FUJITSU

AN07-00200-03E

F^2MC-8FX Family

8-BIT MICROCONTROLLER

MB95F136JBS

bits pot yellow LIN board

User's Manual

Revision History

Date	Revision
October.24.2008	Revision 1.0: Initial release
May 13, 2009	Revision 1.1:TSUZUKI DENSAN's Logo mark was changed.
April 23,2010	Revision 1.2: Change in company name of FUJITSU MICROELECTORONICS [New] FUJITSU SEMICONDUCTOR LIMITED
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Note

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Introduction

Thank you very much for purchasing the bits pot yellow (referred to as this starter kit or the starter kit hereafter).

This starter kit is a beginner's kit intended for those who wish to start learning microcontrollers and on-board network processors. The kit is designed so that the beginners who ask "What is a microcontroller?", "How does it work?" and "How does it control a network?" can easily learn what it is.

The kit includes flash microcontroller development tools, so if you have slight understanding about the C language, you can rewrite a program to let the microcontroller perform in various ways. Even if you do not know of programming, you may be able to enjoy learning a microcontroller with a study-aid book about the C language.

This starter kit can also serve as an introductory training tool for electronic circuit practice or future embedded software development in a class of a college or high school of technology or training for freshman engineers of a manufacturer.

Contact

Please ask the following e-mail address for the technical question.

Please confirm HP for the latest information and FAQ of bits pot.

Zip code: 105-8420 2-5-3 Nishi-Shinbashi, Minatoku, Tokyo

E-mail: pd-bitspot@tsuzuki-densan.co.jp

bits pot URL: http://www.tsuzuki-densan.co.jp/bitspot/

Suppliers of the parts/materials

muRata

Capacitors	22pF	: GCM1552C1H220JZ02
	220pF	: GCM1552C1H221JA01
	0.1µF	: GCM188R11E104KA42
	10µF	: GCM32ER71E106KA42
Ceramic Resonator	4MHz	: CSTCR4M00G55B
	6MHz	: CSTCR6M00G55B
Buzzer		: PKLCS1212E40A1

TDK

NTC Thermistor	: NTCG164BH103JT1
Ferrite Beads	: MPZ2012S300AT

1 Setting up the starter kit

Before using this starter kit, be sure to check the components listed in Table 1-1 are fully supplied.

Before connecting this starter kit, you need to install software in your PC. You can download the software required for the starter kit from our web site.

bits pot URL: http://www.tsuzuki-densan.co.jp/bitspot/

Table 1-1 Component list

No.	Article	Qty.	Specifications	Remarks
1	bits pot yellow LIN board	1	Board mounted with microcontrollers made by Fujitsu Semiconductor; F^2MC-8FX series MB95F136JBS and F^2MC-8LX series MB89P585B	See Figure 1-1
2	USB cable	1	USB (A to miniB)	Accessory
3	LIN cable	1	2-pin cable	Accessory
4	PC	1	On which Windows XP normally runs and USB2.0 ports are supported	Prepare the PC by yourself.

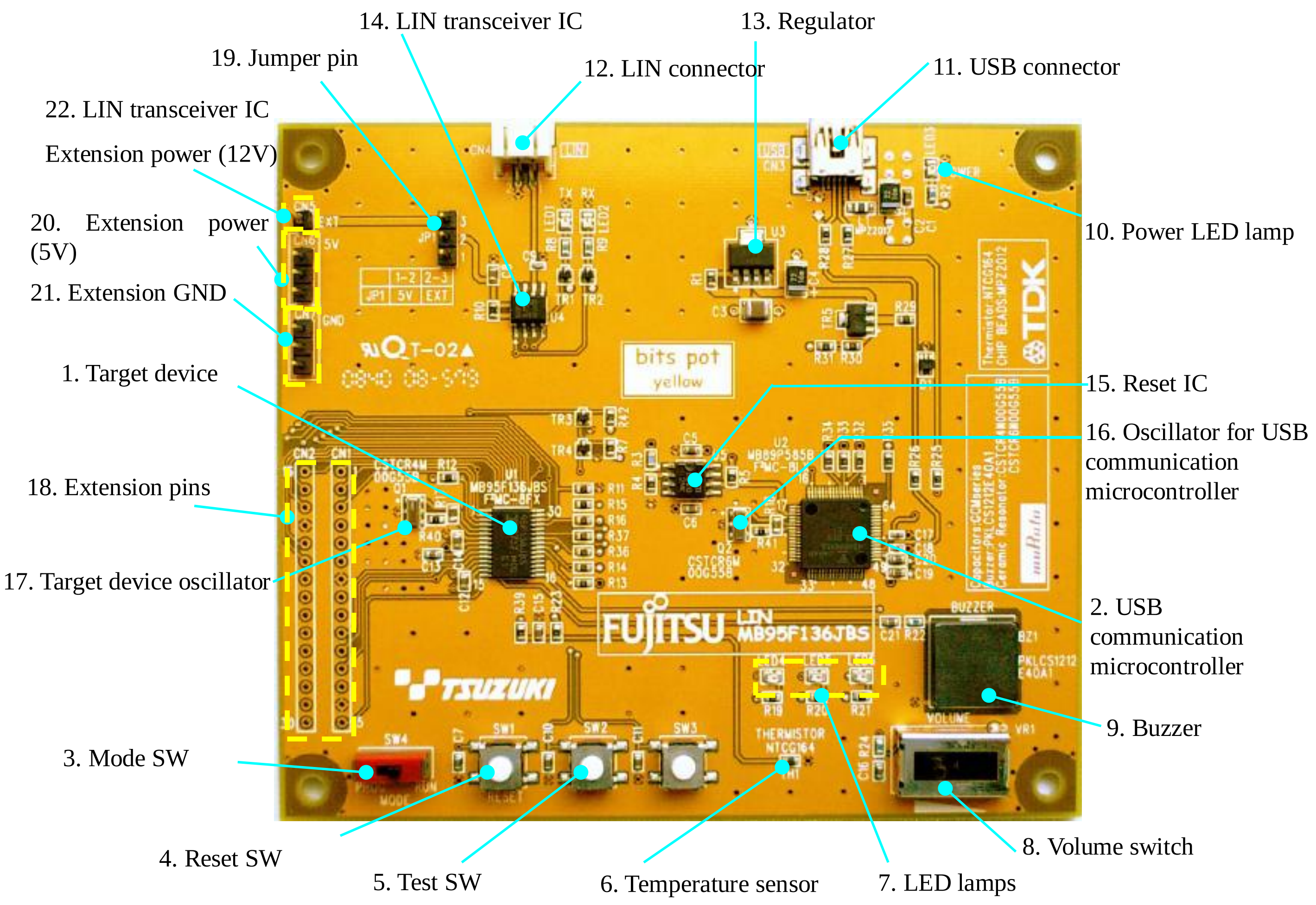


Figure 1-1 External view of a starter kit

“Table 1-2 Description of the respective parts of a starter kit” provides descriptions of the respective onboard parts.

Table 1-2 Description of the respective parts of a starter kit

No.	Name	Specifications	Function
1	Target device	MB95F136JBS	Main microcontroller (MB95F136JBS).
2	USB communication microcontroller	MB89P585B	Microcontroller for USB communications to connect the main microcontroller (MB95F136JBS) and the host PC.
3	Mode SW	Slide switch	Switch for selection of operation mode of the main microcontroller (MB95F136JBS).
4	Reset SW	Push switch	Switch to reset the starter kit.
5	Test SW	Push switch x 2	Push switches for testing, connected to the general-purpose I/O port.
6	Temperature sensor	NTCG164BH103	NTC thermistor made by TDK. Temperature sensor connected to the A/D converter.
7	LED lamps	LED (red) x 3	LED lamps connected to the general-purpose I/O port.
8	Volume SW	Volume switch	Volume switch connected to the A/D converter input.
9	Buzzer	PKLCS1212E40A1	External-drive electric sounder made by Murata Manufacturing. Connected to the PPG timer output port.
10	Power supply LED lamp	LED (green) x 1	LED lamp for the starter kit power supply.
11	USB connector	mini-B	USB connector for connection with the PC to write or to debug a program.
12	LIN connector	2-pin connector	Connector for LIN communication. Connect this connector to the LIN connector on the bits pot white.
13	Regulator	LP3874EMP-3.3	Regulator IC (3.3V).
14	LIN transceiver IC	TJA1020T	Transceiver IC used for LIN communication.
15	Reset IC	M51957BFP	Reset IC.
16	Oscillator for USB communications microcontroller	CSTCR6M00G55B (6MHz)	Ceralock made by Murata Manufacturing. Oscillator for the USB communication microcontroller.
17	Target device oscillator	CSTCR4M00G55B	Ceralock made by Murata Manufacturing.

		(4MHz)	Oscillator for the main microcontroller.
18	Extension pins	-	Extension pins of the main microcontroller. For details, see the circuit diagram.
19	Jumper pin (JP1)	-	Jumper pin for switching the power supply to the LIN transceiver IC. 1-2 Power supply from USB bus power (5V). 2-3 Power supply from external power source (CN5) (12V) The default is 1-2.
20	Extension power (5V)	-	Extension 5V power terminal.
21	Extension GND	-	Extension GND terminal.
22	Extension power supply (12V) for LIN transceiver IC	-	Extension power supply pin for the LIN transceiver IC. This is used to supply external power (12V). When in use, it is necessary to set the jumper pin (JP1) to 2-3.

The system configuration during LIN communication operations, which are enabled by connecting the separate bits pot white to “Figure 1-3 System connection diagram (when performing LIN communication)”, which shows the system configuration during single starter kit operations, is shown in “Figure 1-2 System connection diagram (single-unit operation)”.

Note: Prepare the PC by yourself.

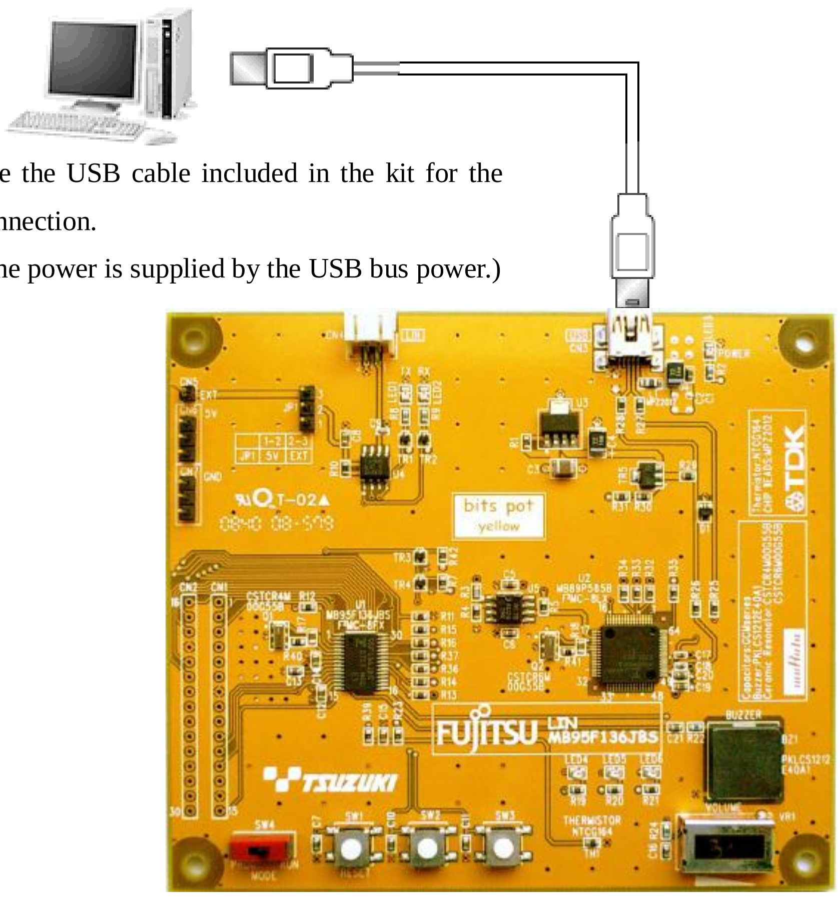

Use the USB cable included in the kit for the connection.
(The power is supplied by the USB bus power.)

Figure 1-2 System connection diagram (single-unit operation)

Connect the PC and starter kit by using the USB cable included in the kit.
The starter kit power is supplied by the USB (USB bus power)

[Note]
Connect the USB to the PC directly. Do not connect the USB via a USB hub or an extension unit such as a docking station.

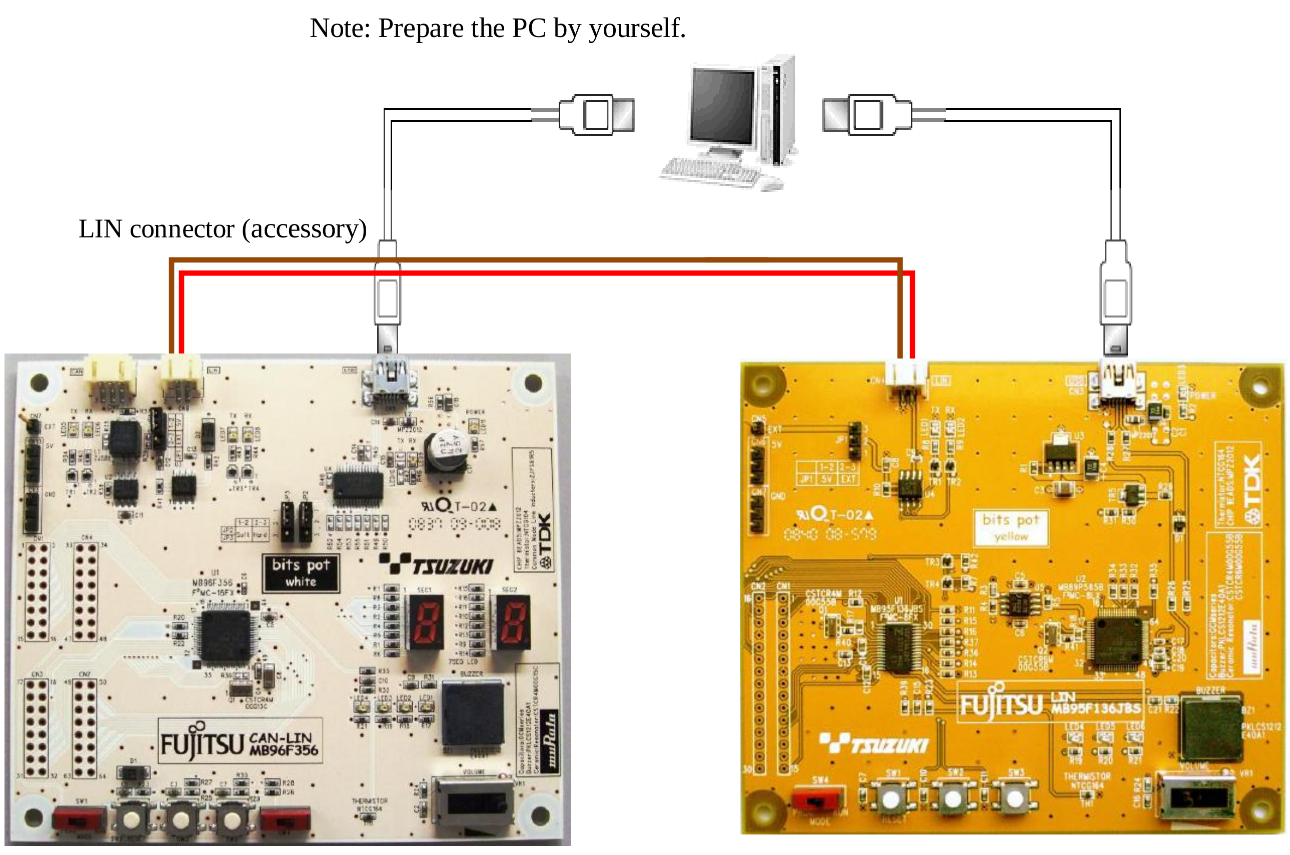


Figure 1-3 System connection diagram (when performing LIN communication)

Connect the PC, the starter kit, and bits pot white using the enclosed USB cables.
The power for the bits pot white is also supplied by the USB in the same way as for the starter kit. (USB bus power)

[Note]
Connect the USB to the PC directly. Do not connect the USB via a USB hub or an extension unit such as a docking station.

“Table 1-3 MB95F136JBS pin assignment” shows the pin assignment for the microcontroller MB95F136JBS.

Table 1-3 MB95F136JBS pin assignment

Pin No.	Function	Connected to	Remarks
1	P16	LED6	L output = On
2	PF0	-	
3	PF1	-	
4	MOD	SW1	-
5	X0	Q1	4MHz oscillator
6	X1	Q1	4MHz oscillator
7	VSS	GND_EARTH	
8	VCC	5V	
9	C	C	
10	PG1	-	
11	PG2	-	
12	RST	RESET	
13	AVCC	5V	
14	AVSS	GND_EARTH	
15	P00/INT00/AN00/PPG00	BUZZER	
16	P01/INT01/AN01/PPG01	VR	Power supply voltage division 0 to 100%
17	P02/INT02/AN02/SCK	LIN TRANSCEIVER	
18	P03/INT03/AN03/SOT	LIN TRANSCEIVER	
19	NC	-	
20	P04/INT04/AN04/SIN	LIN TRANSCEIVER	
21	P05/INT05/AN05/TO00	SW2	SW pressed = L
22	P06/INT06/AN06/TO01	SW3	SW pressed = L
23	P07/INT07/AN07	THERMISTOR	
24	P10/UI0	USB-UART conversion (MB89P585B)	Use when writing to flash or during monitor debugging
25	P11/UO0	USB-UART conversion (MB89P585B)	Use when writing to flash or during monitor debugging
26	NC	-	

27	P12/UCK0/EC0	USB-UART conversion (MB89P585B)	Use when writing to flash or during monitor debugging
28	P13/TRG0/ADTG	PULL-DOWN	
29	P14/PPG0	LED4	L output = On
30	P15	LED5	L output = On

1.1 Setting up the PC

Install the software required to operate this starter kit into the PC.

To set up the PC, use the following procedures.

① Downloading the software
② Installing the integrated development environment SOFTUNE (bits pot dedicated version)
③ Installing the PC Writer FUJITSU FLASH USB Programmer (bits pot yellow dedicated version)
④ Connecting it to the PC and installing the USB driver
⑤ Configuring the starter kit settings

1.1.1 Downloading the software

Download and decompress the file from the following website.

bits pot URL: http://www.tsuzuki-densan.co.jp/bitspot/

1.1.2 Installing the integrated development environment SOFTUNE (bits pot yellow dedicated version)

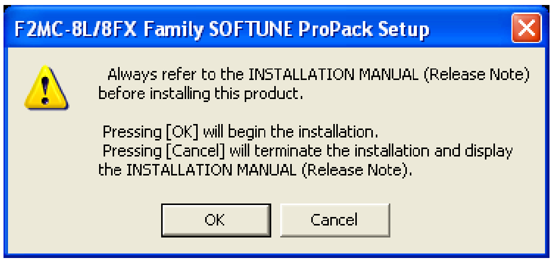
Note

If SOFTUNE V3 of the product version has been installed, first uninstall it, and then install the bits pot yellow dedicated version.

Install the integrated development environment SOFTUNE. Unzip the following file in the folder you decompressed in "1.1.1 Downloading the software".

¥softwares¥SOFTUNE¥ ProPack_Rev300016-BV_8FX.zip

Double-click "Setup.exe" in the decompressed folder. The dialog shown in "Figure 1-4 SOFTUNE setup confirmation" will be displayed. Click the "OK" button.

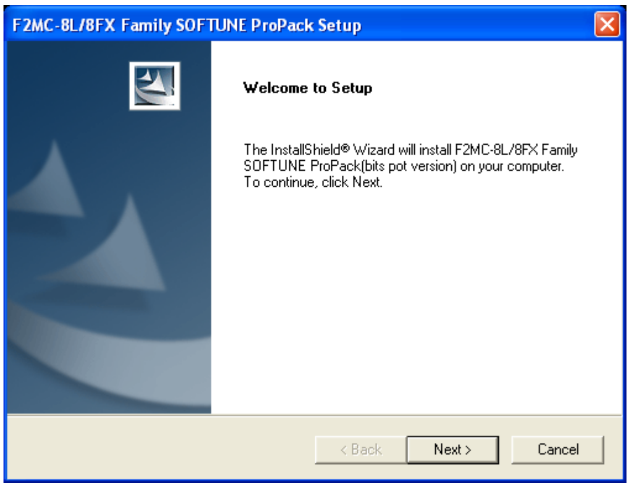

F2MC-8L/8FX Family SOFTUNE ProPack Setup

Always refer to the INSTALLATION MANUAL (Release Note) before installing this product.

Pressing [OK] will begin the installation.
Pressing [Cancel] will terminate the installation and display the INSTALLATION MANUAL (Release Note).

Figure 1-4 SOFTUNE setup confirmation

The setup wizard shown in "Figure 1-5 Starting SOFTUNE setup" will be displayed. Click "Next".

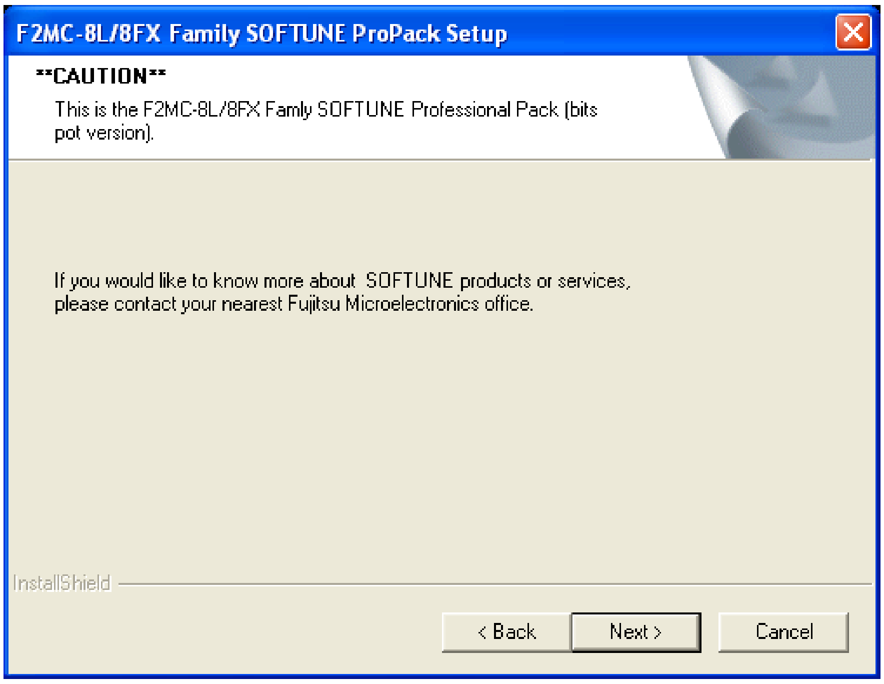

F2MC-8L/8FX Family SOFTUNE ProPack Setup

Welcome to Setup

The InstallShield® Wizard will install F2MC-8L/8FX Family SOFTUNE ProPack(bits pot version) on your computer.
To continue, click Next.

Figure 1-5 Starting SOFTUNE setup

The dialog shown in "Figure 1-6 SOFTUNE setup confirmation" will be displayed. Click the "Next" button.



F2MC-8L/8FX Family SOFTUNE ProPack Setup

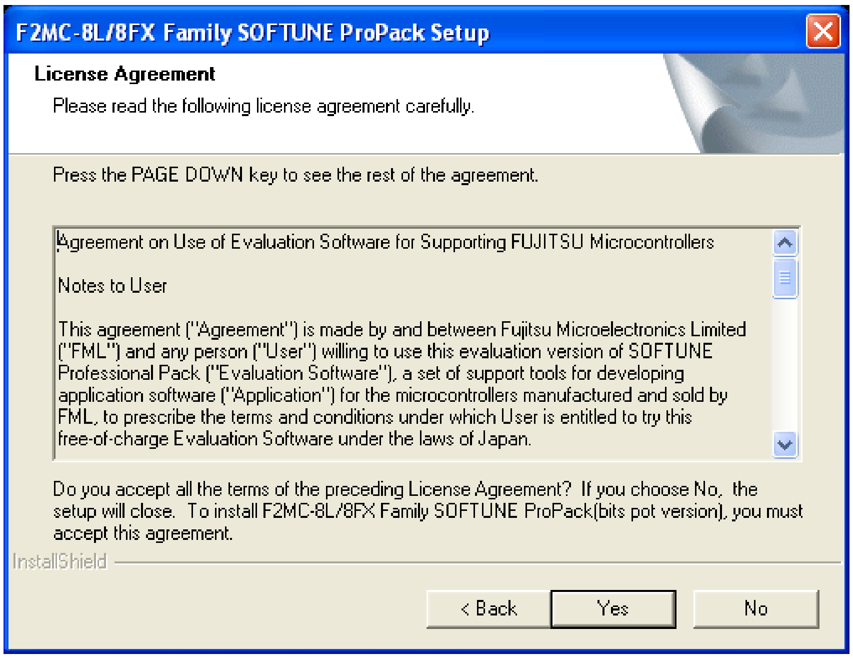
CAUTION

This is the F2MC-8L/8FX Famly SOFTUNE Professional Pack (bits pot version).

If you would like to know more about SOFTUNE products or services, please contact your nearest Fujitsu Microelectronics office.

Figure 1-6 SOFTUNE setup confirmation

The dialog shown in "Figure 1-7 SOFTUNE setup/License agreement" will be displayed. Read the license agreement thoroughly, and then click the "Yes" button.



F2MC-8L/8FX Family SOFTUNE ProPack Setup

License Agreement

Please read the following license agreement carefully.

Press the PAGE DOWN key to see the rest of the agreement.

Agreement on Use of Evaluation Software for Supporting FUJITSU Microcontrollers

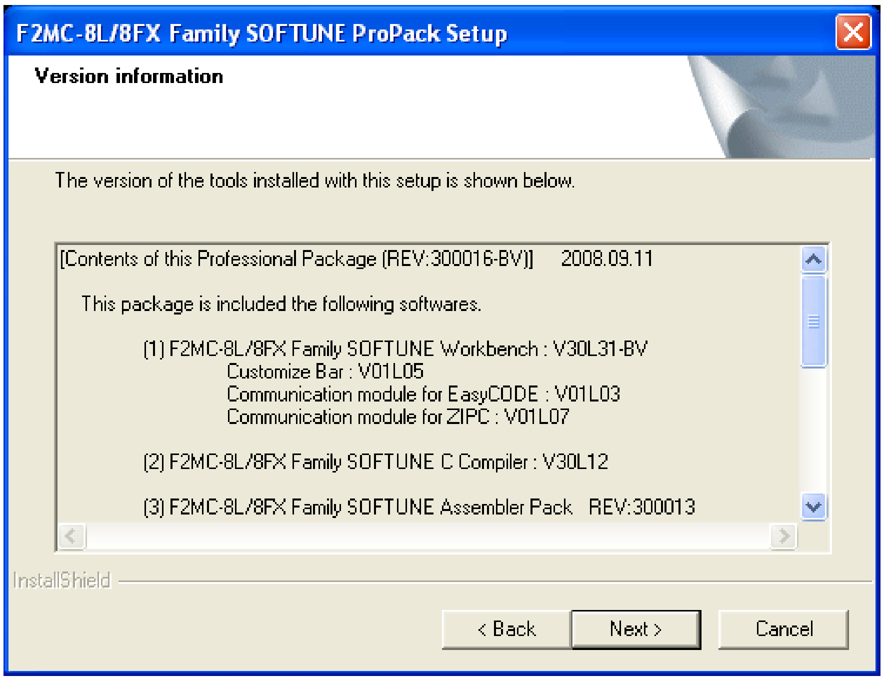
Notes to User

This agreement ("Agreement") is made by and between Fujitsu Microelectronics Limited ("FML") and any person ("User") willing to use this evaluation version of SOFTUNE Professional Pack ("Evaluation Software"), a set of support tools for developing application software ("Application") for the microcontrollers manufactured and sold by FML, to prescribe the terms and conditions under which User is entitled to try this free-of-charge Evaluation Software under the laws of Japan.

Do you accept all the terms of the preceding License Agreement? If you choose No, the setup will close. To install F2MC-8L/8FX Family SOFTUNE ProPack(bits pot version), you must accept this agreement.

Figure 1-7 SOFTUNE setup/License agreement

The dialog shown in "Figure 1-8 SOFTUNE setup/Version information" will be displayed. Click the "Next" button.


F2MC-8L/8FX Family SOFTUNE ProPack Setup

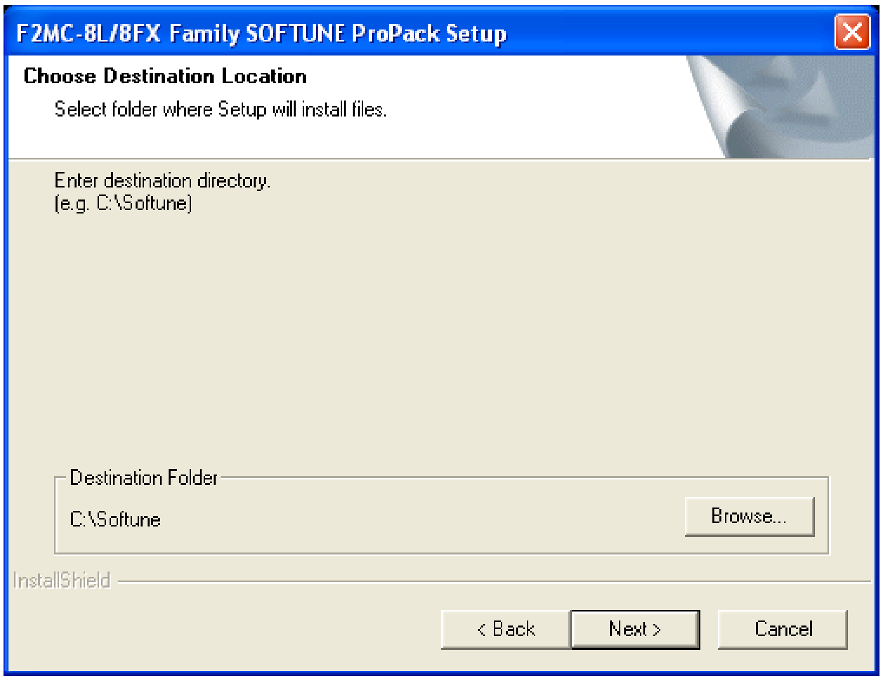
Version information

The version of the tools installed with this setup is shown below.

```
[Contents of this Professional Package (REV:300016-BV)]     2008.09.11

  This package is included the following softwares.

        (1) F2MC-8L/8FX Family SOFTUNE Workbench : V30L31-BV
                Customize Bar : V01L05
                Communication module for EasyCODE : V01L03
                Communication module for ZIPC : V01L07

        (2) F2MC-8L/8FX Family SOFTUNE C Compiler : V30L12

        (3) F2MC-8L/8FX Family SOFTUNE Assembler Pack   REV:300013
```

Figure 1-8 SOFTUNE setup/Version information

The dialog to select the installation path will be displayed as shown in "Figure 1-9 SOFTUNE setup/Selecting the destination of installation". select the default folder or desired folder and then click the "Next" button.


F2MC-8L/8FX Family SOFTUNE ProPack Setup

Choose Destination Location

Select folder where Setup will install files.

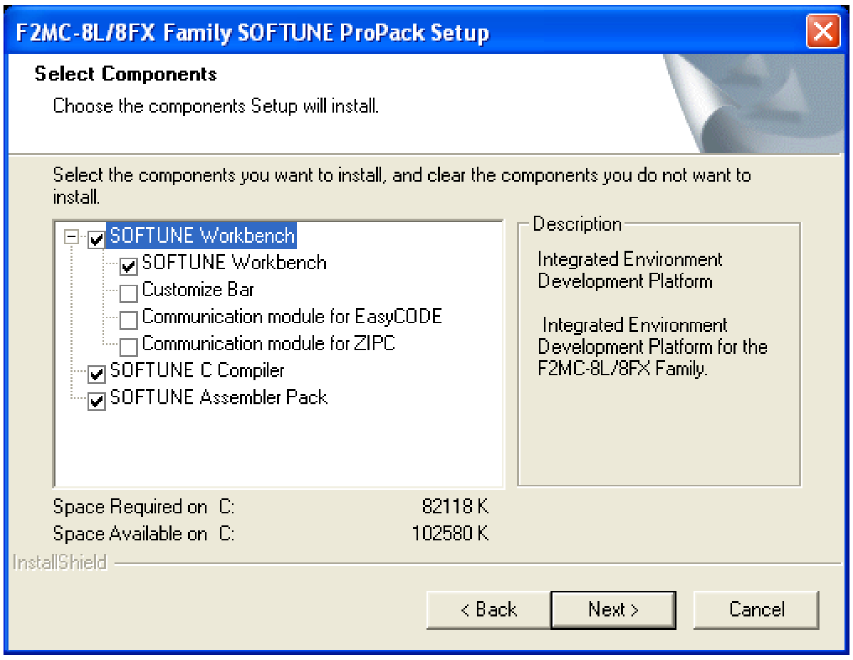
Enter destination directory.
(e.g. C:\Softune)

Destination Folder

C:\Softune

Figure 1-9 SOFTUNE setup/Selecting the destination of installation

The dialog to select the components will be displayed as shown in “Figure 1-10 SOFTUNE setup/Selecting the components”. Leaving the default settings as they are, click the “Next” button.


F2MC-8L/8FX Family SOFTUNE ProPack Setup
Select Components
Choose the components Setup will install.
Description
InstallShield
< Back
Next >
Cancel

Select the components you want to install, and clear the components you do not want to install.

- [✓] SOFTUNE Workbench
  - [✓] SOFTUNE Workbench
  - [ ] Customize Bar
  - [ ] Communication module for EasyCODE
  - [ ] Communication module for ZIPC
- [✓] SOFTUNE C Compiler
- [✓] SOFTUNE Assembler Pack

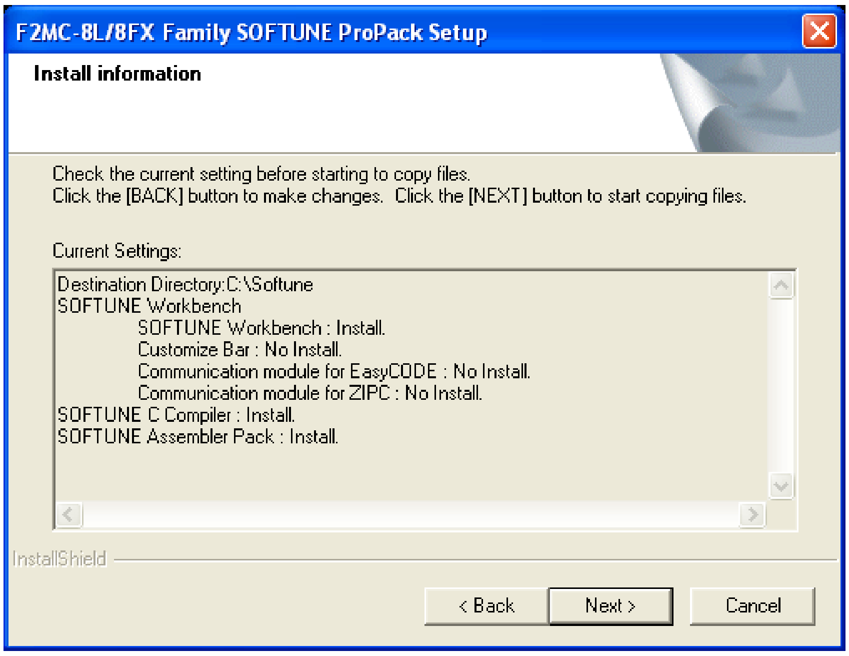
Integrated Environment Development Platform

Integrated Environment Development Platform for the F2MC-8L/8FX Family.

Space Required on C:	82118 K
Space Available on C:	102580 K

Figure 1-10 SOFTUNE setup/Selecting the components

The dialog to check the installation settings is displayed as shown in “Figure 1-11 SOFTUNE setup/Confirming the installation settings”. Click the “Next” button. The installation begins.



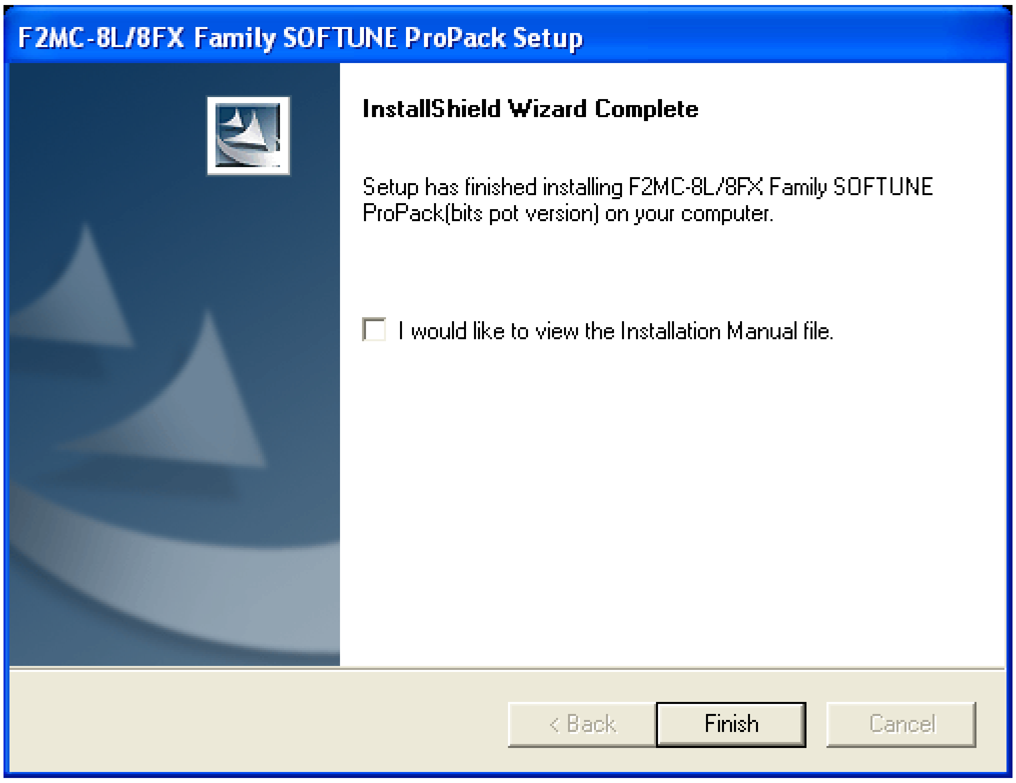
Check the current setting before starting to copy files.
Click the [BACK] button to make changes. Click the [NEXT] button to start copying files.

Current Settings:

```
Destination Directory:C:\Softune
SOFTUNE Workbench
            SOFTUNE Workbench : Install.
            Customize Bar : No Install.
            Communication module for EasyCODE : No Install.
            Communication module for ZIPC : No Install.
SOFTUNE C Compiler : Install.
SOFTUNE Assembler Pack : Install.
```

Figure 1-11 SOFTUNE setup/Confirming the installation settings

When the dialog shown in “Figure 1-12 SOFTUNE setup/Completion” appears to tell the completion of installation; Click the “Finish” button.



InstallShield Wizard Complete

Setup has finished installing F2MC-8L/8FX Family SOFTUNE ProPack(bits pot version) on your computer.

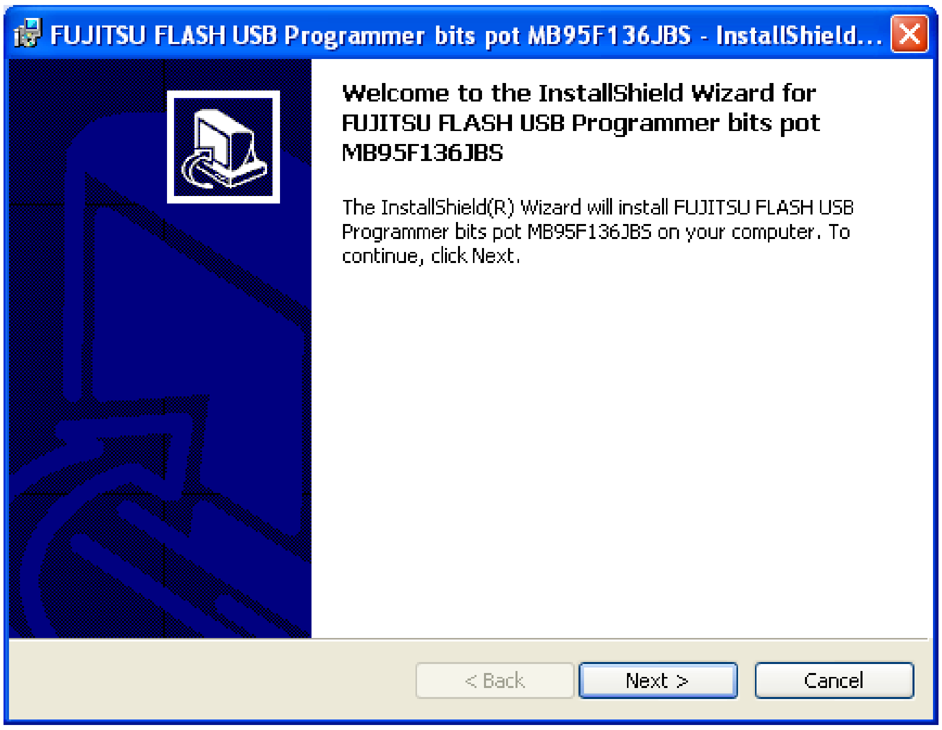
☐ I would like to view the Installation Manual file.

Figure 1-12 SOFTUNE setup/Completion

1.1.3 Installing the PC Writer FUJITSU FLASH USB Programmer (bits pot yellow dedicated version)

Start Installing the PC writer. Select the following file in the folder you decompressed in “1.1.1 Downloading the software”.
¥ softwares¥ USB PROGRAMMER¥ BGM_MB95F136JBS_setup.exe

Double-click “BGM_MB95F136JBS_setup.exe”. The dialog shown in “Figure 1-13 PC writer/Installation dialog” will be displayed, and the installation starts. Click the “Next” button.

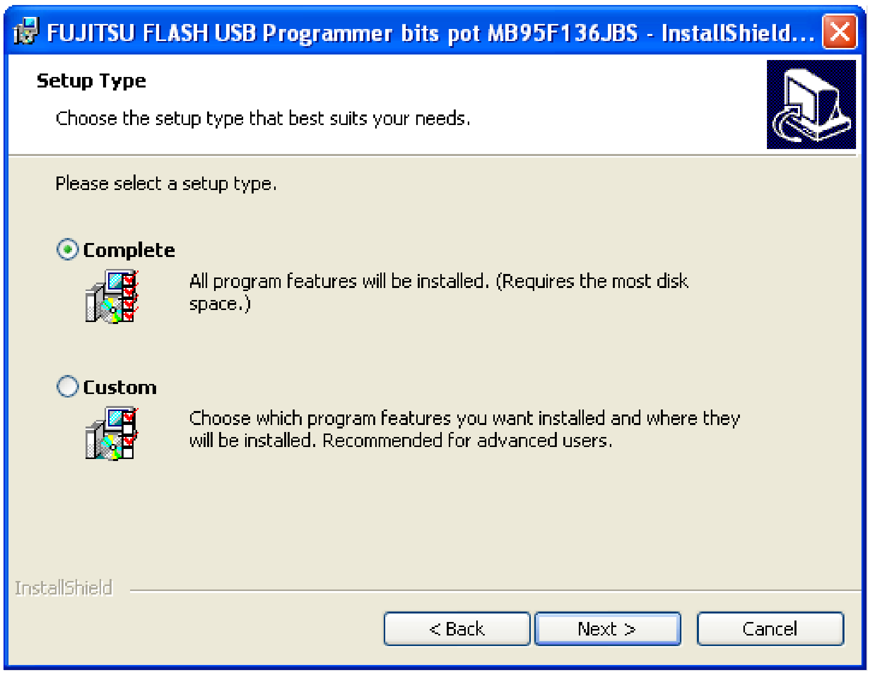

FUJITSU FLASH USB Programmer bits pot MB95F136JBS - InstallShield...

Welcome to the InstallShield Wizard for FUJITSU FLASH USB Programmer bits pot MB95F136JBS

The InstallShield(R) Wizard will install FUJITSU FLASH USB Programmer bits pot MB95F136JBS on your computer. To continue, click Next.

Figure 1-13 PC writer/Installation dialog

The dialog shown in “Figure 1-14 PC Writer/Setup type” will be displayed. Select “complete”, and then click the “Next” button.



FUJITSU FLASH USB Programmer bits pot MB95F136JBS - InstallShield...

Setup Type

Choose the setup type that best suits your needs.

Please select a setup type.

[✓ Complete]

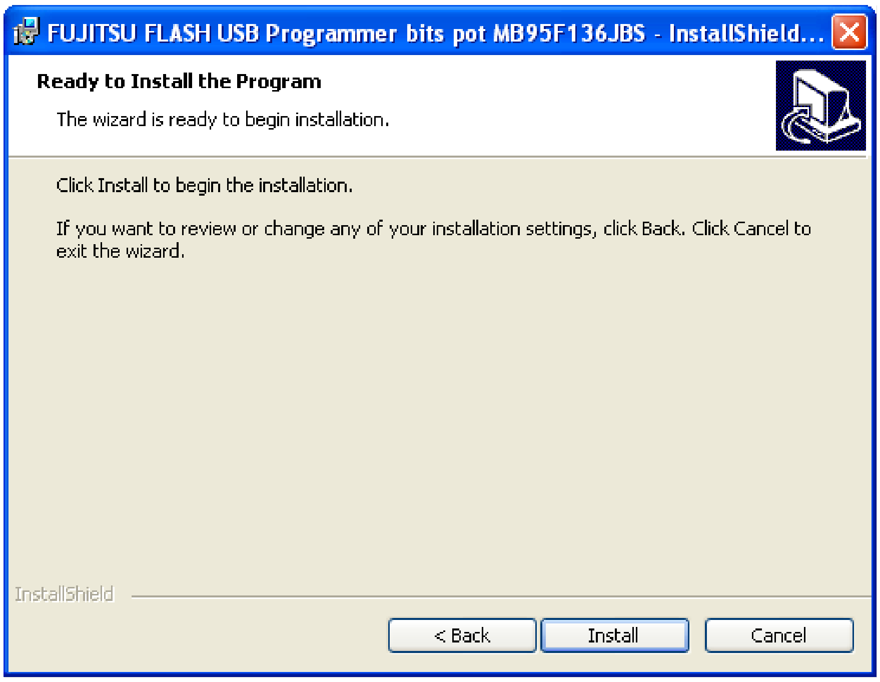
All program features will be installed. (Requires the most disk space.)

Custom

Choose which program features you want installed and where they will be installed. Recommended for advanced users.

Figure 1-14 PC Writer/Setup type

The dialog shown in “Figure 1-15 Finished PC writer/Ready to install” will be displayed. Click the “Install” button.



FUJITSU FLASH USB Programmer bits pot MB95F136JBS - InstallShield...

Ready to Install the Program

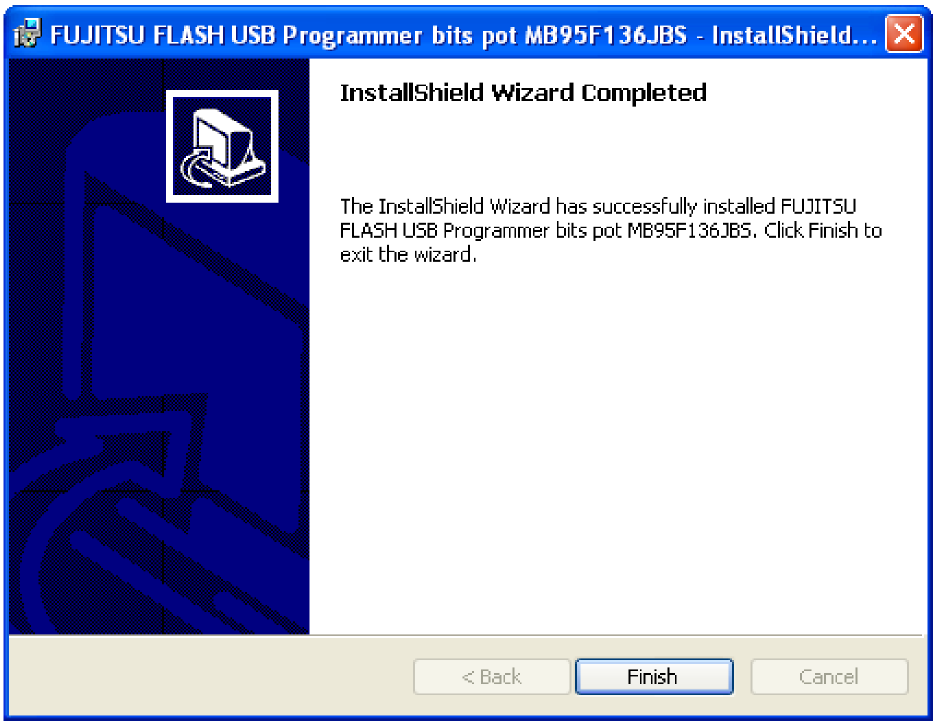
The wizard is ready to begin installation.

Click Install to begin the installation.

If you want to review or change any of your installation settings, click Back. Click Cancel to exit the wizard.

Figure 1-15 Finished PC writer/Ready to install

After the installation complete, the dialog shown in “Figure 1-16 Completing the PC Writer installation” appears to tell the completion of installation; Click “Finish”.


FUJITSU FLASH USB Programmer bits pot MB95F136JBS - InstallShield...
< Back
Finish
Cancel

InstallShield Wizard Completed

The InstallShield Wizard has successfully installed FUJITSU FLASH USB Programmer bits pot MB95F136JBS. Click Finish to exit the wizard.

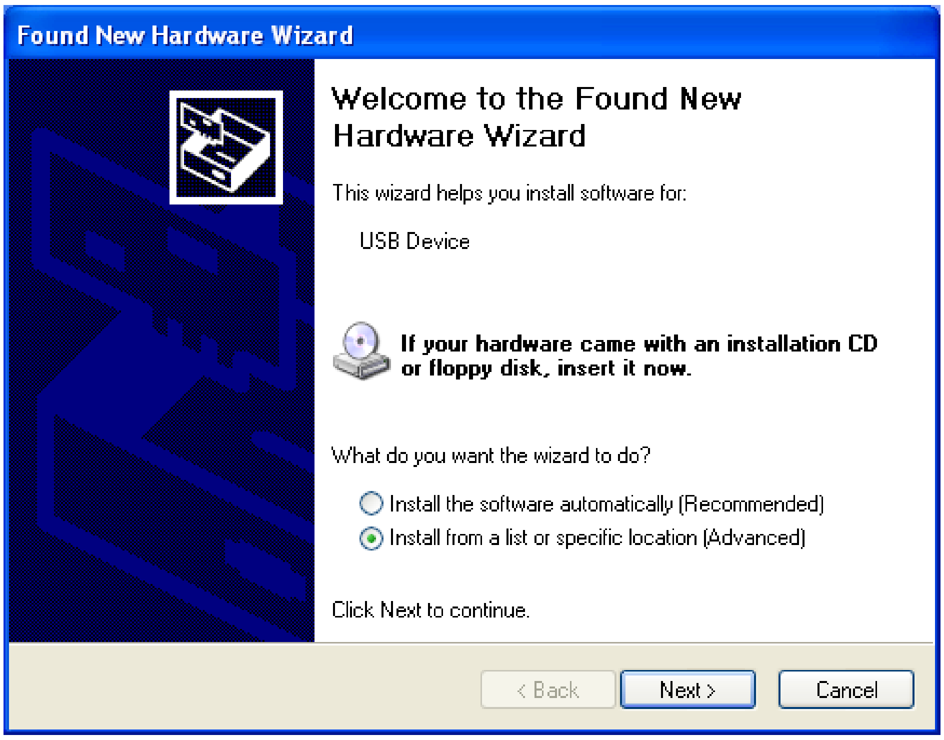
Figure 1-16 Completing the PC Writer installation

This completes the PC writer installation.

1.1.4 Connecting it to the PC and installing the USB driver

Connect the starter kit to the PC, and install the USB drivers.

First, connect the USB port on the PC and the USB port on the starter kit using the enclosed USB cable. Whereupon, the “BGM Adapter (MB2146-09)” installation dialog is displayed as shown in “Figure 1-17 Installing BGM Adapter (MB2146-09)”. Select “Install from a list or specific location”, and click the “Next” button.


Found New Hardware Wizard

Welcome to the Found New Hardware Wizard

This wizard helps you install software for:

USB Device

If your hardware came with an installation CD or floppy disk, insert it now.

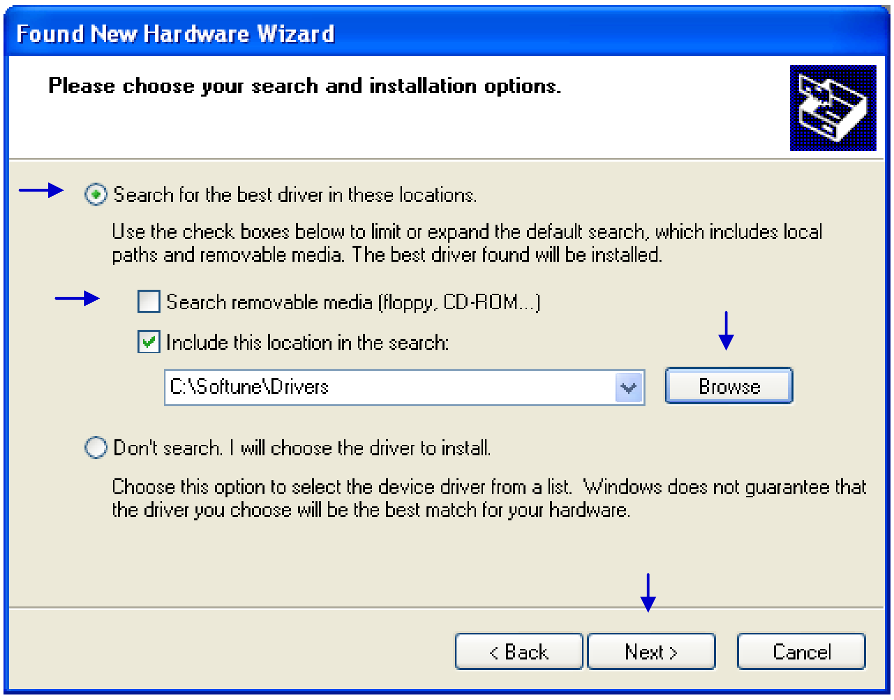
What do you want the wizard to do?

( ) Install the software automatically (Recommended)
(●) Install from a list or specific location (Advanced)

Click Next to continue.

Figure 1-17 Installing BGM Adapter (MB2146-09)

To search for the installation file as shown in “Figure 1-18 Selecting the search locations”, check the “Search for the best driver in these locations” and ”Include this location in the search”. Further, click the “Browse” button, and select the Drivers folder in the SOFTUNE, which has already been installed, and then click the “Next” button.


Found New Hardware Wizard

Please choose your search and installation options.

[✓ Search for the best driver in these locations.]

Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.

- [ ] Search removable media (floppy, CD-ROM...)
- [✓] Include this location in the search:

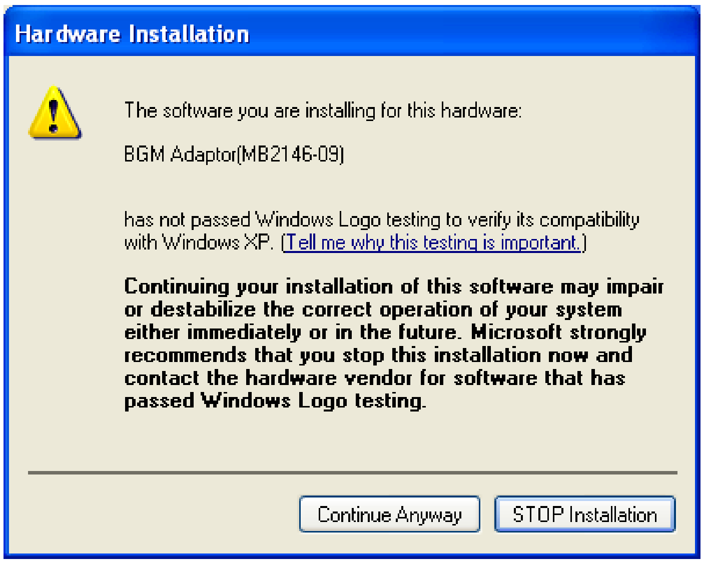
C:\Softune\Drivers

Don't search. I will choose the driver to install.

Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.

Figure 1-18 Selecting the search locations

A warning message will be displayed as shown in “Figure 1-19 Hardware installation”, ignore and click the “Continue Anyway” button.


Hardware Installation

The software you are installing for this hardware:

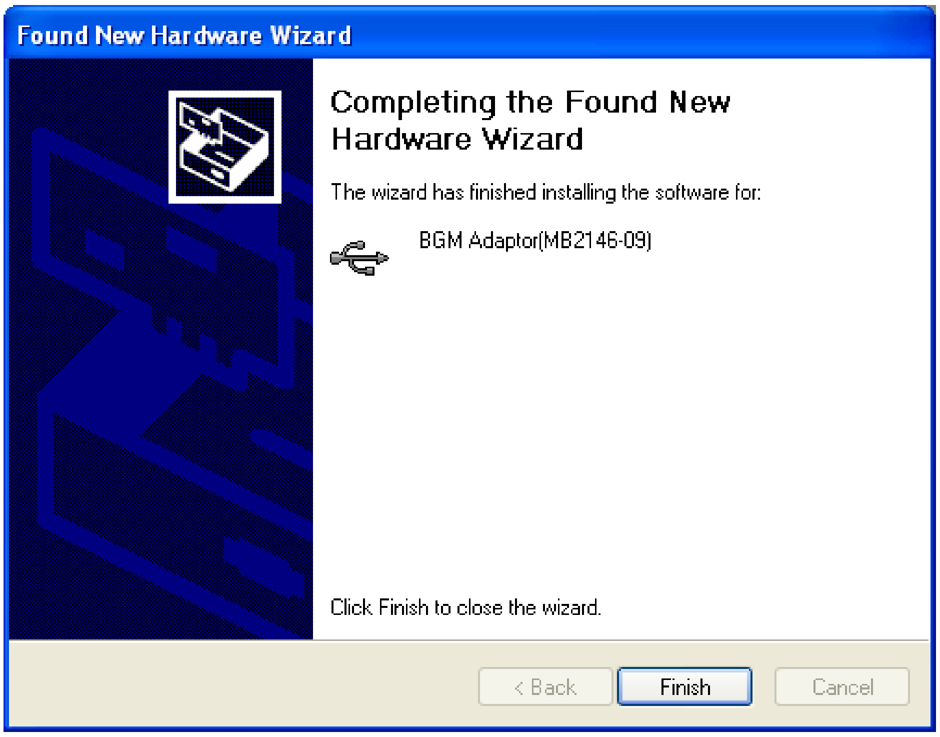
BGM Adaptor(MB2146-09)

has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)

Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the hardware vendor for software that has passed Windows Logo testing.

Figure 1-19 Hardware installation

When the driver installation is complete, the dialog shown in “Figure 1-20 Completing the BGM Adapter (MB2146-09) installation” will be displayed. Click the “Finish” button.


Found New Hardware Wizard

Completing the Found New Hardware Wizard

The wizard has finished installing the software for:

BGM Adaptor(MB2146-09)

Click Finish to close the wizard.

Figure 1-20 Completing the BGM Adapter (MB2146-09) installation

1.1.5 Configuring the starter kit

After the USB driver installation is completed, configure the Mode switches on the starter kit, and then connect it to the PC.

If the starter kit and the PC are connected by USB (i.e., power is being supplied), disconnect the USB temporarily to turn the power OFF. Next, set the starter kit "MODE" selector to "PROG", as shown in "Figure 1-21 MODE selection".

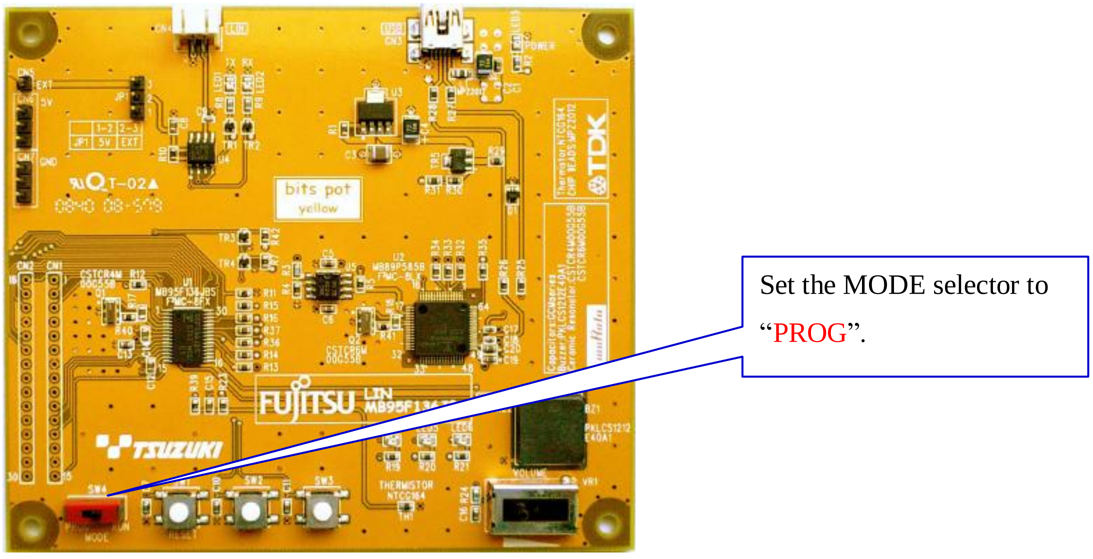


Figure 1-21 MODE selection

MODE Selector	Operation mode
PROG	Flash memory serial write mode: →Used to write a program into the microcontroller.
RUN	Single chip mode: →Used to run the program written into it.

Make sure that the MODE selector is set to "PROG".

Then, connect it to the PC.

After setting the MODE selector, connect the USB port on the PC and the USB port on the starter kit using the USB cable included in the kit. Be sure to connect the PC and starter kit directly, without using a USB hub.

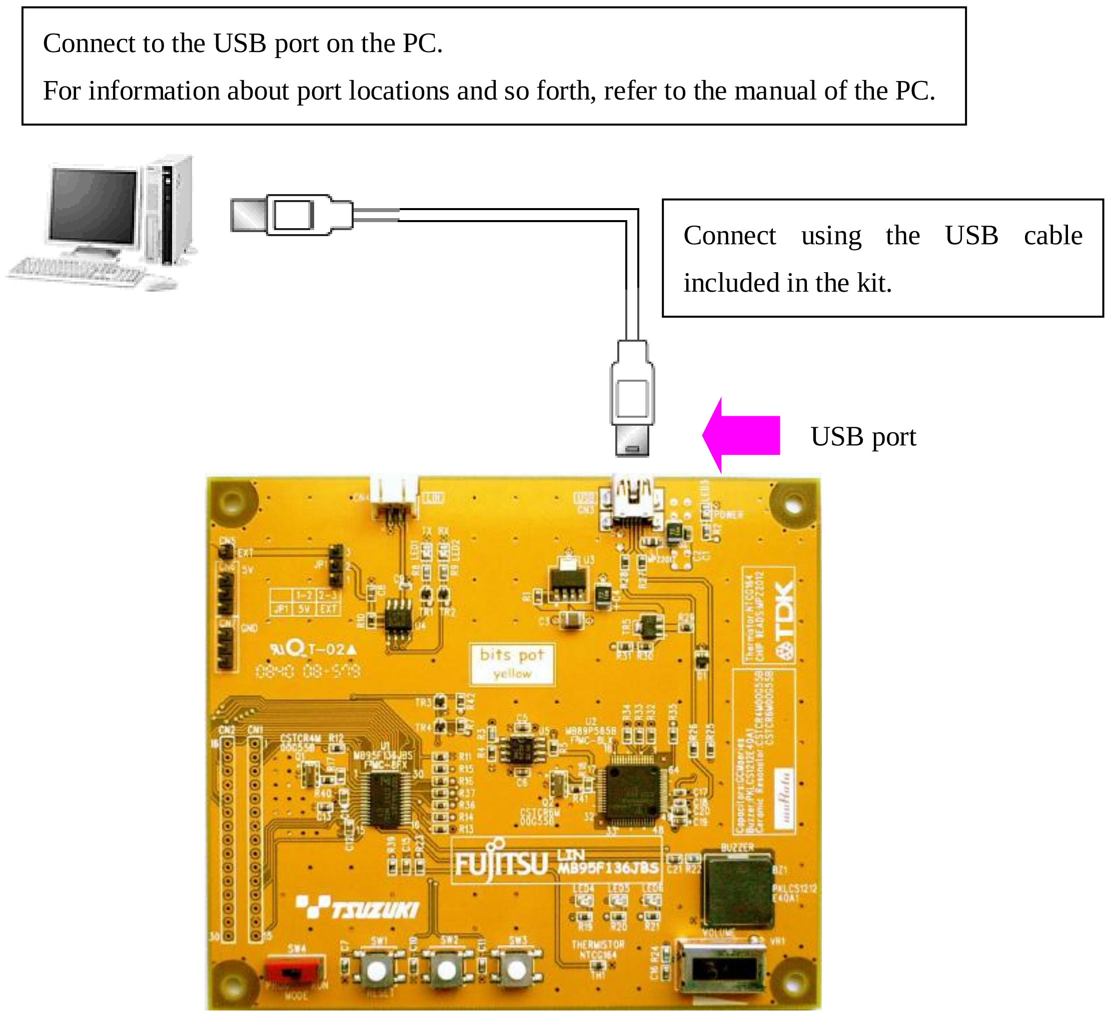

Connect to the USB port on the PC.
For information about port locations and so forth, refer to the manual of the PC.
Connect using the USB cable included in the kit.
USB port

Figure 1-22 Connection between the PC and the starter kit

The power of the starter kit is supplied via USB. (USB bus power)

[Note]

When connecting the PC and starter kit, if the driver installation dialog is displayed, it is possible that the USB driver has not been installed correctly. Return to “1.1.4 Connecting it to the PC and installing the USB driver”, and reinstall the driver.

2 Running the Program

To run a program with the starter kit, take either of the following procedures.

①	Executing in single chip mode	**See P.36**
②	Debugging by using Monitor Debugger	**See P.43**

2.1 Executing in single chip mode

In single chip mode, take the following procedures.

① Building a project

② Writing the program into the microcontroller

2.1.1 Building a project

Preparation

Decompress the following file in advance within the folder you decompressed in "1.1.1 Downloading the software".

¥ sample program¥ bitspot_yellow_SampleProgram.zip

Activate SOFTUINE (dedicated bits pot version).

In Windows, click the "Start" → "All Programs (P)", "Softune V3", → "FFMC-8L Family Softune Workbench" to activate SOFTUNE as shown in "Figure 2-1 SOFTUNE Workbench start window".

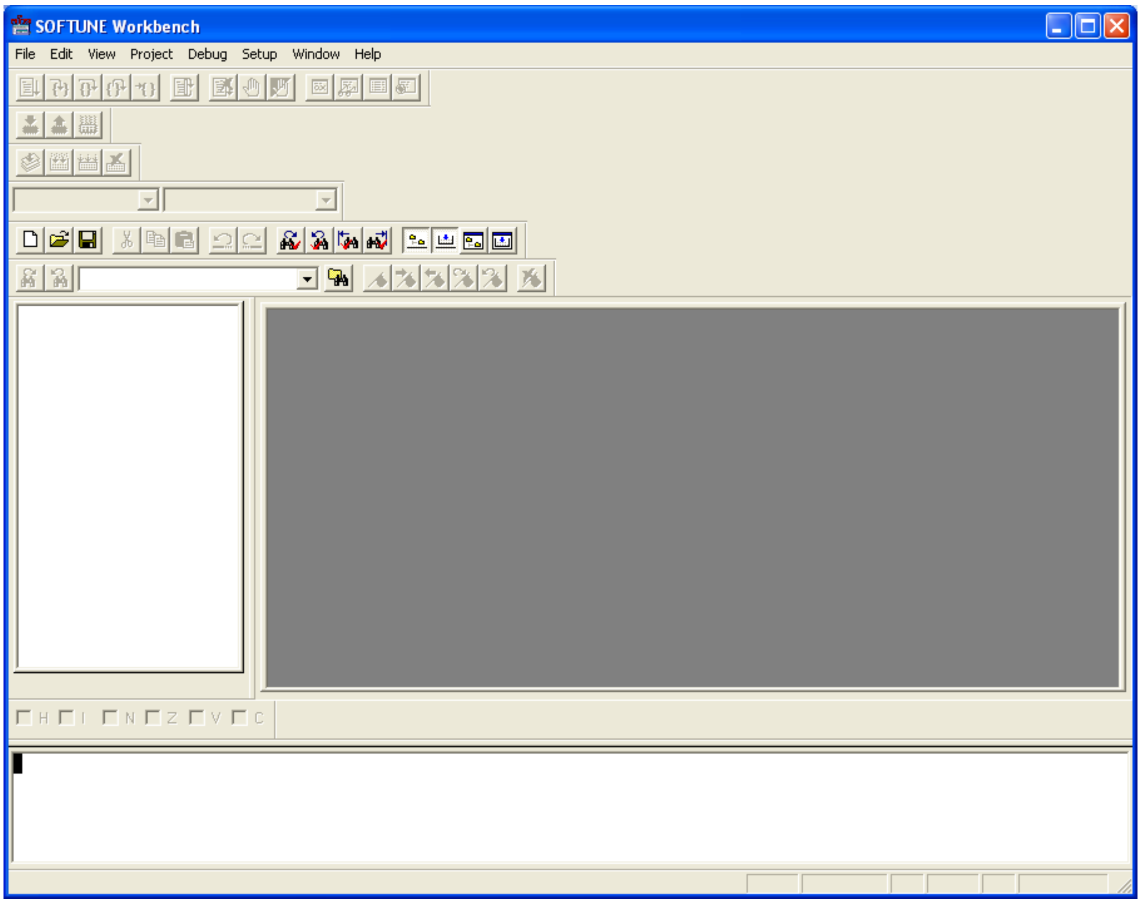


Figure 2-1 SOFTUNE Workbench start window

Click “File” → “Open Workspace” from the SOFTUNE menu as shown in “Figure 2-2 Opening a workspace”. The workspace opens.

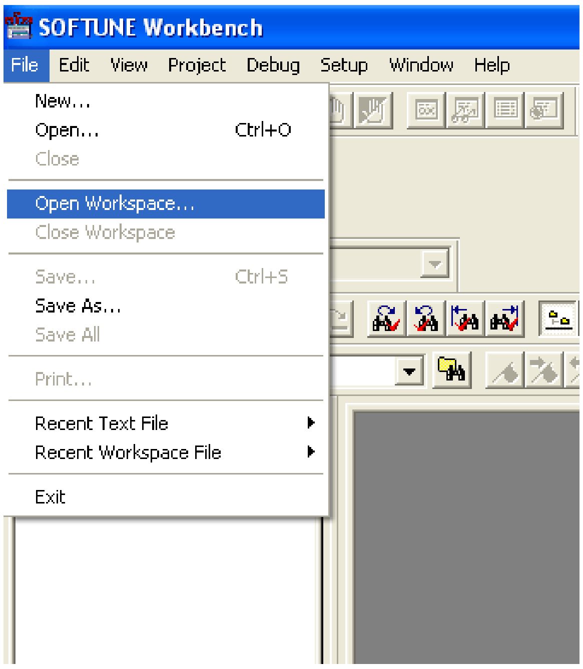
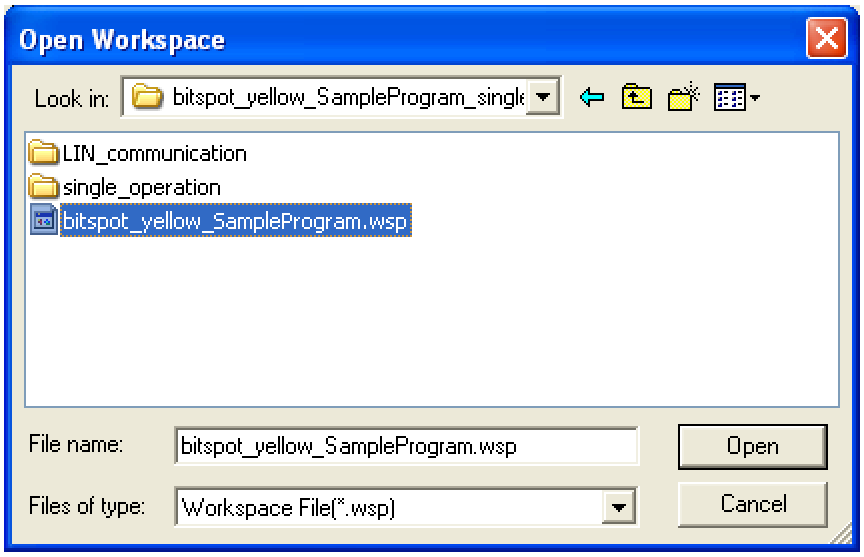


Figure 2-2 Opening a workspace

As shown in “Figure 2-3 Selecting a workspace”, the dialog that allows you to select a workspace is displayed. Select the folder containing the sample program for single chip, select the workspace “bitspot_yellow_SampleProgram.wsp”, and then click “Open”.
¥bitspot_yellow_SampleProgram¥bitspot_yellow_SampleProgram_single-chip¥bitspot_yellow_SampleProgram.wsp


Open Workspace
Look in:
bitspot_yellow_SampleProgram_single
LIN_communication
single_operation
bitspot_yellow_SampleProgram.wsp
Open
Cancel

File name: bitspot_yellow_SampleProgram.wsp

Files of type: Workspace File(*.wsp)

Figure 2-3 Selecting a workspace

As workspace opens, set it as the active project. In this sample program, there are two pre-built projects “single_operation.prj” and “LIN_communication.prj”. Set the project to be built to “Set as Active Project” as projects are built per project basis. In this section, as single-unit operation is described, check that “single_operation” is set to the active project, as shown in “Figure 2-4 Setting the active project”.

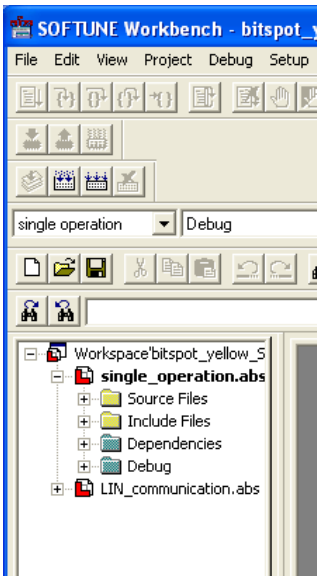


Figure 2-4 Setting the active project

To set the project for LIN communication as the active project, select the project for LIN communication and right-click on it, as shown in “Figure 2-5 Changing the active project”. The sub-menu is displayed, so select “Set Active Project”. The project name will be displayed in bold, and the build for that project will be enabled.

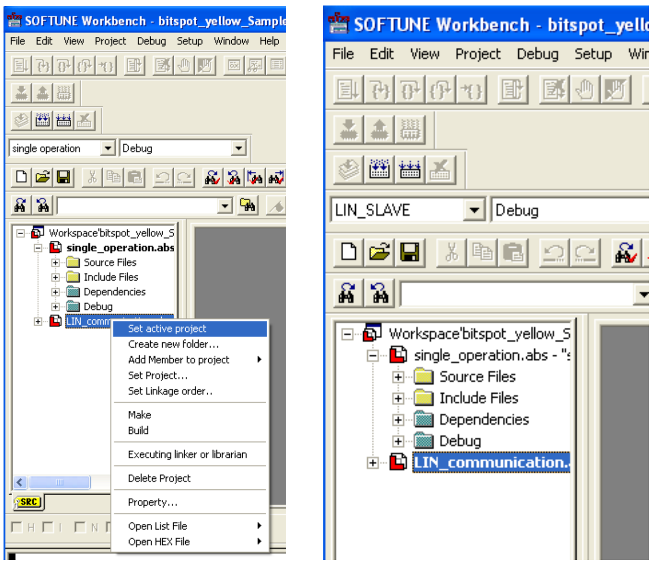


Figure 2-5 Changing the active project

Click “Project” → “Build” from the menu as shown in “Figure 2-6 Building a project”, to build the project.

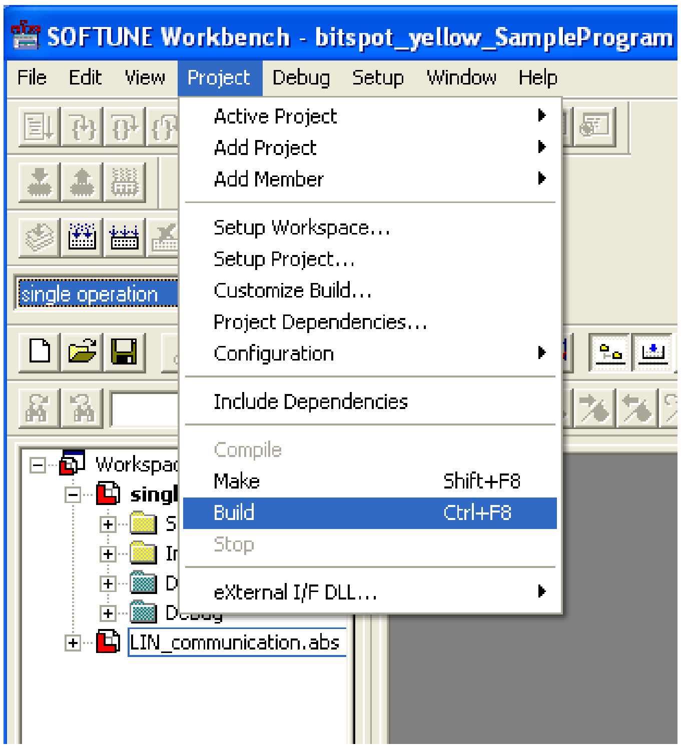
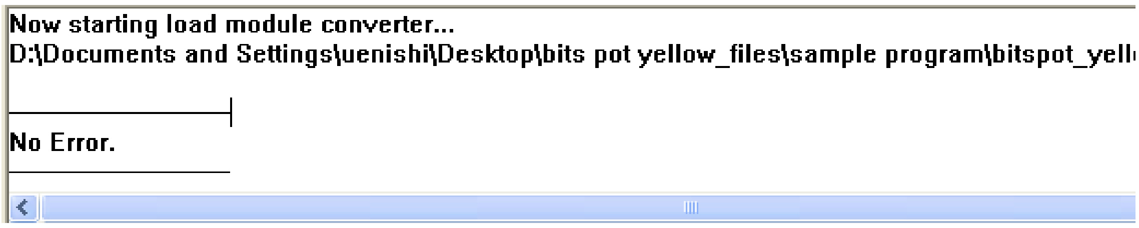


Figure 2-6 Building a project

The message pane at the bottom of the windows shows the message as shown in “Figure 2-7 Completing the build” to notify you that the build has been completed successfully.



```
Now starting load module converter...
D:\Documents and Settings\uenishi\Desktop\bits pot yellow_files\sample program\bitspot_yell

No Error.
```

Figure 2-7 Completing the build

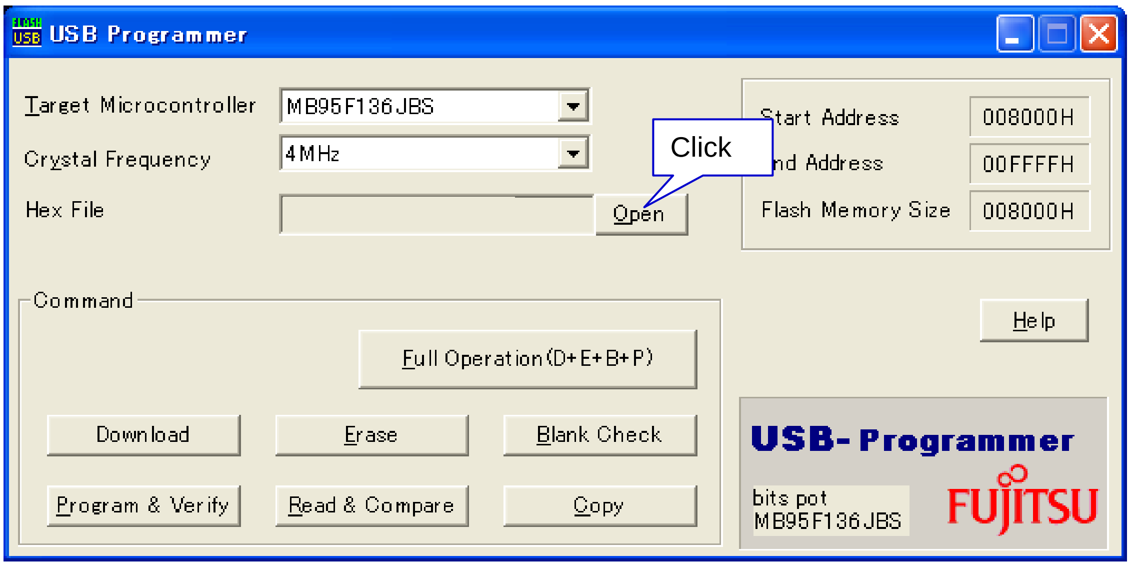
2.1.2 Writing the program into the microcontroller

Preparation

To write the program, it is necessary to set the Mode SW on the starter kit to “PROG” in advance. Turn OFF the starter kit, switch the mode setting to “PROG”, and then turn ON the power supply to the starter kit again.

From the Windows start menu, click “All Programs” → “FUJITSU USB PROGRAMMER” → “MB95F136JBS” to activate the PC writer.

To select the file to be written as shown in “Figure 2-8 Opening the file to write”, click the “Open” button.

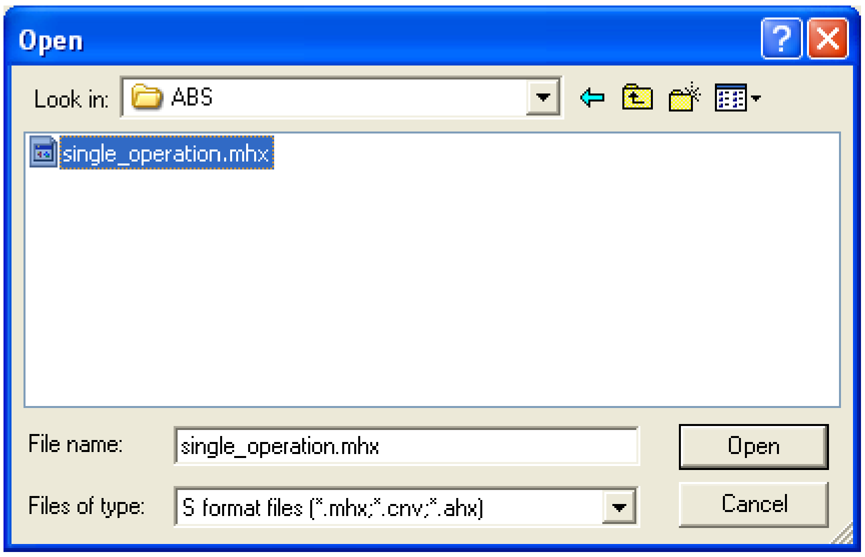

USB Programmer

Target Microcontroller: MB95F136JBS
Crystal Frequency: 4MHz
Hex File:

Start Address: 008000H
End Address: 00FFFFH
Flash Memory Size: 008000H

Figure 2-8 Opening the file to write

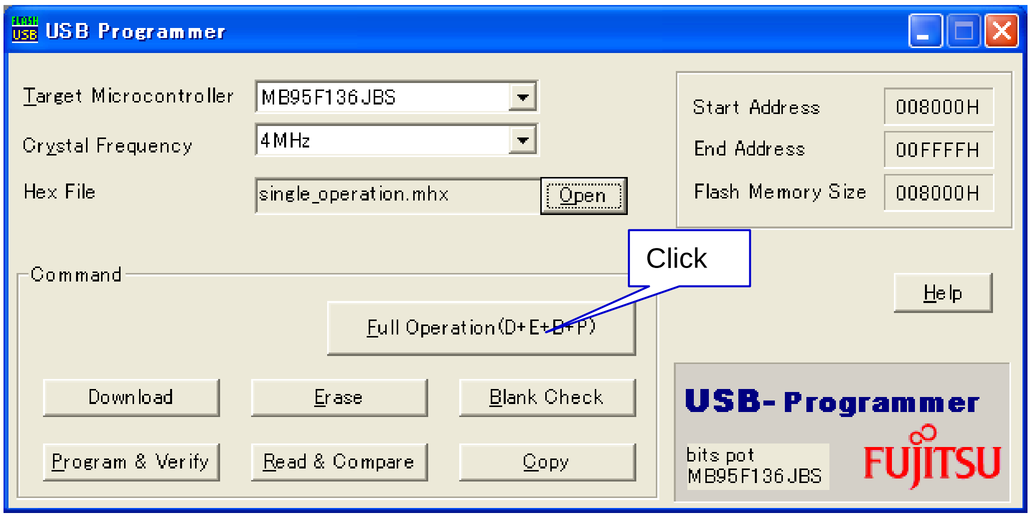
The dialog to select the file to which to write will be displayed as shown in "Figure 2-9 Selecting the file to write", select the file built in "2.1.1 Building a project", and click "Open".
¥bitspot_yellow_SampleProgram¥bitspot_yellow_SampleProgram_single-chip¥single_operation ¥Debug¥ABS¥ single_operation.mhx
If you built a LIN communication project in "Figure 2-6 Building a project", select the following file, and click "Open".
¥bitspot_yellow_SampleProgram¥bitspot_yellow_SampleProgram_single-chip¥LIN_communication¥Debug¥ABS¥LIN_communication.mhx



File name: single_operation.mhx
Files of type: S format files (*.mhx;*.cnv;*.ahx)
single_operation.mhx

Figure 2-9 Selecting the file to write

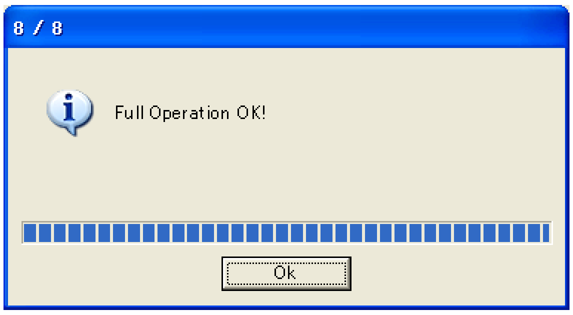
Click the "Full Operation" button as shown in "Figure 2-10 Writing the program" to start writing the program. The program writing begins.



Target Microcontroller: MB95F136JBS
Crystal Frequency: 4MHz
Hex File: single_operation.mhx
Start Address: 008000H
End Address: 00FFFFH
Flash Memory Size: 008000H
bits pot
MB95F136JBS

Figure 2-10 Writing the program

The dialog shown in "Figure 2-11 Completing the program writing" is displayed to notify you that the program writing has been completed. Click the "OK" button to quit the PC writer.



Full Operation OK!

Figure 2-11 Completing the program writing

Switch the MODE SW on the starter kit to "RUN", and then press the Reset button; the program starts running.

2.2 Debugging by using Monitor Debugger

To debug by using Monitor Debugger, take the following procedures.

① Activating SOFTUNE and configuring the debug settings
② Writing the program into the microcontroller (including monitor programs)
③ Loading the target file
④ Running the debugger

2.2.1 Activating SOFTUNE and configuring the debug settings

Preparation

Decompress the following file in the folder you decompressed in "1.1.1 Downloading the software" in advance.

¥ sample program¥ bitspot_yellow_SampleProgram.zip

From Windows start menu, click "All Programs (P)" → "Softune V3" → "FFMC-8L Family Softune Workbench" to activate SOFTUNE.

Click "File" → "Open workspace" from the SOFTUNE menu as shown in "Figure 2-12 Opening a workspace" to open a workspace.

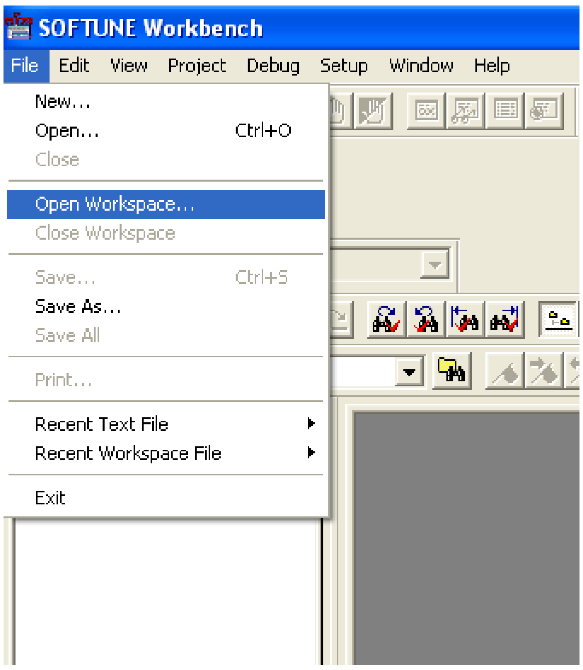


Figure 2-12 Opening a workspace

As shown in “Figure 2-13 Selecting a workspace”, the dialog that allows you to select a workspace is displayed. Select the folder containing the sample program for the monitor debugger, and then select the “bitspot_yellow_SampleProgram_monitordebugger.wsp” workspace, and click “Open”.
¥bitspot_yellow_SampleProgram¥bitspot_yellow_SampleProgram_monitor-debugger¥ bitspot_yellow_SampleProgram_monitordebugger.wsp

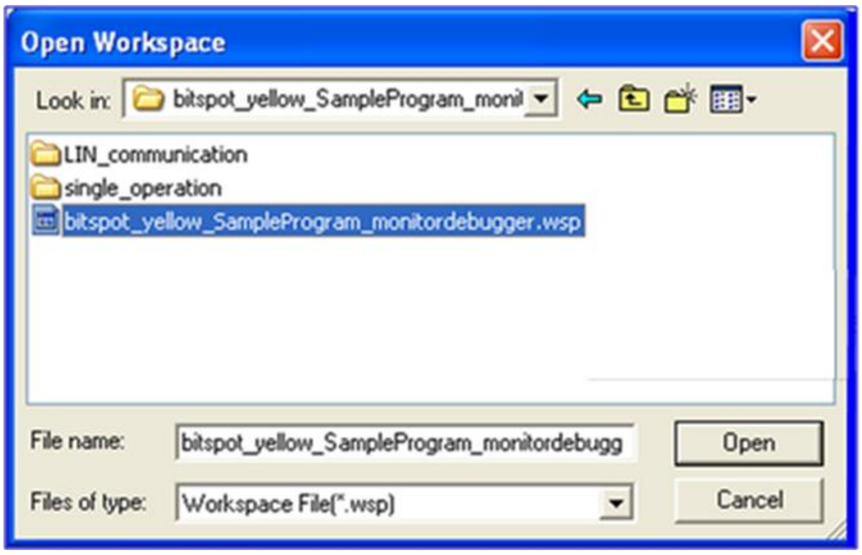

Open Workspace
Look in: bitspot_yellow_SampleProgram_monit
LIN_communication
single_operation
bitspot_yellow_SampleProgram_monitordebugger.wsp
File name: bitspot_yellow_SampleProgram_monitordebugg
Files of type: Workspace File(*.wsp)
Open
Cancel

Figure 2-13 Selecting a workspace

The workspace opens, check that the “single_operation” project is set to the active project. To change the active project to the project for the LIN communication, select the project for the LIN communication as shown in “Figure 2-5 Changing the active project”, and then right-click and select “Set as Active project” from the sub-menu.
After setting the active project, click “Project” → “Build” from the menu as shown in “Figure 2-14 Building a project”, to build it.

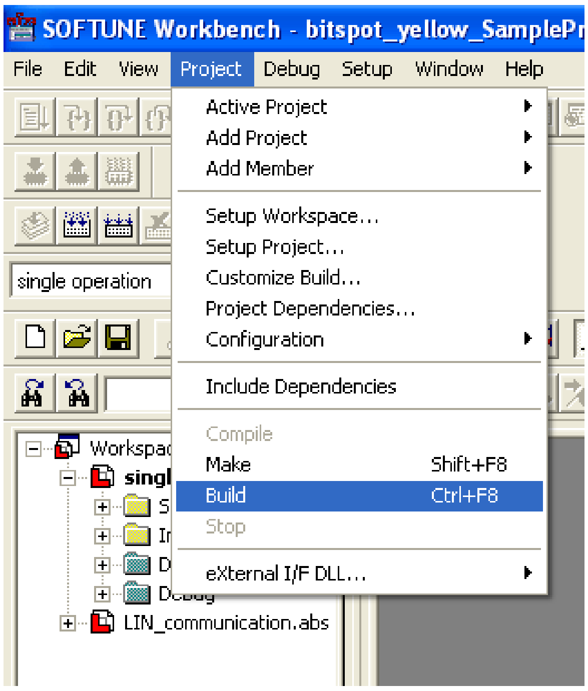
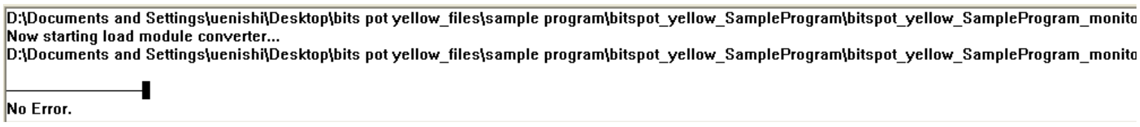


Figure 2-14 Building a project

The message pane at the bottom of the screen displays the message as shown in “Figure 2-15 Completing the build” to notify you that the build has been completed successfully.

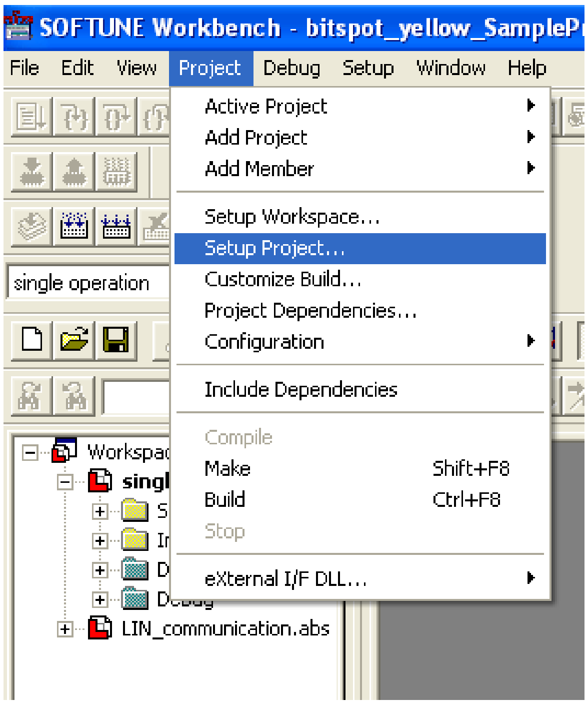


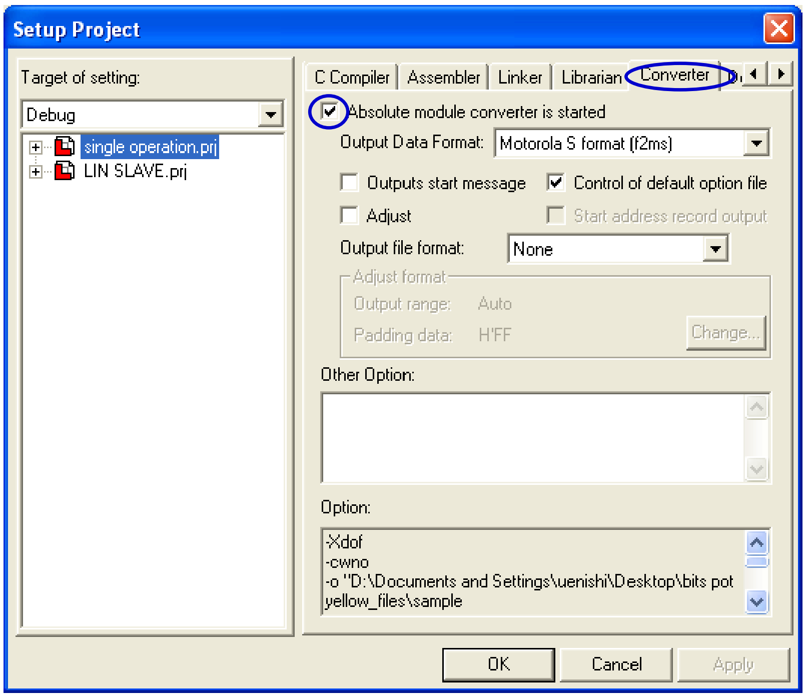
```
D:\Documents and Settings\uenishi\Desktop\bits pot yellow_files\sample program\bitspot_yellow_SampleProgram\bitspot_yellow_SampleProgram_monito
Now starting load module converter...
D:\Documents and Settings\uenishi\Desktop\bits pot yellow_files\sample program\bitspot_yellow_SampleProgram\bitspot_yellow_SampleProgram_monito

No Error.
```

Figure 2-15 Completing the build

Next, configure the load module output settings.

As shown in “Figure 2-16 Load module outputs”, select “Project” → “Setup Project” from the menu. The project settings dialog opens, check that “Start load module converter” is enabled on “Converter”. By enabling this checkbox, the load module will be output.





Target of setting: Debug

single operation.prj
LIN SLAVE.prj

[✓] Absolute module converter is started

Output Data Format: Motorola S format (f2ms)

[ ] Outputs start message [✓] Control of default option file

[ ] Adjust [ ] Start address record output

Output file format: None

Adjust format
Output range: Auto
Padding data: H'FF
Change...

Other Option:

Option:

```
-Xdof
-cwno
-o "D:\Documents and Settings\uenishi\Desktop\bits pot
yellow_files\sample
```

Figure 2-16 Load module outputs

Next, configure the debug settings. On the same project settings dialog, open the "Debug" tab. The debug settings dialog opens as shown in "Figure 2-17 Debug settings".

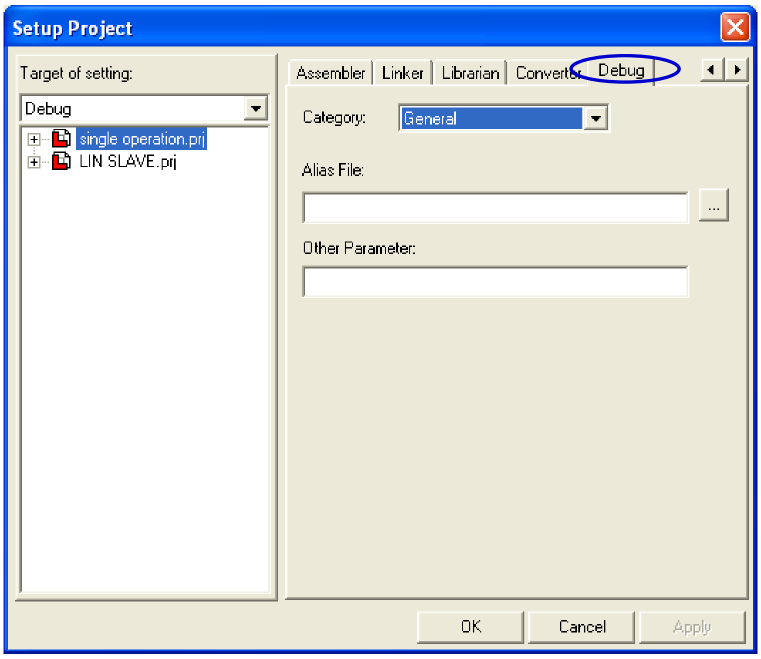


Figure 2-17 Debug settings

Change the category from "General" to "Setup", and select "mon_dbg" from the setup name list. In the setup name, "mon_dbg" is entered as shown in "Figure 2-18 Changing the debug settings". Here, click the "Change" button to change the settings. (The setup wizard activates.)

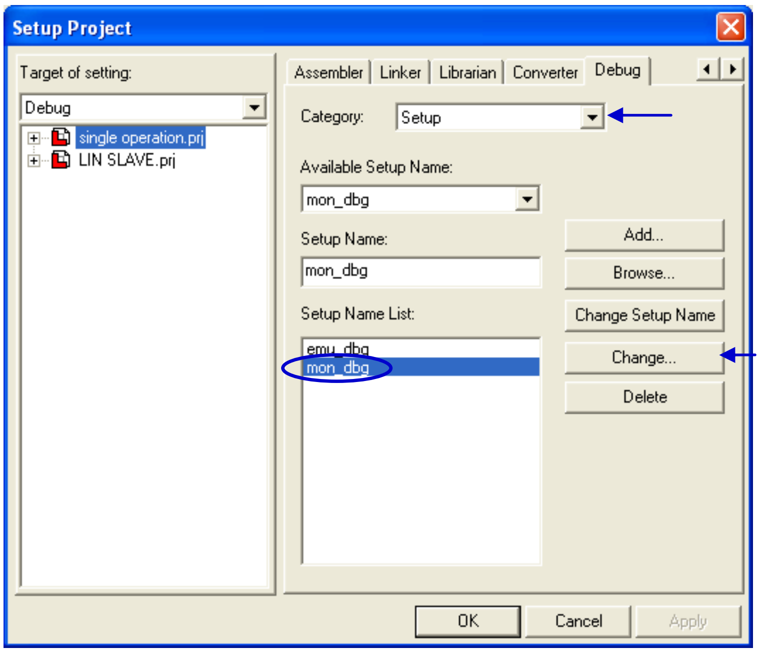
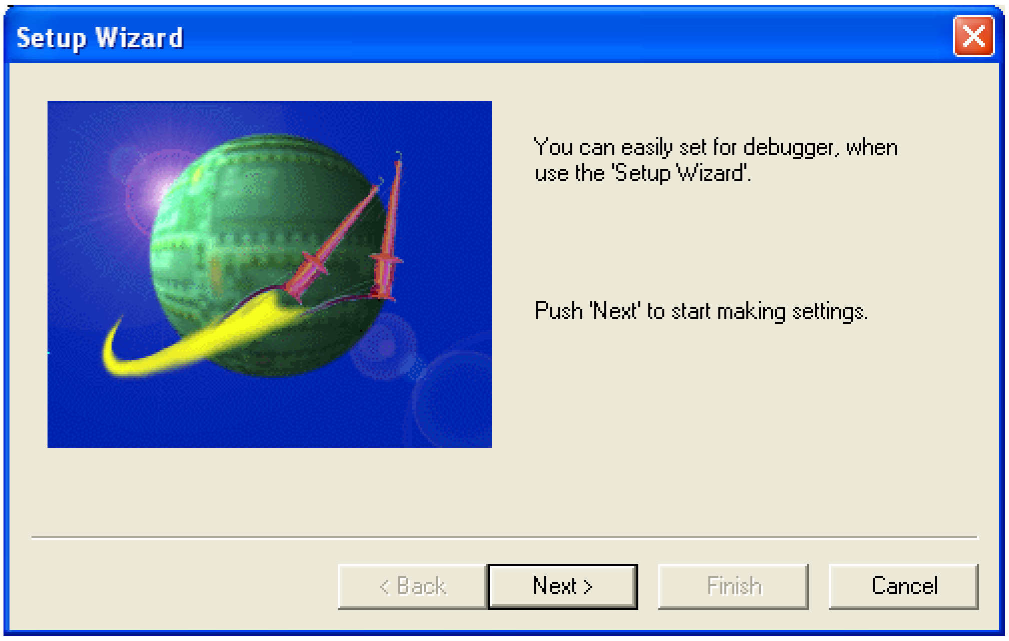


Figure 2-18 Changing the debug settings

The debug setup wizard is displayed as shown in “Figure 2-19 Starting the debug setting wizard” Click the “Next” button.

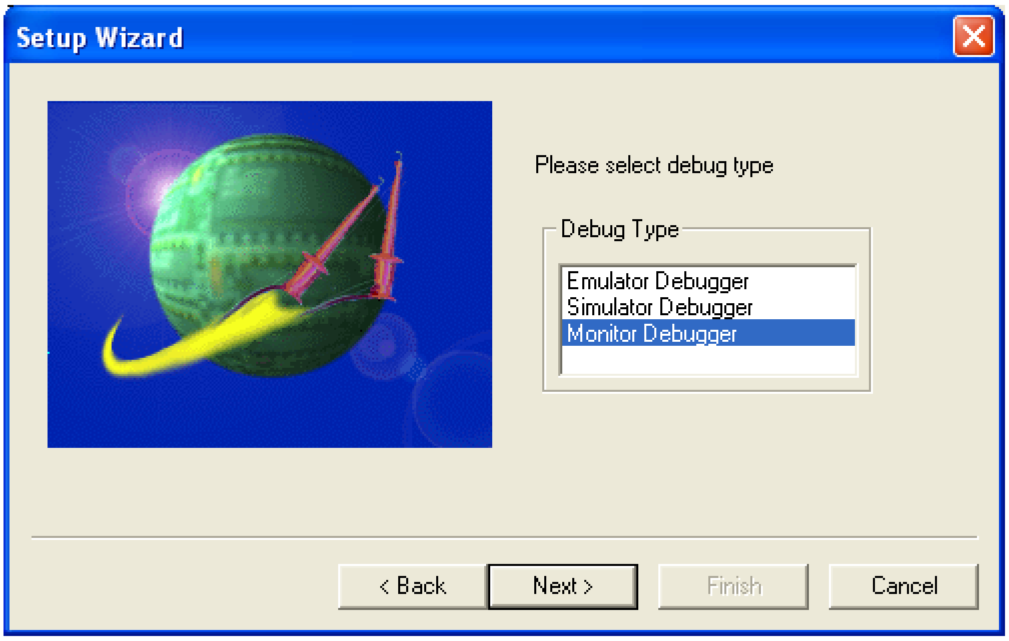


You can easily set for debugger, when use the 'Setup Wizard'.

Push 'Next' to start making settings.

Figure 2-19 Starting the debug setting wizard

Select the debugger type as shown in “Figure 2-20 Selecting the debugger type”; select “Monitor Debugger” and then click the “Next” button.



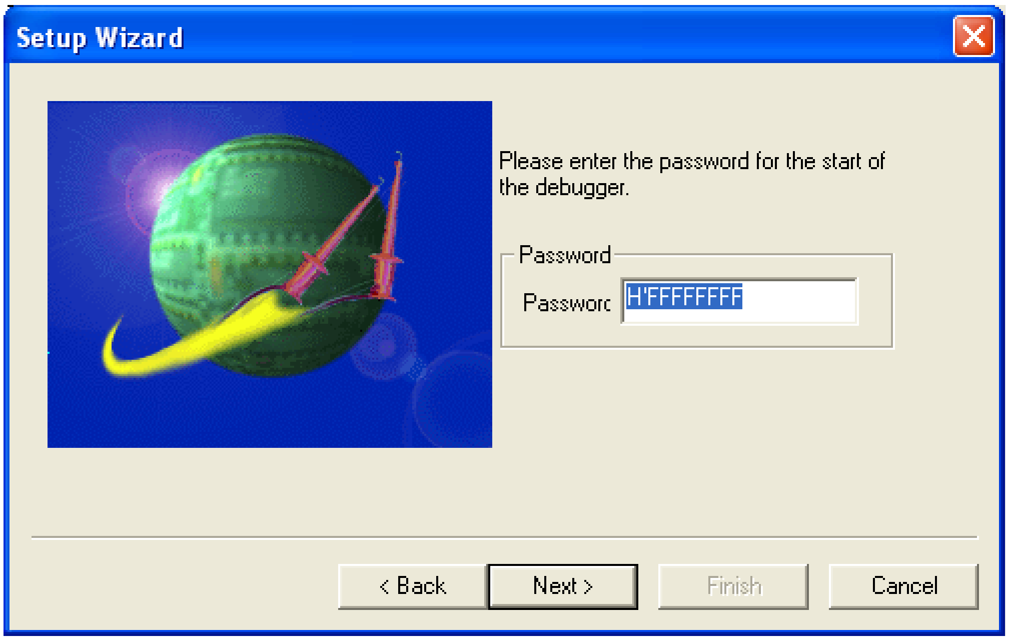
Please select debug type

Debug Type

Emulator Debugger
Simulator Debugger
Monitor Debugger

Figure 2-20 Selecting the debugger type

Enter the password as shown in "Figure 2-21 Entering password when starting debugger". Keep the default settings and then click the "Next" button.



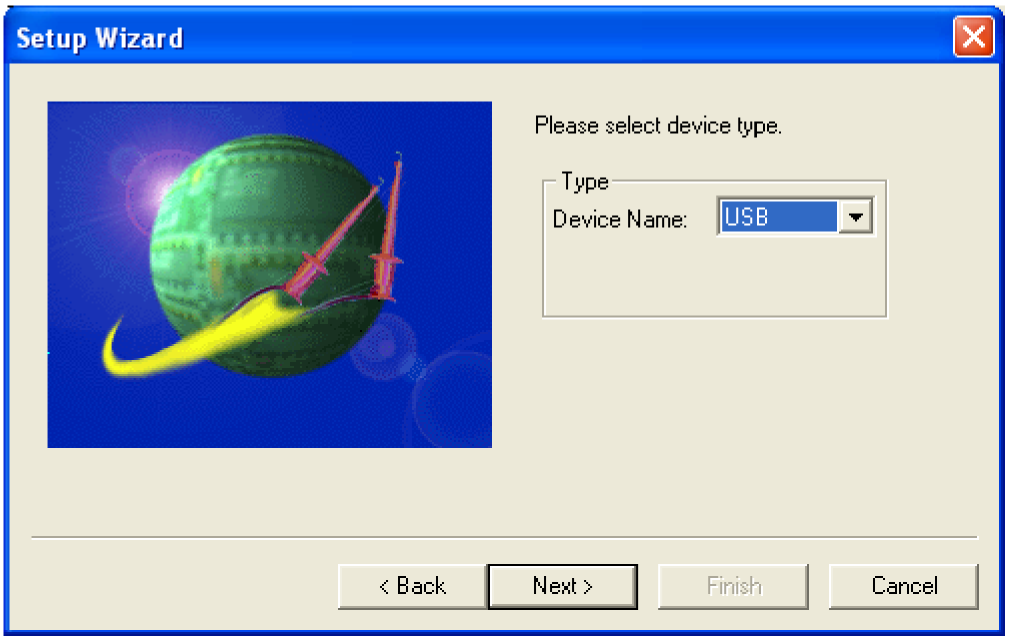
Please enter the password for the start of the debugger.

Password

Passworc: H'FFFFFFFF

Figure 2-21 Entering password when starting debugger

Select the device type as shown in "Figure 2-22 Selecting the device type". Check that "USB" has been selected in the device name, and click the "Next" button.



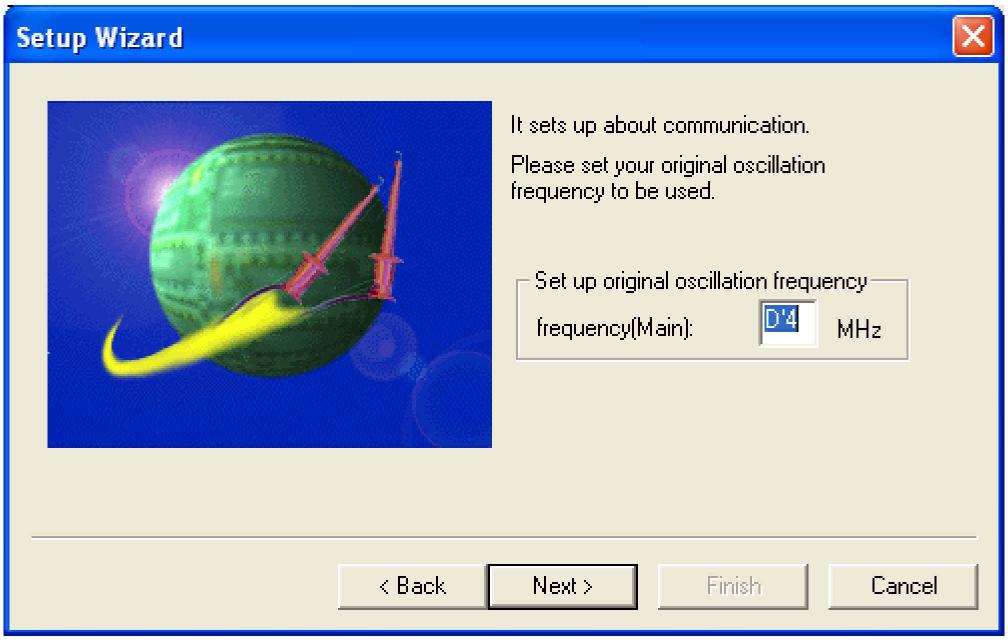
Please select device type.

Type

Device Name: USB

Figure 2-22 Selecting the device type

Set the frequency as shown in "Figure 2-23 Setting the primary oscillation frequency". Set to "D'4" (4MHz frequency setting), and click the "Next" button.


Setup Wizard

It sets up about communication.

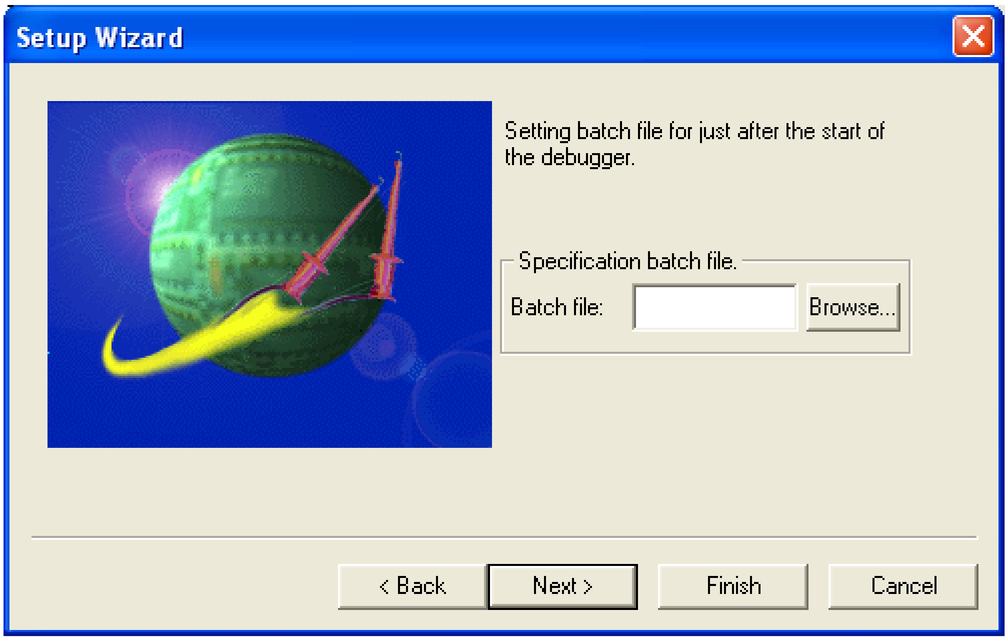
Please set your original oscillation frequency to be used.

Set up original oscillation frequency

frequency(Main): D'4 MHz

Figure 2-23 Setting the primary oscillation frequency

Specify nothing to the batch file field as shown in "Figure 2-24 Specifying a batch file"; keep the field left blank and click the "Next" button.


Setup Wizard

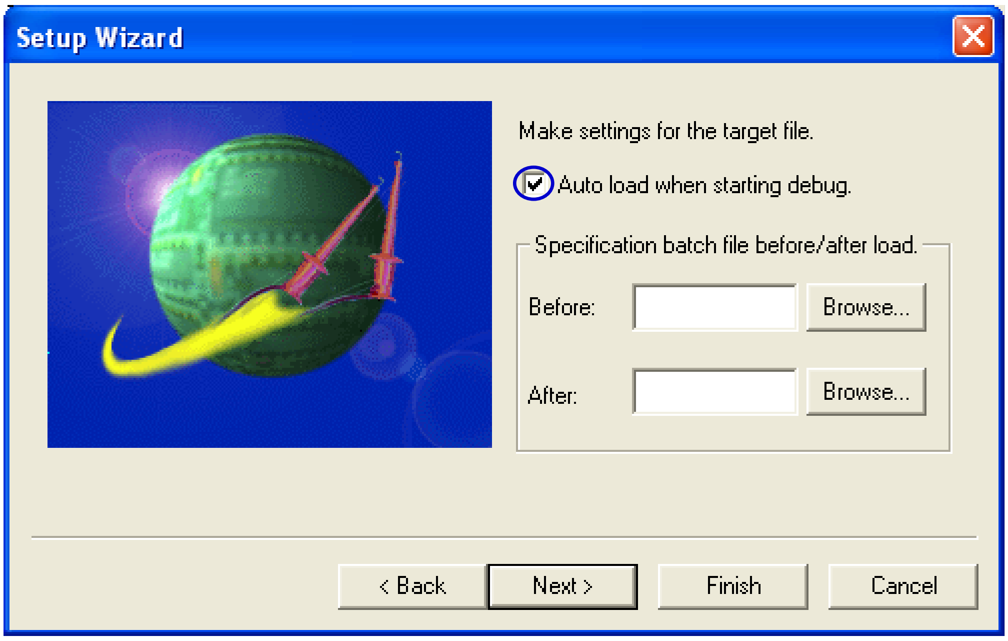
Setting batch file for just after the start of the debugger.

Specification batch file.

Batch file:

Figure 2-24 Specifying a batch file

Enable the “Auto load when starting debug” checkbox as shown in “Figure 2-25 Configuring the target file settings”, and click the “Next” button.



Make settings for the target file.

[✓] Auto load when starting debug.

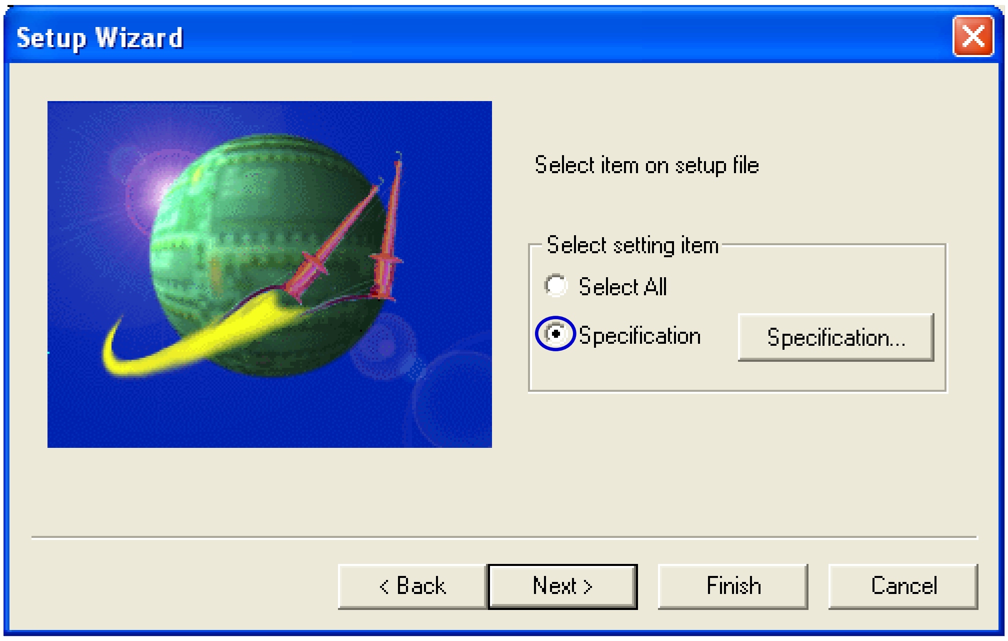
Specification batch file before/after load.

Before:

After:

Figure 2-25 Configuring the target file settings

Select “Specification” for setup file selection as shown in “Figure 2-26 Setting setup file selection”, and click the “Next” button.



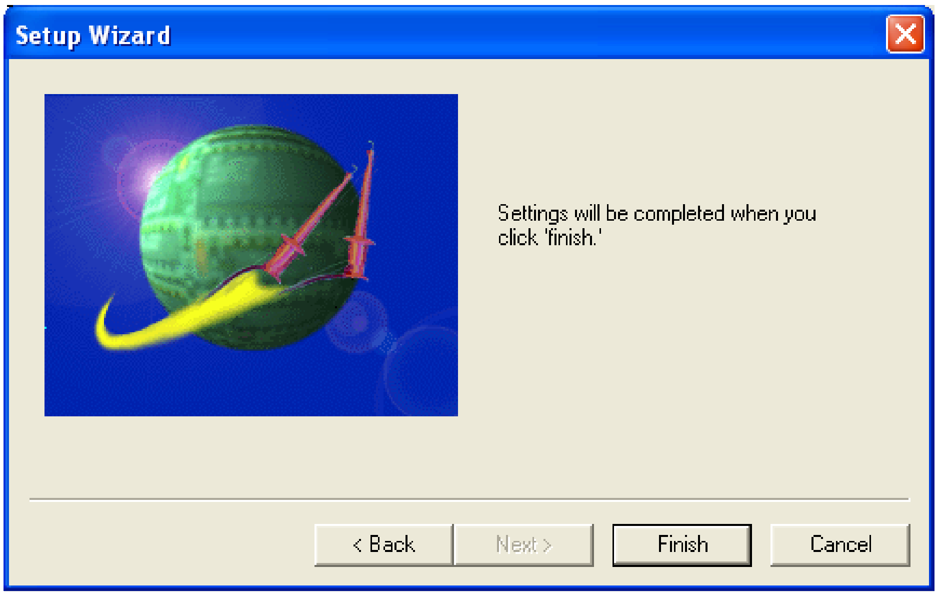
Select item on setup file

Select setting item

Select All [✓ Specification]

Figure 2-26 Setting setup file selection

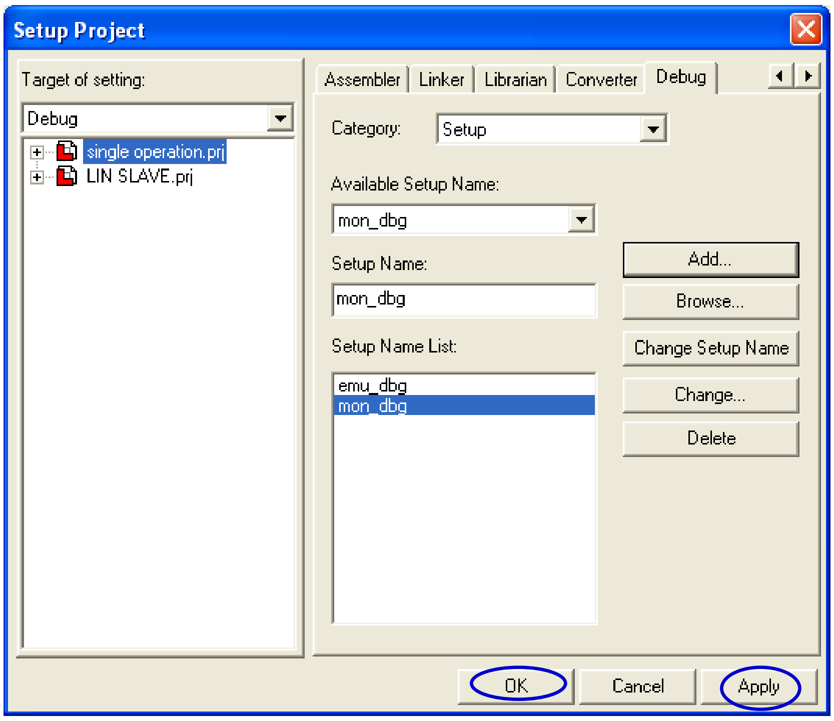
When all the settings have been completed as shown in “Figure 2-27 Completing the setup wizard”, click the “Finish” button.



Settings will be completed when you click 'finish.'

Figure 2-27 Completing the setup wizard

When the debug settings have been completed, click the “Apply” button and then click the “OK” button as shown in “Figure 2-28 Completing the project settings” to finish configuring the project settings.



Target of setting: Debug

single operation.prj
LIN SLAVE.prj

Category: Setup

Available Setup Name: mon_dbg

Setup Name: mon_dbg

Setup Name List:
emu_dbg
mon_dbg

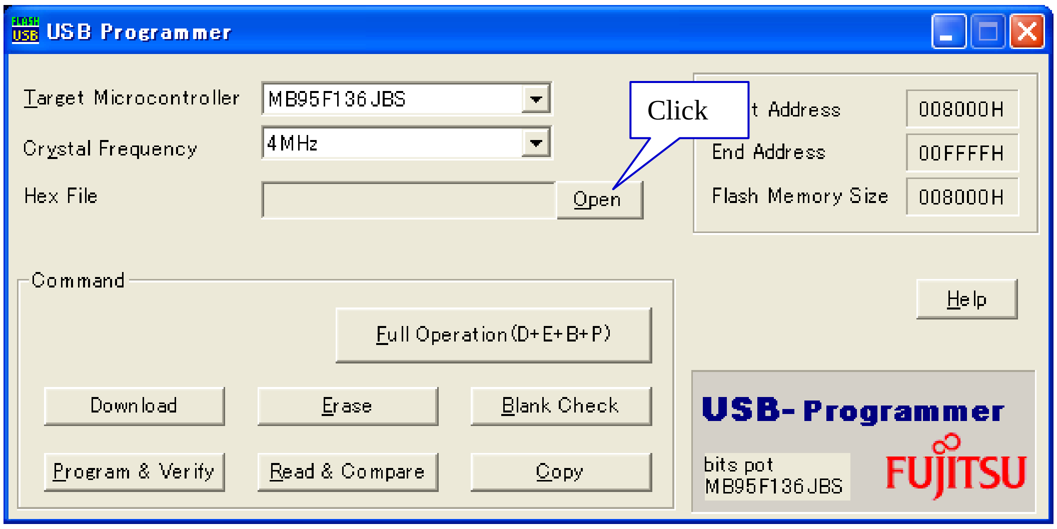
Figure 2-28 Completing the project settings

2.2.2 Writing the monitor program into the microcontroller

Preparation

To write programs, it is necessary to set the MODE SW on the starter kit to “PROG” in advance. Turn OFF the starter kit, switch the mode setting to “PROG”, and then turn ON the power supply to the starter kit again.

To activate the PC writer and select the file to be written as shown in “Figure 2-29 Opening the file to write”, click the “Open” button.


USB Programmer

Target Microcontroller: MB95F136JBS
Crystal Frequency: 4MHz
Hex File:

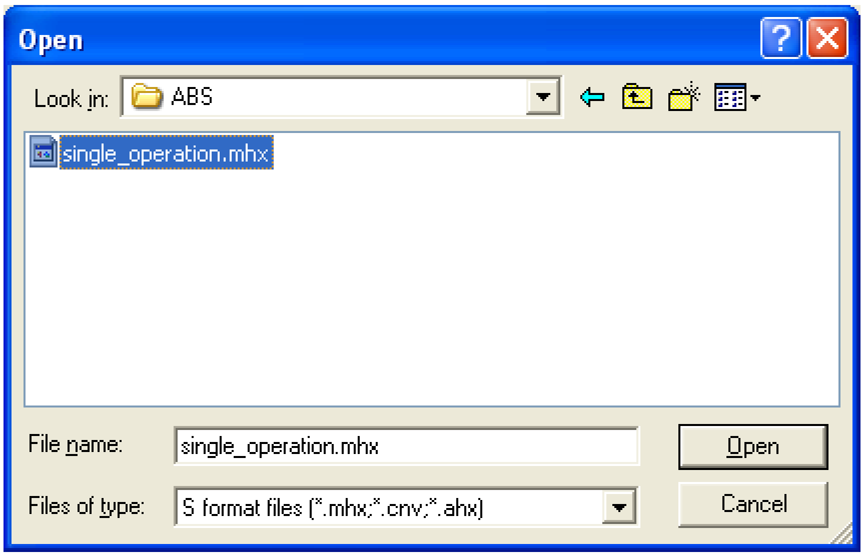
t Address: 008000H
End Address: 00FFFFH
Flash Memory Size: 008000H

bits pot
MB95F136JBS

Figure 2-29 Opening the file to write

The dialog to select the file to which to be written is displayed as shown in "Figure 2-30 Selecting the file to write", so select the file built in "2.2.1 Activating SOFTUNE and configuring the debug settings", and click the "Open" button.
¥bitspot_yellow_SampleProgram_monitor-debugger¥single_operation¥Debug¥ABS¥single_operation.mhx

If you built a LIN communication project in "2.2.1 Activating SOFTUNE and configuring the debug settings", select the following file, and click the "Open" button.
¥bitspot_yellow_SampleProgram_monitor-debugger¥LIN_communication¥Debug¥ABS¥LIN_communication.mhx



File name: single_operation.mhx

Files of type: S format files (*.mhx;*.cnv;*.ahx)

Figure 2-30 Selecting the file to write

Click the “Full Operation” button as shown in “Figure 2-31 Writing the program” to start writing. The program writing begins.

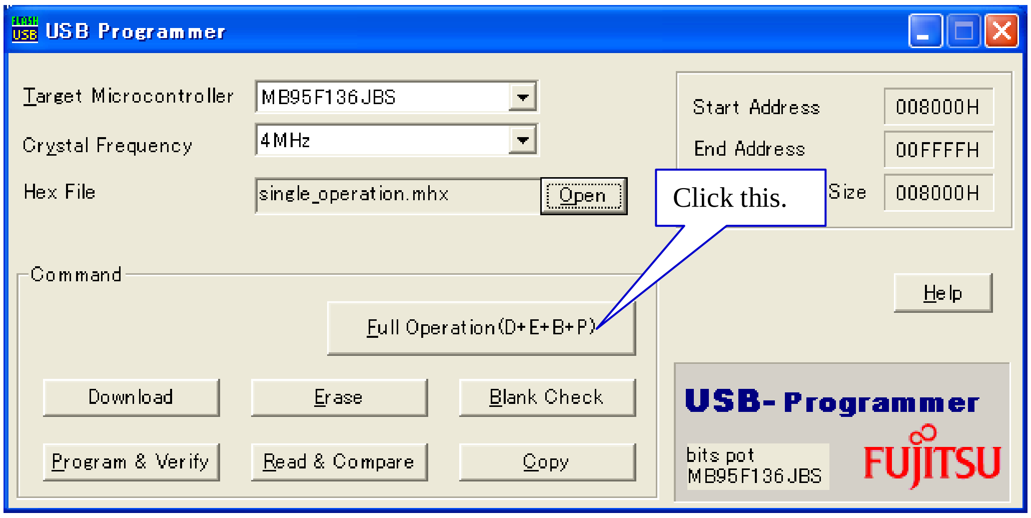
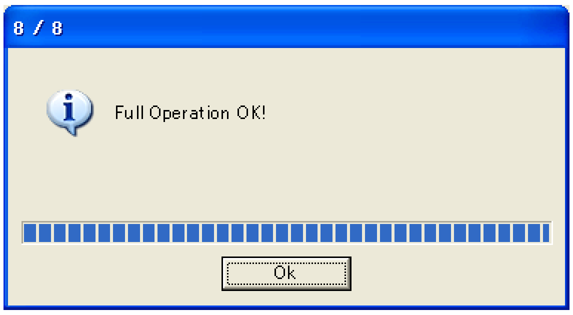


Figure 2-31 Writing the program

The dialog shown in “Figure 2-32 Completing the program writing” is displayed to notify you of the completion of the program writing; press the “OK” button to quit PC Writer..


8 / 8

Full Operation OK!

Figure 2-32 Completing the program writing

After completing the program writing, turn OFF the starter kit power supply, and set the Mode SW to “RUN” before reconnecting the power supply to the starter kit.

2.2.3 Loading the target file

Click “Debug” → “Start debug” from the menu as shown in “Figure 2-33 Start debugging”. When the debug starts, the target file will be loaded automatically.

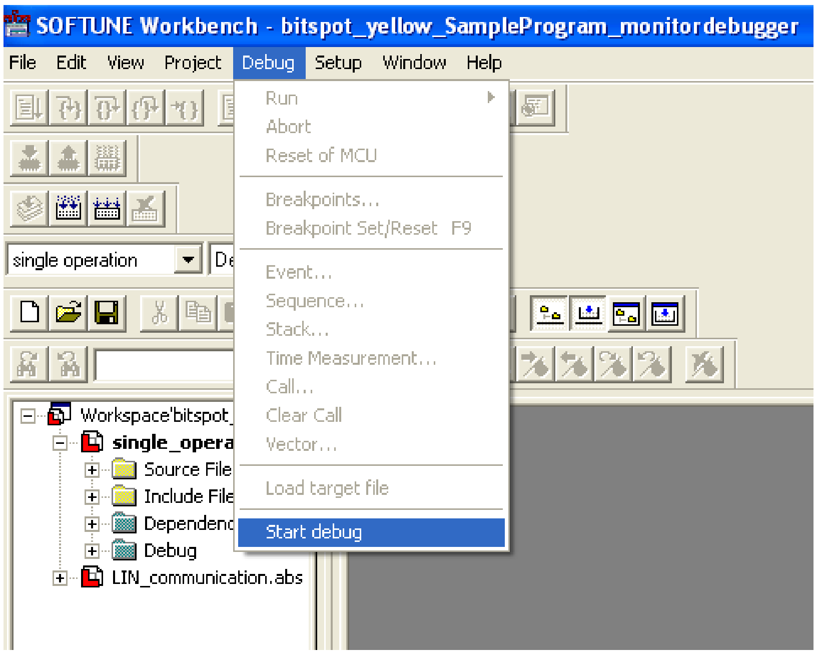


Figure 2-33 Start debugging

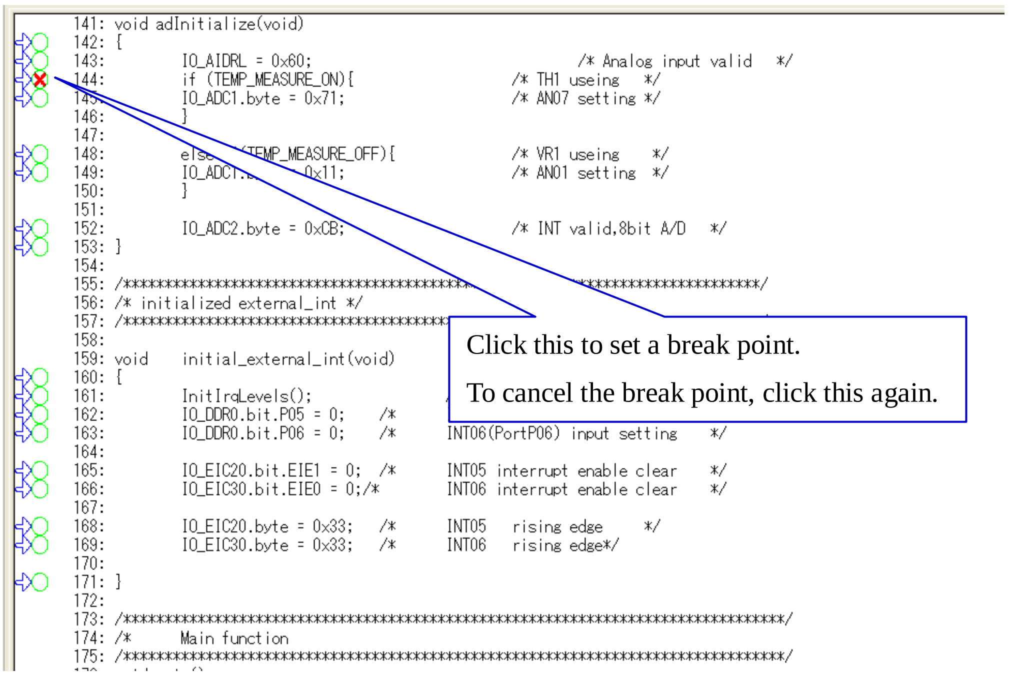
Once the monitor program itself is loaded to flash memory, the module can be loaded by the monitor debugger functions subsequently, and, it is not necessary to use the PC writer.

Note: It may take several minutes for the monitor debugger to load.

2.2.4 Running the debugger

As shown in “Figure 2-34 Setting break points”, you can set break points to where green round mark is located which is shown on the left side of lines in the source file. .A maximum of only two break points can be set.

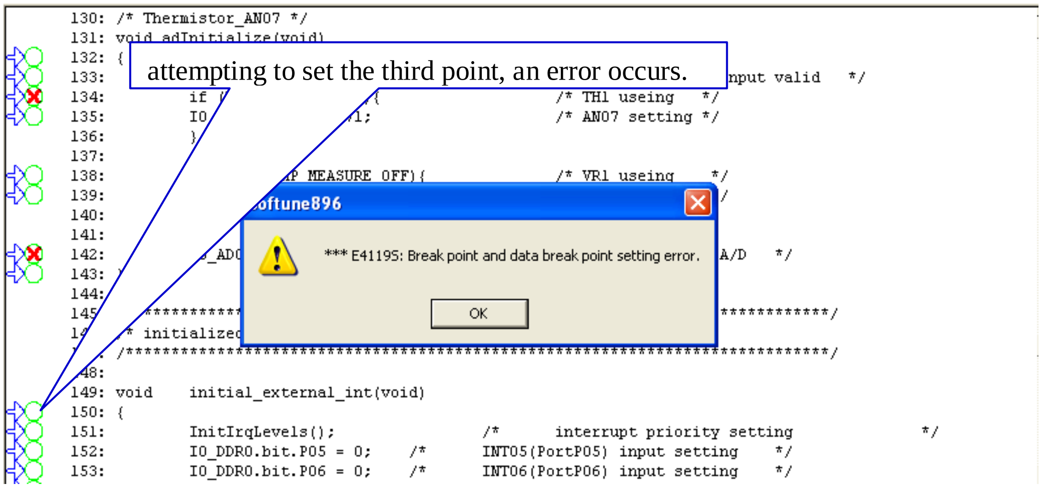
Note that you cannot set break points while the program is running.



```
void adInitialize(void)
{
        IO_AIDRL = 0x60;                        /* Analog input valid   */
        if (TEMP_MEASURE_ON){           /* TH1 useing   */
        IO_ADC1.byte = 0x71;            /* AN07 setting */
        }

        else   (TEMP_MEASURE_OFF){      /* VR1 useing   */
        IO_ADC1.b      0x11;            /* AN01 setting */
        }

        IO_ADC2.byte = 0xCB;            /* INT valid,8bit A/D   */
}

/*****************************************            ***********************/
/* initialized external_int */
/*****************************************

void    initial_external_int(void)
{
        InitIrqLevels();
        IO_DDR0.bit.P05 = 0;    /*
        IO_DDR0.bit.P06 = 0;    /*      INT06(PortP06) input setting    */

        IO_EIC20.bit.EIE1 = 0;  /*      INT05 interrupt enable clear    */
        IO_EIC30.bit.EIE0 = 0;/*        INT06 interrupt enable clear    */

        IO_EIC20.byte = 0x33;   /*      INT05   rising edge     */
        IO_EIC30.byte = 0x33;   /*      INT06   rising edge*/

}

/*****************************************************************************/
/*      Main function
/*****************************************************************************/
```

Click this to set a break point.

To cancel the break point, click this again.



```
/* Thermistor_AN07 */
void adInitialize(void)
{
                                                        nput valid    */
        if                      {               /* TH1 useing   */
        IO                      1;              /* AN07 setting */
        }

                   P MEASURE OFF){              /* VR1 useing   */
                                                              /


                  _ADC                                  A/D    */


     ***********                                       ************/
     * initialized
  /***************************************************************************/

void    initial_external_int(void)
{
        InitIrqLevels();                /*      interrupt priority setting              */
        IO_DDR0.bit.P05 = 0;    /*      INT05(PortP05) input setting    */
        IO_DDR0.bit.P06 = 0;    /*      INT06(PortP06) input setting    */
```

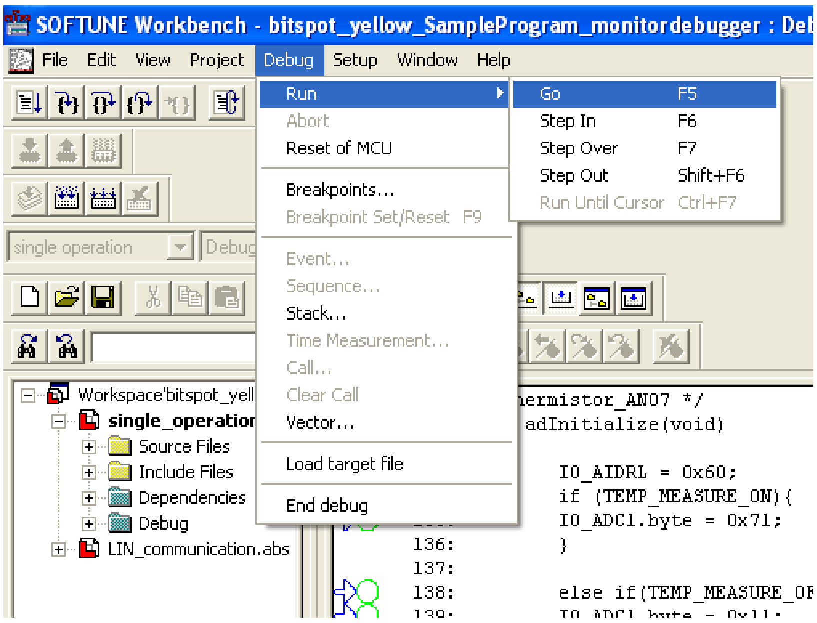
attempting to set the third point, an error occurs.

oftune896

*** E4119S: Break point and data break point setting error.

Figure 2-34 Setting break points

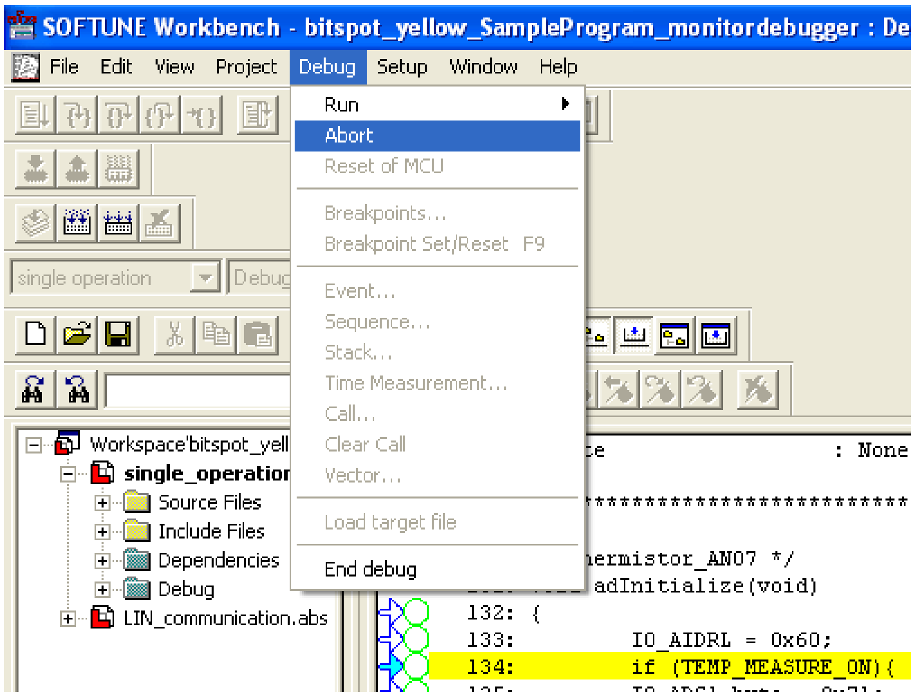
Click “Debug” → “Run” → “Go” from the menu, as shown in “Figure 2-35 Running the program”. By this operation, the program runs and the starter kit operates.



```
hermistor_AN07 */
adInitialize(void)

        IO_AIDRL = 0x60;
        if (TEMP_MEASURE_ON){
        IO_ADC1.byte = 0x71;
        }

        else if(TEMP_MEASURE_OF
```

Figure 2-35 Running the program

To stop the program, click “Debug” → “Abort” from the menu as shown in “Figure 2-36 Stopping the program”.



```
te                          : None
**************************
hermistor_AN07 */
adInitialize(void)
{
        IO_AIDRL = 0x60;
        if (TEMP_MEASURE_ON){
```

Figure 2-36 Stopping the program

2.2.4.1 If the monitor debugger cannot be controlled

It may become unable to control the monitor debugger (I.e., communications between the host system and the target fails.), due to, such as the application program unexpected behavior. In such cases, restart the debugger using the following procedure.

① Select “Debug (D)”, ー “Abort”.(Alternatively, click the Run Stop button.)
② Click the “Abort(A)” button in the abort dialog. Note: MCU cannot be reset at this time. This dialog may be displayed several times, but ignore it.
③ If the warning “Cannot abort” is displayed, click “OK”
④ Close the debugger and reset the target system.
⑤ Restart the debugger.

2.2.4.2 Debugger prohibitions

① Do not operate resources that use the monitor debugger (IO ports P10, P11, P12).
② Do not operate the PLLC and SYCC registers by using the debugger.
③ Do not set break points in the monitor program.
④ Do not single step thorough within API FGM_WDTON process.

2.2.4.3 Debugger limits

① The initial values for the SP register changes.
② The startup time changes after the reset cancellation.
③ Forced breaks are disabled when UART/SIO interrupts are prohibited.
④ The response time of clock 2 system products (with sub-clock inputs) is lengthened.
⑤ Code breaks are disabled during step-in operations.
⑥ Add four bytes to the stack area for the monitor program.
⑦ Make sure to combine use with the “flash security function” also.
⑧ Use the flash programmer when changing the password.
⑨ A reset occurs after an object has been loaded.

3 Operation of the sample Programs

This section describes the operation of the sample program. The operation of the sample programs is classified into the following two categories.

① bits pot yellow single-unit operation

② LIN communication operation (LIN communication operation with the bits pot white)

3.1 bits pot yellow single-unit operation

Explanations of the operation and control parts as shown in “Figure 3-1 Single-unit operation/Controls and mechanicals” are described in “Table 3-1 Single-unit operation/Descriptions of the controls and mechanicals”.

The LEDs (red) and buzzer are controlled by SW 2, SW 3, volume switch, and temperature sensor on the starter kit.

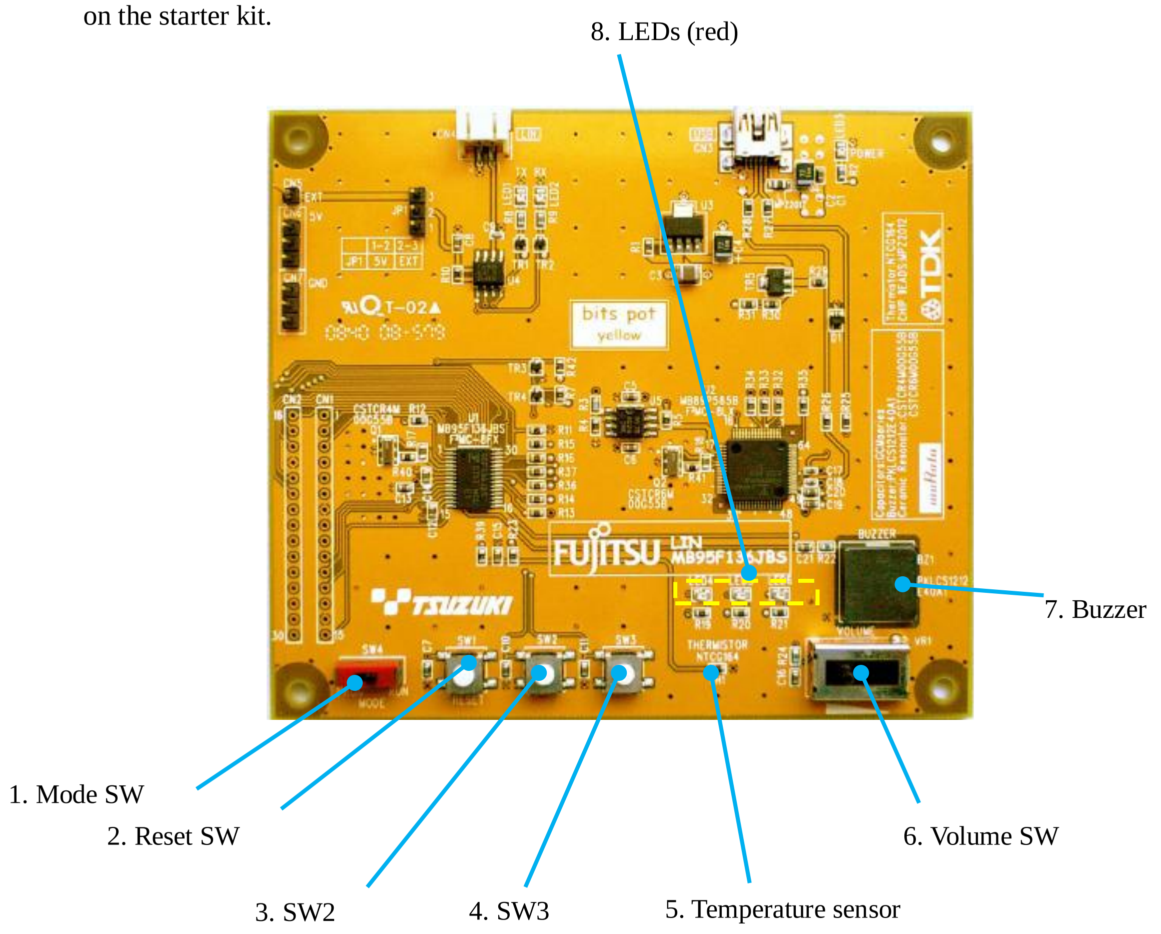


Figure 3-1 Single-unit operation/Controls and mechanicals

Table 3-1 Single-unit operation/Descriptions of the controls and mechanicals

No.	Name	Specifications	Function
1	Mode SW	Control	Switches between PROG mode and RUN mode. PROG: Write a program RUN: Run the program
2	Reset SW	Control	Resets the MCU when pressed.
3	SW2	Control	Turns ON and OFF the LED when pressed. Light up LEDs 4 to 6 in order and turn OFF when they are all ON, each time the switch is pressed.
4	SW3	Control	Turns ON and OFF the buzzer outputs each time the switch is pressed.
5	Temperature sensor	Control	Displays the temperature sensor information on the LED. The ON/OFF pattern depends on the temperature.
6	Volume SW	Control	Change the buzzer sound when the sound is ON. Slide to the left to raise the tone.
7	Buzzer	Mechanical	Press SW 3 to sound the buzzer. Further, operate the volume switch to change the tone.
8	LEDs (red)	Mechanical	This LED is turned ON either by pressing SW2 or by the temperature sensor operations.

3.2 LIN communication operation (LIN communication operation with the bits pot white)

Explanations of the operation and control parts as shown in “Table 3-2 LIN communication/Descriptions of the controls and mechanicals” are described in “Figure 3-2 LIN communication operation/Controls and mechanicals”.

Perform LIN communication with bits pot white. The starter kit sends responses to the bits pot white as a LIN slave. LED (red) and 7SEG ON signals, and buzzer outputs of the starter kit and the bits pot white are controlled, by switch operation, and temperature sensor and volume switch operation of each starter kit. Further, if an error occurs during LIN communication, a buzzer output is sent.

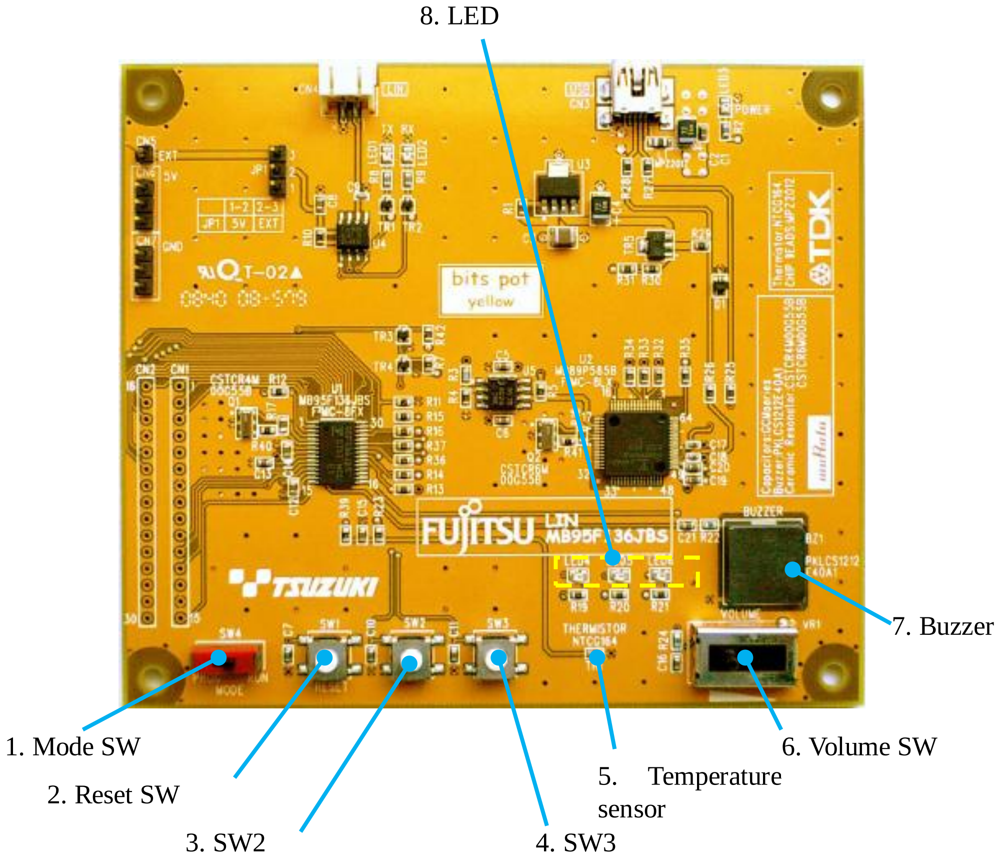


Figure 3-2 LIN communication operation/Controls and mechanicals

Table 3-2 LIN communication/Descriptions of the controls and mechanicals

No.	Name	Function	Description
1	Mode SW	Control	Switches between PROG mode and RUN mode. PROG: Write a program RUN: Run the program
2	Reset SW	Control	Resets the MCU when pressed.
3	SW2	Control	If SW 2 is pressed when the bits pot white SW4 is set to the left, the value on the LED currently displayed in the starter kit is incremented, and the bits pot white LED and 7SEG LED are also incremented. If bits pot white SW4 is set to the right, no operation is performed.
4	SW3	Control	If SW2 is pressed when the bits pot white SW4 is set to the left, the value on the LED currently displayed in the starter kit is decremented, and the bits pot white LED and 7SEG LED are also decremented. If bits pot white SW4 is set to the right, no operation is performed.
5	Temperature sensor	Control	When bits pot white SW4 is set to the right, the temperature of the starter kit temperature sensor is sent.
6	Volume SW	Control	When bits pot white SW4 is set to the right, the information of the starter kit Volume SW is sent. The sound of the bits pot white buzzer output changes when the volume switch is operated.
7	Buzzer	Mechanical	Buzzer sounds are output when bits pot white SW4 is set to the right. Further, the buzzer sound output changes according to volume switch operations. In addition, if an error occurs during LIN communication, a buzzer sound is output.
8	LED (red)	Mechanical	When bits pot white SW4 is set to the left, the count is incremented or decremented by pressing starter kit SW2 and SW3, and bits pot white SW3 and SW5.When bits pot white SW4 is set to the right, the temperature information from the bits pot white temperature sensor is displayed.

4 Try to operate the bits pot yellow (single-unit)

4.1 Overview of single-unit operation

After system startup, the starter kit LEDs and buzzers are operated by the switches (SW2, SW3, and volume switch) and temperature sensor as described below.

4.1.1 Turning ON LEDs using switch operations

General push switches and LEDs are mounted to the starter kit as shown in “Figure 4-1 Single-unit operation/Switches and LEDs”, and connected to the microcontroller respectively.

This section explains how to turn ON and OFF the LEDs using SW2 operations.

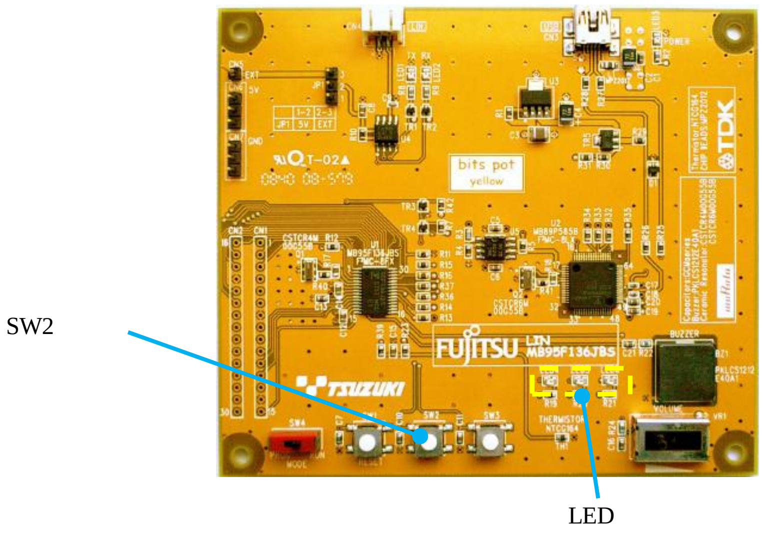


Figure 4-1 Single-unit operation/Switches and LEDs

First, describes how to control turning ON the LEDs using the microcontroller.

The LEDs and microcontroller of the bits pot yellow are connected as shown in “Figure 4-2 LED lighting circuit”. This is shown diagrammatically in “Figure 4-3 LED ON/OFF circuit example (schematic diagram)”. When the LED is OFF as shown in Figure 4-3(a), pin P14 outputs are high, so current does not flow to the LED, and the LED remains OFF. When the LED is ON as shown in Figure 4-3(b), pin P14 outputs are low, so current flows to the LED, and the LED turns ON. The switches of the microcontroller can be switched using the program that controls the microcontroller.

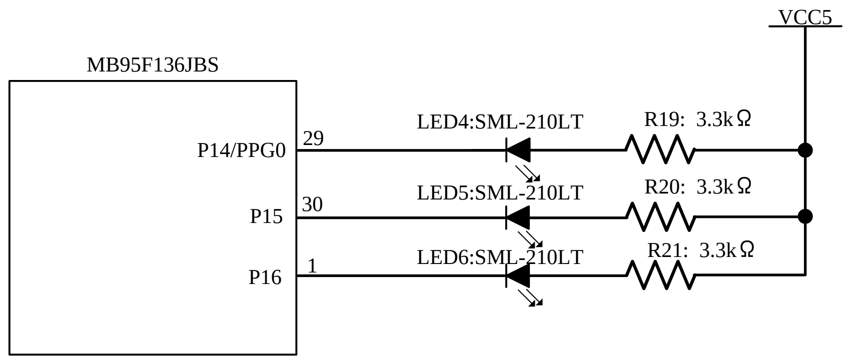


Figure 4-2 LED lighting circuit

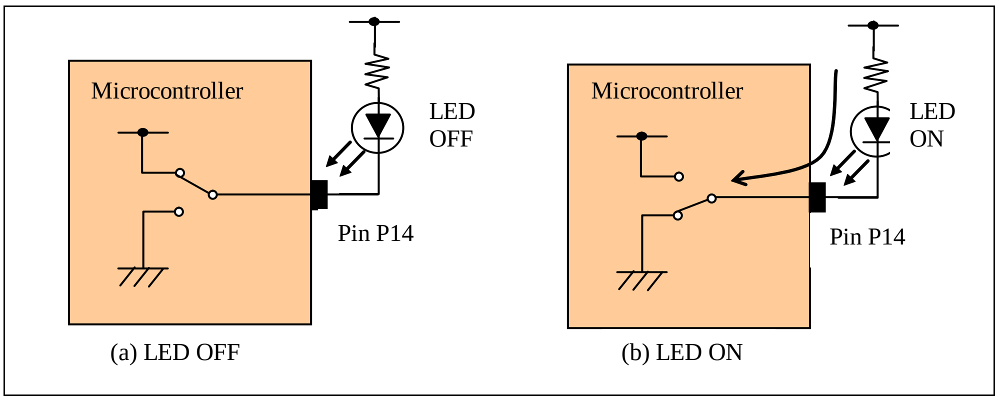


Figure 4-3 LED ON/OFF circuit example (schematic diagram)

The pin P14 is controlled by the PDR1 register and the DDR register. If using the ports as outputs, write the value to be output to the bit corresponding to the pins in the PDR1 register (0: Low, 1: High), and write “1" to the bits corresponding to the pins in the DDR1 register.

Next, regarding switch controls, the switches on the starter kit are connected to the pin P5, which is the external interrupt input pin, and the general I/O ports on the microcontroller. This section explains how to detect switch operations (i.e., when the switch is pushed) on the microcontroller using the pins as external interrupt input pins (INT5).
An overview of the SW2 connection circuit in the starter kit is shown in “Figure 4-4 Connection configuration between SW2 and microcontroller pins (schematic diagram)”. In the starter kit, SW2 is connected to the INT5 pin, which is the external interrupt input pin on the microcontroller. If SW2 is not pressed (i.e., is OFF), the voltage applied to the INT5 pin on the microcontroller is VCC (5V), which is High. Further, if SW 2 is pressed (i.e., is ON), the voltage applied to the INT5 pin is grounded, so the INT5 (P5) pin input status is Low. Consequently, when SW2 is pushed, the

input to the INT5 pin changes from High to Low. Further, when SW2 is released, the input to the INT5 pin changes from Low to High. If using the external interrupt function on the microcontroller, an interrupt can be created using timing that changes the pin status. In other words, if using this mechanism, the fact that the switch has been operated can be identified using the interrupt. Further, SW3 can also be operated in the same way as SW2, but SW3 is connected to the INT6 pin on the microcontroller. Consequently, when SW3 is operated, an INT6 pin external interrupt is created.

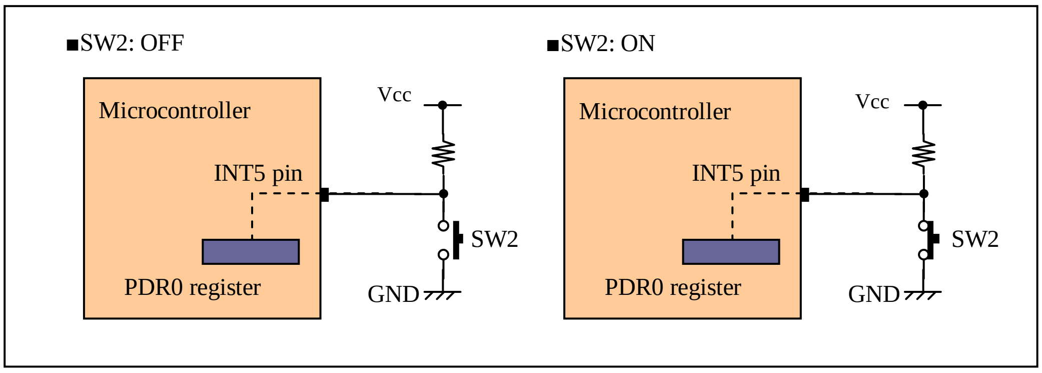


Figure 4-4 Connection configuration between SW2 and microcontroller pins (schematic diagram)

The next section explains the methods and procedures for using the INT5 pin on the microcontroller as an external interrupt pin. If using the INT5 pin as an external interrupt, set the I/O direction to “input” using register DDR0 on port 0 and, further, if using combined analog input pins, it is necessary to make port input settings. Register DDR0 on port 0 is an 8-bit register for switching the direction (input or output direction) used by the port 0 pins. If using the pins as input ports, write “0” to the bit corresponding to DDR0.

Further, to use the external interrupt function on the microcontroller, it is necessary to set the external interrupt register EIC00. EIC00 is a register that selects the edge polarity and controls interrupts for the external interrupt inputs.

This section considers when SW 2 being turned ON is detected by an interrupt. When SW2 is released, the fact that the input level of the INT5 pin changes from Low to High has already been explained. With the external interrupt function, it is possible to detect the change in the level from Low to High (i.e., the rising edge) of the INT5 pin by setting the external interrupt register using the steps (1) to (5) in the procedure described below. Consequently, using this method, it is possible to detect when SW2 is turned ON using an interrupt.

(1) Write "1” to AIDRL bit 5, and make the settings so that the P5 pin on port 0 is used as the input port.

(2) Write “0” to DDR0 bit 5, and set SW2 to inputs.

(3) Set EIC20 bit 4 to “0”. (This prohibits INT5 interrupts.)

(4) Set EIC20 bit 5 to “1”, and bit 6 to “0”. (Set so that an external interrupt is created when

the rising edge is detected.)

(5) Set EIC20 bit 5 to “1”. (This permits INT5 interrupts.)

4.1.2 Controlling the buzzer using the volume switch

This section introduces processing to change the buzzer sound according to changes in the digital signal converted from the analog signals input into the microcontroller. By Volume SW operations, the analog signals input into the microcontroller is converted to digital using an A/D converter and acquire them as digital signals internally. Further, the A/D converter is a function that separates and converts analog values to digital values using standards based on certain rules. In addition, this function is built into the microcontroller, and the conversion process is called “A/D conversion”.
In the starter kit, the voltage values applied to the analog pins for A/D conversion can be controlled using the volume switch, which is built into the starter kit. Analog signals are input to the microcontroller using this knob. Analog signals that have been entered are processed by the microcontroller after being converted to digital signals by the A/D converter.

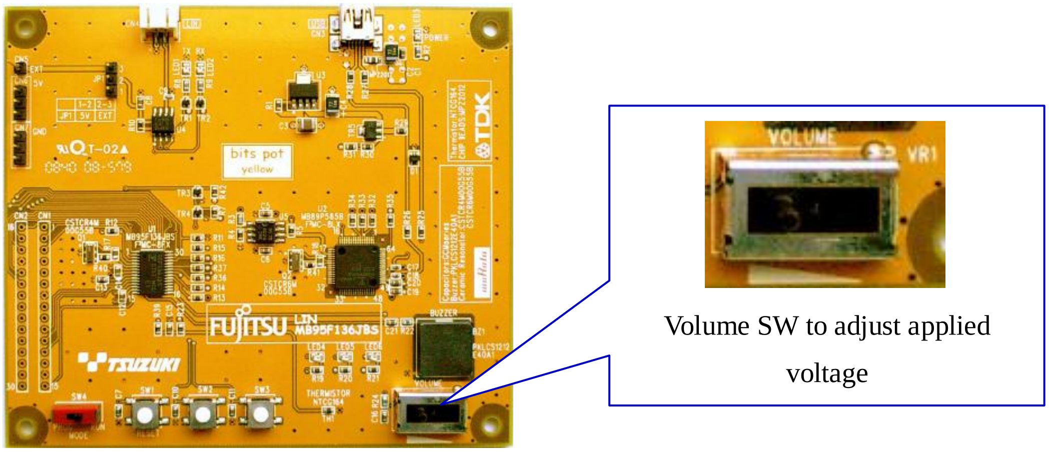


Figure 4-5 Single-unit operation/Volume SW

An A/D converter with 8-bit resolution (10-bit resolution can also be used) is built into the main microcontroller in the starter kit.8-bit resolution is the name given to the ability to deblock and convert analog values to digital values in 2^8 (i.e., 256) steps.1-bit voltage accuracy (at 5V) during 8-bit resolution is described below.

1-bit voltage accuracy (at 5V)

With 8-bit resolution 5V/256 = Approx. 0.01953V

This explanation concerns the volume switch mechanism, but the symbol for a variable resistor is used in “Figure 4-6 Volume SW (variable resistor)”. In truth, the volume switch is really a variable resistor.

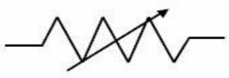


Figure 4-6 Volume SW (variable resistor)

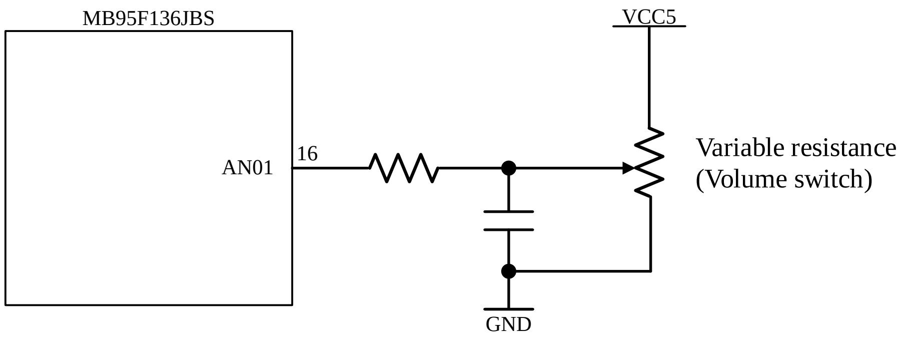


Figure 4-7 Circuit surrounding the voltage adjustment knob

In the starter kit, the circuit is configured as shown in “Figure 4-7 Circuit surrounding the voltage adjustment knob”, and adjusting this volume switch changes the value of the voltage applied, and applies this voltage to the pins that perform the A/D conversion. The applied voltage can be digitally converted in 256 steps, and handled as internal signals. In this sample program, the size of the applied voltage is obtained using an A/D converter, and the buzzer sound changes according to this value.

Next, here explains how to output buzzer sounds.

An element called a piezoelectric element is used in the buzzer. Piezoelectric elements are elements that use the piezoelectric effect, and which use materials that create a voltage when shock or pressure are applied (piezoelectricity) or, conversely, which use materials with properties that create a distortion in the crystal configuration when a voltage is applied (reverse piezoelectricity).As shown in “Figure 4-8 Piezoelectricity”, piezoelectric elements have the property of expanding when a voltage is applied in the direction of polarization (the direction of the green arrows) and contracting when a voltage is applied in the opposite direction to polarization (the opposite direction from the green arrows).

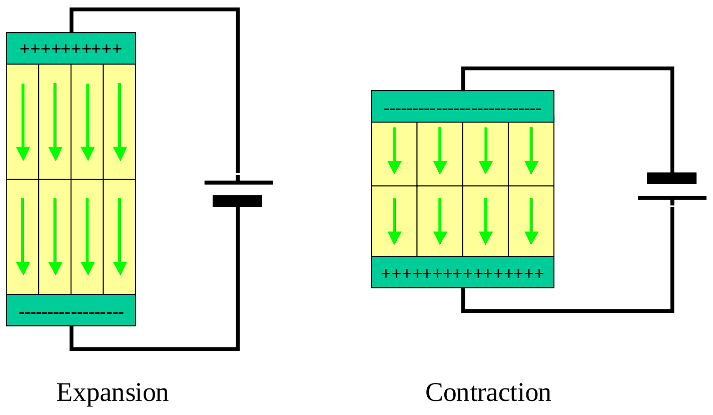


Figure 4-8 Piezoelectricity

Consequently, as shown in “Figure 4-9 Principle of piezoelectric elements”, when an AC voltage is applied, the crystals repeatedly expand and contract each time the direction of the voltage alternates. By changing the frequency of the AC voltage, the speed of the crystal contraction and expansion also changes. If this property is used skillfully, the crystal can be vibrated at various frequencies. If the vibration energy of the crystal is sufficiently great, it can also vibrate the air to create sound. This is the principle used in the piezoelectric buzzer.

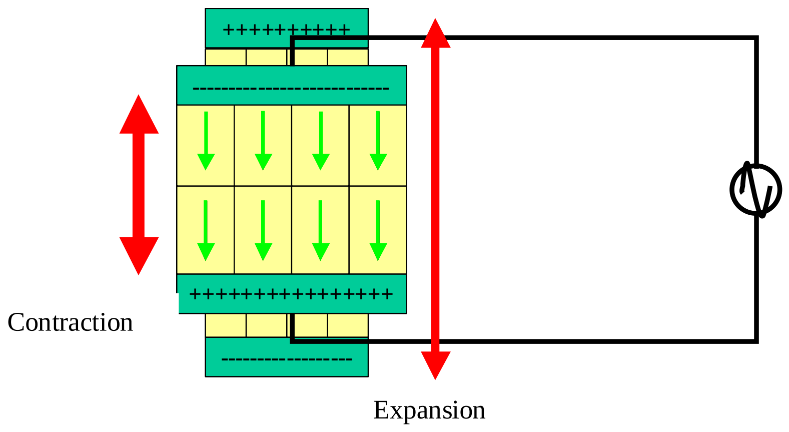


Figure 4-9 Principle of piezoelectric elements

In this way, a sound can be created by applying a voltage that changes in AC voltage or pulse voltage to the piezoelectric buzzer. Here, the method outputs a pulse wave using the PPG timer that is built into the microcontroller. PPG is an initialize for Programmable Pulse Generator, and as the name implies, pulse outputs of various widths are obtained from the microcontroller by using programs. Basically, pulse outputs using the PPG timer are enabled by setting the cycle, H width, and operations clock. In reality, in addition to this pulse information, the PPG pin output enable settings and PPG operations enable settings are also required.

4.1.3 LED displays using temperature sensor operations

This section explains how to display temperature information on the LED using the temperature sensor, which is mounted to the starter kit. A temperature sensor is a sensor for detecting changes in temperature. Put simply, it is a thermometer for measuring the temperature. Although there are various methods of measuring the temperature, the temperature sensor mounted to the starter kit is called a thermistor. A thermistor is a resistor that uses the temperature characteristics of semiconductors, and is a temperature sensor in which the resistance value changes according to the temperature

The circuit surrounding the temperature sensor on the starter kit is shown in "Figure 4-10 peripheral circuit diagram for temperature sensor". As explained in the section on the volume switch, with this circuit also, if the resistance value of the temperature sensor changes, the input voltage of the A/D converter in the microcontroller changes.

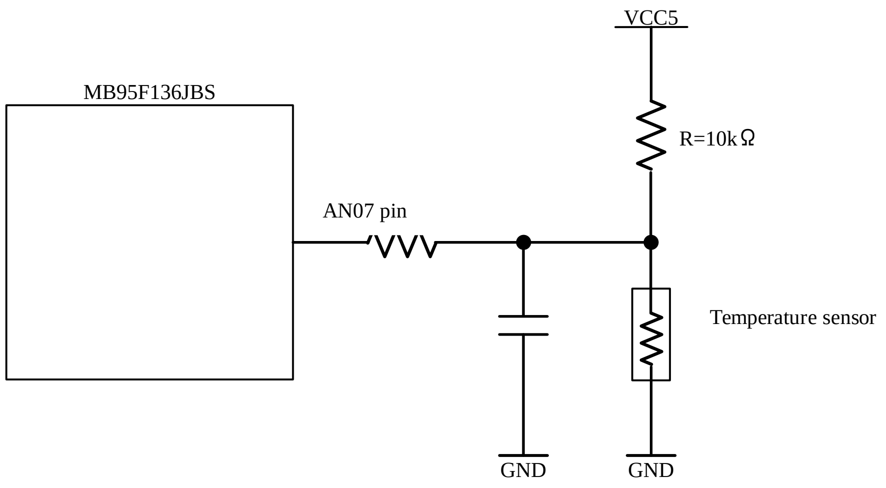
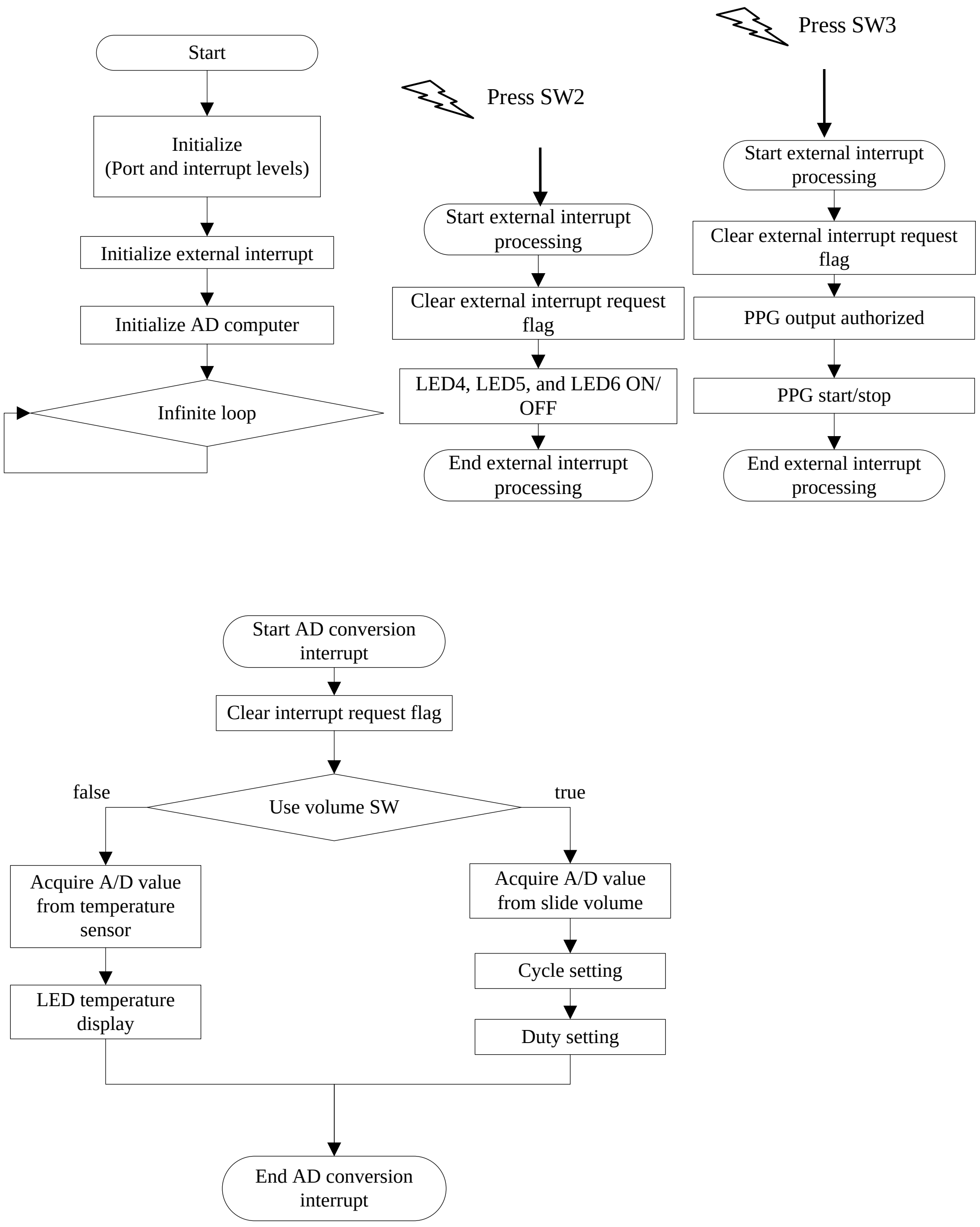


Figure 4-10 peripheral circuit diagram for temperature sensor

Next, about the LED display, is basically the same as turning ON/OFF the LED. Here, The LED is turned ON in multiple patterns according to the digital values acquired from the temperature sensor.

4.2 Understanding and running the program in single-unit operation

This section explains sample programs as programs that practically turn on/of the LED using switch operations and that control the buzzer using the A/D converter operations.



Start
Initialize
(Port and interrupt levels)
Initialize external interrupt
Initialize AD computer
Infinite loop
Press SW2
Start external interrupt processing
Clear external interrupt request flag
LED4, LED5, and LED6 ON/ OFF
End external interrupt processing
Press SW3
Start external interrupt processing
Clear external interrupt request flag
PPG output authorized
PPG start/stop
End external interrupt processing
Start AD conversion interrupt
Clear interrupt request flag
Use volume SW
false
true
Acquire A/D value from temperature sensor
LED temperature display
Acquire A/D value from slide volume
Cycle setting
Duty setting
End AD conversion interrupt

Figure 4-11 Single-unit operation flowcharts

The flowcharts for the sample programs are shown in “Figure 4-11 Single-unit operation flowcharts”. First, the ports, interrupt levels, external interrupts, and A/D converter are initialized. Thereafter, the program enters a loop. Here, when SW2 is pressed, an external interrupt is created, and the LED on/of processing is performed. Further, when SW3 is pressed, the buzzer is output. Here, the buzzer sound can be changed by operating the Volume SW.
So, let us look at an actual program.

Check the following folder for the sample program. The folder contains several files. First, open “main.c”.

¥bitpot_yellow_SampleProgram_single-chip¥single_operation¥source

Check around the line 37 as shown in “Figure 4-12 Operation mode settings (when using volume switch)” to select the operation mode. #define is set, so that whether to use the temperature sensor, and the enable/disable settings can be configured. To use the Volume SW for inputs to the A/D converter, configure the settings as shown in Figure 4-14, and to use the temperature sensor, configure the settings as shown in Figure 4-15.

In this explanation, the temperature sensor is not used, but use of the volume switch is enabled.

```
/* Temperature sensor use (1), or unused (0)            */
#define TEMP_SENSOR_USE                         (0)   ←Temperature sensor not used
/* Temperature measurement permission, non-permission   */
#define TEMP_MEASURE_ON                         (0)   ←Temperature sensor disabled
#define TEMP_MEASURE_OFF                        (1)   ←Volume SW enabled
```

Figure 4-12 Operation mode settings (when using volume switch)

```
/* Temperature sensor use (1), or unused (0)            */
#define TEMP_SENSOR_USE                         (1)   ←Temperature sensor used
/* Temperature measurement permission, non-permission   */
#define TEMP_MEASURE_ON                         (1)   ←Temperature sensor enabled
#define TEMP_MEASURE_OFF                        (0)   ←Volume switch disabled
```

Figure 4-13 Operation mode settings (when using the temperature sensor)

Note: The operation mode settings must be configured not only for main.c, but also for ADC.c and ext_int.c.

As shown in “Figure 4-14 Main function program”, the main functions are around line 165. “Port initialization”, “A/D converter initialization”, and “external interrupt initialization” are contained herein.

```
void main()
{
        sysInitialize();              ←Port initialization
        adInitialize();               ←AD converter initialization
        initial_external_int();       ←External interrupt initialization
        __set_il(3);
        __EI();
        while(1);                     ←Infinite loop
}
```

Figure 4-14 Main function program

Next, an interrupt is created when SW2 is pushed. The external interrupt function _interrupt void Ext_int1_5 in ext_int.c will be called as shown in "Figure 4-15 SW2 interrupts (LED on/off processing)".Here, the LED display is turned on/off, due to the output settings for the port connected to the LED, or due to the switch being pressed several times, is shown.

```
_interrupt void Ext_int1_5(void)
{
            IO_EIC20.bit.EIR1 = 0;
            if (TEMP_MEASURE_OFF){          ←When using Volume SW
                        IO_DDR1.bit.P14 = 1;
                        IO_DDR1.bit.P15 = 1;
                        IO_DDR1.bit.P16 = 1;     ←Port output setting
                        SW_count++;
                        if(SW_count > 3){
                        SW_count = 0;
                        }
                        IO_PDR1.byte = LED_pat[SW_count];    ←LED ON processing
            }
            else if(TEMP_MEASURE_ON){       ←Using temperature sensor
                        (Omitted)
            }
}
```

Figure 4-15 SW2 interrupts (LED on/off processing)

An interrupt is also created if SW3 is pressed, and the external interrupt function __interrupt void Ext_int2_6 in ext_int.c is called as shown in "Figure 4-16 SW3 interrupts (buzzer output processing)".This is where the PPG timer output settings are made, and timer start/stop process is performed.

```
__interrupt void Ext_int2_6(void)
{
            IO_EIC30.bit.EIR0 = 0;
            IO_PC00.byte = 0x0E;            ←PPG timer output setting
            IO_PPGS.byte = ~IO_PPGS.byte;     ←PPG timer start/stop
}
```

Figure 4-16 SW3 interrupts (buzzer output processing)

The A/D conversion is started in the A/D converter initialization function. Thereafter, when the A/D conversion is finished, an A/D converter interrupt is created as shown in “Figure 4-17 A/D converter interrupts”. Here, the A/D conversion values are acquired from the Volume SW or temperature sensor. If using the SW, the PPG timer cycle and duty changes are implemented using the A/D conversion values that have been acquired, to change the sound of the buzzer. If using the temperature sensor, the temperature is displayed according to the A/D conversion values acquired.

```
__interrupt void ad_int(void)
{
        IO_ADC1.bit.ADI = 0;
        ad = ~IO_ADD.byte.ADDL;         ←Acquire A/D conversion value
        if (TEMP_MEASURE_OFF){          ←If using Volume SW
                if(ad < 51){
                        IO_PPS00 = 0xFA;
                                                ←Change interval
                        IO_PDS00 = 0x7D;
                }
                else if(ad < 102){
                        (Omitted)
                }
        else if (TEMP_MEASURE_ON){      ←If using temperature sensor
                if(ad < 66)
                {
                        IO_PDR1.bit.P14 = 0;
                        IO_PDR1.bit.P15 = 1;    ←Change LED display
                        IO_PDR1.bit.P16 = 0;
                }
                (Omitted)
        }
        IO_ADC1.bit.AD = 1;             ←Start A/D conversion
}
```

Figure 4-17 A/D converter interrupts

5 Try to use LIN communication

Communication is to send/receive information. There are, in fact, various communications formats, such as transmission by people talking, letters written in script, and electronic communications, etc. Among these, there are various plans for communications using electricity. This chapter explains communications in a standard called LIN.

5.1 What is LIN?

LIN is an acronym for Local Interconnect Network, and is a type of communications protocol for vehicle-mounted LAN. The LIN consortium was proposed in 1999 with the objective of enabling a less expensive configuration than CAN, which is the most widespread control system vehicle-mounted LAN. Thereafter, after several version upgrades, LIN2.0, which has added diagnostic and other functions, was launched in 2003. Further, in 2006, the version was upgraded to LIN2.1.

This section explains LIN applications. Concomitant with multi-function vehicles, the existence of a network in vehicles also became indispensable. Currently, vehicle-mounted LANs are broadly divided into two classifications: control systems, which are concerned with motoring and the vehicle body, and information systems, which connect devices such as the satellite navigation system and audio, and so different LANs are used depending on the application. In particular, vehicle body devices such as electric mirrors and power windows, which are classified as body systems, do not require such fast or detailed control. Consequently, they are also inexpensive. This is where LIN is used.

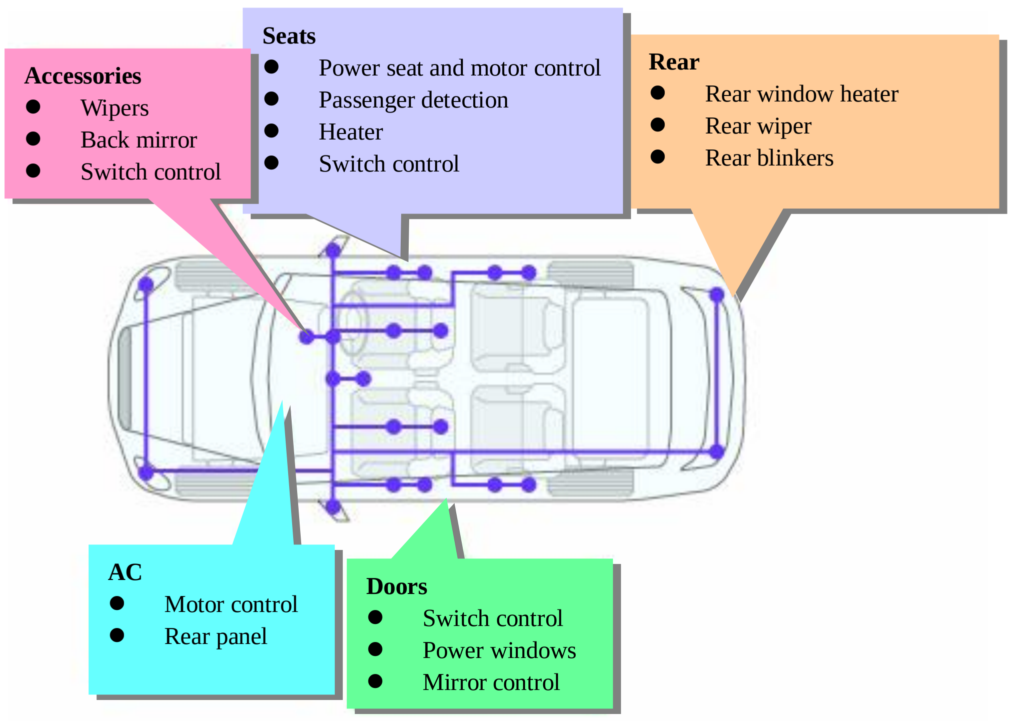


Figure 5-1 Example of vehicle LIN applications

The characteristics of LIN used in the way described above, are collated and introduced in the following five points.

1. Single master communication

   LIN has two types of communication nodes. One is the "master" (sender).This controls the start of all communications. The other is the slave (recipient).The slave responds to commands sent by the master. LIN communication must start from the master, and cannot be started by a slave. Further, the LIN communication mode designated as the master is pre-determined. This format is called a "single master format".

2. A maximum of 15 slave nodes can be connected using bus wiring.

   The LIN network configuration (topology) is a bus. With single master LINs, the slaves communicate only when they receive commands from the master, so there is no conflict of signals in the bus. A maximum of 15 slave nodes can be connected to one master.

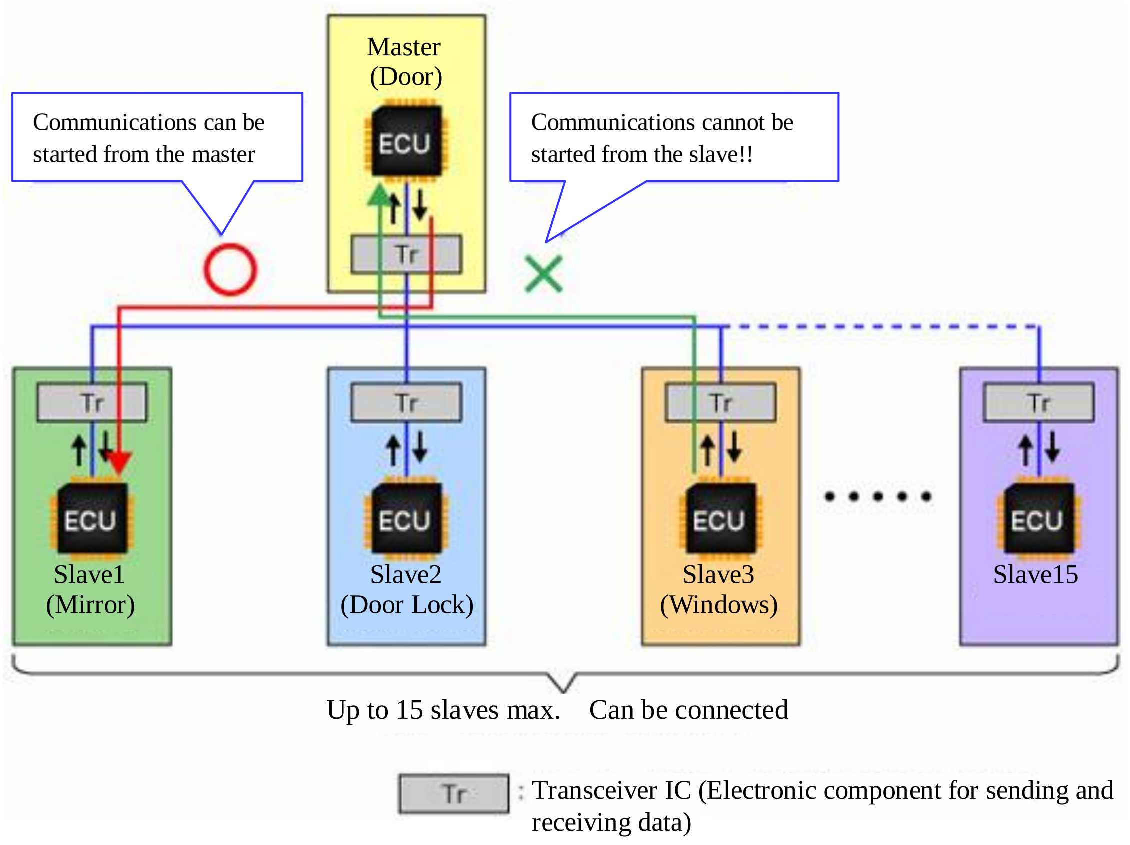

Master
(Door)
ECU
Tr
Communications can be started from the master
Communications cannot be started from the slave!!
Tr
ECU
Slave1
(Mirror)
Tr
ECU
Slave2
(Door Lock)
Tr
ECU
Slave3
(Windows)
Tr
ECU
Slave15
Up to 15 slaves max. Can be connected
Tr : Transceiver IC (Electronic component for sending and receiving data)

Figure 5-2 Main LIN network configuration

3. Wiring is completed using a single wire

   The on-board ECUs are connected to the LIN network via transceiver ICs (electronic components that send and receive data), and each ECU is connected on the bus from the master

to a slave. An ordinary single metal wire is used as the bus cable. CAN combines two opposing metal wires to make one twisted pair cable. FlexRay uses two twisted pair cables. Consequently, LIN has the advantage of using a single cable for numerous network wires, unlike CAN and FlexRay, which use twisted pair cables.
The communications distance is 40m max. LIN can be used in combination with CAN, and in such cases, CAN is most frequently used as the core network, and LIN is used as the branch network.

4. The baud rate is 20kbps max.
   The baud rate according to LIN specifications is within the range 1 to 20kbps. Practically, the baud rate of LINs used as LANs depends on the individual vehicle manufacturer's system specifications, but generally one of the following is used: 2,400kbps, 9,600kbps, or 19,200kbps.

5. Communications errors are detected only, and subsequent processing depends on the application
   With LIN, communications errors are detected based on information as to whether transmitting and receiving has been performed successfully. Processing after an error has been detected, however, is not specified. Here, LIN error processing can be customized according to the application. CAN and FlexRay management of the communications status depends on the counter value, which is called the error counter, is featured by the specifications, but in LIN, if an error occurs, simple error processing is possible, in which LIN merely waits for the next command.

5.2 LIN specifications

This section explains briefly the LIN specifications.

For detailed specifications, access the LIN consortium website (http://www.lin-subbus.org/), and register your name and e-mail address to get a specifications.

5.2.1 Lin frame configuration

This section explains frames, which is the basic unit of LIN communication.
LIN frames are configured using "headers" and "responses". As shown in "Figure 5-3 LIN communication flow", the basic communications flow is a procedure in which the master sends headers to the slaves, and the slaves implement processing according to the contents of the headers received, and then send a response to the master.

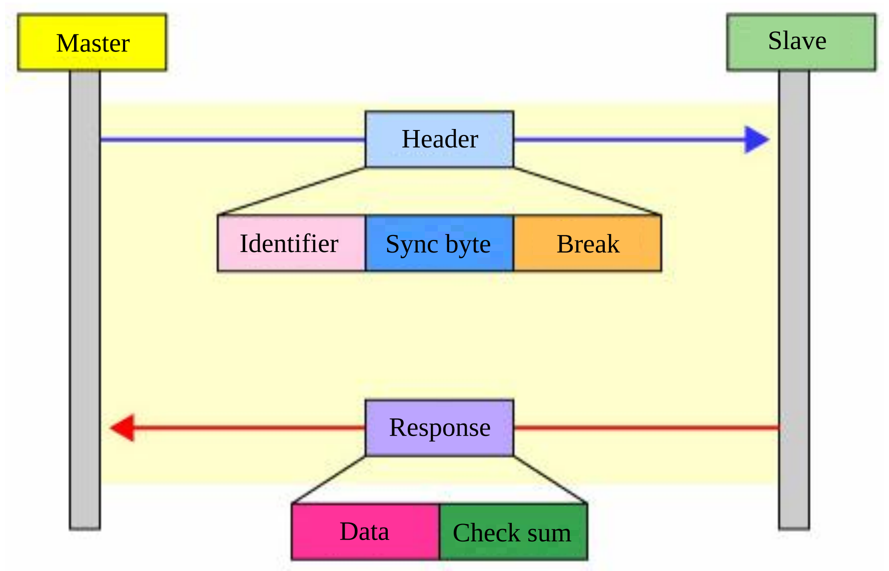


Figure 5-3 LIN communication flow

Further, headers are configured using three fields: Break, Sync byte, and ID field (Identifier), and responses are configured using two fields: Data field and Checksum field.

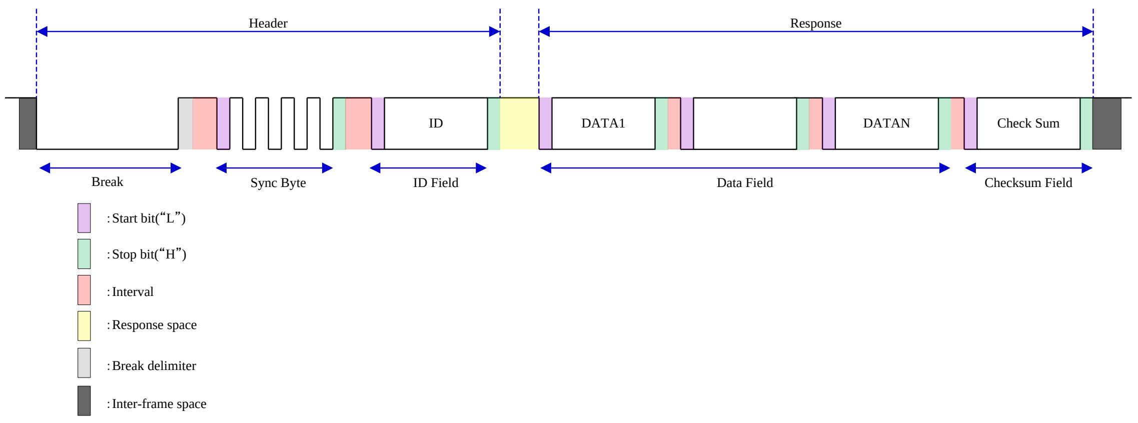


Figure 5-4 LIN frame configuration

1. Break

   Break, which are in the header fields, are variable-length fields that indicate the start of a new frame. They comprise 13 to 16 “0” bits (fixed value zero) min. The general frame length is 13 bits.

2. Sync Byte

   Sync byte, which follow on from breaks, are 10-bit fixed-length fields that synchronize the master and the slaves. Sync byte configurations comprise 1 starter bit (“0”), 8 data bits, and 1 stop bit (“1”).The 8-bit data bit has the fixed value “0x55” (which is expressed as “0x01010101” in binary).If the slave receives the 0x55 in the synch byte send by the master normally, the master and slave are synchronized.

3. ID field

   The “ID field”, which is the final header field and comes after the synchronous byte, is a 10-bit fixed-length field that specifies the frame type and objective. ID fields have values from “0” to “63” (6 bits).This ID field is also used by the master to specify individual slaves. Slaves judge what type of frame has been sent and if it was intended for them according to the ID field sent by the master, and send responses to the master accordingly. Further, the ID field has a 2-bit parity bit following the “0” to “63” (6 bits).This is bracketed by a 1-bit starter bit and 1-bit stop bit in the same way as the synchronous byte, so overall the field is 10 bits in length.

4. Data field

   The “data”, which is in the response header, is a variable-length field that literally transfers data. The data in the number of bytes that has been predetermined (1 to 8 bytes) is sent. As there is a 1-bit start bit and 1-bit stop bit bracketing the 1-byte data in the same way as the header synchronous byte, 1 byte of data is configured from 10 bits. Consequently, the total data field length is “number of bytes x 10 bites”.

5. Checksum field

   The “checksum”, which follows the data, is a 10-bit fixed-length field for checking data. The data recipient checks whether there is an error in the data by comparing the data received with the checksum. The checksum field length is also 10 bits: a start bit and a stop bit added to the 8-bit checksum in the same way as the synchronous byte.

5.3 LIN communication flow

In general LIN communication, one master communicates with numerous slaves. LINs, which adopt a bus topology, connect the master and all the slaves using a single wire, so header electrical signals sent by the master are transmitted by the wire to all the slaves. The slaves check the frame ID, and if the header is addressed to them, sent a response to the master according to the content received. If the header received is addressed to another slave, it is ignored. In this way, 1-to-1 communication between the master and each slave is achieved.

This section explains the actual trading of communications. Currently, functions are allocated to each of the slaves from 1 to 15.The master first communicates with slave 1 and turns the motor ((1) in Figure 5-5 Main LIN network configuration and Figure 5-6 Example of communication sequence between the master and slaves during normal communication), and next acquires sensor information by communicating with slave 3. ((2) in “Figure 5-5 Main LIN network configuration” and Figure 5-6 Example of communication sequence between the master and slaves during normal communication.) Thereafter, the motor is turned by communications with slave 2 ((3) in Figure 5-5 Main LIN network configuration and Figure 5 6 Communications sequence between master and slave during normal communications).The master acquires sensor information from slave 3 again ((4) in Figure 5-5 Main LIN network configuration and Figure 5 6 Communications sequence between master and slave during normal communications), and finally turns ON the lamp by communicating with slave 15 ((5) in Figure 5-5 Main LIN network configuration and Figure 5 6 Communications sequence between master and slave during normal communications).In this chain of communications, communications between the master and slaves 2 and 3 are contiguous, and the master processes the motor turning by communicating with slave 2 using sensor information acquired by communicating with slave 3 first. In this way, during actual communications the master and multiple slaves repeatedly communicate on a 1-to-1 basis.

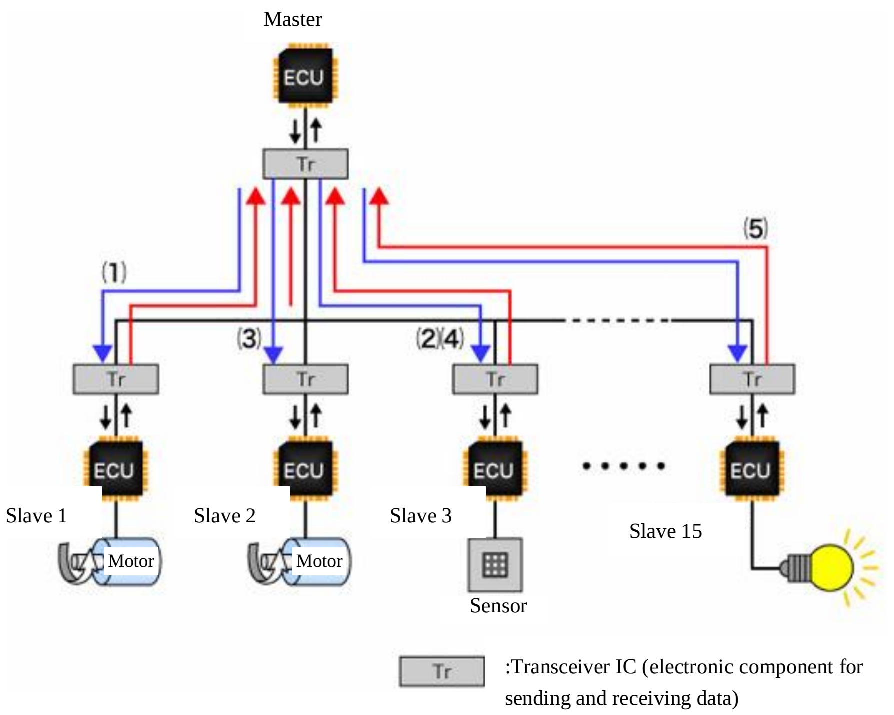


Figure 5-5 Main LIN network configuration

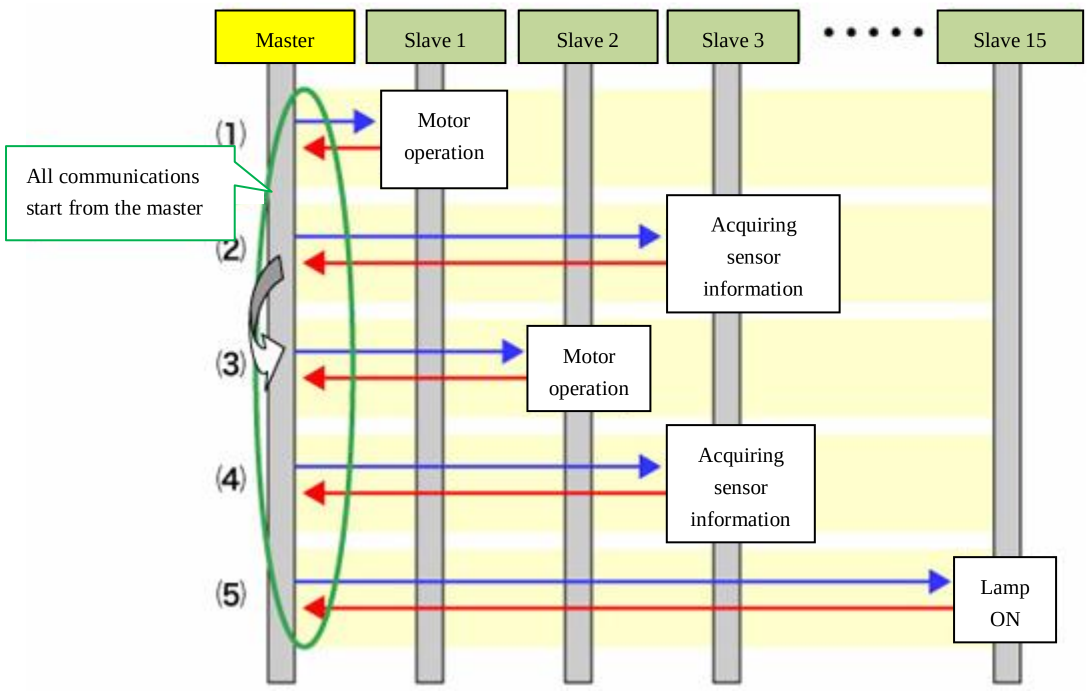

Master
Slave 1
Slave 2
Slave 3
Slave 15
(1)
(2)
(3)
(4)
(5)
All communications start from the master
Motor operation
Acquiring sensor information
Motor operation
Acquiring sensor information
Lamp ON

Figure 5-6 Example of communication sequence between the master and slaves during normal communication

5.4 Communication between master and slave if an error occurs

LIN error processing is not determined by the protocols, and so depends on the application. Consequently, during design, it is necessary to consider the error detection methods and the process after the error has been processed. As this is not determined by the protocols in the LIN specifications either, however, examples of system design if an error occurs are introduced in the chapter “Status Management”. In the examples introduced, errors are managed by slaves reporting their own status to the master. This mechanism is described below.

The basic master operation is merely to send the header to the next slave when communications with the current slave have ended. On the other hand, the slave operation is to perform error checking when a header is received and when a response is sent. Checksums and other checks are implemented during reception. When sending, checks are performed by comparing the sent data and the bus data that performs the monitoring. In this way, the slave identifies its own status, and inserts the results into the response that is sent to the master. The master identifies the slave status from the response, and if there is a nonconformance, initializes the slave. In this way, the error status is completely cleared.

5.5 LIN communication by using microcontroller

This section explains practical LIN communication using microcontrollers.

In the starter kit, the microcontroller and LIN transceiver IC (TJA1020T) are connected as shown in "Figure 5-7 LIN circuit".In the microcontroller, SOT sends, SIN receives, and SCK is the port that controls the transceiver IC. Sending and receiving signals flow on the bus via the LIN transceiver IC.

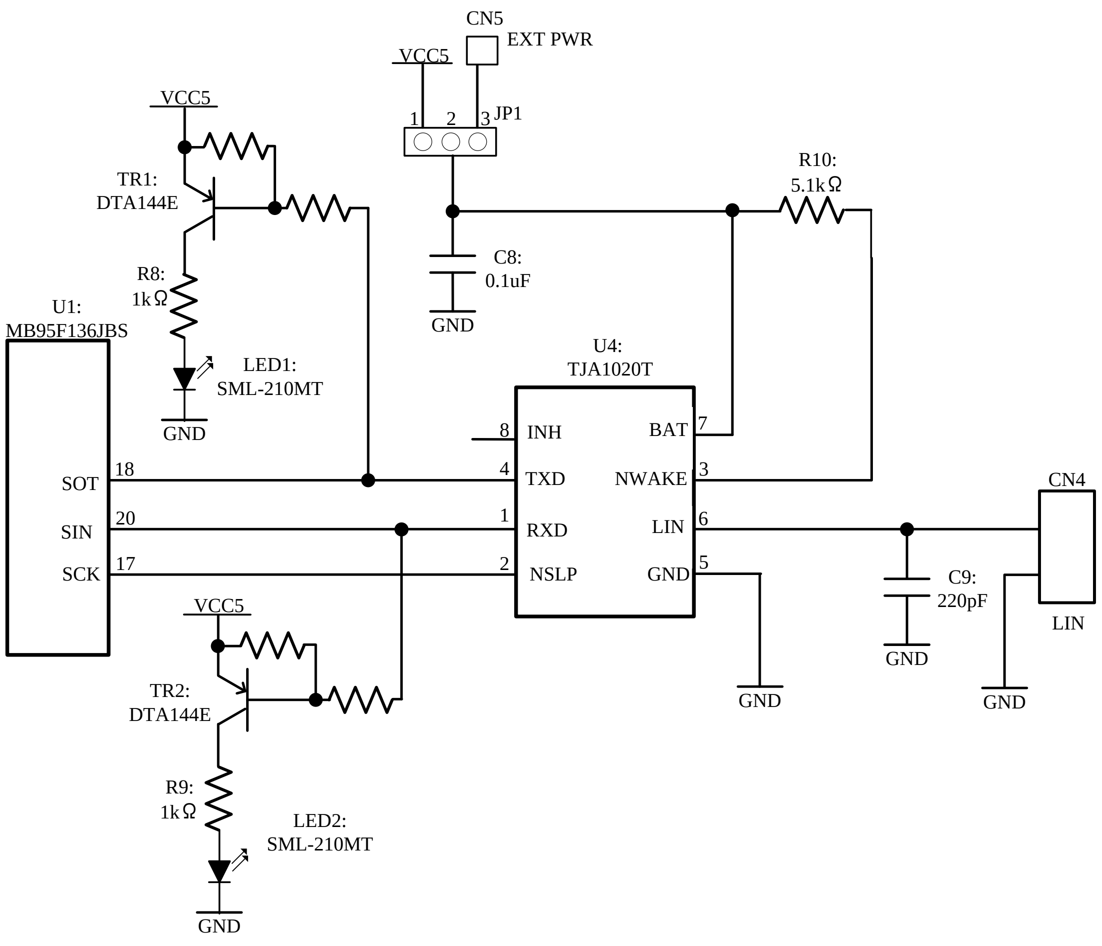


Figure 5-7 LIN circuit

The registers used for entire LIN communication control on the microcontroller are as described in “Figure 5-8 Entire LIN communication control registers”. Registers named “res” cannot be used as they are reserved bits.

The description of each register, and the setting values in the sample programs, are described in “Table 5-1 Description of the entire LIN communication control registers and setting values”. For more information of the registers, refer to the microcontroller hardware manual.

LIN-UART serial control register

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SCR	PEN	P	SBL	CL	AD	CRE	RXE	TXE

LIN-UART serial mode register

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SMR	MD1	MD0	OTO	EXT	REST	UPCL	SCKE	SOE

LIN-UART serial status register

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
SSR	PE	ORE	FRE	RDRF	TDRE	BDS	RIE	TIE

LIN-UART data receiving register / data send register

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
RDR/TDR								

LIN-UART expanded status control register

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
ESCR	LBIE	LBD	LBL1	LBL0	SOPE	SIOP	CCO	SCES

LIN-UART expanded communications control register

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
ECCR	res	LBR	MS	SCDE	SSM	res	RBI	TBI

LIN-UART baud rate generator register 1

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
BGR1	-							

LIN-UART baud rate generator register 0

	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
BGR0								

Figure 5-8 Entire LIN communication control registers

Table 5-1 Description of the entire LIN communication control registers and setting values

Register name	Set value (contents)	Explanation
SCR_PEN	0 (no parity)	Parity authorization bit
SCR_P	0 (even parity)	Parity selection bit
SCR_SBL	0 (1 bit)	Stop bit length selection bit
SCR_CL	1 (8 bit)	Data length selection bit
SCR_AD	0 (data frame)	Address / data format selection bit
SCR_CRE	1 (clear flag)	Clear reception error flag bit
SCR_RXE	0 (Receive prohibited)	Receive prohibition enable bit
SCR_TXE	1 (Transmit enabled)	Transmit enable bit
SMR_MD1	1 (mode 3)	Operation mode selection bit
SMR_MD0	1 (asynchronous LIN mode)	
SMR_OTO	0 (use external clock)	1-to-1 external input enable bit
SMR_EXT	0 (use baud rate generator)	External serial clock source selection bit
SMR_REST	0	Reload counter restart bit
SMR_UPCL	1 (LIN-UART reset)	Programmable clear bit (LIN-UART software reset)
SMR_SCKE	0 (general I/O port or LIN-UART clock input pin)	Serial clock output enable bit
SMR_SOE	1 (LIN-UART serial data output pin)	Serial data output enable bit
SSR_BDS	0 (LSB first (transfer from least significant bit))	Transfer direction selection bit
SSR_RIE	1 (Receive interrupt enable)	Receive interrupt request enable
SSR_TIE	0 (Transmit interrupt prohibited)	Transmit interrupt request enable
ESCR_LBIE	0 (LIN synch break detection interrupt prohibited)	LIN synch break detection interrupt enable bit
ESCR_LBD	0 (LIN synch break detection flag clear)	LIN synch break detection flag bit
ESCR_LBL1	0	LIN synch break length selection bit
ESCR_LBL0	0 (13 bits)	
ESCR_SOPE	0 (serial output pin access prohibited)	Serial output pin direct access enable bit
ESCR_SIOP	0	Serial I/O pin direct access enable bit
ESCR_CC0	0	Continuous clock output enable bit
ESCR_SCES	0	Sampling clock edge selection bit

ECCR_LBR	0 (LIN synch break not created)	LIN synch break creation bit
ECCR_MS	0	Serial clock send/receive selection bit
ECCR_SCDE	0	Serial clock delay enable bit
ECCR_SSM	0	Start / stop bit mode enable bit
BGR_BGR1	0x16 (when set to 9600bps)	Baud rate generator 1
BGR_BGR0	0x66 (when set to 9600bps)	Baud rate generator 0

5.6 Understanding and overview of the program for LIN communication

This section explains sample programs as programs that actually perform LIN communication. In bits pot LIN communication, the starter kit operates as a LIN slave, and bits pot white operates as the master.

5.6.1 LIN communication configuration

The LIN communication conditions for the sample program are described in "Table 5-2 LIN communication conditions".

Table 5-2 LIN communication conditions of the sample program

Condition	Setting value
Baud rate	2400 / 9600 (default value) / 19200bps
Peripheral clock frequency	16MHz
Synch break length	13 bits (Receive is fixed to detect 11-bits)
Data length	8 bits
Data bit format	LSB first
Data byte count	8 bytes

Next, this section explains message IDs using LIN communication as described in "Table 5-3 LIN message IDs in the sample program".

Table 5-3 LIN message IDs in the sample program

ID	Description	Communication direction
0x00	Temperature measurement command / temperature display command	white → yellow
0x01	Temperature sensor information	white → yellow white ← yellow
0x02	Buzzer output command / volume value measurement command	white → yellow
0x03	Volume (VR) information	white → yellow white ← yellow
0x04	LED ON change command: count up / count down	white → yellow
0x05	LED value	white → yellow white ← yellow

The details of each ID are explained below.

1. ID: 0x00

byte 0	Temperature measurement command
byte 1	A/D value (temperature sensor information)
byte 2	Reserved
byte 3	Reserved
byte 4	Reserved
byte 5	Reserved
byte 6	Reserved
byte 7	Reserved

Field name	**Setting value**	**Remarks**
Temperature measurement command	0x55: Start; 0x0F: Stop	If bits pot white SW4 is set to the right, temperature information is acquired from the temperature sensor on the starter kit by receiving 0x55. If bits pot white SW4 is set to the left, no operation is performed.
A/D value (temperature sensor information)	0 to 255	This is temperature sensor information from the bits pot white. The temperature is displayed on the starter kit using this A/D value.

2. ID: 0x01

byte 0	Reserved
byte 1	Reserved
byte 2	A/D value (temperature sensor information)
byte 3	Reserved
byte 4	Reserved
byte 5	Reserved
byte 6	Reserved
byte 7	Reserved

Field name	Set value	Remarks
A/D value (Temperature sensor information)	0 to 255	This is the starter kit response to the ID 0x00 temperature measurement command. Temperature sensor information is sent as A/D values, and displayed on the bits pot white 7SEG LED.

3. ID: 0x02

byte 0	Volume value acquire command
byte 1	A/D value (VR information)
byte 2	Reserved
byte 3	Reserved
byte 4	Reserved
byte 5	Reserved
byte 6	Reserved
byte 7	Reserved

Field name	Set value	Remarks
Volume value acquire command	0x55: Start; 0x0F: Stop	If bits pot white SW4 is set to the right, volume information is acquired from the starter kit by receiving 0x55, and the buzzer sound is output. If bits pot white SW4 is set to the left, the buzzer sound is not output.
A/D value (VR information)	0 to 255	This is the bits pot white volume information. The starter kit outputs the buzzer sound according to the A/D value received.

4. ID: 0x03

byte 0	Reserved
byte 1	Reserved
byte 2	A/D value (VR information)
byte 3	Reserved
byte 4	Reserved
byte 5	Reserved
byte 6	Reserved
byte 7	Reserved

Field name	Setting value	Remarks
A/D value (VR information)	0 to 255	This is the response to the ID 0x02 volume value measurement command. The volume information is sent as A/D values.

5. ID: 0x04

byte 0	LED on/off change command
byte 1	Reserved
byte 2	Reserved
byte 3	LED value
byte 4	Reserved
byte 5	Reserved
byte 6	Reserved
byte 7	Reserved

Field name	Setting value	Remarks
LED on/off change command	0x55: Start; 0x0F: Stop	This is the LED on/off change command from bits pot white. If bits pot white SW4 is set to the left, 0x55 is received, and if the LED value is not 0xFF, the received LED value is displayed on the starter kit LED.
LED value	0 to 7 (otherwise 0xFF)	This is the value of the LED displayed on bits pot white. when 0xFF is received, the data is invalid.

6. ID: 0x05

byte 0	Reserved
byte 1	Reserved
byte 2	Reserved
byte 3	LED value
byte 4	Reserved
byte 5	Reserved
byte 6	Reserved
byte 7	Reserved

Field name	**Set value**	**Remarks**
LED value	0 to 7	This is the value of the LED displayed on the starter kit.

5.6.2 Sample programs sequence

The LIN communication flowcharts for the sample programs are shown in “Figure 5-9 LIN communication flowchart (main routine)” and “Figure 5-10 LIN communication flowchart (interrupt routine: UART reception interrupts)”.First, initialize the microcontroller, LIN-UART, and timer. Next, implement LIN bus connection processing as a LIN slave. Thereafter, the program enters a loop. Within the loop, monitor whether the data being sent and received can be completed in a fixed cycle, and when the data has finished being received, implement processing according to the ID. Synch break detection, ID reception, and data sending and receiving to operate as a LIN slave is processed using LIN-UART reception interrupts. Further, the baud rate is adjusted within the input capture interrupts as described in “Figure 5-11 LIN communication flowchart (interrupt routine: input capture interrupts)".

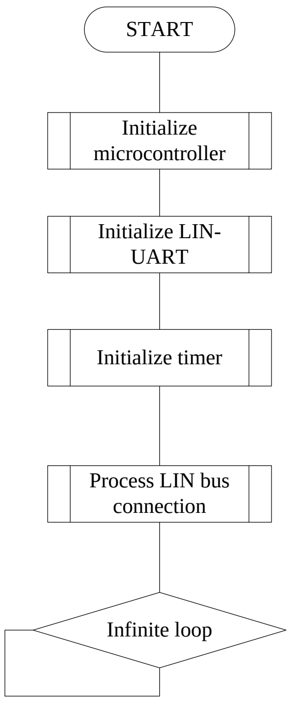


Figure 5-9 LIN communication flowchart (main routine)

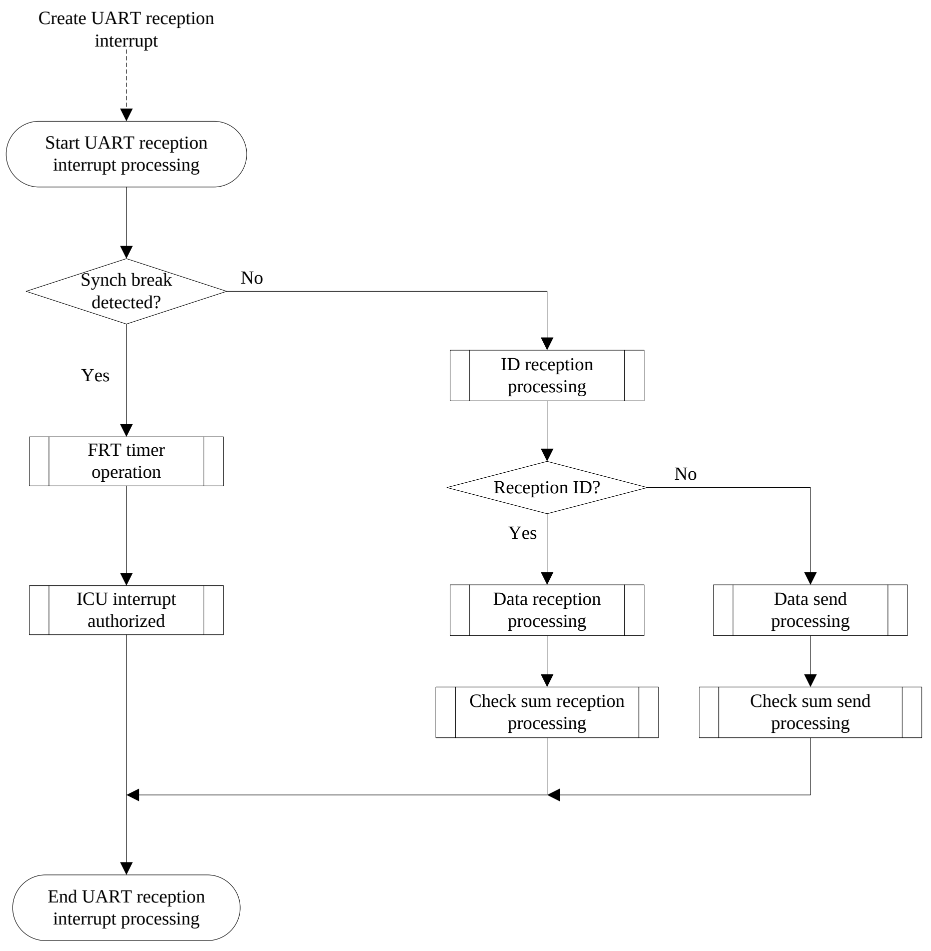

Create UART reception interrupt
Start UART reception interrupt processing
Synch break detected?
No
Yes
ID reception processing
FRT timer operation
Reception ID?
No
Yes
ICU interrupt authorized
Data reception processing
Data send processing
Check sum reception processing
Check sum send processing
End UART reception interrupt processing

Figure 5-10 LIN communication flowchart (interrupt routine: UART reception interrupts)

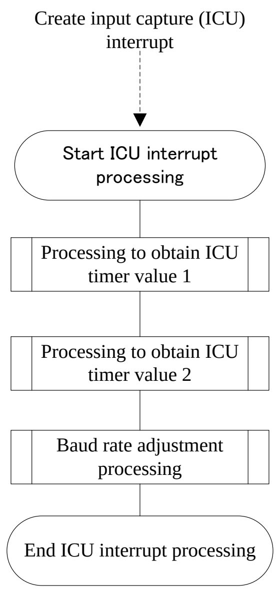

Create input capture (ICU) interrupt
Start ICU interrupt processing
Processing to obtain ICU timer value 1
Processing to obtain ICU timer value 2
Baud rate adjustment processing
End ICU interrupt processing

Figure 5-11 LIN communication flowchart (interrupt routine: input capture interrupts)

The next section explains the sample programs, but the sample programs contain parts in which LIN communication with bits pot white are not used. To make these parts expandable, programs commensurate with LIN use are included. Not all operations, however, are checked. Be careful when using.

The operations points of the sample program in the LIN protocol during LIN communication are shown below. The sample software operates as a LIN slave through multiple interrupt processes, as shown in "
Figure 5-12 Operations points of interrupt processes". Look at the processing of the sample software in the LIN frame fields.

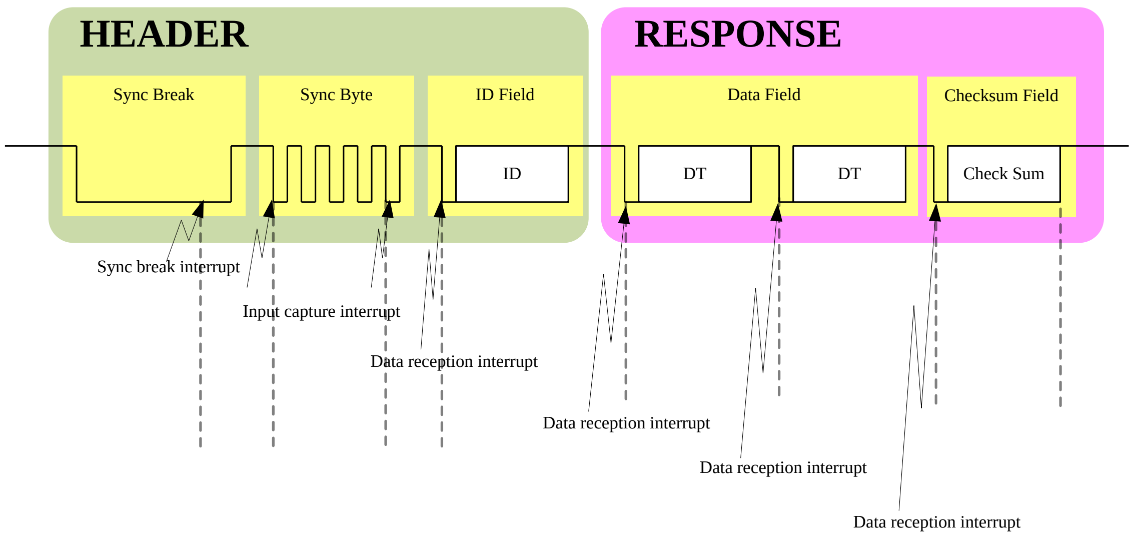


Figure 5-12 Operations points of interrupt processes

① Sync break

In sync breaks, the sync break signals (13 to16-bit Low signals) are received from bits pot white (the master), and when the bus reaches "0" in the 11-bit time or greater, a sync break interrupt is created. When a sync break interrupt is detected, the sync break interrupt prohibition settings and input capture interrupts are authorized, and the system migrates to waiting for the synch field to start.

```
__interrupt void   _LinUartRx(void)
{
        if ((ssr & 0xE0) != 0) {                      ←Error check
        (Omitted)
        } else if (ESCR_LBD == SET) {                 ←Synch break detection
        ESCR_LBD = CLEAR;                             ←Clear synch break detection flag
        (Omitted)
        vSetLinFreerunTimersCompare(hTHEADER_MAX_IND);   ←Complex timer (FRT)
                                                           value set
        ucLinStatus = LIN_WAIT_SYNCH_FIELD_START;     ← State transition:
                                                           Wait synch field start
        (Omitted)
        T00CR1_IE = SET;          ←Input capture interrupt enabled
}
```

Figure 5-13 Synch break interrupt control

② Sync Byte

LIN slaves measure the baud rate using input capture in the sync Byte and perform compensation after a synch break has been detected. In the sample software, 8/16-bit complex timers are used as the input capture, and are set to both edges and free run mode. In free run mode, when an edge is detected, the counter value is sent to the data register, and the interrupt flag changes to "1", so the counter is not cleared, and the count operations continue as is.

When the input capture interrupts are set to enabled and both edge detection, when an edge is detected, an input capture interrupt is created. The timer value at both edges and the number of overflows are measured, and the baud rate calculated and adjusted using interrupts at 8.

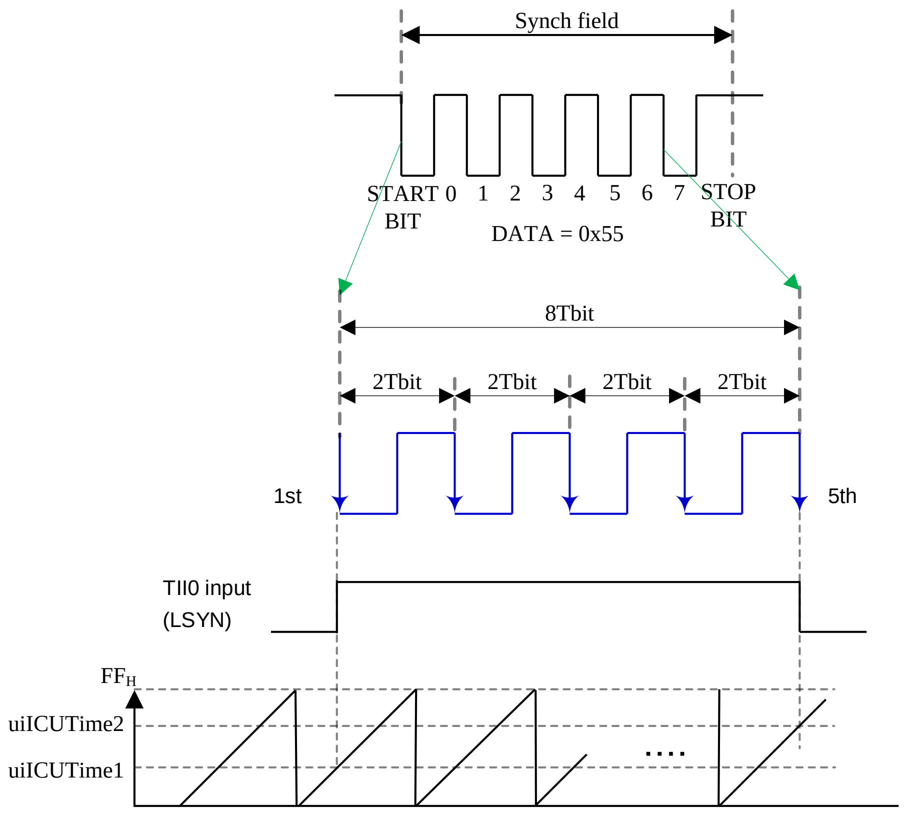


Figure 5-14 Input capture operation in the synch field

```
__interrupt void    _LinICU (void)
{
  (Omitted)
    if (T00CR1_IR ==    SET) {              ←Check edge detection interrupt
                (Omitted)
                if (ucLinStatus == LIN_WAIT_SYNCH_FIELD_START){     ←Synch field start wait
                            uiICUTime1 = T00DR;         ← Acquire timer value
                            (Omitted)
                            ucLinStatus =    LIN_WAIT_SYNCH_FIELD_END;     ←State transition:
                else if(ucLinStatus == LIN_WAIT_SYNCH_FIELD_END){          synch field end wait
                            (Omitted)
                            uiICUTime2= T00DR;          ← Acquire timer value
                            /*    adjust Baud Rate    */            ←Baud rate adjustment processing
                            (Omitted)
                            vEnableLinUartReception();              ←LIN-UART interrupt authorized
                            ucLinStatus = LIN_ID_RECEPTION;         ←State transition: ID received
                }
                (Omitted)
    }else if(T00CR1_IF == SET){             ←Check whether there is an overflow interrupt
                (Omitted)                   ← Acquire number of overflows
    }
}
```

Figure 5-15 Input capture (ICU) interrupt controls

③ ID field

ID reception processing is performed in the LIN-UART interrupt function _LinUART(void).When an interrupt is created, if no error is created and the cause of the interrupt isn't a synch break interrupt, reception processing is performed.

```
__interrupt void   _LinUART (void)
{
    (Omitted)
    if ((ssr & 0xE0) != 0) {                    ←Error check
              (Omitted)
    } else if (ESCR_LBD == SET) {               ← Synch break detection
              (Omitted)
    }else{
           l_ifc_rx(data);                      ← Receive processing
    }
}
```

Figure 5-16 LIN-UART receive interrupt control

Processing is divided into ID reception, data sending, data reception, and wakeup sending according the status in the reception judgment processing function l_ifc_rx(l_ifc_handle rx_data) as shown in "Figure 5-17 Receive determination processing".In normal sequences, to migrate the status during the second input capture interrupt process to ID FIELD reception waiting, ID reception processing is performed. In ID reception processing, the ID that has been acquired is judged to be either a send ID or reception ID and parity check performed, and if it is a send ID, the status is migrated to send preparation status, and the data to be sent is copied to the buffer. If the ID is a reception ID, the status is migrated to data reception wait status, and a response (data) is received from the master.

```
void        l_ifc_rx(l_ifc_handle rx_data){
    switch(ucLinStatus){
    case   LIN_TRANSMIT:                    ←DATA FIELD send status
               (Omitted)
    case   LIN_DATA_RECEPTION:              ←DATA FIELD receive status
               (Omitted)
    case   LIN_ID_RECEPTION:                ←ID FIELD reception wait status
           ucCurrentId.byte    = rx_data;        ←Store received ID
           if( ucCurrentId.fields.parity != ucRightParity[ucCurrentId.fields.id] ) {    ←Parity check
               (Omitted)                         ←Error processing
           else if( LinRxDataPtr[ucCurrentId.fields.id] != 0 ) {         ←If ID received
                ucLinStatus = LIN_DATA_RECEPTION;            ←State transition: DATA reception
                (Omitted)                                     wait status
                vSetLinFreerunTimersCompare(ucRxCount);      ←8/16bit complex timer set
           } else if ( LinTxDataPtr[ucCurrentId.fields.id] != 0 ) {
                ucLinStatus = LIN_PRETRANSMIT;
               (Omitted)                                     ↓Copy send data to buffer
                vLinWordCopy(ucUartTxBuffer, LinTxDataPtr[ucCurrentId.fields.id], ucTxCount);
                vSetLinFreerunTimersCompare(hTINFRAME_SPACE_IND);     ←8/16bitcomplex
           }                                                          timer set


               (Omitted)
    case   LIN_WAKEUP_TRANSMIT:             ←WAKEUP send status
               (Omitted)
    }
}
```

Figure 5-17 Receive determination processing

④ DATA field

This section explains data sending and reception processing in the data field.

First, regarding data sending, if the ID received in the ID field is for a send ID, the vTimeoutCheckTask function is called by the 8/16-bit complex timer (free run timer) interrupt, as shown in “Figure 5-18 Timeout detection processing”.This function is called when the timeout value set using the free run timer is detected, and in this case, is called the detection of the timeout values from the header reception to the response sending (response space).In the vTimeoutCheckTask function, processing is separated into pre-sending and initialization processing, etc., according to the status information, and if the status is pre-sending, the first data byte is sent.

```
void        vTimeoutCheckTask(void){
        (Omitted)
        if ( uiIntDemandCounter == 0 ) {
                switch ( ucLinStatus ) {
                case        LIN_PRETRANSMIT:                  ←Status before sending
                        ucLinStatus = LIN_TRANSMIT;           ←State transition: DATA FIELD send
                                                               status
                        ucSaveData = ucUartTxBuffer[0];       ←Acquiring 1-byte send data
                        l_ifc_tx(ucUartTxBuffer[0]);          ←Data transmit processing
                        (Omitted)
                case        LIN_UART_INITIAL:
                                (Omitted)
                case        LIN_ID_RECEPTION:
                                (Omitted)
                case        LIN_DATA_RECEPTION:
                                (Omitted)
                case        LIN_TRANSMIT:
                                (Omitted)
                case        LIN_WAIT_SYNCH_FIELD_START:
                                (Omitted)
        }
}
```

Figure 5-18 Timeout detection processing

When sending the first data byte, a reception interrupt is created by receiving the self-sent data. Whereupon, the reception judgment processing function _ifc_rx(l_ifc_handle rx_data) is called in the same way as for ID field operations, and the data is sent from the second byte onwards according to the data field send status as shown in “Figure 5-19 Data send processing”, and the same process is repeated. In these LIN communication, the number of data bytes is set to 8, so when the eighth data byte has finished being sent, finally a checksum is sent, and the send processing ends.

```
void        l_ifc_rx(l_ifc_handle rx_data){
    switch(ucLinStatus){
    case    LIN_TRANSMIT:        ←DATA FIELD send status
            if ( ucTxCurrentIndex < ucTxCount ){          ←If any send data is remaining
            (Omitted)
            l_ifc_tx(ucUartTxBuffer[ucTxCurrentIndex]);   ←Send processing
            (Omitted)
            } else if ( ucTxCurrentIndex == ucTxCount ){  ←If send data has all been sent
            (Omitted)
            l_ifc_tx(((unsigned char)~uiTxCheckSum));     ←Check sum send processing
            (Omitted)
            }
    case    LIN_DATA_RECEPTION:
            (Omitted)
    case    LIN_ID_RECEPTION:
            (Omitted)
    case    LIN_WAKEUP_TRANSMIT:
            (Omitted)
    }
}
```

Figure 5-19 Data send processing

The next section explains data reception processing.

If the ID acquired using ID reception processing is for reception, the status is migrated to data reception status, and data reception from bits pot white awaited. When a data reception interrupt is created by bits pot white sending data, reception is processed in the reception processing function l_ifc_rx(l_ifc_handle rx_data as shown in "Figure 5-20 Data reception processing".When data is received as well, reception is processed using l_ifc_rx(data) each time one byte of data is received in the same way as for the second byte onwards for data that has been sent, and when all eight bytes of data have been received, if there is no checksum error, the reception successful flag is set, and reception processing ends.

```
void        l_ifc_rx(l_ifc_handle rx_data){
    switch(ucLinStatus){
    case   LIN_TRANSMIT:
           (Omitted)
    case   LIN_DATA_RECEPTION:                ←DATA FIELD reception status
           if ( ucRxCurrentIndex >= ucRxCount ) {      ←If all data has been received
                if ( (uiRxCheckSum + rx_data) == 0xFF ) {    ←If Checksum calculations are normal
                     (Omitted)
                     flagsLinTxRx.bit.SucceedReception = SET;     ←Reception successful flag set
                     memcpy( &ucUartRxFixedBuffer[0], &ucUartRxBuffer[0], ucRxCount );
                     (Omitted)                         ↑ Copy received data
                } else {                              ←If there is a check sum error
                     l_flg_tst(hCHECKSUM_ERR);        ←Error processing
           } else {                                ←If there is still remaining reception data
                ucUartRxBuffer[ucRxCurrentIndex] = rx_data;     ←Received data stored to buffer
                (Omitted)
    case   LIN_ID_RECEPTION:
           (Omitted)
    case   LIN_WAKEUP_TRANSMIT:
           (Omitted)
    }
}
```

Figure 5-20 Data reception processing

Finally,about the processes according to the ID received, there is a vBaseTimeTask function around the 100th line of the main routine. This function is called periodically at set cycles, and mainly checks whether or not sending and receiving has finished. If this function is called when all data has finished being sent (i.e., when flagsLinTxRx.bit.SucceedReception has been set), the submain function is called as the reception completion processing as shown in “Figure 5-21 Submain processing”, and temperature measurement processing, buzzer output processing, LED ON processing, and sent data storage are performed.

```
void      submain(void)
{
      switch (ucCurrentId.fields.id){
           case   0x00                    ←ID: 0x00
                   if (ucDATA00[0] == 0x55){
                         IO_ADC2.byte = 0xCB;
                         IO_ADC1.byte = 0x71;      ←Start AD interrupt
                         if(ad_master < 42){          (obtain temperature information)
                            IO_PDR1.byte = LED_pat2[1];      ←Temperature information LED display
                            (Omitted)
           case   0x02
                            IO_ADC2.byte = 0xCB;
                            IO_ADC1.byte = 0x11;   ←Start AD interrupt (obtain VR information)
                            IO_PC00.byte = 0x0E;
                            (Omitted)              ←Buzzer output
           case   0x04
                            if ((ucDATA04[0] == 0x55)&&(ucDATA04[3] != 0xFF)){
                                  (Omitted)        ←Received LED value ON processing
                            else if (LED_count_Flag == 1){      ←If switch 2 is pressed
                                  (Omitted)
                                  ucDATA05[3] = LED_count1;     ←LED value stored after count increases
                            else if (LED_count_Flag == 2){      ←If switch 3 is pressed
                                  (Omitted)
                                  ucDATA05[3] = LED_count1;     ←LED value stored after count decreases
           default:
                                       break;
```

Figure 5-21 Submain processing

6 Appendix

6.1 Sample program folder/file configuration

The folder/file configuration of the sample program is shown in "Table 6-1 Sample program folder/file configuration".

Table 6-1 Sample program folder/file configuration

File/folder name	Provision of the file		Explanation
	Single	Monitor	
bits_pot_yellow_SampleProgram／bits_pot_yellow_Sampleprogram_singlechip ／bits_pot_yellow_Sampleprogram_monitordebugger			
bitspot_yellow_SampleProgram.wsp	Yes	No	Softune workspace file
singlechip_operation			Folder for Single-unit operation
Debug			
ABS			
single_operarion.abs	Yes	Yes	Sample program abs file
single_operarion.mhx	Yes	Yes	Sample program HEX file
LST			
OBJ			
OPT			
emu_dbg.sup	No	Yes	Emulator debugger file
mon_dbg.sup	No	Yes	Monitor debugger file
include			
_f2mc8fx.h	Yes	Yes	Microcontroller header definition file
define.h	Yes	Yes	Header definition file
extern.h	Yes	Yes	External function reference file
fgm.h	Yes	Yes	Header file for incorporated monitor programs
mb95130.h	Yes	Yes	Microcontroller header file
source			
fgm_cfg.asm	Yes	Yes	Monitor operation definition file
startup.asm	Yes	Yes	Microcontroller startup assembler file
ADC.c	Yes	Yes	A/D converter file
autoboot.c	Yes	Yes	Autoboot determination processing file
ext_int.c	Yes	Yes	External interrupt processing function
init.c	Yes	Yes	Internal clock initialization file
main.c	Yes	Yes	Main source file
vector.c	Yes	Yes	Vector table source file
fgm_cfg.h	Yes	Yes	Monitor operation definition file
FGM.rel	Yes	Yes	Monitor program
sample.dat	Yes	Yes	Softune settings file
single operation.prj	Yes	Yes	Softune project file
LIN_communication			
Debug			
ABS			
LIN_communication.abs	Yes	Yes	Sample program abs file
LIN_communication.mhx	Yes	Yes	Sample program HEX file
LST			

OBJ			
OPT			
emu_dbg.sup	Yes	Yes	Emulator debugger file
mon_dbg.sup	Yes	Yes	Monitor debugger file
include			
_f2mc8fx.h	Yes	Yes	Microcontroller header definition file
define.h	Yes	Yes	Header definition file
define_l.h	Yes	Yes	Header file for LIN driver definition
extern.h	Yes	Yes	External function reference file
fgm.h	Yes	Yes	Header file for incorporated monitor programs
lin.h	Yes	Yes	Header file for LIN drivers
linapi.h	Yes	Yes	Data communications system API code header file
lindbcpu.h	Yes	Yes	CPU compatible definitions header file
lindbmsg.h	Yes	Yes	Header file for LIN communication definition (baud rate settings, ID settings, single registration, etc.)
linhibios.h	Yes	Yes	LIN driver high level header file
linlobios.h	Yes	Yes	LIN driver low level header file
linnode.h	Yes	Yes	Header file for definitions by LIN communication node
mb95130.h	Yes	Yes	Microcontroller header file
source			
fgm_cfg.asm	Yes	Yes	Monitor operations definition file
fgm_main.asm	Yes	Yes	Monitor debugger assembler file
startup.asm	Yes	Yes	Microcontroller startup assembler file
ADC.c	Yes	Yes	A/D converter file
autoboot.c	Yes	Yes	Autoboot determination processing file
ext_int.c	Yes	Yes	External interrupt processing function
init.c	Yes	Yes	Internal clock initialization file
linapi.c	Yes	Yes	Data communications system API source file
linhibios.c	Yes	Yes	Driver high level source file (LIN protocol control)
linlobios.c	Yes	Yes	Driver low level source file (CPU resource control)
main.c	Yes	Yes	Main source file
vector.c	Yes	Yes	Vector table source file
fgm_cfg.h	Yes	Yes	Monitor operations definition file
FGM.rel	Yes	Yes	Monitor program
fsg_sample.dat	Yes	Yes	Softune settings file
LIN SLAVE.prj	Yes	Yes	Softune project file