC Electronics Microcontroller web page provides with the latest product/tool information and FAQs.

<6> Exit

Terminate the setup.

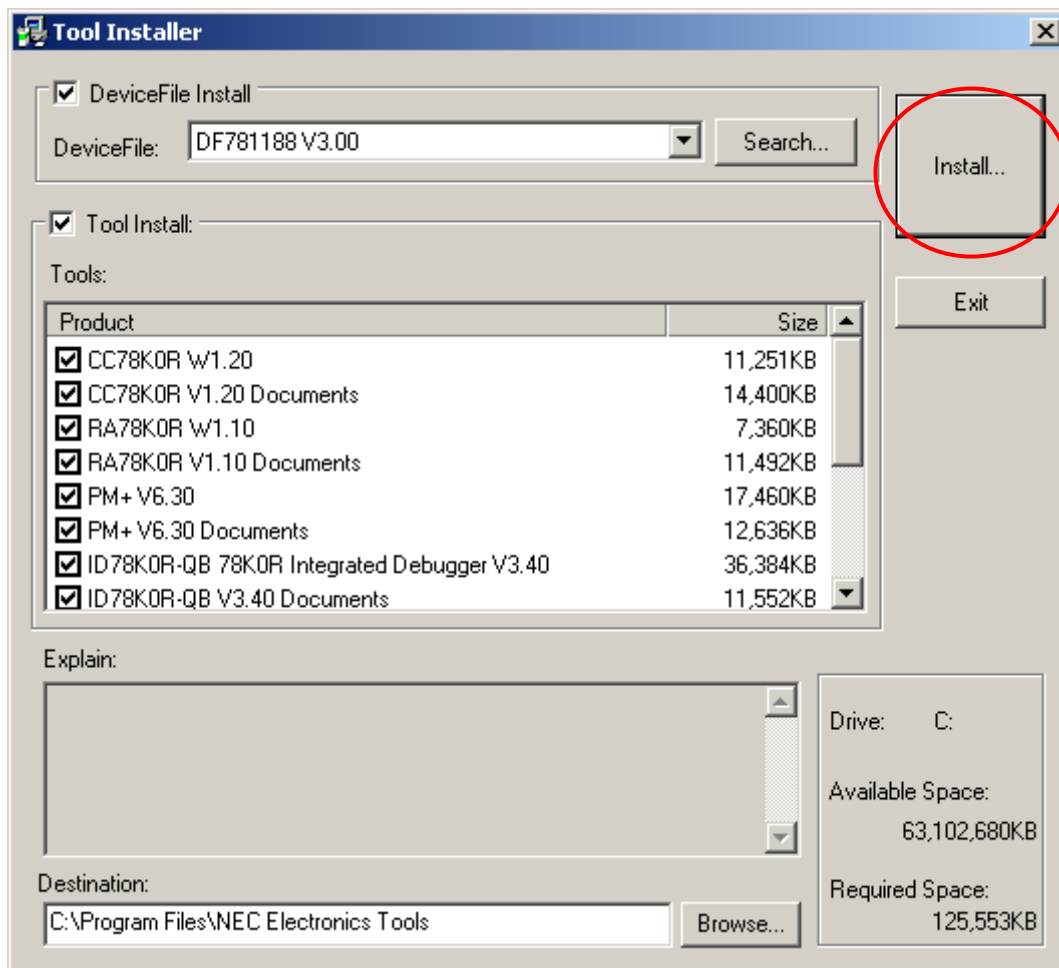
- ① Select products that you need to install.
(as default, all the products that you need to use the demonstration kit are selected.)

"Explain" area displays an explanation of the selected product.

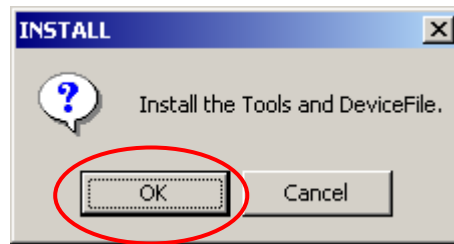
To change the installation destination, click .

When all the settings are completed, click .

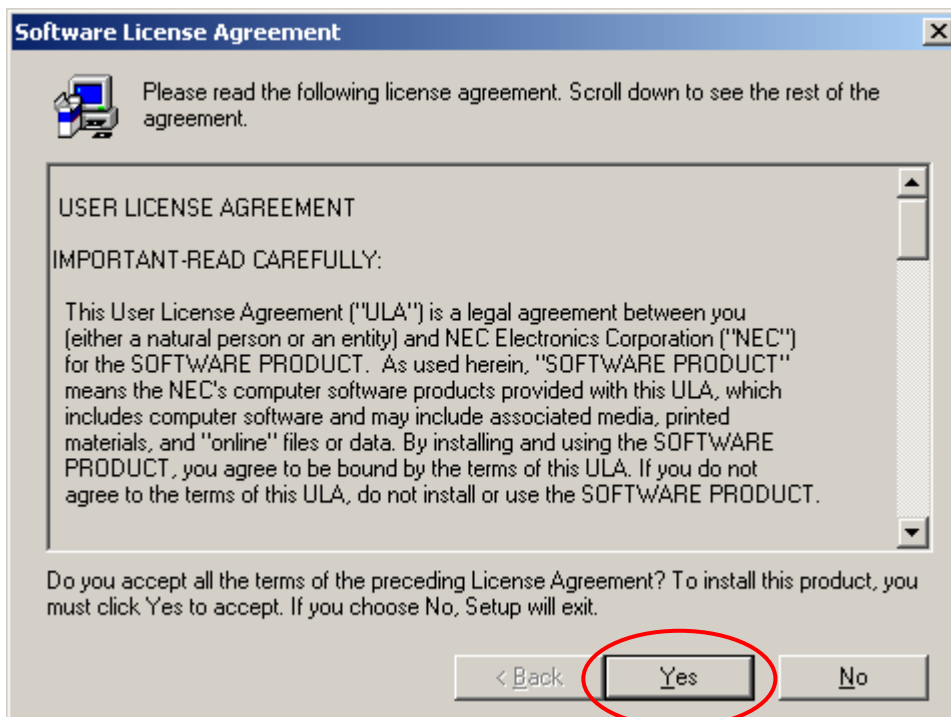
- * In this document, it is assumed that users install the programs under "NEC Electronics Tools" directory (default installation directory). Users can find the tools by selecting "Start Menu" -> "Programs" -> "NEC Electronics Tools".



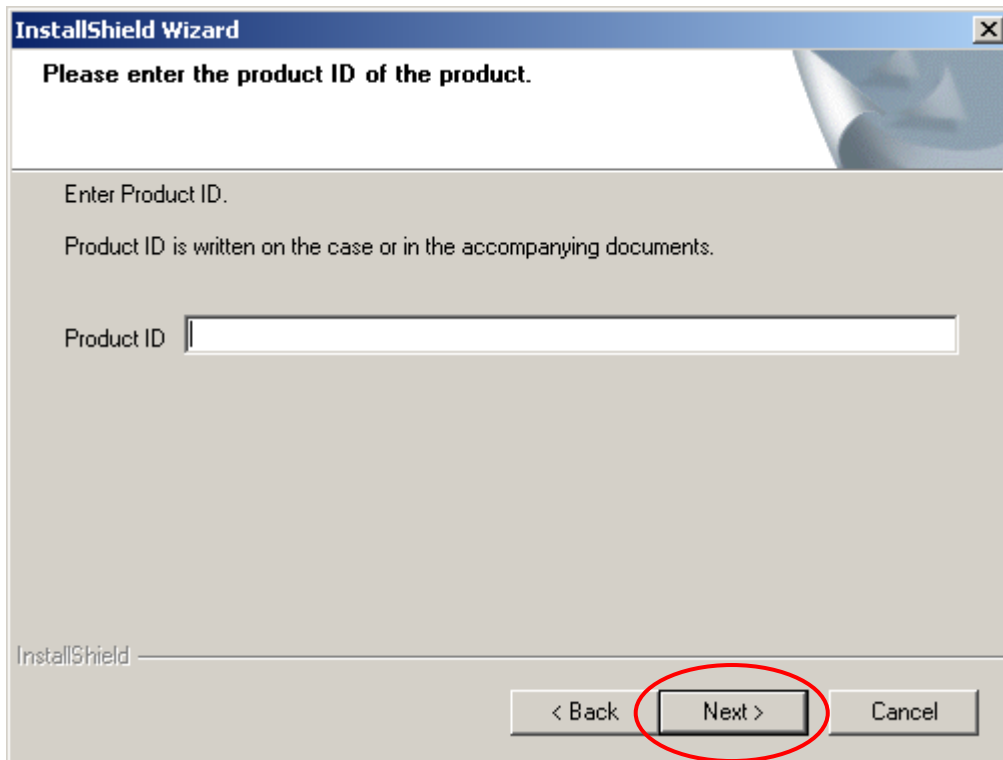
- ② Click **OK** when "Install" confirmation dialog box is opened.



- ③ Read "software license agreement" and click **Yes** for continuing the installation. To stop the installation, click **No**.

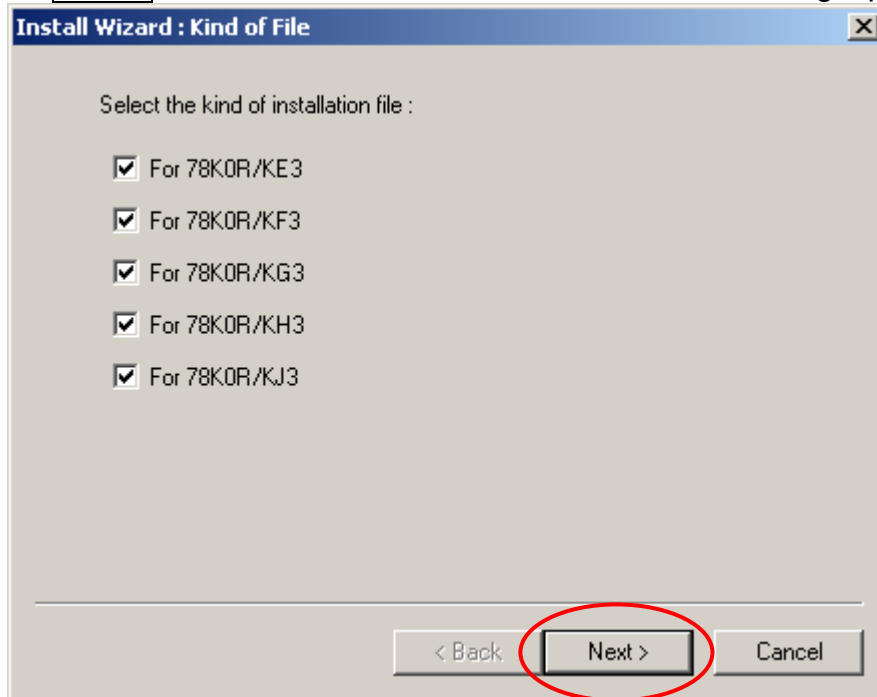


- ④ Enter the product ID, and click **Next** .
* The product ID is available on the “README.html” the other sheet.

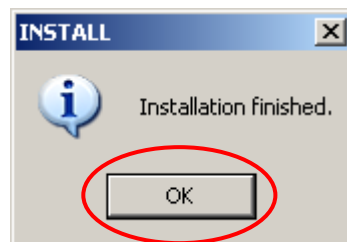


- ⑤ It starts copying the files.

- ⑥ Click **Next** when "Select Files" installation wizard dialog opened.



- ⑦ When the installation is completed, the following dialog opens. Click **OK** .



- ⑧ "NEC Electronics Starter Kit Virtual UART" USB driver must be installed on PC before you connect to TK-78K0R/KG3+UZ. Install the USB driver by referring "2.4 USB Driver".

Notes on the installation authority

To install this tool in Windows 2000 or XP, the authority of an administrator is necessary. Therefore, please login as an administrator.

Notes on the install-directory

Please do not use 2-byte characters, such as umlaut in the directory name, where the product is to be installed.

Note on the version of Windows

If the language of the Windows is not English, a file transfer error during installation might be observed. In this case, please abort the installation in the language, and re-install it in an English version of Windows.

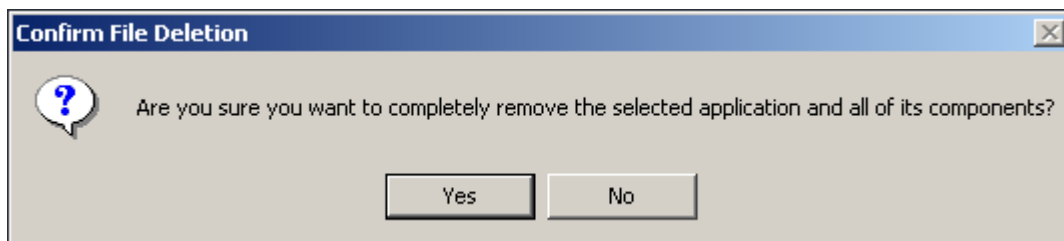
The identical problem may be observed, if a language other than English is specified as the system language in the “Regional Settings Properties” tab.

2.2.3 Uninstall

- <1> Start "Add /Remove Programs" in the Control Panel.
(Example here is based on Windows2000)



- <2> Select the tool that you want to uninstall from the list displayed in "Install/Uninstall" and click [Add/Remove...].
- <3> A dialog box for confirming deletion of files will be displayed. Click . Deleting of the files will be started.



- <4> When the completion message is displayed, click .

Caution:

Deletion of some files may be asked during uninstallation. Normally, deletion of these files causes no problem.

- <5> This completes uninstalling this tool.

2.2.4 File Configuration in PC

Software Development Tools are installed in "C:\Program Files\NEC Electronics Tools" on default setting.

When you use the tools, please open the tools from [Start menu] -> [Programs]->[NEC Electronics Tools].

2.3 Sample Environment

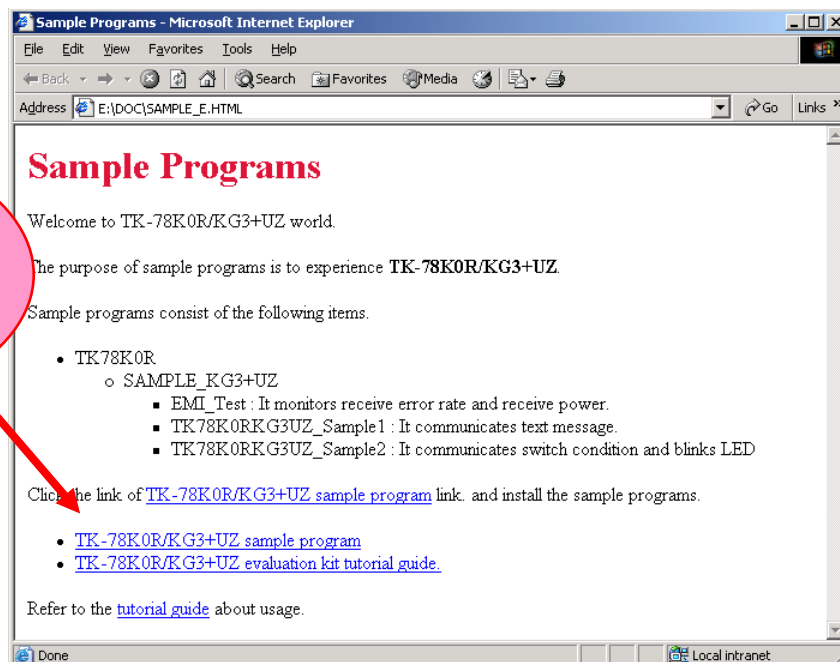
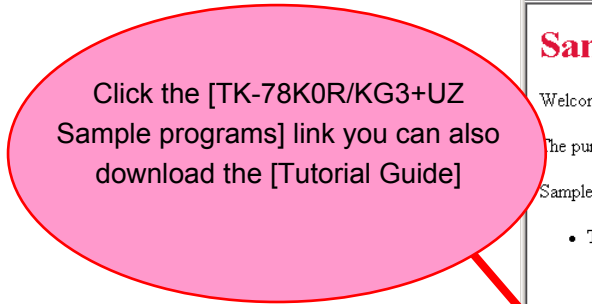
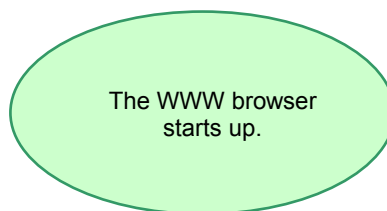
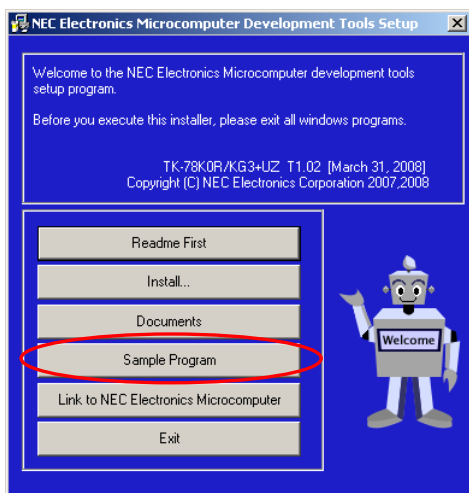
This section explains the overview and preparation of sample programs. You need to install the sample programs on your system first before using them.

How to install the sample programs and where they should be installed on your system will be explained.

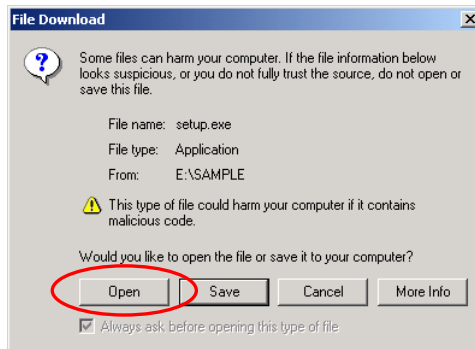
2.3.1 Installation of the sample programs

Insert the CD-ROM disk in the CD-ROM drive of your PC. The [NEC Electronics Microprocessor Development Tools Setup] screen automatically appears.(if this screen does not appear automatically, start setup.exe from Explorer. etc.)

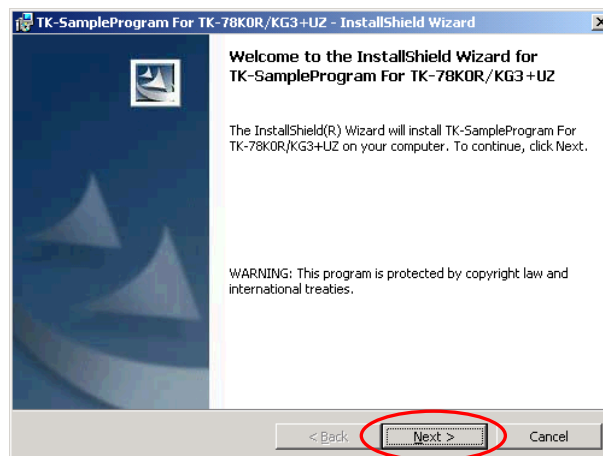
Press the **Sample Program** button to start the WWW browser, and then click the [TK-78K0R/KG3+UZ Sample Programs] link.



When[TK-78K0R/KG3+UZ Sample Programs] is clicked, the following download confirmation window appears.

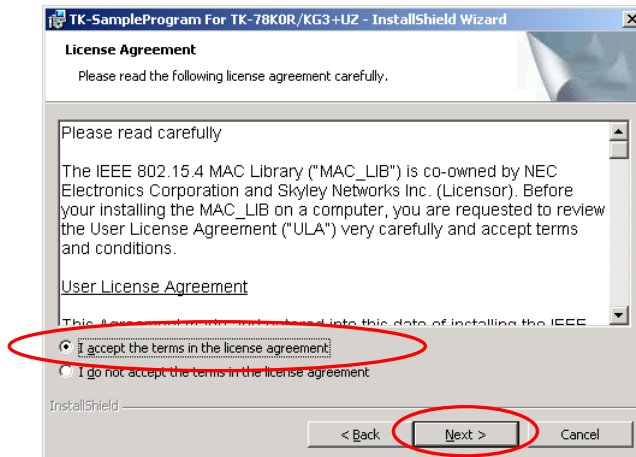


Please click the **Open** button.
In case of windows 2000,
you will see the [Security Warning] window. Please click **Run**.

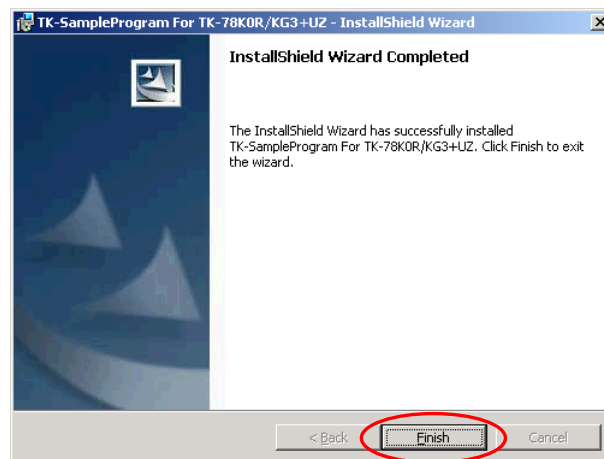


InstallShield wizard for TK-Sample Program starts up
Please click **Next**.





License agreement screen is displayed.
Please select "I accept the terms in the license agreement".and click **Next**.



Please click **Finish**.

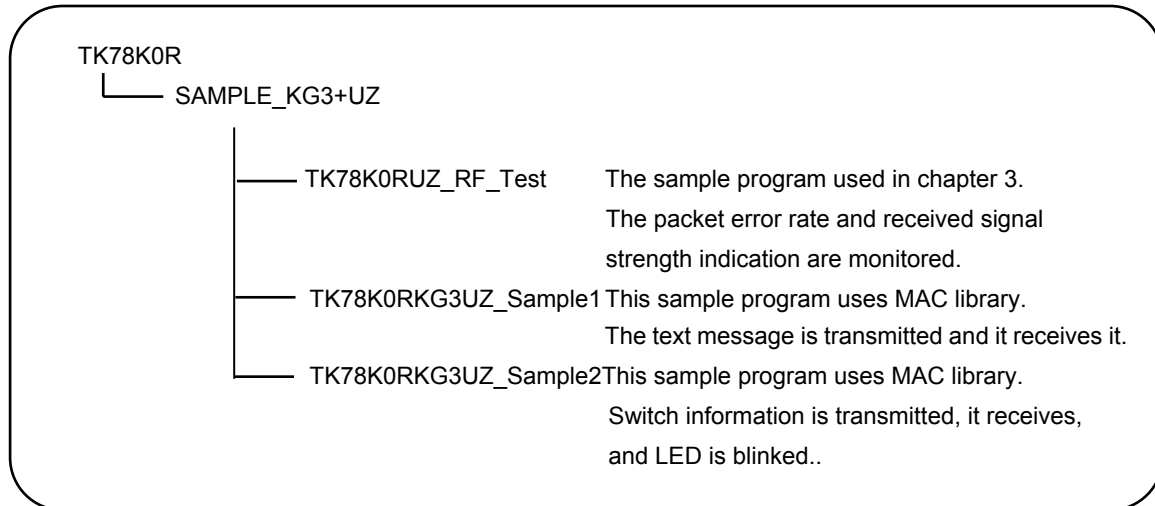
The sample programs are installed under "C:¥" now.

The sample program "TK78K0R.EXE" with self-extract file is also installed. When you need to use the original sample programs, you can extract the file "C:¥TK78K0R.EXE".

When you uninstall the sample program.
Please use "Add /Remove Programs" in the Control Panel.

2.3.2 File Configuration of the sample program

The sample programs were the following folders.



2.4 USB Driver

You need to install “NEC Electronics Starter Kit Virtual UART” in your PC.

When TK-78K0R is used, it is necessary to install the “NEC Electronics Starter Kit Virtual UART” driver in the host machine. Please install the driver according to the following procedures with appending CD in the drive.

“Starter Kit USB Driver” must be installed on the PC. If not, please refer to “2.2 Installation of Software Development Tools” to install the “Starter Kit USB Driver” first.

Attention **Do not use a USB hub for connecting TK-78K0R/KG3+UZ.**

Depending on the version of Windows OS, the installation will be differed.

Please check your Windows version, and follow the instructions

- Windows XP -> “2.4.1 Installation to Windows XP”
- Windows 2000 -> “2.4.2 Installation to Windows 2000”

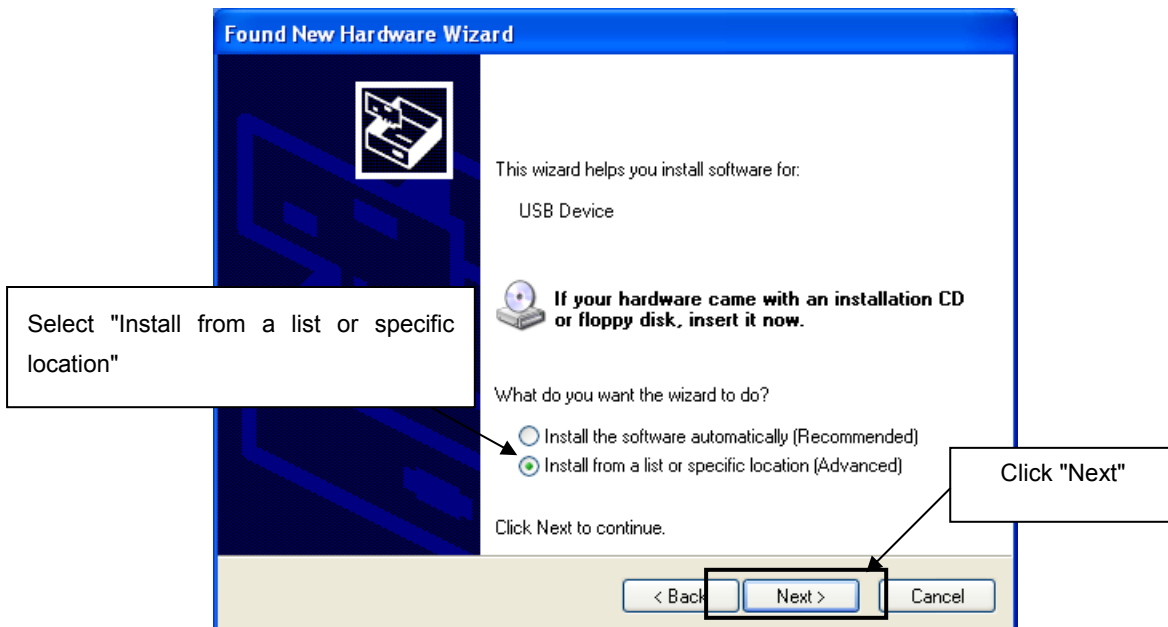
After the installation, go to “2.4.3 Confermation of the installation”

2.4.1 Install to Windows XP

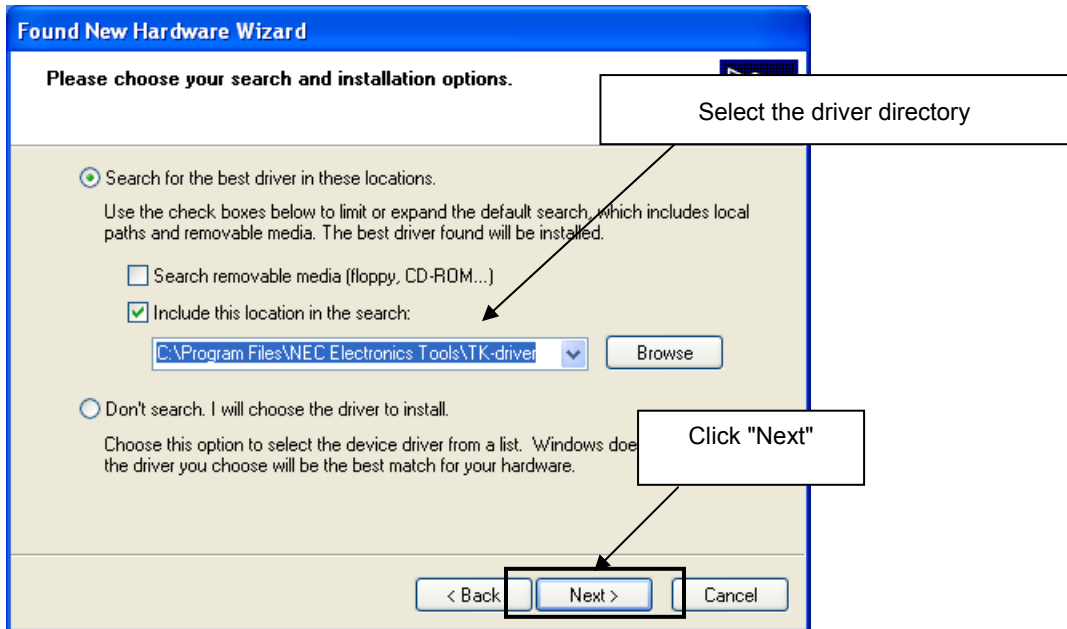
1. Once the TK-78K0R/KG3+UZ is connected with USB, the "Found New Hardware Wizard" will be started. Select "No, not this time" and click **Next >** .



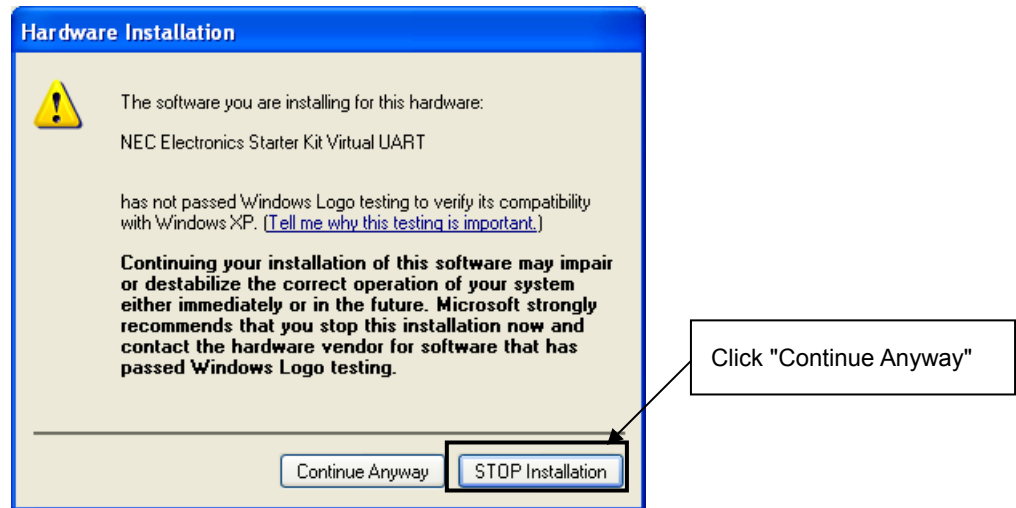
2. Select "Install from a list or specific location" and click **Next >** .



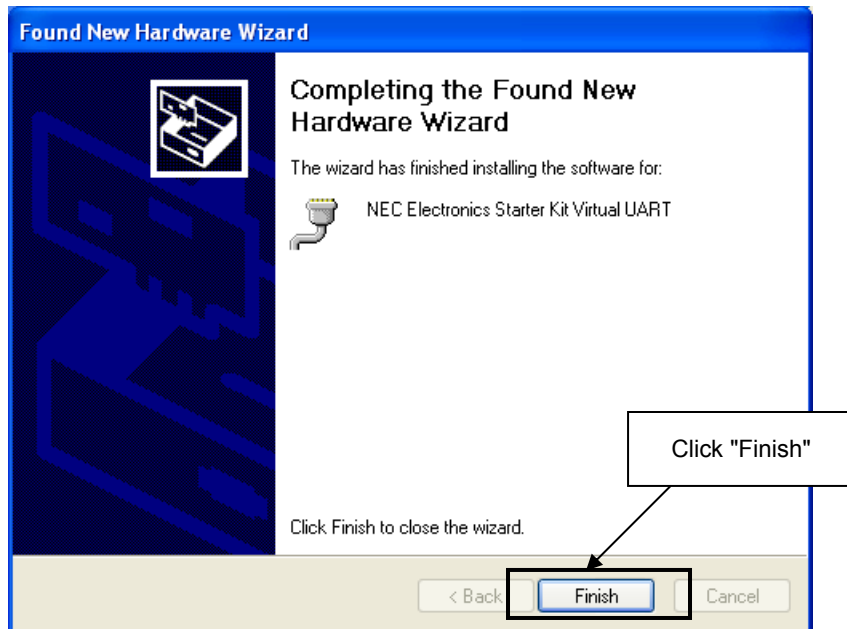
3. Select "Search for the best driver in these locations.", check "Include this location in the search:", and then click "Browse..." to select the driver directory path. The path should be "C:\Program Files\NEC Electronics Tools\TK-driver" as default installation. If the installation directory is not default, then select "TK-driver" under the installation directory.
Click .



4. If the following dialog is opened, click .



5. The installation of "NEC Electronics Starter Kit Virtual UART" driver is completed. Click .



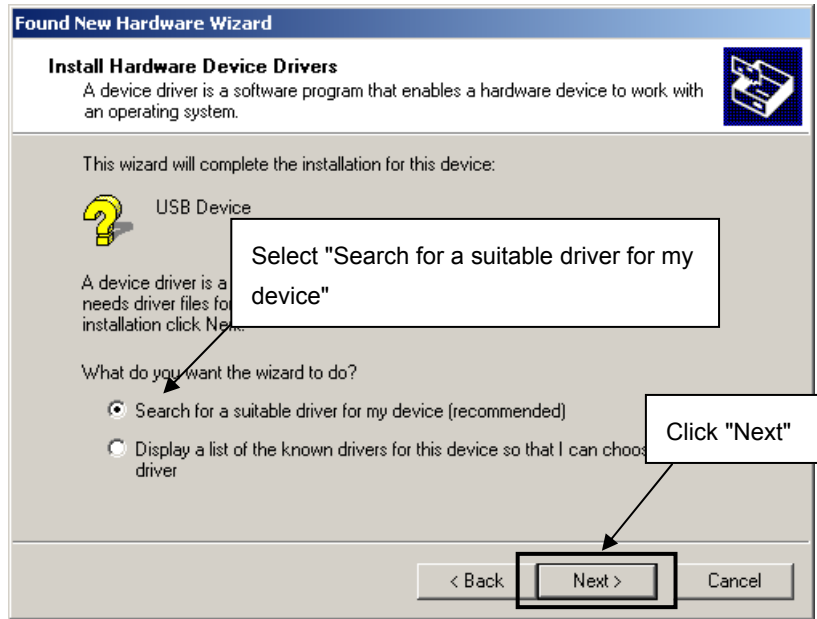
6. Go to "1.3.3 Completion of the installation".

2.4.2 Install to Windows2000

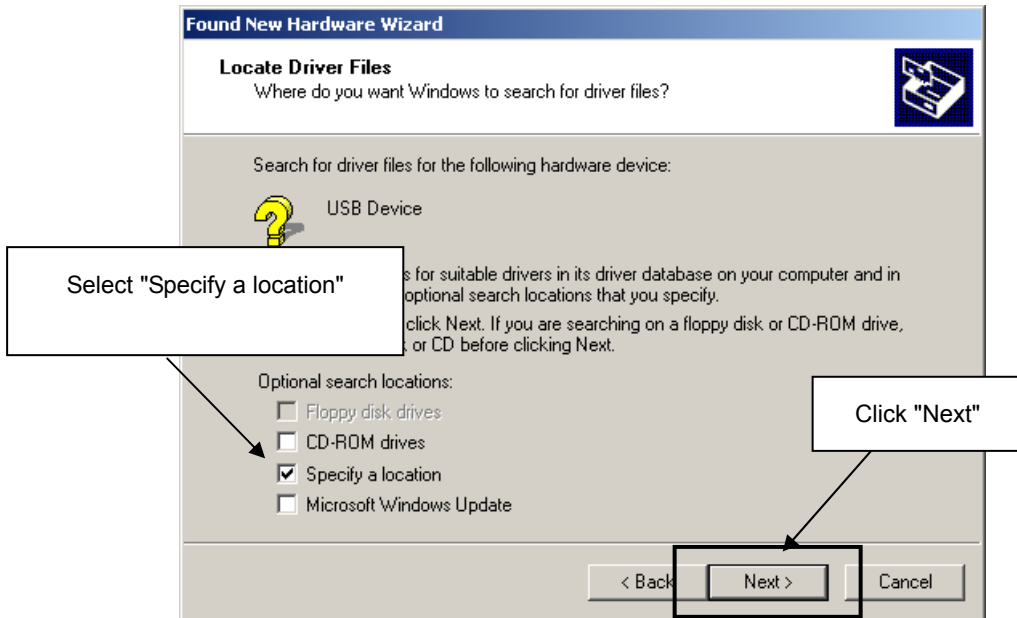
1. Once the TK-78K0R/KG3+UZ is connected with USB, the "Found New Hardware Wizard" will be started.
Select "No, not this time" and click .



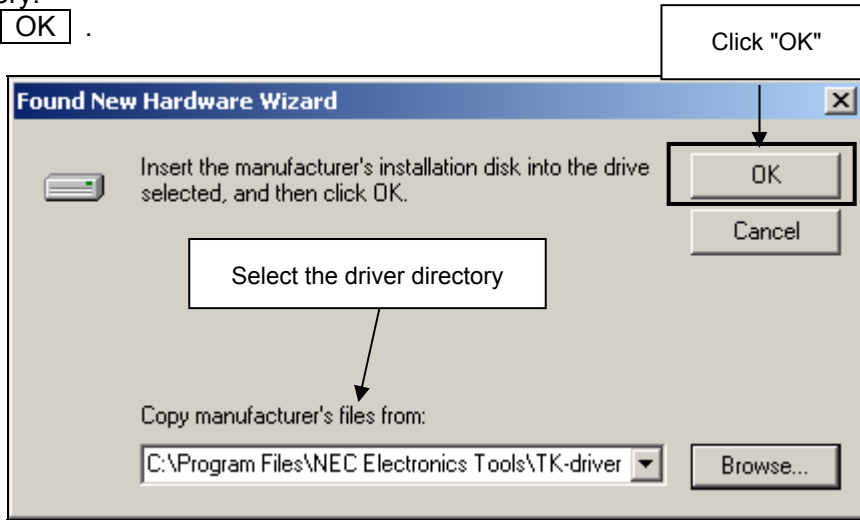
2. Select "Search for a suitable driver for my device".
Click **Next >** .



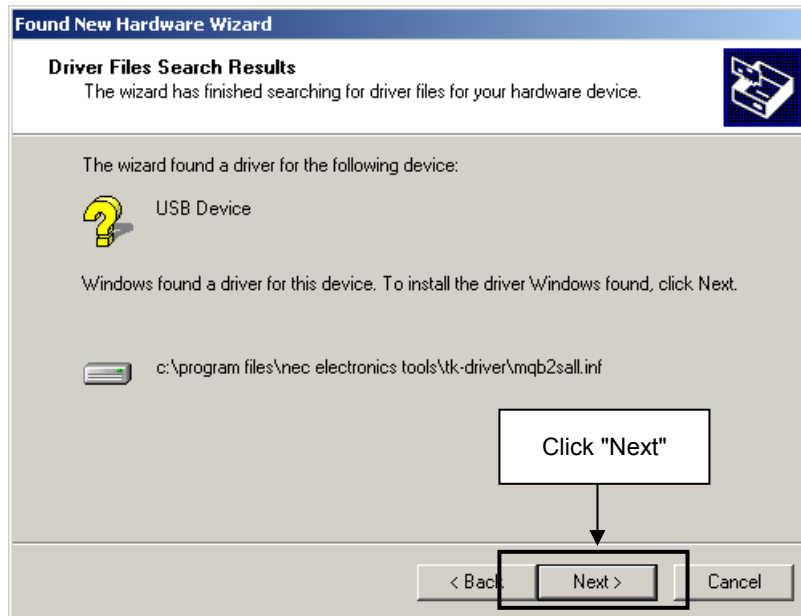
3. Select "Specify a location".
Click **Next >** .



4. Select the driver directory path. The path should be "C:\Program Files\NEC Electronics Tools\TK-driver" as default installation. If the installation directory is not default, then select "TK-driver" under the installation directory. Click **OK** .



5. Click **Next >** .



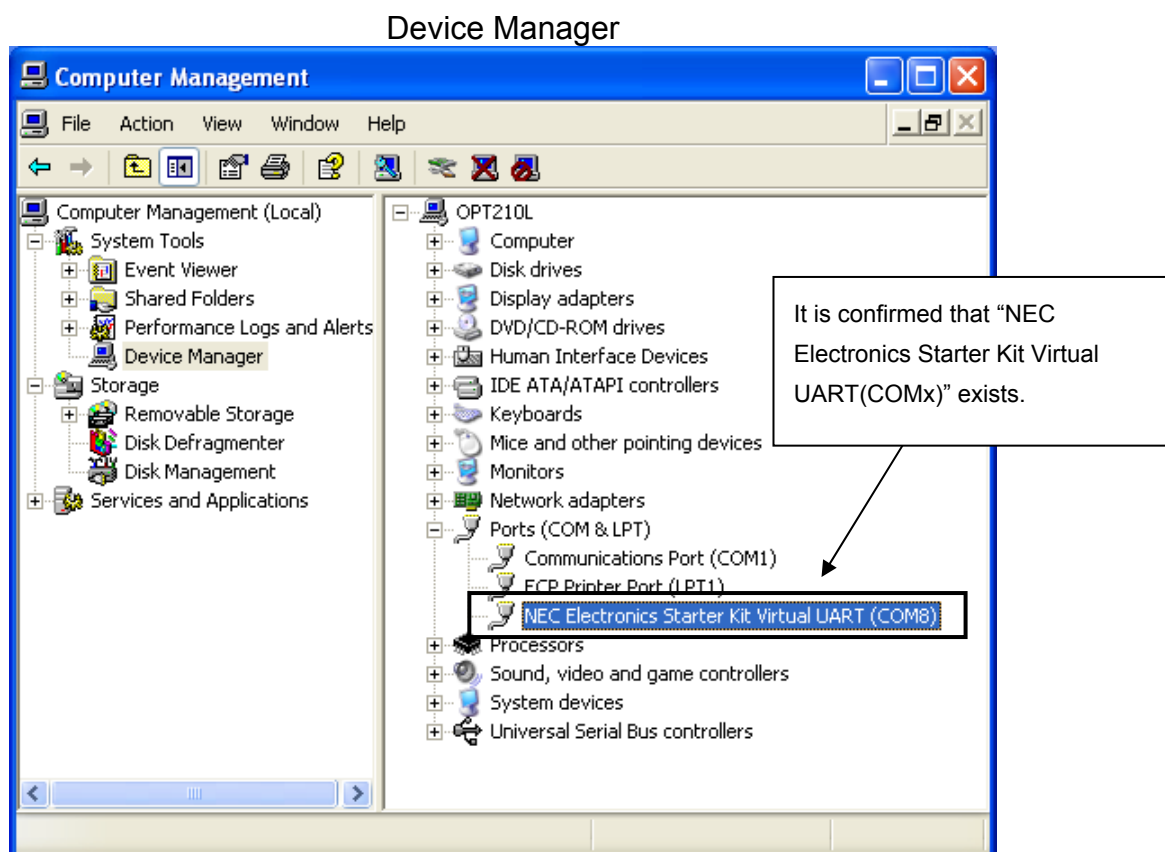
6. The installation of "NEC Electronics Starter Kit Virtual UART" driver is completed. Click **Finish** .



7. Go to "1.3.3 Confirmation of the installation".

2.4.3 Confirmation of the installation

Please confirm “NEC Electronics Starter Kit Virtual UART(COMx)” in the device manager of system in the control panel of the MS Windows.



The screen above shows that the COM port number is "COM8". If ID78K0R-QB is not in use, you can use this port number for connecting TK-78K0R/KG3+UZ. When you change the USB port connection, the COM port number will be changed as well.

CAUTION

- Do not do “Hardware Modification Scan” when you communicate with the target device.

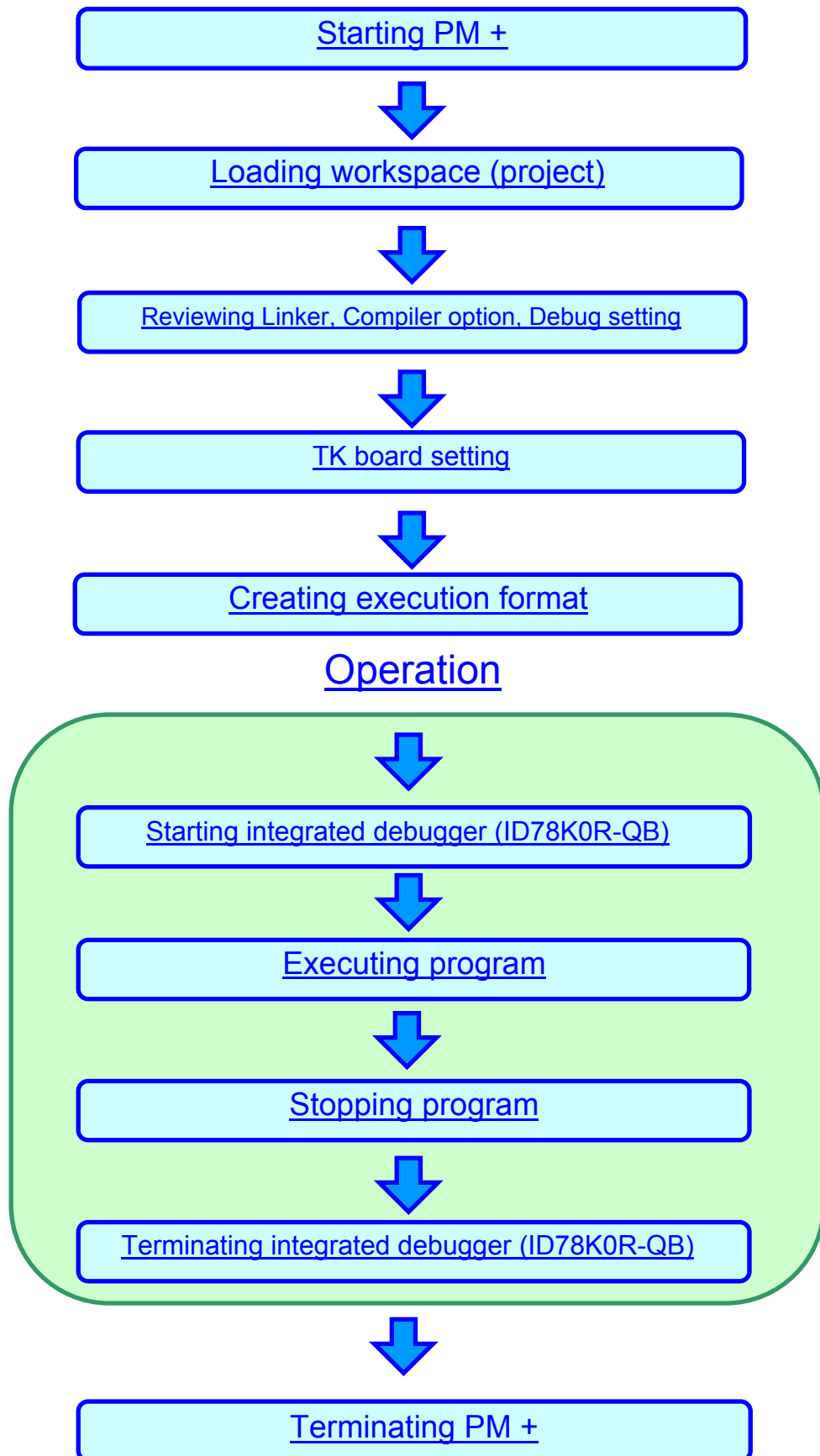
3 Experiences

Now you are ready to experience the operation of the TK-78K0R/KG3+UZ using the integrated development environment, PM +.

As a program for the 78K0R/KG3, the RF test program (RF_Test) which you installed in "2.3.1 Installation of the sample programs" is used.

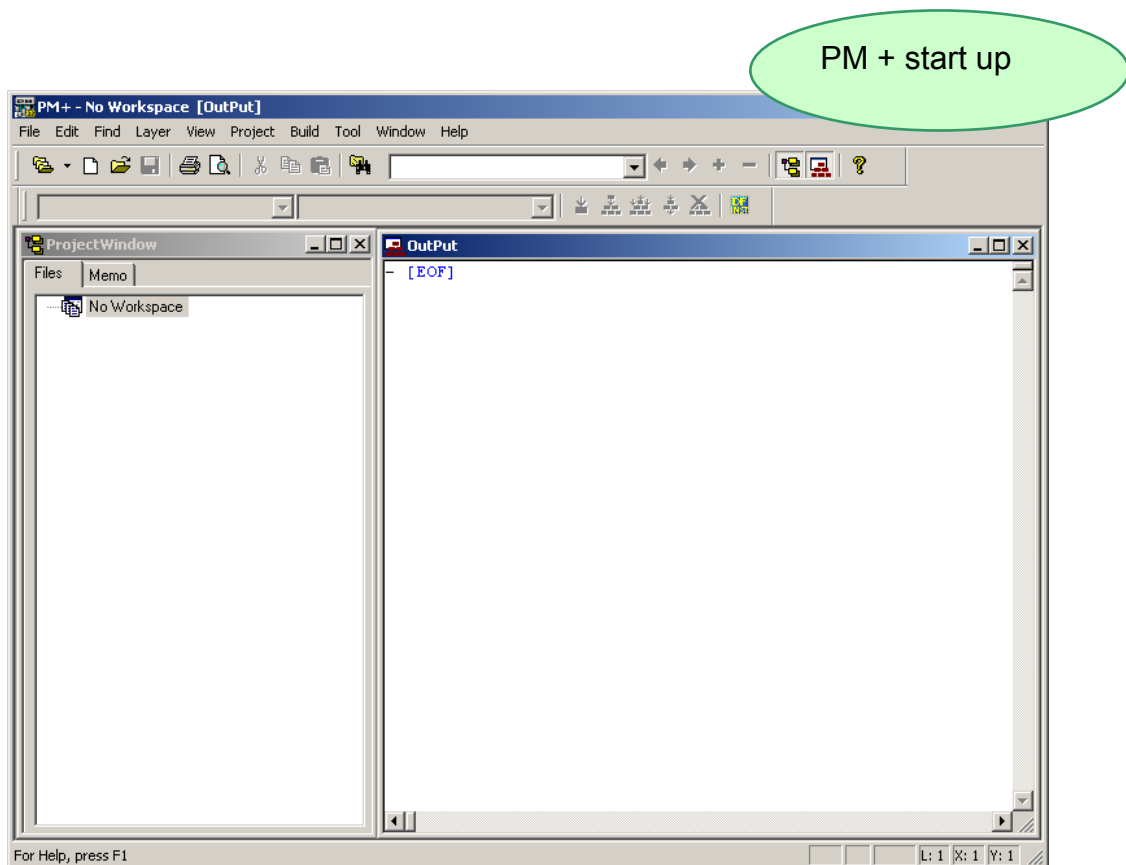
You use two of 78K0R/KG3. One is the stand-alone system with USB power supply. Another is connected to the debugger and run user programs. By building the sample programs and operating with ID78K0R-QB, you can understand the basic operation of the development tools (PM+, ID78K0R-QB) and the basics of the project files that you need when you develop application programs.

The overall flow is as follows.



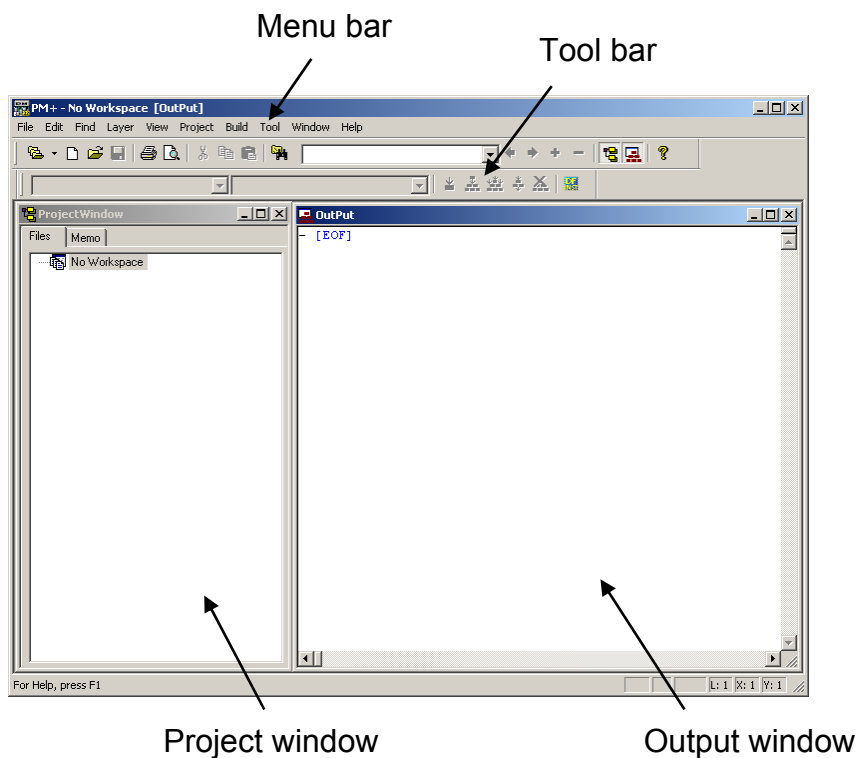
3.1 Starting PM +

In the Windows Start menu, select [Programs]->[NEC Electronics Tools]->[PM + V6.30]



3.2 Introduction to PM +

In PM +, application programs and environment setting are handled as a single [Project](#), and series of actions such as program creation using the editor, source management, build, and debugging are managed. Also, one or more project files is managed together as a workspace.



Project window A window in which project names, source files, and include file are displayed using a tree structure.

Output window A window in which the [build](#) execution status is displayed.

➡ For details regarding menu bars and tool bars, refer to the PM + User's Manual.

What is a project?

A project is the unit in which PM + executes management, and refers to an application system and environment development based on PM +.

PM + compiles project information and saves it in a “project file”, from which it is then referenced.

What is a project file?

A project file is a file to which information such as the source file to be used in the project, the device name, the tool options for compiling, and the editor and debugger to be used have been saved as “project information”.

The file name format is “`△△△△prj`”.

Project files are created in folders that are set when creating new workspaces.

What is a project group?

A project group is a group comprised of a number of projects in an application system.

The target devices of each project that can be registered to one project group must be the same.

What is a workspace?

A workspace is the unit used to manage all the projects or project group required for one application system.

The file name of multiple project files is saved to a workspace file for referencing.

The file name format is “`△△△△prw`”.

3.3 Loading Workspace (Project)

In this section, you will use the workspace that you created in "2.3.1 Installation of the sample programs"

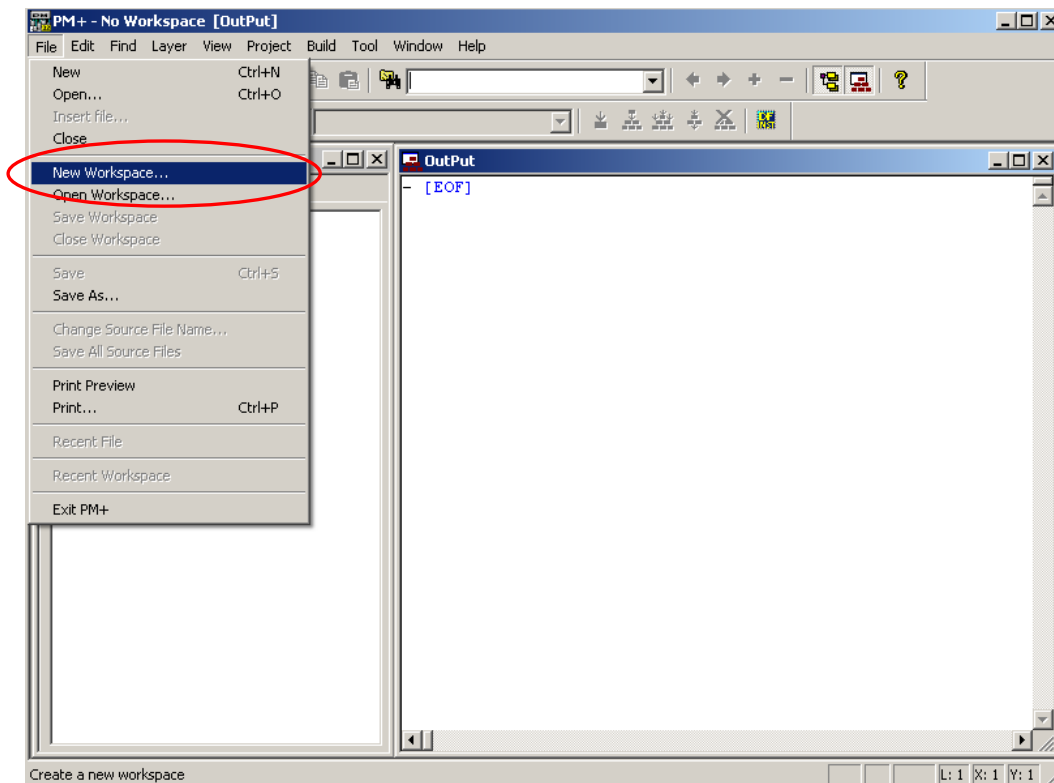
For creating a new workspace, refer to "3.15 Creating a new PM + workspace (project)".

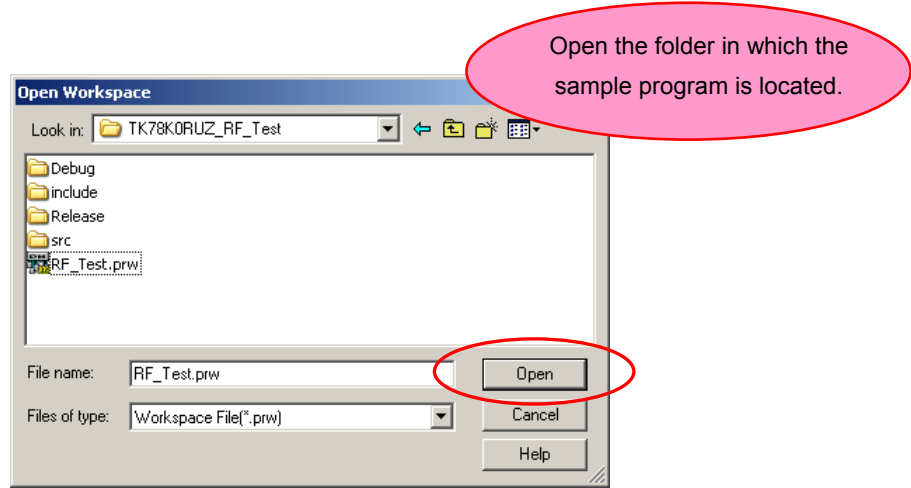
The workspace has information about the build environment for the sample programs.

Select "File" on menu bar and "Open Workspace...".

Then, select

"C:\¥TK78K0R¥SAMPLE_KG3+UZ¥TK78K0RUZ_RF_Test¥RF_Test.prw" .

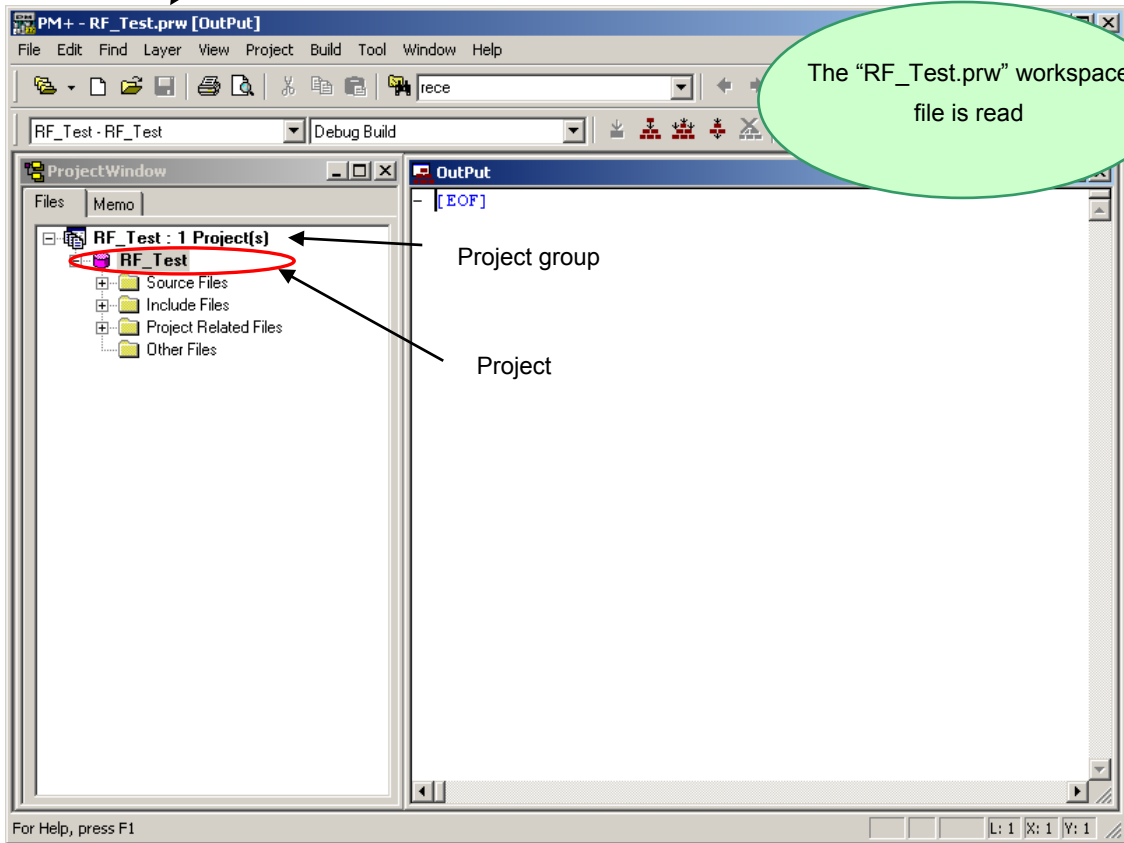




“RF_Test.prw” and then press the **Open** button.



Workspace file name :RF_Test.prw



3.4 Configuration of Linker Option

The linker options have been set by the project file. However, some option settings will be covered in this section because the linker option settings are important for debugging.

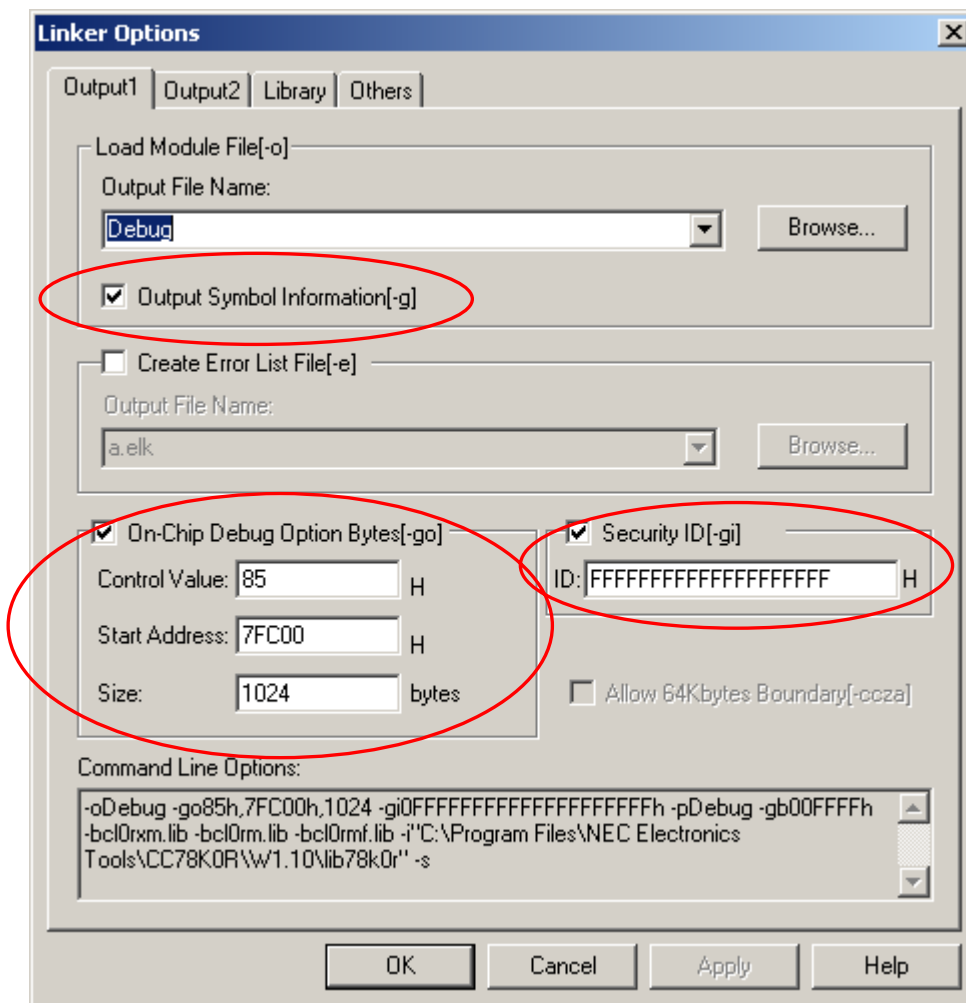
Following three settings are covered specifically.

- Outputs from debugging
- On-chip debug (bytes, security ID)
- Watchdog timer

Select "Tools" on menu bar, then "Linker options".

3.4.1 "Output1" Tab

Select "Output1" tab on "Linker Options" window, and see following settings.



- Load Module File settings

Check "Output Symbol Information".

This enables to do source level debugging (setting break points, monitoring variables in watch window, etc).

Also, you can specify the load module file name.

- On-Chip Debug Option Byte

Check "On-Chip Debug Option Byte". Enter "85" in "Control value". This setting enables the on-chip debugging function of the microcontroller.

*For details of "Control value", refer to the user's manual of 78K0R/KG3 (U17894E). See "Start address" is set to "7FC00", and "Size" is set to "1024".

These settings reserve the memory address area for the monitor program (the flash memory area that the debugger uses for on-chip debugging).

In this case, the "Control value" is allocated to the address of C3H in flash memory, and FFH is set to the next address. Because of this, the following areas could not be set the segments.

<Address area that reserved by on-chip debugging>

- 2H, 3H
- CEH-D7H
- From the address set in "Start address" to the byte set in "Size"

- Security ID

Check "Security ID", and enter the security ID which is a unique ID code (10 bytes) to authenticate when the debugger is launched.

The security ID is stored in the flash memory (C4H-CDH), and checked if it is the same as the code entered in Linker options dialog when the debugger is launched.

The debugger will not be launched when the security ID is unmatched. By using this function, you can secure the programs from leaks.

If you do not need to set the security, it is recommended to set the security ID "FFFFFFFFFFFFFFFF" as this is the initial code.

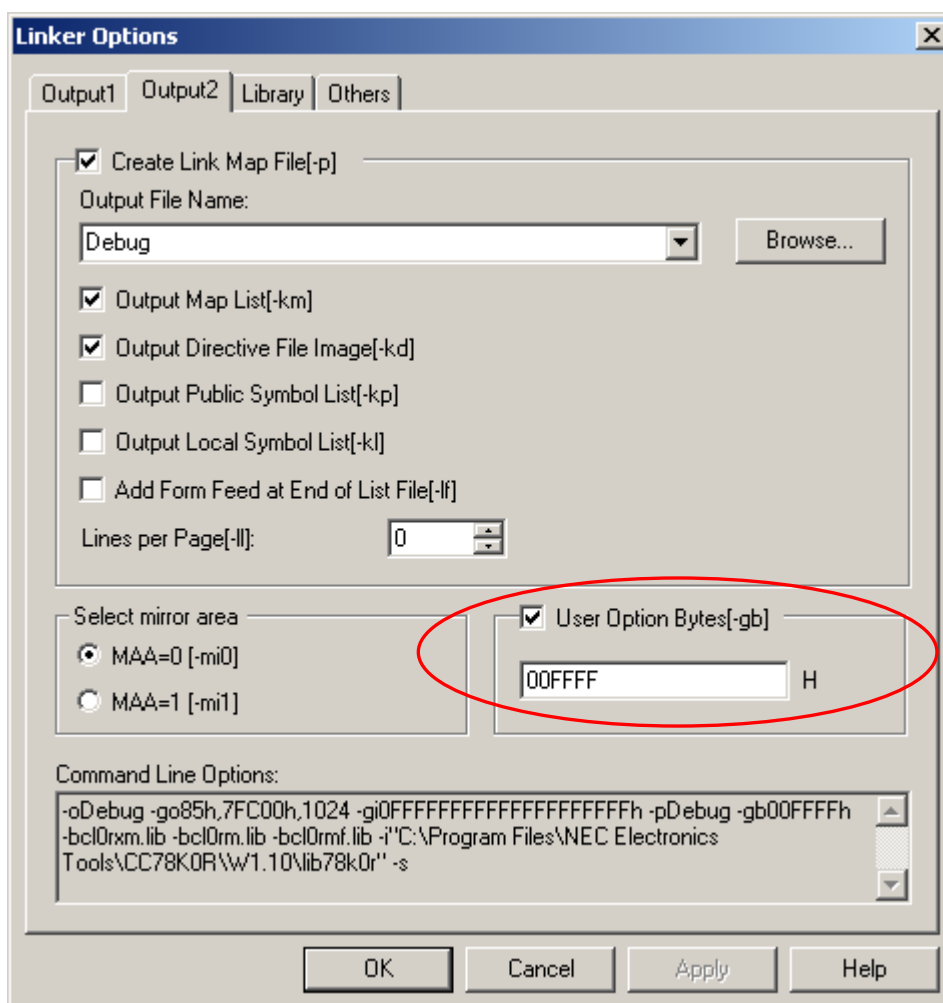
If you forget about the security ID (stored in the address of C4H-CDH) or if you set wrong on-chip debug option byte, you will not be able to use the debugger (ID78K0R-QB).

To solve this, you can use the "78K0R Starter Kit Setting" for changing the setting to initialize the flash memory at the time debugger launched.

For details, refer to "3.9 Starting integrated debugger (ID78K0R-QB)".

3.4.2 "Output2" Tab

Select "Output2" tab on "Linker Options" window, and see following settings.



- User Option Byte

Check "User Option Byte", and then enter "00FFFF". Here, you can do the setting of watchdog timer, low-voltage detector, and system reserved memory area. The 3 bytes you entered are stored at C0H-C2H on flash memory:

- C0H: setting for watchdog timer
- C1H: setting for low-voltage detector
- C2H: setting for system reserved memory area (must be set as FFH)

This time, you disabled the watchdog timer and the default start function of low-voltage detector.

For details, refer to the user's manual, 78K0R/KG3 (U17894E).

3.5 Configuration of Compiler Option

The compiler options have been set by project file. However, because some compiler options are useful, following two settings are covered specifically in this section.

- Enable C++ comments
- Use multiplier and divider

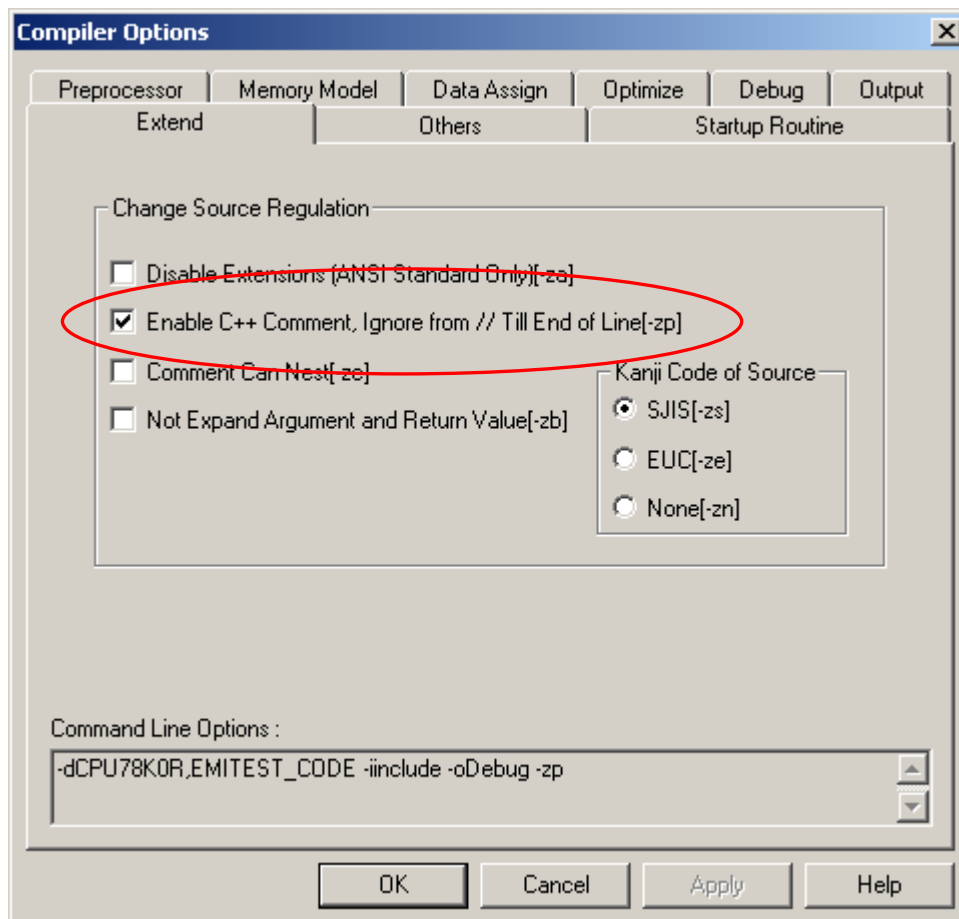
Select "Tools" on menu bar, then "Compiler options".

3.5.1 "Extend" Tab

Select "Extend" tab, and check "Enable C++ Comment".

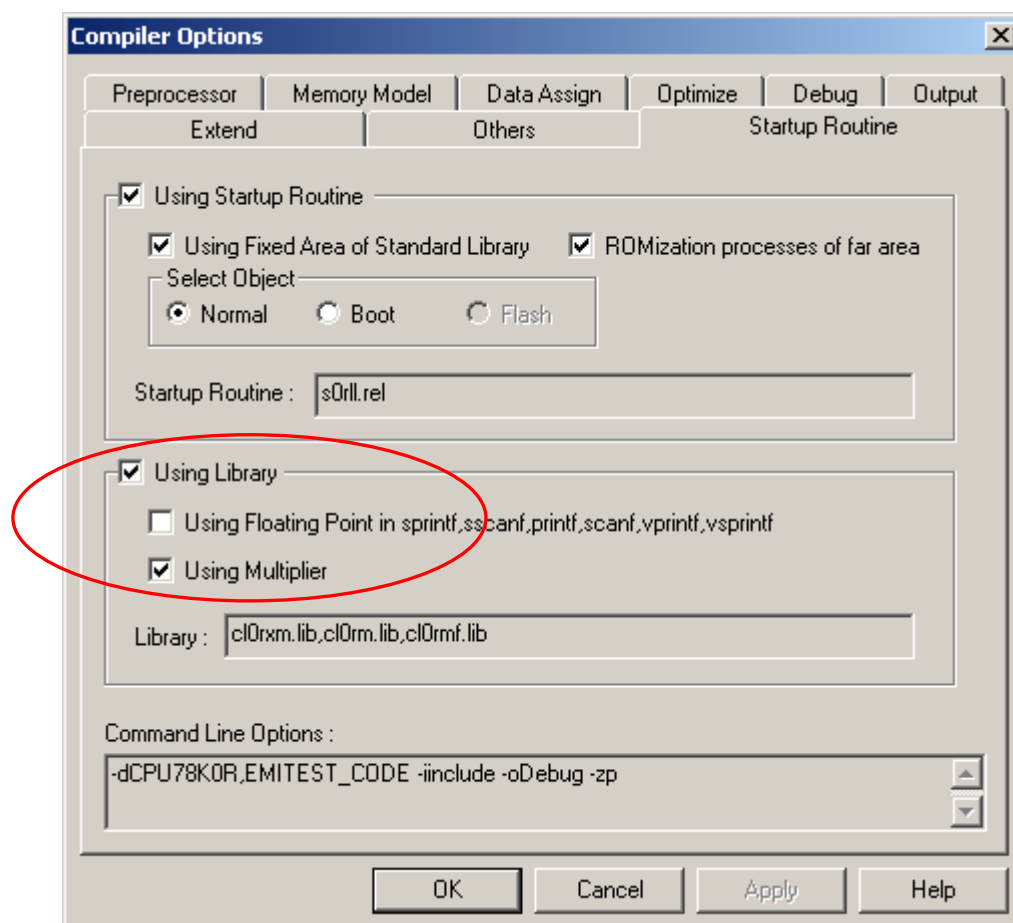
This setting allow you to use the C++ comment using "//".

It is useful feature when developing code.



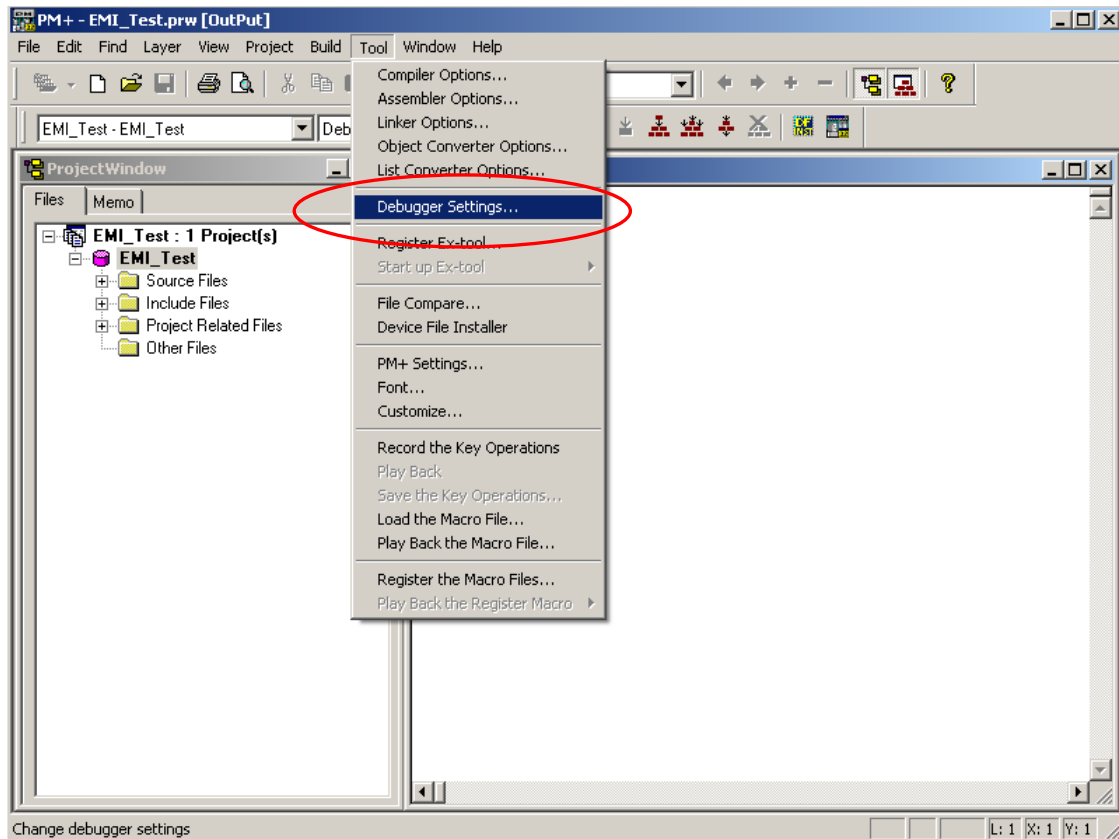
3.5.2 "Startup Routine" Tab

Select "Startup Routine" tab, and check "Using Library" and "Using Multiplier/Divider". The 78K0R/KG3 has feature of multiplier/divider to increase those calculation speed.

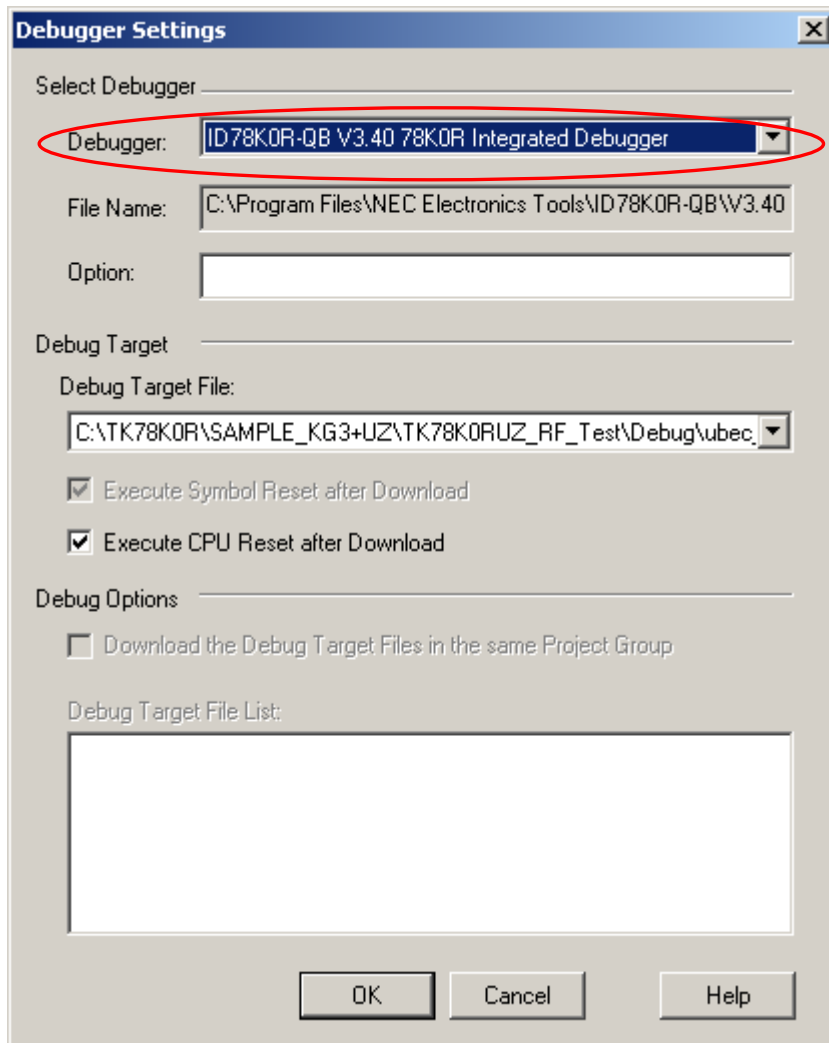


3.6 Configuration of Debugger setting

Please Choose [Tool] -> [Debugger Setting] at the pull-down menu.



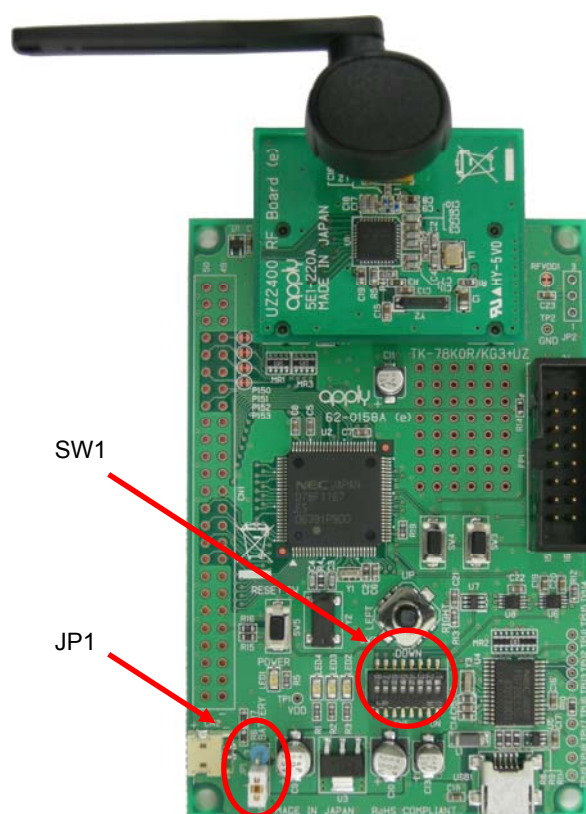
Check if "ID78K0R-QB V3.40 78K0R Integrated Debugger" is selected on "Debugger".



3.7 TK board setting

Please set the switches on the TK-78K0R/KG3+UZ board as follows.

| JP1 | | 1-2 short (USB side) |
|-----|------|----------------------|
| SW1 | Bit1 | ON |
| | Bit2 | ON |
| | Bit3 | ON |
| | Bit4 | OFF |
| | Bit5 | OFF |
| | Bit6 | OFF |
| | Bit7 | OFF |
| | Bit8 | OFF |

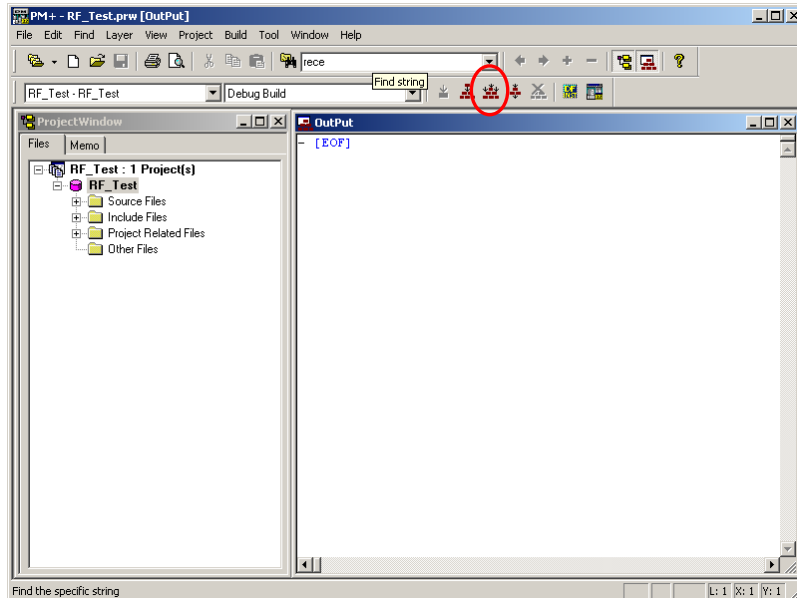


After the switch settings are completed, connect the PC to USB1 on TK-78K0R/KG3+UZ with USB cable. If the "Found New Hardware Wizard" is started, install USB driver with referring "2.4 USB Driver".

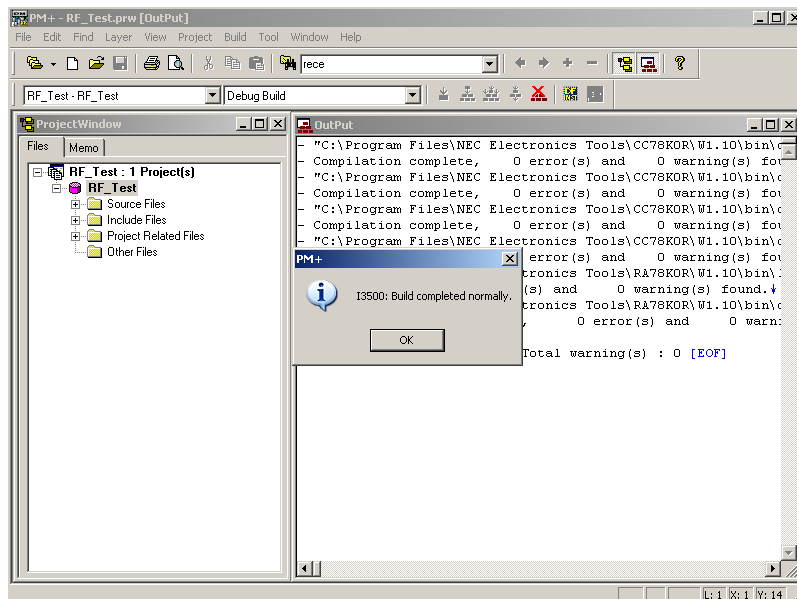
3.8 Creating execution format

Please go back to PM +.

Please re-compile the project by clicking the  button at the menu bar.



Build process is executed



Build has been completed successfully.

What is build ?

Build is a function that creates an executable file, etc., from a source file registered to a project.

PM + automatically performs compiling, linking, and other processing actions.


On the second and subsequent build, PM + also automatically detects files that have been updated from the previous build processing, and compiles and assembles only the relevant files, thereby reducing the time required for build processing.

What is rebuild ?

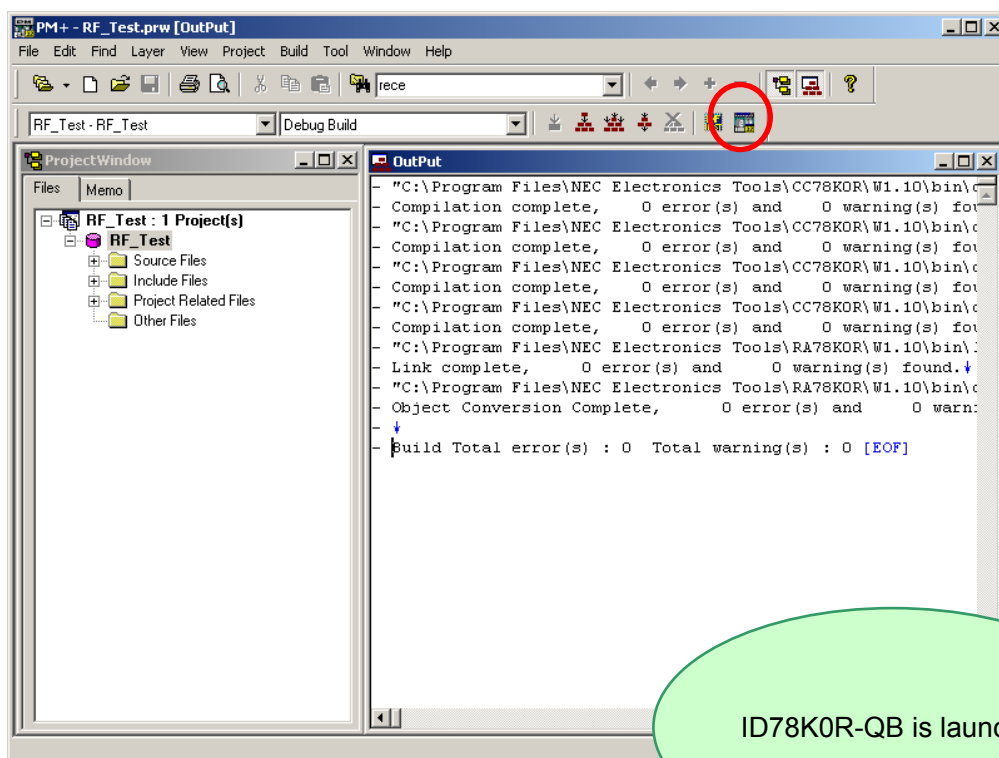
Build compiles and assembles only the source files that have been updated since the previous time, whereas rebuild compiles and assembles all the source files.

When settings, such as compiler options, have been changed, not build, but rebuild, must be Selected.

3.9 Starting integrated debugger (ID78K0R-QB)

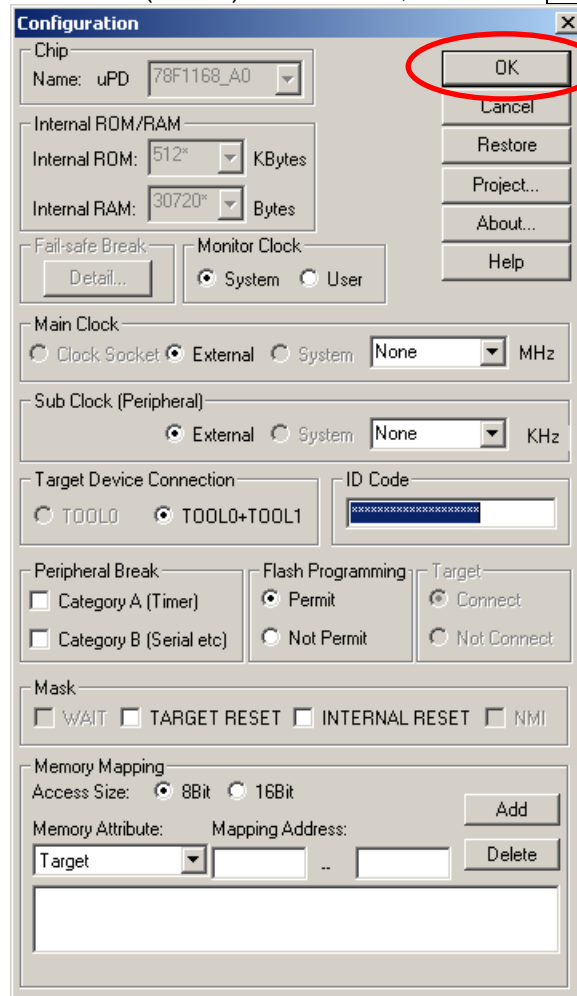
Please select the Debug button  , of PM +, or in the menu, select [Build(B)] →[Debug(D)].

If the debug button is not displayed, in the menu, select [Tool]→[Debugger Setting...]“ID78K0R-QB V3.40 78K0R Integrated Debugger”

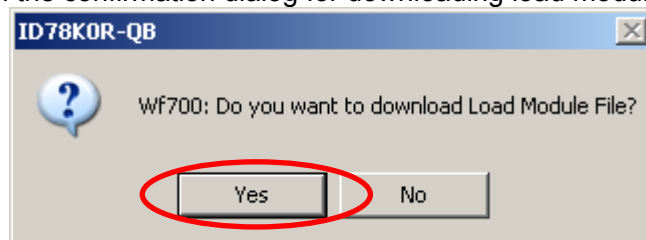


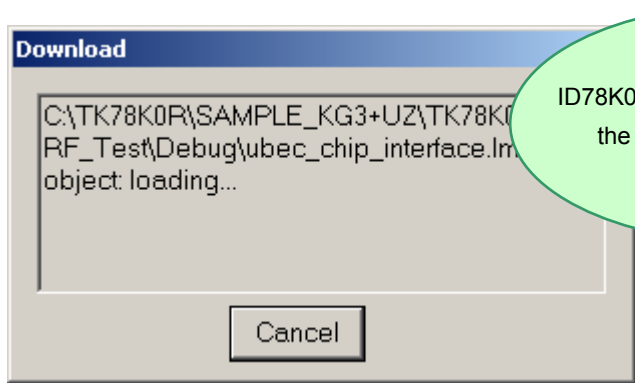
"Configuration" dialog is opened.

Enter "FFFFFFFFFFFFFFFFFFFFFF" (F x 20) in "ID Code", then click **OK** .



Click **Yes** when the confirmation dialog for downloading load module file is opened.

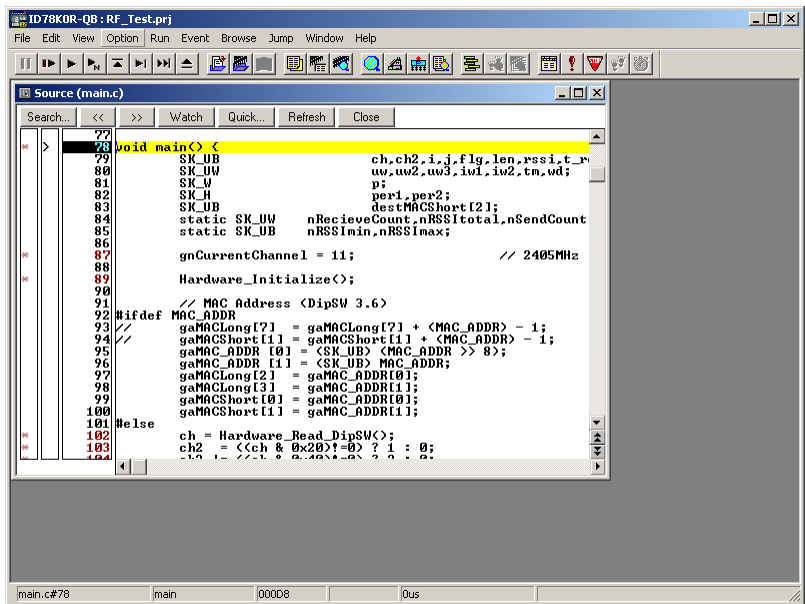




ID78K0R-QB starts and downloading the program to flash memory.

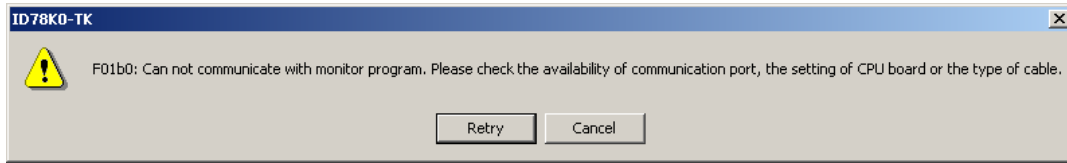


When the download is completed, the source code will be displayed



NOTE: Completion of the download does not mean running the programs. To run the sample programs, go to "3.11 Executing program".

Normally, if communication with the CPU fails, the following error messages are output.



If you observe the message please confirm the following items.

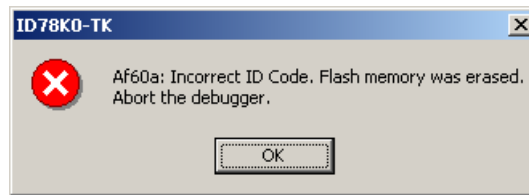
1. Please confirm the switch on the board is set as follows.

| JP1 | | 1-2 short (USB side) |
|-----|------|----------------------|
| SW1 | Bit1 | ON |
| | Bit2 | ON |
| | Bit3 | ON |
| | Bit4 | OFF |
| | Bit5 | OFF |
| | Bit6 | OFF |
| | Bit7 | OFF |
| | Bit8 | OFF |

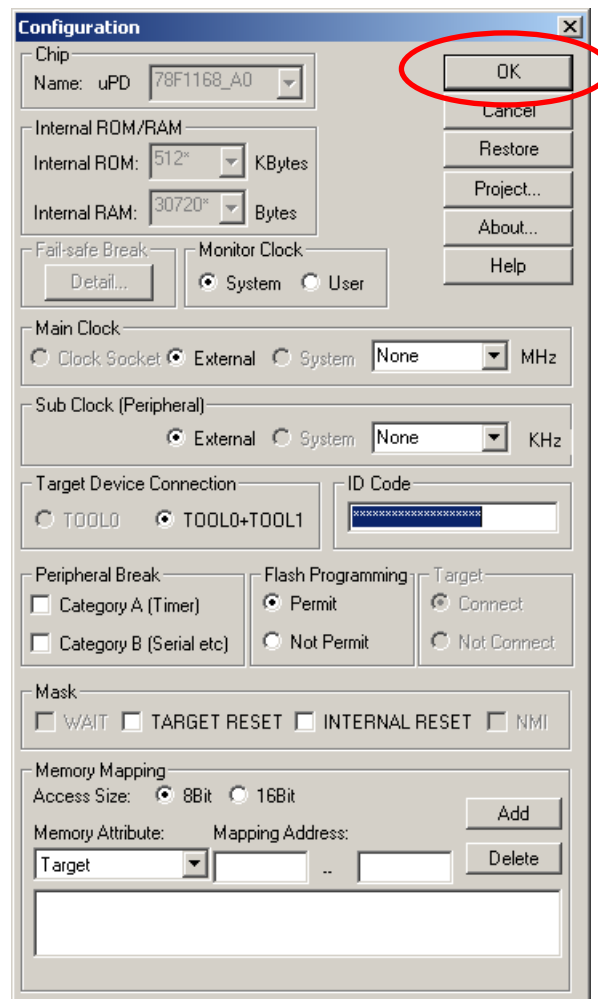
2. Please confirm the power LED1 is lighted.

After checking the above items, start ID78K0R-QB again.

If the ID code is wrong, you may find the following messages on the display.



The following "Configuration" screen is displayed when **OK** is pushed and input a correct ID code, please.

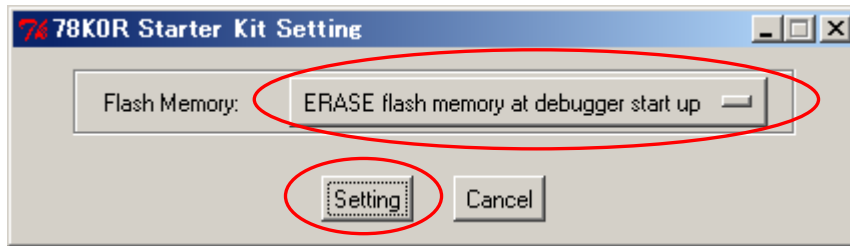


If the setting of On-Chip Debug Option Byte is "Does not erases data of flash memory in case of failures in enabling on-chip debugging" and if you forget the security ID, you need to erase the CPU built-in flash memory. To erase the data in flash memory, do following steps.

Double-click to open the file "exk0r32ocfg.exe" under the directory "C:\Program Files\NEC Electronics Tools\TK-driver" (as the installation directory is default).

"78K0R Starter Kit Setting" starts.

Set "Flash Memory" to " Erase flash memory at debugger start up ", then click "Setting".



Restart the integrated debugger (ID78K0R-QB).

When you could confirm the debugger is working, open "exk0r32ocfg.exe" again. This time, select "KEEP flash memory at debugger start up", then click Setting.

(Because there is a limit of erasing times for flash memory, it is recommended to try not to erase flash memory many times)

※ ID Code

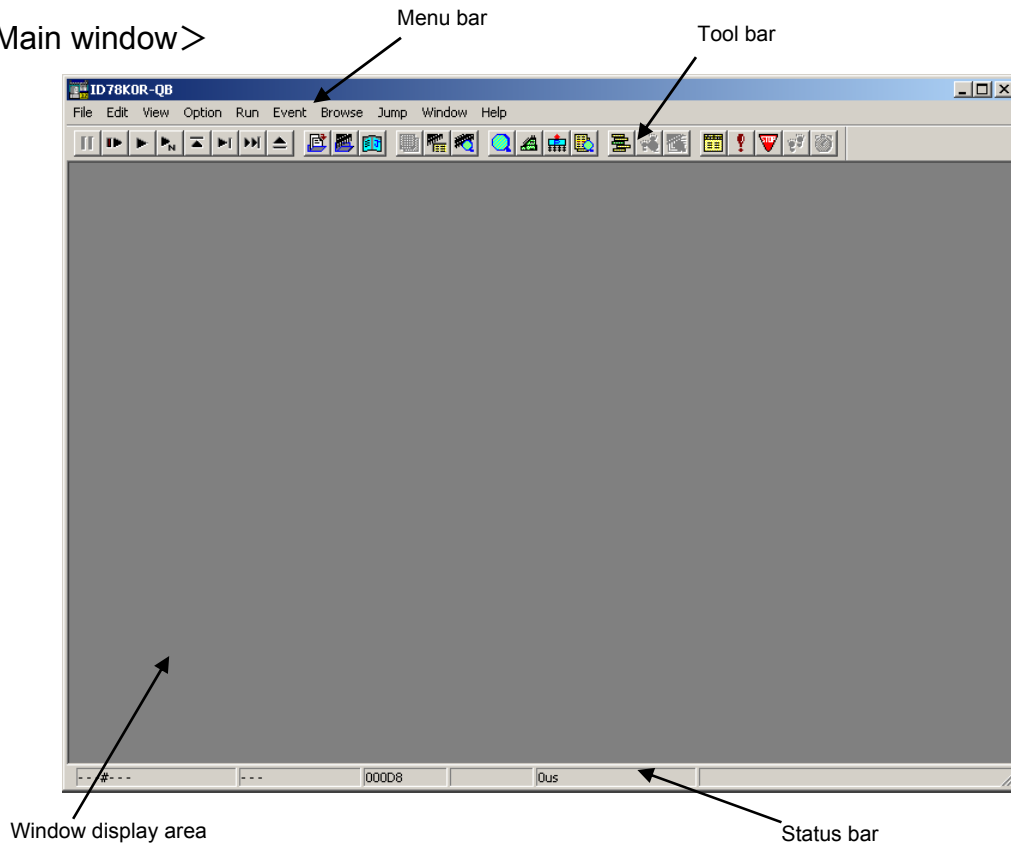
The ID Code is a mechanism to prevent an unwelcome third party from accessing your source code by initiating the debugger. Therefore, it is recommended to modify the ID Code from the default value to secure your original source code. However, once you modify it, then, if you forget the security ID or mistakenly over-write 0x00(value) to the address of 0xC3, the debugger ID78K0R-QB is unable to access to the CPU via OCD interface. In this case, you have to start over from erasing all data in the Flash EEPROM. Then, you can define the new ID Code. You may load your source code from the debugger with a load module file.

3.10 Introduction of integrated debugger (ID78K0R-QB)

ID78K0R-QB displays the internal status of the CPU and controls monitor functions in the main window.


The initial screen of ID78K0R-QB is as follows.

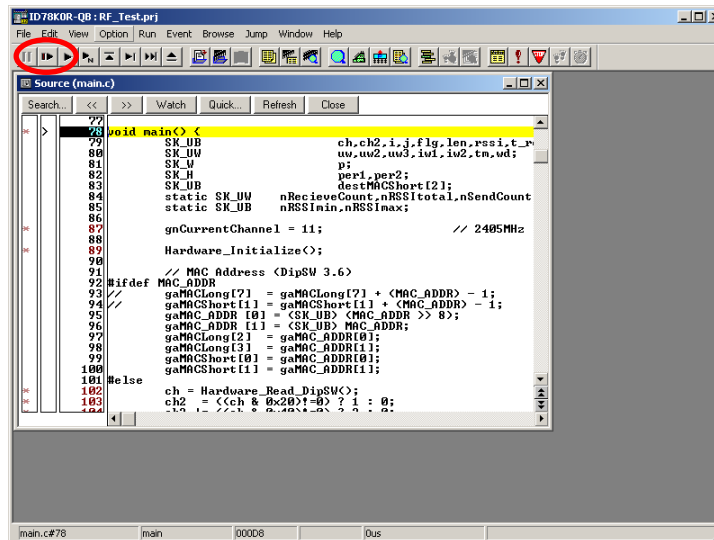
< Main window >



➡ For more details, please refer to the user's manuals of ID78K0R-QB.

3.11 Executing program

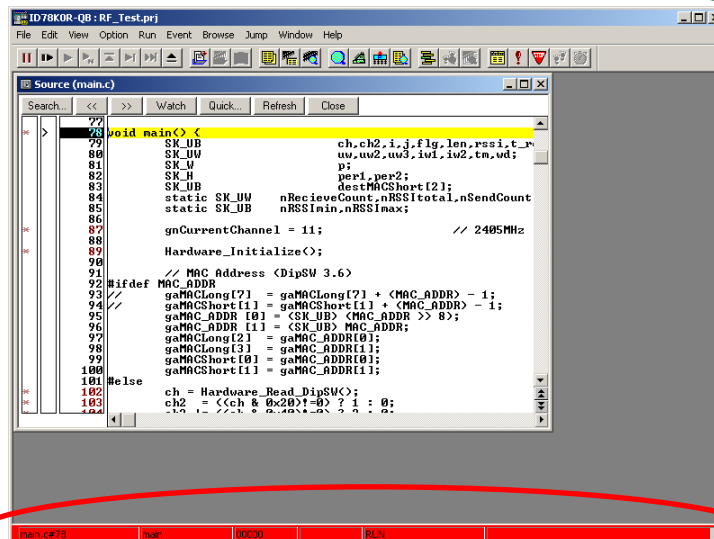
If you click “GO” , the execution of the code will start. You can know it by the red bar at the bottom.



The screenshot shows the IDE interface with the 'GO' button (a play icon) circled in red. The source code for 'main.c' is visible, starting with a 'void main()' function. The status bar at the bottom shows 'main.c#78', 'main', '00008', and 'Ius'.



Execute the program



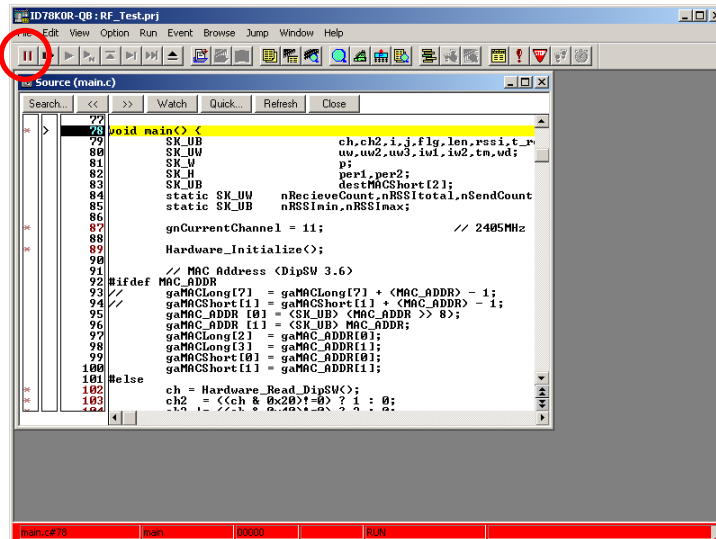
The screenshot shows the IDE interface after the program has been executed. The status bar at the bottom is now red and contains the text 'main.c#78', 'main', '00000', and 'RUN'. The source code is the same as in the previous screenshot.

When programs are running, the status bar will be red.

3.12 Stopping program

Now, you are going to stop the program.

Press the ID78K0R-QB's stop button , or in the menu, select [Run]→[Stop].



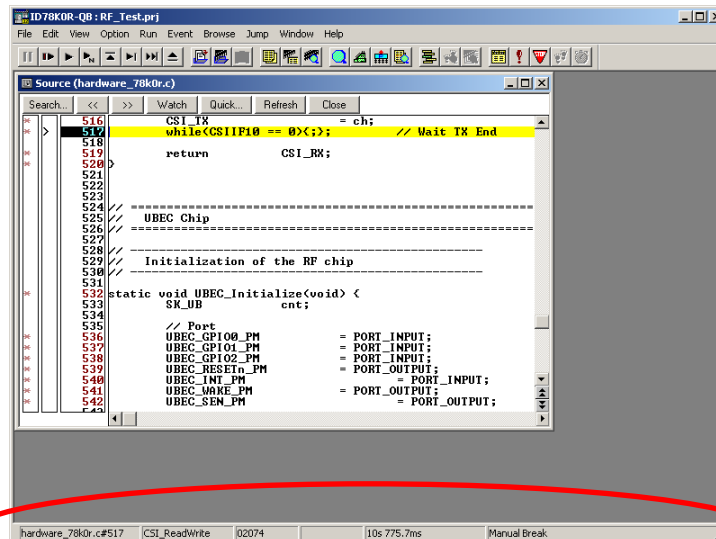
```
void main() {
    SK_UW      ch,ch2,i,j,flg,len,rsst,t_
    SK_UW      uw,uw2,uw3,iw1,iw2,tw,vd;
    SK_U       p;
    SK_H       per1,per2;
    SK_UW      destMACShort[2];
    static SK_UW nReceiveCount,nRSSTotal,nSendCount;
    static SK_UW nRSSImin,nRSSImax;

    gnCurrentChannel = 1; // 2405MHz
    Hardware_Initialize();

    // MAC Address <DipSW 3.6>
    #ifdef MAC_ADDR
    gaMACLong[7] = gaMACLong[7] + <MAC_ADDR> - 1;
    gaMACShort[1] = gaMACShort[1] + <MAC_ADDR> - 1;
    gaMAC_ADDR[0] = <SK_UW> <MAC_ADDR >> 8;
    gaMAC_ADDR[1] = <SK_UW> <MAC_ADDR>;
    gaMACLong[2] = gaMAC_ADDR[0];
    gaMACLong[3] = gaMAC_ADDR[1];
    gaMACShort[0] = gaMAC_ADDR[0];
    gaMACShort[1] = gaMAC_ADDR[1];
    #else
    ch = Hardware_Read_DipSW();
    ch2 = <(ch & 0x20)!=0 ? 1 : 0;
    ch = <(ch & 0x20)!=0 ? 0 : 1;
    }
```



Stop the program



```
CSI_TX = ch;
while(CSIIF10 == 0x<>); // Wait TX End
return CSI_RX;

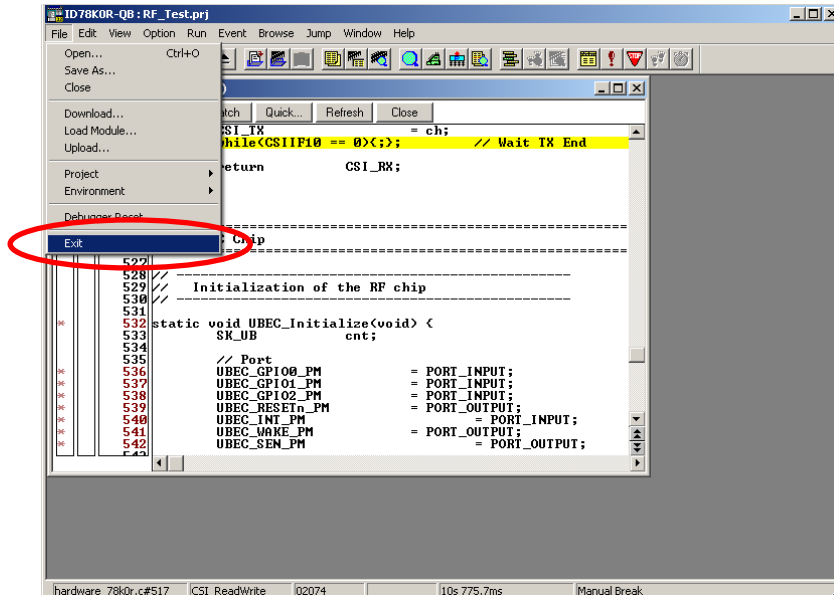
//-----
// UBEC Chip
//-----
// Initialization of the RF chip
//-----
static void UBEC_Initialize(void) {
    SK_UW cnt;

    // Port
    UBEC_GPI00_PM = PORT_INPUT;
    UBEC_GPI01_PM = PORT_INPUT;
    UBEC_GPI02_PM = PORT_INPUT;
    UBEC_RSTEn_PM = PORT_OUTPUT;
    UBEC_INT_PM = PORT_INPUT;
    UBEC_WAKE_PM = PORT_OUTPUT;
    UBEC_SEN_PM = PORT_OUTPUT;
}
```

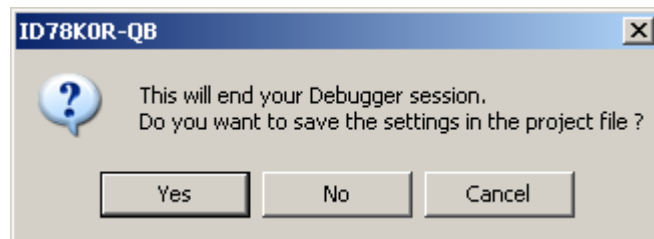
When the program stops, the status bar changes back to the original color.

3.13 Terminating integrated debugger (ID78K0R-QB)

Select "File" on menu bar, then "Exit".



The Exit confirmation dialog box is displayed.



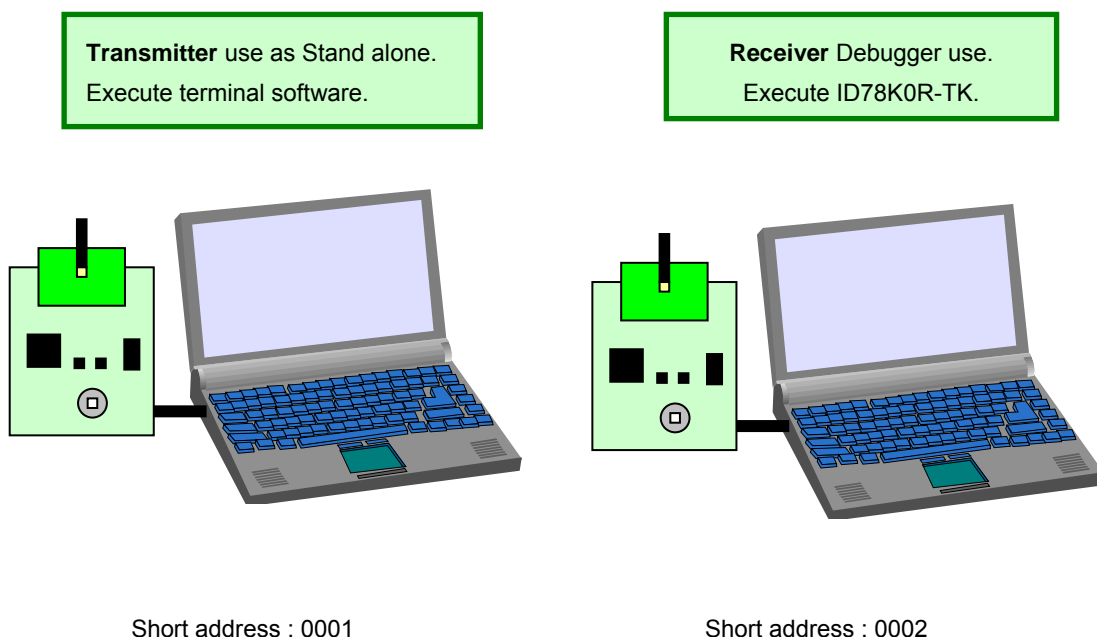
If you push the "Yes", ID78K0R-QB is terminated after preserving a present environment.
If you push the "No", ID78K0R-QB is terminated without preserving a present environment.

3.14 RF Test Program

3.14.1 Procedure for one to one transmit/receive test

- 1). Assumption here in this section is, you have two TK-78K0R/KG3+UZ boards, in one of which the execution code for the “RF_TEST” was programmed by the debugger. You also prepare two PCs or one PC with more than one usb interface.

one PC with USB interface and hyper-terminal to control the transmitter side of the board, and the other one with USB interface to the second PC for debugging at the receiver board.



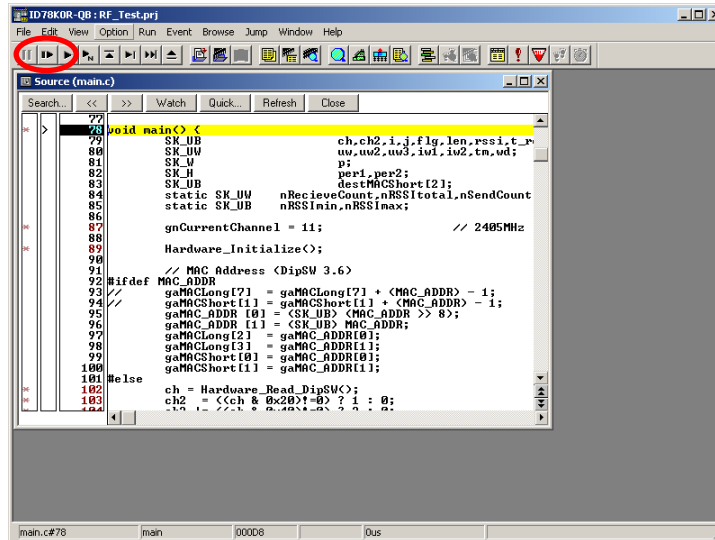
- 2). Now, you designate the one TK-78K0R/KG3+UZ board loaded with the execution code in the previous procedure as a transmitter. Another board, which is not loaded with the execution code is now designated as a receiver, which send back the test result to the sender. The receiver board can work without PC, but now, you set this board to the debug mode. Please set the switches on the receiver board as follows.

| | | |
|-----|------|-------------------------|
| JP1 | | 1-2 short (USB side) |
| SW1 | Bit1 | ON |
| | Bit2 | ON |
| | Bit3 | ON |
| | Bit4 | OFF |
| | Bit5 | OFF |
| | Bit6 | ON for address setting |
| | Bit7 | OFF for address setting |
| | Bit8 | ON for the receive mode |

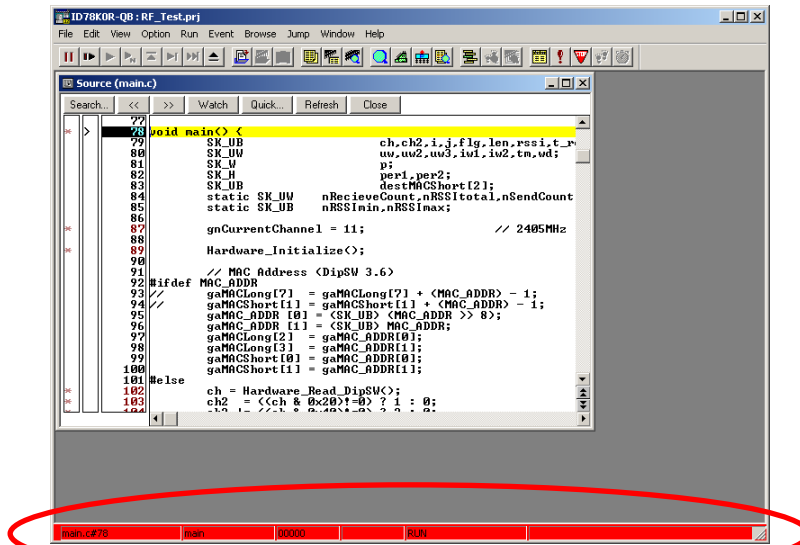
The above example is for the short address of 0002.
There are four ways of the address setting as follows,

| | | Short Address | | | |
|-----|------|---------------|------|------|------|
| | | 0001 | 0002 | 0003 | 0004 |
| SW1 | Bit6 | OFF | ON | OFF | ON |
| | Bit7 | OFF | OFF | ON | ON |

Please connect the receiver board to your first PC with a USB cable.
Now, please repeat the procedures described in the section “3.9 Starting integrated debugger”.
You will see the C-source window, as shown below.



Now, please click "GO" to run the program.



You will see the red bar at the bottom.

Now the receiver board is ready.

3). Please set the transmitter board as follows,

| JP1 | | 1-2 short (USB side) |
|-----|------|--------------------------------|
| SW1 | Bit1 | OFF |
| | Bit2 | OFF |
| | Bit3 | OFF |
| | Bit4 | ON |
| | Bit5 | ON |
| | Bit6 | OFF for address setting |
| | Bit7 | OFF for address setting |
| | Bit8 | OFF for the Hyperterminal mode |

This example is for the short address of 0001.

This board is designated as the transmitter.

Then, please connect it to your second PC with a USB cable.

Then, please identify the COM port number of the USB in your PC at [Control Panel] → [System]

4). Hyper Terminal

On MS-Windows in your PC, please select [All Programs] -> [Accessory] -> [Communication] -> [HyperTerminal]

Setting of Hyperterminal

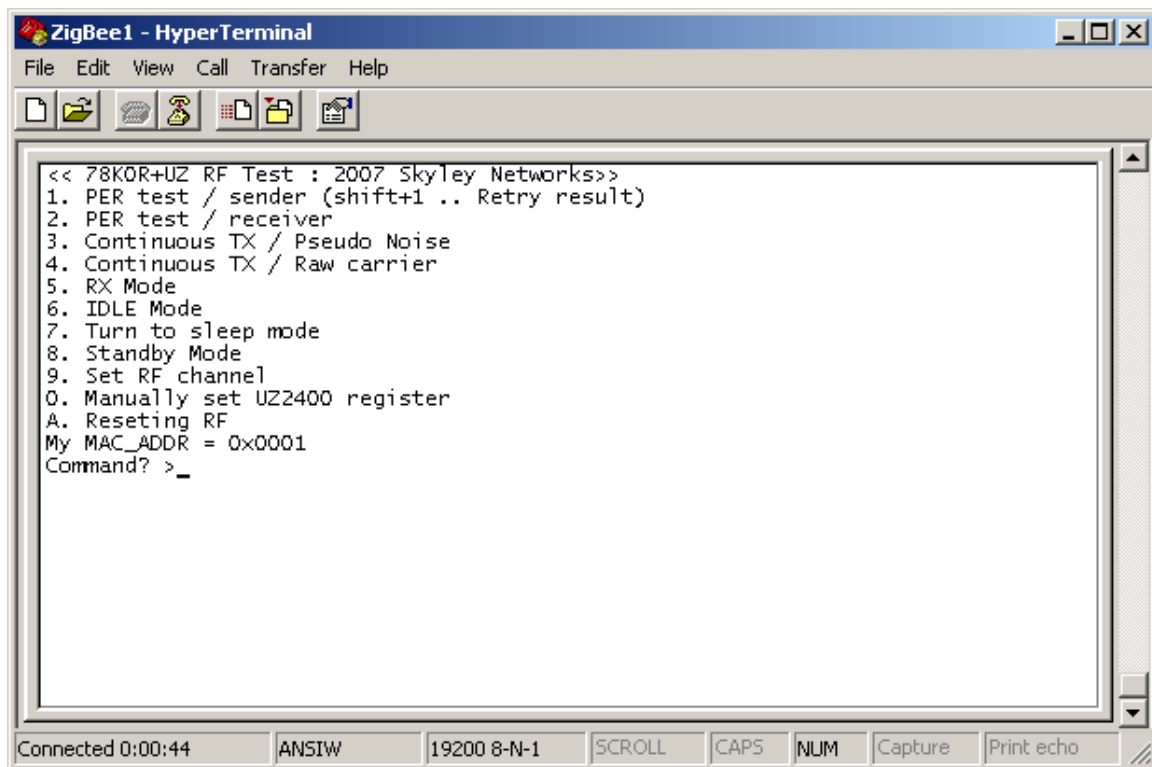
| | |
|-----------------|--------|
| Bits per second | 115200 |
| Data bits | 8 |
| Parity | None |
| Stop bits | 1 |
| Flow control | None |

(Property -> Setting -> ASCII)

Local Echo OFF

No Line Feed

Now you will find the following opening menu in the window.
If not, please try the RESET button on the board.

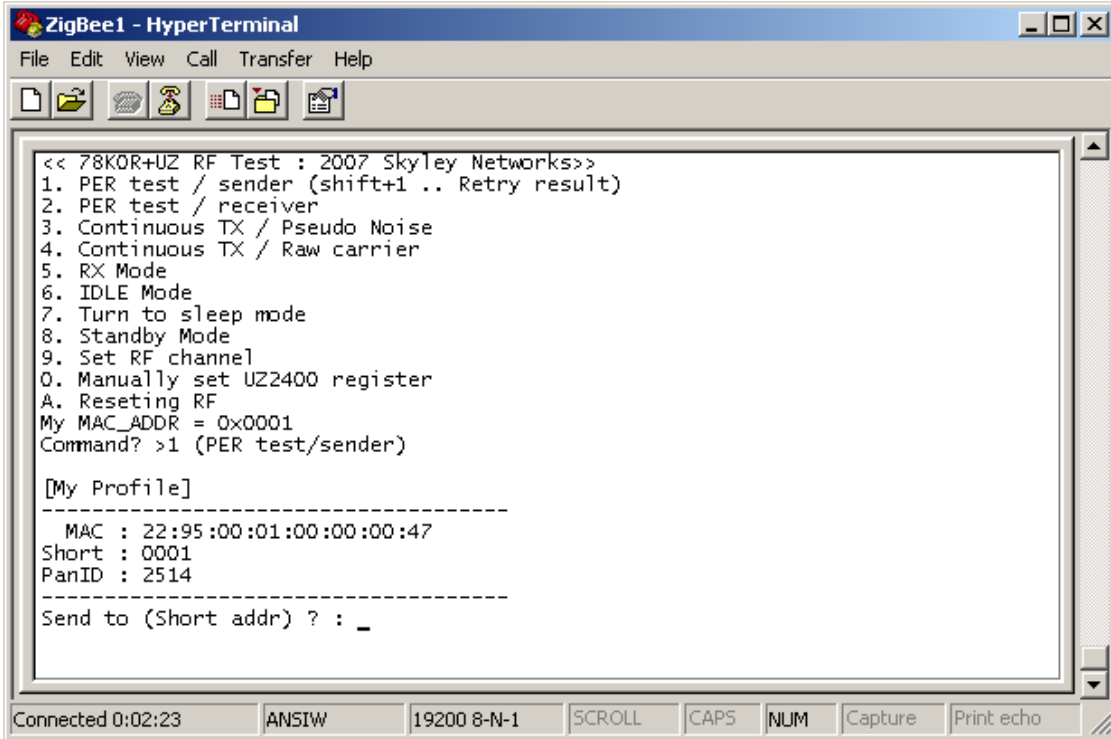


```
<< 78KOR+UZ RF Test : 2007 Skyley Networks>>
1. PER test / sender (shift+1 .. Retry result)
2. PER test / receiver
3. Continuous TX / Pseudo Noise
4. Continuous TX / Raw carrier
5. RX Mode
6. IDLE Mode
7. Turn to sleep mode
8. Standby Mode
9. Set RF channel
0. Manually set UZ2400 register
A. Reseting RF
My MAC_ADDR = 0x0001
Command? > _
```

Connected 0:00:44 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo

5). Execution of the Transmit/Receive Test

To initiate the PER, Packet Error Rate, test, please press “1” in the menu. You will see [My Profile], then, be asked for the destination of the PER test, as shown below.



```
<< 78KOR+UZ RF Test : 2007 Skyley Networks>>
1. PER test / sender (shift+1 .. Retry result)
2. PER test / receiver
3. Continuous TX / Pseudo Noise
4. Continuous TX / Raw carrier
5. RX Mode
6. IDLE Mode
7. Turn to sleep mode
8. Standby Mode
9. Set RF channel
0. Manually set UZ2400 register
A. Reseting RF
My MAC_ADDR = 0x0001
Command? >1 (PER test/sender)

[My Profile]
-----
MAC : 22:95:00:01:00:00:47
Short : 0001
PanID : 2514
-----
Send to (Short addr) ? : _
```

Now, you may input “0002”.

Then, you will be asked how many packets you wish to consume in the PER test.

You may input “1000”.

Then, you will be asked the interval of packets in msec.

You may input 3 msec.

Then, the PER test will be executed.

You will see,

the number of packets sent, that is, 1000 as you input,

the number of the received packets,

the calculated PER in %

and the maximum and minimum RSSI values in the PER test.

[Note]

PER= Packet Error Rate

RSSI= Received Signal Strength Indication

```
ZigBee1 - HyperTerminal
File Edit View Call Transfer Help

PanID : 2514
-----
Send to (Short addr) ? : 0002
Send count (dec) ? : 1000
Interval (dec/msec) ? : 3
[Set channel to 11 (Cmd)]
Prepare to send..OK
[Set channel to 11 (Current)]
Request to result..OK

[Results]
-----
From      : 0001
To        : 0002
-----
Sent      : 1000
Recieved  : 1000
PER       : 0.0000%
RSSI     : max FF / min FF
-----

Press any key to the menu

Connected 0:04:31  ANSIW  19200 8-N-1  SCROLL  CAPS  NUM  Capture  Print echo
```

RSSI is expressed in the hexagonal value of 256 levels, which indicates the signal strength in the received signal. For more details of the RSSI value, please refer to the datasheet of the UZ2400 RF chip.

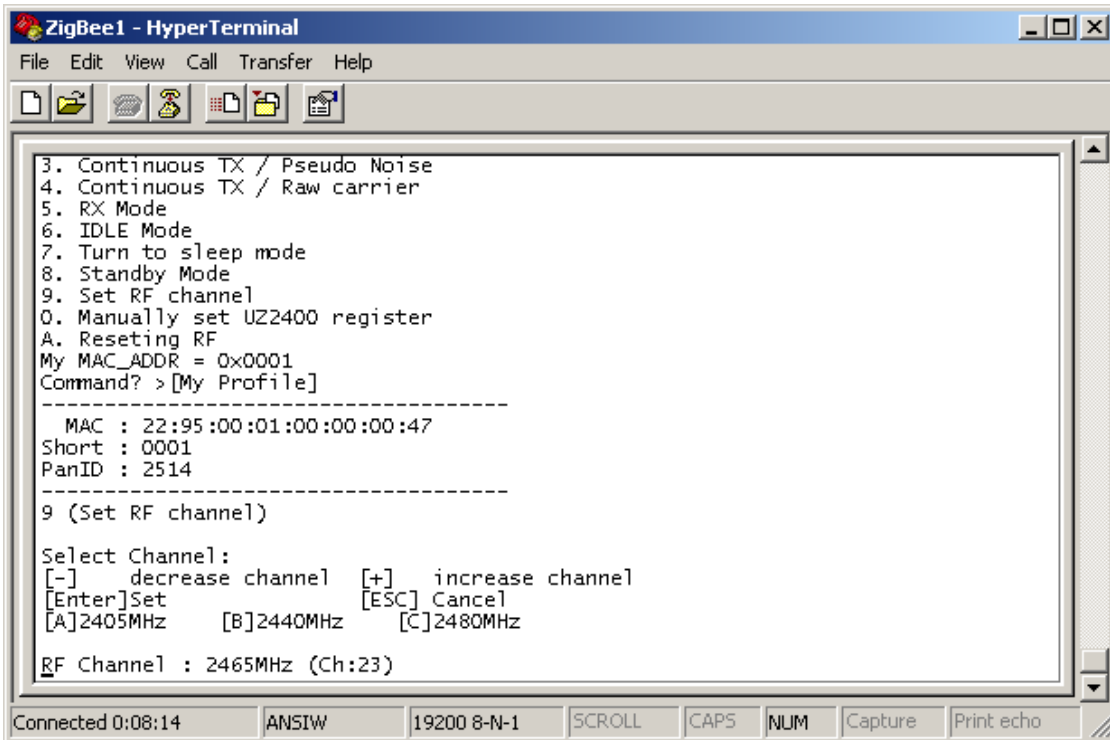
Please note the PER and the RSSI are measured at the receiver side. The receiver does not send back the test packets, but only the test result.

6). Channel setting

In the previous example, you may have also found the RF channel used in this test is the Channel 11. The channel is specified by the IEEE 802.15.4 specification.

The channel 11 is assigned at 2405 MHz. You can change the channel in the PER test in 5MHz step to the maximum channel of 26th at 2480 MHz.

To do it, please press “9” in the command prompt. Then, please choose the channel by [+], [-], [A], [B], or [C]. In the example below, the channel 23th, 2465 MHz, was selected.



```
ZigBee1 - HyperTerminal
File Edit View Call Transfer Help
[Icons]
3. Continuous TX / Pseudo Noise
4. Continuous TX / Raw carrier
5. RX Mode
6. IDLE Mode
7. Turn to sleep mode
8. Standby Mode
9. Set RF channel
O. Manually set UZ2400 register
A. Reseting RF
My MAC_ADDR = 0x0001
Command? >[My Profile]
-----
MAC : 22:95:00:01:00:00:00:47
Short : 0001
PanID : 2514
-----
9 (Set RF channel)
Select Channel:
[-] decrease channel [+] increase channel
[Enter]Set [ESC] Cancel
[A]2405MHz [B]2440MHz [C]2480MHz
RF Channel : 2465MHz (Ch:23)
Connected 0:08:14 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

To execute the PER test at the channel 23, press [Enter] in your keyboard, then, choose "1" to initiate the PER test mode. Then, you may input 1000 packet in 5 msec interval to see the following example. Please confirm the channel used is 23th in the display. Please note the receiver will learn which channel is to be used for the test automatically.

```
[My Profile]
-----
MAC : 22:95:78:01:00:00:00:47
Short : 0001
PanID : 2514
-----
Send to (Short addr) ? : 02
Send count (dec)    ? : 1000
Interval (dec/msec) ? : 5
[Set channel to 11 (Cmd)]
Prepare to send..OK
[Set channel to 23 (Current)]
Send.. 0
Request to result..OK

[Results]
-----
From   : 0001
To     : 0002
-----
Sent   : 1000
Recieved : 1000
PER    : 0.0000%
RSSI   : max FF / min FF
-----
```

7). Adjusting the output power

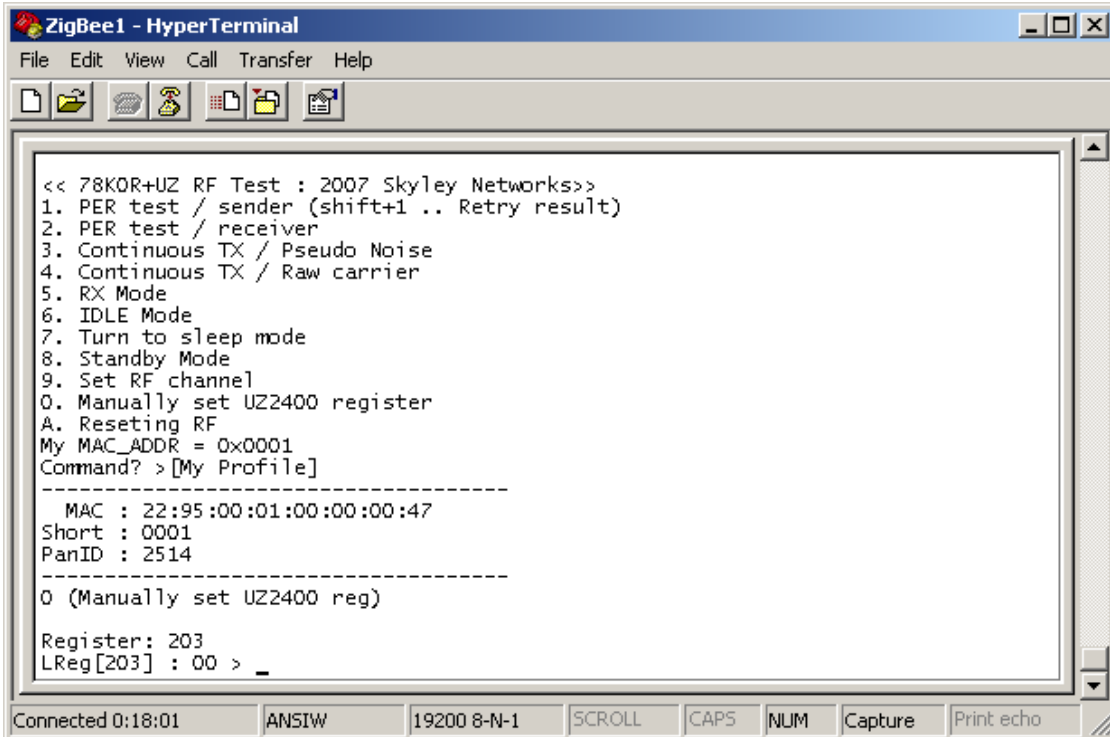
You may wish to control the output power in the PER test.

For it, please select “0” in the menu.

You will be asked the register ID. Please input “203”.

Then you will see, “LREG[203] : 00 >”.

It means the current value at the register [203] is 0x00h, which means 0 dB. 0x00h is the reset default.



```
<< 78KOR+UZ RF Test : 2007 Skyley Networks>>
1. PER test / sender (shift+1 .. Retry result)
2. PER test / receiver
3. Continuous TX / Pseudo Noise
4. Continuous TX / Raw carrier
5. RX Mode
6. IDLE Mode
7. Turn to sleep mode
8. Standby Mode
9. Set RF channel
0. Manually set UZ2400 register
A. Resetting RF
My MAC_ADDR = 0x0001
Command? > [My Profile]
-----
MAC : 22:95:00:01:00:00:47
Short : 0001
PanID : 2514
-----
0 (Manually set UZ2400 reg)

Register: 203
LReg[203] : 00 > _
```

The register bits are defined as follows,

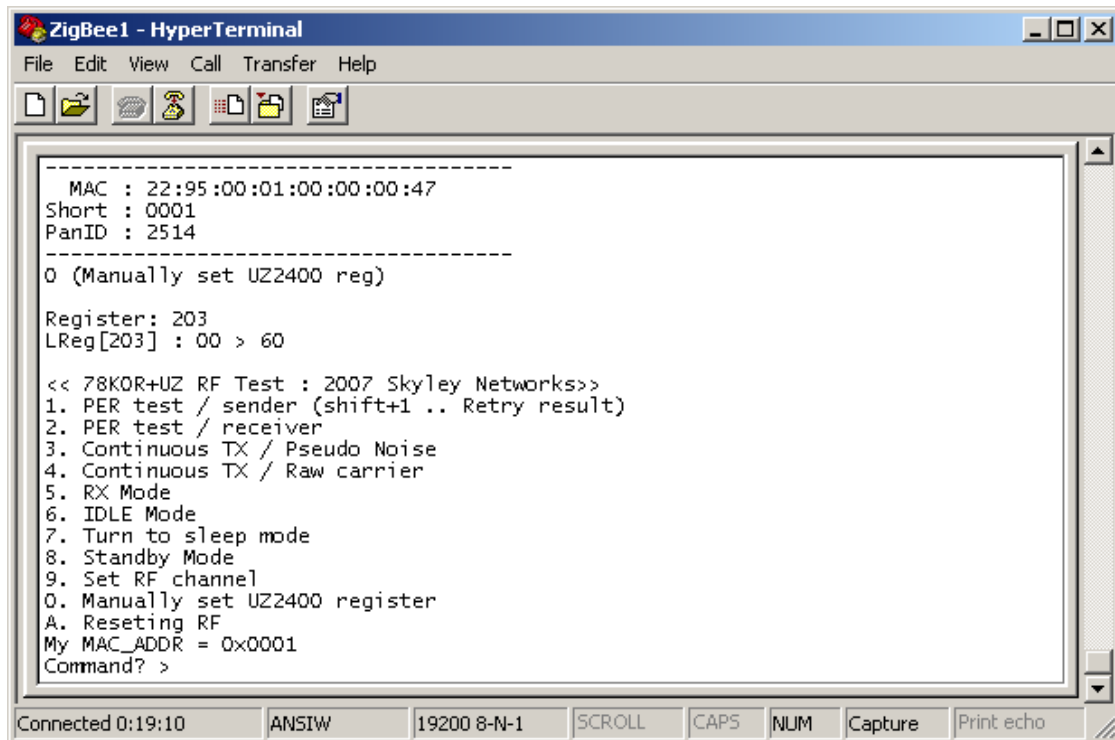
LREG[203]:

[7:6] -> large scale tuning
00: 0 dB
01: -10 dB
10: -20 dB
11: -30 dB
[5:3] -> small scale tuning
000: 0 dB
001: -1.25 dB
010: -2.5 dB
011: -3.75 dB
100: -5 dB
101: -6.25 dB
110: -7.5 dB
111: -8.75 dB
[2:0] -> 000

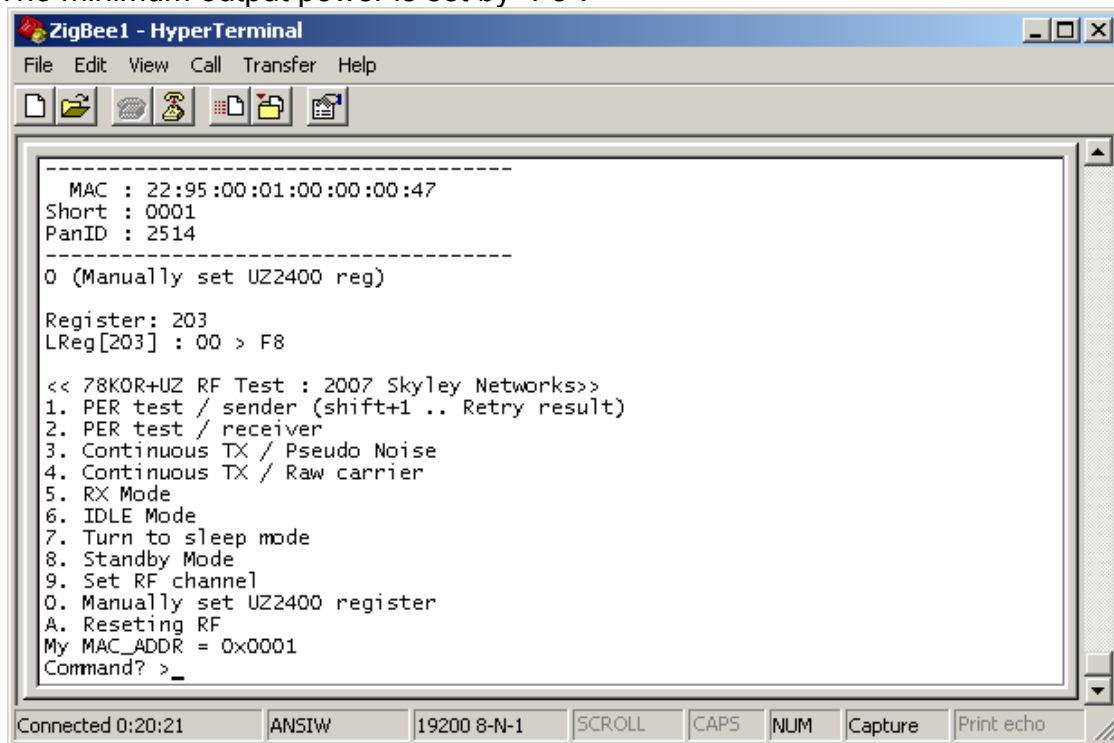
For instance, if you wish -15 dB, please input "60", as follows,

"LREG[203] : 00 > 60"

Then, you will start the PER test.



The minimum output power is set by "F8".



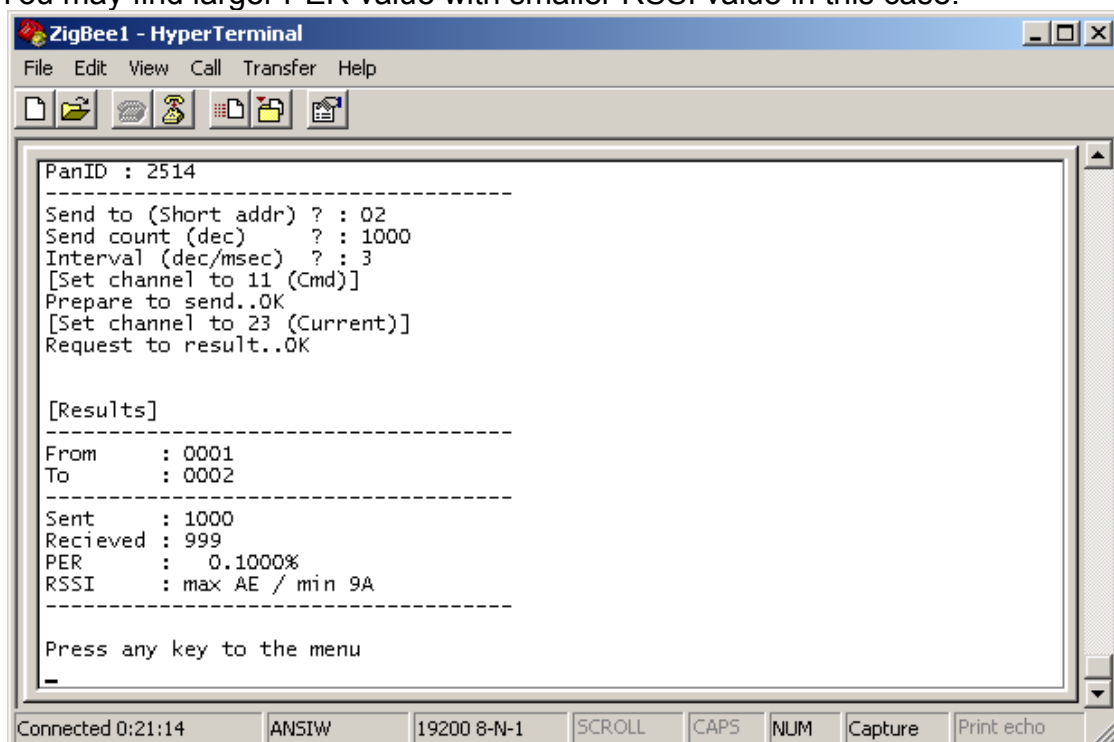
```
ZigBee1 - HyperTerminal
File Edit View Call Transfer Help
-----
MAC : 22:95:00:01:00:00:47
Short : 0001
PanID : 2514
-----
0 (Manually set UZ2400 reg)

Register: 203
LReg[203] : 00 > F8

<< 78KOR+UZ RF Test : 2007 Skyley Networks>>
1. PER test / sender (shift+1 .. Retry result)
2. PER test / receiver
3. Continuous TX / Pseudo Noise
4. Continuous TX / Raw carrier
5. RX Mode
6. IDLE Mode
7. Turn to sleep mode
8. Standby Mode
9. Set RF channel
0. Manually set UZ2400 register
A. Reseting RF
My MAC_ADDR = 0x0001
Command? > _

Connected 0:20:21  ANSIW  19200 8-N-1  SCROLL  CAPS  NUM  Capture  Print echo
```

You may find larger PER value with smaller RSSI value in this case.



```
ZigBee1 - HyperTerminal
File Edit View Call Transfer Help
-----
PanID : 2514
-----
Send to (Short addr) ? : 02
Send count (dec) ? : 1000
Interval (dec/msec) ? : 3
[Set channel to 11 (Cmd)]
Prepare to send..OK
[Set channel to 23 (Current)]
Request to result..OK

[Results]
-----
From : 0001
To : 0002
-----
Sent : 1000
Recieved : 999
PER : 0.1000%
RSSI : max AE / min 9A
-----

Press any key to the menu
_

Connected 0:21:14  ANSIW  19200 8-N-1  SCROLL  CAPS  NUM  Capture  Print echo
```

Please note this adjustment is applied only to the transmitter. The receiver always sends back the test results with the 0 dB output power using the channel 11th.

3.14.2 PER test / receiver

The Menu 2 sets the board to the receiver in the PER test.

If you have two PCs, you can connect two boards to each of two PCs, then, you will apply this mode to one of them.

In your current case, your receiver board is now being connected to the debugger. Therefore, you cannot access to these menu to utilize this mode setting. Alternatively, you have set the receiver board to the receiver mode by setting the switch 1-8.

3.14.3 Continuous TX / Pseudo Noise

The Menu 3 initiates the modulated RF transmission. The data carried are pseudo random numbers. You can define the channel using the menu 9, and the output power using the menu 0.

3.14.4 Continuous TX / Raw carrier

The Menu 4 initiates the carrier transmission. The output power is not 0 dB as a reset default. You can define the channel using the menu 9.

3.14.5 RX Mode

The Menu 5 initiates the receiver mode.

3.14.6 IDLE MODE

The Menu 6 sets the UZ2400 into the IDLE mode.

3.14.7 Sleep MODE

The Menu 7 sets the UZ2400 into the Deep Sleep mode.

3.14.8 Standby MODE

The Menu 8 sets the UZ2400 into the Standby mode.

3.14.9 Set RF channel

The Menu 9 allows you to set the RF channel.

3.14.10 Manually set UZ2400 register

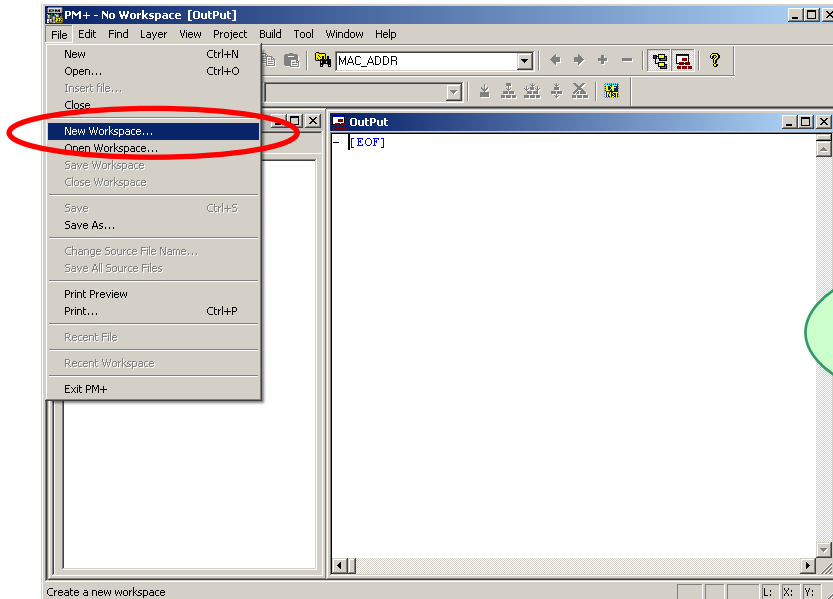
The Menu 0 allows you to set the UZ2400 registers.
Please refer to the datasheet of the UZ2400 RF chip for the definition of registers.

3.14.11 Resetting RF

The Menu A allows you to reset the UZ2400 registers.

3.15 Creating a new PM + workspace (project)

You may wish to create a new work space in the PM + to initiate a new project. Please select select [File]→[New Workspace...] in the pull-down menu of the PM +.



The dialog box for creating New workspace is displayed

<Description of items>

Workspace File Name:

-> Specify the name of the workspace file that manages the project files.
.prw is automatically suffixed as the file type.
A project file (.prj) of the same name is simultaneously created.

Folder:

-> Specify the folder for saving the workspace file by writing its absolute path.
This item can be selected from a reference dialog box by pressing the **Browse...** button.

Project Group Name:

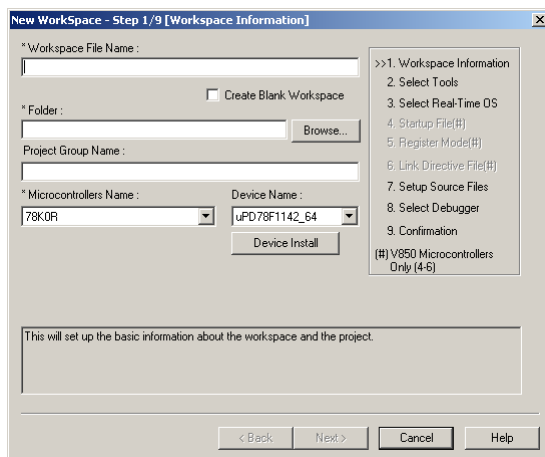
-> Specify this item if wishing to manage multiple projects together in function units.
If nothing is specified, this item is the same as the workspace file name.

Series Name:

-> Specify the series name of the device to be used.

Device Name:

-> Specify the name of the device to be used.



The concrete information set here is described on the following pages

Input the workspace information setting as follows.

Workspace file name

→ test

Folder

→ C:/test

Project Group Name

→ Don't input this item.

Series Name

→ 78K0R

Device Name

→ uPD78F1168_A0

New Workspace - Step 1/9 [Workspace Information]

* Workspace File Name : test

Create Blank Workspace

* Folder : C:\test Browse...

Project Group Name :

* Microcontrollers Name : 78K0R Device Name : uPD78F1168_A0

Device Install

>>1. Workspace Information
2. Select Tools
3. Select Real-Time OS
4. Startup File(#)
5. Register Model(#)
6. Link Directive File(#)
7. Setup Source Files
8. Select Debugger
9. Confirmation
(#) V850 Microcontrollers Only (4-6)

This will set up the basic information about the workspace and the project.

< Back Next > Cancel Help

Push the **Next >** button.



PM+

Q2011: C:\test

This folder cannot be found. Do you wish to create it?

Yes No

Push the **Yes** button.



New Workspace - Step 2/9 [Select Tools]

Tool Set : [Selected]0178K0R_Series Software Package V1.00[English Ver]

Save Delete

Tool Versions :

| Tool | Version |
|------|---------|
|------|---------|

Select only Installed Tools

Detail Setting...

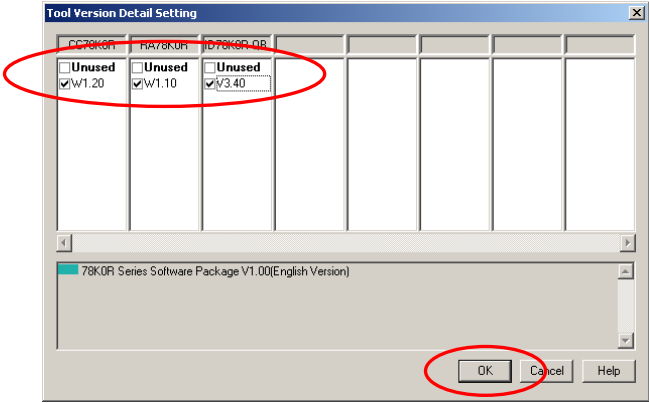
Please select the Tools from NEC Electronics to be used.

The following tools have been excluded from selection because they are not installed.
CC78K0R, RA78K0R, ID78K0R-QB, 5M+ for 78K0R

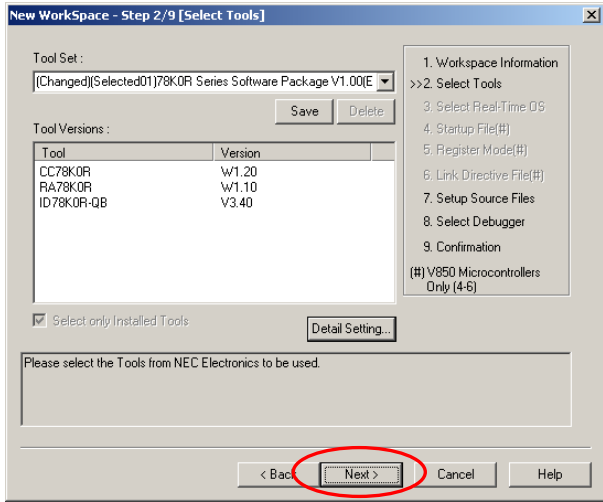
< Back Next > Cancel Help

Push the **Detail setting** button

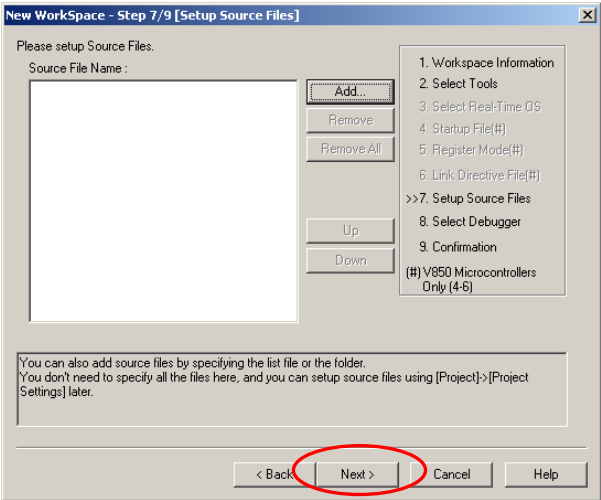
Set the version of tools as follows.
 CC78K0R : W1.20
 RA78K0R : W1.10
 ID78K0R-QB : V3.40



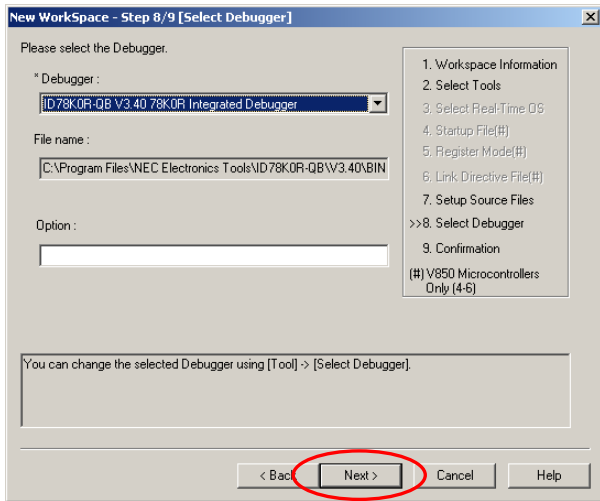
Select tools as above screenshot, then click **OK** .



Click **Next >**



Click **Next >**

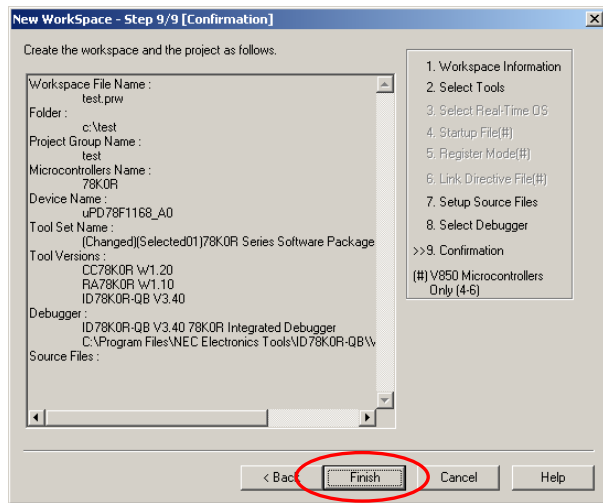


Select ID78K0R-QB V3.40

Click **Next >**

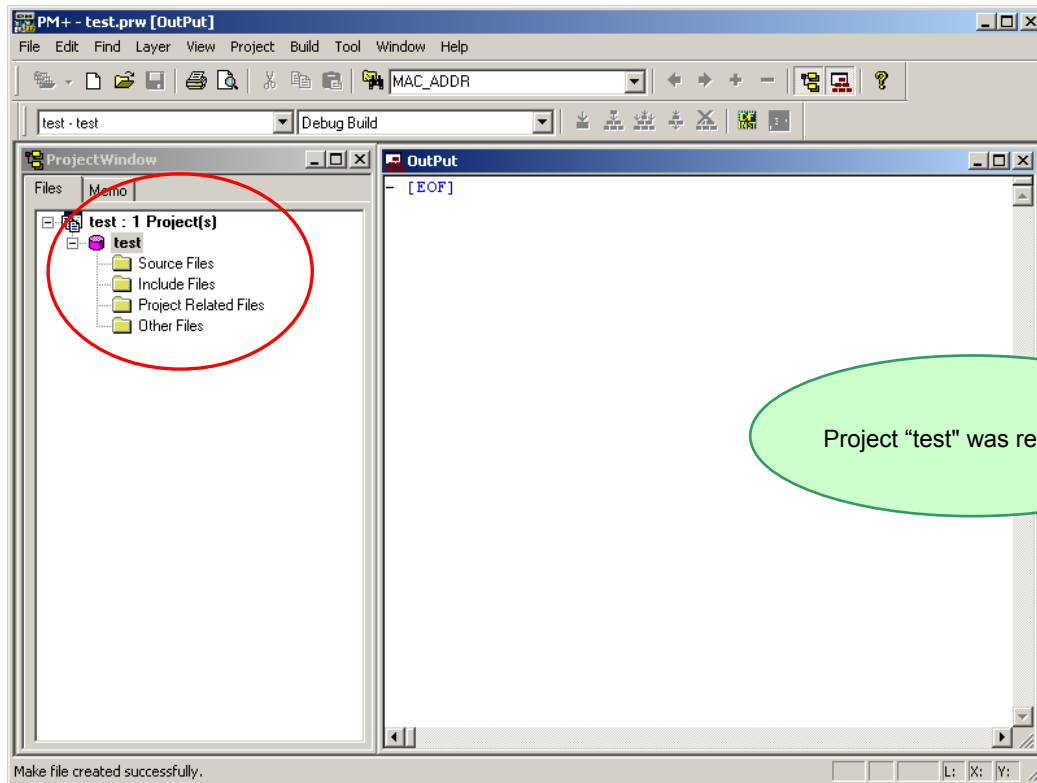


Check the project information setting contents.



Click **Finish**





This completes workspace and project creation.

Additional source files can be registered at any time thereafter.

➡ For details, refer to "[Registering additional source file](#)"

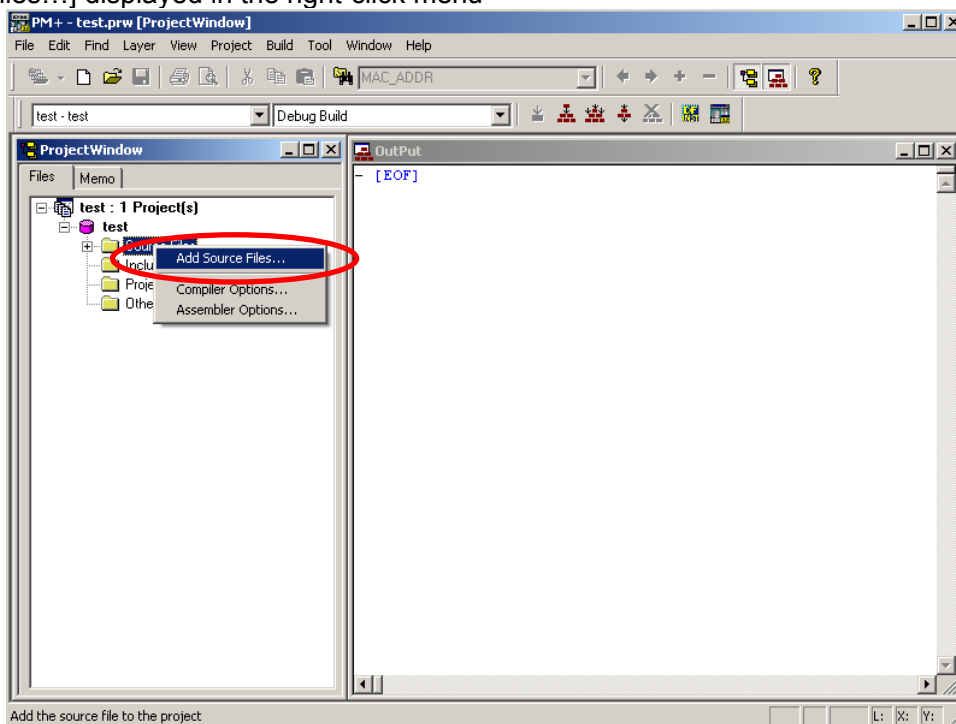
Also, you need to do the settings for on-chip debug. Please refer to "[2.4 Set Linker Options](#)", "[2.5 Set Compiler Options](#)", and "[2.7 Check Debugger Settings](#)".

3.16 Registering additional source file

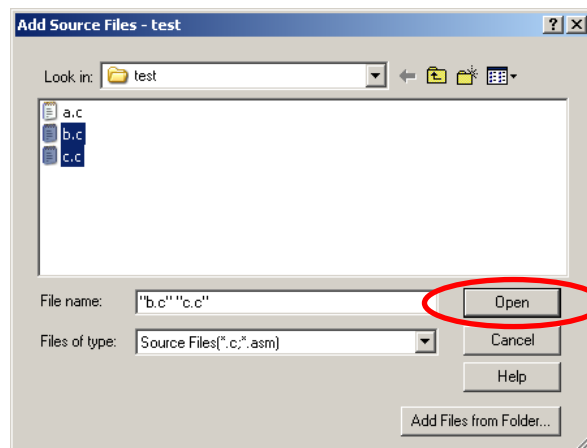
The method for registering additional source files to a project is described below.

The following example shows the additional registration of source files “b.c” and “c.c” with source file “a.c” already registered.

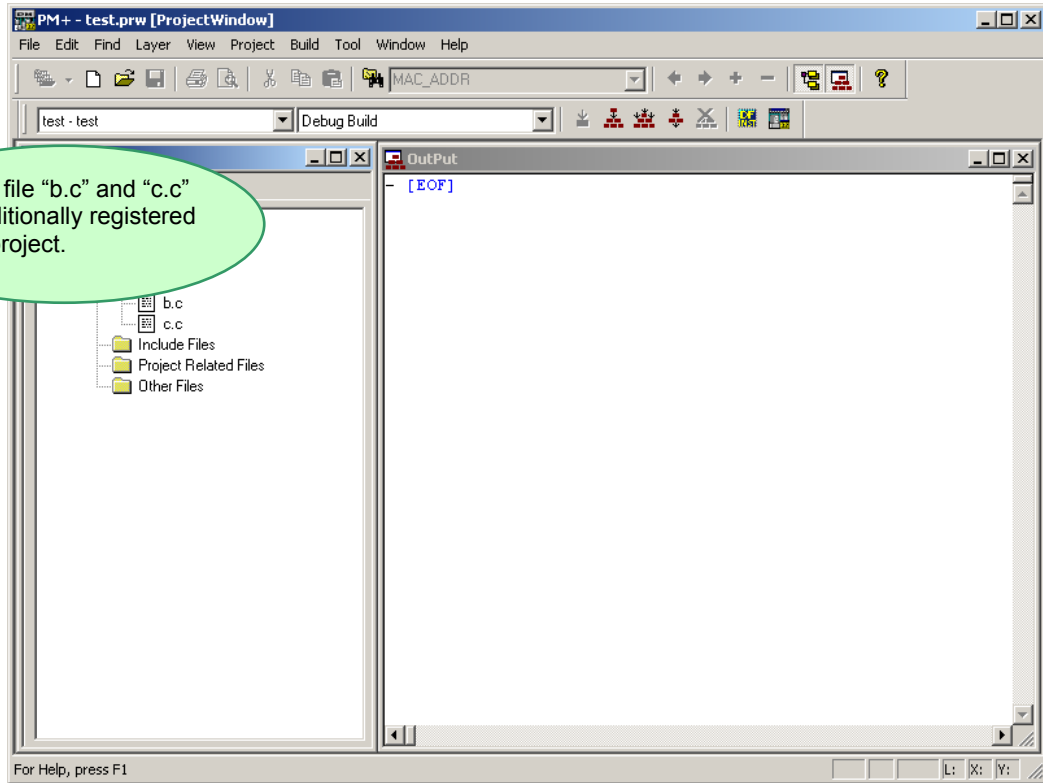
Place the cursor on the source file in the Project window of PM +, and select [Add Source Files...] displayed in the right-click menu



Select source files “b.c” and “c.c” and then press the **Open** button.



Multiple source files can be selected by clicking the desired source files where pressing **Ctrl** key.

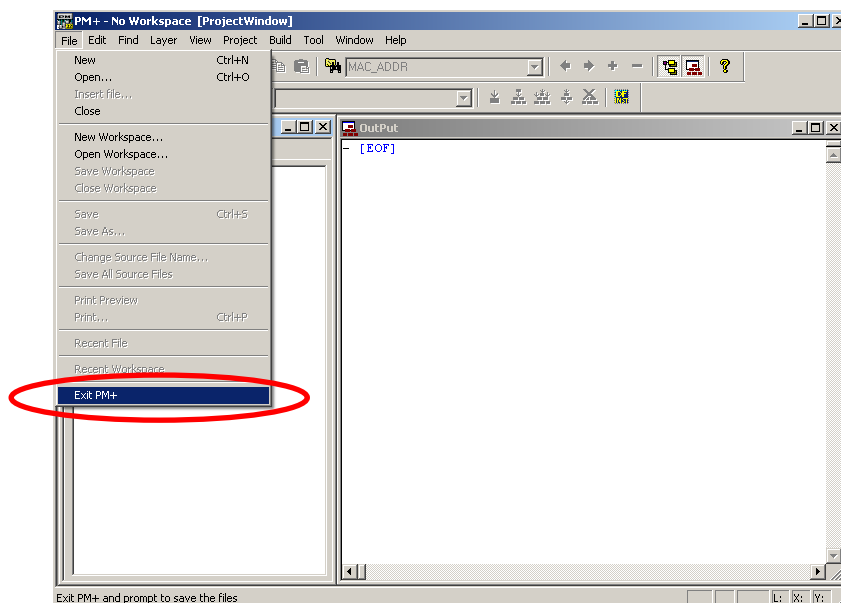


Source file "b.c" and "c.c" are additionally registered to the project.

3.17 Terminating PM +

In the PM + menu, select [File]→[Save Workspace].
Then, select [File]→[Close Workspace].

In the PM + menu, select [File]→[Exit PM +].



PM + ends.

4 IEEE 802.15.4 MAC Sample Program

Two sample implementations utilizing the MAC stack are offered in this evaluation kit.

4.1 The MAC Sample program 1 :TextChat

This chapter introduces the usage of MAC application 1

The MAC Sample program 1 is developed to provide with a simple example to construct a star network utilizing the IEEE 802.15.4 PHY/MAC standard.

The MAC Sample Program offers,

1. Designation of a network coordinator in a star configuration
2. Text chat between a coordinator and an end device

To use the MAC Sample Program 1, you need to prepare at least two PC with a USB interface or one PC with more than one USB interface, and two TK-78K0R/KG3+UZ boards.

The MAC Sample Program 1 is provided in the form of the C source codes.

If you wish to tailor the sample program to meet your specific needs, you can edit the source code, re-compile it with debug build to generate a load module file, then, start the debugger to load the tailored execution code on to the microcontroller for further debugging on the project manager PM +. In this procedure, the Flash programmer is not required. However, because the USB connection to instruct operation to the program is occupied for the debugging purpose, alternatively, you can make a release build to achieve a new hex file, on the project manager PM +.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0R/KG3+UZ board in a radio anechoic chamber.

It supports text chat for one coordinator and 4 end devices.

4.1.1 Programming to the TK boards

For chatting, please prepare minimum 2, or maximum 5 TK-78K0R/KG3+UZ boards. You need identical numbers of PCs.

Some laptop PCs do not support full functionality of hyperterminal. This software has been confirmed at
NEC MATE MY25XCZEG
and, NEC VERSAPRO VY10F/BH-M

Start PM+, and open the file

"C:\TK78K0R\SAMPLE_KG3+UZ\TK78K0RKG3UZ_Sample1\TK78K0RKG3UZ_Sample1.prw".

Select "Tools" on menu bar, then "Compiler options".

Select "Preprocessor" tab on "Compiler Options" window.

To write programs on the first TK-78K0R/KG3+UZ, enter "CPU78K0R,MAC_ADDR=0x0001" on "Define Macro". For the second and third TK-78K0R/KG3+UZ, enter "CPU78K0R,MAC_ADDR=0x0002" and "CPU78K0R,MAC_ADDR=0x0003". The number "x" of "MAC_ADDR=x" must be a unique number.

Click re-build button on PM+ or select "Build" -> "Rebuild" on menu bar to rebuild.

Start the debugger from PM+, then write different programs to each TK-78K0R/KG3+UZ (for the information about how to write programs, refer to "3.1 Starting PM+" through "3.9 Starting integrated debugger (ID78K0R-QB)").)

4.1.2 Setting up the board to your PC

Set the TK-78K0R/KG3+UZ as shown below.

Connect it to PC with USB cable.

Confirm the power LED on TK-78K0R/KG3+UZ is lighted.

| JP1 | | 1-2short (USB side) |
|-----|------|---------------------|
| SW1 | Bit1 | OFF |
| | Bit2 | OFF |
| | Bit3 | OFF |
| | Bit4 | ON |
| | Bit5 | ON |
| | Bit6 | OFF |
| | Bit7 | OFF |
| | Bit8 | OFF |

Start Hyper Terminal with referring to "3.14 RF Test Program".

Settings of the Hyper Terminal should be set as follows.

| | |
|-----------------|--------|
| Bits per second | 115200 |
| Data bits | 8 |
| Parity | None |
| Stop bits | 1 |
| Flow control | None |

Press SW5 (RESET SW) once after Hyper Terminal is started. The sample application starts after resetting.

In the same way, connect the other TK-78K0R/KG3+UZ board to PC, and start Hyper Terminal. If the PC has more than one USB ports, you can connect to more than one TK-78K0R/KG3+UZ boards, and you can start more than one Hyper Terminals for those COM ports on each board.

4). Hyper Terminal

Now you will find the following opening menu in the window.
If not, please try the RESET button on the board.

```
-----  
TK-78K0R+UZ Sample Application  
-----  
2007 Skyley Networks  
  
MY MAC extended address  
=123412349ABC001  
  
Command >
```

Then, press Enter,

```
[Help] -----  
S: Send Message  
M: MLME Associate test  
C: Start Coordinator test  
-----  
  
Command? >
```

Please do the same for your other boards and PCs.

4.1.3 Designation of a coordinator

Now, you must decide which board is a coordinator.
Go to the PC of the coordinator board, and press C.

```
Command? >C  
  
> MLME-START.request  
> MLME-START.confirm  
> Status:00  
  
Command? >
```

Now the coordinator has started.

4.1.4 Network Association

For other PCs for other boards, please press M.

```
Command? >M  
  
> MLME-ASSOCIATE.request  
> MLME-ASSOCIATE.confirm  
> Associated ShortAddr:4321  
> Status:00  
  
Command? >
```

Now, this particular board was associated to the network as an end device with the short address of 4321. Please repeat this step for your third, fourth, and possibly fifth board.

On the coordinator side, you will find the following message, if the association is successful.

```
> MLME-ASSOCIATE.indication
> from 123400019ABC0001 associated to 4321

[Help] -----
S: Send Message
-----

Command? >
```

4.1.5 Text Chat

Now the network is prepared for you to start text chat between an end device and the coordinator.

At first, you may start with the coordinator.

Press S, then input the short address of an end device, 4321 in this example, then, input your text message, up to 102 bytes.

```
Command? >S

> MCPS-DATA.request
> Send to (short address) ? 4321
> Message ? Hello!

Command? >
```

You will find the following message on the end device, 4321.
The sender's short address is "1975", and the PAN ID is 2420 in this example.

```
Command? >  
> MCPS-DATA.indication  
> from 1975/2420  
Hello!
```

Now, you can reply from the end device "4321" to the coordinator "1975" by inputting S, 1975, and your reply text.

4.2 The MAC Sample Program2 : LED Control

The MAC Sample program 2 is developed to provide with another simple example to construct a star network utilizing the IEEE 802.15.4 PHY/MAC standard.

The MAC Sample Program 2 offers,

- 1). Designation of a network coordinator in a star configuration
- 2). If you push a switch on the nth end device, an LED on the coordinator board blinks on and off n times.

To use the MAC Sample Program 2, you need to prepare one PC with a USB interface and two TK-78K0R/KG3+UZ boards or more boards, up to 5. The MAC Sample Program 2 is provided in the form of the C source codes with the MAC library.

If you wish to tailor the sample program to meet your specific experiment, you can edit the source code, re-compile it with debug build to generate a load module file, then, start the debugger to load the tailored execution code on to the microcontroller for further debugging on the project manager PM+. In this procedure, the Flash programmer is not required. However, because the USB connection is occupied for the debugging interface, the USB connection is not available for applications. In this application example, Hyperterminal with USB connection offers information on the network association. However, the LED operation can be made without Hyperterminal. Therefore, you can use the USB connection for debugging for the LED operation. Alternatively, you may make a release build to achieve a new hex file, on the project manager PM+.


As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0R/KG3+UZ board in a radio anechoic chamber.

4.2.1 Programming to the TK boards

Prepare TK-78K0R/KG3+UZ boards (2 to maximum of 6 boards).
You also need at least one PC to write programs, however no PC is needed when running the programs.

One TK-78K0R/KG3+UZ board will be "Coordinator". Other 1-5 boards will be "End device".
You use the same project files for both "Coordinator" and "End device".

Start PM+ and open the file
"C:\TK78K0R\SAMPLE_KG3+UZ\TK78K0RKG3UZ_Sample2\TK78K0RKG3UZ_Sample2.prw".

Click the build button  or select "Build" on menu bar, then "Build" to build.
Start the debugger from PM+ and write programs to each TK-78K0R/KG3+UZ board.
(for the information about how to write programs, refer to "3.1 Starting PM+" through "3.9 Starting integrated debugger (ID78K0R-QB)")

The address of each board will be set by pressing SW2 when the boards start up (when power is supplied). Therefore, you use the same programs to all boards.

4.2.2 Starting up a coordinator

By connecting the TK-78K0R/KG3+UZ which takes the role of "Coordinator", you can monitor those programs running (you can monitor the output itself with LED without PC).

When you wish to connect PC, set the TK-78K0R/KG3+UZ as follows. Then, connect USB cable to PC. Confirm the power LED is lighted after connecting the USB cable.

| JP1 | | 1-2 short (USB side) |
|-----|------|----------------------|
| SW1 | Bit1 | OFF |
| | Bit2 | OFF |
| | Bit3 | OFF |
| | Bit4 | ON |
| | Bit5 | ON |
| | Bit6 | OFF |
| | Bit7 | OFF |
| | Bit8 | OFF |

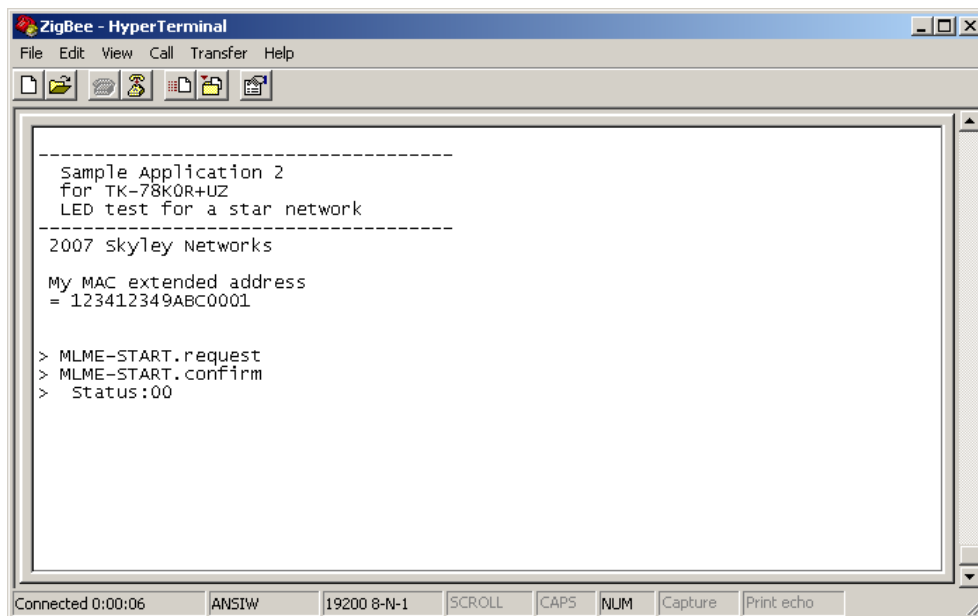
Start Hyper Terminal with referring to "3.14 RF Test Program".

Settings of the Hyper Terminal should be set as follows.

| | |
|-----------------|--------|
| Bits per second | 115200 |
| Data bits | 8 |
| Parity | None |
| Stop bits | 1 |
| Flow control | None |

6). After you open the window of the HyperTerminal, please push the reset button on the board. Now you will find the following opening message in the window.

If not, please reconfirm the COM port number of the USB connection.



Now the coordinator has started up successfully.

4.2.3 Starting up end devices

Set TK-78K0R/KG3+UZ settings as follows when you use PC connected to TK-78K0R/KG3+UZ which takes the role of "End device". Then, connect USB cable to PC. Confirm the power LED is lighted after connecting the USB cable.

| | | |
|-----|------|----------------------|
| JP1 | | 1-2 short (USB side) |
| SW1 | Bit1 | OFF |
| | Bit2 | OFF |
| | Bit3 | OFF |
| | Bit4 | ON |
| | Bit5 | ON |
| | Bit6 | OFF |
| | Bit7 | OFF |
| | Bit8 | OFF |

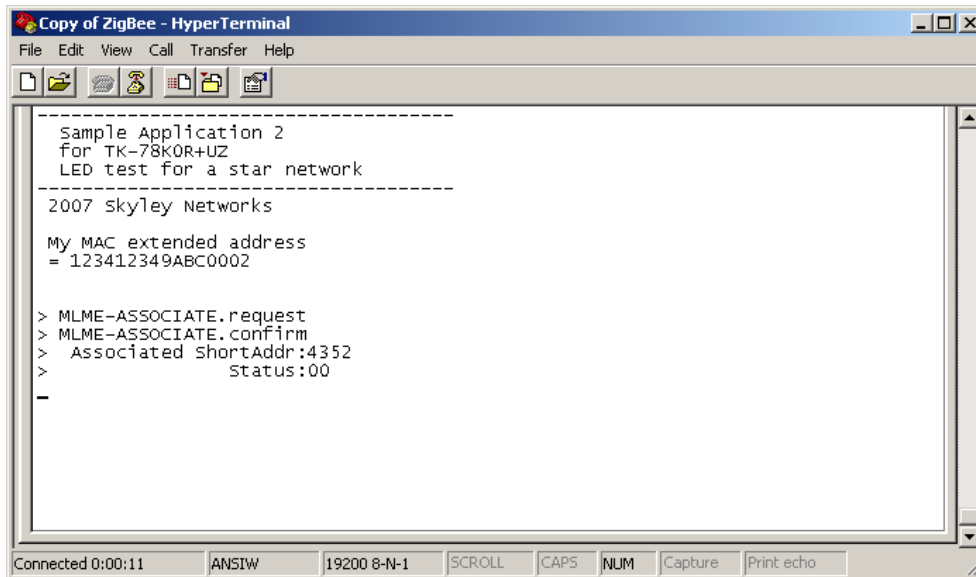
When you wish to use TK-78K0R/KG3+UZ as itself, set JP1 to BATTERY side (2-3short) and SW1 to all OFF, then connect battery.

You must set the position of SW2 when you supply power to TK-78K0R/KG3+UZ. The TK-78K0R/KG3+UZ board functions of each SW2 position are described as follows.

| Position of Joy Stick during start-up | Function | Extended Address |
|---------------------------------------|-------------|--------------------|
| Default | Coordinator | 0x1234XXXX9ABC0001 |
| Up | End Device | 0x1234XXXX9ABC0002 |
| Center | End Device | 0x1234XXXX9ABC0003 |
| Left | End Device | 0x1234XXXX9ABC0004 |
| Right | End Device | 0x1234XXXX9ABC0005 |
| Down | End Device | 0x1234XXXX9ABC0006 |

※The "XXXX" of Extended Address filled with "MAC_ADDR=0xXXXX" that configured at "Compiler Options" -> "Defined Macro".

If you start-up a board while keeping the Joy Stick up, you will see the following message on the HyperTerminal.



```
Copy of ZigBee - HyperTerminal
File Edit View Call Transfer Help
-----
Sample Application 2
For TK-78KOR+UZ
LED test for a star network
-----
2007 skylley Networks

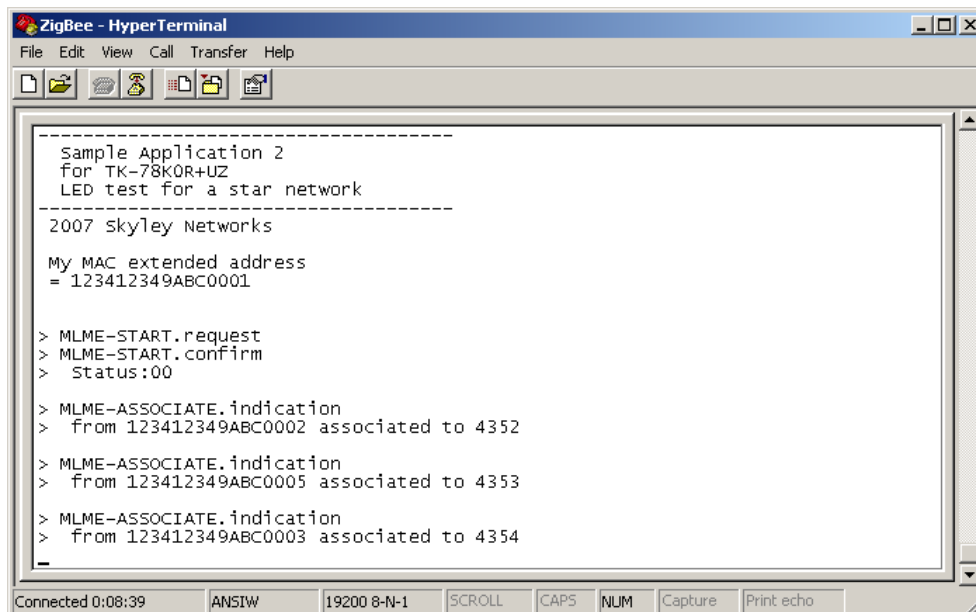
My MAC extended address
= 123412349ABC0002

> MLME-ASSOCIATE.request
> MLME-ASSOCIATE.confirm
> Associated ShortAddr:4352
> Status:00
-
```

A short address of “4352” was assigned to the board.

A short address is assigned sequentially, independent from the long address.

Then, if you start-up the third board while keeping the Joy Stick center, you will see the following message on the HyperTerminal.



```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
-----
Sample Application 2
For TK-78KOR+UZ
LED test for a star network
-----
2007 skylley Networks

My MAC extended address
= 123412349ABC0001

> MLME-START.request
> MLME-START.confirm
> Status:00

> MLME-ASSOCIATE.indication
> From 123412349ABC0002 associated to 4352

> MLME-ASSOCIATE.indication
> From 123412349ABC0005 associated to 4353

> MLME-ASSOCIATE.indication
> From 123412349ABC0003 associated to 4354
-
```

4.2.4 Operation

The coordinator generates beacon at channel 11 of 2405 MHz.
LED4 on the board is ON.

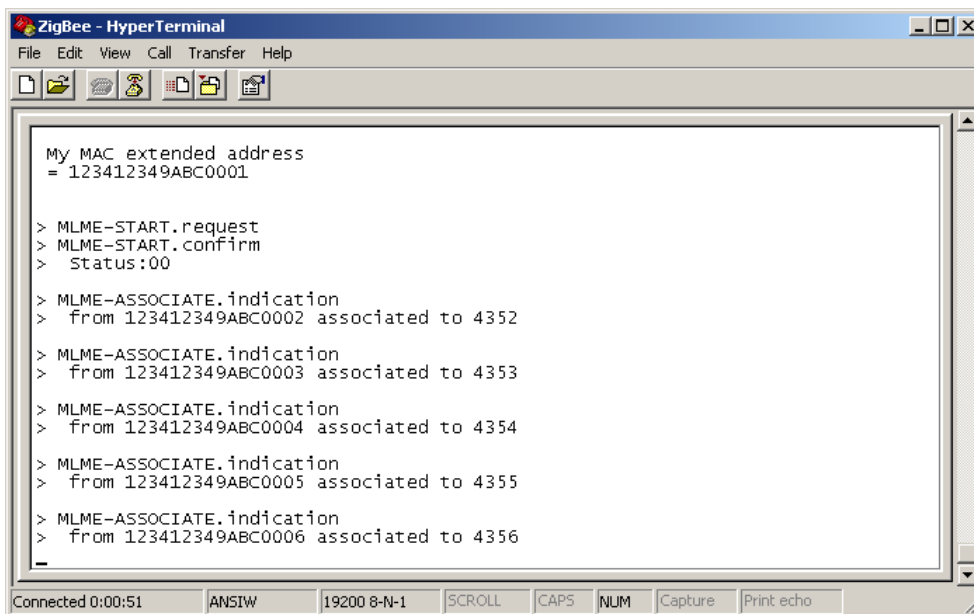
An end device makes a network association. If successful, LED2 on the board is ON.

If you push SW3 on an end device, LED4 on the coordinator blinks.
And, if you push SW4 on an end device, LED3 on the coordinator blinks.

The number of times of blink depends on the sequence the end device joined in the network. For instance, if an end device is the third end device for the network, the LED will blink three times.

| LED on Coordinator | SW on End Device |
|--------------------|------------------|
| LED2 | SW3 |
| LED3 | SW4 |

The following example shows, the SW3 on the fifth end device, “4356”, was pushed. You will see the LED2 on the coordinator will blink 5 times.
The default PAN ID of this network is “2420”.



```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
My MAC extended address
= 123412349ABC0001

> MLME-START.request
> MLME-START.confirm
> Status:00

> MLME-ASSOCIATE.indication
> from 123412349ABC0002 associated to 4352

> MLME-ASSOCIATE.indication
> from 123412349ABC0003 associated to 4353

> MLME-ASSOCIATE.indication
> from 123412349ABC0004 associated to 4354

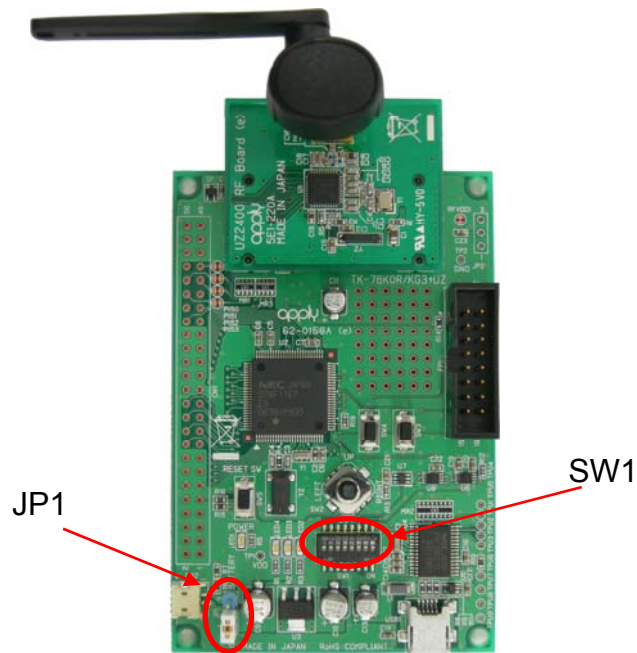
> MLME-ASSOCIATE.indication
> from 123412349ABC0005 associated to 4355

> MLME-ASSOCIATE.indication
> from 123412349ABC0006 associated to 4356

Connected 0:00:51 ANSIW 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

5 Mode setting of the board

The combination table of the switch of this board is shown.



| Usage case | | Normal | Debug (USB Connection) | Normal (Serial Connection) |
|------------|------|-------------------------------|------------------------|----------------------------|
| SW | JP1 | Select by power supply source | 1-2short (USB side) | 1-2short(USB side) |
| SW1 | Bit1 | OFF | OFF/ON ※1 | OFF |
| | Bit2 | OFF | ON | OFF |
| | Bit3 | OFF | ON | OFF |
| | Bit4 | OFF | OFF | ON |
| | Bit5 | OFF | OFF | ON |

※1

- ON:** The microcontroller stays being reset until ID78K0R-QB is started.
OFF: The microcontroller runs the programs stored in the flash memory as soon as it gets power supply.

6 Revision History

| Revision | Contents | Date |
|----------|--|----------------|
| Rev. 1.0 | Initial Version | April 2, 2007 |
| Rev. 2.0 | Correction With the sample program change. | July 2, 2007 |
| Rev. 3.0 | Correction With the sample program change. | March 31, 2008 |
| Rev. 3.1 | Manufacturer change. | June 24, 2008 |
| Rev. 4.0 | Correction With the sample program change. | March 7, 2009 |