

User's Manual

TK-78K0/KF2+UZ

ZigBee™-ready

Wireless Network Evaluation Board

Using the UZ2400 RF chip

and the 78K0/KF2 Microcontroller

Tutorial

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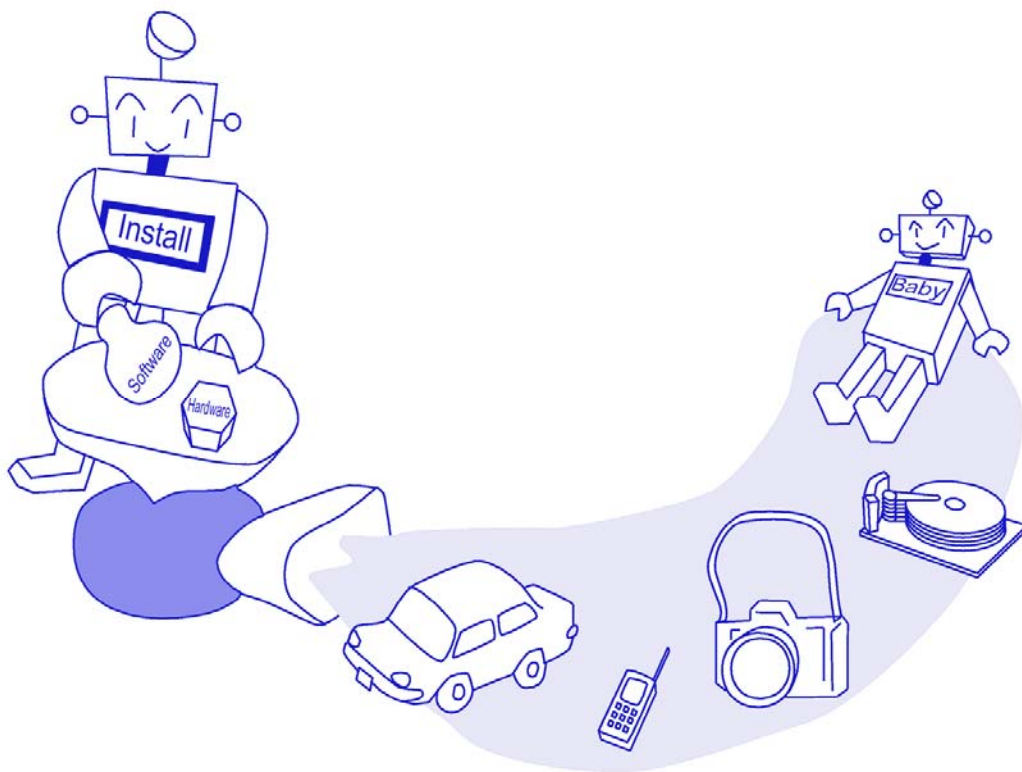
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Welcome to the world of TK-78K0/KF2+UZ.

You are now being navigated to the design environment of the 78K0 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.

Contents

1	INTRODUCTION.....	7
2	PREPARATIONS.....	8
2.1	Development Tools, Sample Programs, and the MAC Library.....	9
2.1.1	Integrated Development Environment PM plus V5.21	9
2.1.2	Device file DF780547 V2.10	9
2.1.3	C Compiler CC78K0 W3.70: Code size limited version	9
2.1.4	Assembler RA78K0 W3.80: Code size limited version.....	9
2.1.5	78K0 integrated debugger ID78K0-TK V2.02.....	9
2.1.6	Portconfig for ID78K0-TK.....	9
2.1.7	USB driver.....	9
2.1.8	Flash EEPROM Programmer PG-FPL3	10
2.1.9	Parameter file	10
2.1.10	The RF Test Program.....	10
2.1.11	IEEE 802.15.4 MAC Library	10
2.1.12	The MAC Sample Program1 : Text Chat Program.....	11
2.1.13	The MAC Sample Program2 : LED Control	11
2.2	Installation of Software Development Tools.....	13
2.2.1	Start-up of the installation CD-ROM	13
2.2.2	Installation of the software development tools.....	13
2.2.3	Uninstall	19
2.2.4	File Configuration in PC.....	20
2.3	Sample Environment.....	21
2.3.1	Installation of the sample programs.....	22
2.3.2	File Configuration of the sample program	24
2.4	USB Driver	25
2.4.1	Installation of the USB driver	25
2.4.2	Confirmation of the installation	34
2.4.3	Uninstallation of the USB driver.....	35
3	EXPERIENCES.....	37
3.1	Starting PM plus	39
3.2	Introduction to PM plus.....	40
3.3	Loading Workspace (Project)	42

3.4	Configuration of Linker Option.....	44
3.5	Configuration of Compiler Option.....	46
3.6	Configuration of Debugger setting	50
3.7	TK board setting	52
3.8	Creating execution format	54
3.9	Starting integrated debugger (ID78K0-TK)	56
3.10	Introduction of integrated debugger (ID78K0-TK)	61
3.11	Executing program.....	62
3.12	Stopping program	63
3.13	Terminating integrated debugger (ID78K0-TK)	64
3.14	RF Test Program.....	65
3.14.1	Procedure for one to one transmit/receive test	65
3.14.2	PER test / receiver	77
3.14.3	Continuous TX / Pseudo Noise	77
3.14.4	Continuous TX / Raw carrier	77
3.14.5	RX Mode.....	77
3.14.6	IDLE MODE.....	77
3.14.7	Sleep MODE.....	77
3.14.8	Standby MODE.....	77
3.14.9	Set RF channel.....	78
3.14.10	Manually set UZ2400 register	78
3.14.11	Resetting RF.....	78
3.15	Creating new hex files.....	79
3.16	Creating a new PM plus workspace (project).....	81
3.17	Registering additional source file	86
3.18	Terminating PM plus	88
4	HOW TO USE PG-FPL3.....	89
4.1	Installation of PG-FPL3	89
4.2	How to use PG-FPL3	89

5	IEEE 802.15.4 MAC SAMPLE PROGRAM	95
5.1	The MAC Sample program 1 :TextChat.....	96
5.1.1	Programming to the TK boards.....	97
5.1.2	Setting up the board to your PC.....	97
5.1.3	Designation of a coordinator.....	99
5.1.4	Network Association	99
5.1.5	Text Chat	100
5.2	The MAC Sample Program2 : LED Control.....	102
5.2.1	Programming to the TK boards.....	103
5.2.2	Starting up a coordinator	103
5.2.3	Starting up end devices	105
5.2.4	Operation	107
6	MODE SETTING OF THE BOARD.....	108
7	REVISION HISTORY	109

1 Introduction

Target Reader	Software development engineers who wish to become familiar with the development environment of the 78K0 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 Preparations → Introduction of soft tools, and sample programs and installation
	Chapter 2 Experiences → Guide to the basic operations of PM plus and the integrated debugger using sample programs.
	Chapter 3 How To Use PG-FPL3 → How to program Flash EEPROM
	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 plus V5.21

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 DF780547 V2.10

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 CC78K0 W3.70: Code size limited version

This is a free compiler for the 78K0 microcontrollers. The object code size is limited to 32 Kbytes. It works on MS Windows 2000 or XP.

2.1.4 Assembler RA78K0 W3.80: Code size limited version

This is a free assembler for the 78K0 microcontrollers. The object code size is limited to 32 Kbytes. It works on MS Windows 2000 or XP. The RA78K0 Assembler Package contains Structured Assembler Preprocessor, Assembler, Linker, Object Converter, Librarian, and List Converter.

2.1.5 78K0 integrated debugger ID78K0-TK V2.02

The Integrated Debugger ID78K0-TK 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. ID78K0-TK is a software module added on ID78K0-QB.

2.1.6 Portconfig for ID78K0-TK

"Portconfig for ID78K0-TK" assigns the COM port number for the connection to the TK board. This is installed automatically, if the ID78K0-TK is installed in the PC.

2.1.7 USB driver

This is a software driver for PC to access to the USB interface of the TK-78K0/KF2+UZ board.

2.1.8 Flash EEPROM Programmer PG-FPL3

PG-FPL3 is a software Flash EEPROM programmer, working on MS Windows. PG-FPL3 enables you to program your application program file of hex format in the Flash EEPROM, embedded on the 78K0/KF2 microcontroller in the TK-78K0/KF2+UZ board, via the USB interface of the board.

You do not need any hardware, additionally to your PC and the TK-78K0/KF2+UZ board, to make the programming.

2.1.9 Parameter file

A parameter file is required to inform PG-PFL3 of device specific parameters of Flash EEPROM. Please do not mix it up with a device file.

2.1.10 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 hex file, as well as the C source codes.

The hex file, TK78K0KF2UZ_RF_TEST.hex, allows you to immediately program to your TK-78K0KF2+UZ boards using the PG-FPL3 Flash EEPROM programmer, and start RF testing. The TK78K0KF2UZ_RF_TEST.hex file is available at C:/Program Files/TK78K0KF2UZ_RF_Test_v2/Release.

Or, 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 plus. In this procedure, the Flash programmer PG-FPL3 is not required.

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

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0/KF2+UZ board in a radio anechoic chamber.

2.1.11 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.

2.1.12 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-78K0/KF2+UZ boards.

The MAC Sample Program 1 is provided in the form of the hex file, as well as the C source codes.

The hex files, TK78K0KF2UZ_Sample1_01.hex, _02.hex, _03.hex, _04.hex and _05.hex allow you to immediately program to your TK-78K0KF2+UZ boards using the PG-FPL3 Flash EEPROM programmer, and start the sample application. The TK78K0KF2UZ_Sample1_0x.hex files are available at

C:/TK78K0/SAMPLE_KF2+UZ/TK78K0KF2UZ_Sample1/Release.

Or, 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 plus. In this procedure, the Flash programmer PG-FPL3 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 plus.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0/KF2+UZ board in a radio anechoic chamber.

2.1.13 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-78K0/KF2+UZ boards or more boards, up to 5. The MAC Sample Program 2 is provided in the form of the hex file, as well as the C source codes.

The hex file, TK78K0KF2UZ_Sample2.hex, allows you to immediately program to your TK-78K0KF2+UZ boards using the PG-FPL3 Flash EEPROM programmer, and start the sample application. The TK78K0KF2UZ_Sample2.hex file is available at
C:/TK78K0/SAMPLE_KF2+UZ/TK78K0KF2UZ_Sample2/Release.

Or, 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 plus. In this procedure, the Flash programmer PG-FPL3 is not required. 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 plus.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0/KF2+UZ board in a radio anechoic chamber.

2.2 Installation of Software Development Tools

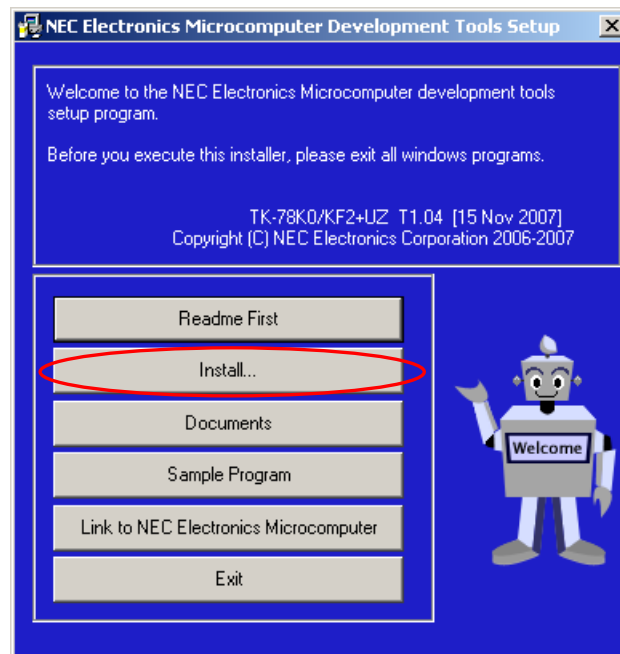
2.2.1 Start-up of the installation CD-ROM

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

You can install it using an installer.
(Expect for FPL3 and Parameter file.)

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)

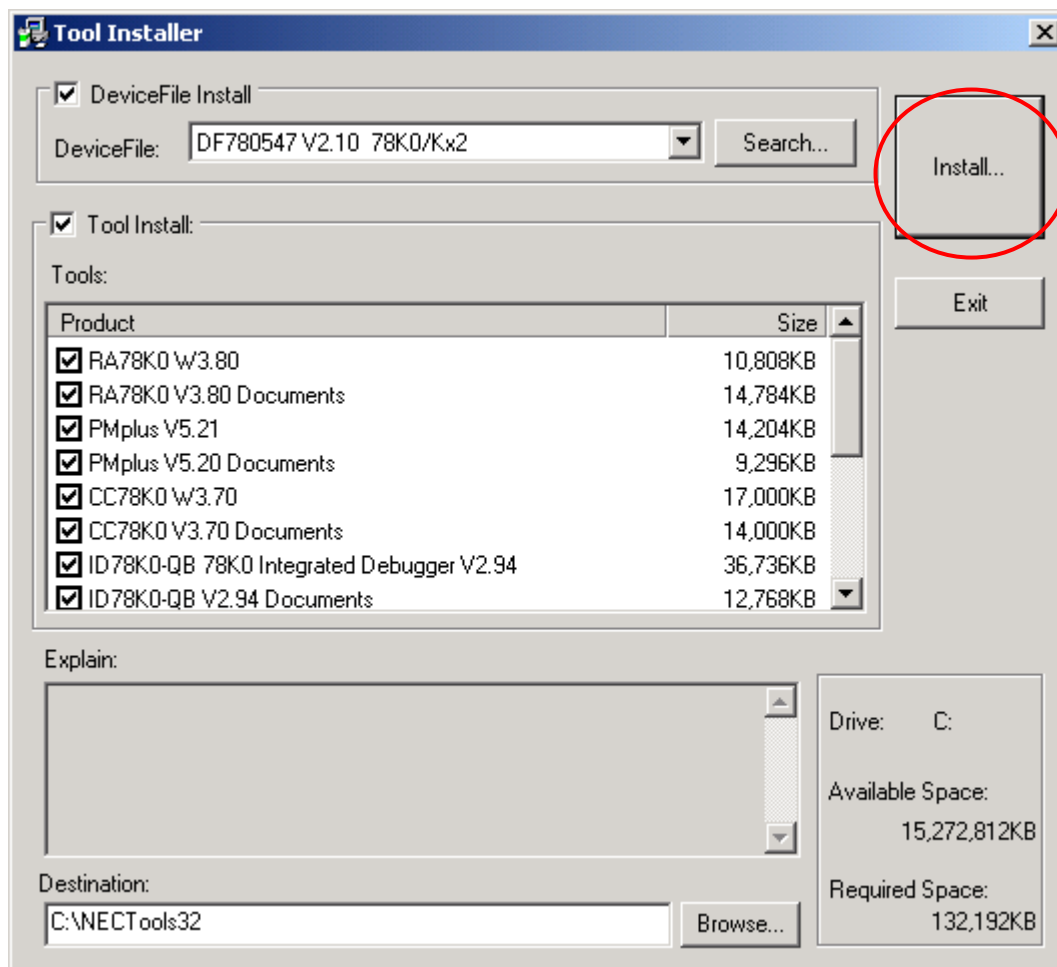
The NEC Electronics Microcontroller web page provides with the latest product/tool information and FAQs.

<6> Exit

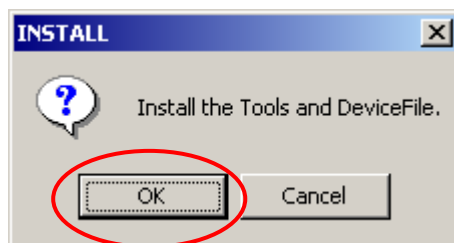
Terminate the setup.

- <1> Select [Install] in the set-up menu with the welcoming robot.
Check the box for “Tool Install”, check/clear the product to be installed in the boxes.
“Explain” displays an explanation of the selected product.
To change the installation destination, click [Browse...].

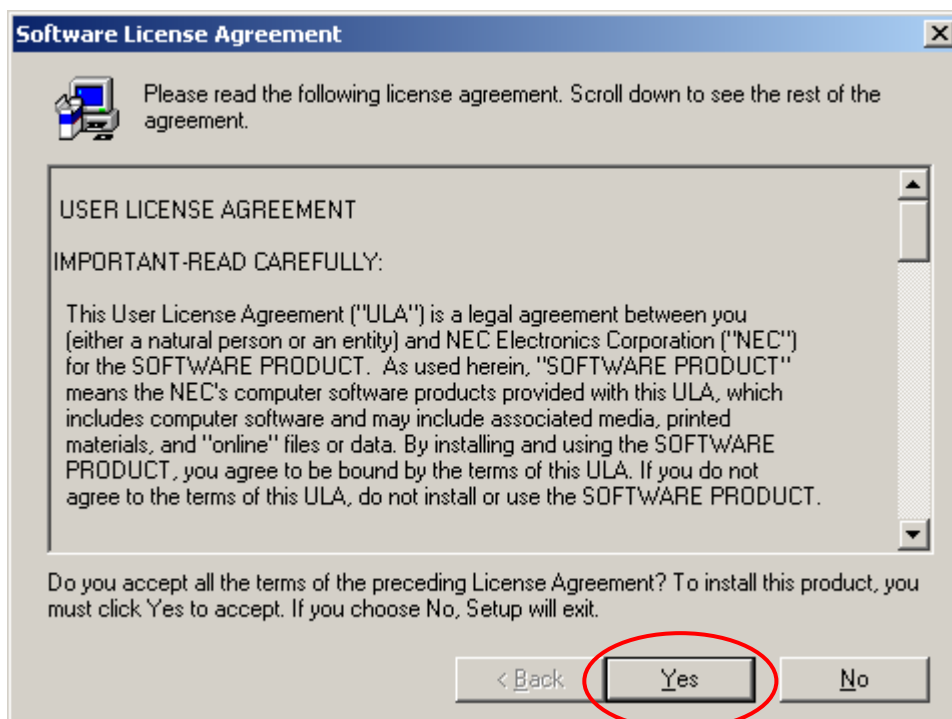
When all the settings are completed, click [Install...].



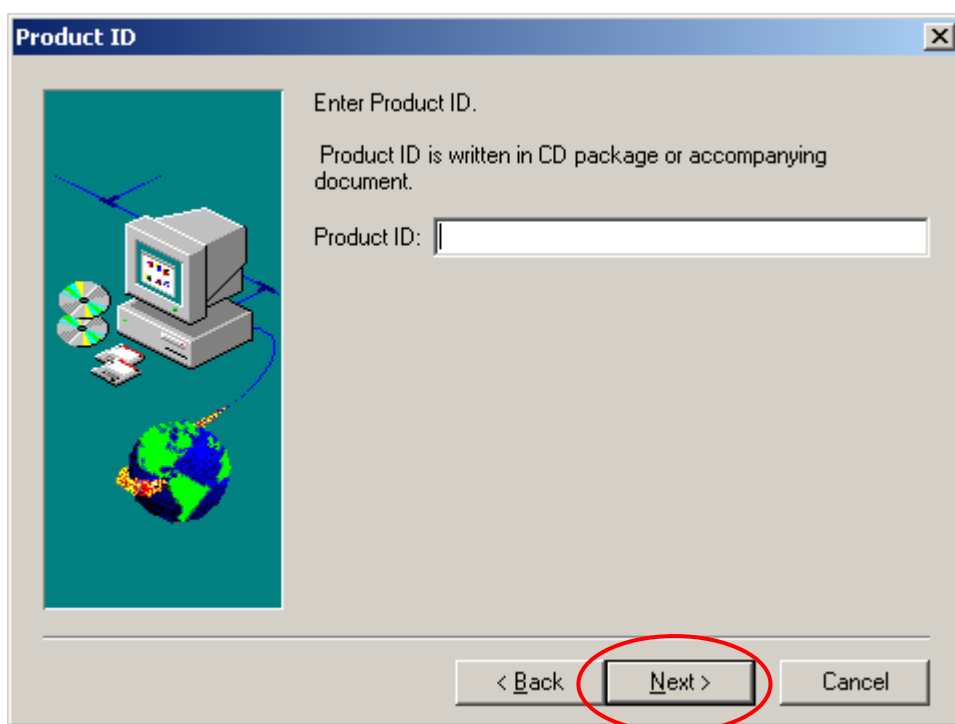
<2> To install each development tool, click **OK** when the install confirmation screen is displayed. To stop installation, click **Cancel**.



<3> To install a product, click **Yes** when the software license agreement screen is displayed. To stop installation, click **No**.
To return to the previous screen, click **< Back**.

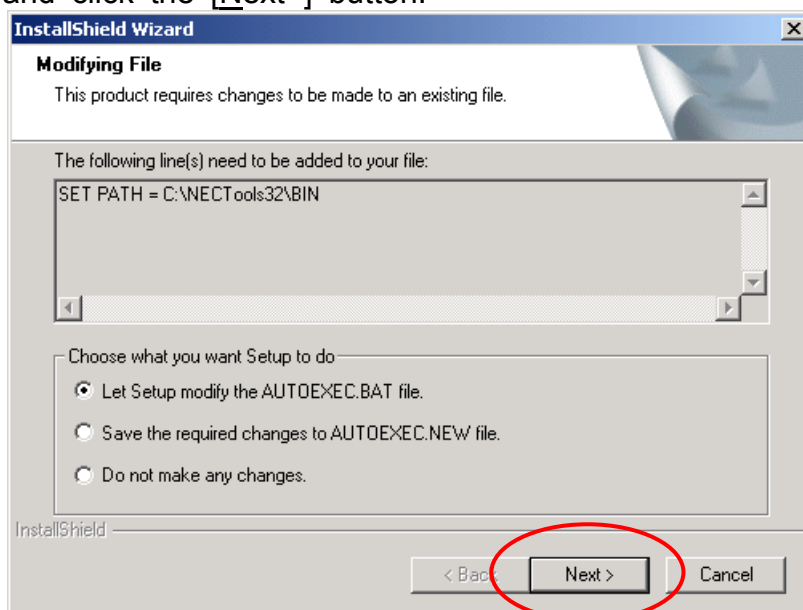


- <4> Enter the product ID. The product ID is available on the CD-ROM package.



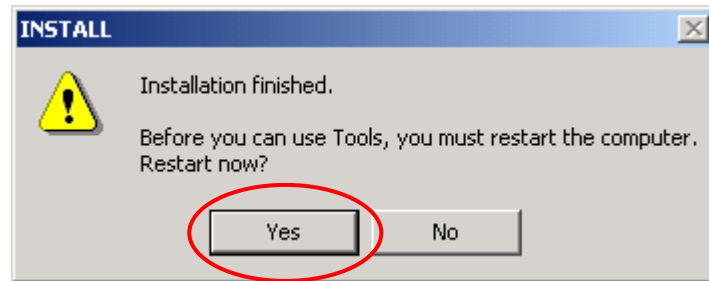
- <5> Copying the files is started.

- <6> When the files have been completely copied and if AUTOEXEC.BAT must be corrected, the following dialog box is displayed. Select an option and click the [Next>] button.



<7> If it is necessary to restart the computer, the following dialog box is displayed.

Click [Yes] to restart the computer.



<8> If the computer does not have to be restarted, a dialog box indicating completion of setup is displayed. Click the [OK] button. This completes installation of each development tool.



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.

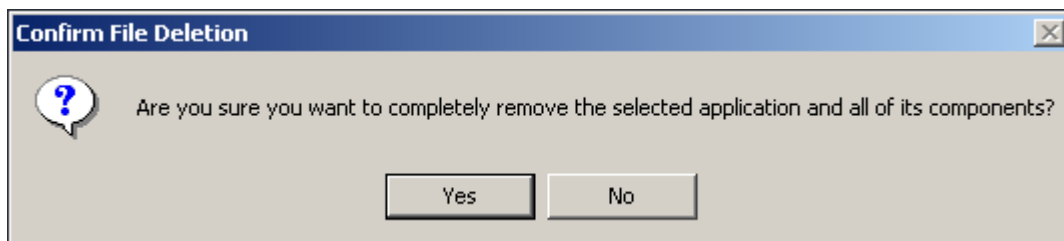
The identical problem may be observed, if a language other than English is specified as the system language in the “Regional Settings Properties” tab.

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:/NECTOOLS32" on default setting.

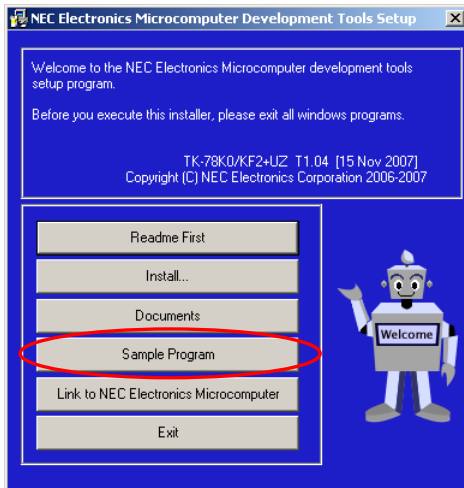
When you use the tools, please open the tools from [Start menu] -> [Programs]->[NEC Tools32].

2.3 Sample Environment

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.)

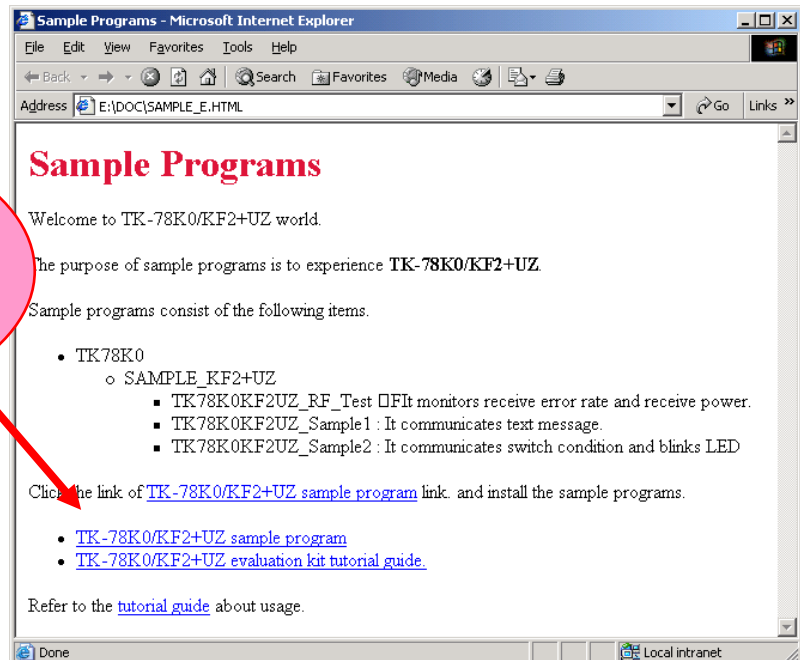
Press the **Sample Program** button to start the WWW browser, and then click the [TK-78K0/KF2+UZ Sample Programs] link.



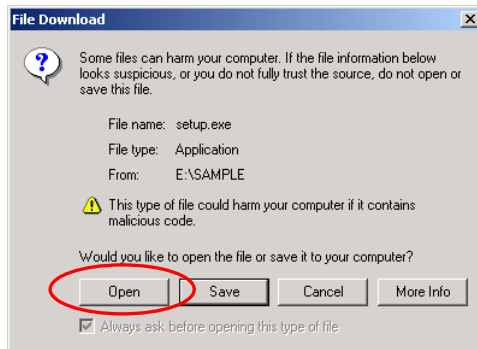
The WWW browser starts up.



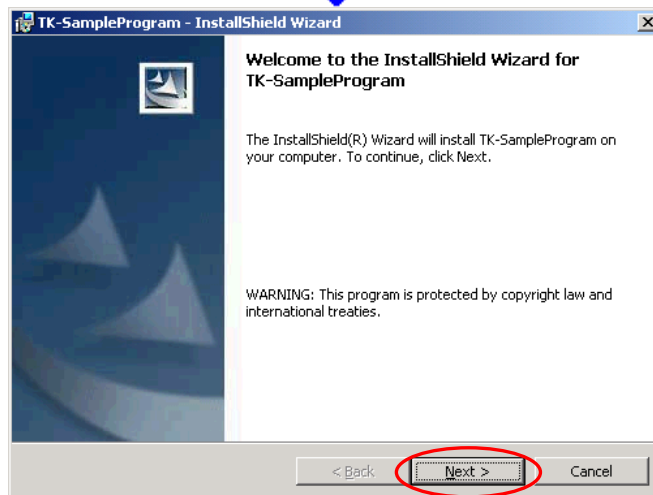
Click the [TK-78K0/KF2+UZ Sample programs] link you can also download the [Tutorial Guide]



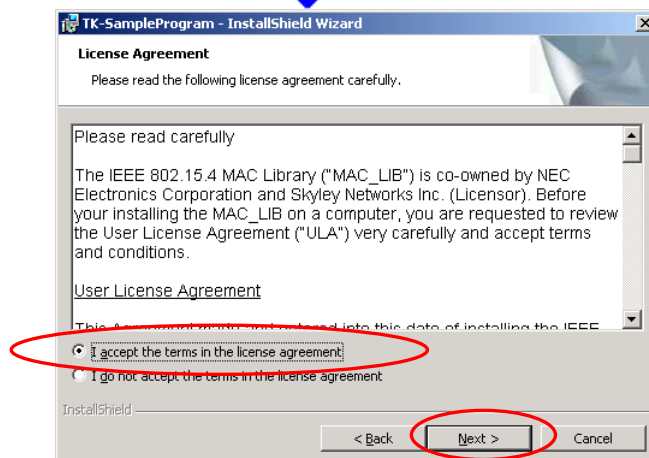
When [TK-78K0/KF2+UZ Sample Programs] is clicked, the following download confirmation window appears.



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

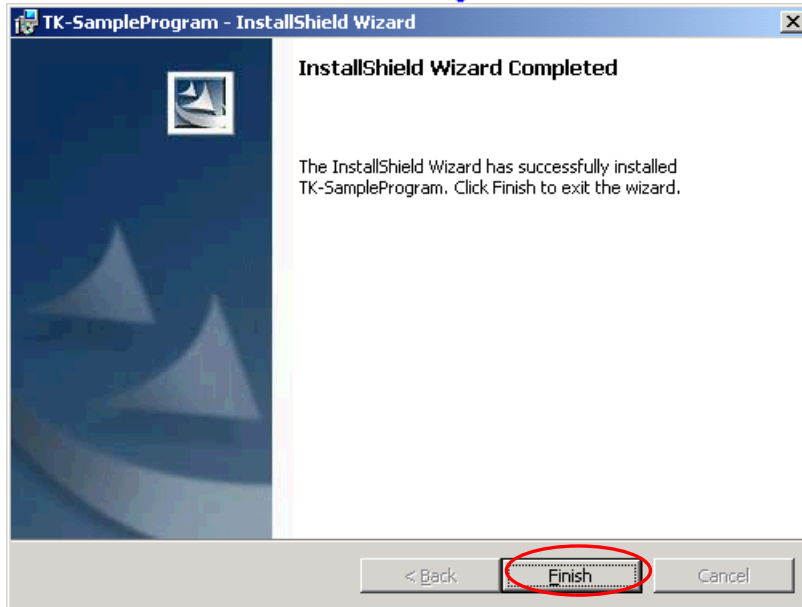


InstallShield wizard for TK-Sample Program starts up
Please click **Next**.



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.

Installed files

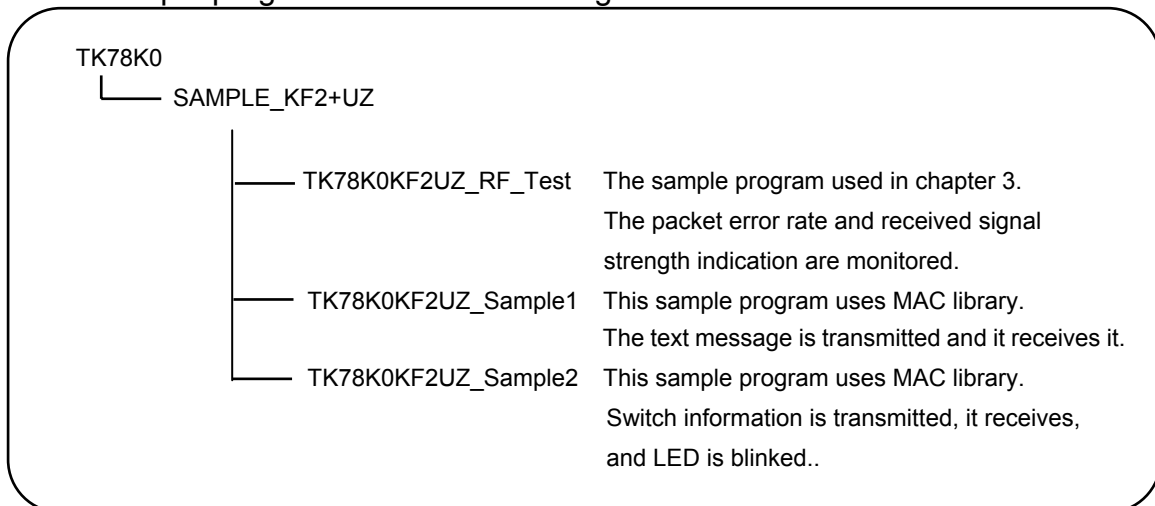
- TK78K0 folder ----- sample programs
- TK78K0.EXE ----- execute file

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 “USB Serial Converter” and “USB Serial Port” in your PC.

When TK-78K0 is used, it is necessary to install “USB Serial Converter” and the “USB Serial Port” driver in the host machine. Please install the driver according to the following procedures with appending CD in the drive.

Attention Please do not connect TK-78K0 by way of the USB hub. It is likely not to operate normally.

2.4.1 Installation of the USB driver

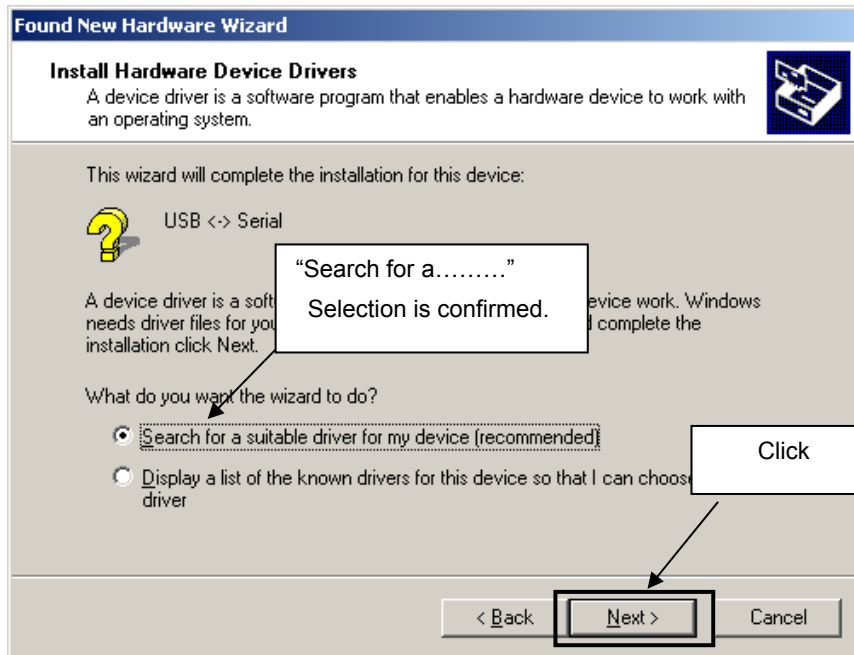
Install to Windows2000

1. Once the TK-78K0/KF2+UZ board is inserted to the PC USB terminal, a wizard will be initiated by the MS Windows.



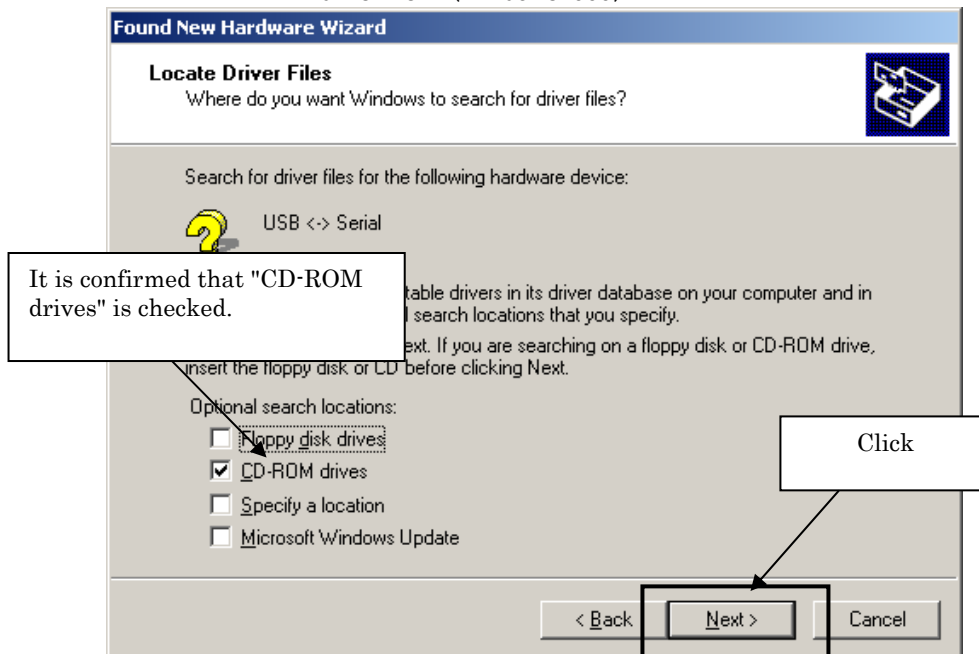
2. The following window is displayed, please click “search for a suitable driver

Method 1 (Windows2000)



3. Please select the “CD-ROM drives” only. and click **NEXT(N)>**.

driver file 1 (Windows2000)

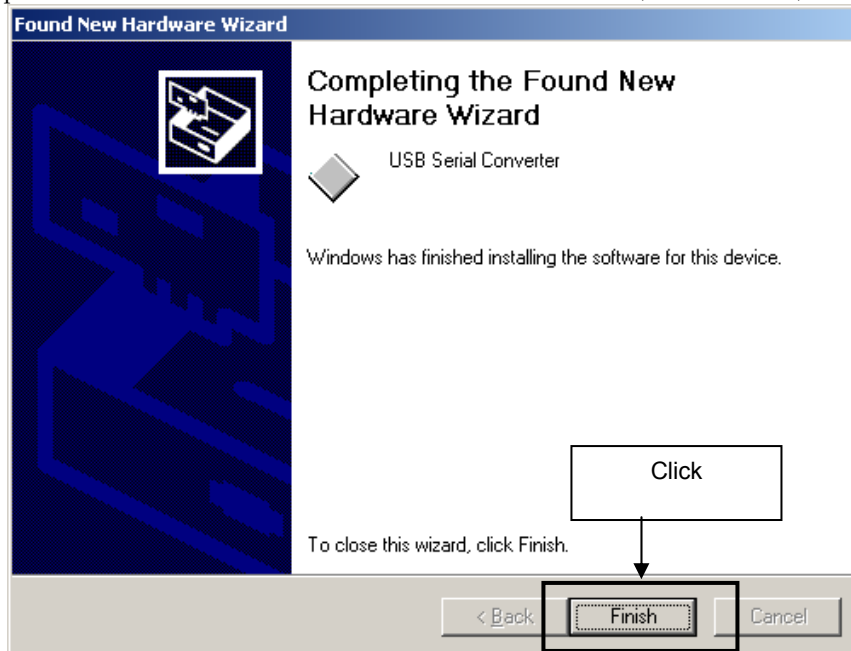


4. Please click **NEXT(N)>**

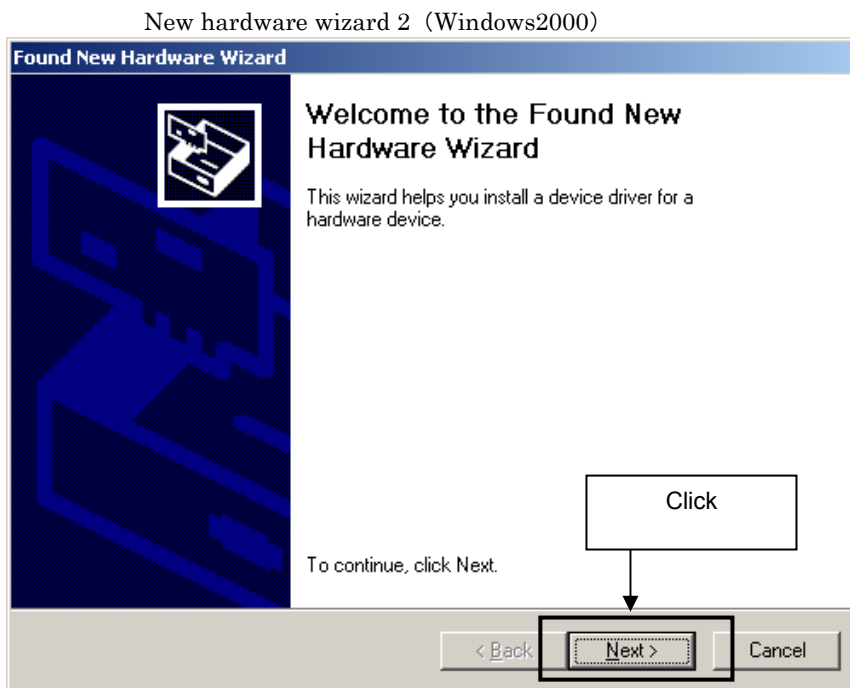


5. The "USB Serial Converter" driver's installation is completed. Click **Finish**.

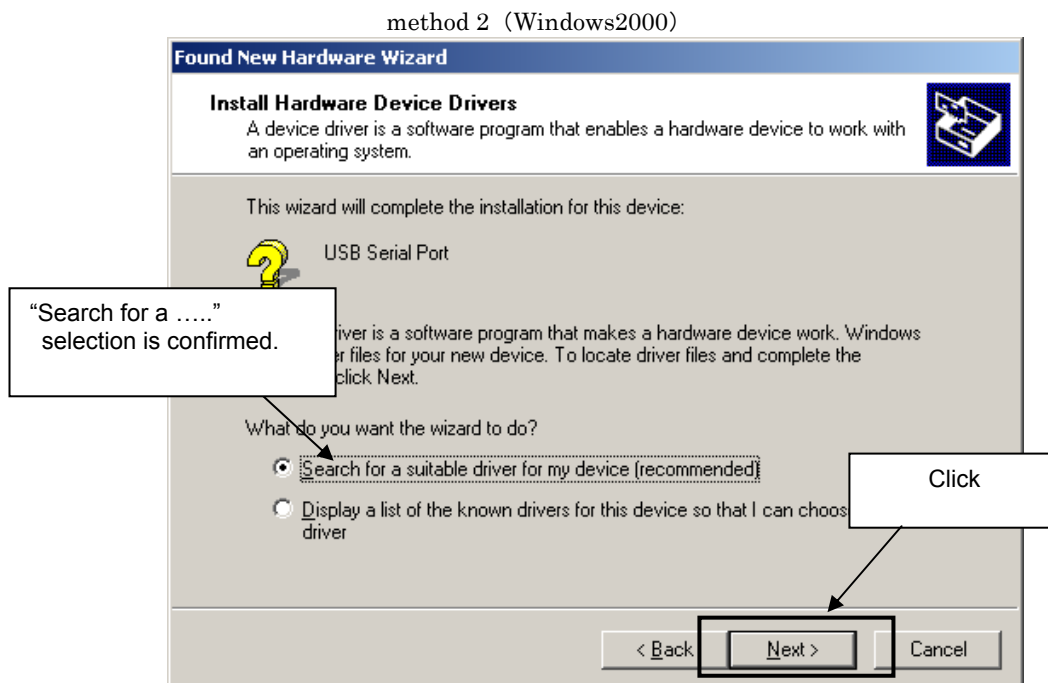
Completion of the USB Serial Converter driver installation 1 (Windows2000)



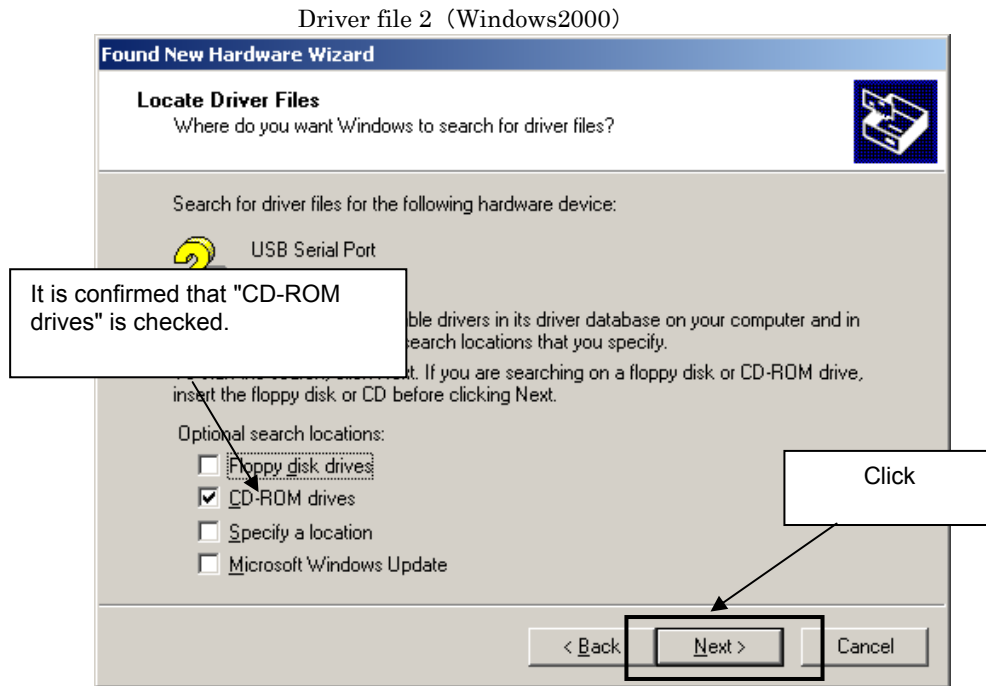
6. The "USB Serial Port" driver's installation begins continuously. Click **NEXT(N)>**.



7. The following window is displayed. Select "Search for a suitable driver for my device" . and click **NEXT(N)>**.



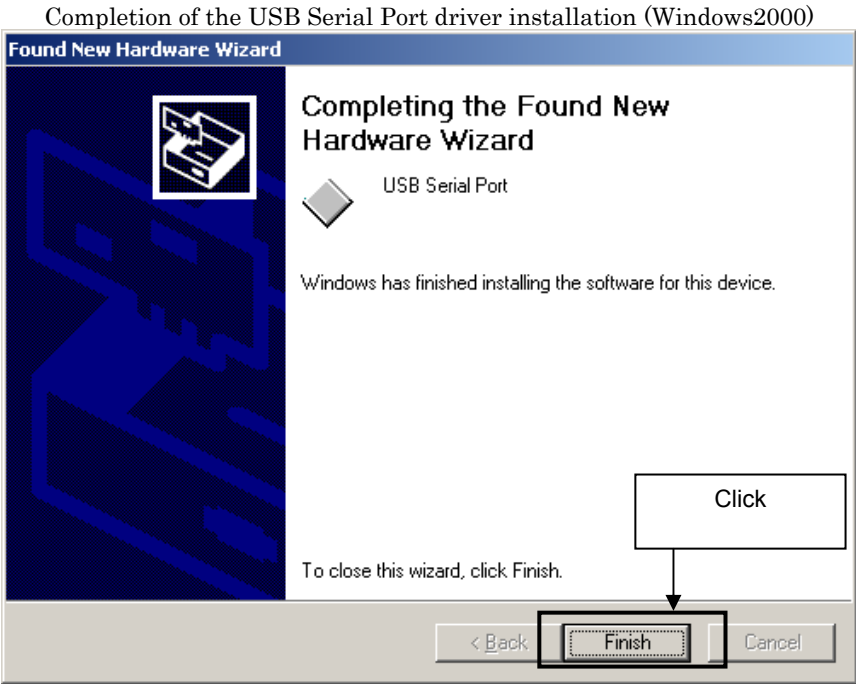
8. Please Select the "CD-ROM drives" only. And click **NEXT(N)>**.



9. Please Click **NEXT(N)>**.



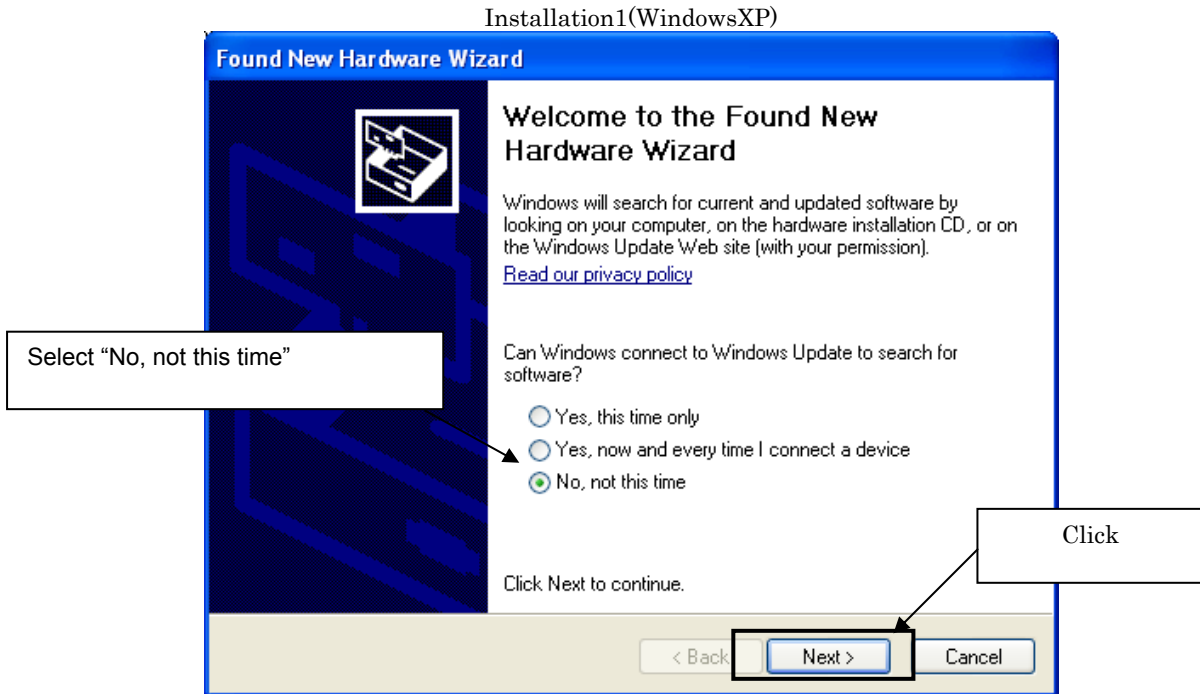
1 0. The "USB Serial Port" driver's installation is completed. Click **Finish**.



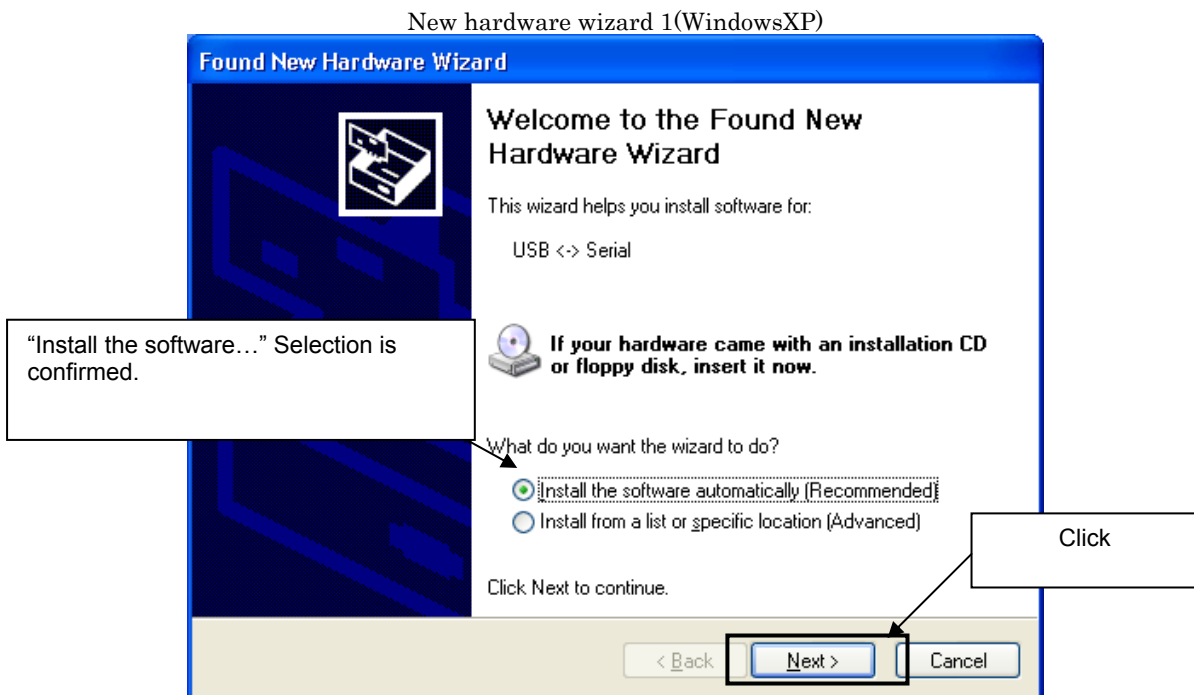
1 1. Driver Install was finished.

Install to Windows XP

1. Once the TK-78K0/KF2+UZ board is inserted to the PC USB terminal, a wizard will be initiated by the MS Windows.



2. Select the "Install the software automatically ..." has been selected, and click **NEXT(N)>**.



3. The "USB Serial Converter" driver's installation is completed. Click **Finish**.

Completion of the USB Serial Converter driver installation 1 (WindowsXP)

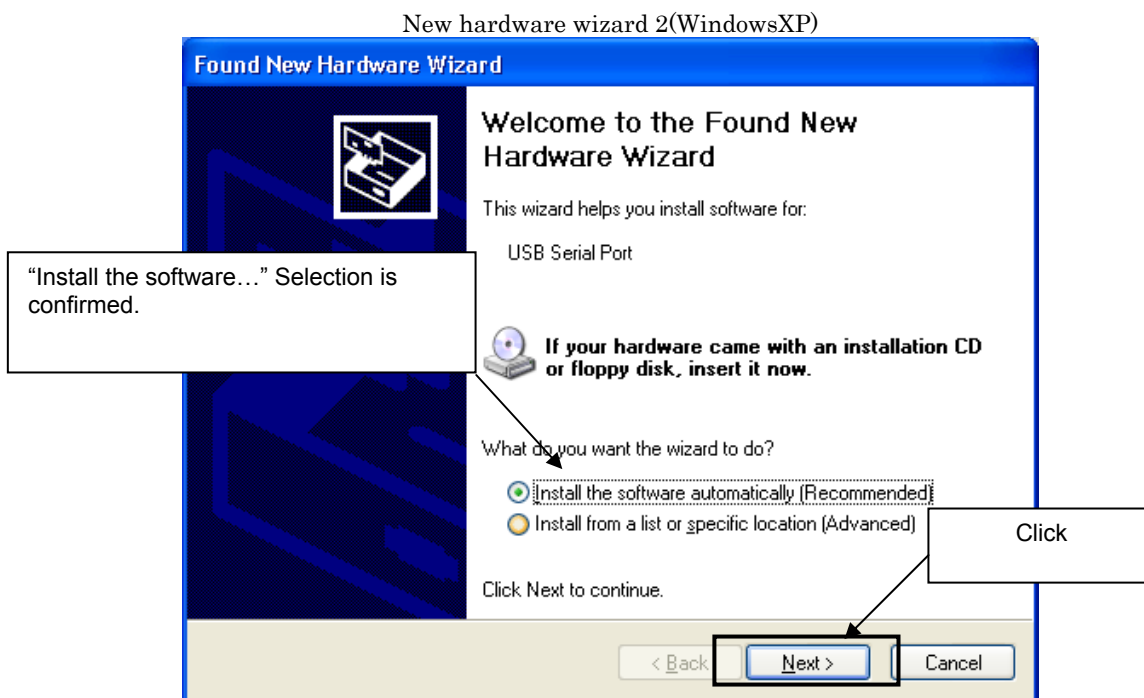


4. The "USB Serial Port" driver's installation begins continuously. Click **NEXT(N)>**.

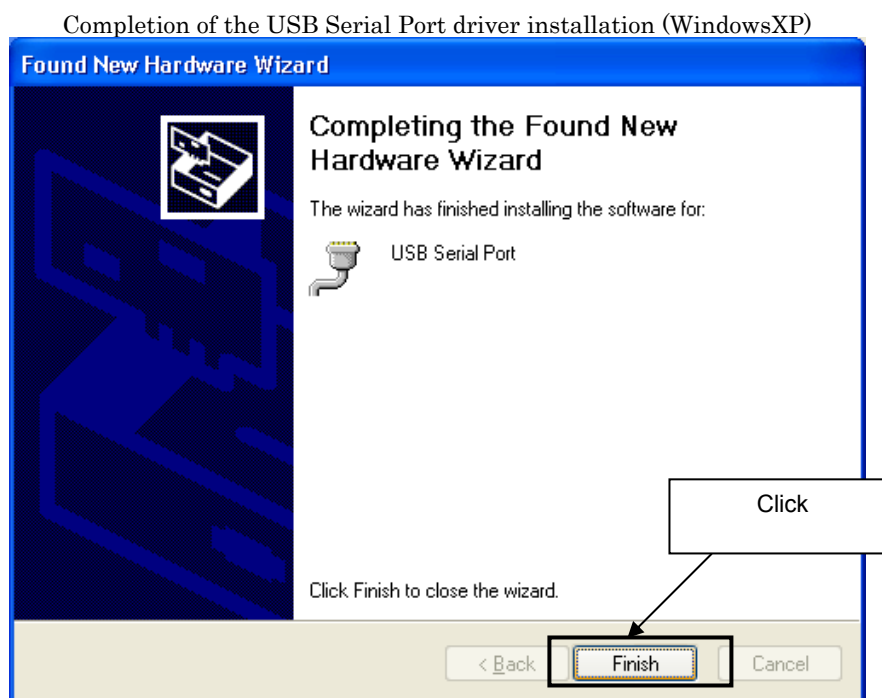
Installation2(WindowsXP)



5. The "USB Serial Port" driver's installation begins continuously. Click **NEXT(N)>**



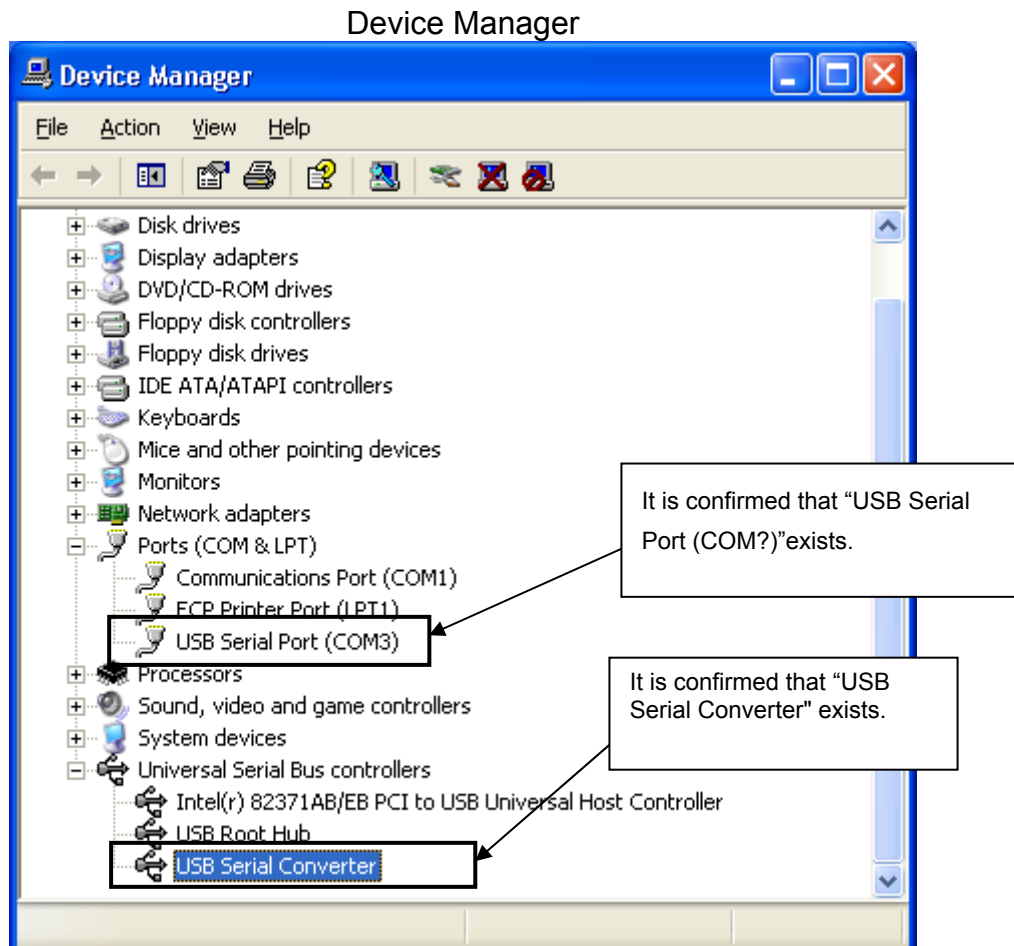
6. If the following window is displayed, the USB driver's installation is completed. Click **Finish**.



7. Driver Installation has been finished.

2.4.2 Confirmation of the installation

Please confirm “USB Serial Port (COM?)” in the device manager of system in the control panel of the MS Windows. Then, please confirm “USB Serial Converter”.



※Attention

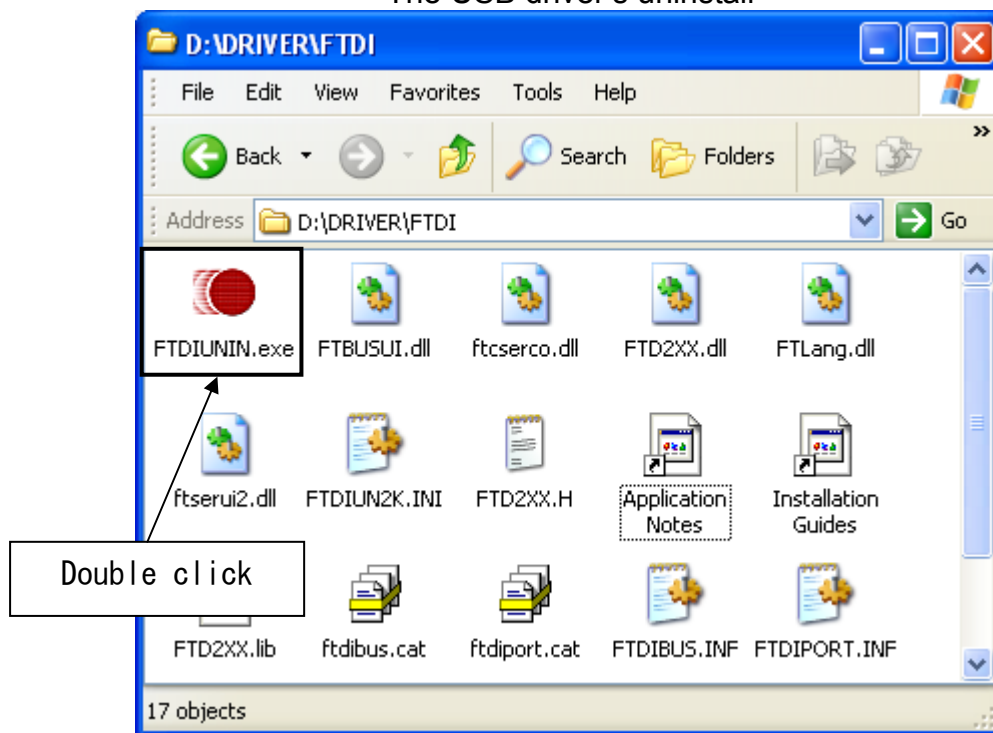
Windows2000/XP

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

2.4.3 Uninstallation of the USB driver

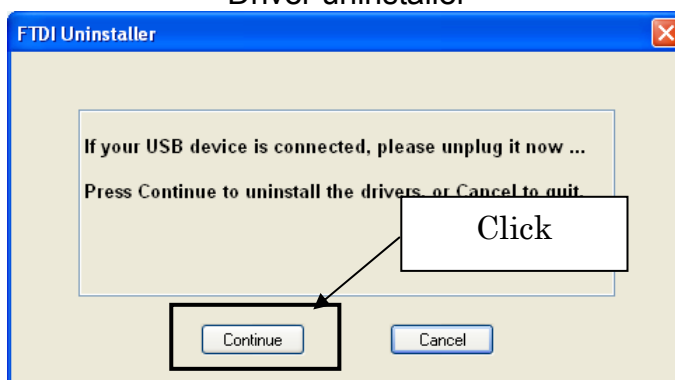
The uninstall program, Ftdiunin.exe, is available at “/DRIVER/FTDI”. Please log on as an administrator, then, execute the Ftdiunin.exe

The USB driver’s uninstall



After TK-78K0 is detached, please click is Continue .

Driver uninstaller



Please click **Finish**.

The driver's uninstall completion



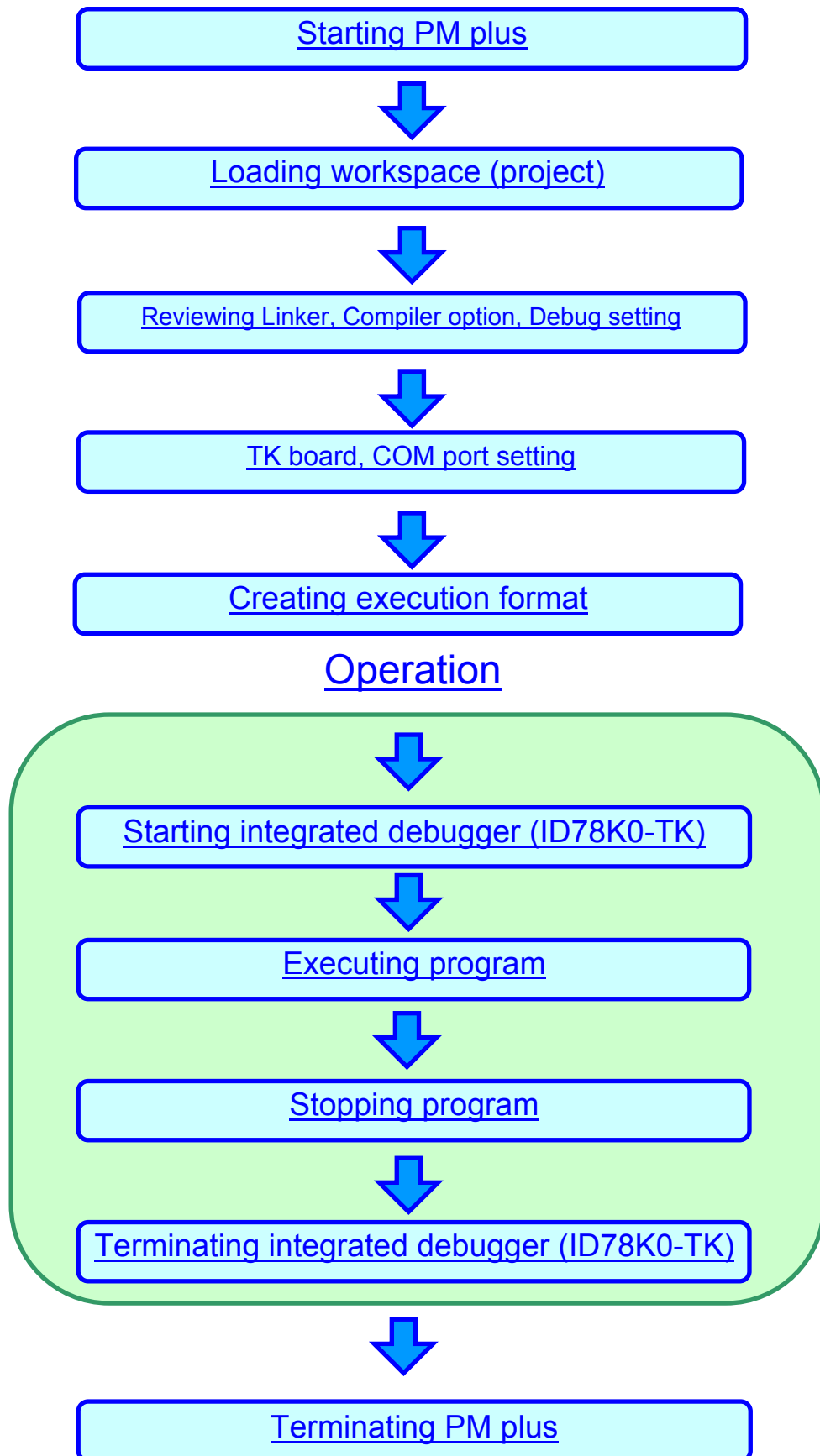
3 Experiences

Now you are ready to experience the operation of the TK-78K0/KF2+UZ using the integrated development environment, PM plus.

Here, we use RF test program [TK78K0KF2UZ_RF_Test] as an example.

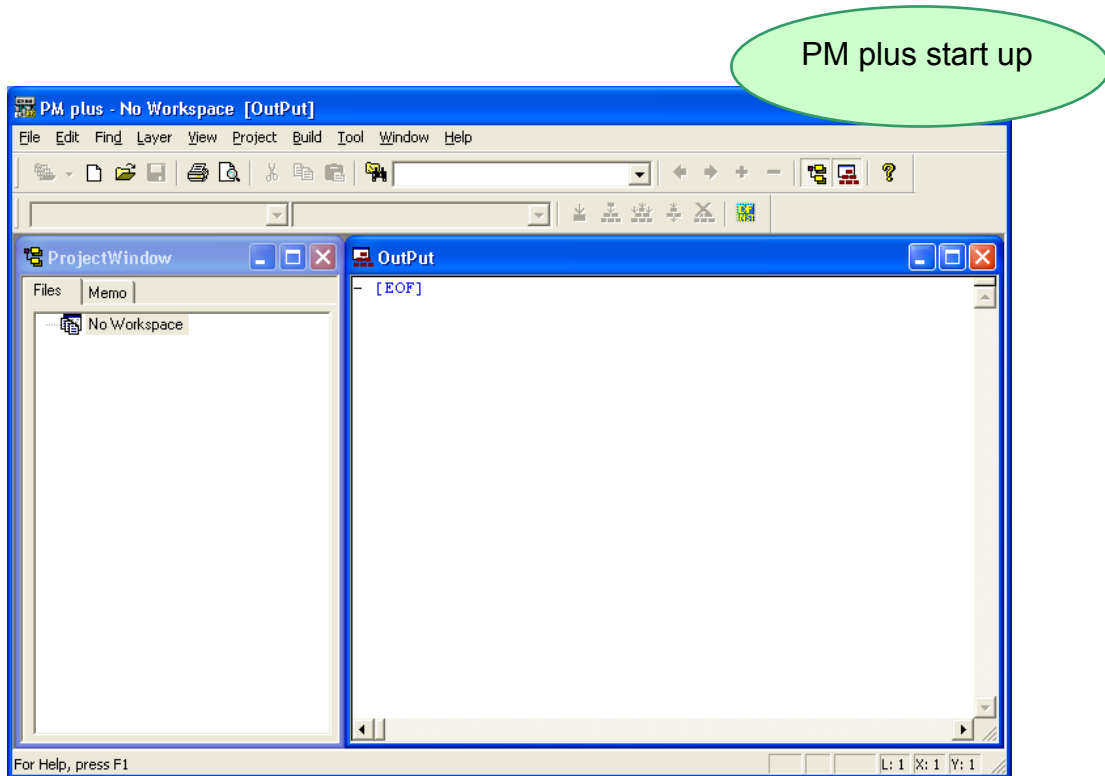
This chapter is designed to provide with an understanding of how to work on PM plus, how to start-up the TK debugger, how to generate a hex file, and how to use the Flash programmer.

The overall flow is as follows.



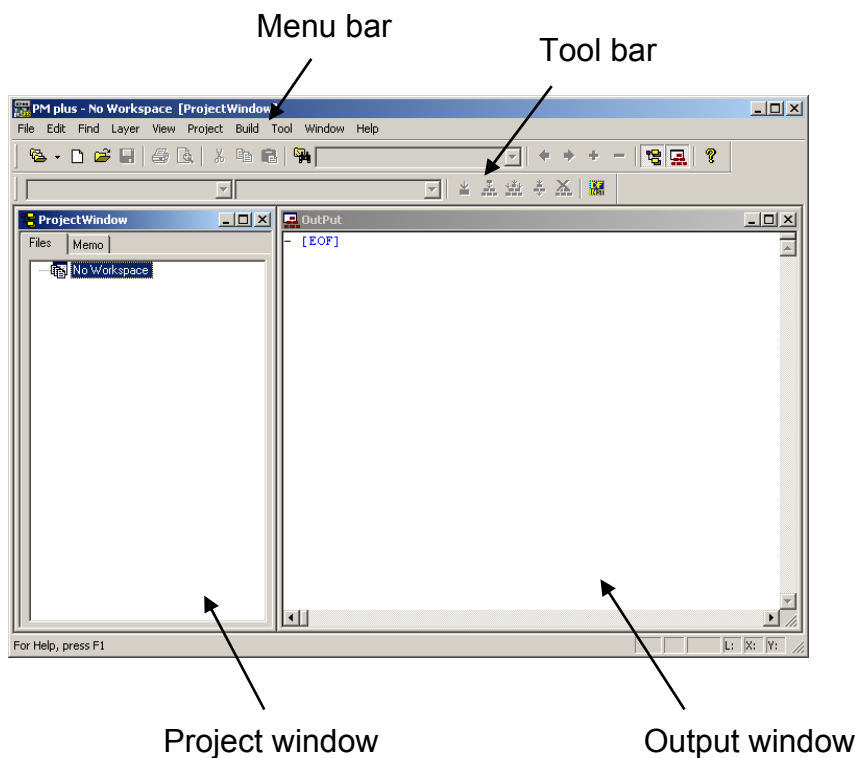
3.1 Starting PM plus

In the Windows Start menu, select [Programs]->[NEC Tools32]->[PM plus]



3.2 Introduction to PM plus

In PM plus, 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 plus User's Manual.

What is a project?

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

PM plus 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?

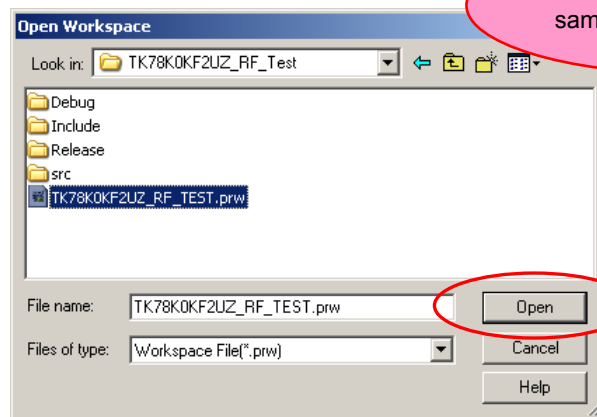
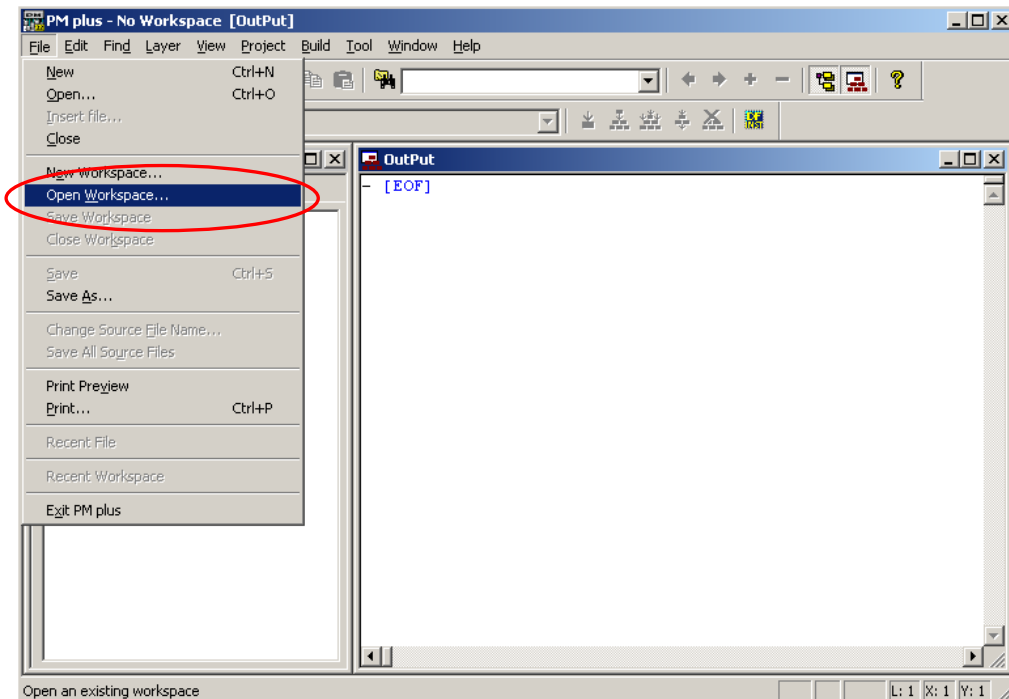
A workspace is the unit used to manage all the projects or project group required for one application system.

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)

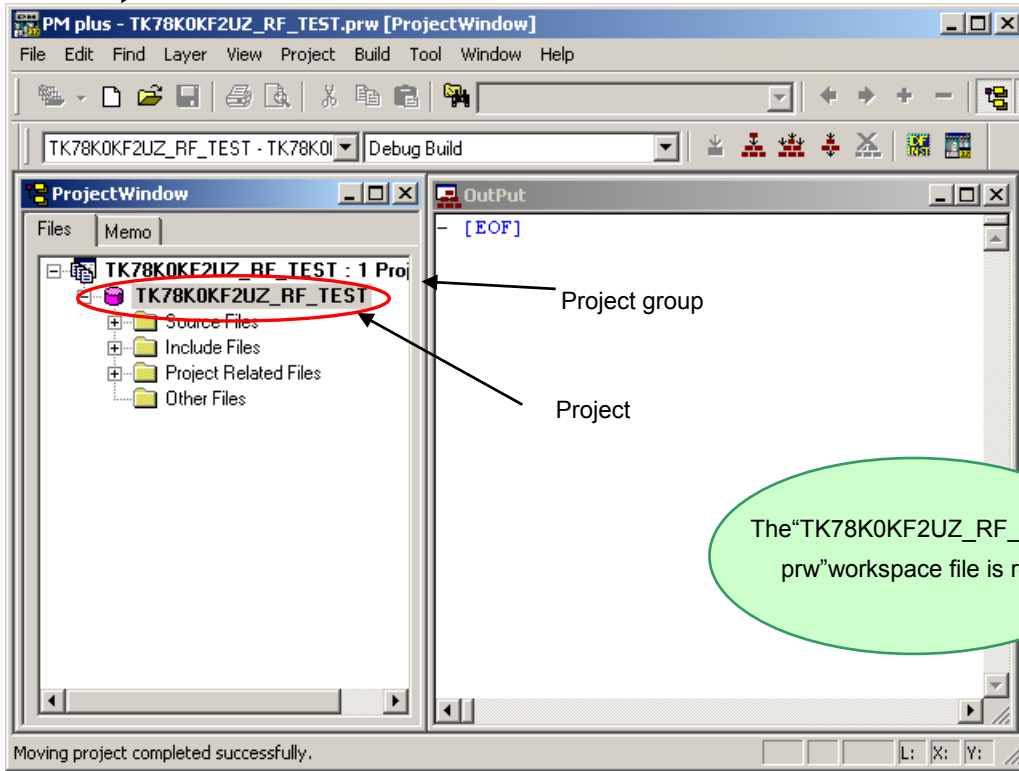
Please place the file “TK78K0KF2UZ_RF_TEST” at
C:¥TK78K0¥SAMPLE_KF2+UZ¥TK78K0KF2UZ_RF_Test
Please start PM plus from [All Programs] -> [NEC Tools32] -> [PM plus]
Then, please select “Open Workspace” as shown below.



“TK78K0KF2UZ_RF_TEST.prw” and then press the **Open** button.

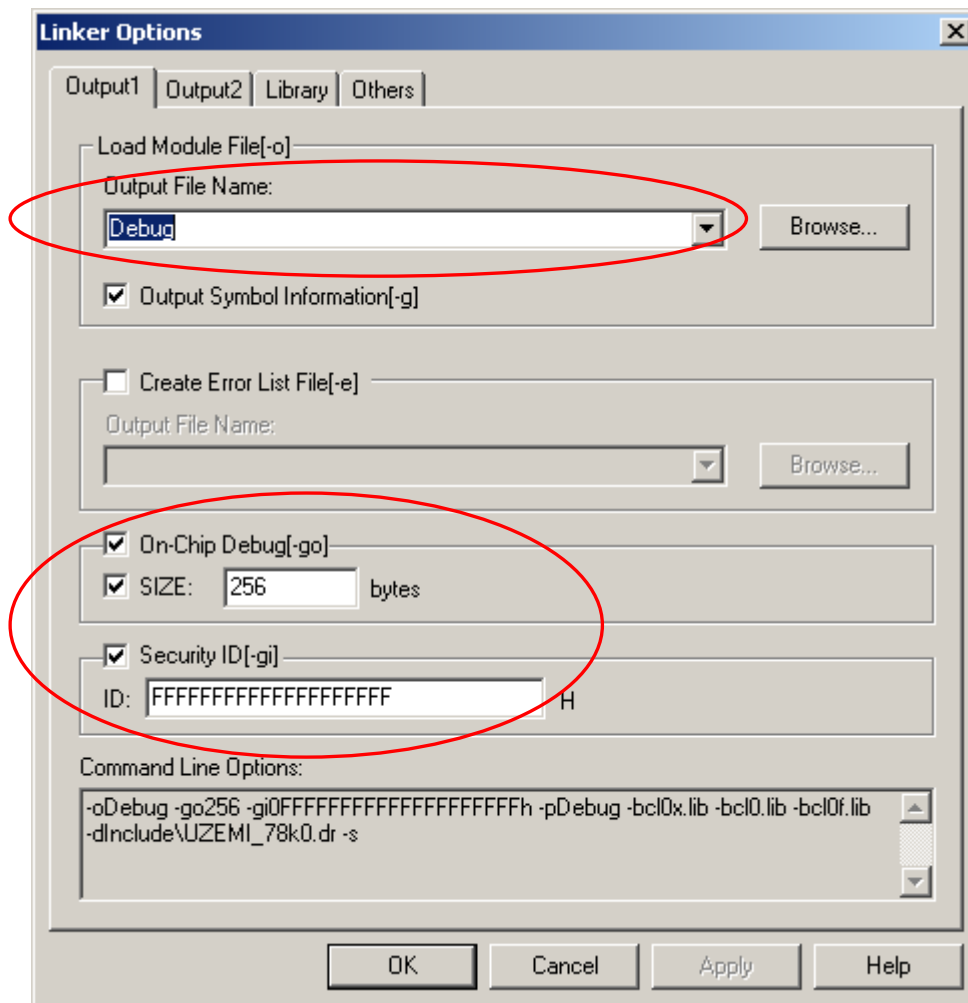


Workspace file name :TK78K0KF2UZ_RF_TEST.prw



3.4 Configuration of Linker Option

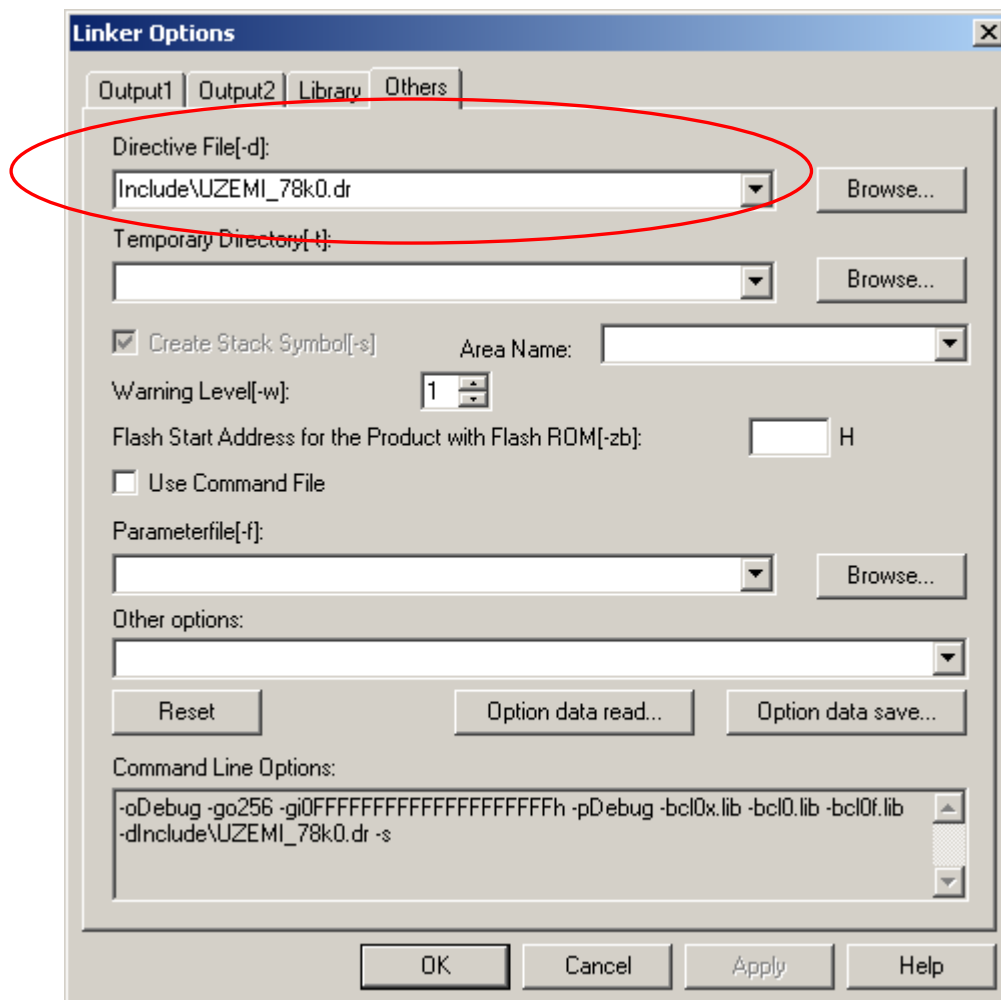
Please open the “Linker Options” window from the pull down menu of [Tools] -> [Linker options]. Please set the “Load module file”, “On Chip Debug”, and “Security ID”, as shown below.



The Load Module File is required for debugging.

The Security ID in all of the sample programs is “FFFFFFFFFFFFFFFFFFFFh”. You can change the ID code by writing a new ID code in the ten bytes starting at 85H. The intension of using the unique ID code is to prevent an unwelcome third party from debugging and modifying your source code. To enable the ID code, you have to write non-zero value at 84H. In the sample programs, “84H” is set to a non-zero value, “2”, by the “option.asm” file. If you set “0” at 84H, the On-chip debug operation are disabled. If you forget your unique ID code, or mistakenly over-write 0x00(value) at the address of 0x84, the debugger ID78K0-TK 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, after your defining a new ID Code, you can load the hex file using PG-FPL3 with the new ID code. How to use “PG-FPL3” will be explained later.

In the “Others” tab, please confirm the path for the directive file as, “Include\UZEMI_78k0.dr”



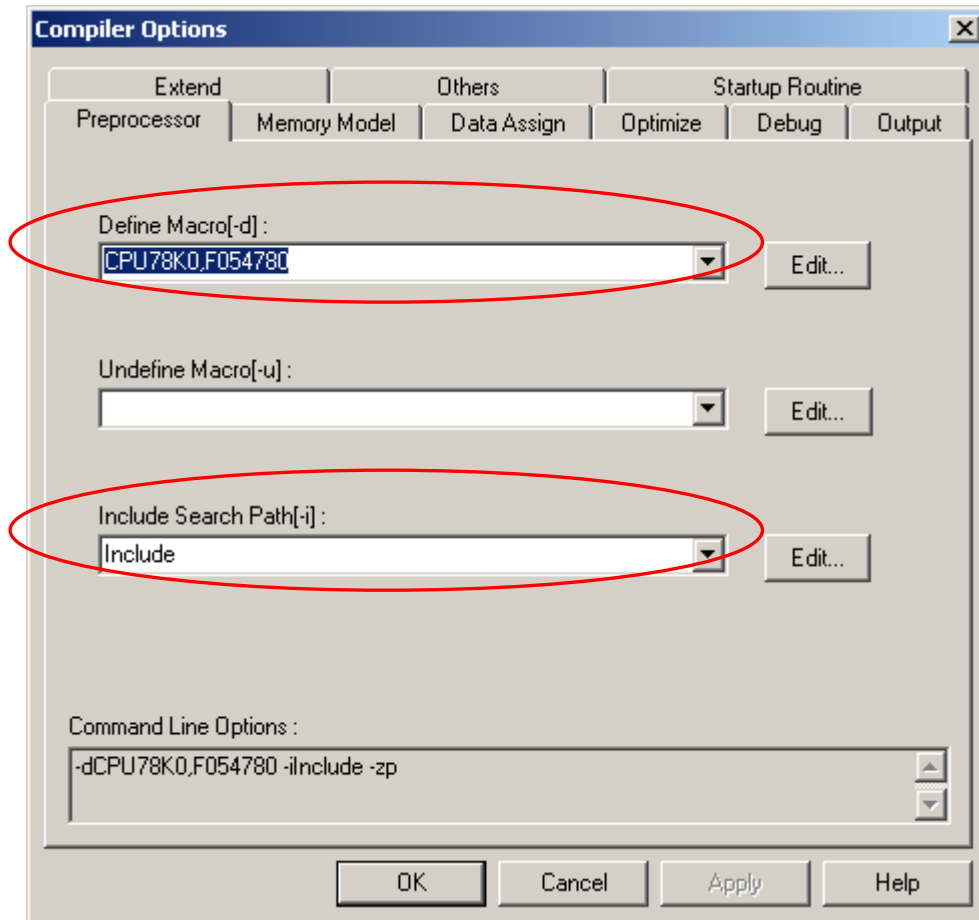
3.5 Configuration of Compiler Option

Please choose [Tools] -> [Compiler Options] at the pull-down menu.

In the opening tab, Macros and path to include files are defined, as shown below.

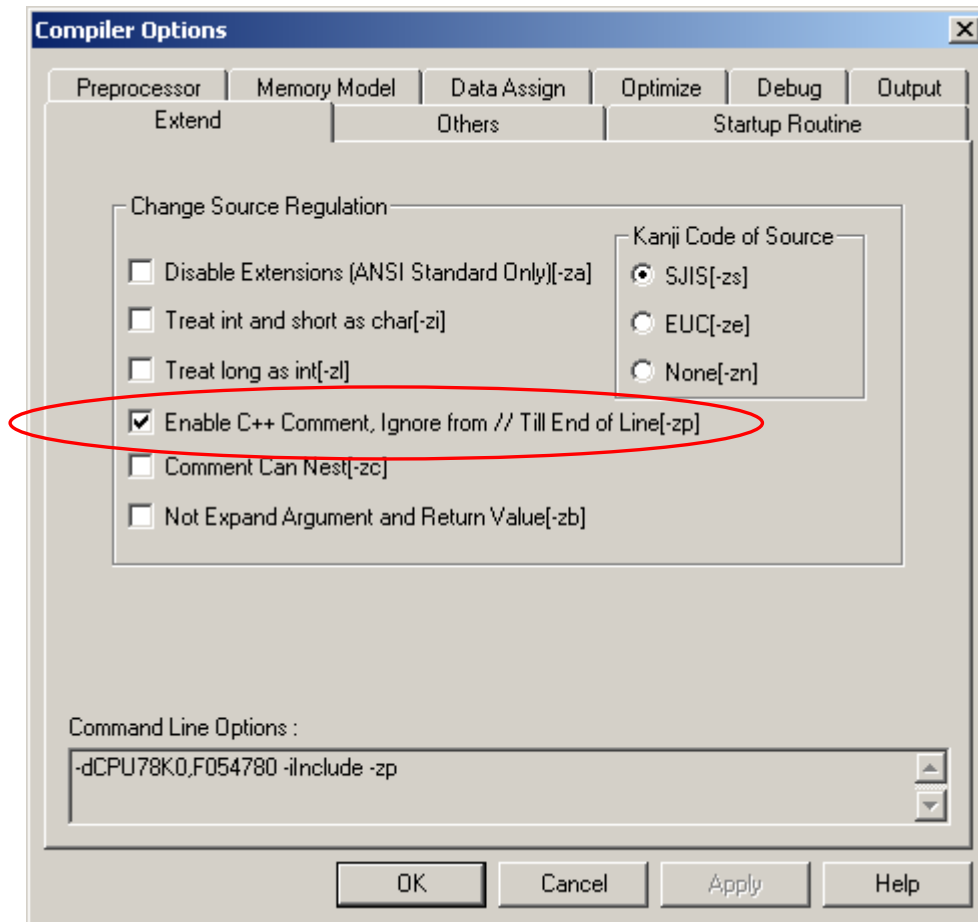
You will find two defined macros of “CPU78K0”, and “F053764”.
The meanings of the macros are as follows, “CPU78K0”: The target CPU is 78K0. “F054780”: The target MCU is UPD78F0547, and the MCU has 80 pins.

Include Search Path will be,
Include,
if you install the project file at this location. If not, please modify it for your appropriate path.



Please select the Extend tab.

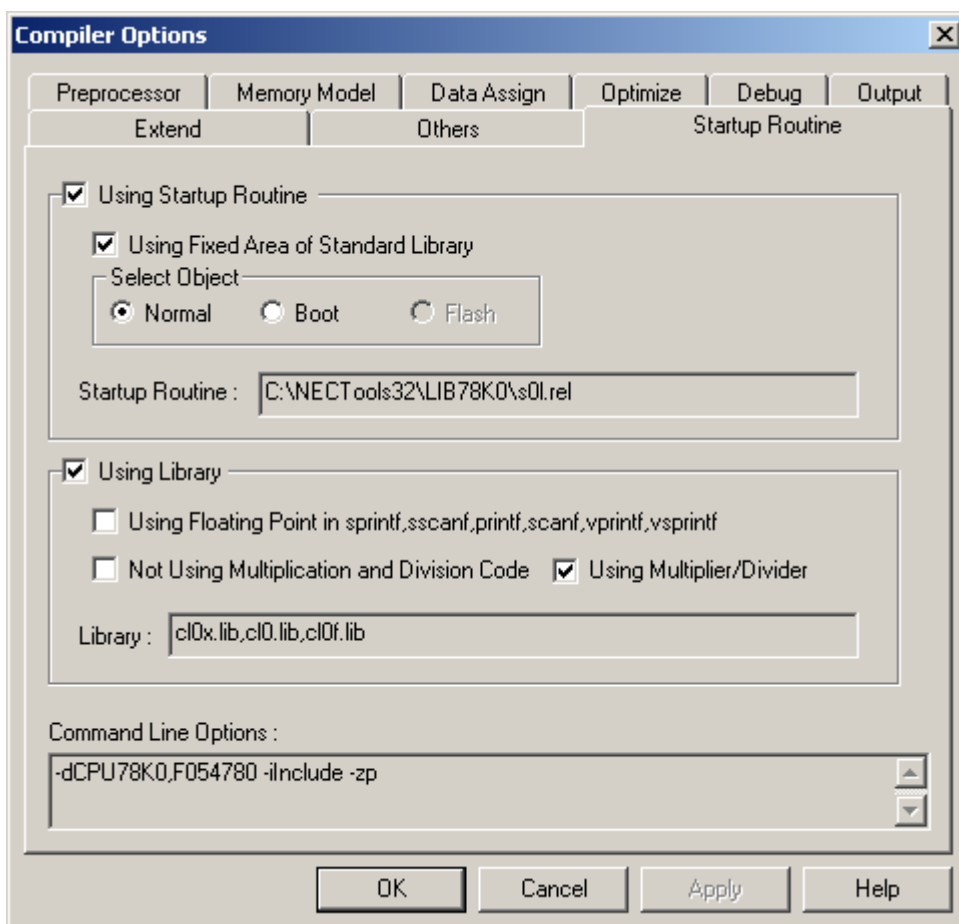
You will allow the comment in a way supported by C++, using “//”.



Then, you will check the Startup Routine.

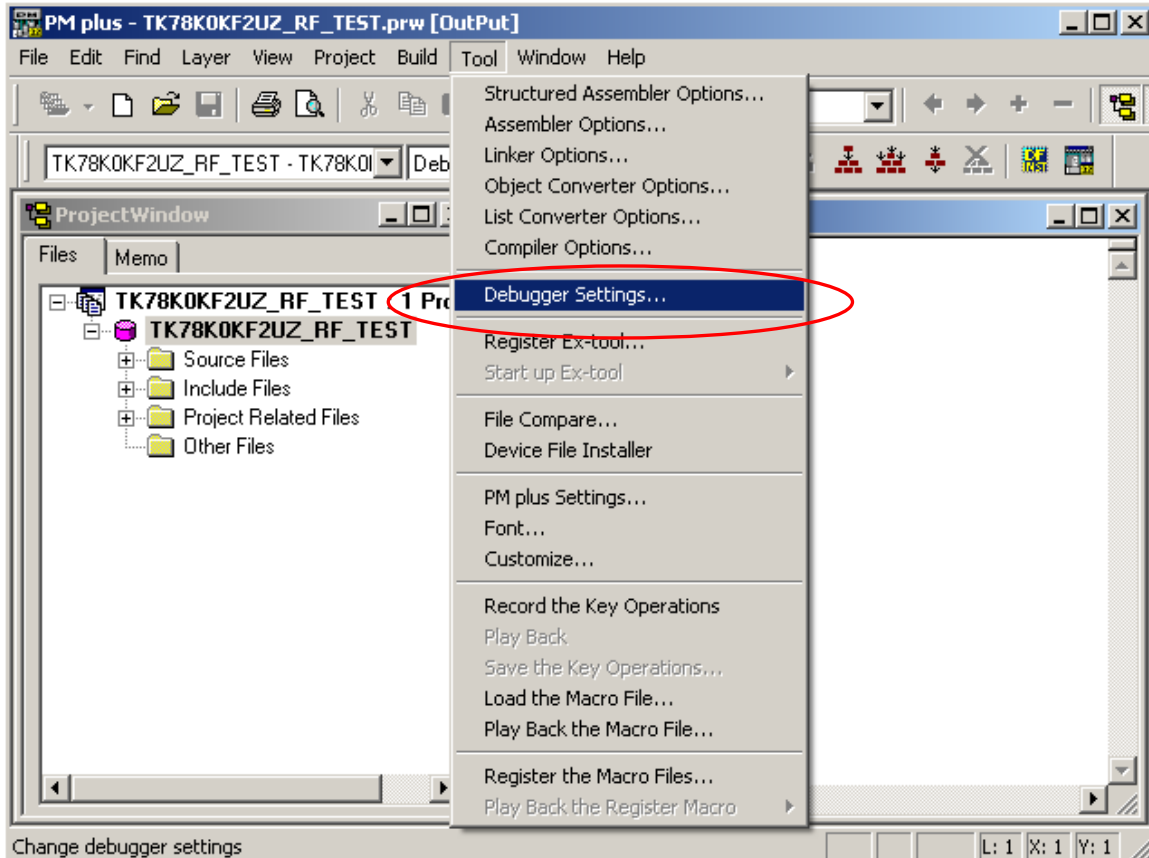
The “Multiplier/Divider” library is supported at the Startup Routine tab. Please note the “Multiplier/Divider” library has been newly introduced in the CC78K0 v3.7/W3.7. If you try to use library created by using the older versions of the CC78K0 compiler, you will find an error message.

In that case, you have a good chance to solve the problem by clearing the check at “Using Multiplier/Divider”.

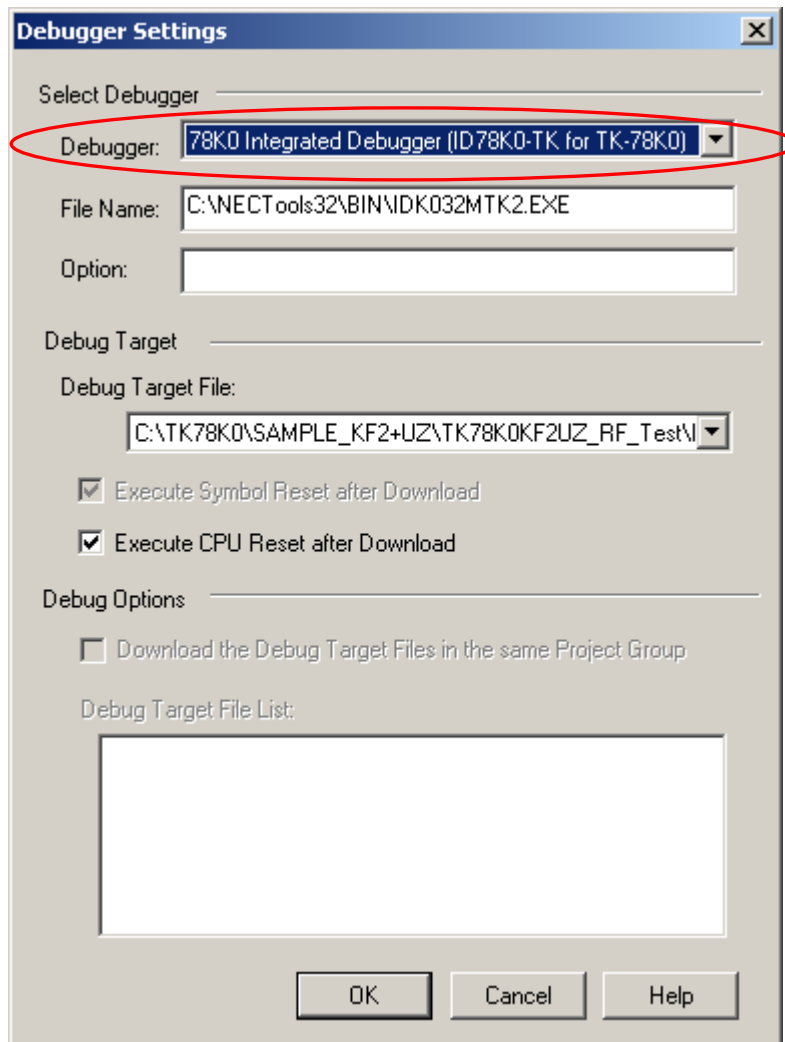


3.6 Configuration of Debugger setting

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



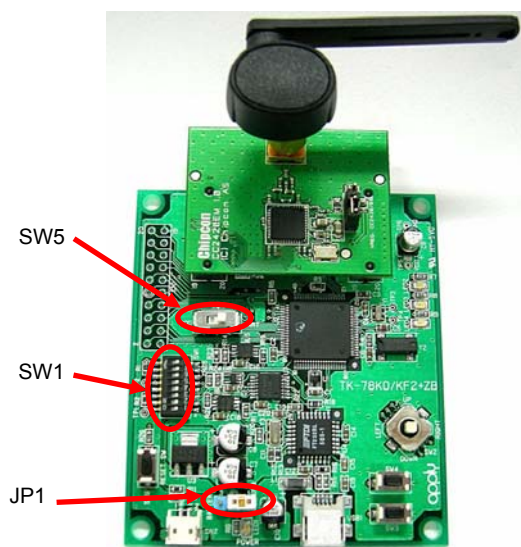
Please select the “78K0 Integrated Debugger (ID78K0-TK for TK-78K0)”.



3.7 TK board setting

Please set the switches on the TK-78K0/KF2+UZ board as follows.

JP1	1-2 short (USB side)	
SW5	OCD side	
SW1	Bit1	ON
	Bit2	ON
	Bit3	ON
	Bit4	ON
	Bit5	ON
	Bit6	OFF
	Bit7	OFF
	Bit8	OFF



Next, the COM port number allocated by connecting the TK-78K0/KF2+UZ board with PC is set by "Portconfig for ID78K0-TK".

Now, you need to learn which COM port of your PC is connected to the board.

To find it, please go to

[Control Panel] -> [System] -> [Hardware] -> [Device Manager]

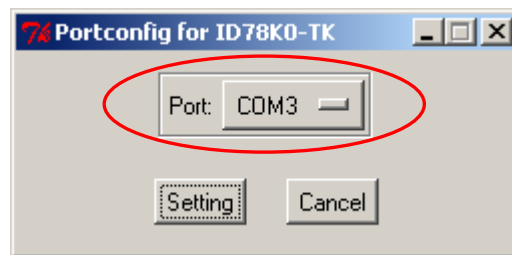
to find something like "USB Serial Port (COM3)". In this particular case, it is "3".

Then, please select Portconfig

at [Programs] -> [NEC Tools32] -> [Portconfig for ID78K0-TK].

You will find the following window.

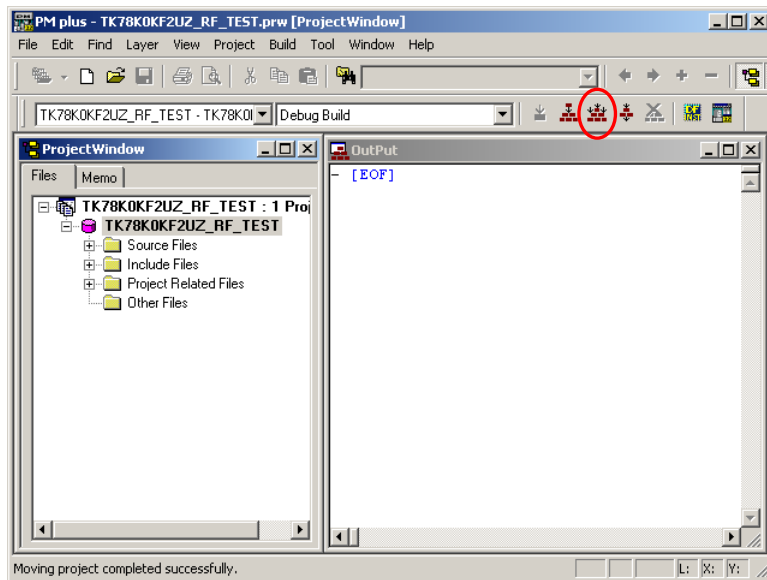
Please set the COM3 in this particular case, but the number of COM port may depend on your PC.



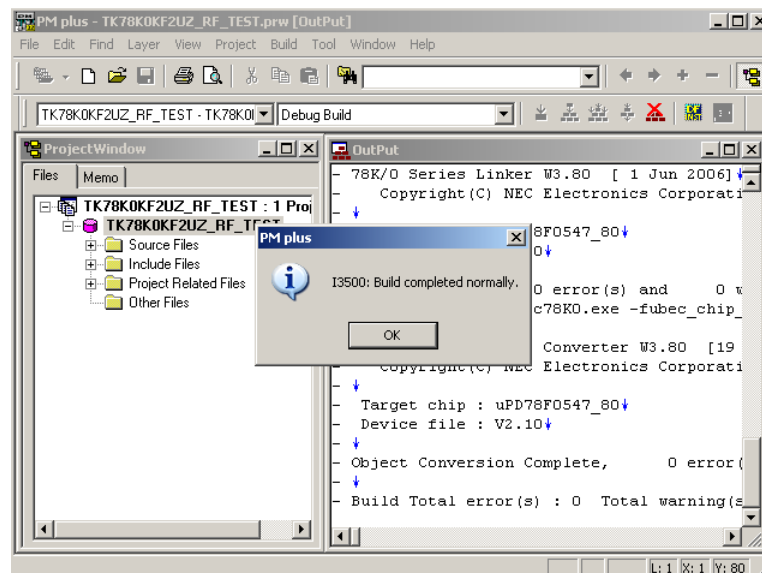
3.8 Creating execution format

Please go back to PM plus.

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 plus automatically performs compiling, linking, and other processing actions.


On the second and subsequent build, PM plus 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 ?

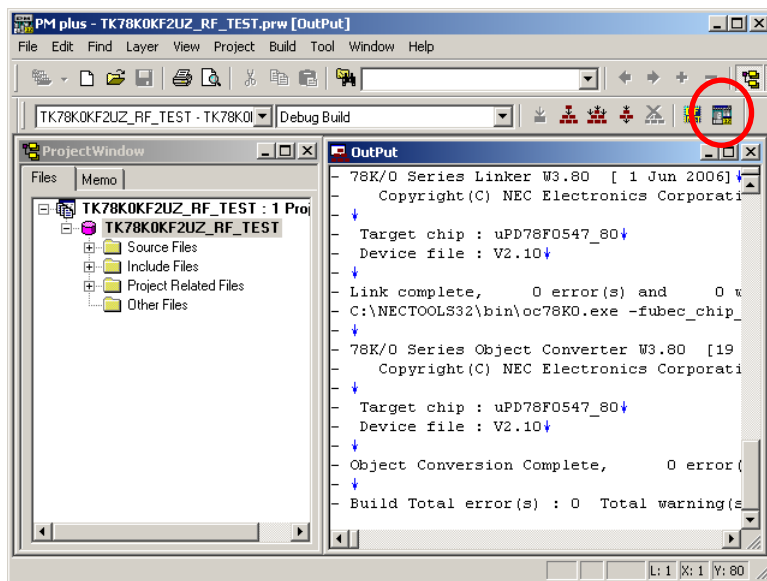
Build compiles and assembles only the source files that have been updated since the previous time, whereas rebuild compiles and assembles all the source files.

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

3.9 Starting integrated debugger (ID78K0-TK)

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

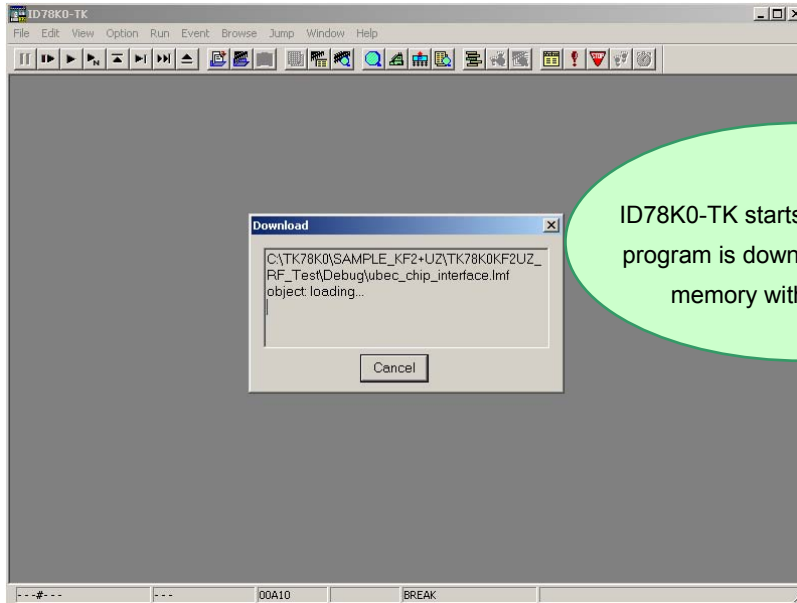
If the debug button is not displayed, in the menu, select [Tool] → [Debugger Setting...] “78K0 Integrated Debugger (ID78K0-TK for TK-78K0)”



If "Configuration" screen displayed, click .

If "Do you want to download Load Module File" message displayed, click .

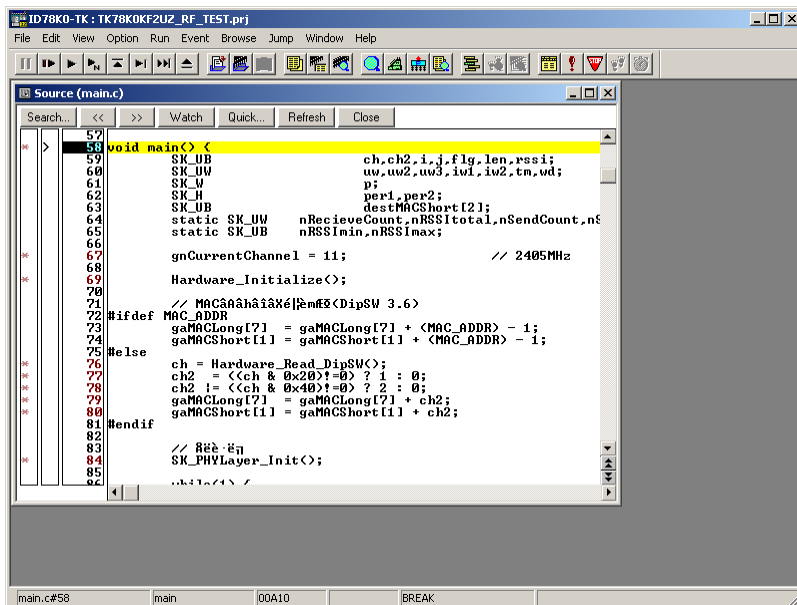




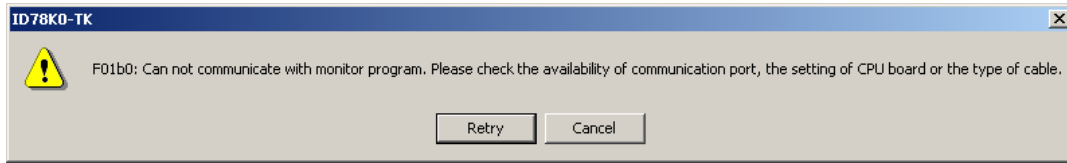
ID78K0-TK starts, and the compiled program is downloaded to the flash memory with built-in CPU.



If everything goes well the sourcecode will be displayed.



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)
SW5		OCD side
SW1	Bit1	ON
	Bit2	ON
	Bit3	ON
	Bit4	ON
	Bit5	ON
	Bit6	OFF
	Bit7	OFF
	Bit8	OFF

2. Please confirm the COM port number is identical with the one allocated by "Portconfig for ID78K0-TK" in TK-78K0?

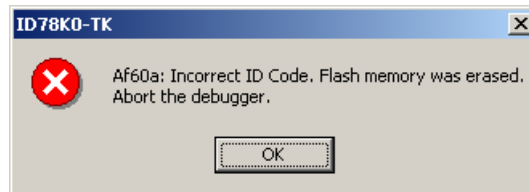
The COM port number can be confirmed by Start -> Settings -> Control Panel -> System -> Hardware -> Device Manager -> Ports.

"Portconfig for ID78K0-TK" can be executed by Start -> Program -> NEC Tools 32 -> Portconfig for ID78K0-TK.

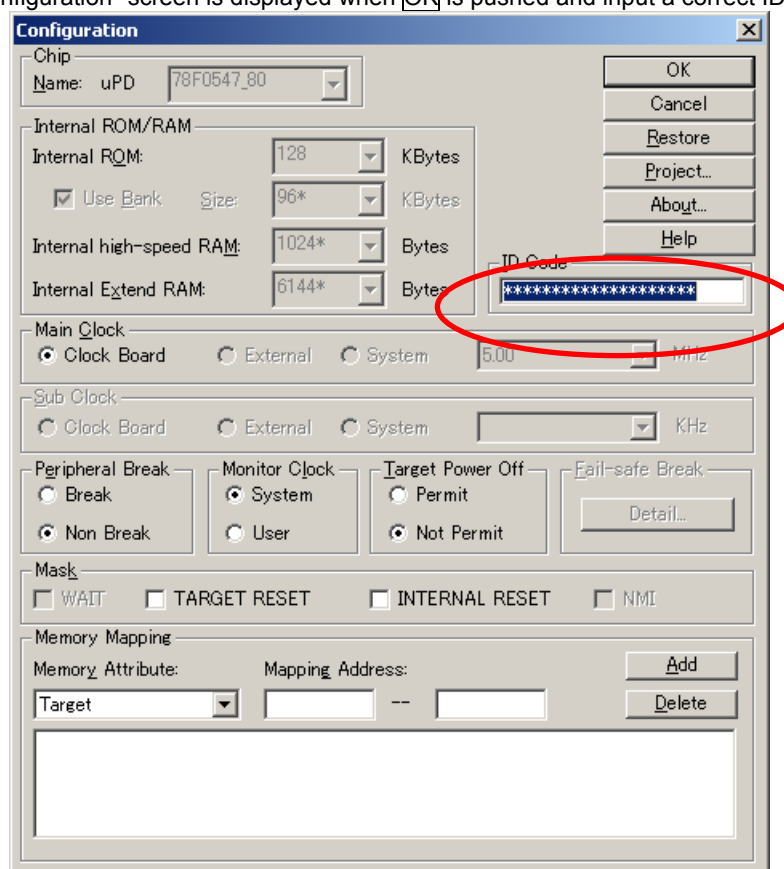
After checking the above items, start ID78K0-TK again.

Now, please start ID78K0-TK 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.



The ID code in all of the sample programs is "FFFFFFFFFFFFFFFFFh". You can change the ID code by writing a new ID code in the "Linker Options".

The intension of using the unique ID code is to prevent a third party from debugging and modifying your source code. To enable the ID code, you have to write non-zero value at 84H. In the sample programs, "84H" is set to a non-zero value, "2", by the "option.asm" file. If you set "0" to 84H, the ID code is ignored.

When the ID code is forgotten, it is necessary to delete all flash memories with built-in CPU.

Please delete the flash memory by installing "PG-FPL3" from CD of the attachment.

Please refer to Chapter 3 for the usage of "PG-FPL3".

※ ID Code

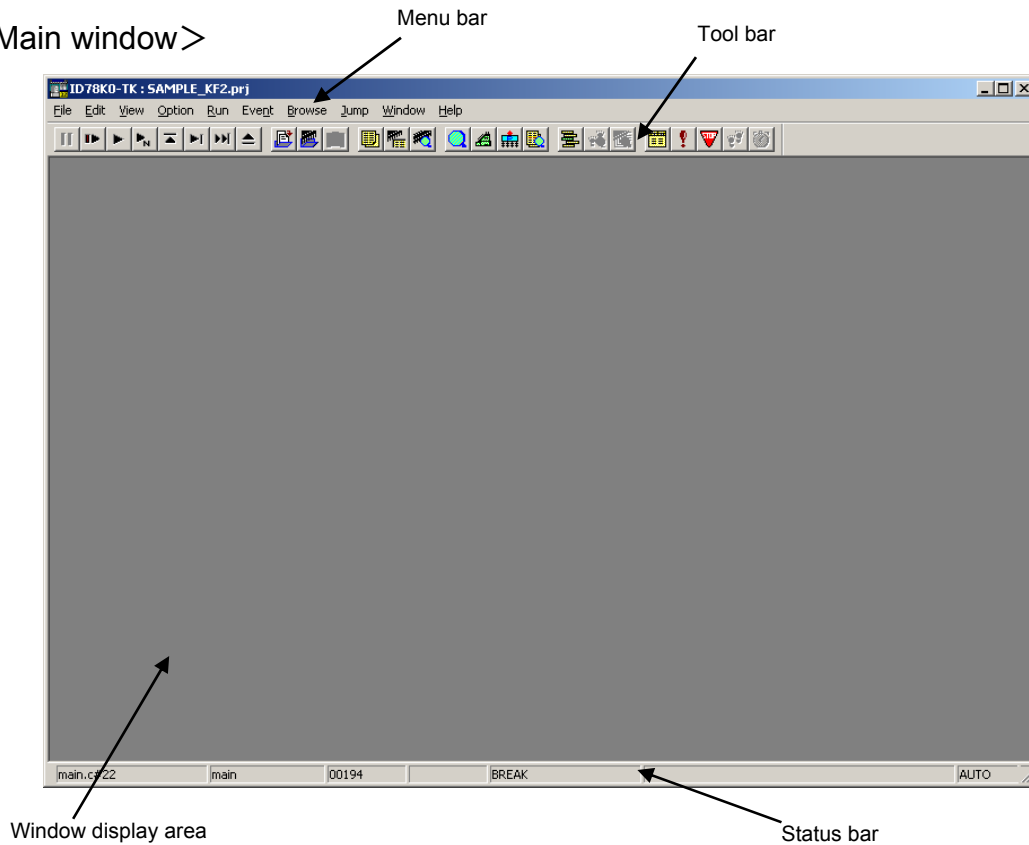
The ID Code is a mechanism to prevent an unwelcome third party from accessing your source code by initiating the debugger. Therefore, it is recommended to modify the ID Code from the default value to secure your original source code. However, once you modify it, then, if you forget the security ID for address of 0x85 - 0x8E or mistakenly over-write 0x00(value) to the address of 0x84, the debugger ID78K0-TK 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, or you may load the hex file using PG-FPL3 with the new ID code.

3.10 Introduction of integrated debugger (ID78K0-TK)

ID78K0-TK displays the internal status of the CPU and controls monitor functions in the main window.


The initial screen of ID78K0-TK is as follows.

< Main window >

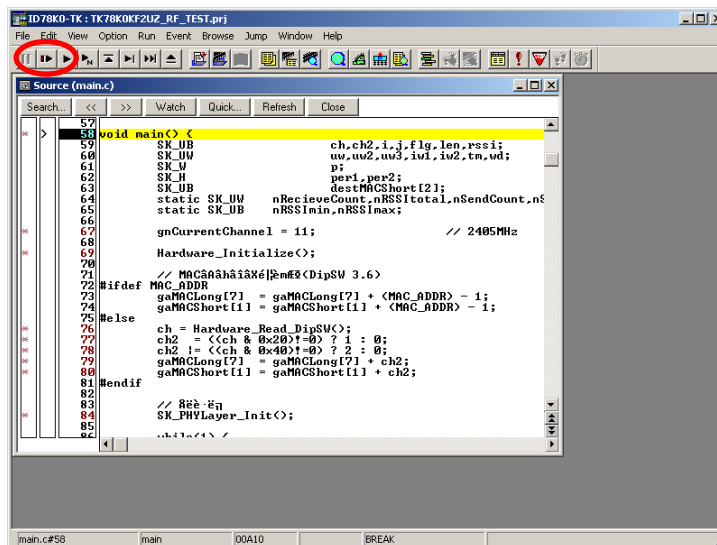


➡ For more details, please refer to the user's manuals of ID78K0-TK and ID78K0-QB.

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.

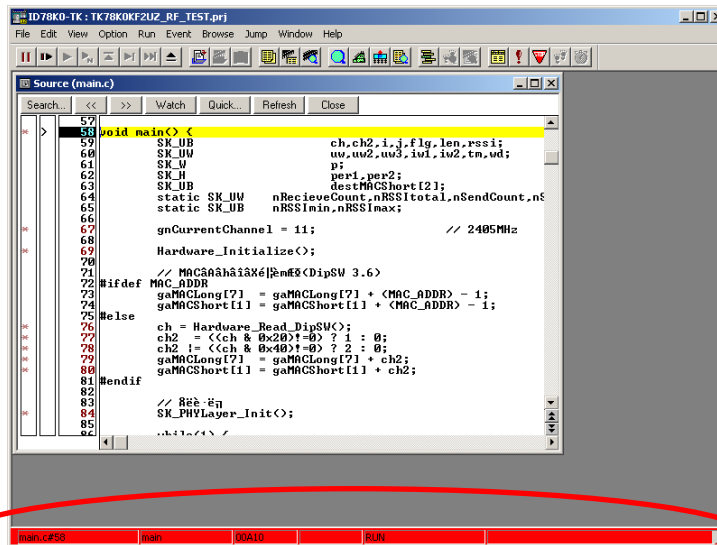
However, because this RF Test program requires a key input from Hyperterminal to set a test mode, the program is waiting for the key input, while the USB connection to PC is occupied with the debugger interface. To debug the each test mode of operation, you may modify the source code to specify a test mode by skipping the key input. The test modes will be explained later.



```
59 void main() {
60     SK_UB          ch, ch2, i, j, flag, len, rssi;
61     SK_UW          uv, uv2, uv3, iv1, iv2, tn, ud;
62     SK_W           p;
63     SK_H           per1, per2;
64     SK_UB          destMACShort[2];
65     static SK_UW   nReceiveCount, nRSSItotal, nSendCount, n;
66     static SK_UB   nRSSImin, nRSSImax;
67     gnCurrentChannel = 11; // 2405MHz
68     Hardware_Initialize();
69     // MAC_AAAhAAXeEEnE8<DipSW 3.6>
70 #ifdef MAC_ADDR
71     gaMACLong[7] = gaMACLong[7] + <MAC_ADDR> - 1;
72     gaMACShort[11] = gaMACShort[11] + <MAC_ADDR> - 1;
73 #else
74     ch = Hardware_Read_DipSW();
75     ch2 = ((ch & 0x20) != 0) ? 1 : 0;
76     ch2 = ((ch & 0x40) != 0) ? 2 : 0;
77     gaMACLong[7] = gaMACLong[7] + ch2;
78     gaMACShort[11] = gaMACShort[11] + ch2;
79 #endif
80 // R&E -Ej
81 SK_PHYLayer_Init();
82
83
84
85
86
```



Execute the program

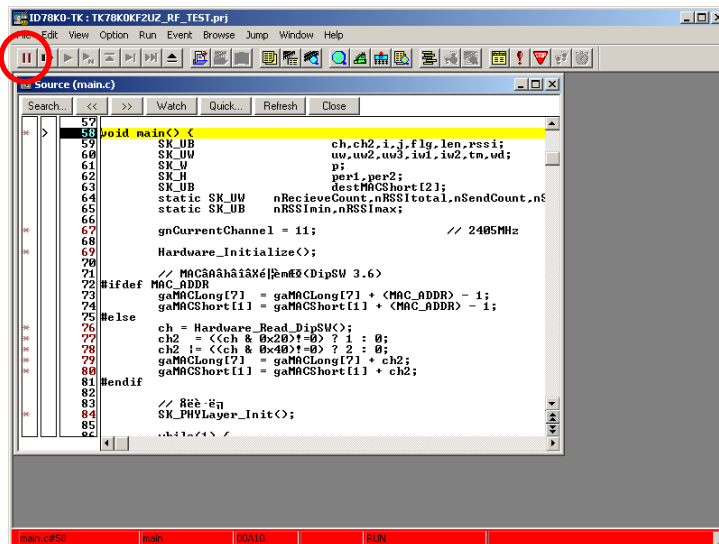


```
59 void main() {
60     SK_UB          ch, ch2, i, j, flag, len, rssi;
61     SK_UW          uv, uv2, uv3, iv1, iv2, tn, ud;
62     SK_W           p;
63     SK_H           per1, per2;
64     SK_UB          destMACShort[2];
65     static SK_UW   nReceiveCount, nRSSItotal, nSendCount, n;
66     static SK_UB   nRSSImin, nRSSImax;
67     gnCurrentChannel = 11; // 2405MHz
68     Hardware_Initialize();
69     // MAC_AAAhAAXeEEnE8<DipSW 3.6>
70 #ifdef MAC_ADDR
71     gaMACLong[7] = gaMACLong[7] + <MAC_ADDR> - 1;
72     gaMACShort[11] = gaMACShort[11] + <MAC_ADDR> - 1;
73 #else
74     ch = Hardware_Read_DipSW();
75     ch2 = ((ch & 0x20) != 0) ? 1 : 0;
76     ch2 = ((ch & 0x40) != 0) ? 2 : 0;
77     gaMACLong[7] = gaMACLong[7] + ch2;
78     gaMACShort[11] = gaMACShort[11] + ch2;
79 #endif
80 // R&E -Ej
81 SK_PHYLayer_Init();
82
83
84
85
86
```

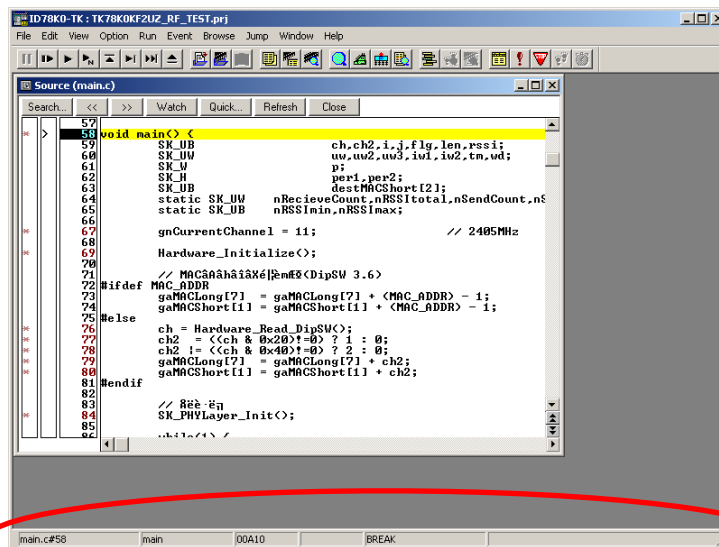
3.12 Stopping program

Stop the program.

Press the ID78K0-TK's stop button , or in the menu, select [Run]→[Stop].



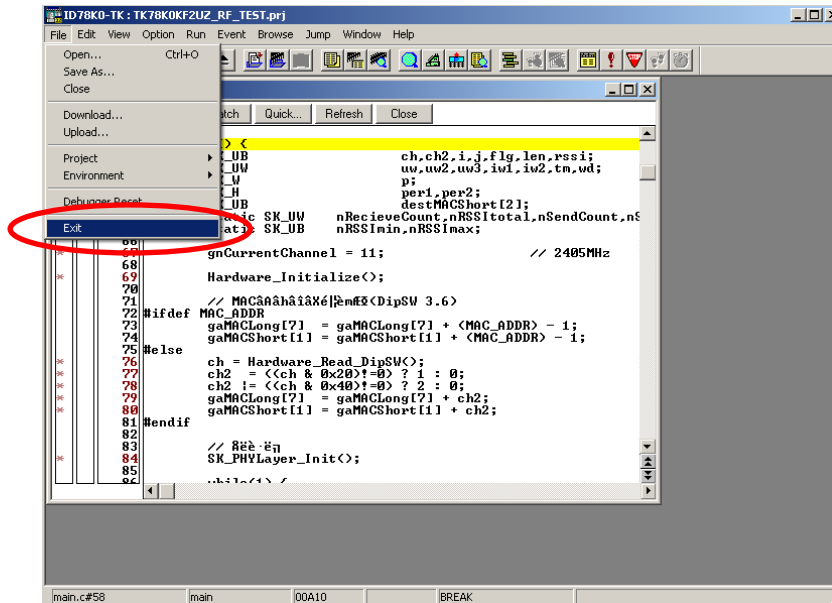
Stop the program



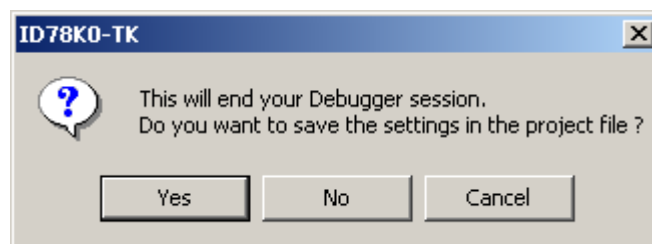
When the program stops, the status bar changes back to its original color.

3.13 Terminating integrated debugger (ID78K0-TK)

In the ID78K0-TK menu, select [File]→[Exit].



The Exit confirmation dialog box is displayed.



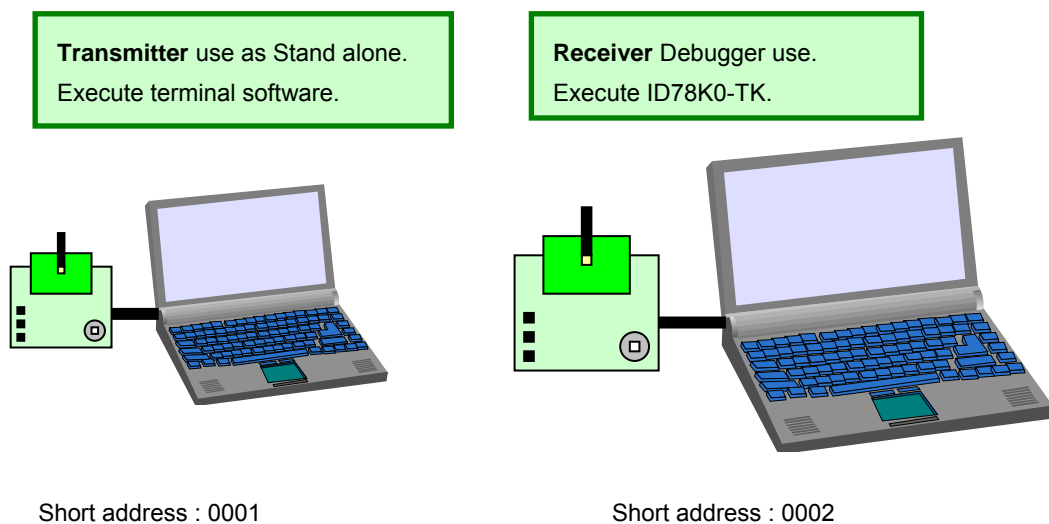
If you push the “Yes”, ID78K0-TK is terminated after preserving a present environment.

If you push the “No”, ID78K0-TK 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-78K0/KF2+UZ boards, in one of which the execution code for the TK78K0KF2UZ_RF_TEST was programmed by the debugger. You also prepare two PCs, 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.



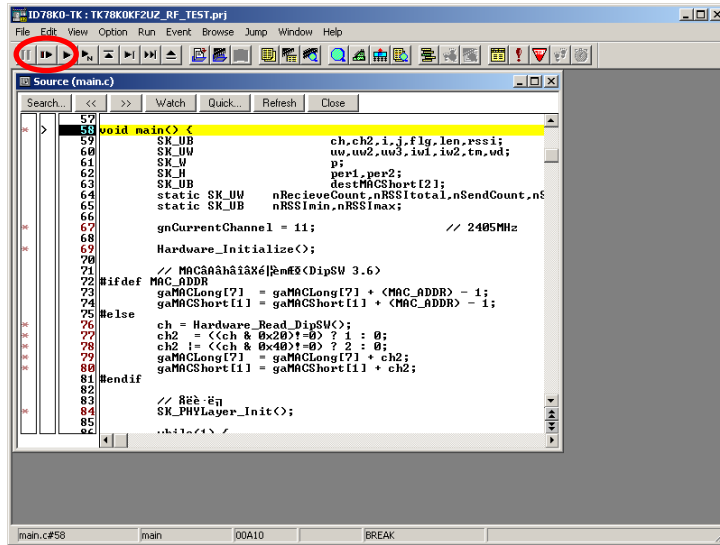
2). Now, you designate the one TK-78K0/KF2+UZ board loaded with the execution code in the previous procedure as a transmitter. Another board, which is not loaded with the execution code is now designated as a receiver, which send back the test result to the sender. The receiver board can work without 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)
SW5		OCD side
SW1	Bit1	ON
	Bit2	ON
	Bit3	ON
	Bit4	ON
	Bit5	ON
	Bit6	ON for address setting
	Bit7	OFF
	Bit8	ON for the receiver mode

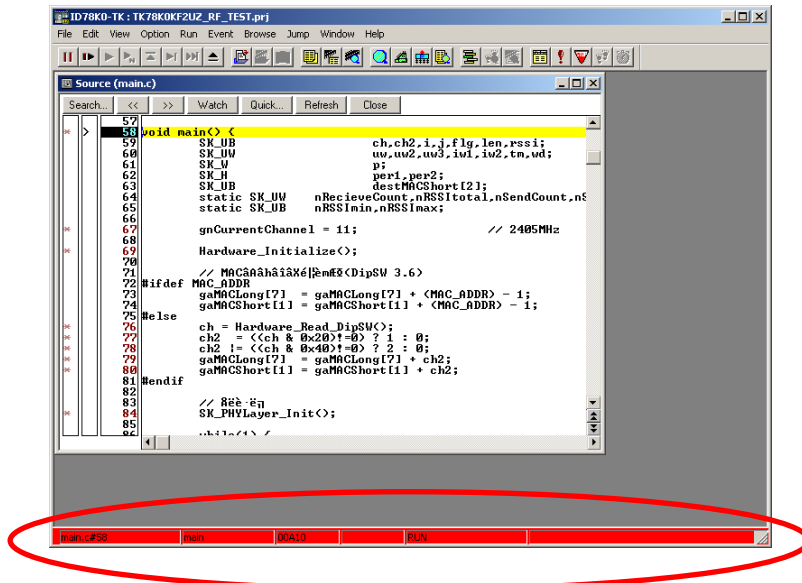
The above example is for the short address of 0002.
There are four ways of the address setting as follows,

		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 “2.9 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.

Please set the transmitter board as follows,

JP1	1-2 short (USB side)	
SW5	UART side	
SW1	Bit1	OFF
	Bit2	OFF
	Bit3	OFF
	Bit4	OFF
	Bit5	OFF
	Bit6	OFF for address setting
	Bit7	OFF
	Bit8	OFF for the transmitter 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

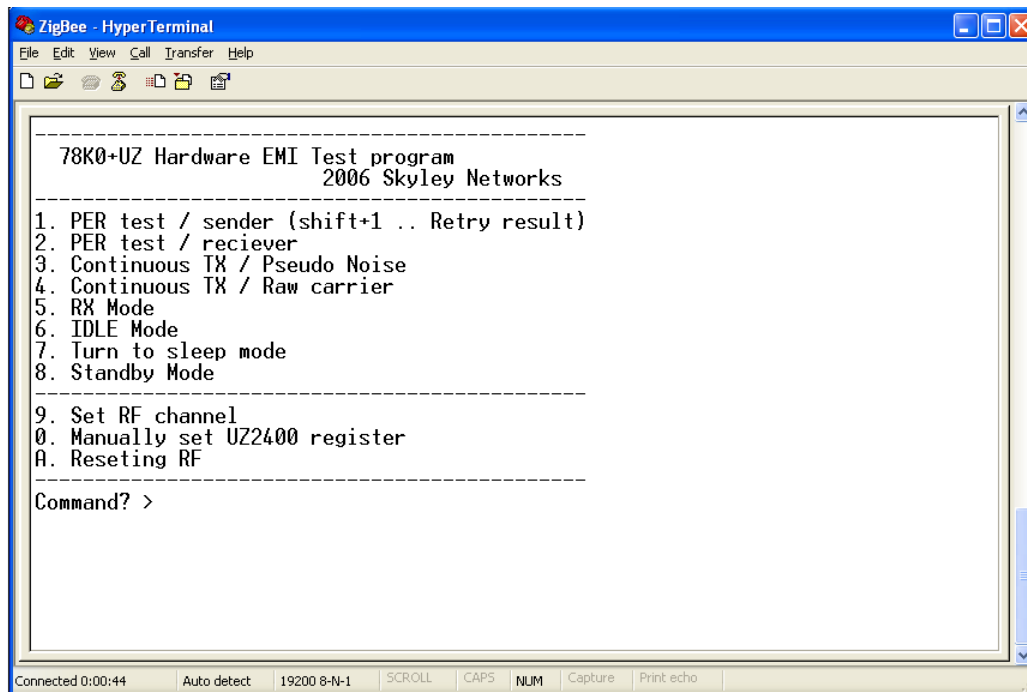
Bits per second	19200
Data bits	8
Parity	None
Stop bits	1
Flow control	None

(Property -> Setting -> ASCII)

Local Echo OFF

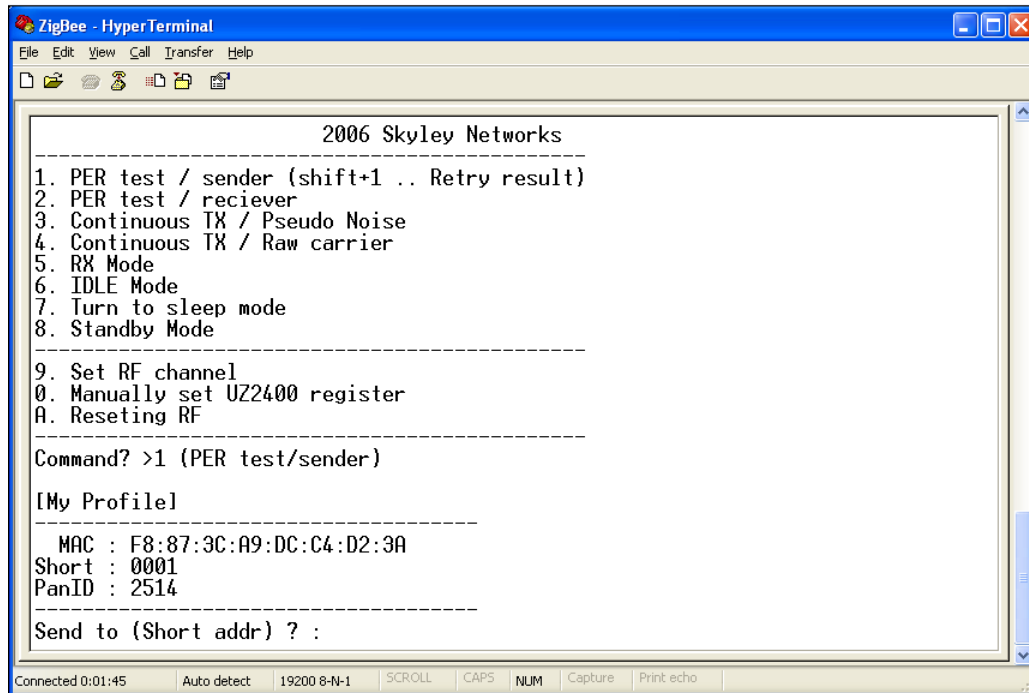
No Line Feed

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



7). 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.



```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
-----
2006 Skyley Networks
-----
1. PER test / sender (shift+1 .. Retry result)
2. PER test / reciever
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
-----
Command? >1 (PER test/sender)

[My Profile]
-----
MAC : F8:87:3C:A9:DC:C4:D2:3A
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

```
MAC : F8:87:3C:A9:DC:C4:D2:3A
Short : 0001
PanID : 2514

-----
Send to (Short addr) ? : 02
Send count (dec) ? : 1000
Interval (dec/msec) ? : 3
[Set channel to 11 (Cmd)]
Prepare to se
[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
-----

[Set channel to 11 (Current)]
```

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.

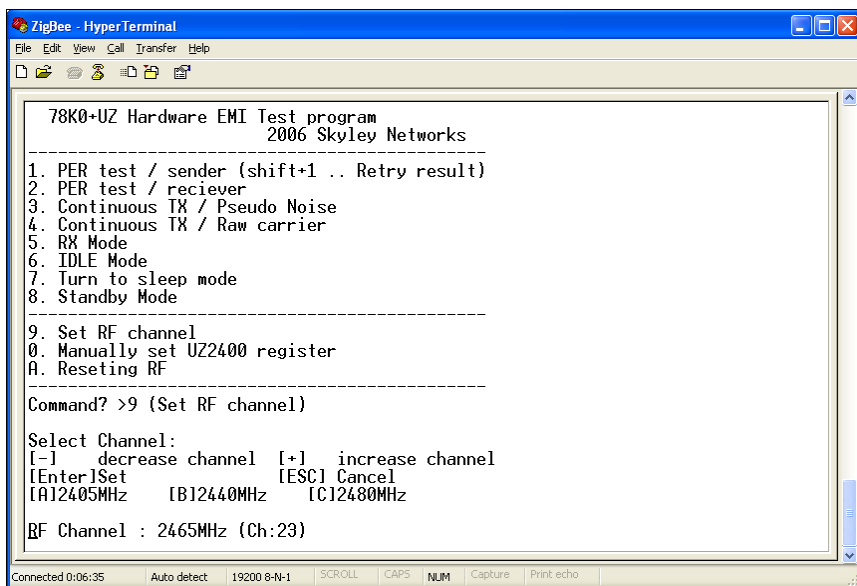
Please note the PER and the RSSI are measured at the receiver side. The receiver does not send back the test packets, but only the test result.

8). 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.



```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
78K0+UZ Hardware EMI Test program
2006 Skyley Networks
-----
1. PER test / sender (shift+1 .. Retry result)
2. PER test / reciever
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
-----
Command? >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 0:06:35 Auto detect 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 : F8:87:3C:A9:DC:C4:D2:3A
Short : 0001
PanID : 2514
-----
Send to (Short addr) ? : 0002
Send count (dec) ? : 1000
Interval (dec/msec) ? : 5
[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 : 1000
PER : 0.0000%
RSSI : max FD / min D9
-----
[Set channel to 23 (Current)]
-----
78K0-UZ Hardware EMI Test program
2006 Skyley Networks
-----
1. PER test / sender (shift+1 .. Retry result)
2. PER test / reciever
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
-----
Command? >_

Connected 0:09:11 Auto detect 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

9). Adjusting the output power

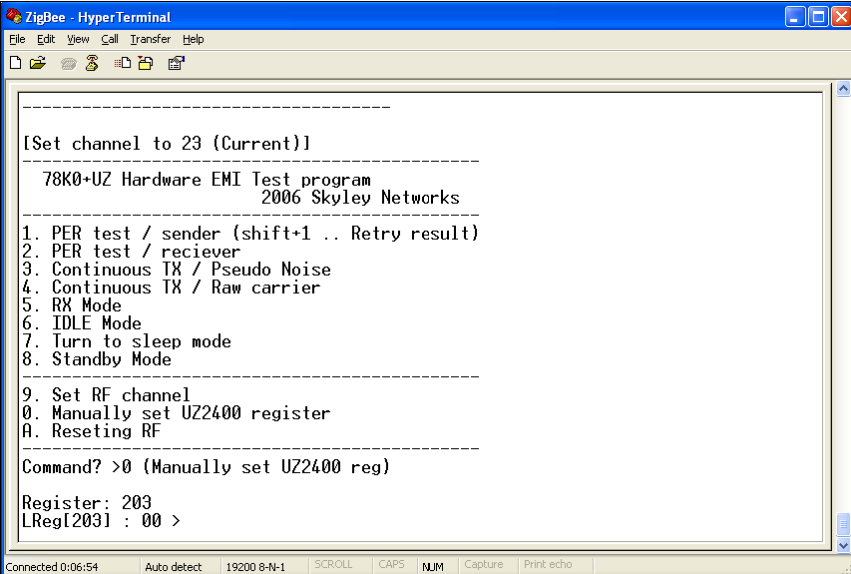
You may wish to control the output power in the PER test.

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.



```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
-----
[Set channel to 23 (Current)]
-----
78K0+UZ Hardware EMI Test program
2006 Skyley Networks
-----
1. PER test / sender (shift+1 .. Retry result)
2. PER test / reciever
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
-----
Command? >0 (Manually set UZ2400 reg)

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

The register bits are defined as follows,

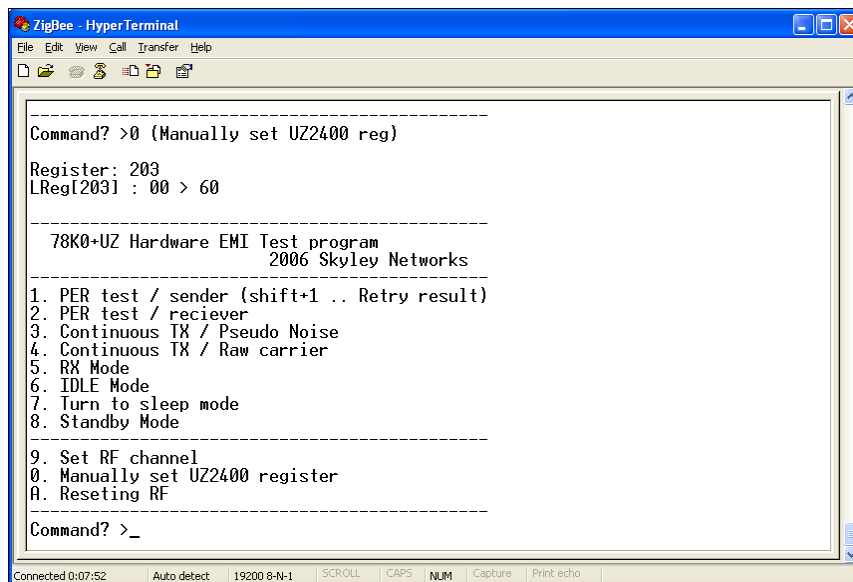
LREG[203]:

- [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

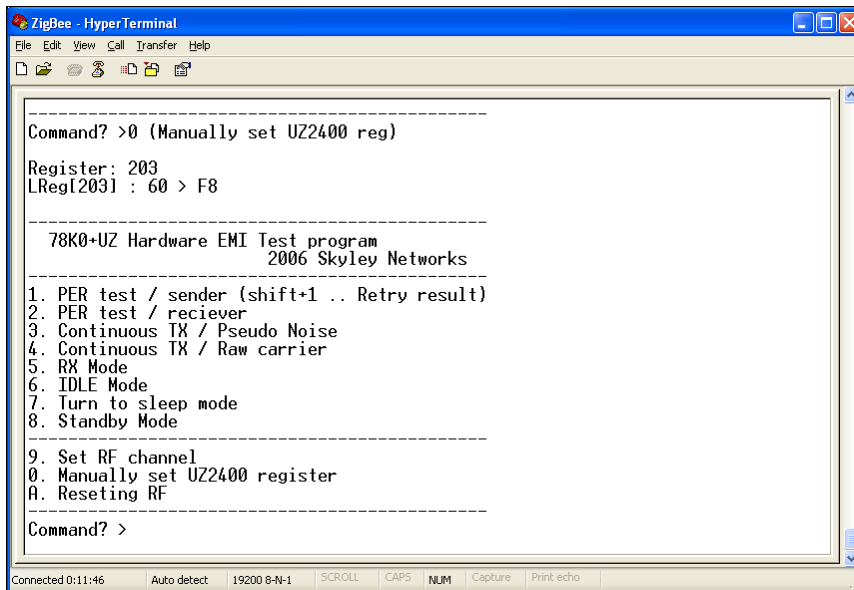
For instance, if you wish -15 dB, please input "60", as follows,

"LREG[203] : 00 > 60"

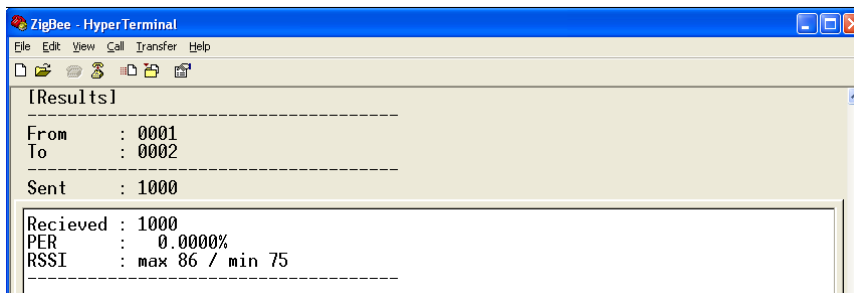
Then, you will start the PER test.



The minimum output power is set by “F8”.



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



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

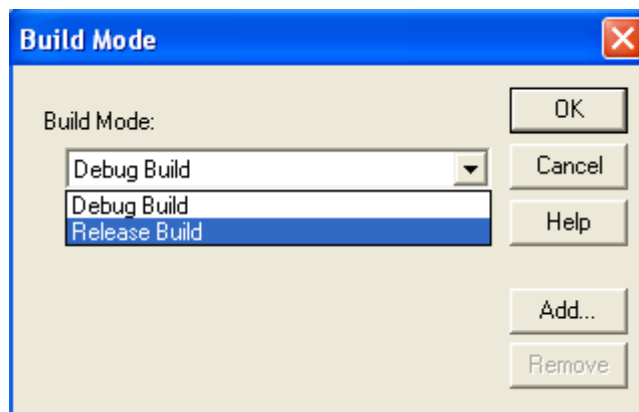
The Menu 0 allows you to set the UZ2400 registers.
Please refer to the datasheet of the UZ2400 RF chip for the definition of registers.

3.14.11 Resetting RF

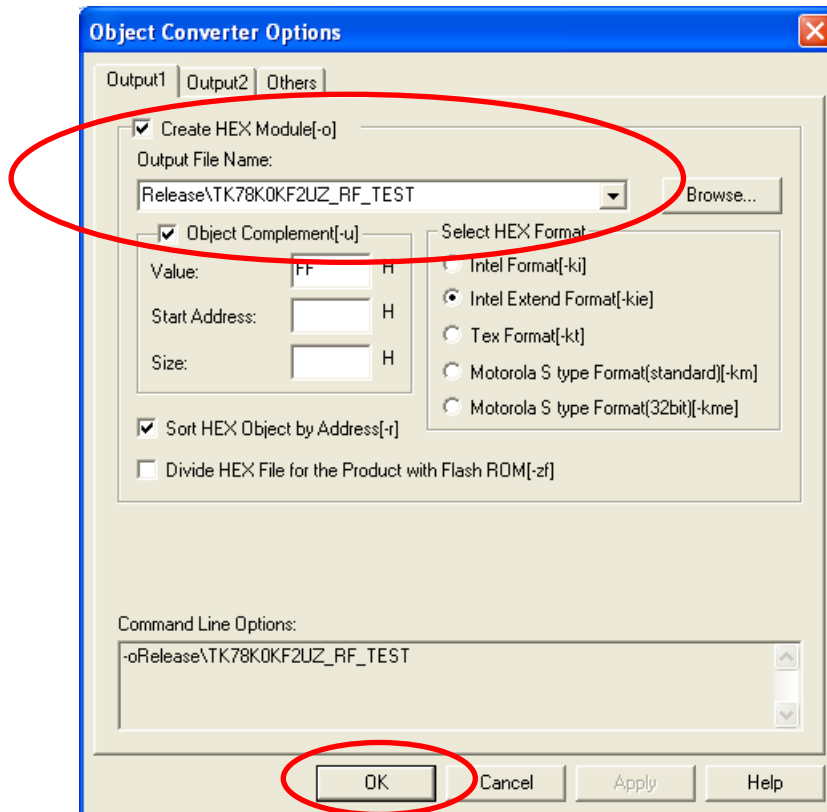
The Menu A allows you to reset the UZ2400 registers.

3.15 Creating new hex files

After debugging, you may wish to copy the new object code to other TK boards. In this case, you may not want to start-up the debugger for every board, but, may wish to make copies using the PG-FPL3 Flash programmer. For it, please create a new hex file, following the procedure described in this session.



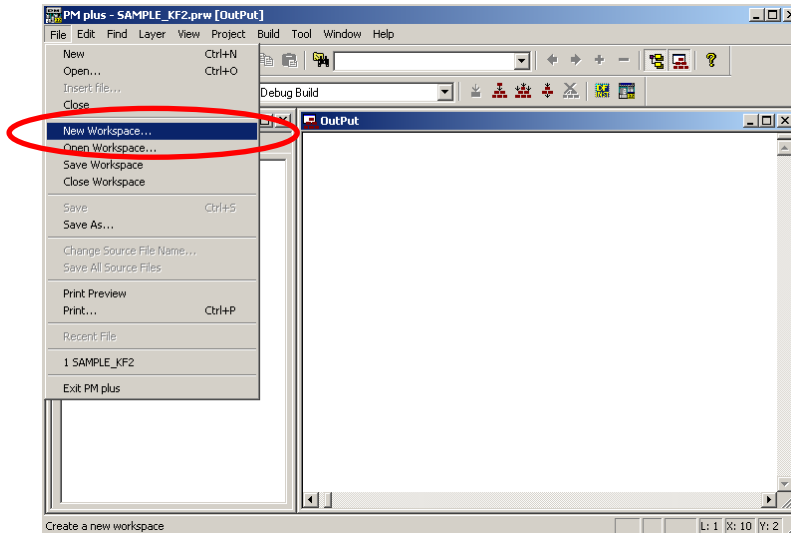
In the release build mode of the PM plus, please open the "Object Converter Options" window from the pull-down menu of [Tool]. Please click "Create HEX Module" tab and define the path and the file name of the new hex file. In this example, it is "Release/TK78K0KF2UZ_RF_TEST". After re-compile, you will find the "TK78K0KF2UZ_RF_TEST.hex" in the directory.



You will learn how to program other TK boards with the hex file in the next chapter.

3.16 Creating a new PM plus workspace (project)

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



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:

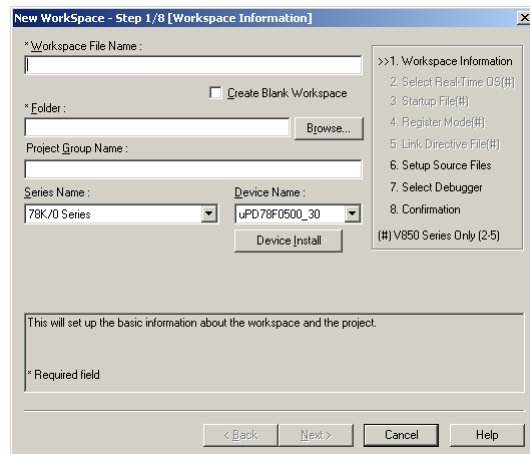
- > Specify this item if wishing to manage multiple projects together in function units.
If nothing is specified, this item is the same as the workspace file name.

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:\TK78K0\test

Project Group Name

→ Don't input this item.

Series Name

→ 78K/0 Series

Device Name

→ uPD78F0547_80

New Workspace - Step 1/8 [Workspace Information]

* Workspace File Name : test

Create Blank Workspace

* Folder : C:\TK78K0\test [Browse...]

Project Group Name :

Series Name : 78K/0 Series Device Name : uPD78F0547_80 [Device Install]

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

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

* Required field

< Back [Next >] Cancel Help

Push the **Next >** button.



PM plus

! Q2011: C:\TK78K0\test
This folder cannot be found. Do you wish to create it?

[Yes] [No]

Push the **Yes** button.



New Workspace - Step 6/8 [Setup Source Files]

Please setup Source Files.

Source File Name :

[Add..] [Remove] [Remove All]

[Up] [Down]

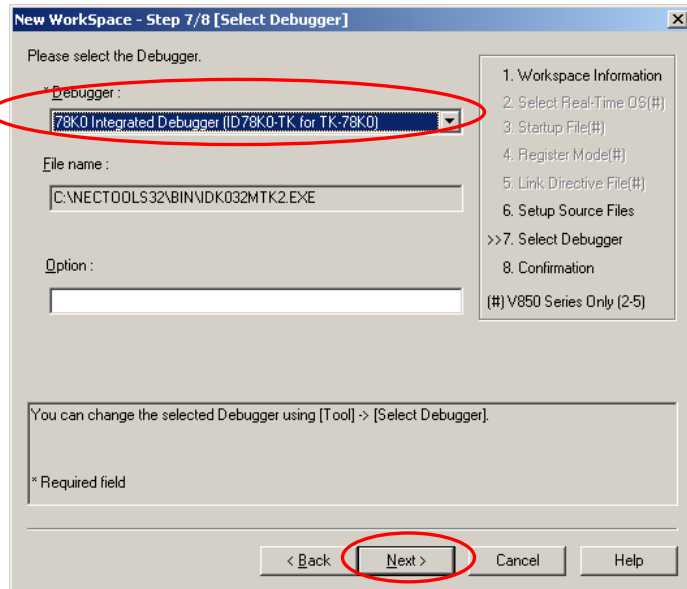
>> 6. Setup Source Files
7. Select Debugger
8. Confirmation
(#) V850 Series Only (2-5)

You can also add source files by specifying the list file or the folder.
You don't need to specify all the files here, and you can setup source files using [Project]>[Project Settings] later.

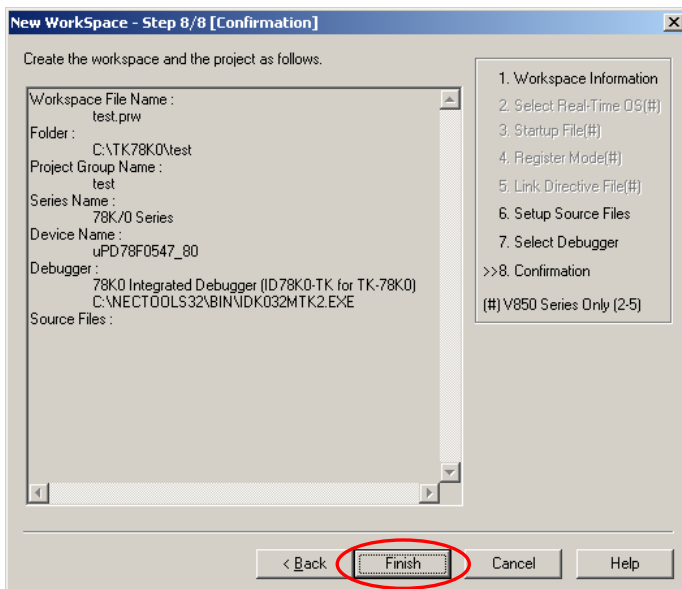
< Back [Next >] Cancel Help

Push the **Next >** button.

Please select 78K0 Integrated Debugger (ID78K0-TK for TK-78K0)



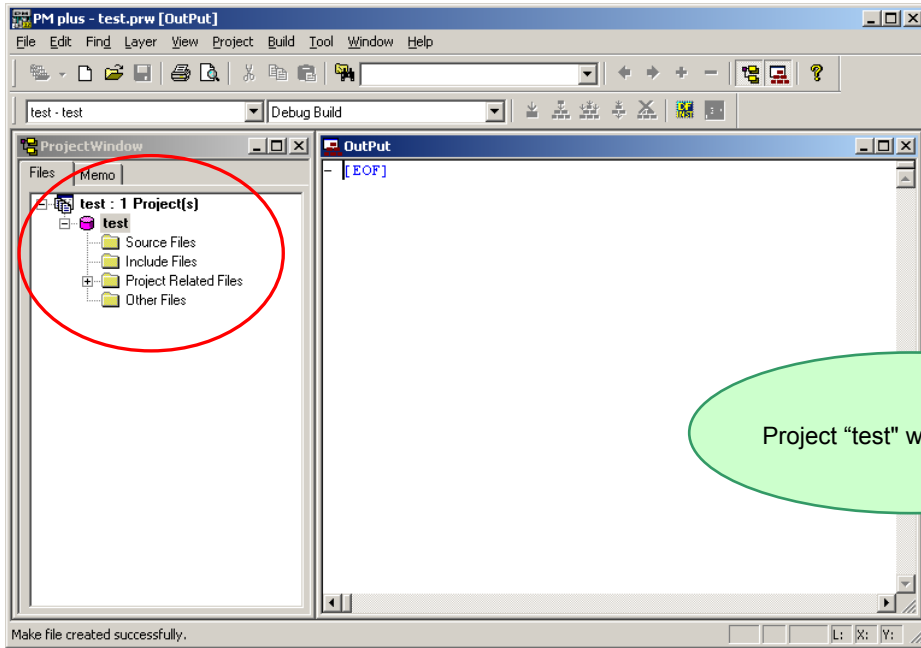
Push the Next > button.



Push the Finish button.

Check the project information setting contents.





This completes workspace and project creation.

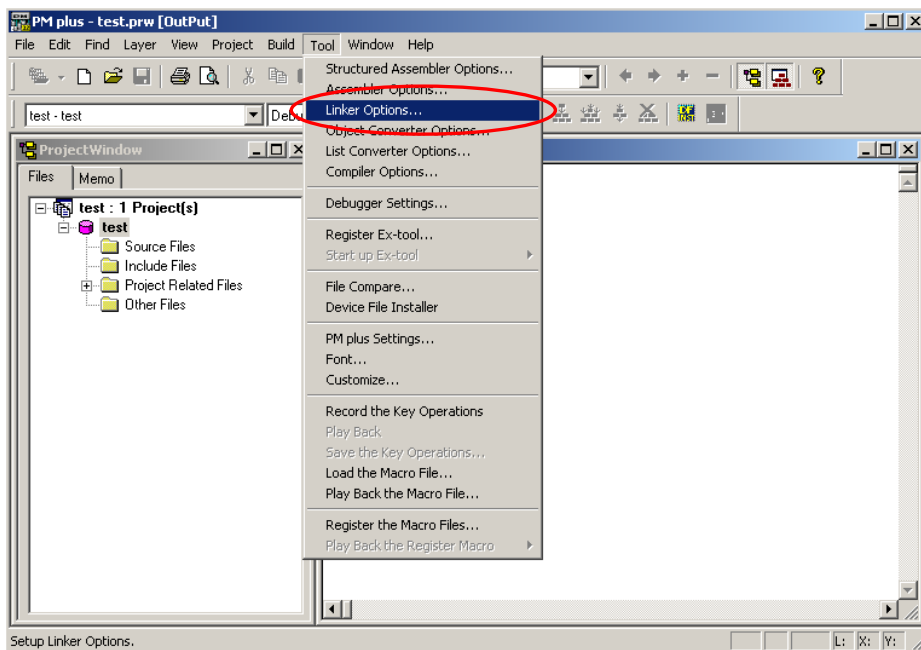
Additional source files can be registered at any time thereafter.

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

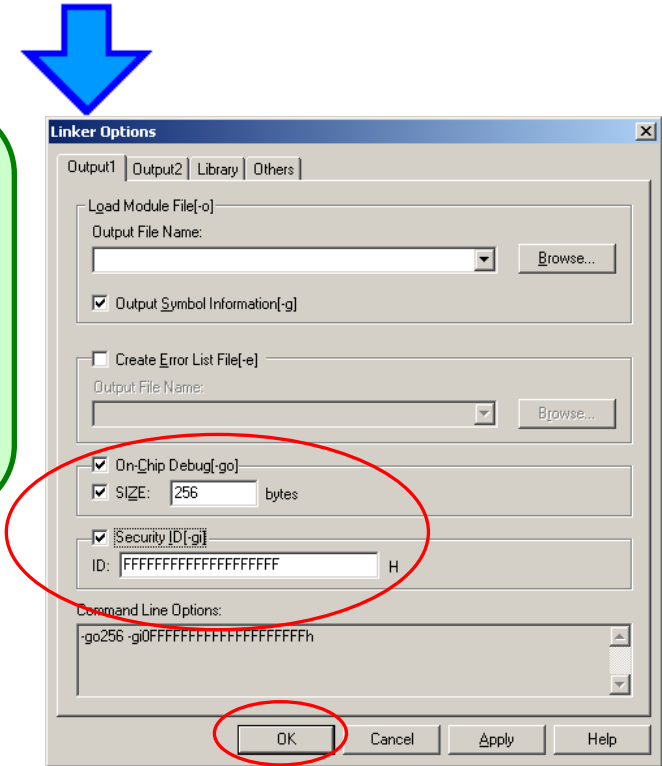


Next, on chip debug function can be used.

[Tool] → [Linker Options...] is selected.



Checks are put in "On-Chip Debug" and "SIZE". Then input a default value of "256" into the "SIZE".
A check is put in "Security ID".
The actualities of "FFFFFFFFFFFFFFFF" are taken if there is no problem in the value of ID in security.



Push the **OK** button.

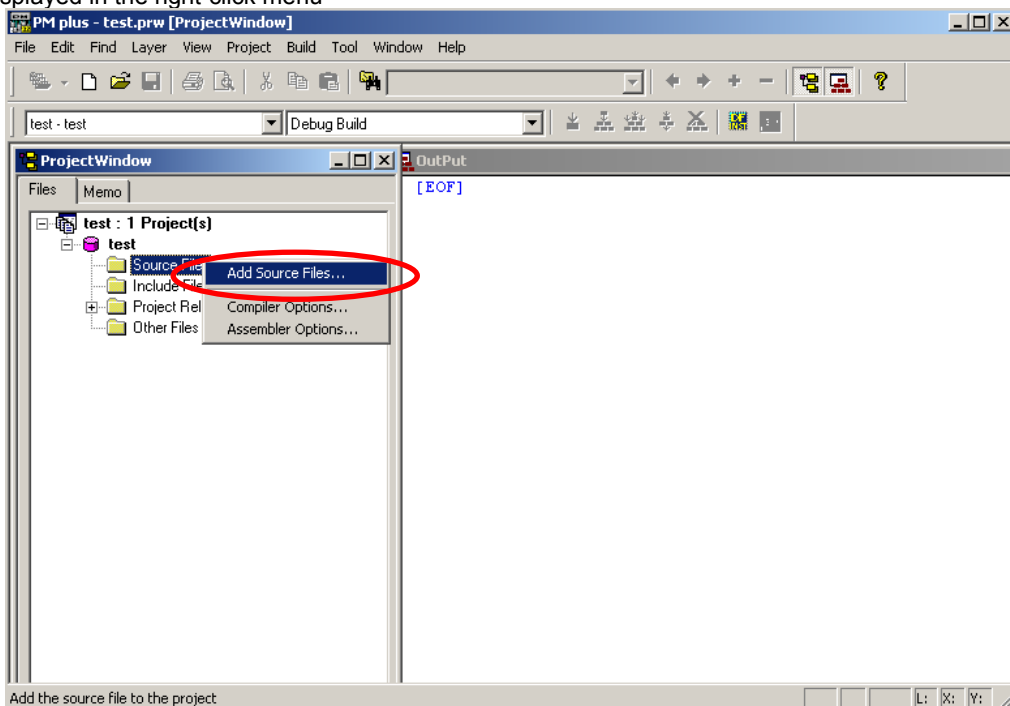
Please copy the "option.asm" file to the new work space from the "RF Test Program".
Please refer to the "1.1 Configuration of Linker Option" for further details of security ID.

3.17 Registering additional source file

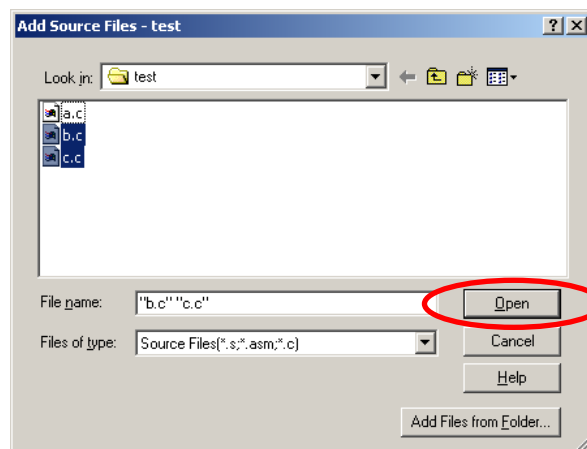
The method for registering additional source files to a project is described below.

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 plus, and select [Add Source Files...] displayed in the right-click menu



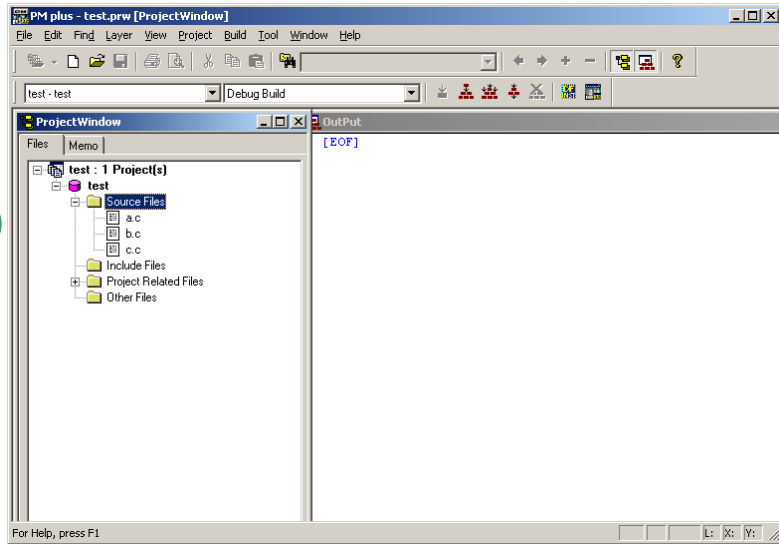
Select source files "b.c" and "c.c" and then press the **Open** button.



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



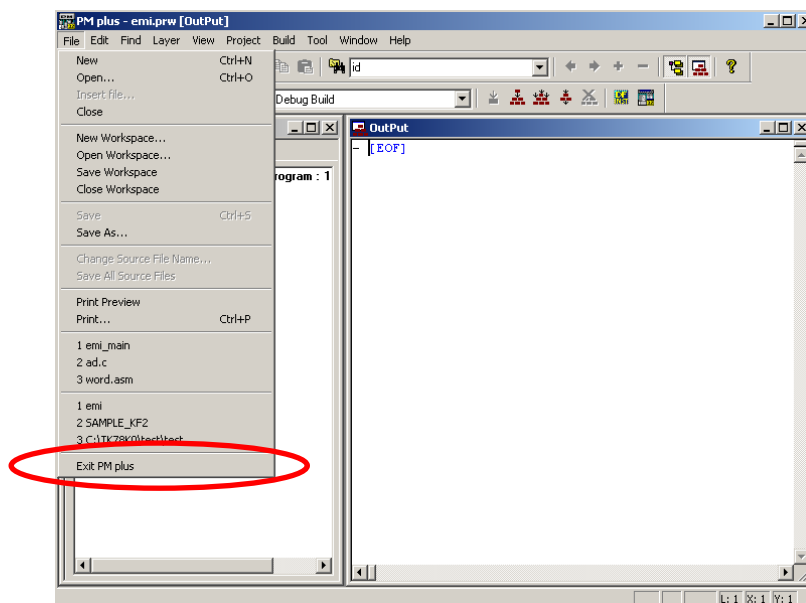
Source file "b.c" and "c.c" are additionally registered to the project.



3.18 Terminating PM plus

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

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



PM plus ends.

4 How to use PG-FPL3

PG-FPL3 is a software Flash EEPROM programmer, working on MS Windows. PG-FPL3 enables you to program your application program file of hex format in the Flash EEPROM, embedded on the 78K0/KF2 microcontroller on the TK-78K0/KF2+UZ board, via the USB interface of the board. You do not need any hardware, additionally to your PC and the TK-78K0/KF2+UZ board, to make the programming.

4.1 Installation of PG-FPL3

Please set the CD-ROM in your PC.
Please find "Setup.exe" at /FPL3/FPL3_V110, then, execute it.

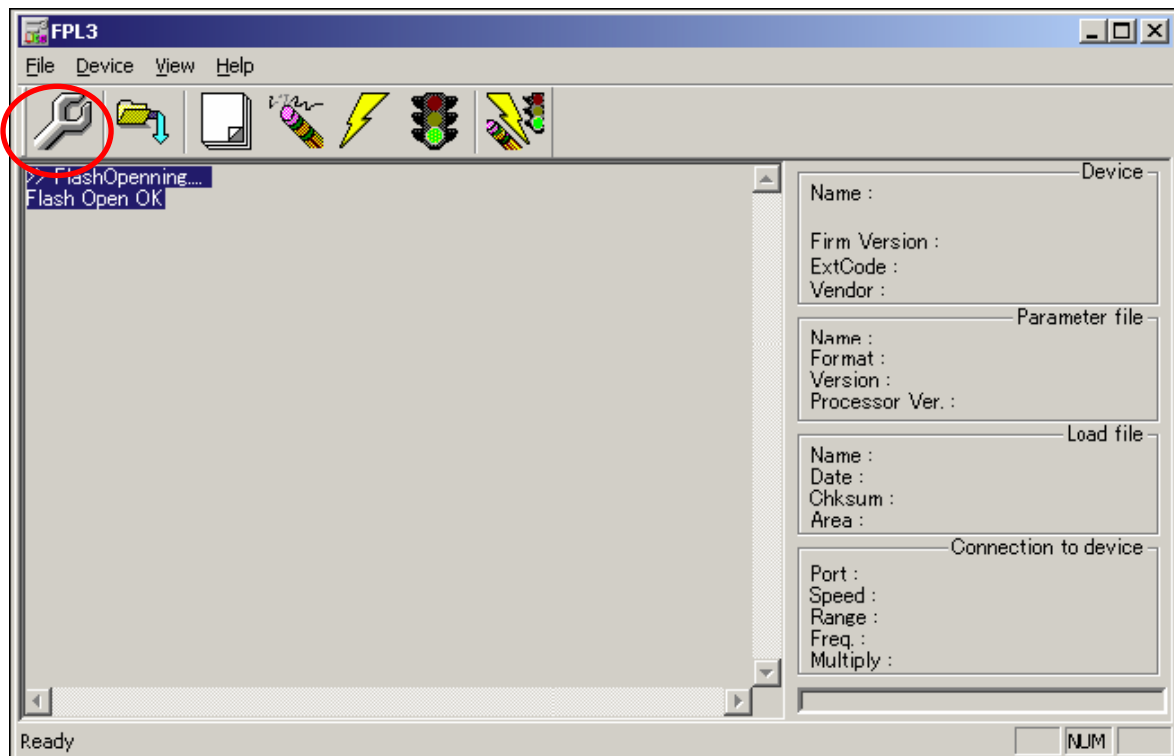
4.2 How to use PG-FPL3

Please keep the CD-ROM in your PC.
Please set switches on the TK-78K0/KF2+UZ board as shown below.

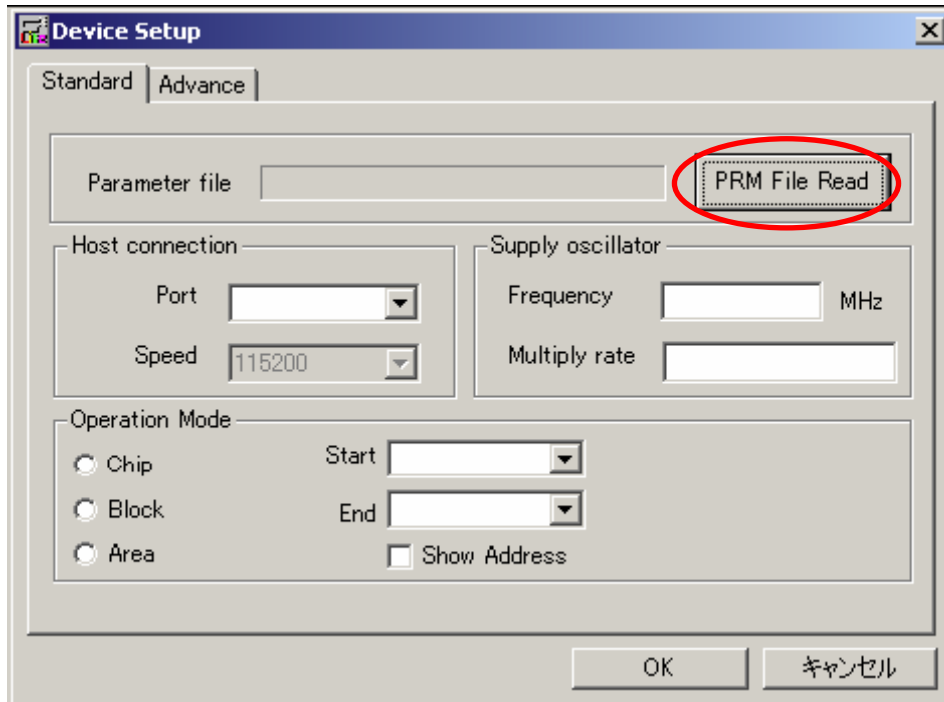
JP1	1-2 short (USB side)	
SW5	UART side	
SW1	Bit1	ON
	Bit2	ON
	Bit3	OFF
	Bit4	OFF
	Bit5	OFF
	Bit6	OFF
	Bit7	OFF
	Bit8	OFF

Now you connect the TK-78K0/KF2+UZ to your PC. And confirm the green LED lighting.

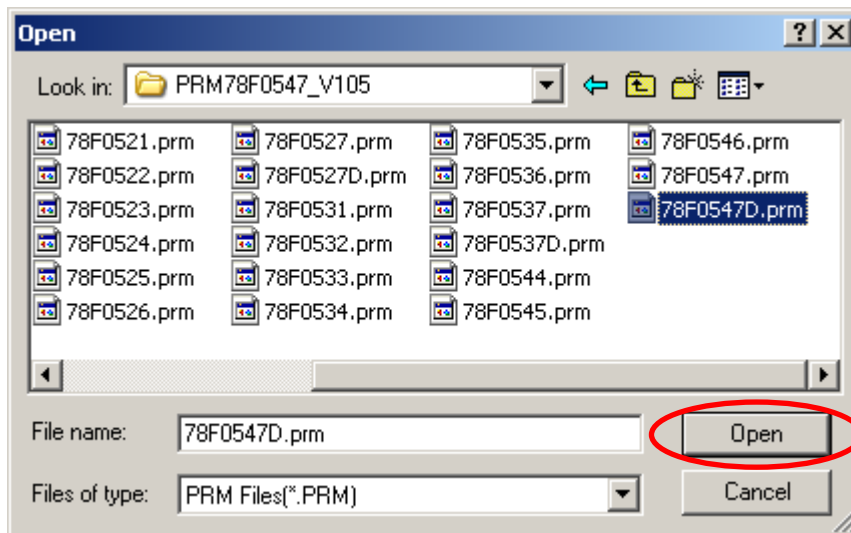
Please select PG-FPL3 at [Programs] -> [NEC Tools32] -> [PG-FPL3].
You will see the main window, as shown below. Please click “Setup”.



You will see the setup window, shown below.
Please click “PRM File Read”.



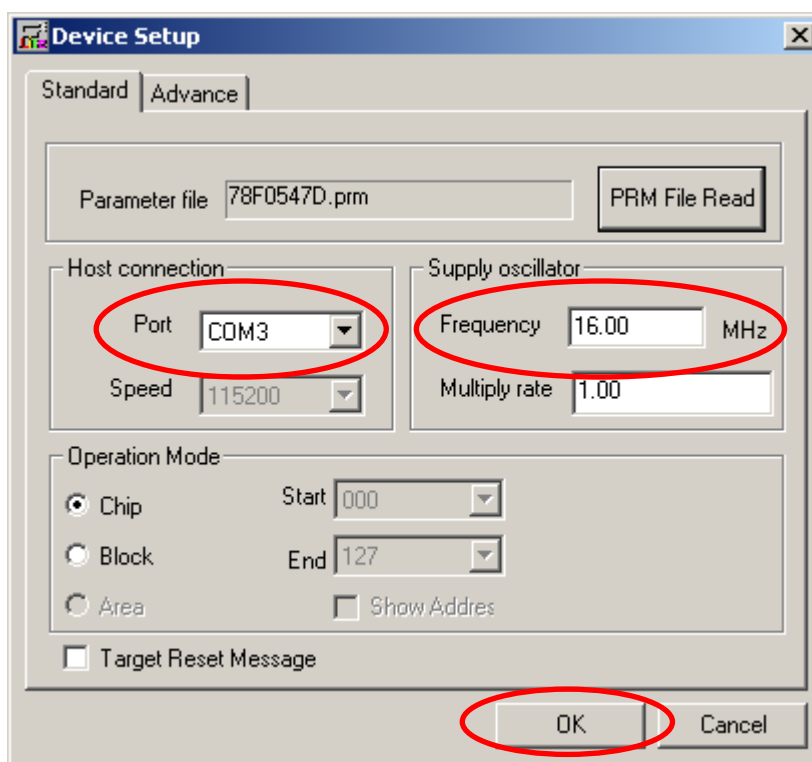
Please select “78F0547D.prm” in the directory of “PRM78F0547_V105” in the CD-ROM.



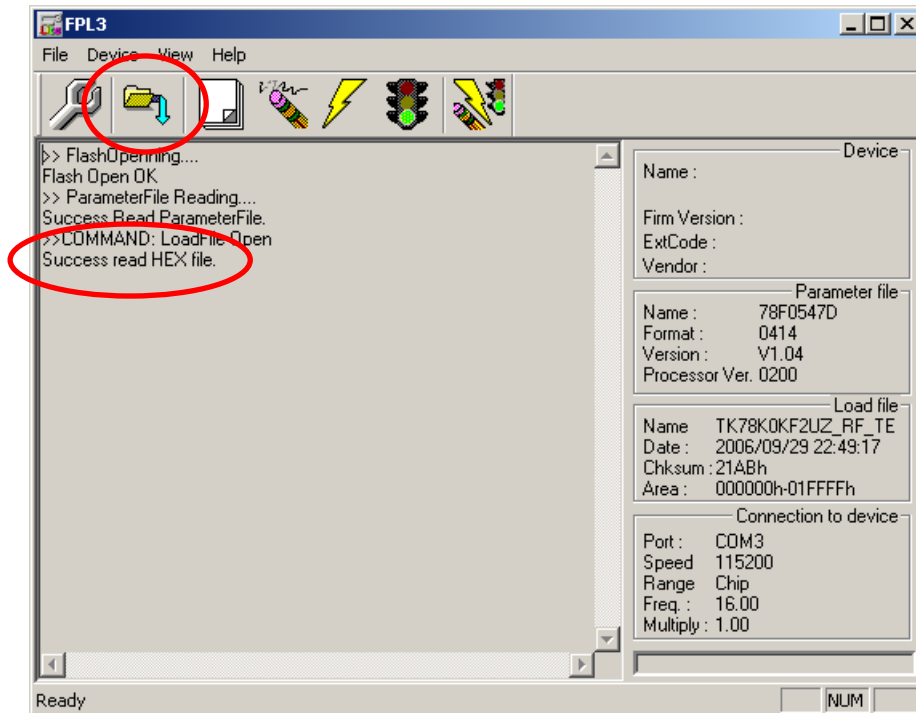
Then, "Port" is to be selected. You will choose the number of the COM port, where the 78K0 UZ Stick is inserted.

If you do not know the COM port number, please go to Control Panel Start -> Control panel -> System -> Hardware -> Device Manager to find something like "USB Serial Port (COM3)". In this particular case, it is "3". The number may be another one, depending on a PC or a USB terminal. Please select your COM port number in the pull-down menu. The pull-down menu displays all of available COM ports in your PC.

Please set "16.00" in the "Frequency", then, click OK.



The next action is the loading of the hex file to the PG-FPL3. In this example, “TK78K0KF2UZ_RF_TEST.hex” found at “TK78K0KF2UZ_RF_Test/Release” is loaded. If everything goes well, you will see a message of “Success read HEX file”, as shown below.

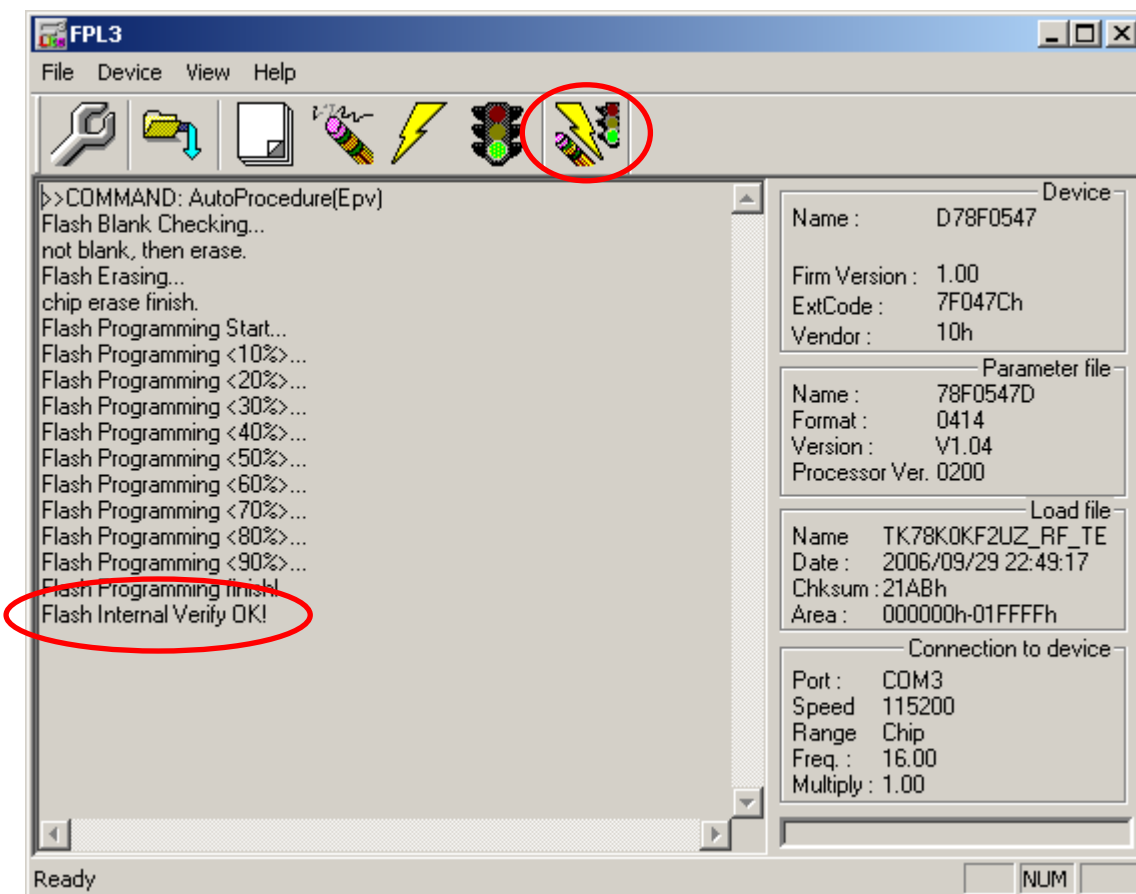


Then, if you click “Auto procedure”, erasing, programming, and verification are executed. Alternatively, you can execute erasing, programming, and verification, one by one by clicking the three buttons located at the left of the “Auto procedure” button.

If you see “Flash internal Verify OK!”, your program has been successfully loaded in the Flash EEPROM. Then, you can disconnect the TK-78K0/KF2+UZ from your PC.

Now, you will program the hex file in the second, or possibly third, and more.

Or, if you like to initiate the program immediately, while keeping the USB connection, please set the Switch 1-1, and 1-2 to OFF, then the program will start with Hyper-terminal. Please go to the next chapter for this procedure.



5 IEEE 802.15.4 MAC Sample Program

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

5.1 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 and two TK-78K0/KF2+UZ boards.

The MAC Sample Program 1 is provided in the form of the hex file, as well as the C source codes.

The hex files, TK78K0KF2UZ_Sample1_01.hex, _02.hex, _03.hex, _04.hex and _05.hex allow you to immediately program to your TK-78K0KF2+UZ boards using the PG-FPL3 Flash EEPROM programmer, and start the sample application. The TK78K0KF2UZ_Sample1_0x.hex files are available at
C:/TK78K0/SAMPLE_KF2+UZ/TK78K0KF2UZ_Sample1/Release.

Or, 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 plus. In this procedure, the Flash programmer PG-FPL3 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 plus.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0/KF2+UZ board in a radio anechoic chamber.

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

5.1.1 Programming to the TK boards

For chatting, please prepare minimum 2, or maximum 5 TK-78K0/KF2+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

Please program the hex files of TK78K0KF2UZ_Sample1_01.hex, _02.hex, _03.hex, _04.hex and _05.hex to each of your TK-78K0/KF2+UZ boards using PG-FPL3.

5.1.2 Setting up the board to your PC

- 1). Assumption here in this section is, you have two or more TK-78K0/KF2+UZ boards, in which the TK78K0KF2UZ_Sample1_0x.hex were programmed.
- 2). Please set the following switch configuration on all of your boards.

JP1		1-2 short (USB side)
SW5		UART side
SW1	Bit1	OFF
	Bit2	OFF
	Bit3	OFF
	Bit4	OFF
	Bit5	OFF
	Bit6	OFF
	Bit7	OFF
	Bit8	OFF

- 3). Then, please connect it to your PC with a USB cable.

Please set the Jumper 1 to USB to supply voltage to the board from USB I/F of the PC.

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	19200
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.

```
-----  
TK-78K0/UZ Sample Application  
-----  
2006 Skyley Networks  
  
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.

5.1.3 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.

5.1.4 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 123456789ABC0001 associated to 4321

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

Command? >
```

5.1.5 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.

5.2 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-78K0/KF2+UZ boards or more boards, up to 5.

The MAC Sample Program 2 is provided in the form of the hex file, as well as the C source codes with the MAC library.

The hex file, TK78K0KF2UZ_Sample2.hex, allows you to immediately program to your TK-78K0KF2+UZ boards using the PG-FPL3 Flash EEPROM programmer, and start the sample application. The TK78K0KF2UZ_Sample2.hex file is available at

C:/TK78K0/SAMPLE_KF2+UZ/TK78K0KF2UZ_Sample2/Release.

Or, 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 plus. In this procedure, the Flash programmer PG-FPL3 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 plus.

As a general remark, please respect your local regulation of electro-magnetic emission. In general, it is suggested to use the TK-78K0/KF2+UZ board in a radio anechoic chamber.

5.2.1 Programming to the TK boards

Please prepare minimum 2, or maximum 5 TK-78K0/KF2+UZ boards. You need at least one PC to load the hex file on to the boards. However, for LED operation, you don't need any PC.

You will designate one board as a coordinator, and the rests as end devices. However, the hex file is common for both a coordinator and end devices, because the role setting is made by a switch on board.

Please program the hex files of TK78K0KF2UZ_Sample2.hex to all of your TK-78K0/KF2+UZ boards using PG-FPL3. You will find the TK78K0KF2UZ_Sample2.hex file at the directory of "TK78K0KF2UZ_Sample2¥Release".

5.2.2 Starting up a coordinator

- 1). Please set the following switch configuration on all of your boards.

JP1		1-2 short (USB side)
SW5		UART side
SW1	Bit1	OFF
	Bit2	OFF
	Bit3	OFF
	Bit4	OFF
	Bit5	OFF
	Bit6	OFF
	Bit7	OFF
	Bit8	OFF

- 2). Now, you choose one board as a coordinator.
- 3). Then, you have a choice if you use the coordinator with or without HyperTerminal.
- 4). If you like to use HyperTerminal, please set the Switch 5 to battery, then, connect the coordinator board to the PC with a USB cable.

Then, please connect it to your PC with a USB cable. Please set the Jumper 1 to USB to supply voltage to the board from USB I/F of the PC.

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

5). HyperTerminal

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

Please set the parameters of HyperTerminal as follows,

Bits per second	19200
Data bits	8
Parity	None
Stop bits	1
Flow control	None

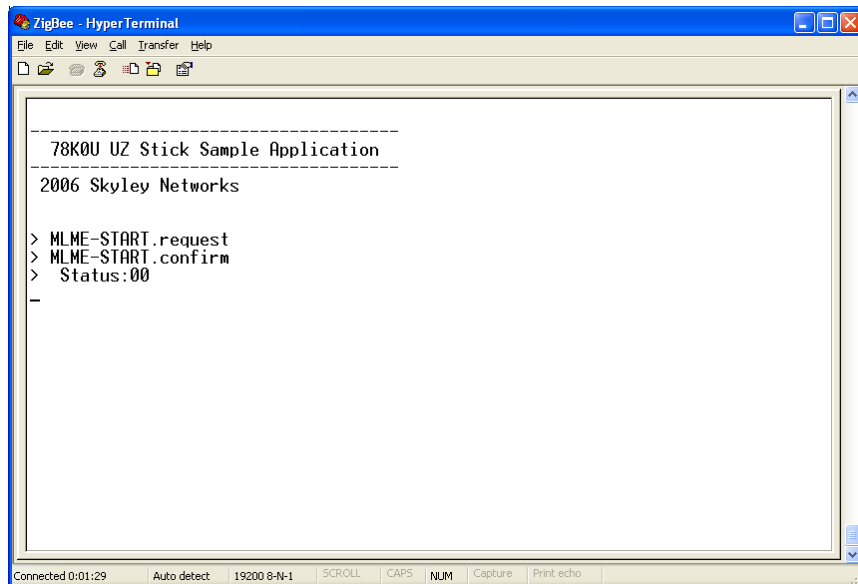
(Property -> Setting -> ASCII)

Local Echo OFF

No Line Feed

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.



```
-----
78K0U UZ Stick Sample Application
-----
2006 Skyley Networks

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

```

Now the coordinator has started up successfully.

5.2.3 Starting up end devices

1). Please set the following switch configuration on all of your boards.

JP1		2-3 short (USB side)
SW5		UART side
SW1	Bit1	OFF
	Bit2	OFF
	Bit3	OFF
	Bit4	OFF
	Bit5	OFF
	Bit6	OFF
	Bit7	OFF
	Bit8	OFF

2). Now, you connect batteries to all of your boards for end devices..

3). Then, if you set Jumper 1 to battery, the board starts up as another coordinator. You need to keep pushing the Joy stick, Switch 2, to start up as an end device. You can assign 5 different MAC addresses by a position of the Joy Stick during power-up sequence, or RESET start-up.

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

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

```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
-----
78K0U UZ Stick Sample Application
-----
2006 Skyley Networks

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

> MLME-ASSOCIATE.indication
> from 123456789ABC0002 associated to 4352

Connected 0:02:30 Auto detect 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

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
-----
78K0U UZ Stick Sample Application
-----
2006 Skyley Networks

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

> MLME-ASSOCIATE.indication
> from 123456789ABC0002 associated to 4352

> MLME-ASSOCIATE.indication
> from 123456789ABC0003 associated to 4353

Connected 0:03:17 Auto detect 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

5.2.4 Operation

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

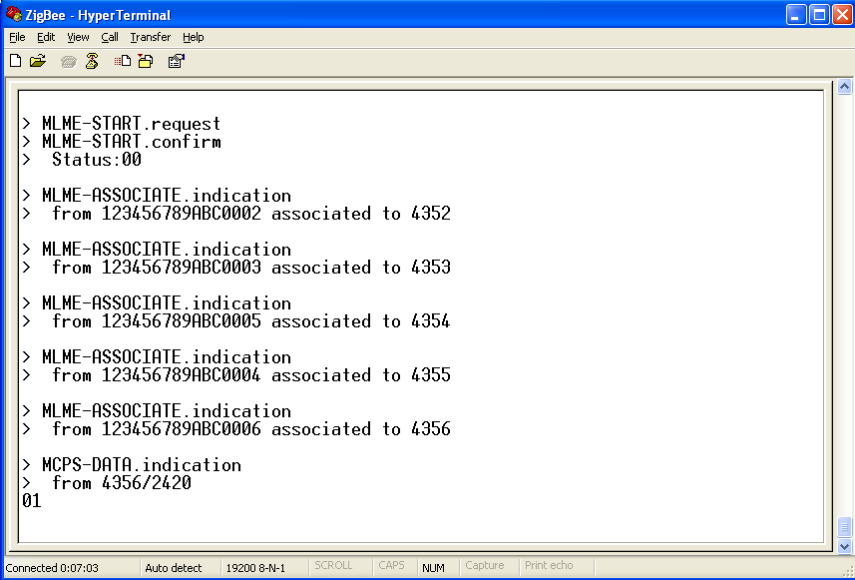
An end device makes a network association. If successful, LED4 on the board is ON.

If you push SW3 on an end device, LED2 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

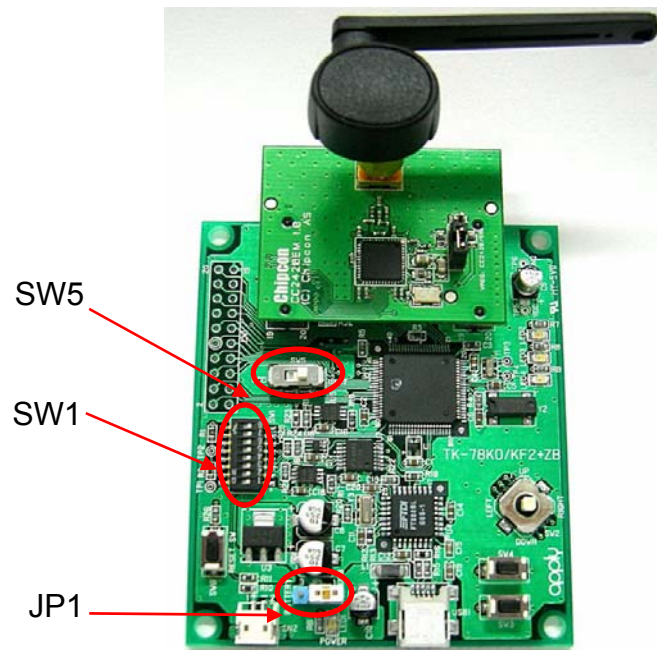
The following example shows, the SW3 on the fifth end device, “4356”, was pushed. You will see the LED2 on the coordinator will blink 5 times.
The default PAN ID of this network is “2420”.



```
ZigBee - HyperTerminal
File Edit View Call Transfer Help
> MLME-START.request
> MLME-START.confirm
> Status:00
> MLME-ASSOCIATE.indication
> from 123456789ABC0002 associated to 4352
> MLME-ASSOCIATE.indication
> from 123456789ABC0003 associated to 4353
> MLME-ASSOCIATE.indication
> from 123456789ABC0005 associated to 4354
> MLME-ASSOCIATE.indication
> from 123456789ABC0004 associated to 4355
> MLME-ASSOCIATE.indication
> from 123456789ABC0006 associated to 4356
> MCPS-DATA.indication
> from 4356/2420
01
Connected 0:07:03 Auto detect 19200 8-N-1 SCROLL CAPS NUM Capture Print echo
```

6 Mode setting of the board

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



Usage case		Normal (Written program works)	Debug (USB Connection)	Writing flash
SW5		UART side	OCD side	UART side
JP1		Select by power supply source	1-2short (USB side)	1-2short(USB side)
SW1	Bit1	OFF	ON	ON
	Bit2	OFF	ON	ON
	Bit3	OFF	ON	OFF
	Bit4	OFF	ON	OFF
	Bit5	OFF	ON	OFF

7 Revision History

Revision	Contents	Date
Rev. 1.0	Initial Version	November 29, 2006
Rev. 1.1	Corrections	January 20, 2007
Rev. 2.0	Corrections	February 7, 2007
Rev. 3.0	Modification on IEEE 802.15.4 MAC Library	November 15, 2007
Rev. 3.1	Manufacturer name change	June, 10 2008
Rev. 4.0	Correction With the sample program change.	March 7, 2009