

User's Manual

Low-Voltage Starter Kit for Motor Control

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Notes for CMOS Devices

1. VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between VIL (MAX) and VIH (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between VIL (MAX) and VIH (MIN).

2. HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can result in malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to VDD or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

3. PRECAUTION AGAINST ESD

A strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and to quickly dissipate it should it occur. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

4. STATUS BEFORE INITIALIZATION

Power-on does not necessarily define the initial status of a MOS device. Immediately after the power source is turned ON, devices with reset functions have not yet been initialized. Hence, power-on does not guarantee output pin levels, I/O settings or contents of registers. A device is not initialized until the reset signal is received. A reset operation must be executed immediately after power-on for devices with reset functions.

5. POWER ON/OFF SEQUENCE

In the case of a device that uses different power supplies for the internal operation and external interface, as a rule, switch on the external power supply after switching on the internal power supply. When switching the power supply off, as a rule, switch off the external power supply and then the internal power supply. Use of the reverse power on/off sequences may result in the application of an overvoltage to the internal elements of the device, causing malfunction and degradation of internal elements due to the passage of an abnormal current. The correct power on/off sequence must be

judged separately for each device and according to related specifications governing the device.

6. INPUT OF SIGNAL DURING POWER OFF STATE

Do not input signals or an I/O pull-up power supply while the device is not powered. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Input of signals during the power off state must be judged separately for each device and according to related specifications governing the device.

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- Product release schedule
- Availability of related technical literature
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Preface

- **Readers** This manual is intended for users who want to understand the functions of the low voltage starter kit for motor control.
- **Purpose** This manual presents the hardware manual of the low voltage starter kit for motor control.
- **Organization** This system specification describes the following sections:
 - Kit Contents
 - Hardware Setup
 - Standalone Operation
 - Drive and Motor Protection
 - Software Setup
 - Using the IAR C Compiler and Source Code Debugger
 - Download and Debug the Code
 - GUI Operation

Legend Symbols and notation are used as follows:

- Weight in data notation: Left is high order column, right is low order column
- Active low notation: xxx (pin or signal name is over-scored) or /xxx (slash before signal name)
- Memory map address: High order at high stage and low order at low stage

Note Additional remark or tip

Caution Item deserving extra attention

Numeric Notation

- Binary: xxxx or xxxB
- Decimal: xxxx
- Hexadecimal: xxxxH or 0x xxxx

Prefixes representing powers of 2 (address space, memory capacity):

- K (kilo): 210 = 1024
- M (mega): 220 = 10242 = 1,048,576
- G (giga): 230 = 10243 = 1,073,741,824

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Chapter 1 Introduction

The low-voltage starter kit for motor control (MC-LVKIT-714) is a complete 3phase motor control evaluation system for NEC Electronics' microcontroller application-specific standard products (ASSP's) for motor control.

The kit contains all necessary hardware and software to quickly set up and run a low-voltage brushless DC motor (BLDCM).

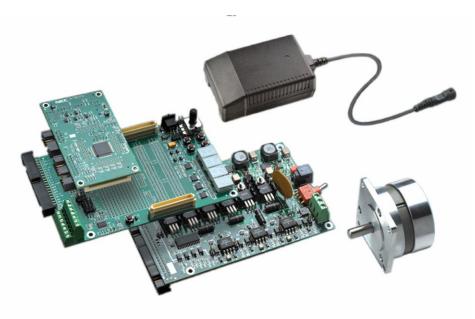


Figure 1-1 Motor Control Starter Kit

Chapter 2 Kit Contents

٠

- MC-78F0714 microcontroller board containing the µPD78F0714 ASSP microcontroller
- MC-I/O interface board. Connects the microcontroller board to the power module
- Low-voltage power module (MC-PWR-LV) containing the inverter MOSFET
- BLDC motor
 - Pitman N2311 12V motor or
 - Ametek 150093-50 24V motor
 - FW7362/15 DC power supply
- 20 MHz oscillator (For use with an On Chip Debug Unit)

For information about the electrical characteristics and hardware functions of the μ PD78F0714 microcontroller, refer to μ PD78F0714 User's Manual (U16928EJ1V0UD00).

For the instruction descriptions, refer to the **78K0 Series Instruction User's Manual** (U12326E)

Chapter 3 Hardware Setup

The kit can be purchased as one unit with all three boards connected as shown below: Replacement board can be ordered separately.



Figure 3-1 MC-LV-KIT-714 Kit Configuration

To attach the motor, connect the phase U, V and W terminals to the J3 connector block on the MC-PWR-LV power board and the Hall sensor terminals to the J5 connector block on the MC-IO control board.

Table 3-1 Motor Connections

Motor Terminals		I/O Board	Power Board (MV-PWR-LV)	
Connection	Pitman	Pitman Ametek		
Phase U	Beige	Black	-	J3 - 1
Phase V	Red	White	_	J3 - 2
Phase W	Orange	Red	_	J3 - 3
Hall sensor 1	Grey	Blue	J5 - 13	_
Hall sensor 2	Blue	Green	J5 - 14	_
Hall sensor 3	White	Yellow	J5 - 7	_
Hall sensor 5VDC	Purple	Purple	J5 - 6	_
Hall sensor GND	Black	Orange	J5 - 5	—

Motor terminal connections are shown in Figure 3-2 and Figure 3-3.



Figure 3-2 Motor Phase Connections

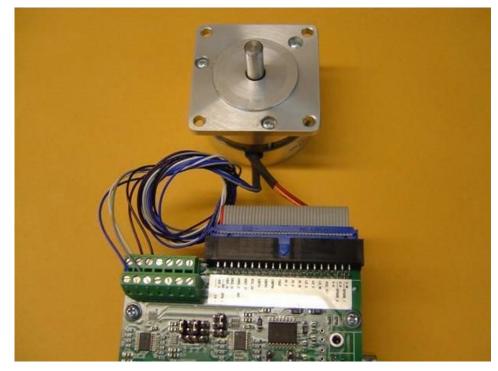


Figure 3-3 Hall Sensor Connections

Figure 3-2 and *Figure 3-3* - Pitman Motor shown for reference. See *Table 3-1* for equivalent Ametek motor connections.

Chapter 4 Standalone Operation

For Stand alone use (i.e. without the GUI), please check that the following jumpers and links are as defined below

Microcontroller Board

- 2JP5 Pins 2 7 Shorted , Pins 3 5 shorted
- 2JP1 Pins1 2 shorted
- 2JP6 Pins 1 2 shorted
- 2JP8 Pins 2 3 shorted
- 2JP9 Pins 2 3 shorted
- 2JP10 Pins 2 3 shorted
- 2SB24 shorted

I/O Board

- JP1 Pins 2 3 shorted
- JP2 Pins 2 3 shorted
- JP3 Pins 2 3 shorted
- JP11 Pins 1 2 and 3 4 shorted
- JP5 Pins 1 2 and 3 4 shorted

Low Voltage Power Board

- SB24 Open
- SB25 Shorted
- JP2 Shorted

Example software to run the motor is pre-programmed into the microcontroller's flash memory. After the motor is connected, the program is ready to run the motor as soon as the 15VDC power supply is plugged into J6 of the MC-IO board and power switch SW1 on the MC-PWR-LV power module is turned ON.

When the kit is powered up or reset, the LED displays "**SELF**", indicating that the kit is in standalone mode and you can use the pushbuttons and potentiometer on the MC-IO board to control the motor.



Figure 4-1 Stand Alone Operation

Three seconds after power up, the LED displays the current (start-up) set speed.



Figure 4-2 Initial Speed Display

Note Ametek motor starting speed is 500 RPM

After power up in standalone mode, the motor can be operated as follows:

- 1. Press the **START/STOP** button to run the motor.
- 2. Turn the potentiometer clockwise to increase the speed of the motor or counter clockwise to decrease the speed of the motor.
- 3. The LED will display the actual motor speed calculated from the Hall sensor interrupts. The display can be toggled between actual and demanded speed by use of the **MODE** button
- 4. Press the **FORWARD** or **REVERSE** button to change the rotation direction.
- 5. Press **START/STOP** to stop the motor.
- **Caution** If the potentiometer position is set to higher speeds, and the motor rotation is suddenly reversed, an error condition may occur due to a timeout or over-current detection and the motor will stop operating. To reboot, press the **RESET** switch on the MC-IO board, adjust the potentiometer to a lower speed and restart.

To control the motor from the Graphical Interface (GUI) from your PC, please refer to "section 6".

Chapter 5 Drive and Motor Protection

The starter kit and the motor are protected against unexpected events such as overload, motor stall and malfunction of the Hall sensors. If such faults are detected, the motor stops rotating and the fault conditions are displayed on the seven-segment LED. For details on the protection functions implemented in hardware, consult the user's manual for MC-PWR-LV low-voltage power module. The sample code software also has built-in fault detection algorithms as an extra measure of protection. Consult the software manual for details.

In standalone (SELF) mode, the LED displays the following fault conditions:

- Motor over-current: "O C "
- Motor stall fault: "----"
- Hall sensor fault: "H A L L"

In the Graphical Interface mode (PC), the LED displays "PC" all the time and the GUI will displays all fault conditions. Refer to "section 6" for more information.

Chapter 6 GUI Operation

To operate the motor from the PC GUI, the Hex file for the motor control software including the GUI interface, will need to be programmed into the Flash memory of the 78F0714 microcontroller. The complete IAR embedded Workbench project can be downloaded from the Motor Control starter kit web site.

To program the "hex" file (BLDC_714_GUI.hex) into the microcontroller please refer to "section 7".

Once the Graphical Interface program has been programmed ensure that the jumpers on the microcontroller board are returned to the settings described in chapter 4 above

It is necessary to locate the following files on to the PC in order to connect to the starter kit. The two programs should always be located together in the same directory

- MotorPanel.exe (GUI Application)
- Motor.inf (set up file)

To operate the PC GUI a "Female-Female" RS232 serial cable (with crossover) is required.

(Not supplied).

Connect the PC serial port to the starter kit J9 DB-9 RS232 connector with an RS232 serial cable.

The pin connection of the RS232 cable needs to be as follows (crossover)

Table 6-1 GUI RS232 Cable Connections

Signal Name	PC Connection	Starter Kit connection
Rx Signal Detect (Not Used)	Pin 1	Pin 1
Rx Data	Pin 2	Pin 3
Tx Data	Pin 3	Pin 2
DTE Ready	Pin 4	Pin 4
Signal Ground	Pin 5	Pin 5
DCE Ready	Pin 6	Pin 6
RTS	Pin 7	Pin 8
CTS	Pin 8	Pin 7
Ring Indicator (Not used)	Pin 9	Pin 9

To launch the communication program Run the "MotorPanel.exe" application program and the following window should open.

1. Select the appropriate COM port on your PC and click OK.

ionnect Por	t	2
Port Name:	СОМЗ	OK
		Cancel

Figure 6-1 PC COM Port Selection

The GUI will launch if the connection is established:

rushless DC Motor (BLDCM)	
Operation	
Rotational Speed: 300 rpm	
View	
Rotation Speed:	
O rpm	
Status: Stopped.	

Figure 6-2 BLDC Motor Control GUI

- 2. To operate the motor, use the controls in the GUI window The user has the same controls as described for the "Stand Alone" mode (Start / Stop, Clockwise / Anti-Clockwise, Speed increase / decrease)
- 3. It is also possible to change the PID parameters from the GUI interface. (Please note that changes can only be made when the motor is stopped) To change the PID parameters click on the tuning key symbol

	= •		
Rot Tuning ed:	300 rpm	•	

Figure 6-3 Launching PID Parameter Window

The tuning window will open allowing the user to change the values of P, I or D constants:

Kp:	0.500	•
Ki:	0.300	×
Kd:	0.100	×

Figure 6-4 PID Parameter Window

The new parameter values will be down loaded to the starter kit into the internal RAM when the motor is restarted again.

To make the changes permanent, the user will have to modify the definitions in the original IAR project files (control.h) and then rebuild the project. This requires a licensed version of either.

IAR Embedded Workbench (Full Version) or IAR Embedded Workbench (Kick Start Version).

The three PID values that require changing are

#define KP_DEF

#define KI_DEF

#define KD_DEF

Set these parameters to the values shown in the Tuning Window of the GUI.

Chapter 7 Programming the Microcontroller

If the user wishes to modify the program in the 78F0714 device on the microcontroller board, a Flash Programmer is required (not included in the Starter Kit).

Two programmers are available

- 1. PG-FP4 Full Programmer
- 2. QB Programmer MiniCube 2 On Chip Debug / Low Cost Programmer



Figure 7-1 PG-FP4 Programmer



Figure 7-2 QB Programmer (MiniCube2)

The Graphical Interface for either of these programmers can be downloaded from the NEC Electronics Development tools web site.

In this guide we have shown only the MiniCube2 (QB Programmer). The interface for the microcontroller board is the same for both programmers.

- **Note** 1. It is easier to remove the Microcontroller board from the starter kit to program the device. However it is possible to program the device while connected to the I/O board. The set up of the programmer is slightly different although the actual programming of the device is the same. Programming the microcontroller with the board attached to the kit is described in "section 7.2" of this user guide.
 - 2. Older programmers such as the PG-FPL can still be used with this device. Please refer to the previous version of this user guide for details on how to use this programmer.

7.1 Progamming with the Microcontroller Board disconnected

- Download the following files
 - The MiniCube2 (QB programmer) Flash Programming Graphical Interface (From the NEC Electronics Tool download web site)
 - The Appropriate IAR Work bench project (with or without the GUI) (From the NEC Electronics Motor Control Starter Kit web site)
 - Uncompress and Install the QB programmer GUI software (Run the "SETUP" application)
- Save and uncompress the IAR Workbench project
 - For Flash programming, no changes to the jumper settings on the Microcontroller board are necessary
- Check that the switches on the QB programmer are set as shown below
 - a) Switch M1 / M2 is set to "M2"
 - b) Switch 3 T 5 is set to "5"
- Then attach the QB programmer to connector 2J2 on the microcontroller board using the 16-pin cable



Flash Programming Connector 2J2

Figure 7-3 Microcontroller Board Flash Connection

Copy the 78F0714 Flash programming parameter file (78F0714.prm) into the installation directory for the QB programmer program.

\$installation path\$\....\PG-FPL\PRM

(This file is included with the IAR project download)

Once the Microcontroller board is configured and the programmer connected to the PC, open the Flash programming Graphical interface "PG-FPL".

The following Screen should appear. (Note the text may differ after the 1st two lines)

🚆 QB-Programmer	<u>_ </u>
File Device Help	
🔎 🔄 🗋 🖏 📝 🀉 🎎 🛛 💸	
>Q8-Programmer startup >Command standby > >Device Setup	QB-Programmer : V2.20 Firmware : V4.04
Parameter File Read PASS. >	Name : Firmware:
	Name : 78F0714.prm Version : V1.10
	Load file Date : Chksum : Area :
	File checksum Chksum : Area :
	Connection to device Port : UART-ch0 Pulse : 0 Speed : 153600bps Range : Chip Freq. : 20.00MHz Multiply : 1.00
	PASS
Ready	NUM ///

Figure 7-4 MiniCube 2 Programmer GUI (QB Programmer)

Next the device needs to be set up from the menu follow the following sequence:

Device =>Setup...

Or press the "Spanner" symbol in the ICON taskbar

The following screen should appear:

g QB-Programmer File Device Help		<u>_0×</u>
QB-Programmer startur Command standby Device Setup Parameter File Read PA Device Setup	Standard Advanced Parameter File 78F0714.prm PRM File Read Target Device Connection Supply Oscillator Image: Connection Port UART-ch0 Speed 153600bps Operation Mode	Programmer : V2.20 : V4.04 Device Parameter file 4.prm Load file File checksum
	Chip Start 000 Block End 015 Show Address OK Cancel Multiply : 1.00	Connection to device- ch0 bps Hz

Figure 7-5 Device Setup

Set the details for the COM port, Speed etc as shown above.

Note Enter your COM port number as this will vary.

Next press the "**PRM File Read**" button and the following screen should appear. Select the 78F0714.prm file and press the "**Open**" button

🞇 QB-Programmer					. O ×
File Device Help					
P 🖣	Device Set	- <mark>// 18</mark> <u>A</u> .	2	×	
>QB-Programmer starts >Command standby > >Device Setup	ur Standard Open	Advanced		1 ? ×	Programmer - : V2.20 : V4.04
Parameter File Read F > >Device Setup	Look in: 📔	PRM-78F0714_V112			Device
	78F0711 78F0712 78F0714				Parameter file prm
					Load file -
	File name:	78F0714		Open	File checksum
	Files of type:	PRM Files(*.PRM)		Cancel	onnection to device
			OK	Cancel	bps Hz
र	-		▼	Multiply : 1.00	
Ready					NUM

Figure 7-6 Parameter File Read

Then press the ""OK" button to return to the main menu system

The text in the main screen should read

> Device Setup
 Parameter File Read Pass
 >

Next press the select the "HEX" file to be programmed from the Menu

File => Load

Or press the "Load File" symbol in the ICON taskbar

The following screen should open

🎇 QB-Programmer					_ 🗆 🗙
File Device Help					
🎾 🎮 [J WW	📝 🐉 🎰	200		
>QB-Programmer startu >Command standby > >Device Setup	ıp Open		4	QB-Programmer	Programmer :V2.20 ;V4.04
Parameter File Read F > >Device Setup Cancel Device Setup.	Look in:		• 🗢 💽	* •	Device
> >Open Load File	BLDC_Hai	_714_V2.hex			Parameter file prm
					Load file
	 File name:	BLDC_Hall_714_V2		Open	File checksum
	Files of type:	S-rec / Hex files (*.rec;*.s;*.hex)	•	Cancel	onnection to device
			<u>×</u>	Pulse : 0 Speed : 153600t Range : Chip Freq. : 20.00Mł Multiply : 1.00	
			<u>}</u>		
Ready					NUM //

Figure 7-7 Hex File Selection

Locate the file as shown in the window from the downloaded IAR project.

The file will be located as follows

\$saved directory\$\BLDC_Hall_714_GUI\Debug\Exe\

Select the file (BLDC_714_GUI.hex) and press the "OPEN" button

This will close the "**LOAD**" file window. The following should be displayed on the main screen

> Open Load File Success read Load file

The Flash programming setup is now complete.

Now press the "AUTOPROCEDURE" button to start the programming sequence

The following sequence should be seen

>AutoProcedure(Epv) Blank check Block 000: Not blank, Erase need. Erasing... Erase Chip: PASS Program Chip: 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% PASS Verify Chip: 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% PASS AutoProcedure(Epv) PASS >

Note The "Verify Chip operation is enabled by setting the "Read Verify after Program" option in the "Advanced" Tab of the "Device Setup" Window. The 78F0714 device has now been reprogrammed with the example program using the graphical interface. To re program the "stand Alone" again follow the same procedure as above, but download the "SK BLDC_HALL_714" IAR project instead.

The file to be programmed is "SK BLDC_HALL_714.hex"

7.2 Progamming with the Microcontroller Board connected

The only difference from the procedure defined above, is that the QB programmer switches need to be set as shown below

a) Switch M1 / M2 is set to "M2" (78K0)
b) Switch 3 - T - 5 is set to "T" (Target Power Supply)

Connect the QB programmer as described previously and ensure that once the setup is completed the 15V DC power supply is connected to the starter kit and switched on.

Chapter 8 Using the IAR Embedded Workbench

As already explained the example software for use with the starter kit comprises two versions

- Sensored BLDC control without the Graphical Interface (GUI)
- Sensored BLDC control with the Graphical interface (GUI)

As described above the kit is supplied pre programmed for use in "Stand Alone" mode.

(This is without the GUI)

The complete example project program for the IAR 78K0 Embedded Workbench development tool environment can be downloaded from the motor control web site as detailed in starter kit package (i.e. where this manual was downloaded).

The software is supplied in source format and can be modified as required.

The following sections describe IAR 78K0 embedded Workbench development tool environment, how to install it on your computer, and how to rebuild and download executable code to the microcontroller's flash memory.

Before proceeding with the tools installation, however, refer to all of the documentation for the starter kit, On Chip Debugger tool and the IAR Embedded Workbench.

(Please note that a 16Kbyte code limited version is included with the On Chip Debug unit and can be used to run the example software.)

Please note that a Flash Programmer, On Chip debugging tool or IAR Embedded workbench are not included in this package. These items are available from your local NEC Electronics Distributor or contact your local NEC Electronics sales office.

8.1 Software Installation

- 1. If a version of the IAR tool is not already installed, then install the IAR embedded Workbench tool as per the instructions provided by IAR.
- Ensure that if not already that the example software has been downloaded from the NEC starter kit web site and "unzipped" into an suitable location.

The example software can operate on any revision of either the IAR Kick Start or IAR Full versions. However it may be necessary to define your own project and workspace. This is described later in this chapter.

8.2 MC-LVKIT-714 Setup for On-chip Debugging

To set up the MC-LVKIT-714 starter kit for debugging, follow the steps below.

- 1. Disconnect the M-78F0714 micro board by separating it from the MC-IO board.
- 2. Remove jumpers 2JP5 2-5, JP5 3-6 and 2JP7 1-2
- 3. Ensure that link 2SB24 is open

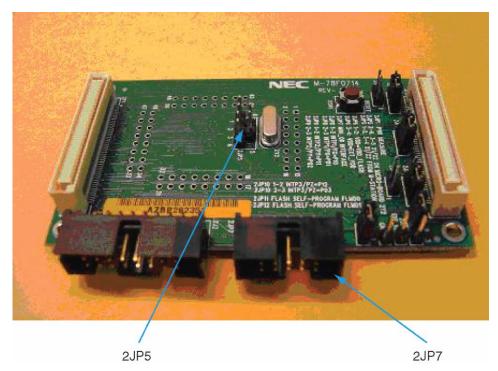
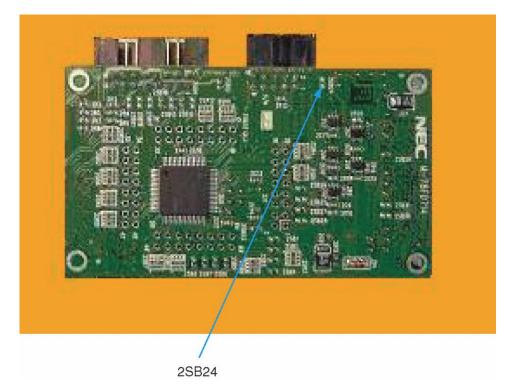


Figure 8-1 Microcontroller Board OCD Configuration





- 4. Reconnect the M-78F0714 board to MC-IO board
- 5. Attach the on-chip debugging emulator's target connector to 2JP7 on the M-78F0714 and the USB cable to your computer as shown below.



Figure 8-3 OCD Debugger Unit Connection

The MC-78F0714 must be operated at 20 MHz. This requires the use of the external 20 MHz oscillator supplied with the kit, which needs to be mounted in the socket inside the OCD unit.

Please refer to the on-chip debugger user's manual for information about how to attach the external oscillator.

8.3 IAR Embedded Workbench Start-up

1. Open the IAR workbench. The following Screen should be opened: (Note the exact display may vary depending on if this is a new installation)

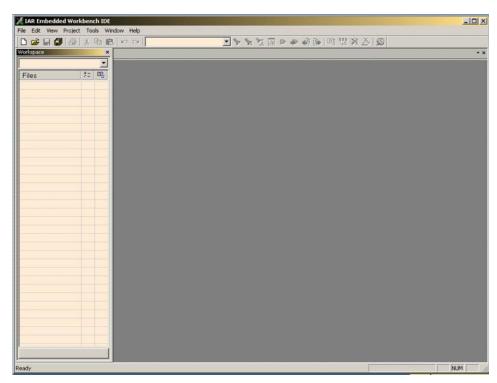


Figure 8-4 IAR Workbench Opening Screen

2. Next open the IAR Workspace by following the sequence and locating and then selecting the appropriate workspace file as shown below:

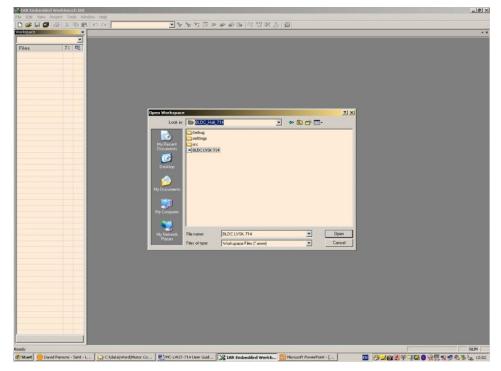


Figure 8-5 IAR Workbench Project Selection

Once the Workspace open the display should look something close to that as shown in *Figure* 8-6.

This shows the workspace where the project is located and has opened either the BLDC non GUI or BLDC GUI project. The display shows the following project files

- Left Hand side window Project File (Source. Header, Map etc)
- Bottom Build Debug messages when the project is re built or the debugger is active
- The main centre display shows any open files in a tabbed form. The file can be viewed by selecting the relevant Tab in the wind

Any of the files shown can be opened by double clicking on the file in the "Project" (left hand side) window. Debugging windows are described later.

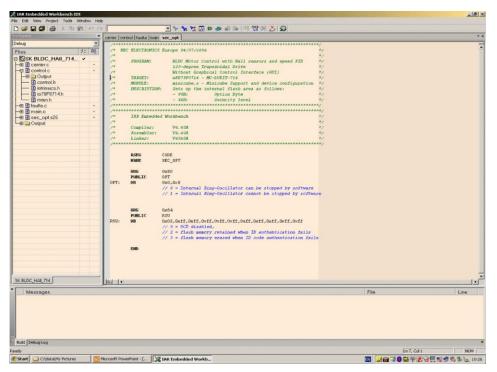


Figure 8-6 Workspace & Project open screen

3. The build options for the project can then be set or changed using the following menus. The build options are entered as shown in *Figure 8-7* below, then ensure all the options are as shown in *Figure 8-8* to *Figure 8-11* below.

File Edit View	Project Tools Window H	lelp		
	Add Files		1	• 🐦 🙀 🖾 📼 🖉 🐺 🖌 •
Workspace	Add Group Import File List		ntrol faulta main *	sec_opt
Debug	Edit Configurations		*******	*************
Files	Remove		C ELECTRONICS Eu	rope 04/07/2006
SK BLD	Create New Project Add Existing Project		PROGRAM:	BLDC Motor Control with Hall sens 120-degree Trapezoidal Drive
UO 🔂 🕀	Options	ALT+F7		Without Graphical Control Interfa
intr	Source Code Control	•	TARGET: MODULE:	uPD78F0714 - MC-LVKIT-714 control.c - Peripheral Control
io7 ima ima ima ima ima ima ima ima	Make Compile Rebuild All Clean	F7 CTRL+F7	DESCRIPTION:	Initialization of timers, ports, push buttons and potentiometr, UR Reads A/D, displays target or act on LED display
⊞ 🔛 sec_c	Batch build	F8	*****	*******
	Stop Build		IAR Embedded W	*************
	Debug	CTRL+D	IAK Embedaea w	orkpench
	Make & Restart Debugger		Compiler:	V4.40A
		1*	Assembler:	V4.40A
		1*	Linker:	V4060A
		1****	***********	*******************

Figure 8-7 Project build options

Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Target Output Library Configuration Device 78K0 - uPD 78F0714 No DIVUW / MULU Code model Standard Data model	Near constant location Mirror ROM 1 Start address: 0xF1000 Size (Kbytes): 16.00 Code banking Reg.address: 0xFFF3 Bank address: 0x8000
	Near	No.of banks: 4 Bank size: (Kbytes): 8

Figure 8-8 General Options – Setting the Target Device

Category: C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Target Output Library Configuration Library Options Stack/Heap Output file Executable Library Output directories Executables/libraries: Debug\Exe Object files: Debug\Obj List files: Debug\List
--	---

Figure 8-9 General Options – Setting the Output Locations

Options for node "SK B	C_HAll_714"	×
Category: C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE	Target Output Library Configuration Library Options Stack/Heap Library: Description: CLIB V Use the legacy C runtime library.	
MINICUBE Simulator TK-78	Library file: \$TOOLKIT_DIR\$\LIB\CLIB\cl78ks1.r26 Configuration file: 	
	OK Cancel	

Figure 8-10 General Options – Selecting the C-Library

Options for node "SK BI Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78	DC_HAll_714" Target Output Library Configuration Library Options Stack size: Heap size DX80 Far: 4096 Near:
IE-78 IECUBE MINICUBE Simulator TK-78	
	OK Cancel

Figure 8-11 General Options – Setting the Stack and Heap

8.4 Compiler Options

Category:	F	actory Setting
General Options C/C++ compiler Assembler	Language Optimizations Output List Preprocessor	Diagnostic ┥
Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE	Language C C C Embedded C++ C Extended Embedded C++ C Automatic (extension based)	
Simulator TK-78	Require prototypes Language conformance Allow IAR extensions C Relaxed ISO/ANSI C Strict ISO/ANSI	
	Enable multibyte support Enable IAR migration preprocessor extensions	

Figure 8-12 Compiler Options – Language Settings

General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Language Optimizations Output List Optimizations Size Image: Comparison of the second	Factory Settings Preprocessor Diagnostic Short address work area Enable work area 20 Bytes
--	---	---

Figure 8-13 Compiler Options – Optimisation

Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Language Optimizations Output List Prepro Module type Override default Program Module C Library Module	Factory Setting
---	--	-----------------

Figure 8-14 Compiler Options – Output Set for Debug

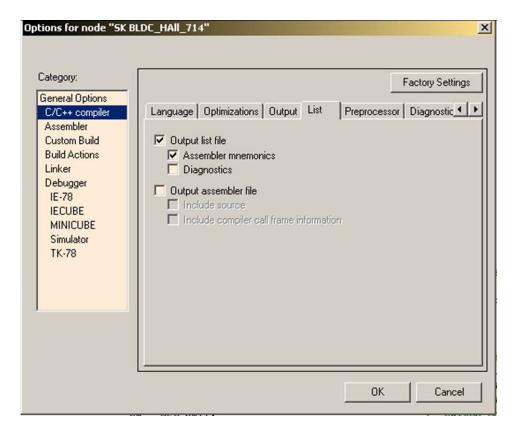


Figure 8-15 Compiler Options – Compiler Listings

ptions for node "SK B	LDC_HAII_714"
Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Factory Settings Language Optimizations Output List Preprocessor Diagnostic Ignore standard include directories \$TOOLKIT_DIR\$\INC\ \$TOOLKIT_DIR\$\INC\CLIB\ Additional include directories: (one per line) Image: Comparison of the symbols: (one per line) Preinclude file: Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of the symbols: (one per line) Image: Comparison of
	OK Cancel

Figure 8-16 Compiler Options – Pre Processor Settings

Note All other Compiler Options settings can be remain as the default settings.

8.5 Assembler Options

Category: General Options					Factory Settings
C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	User Allow Allow	symbols are cas v mnemonics in firs v directives in firs ole multibyte supp uote characters:	rst column t column	Diagnosiics	Exita Options

Figure 8-17 Assembler Options – Language Settings

Category: General Options					_	Factory Setting
C/C++ compiler	Language	Output L	.ist	Preprocessor	Diagnostics	Extra Options
Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Gener	ate debug i	nforma	ation		

Figure 8-18 Assembler Options – Output set for Debug

Category: General Options C/C++ compiler Assembler Custom Build	Factory Settings Language Output List Preprocessor Diagnostics Extra Options
Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	 Include header Include listing Include cross reference Macro definitions #defines Macro expansions Internal symbols Macro execution info Dual line spacing Assembled lines only Multiline code
	Multime code Diagnostics Lines/page: 80 Structured assembly lines Tab spacing: 8 #included text

Figure 8-19 Assembler Options – Listings

Note All other Assembler Options can be left as the default setting.

8.6 Linker Options

Options for node "SK BL Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Factory Settings Output Extra Output #define Diagnostics List Config Proce Image: Config Output file Override default Secondary output file: SK SK SK Default Secondary output file: SK SK BLDC_HAIL_714.d26 (None for the selected format) Format © Debug information for C-SPY Image: With runtime control modules Image: With ru
	Module-local symbols: Include all
L	OK Cancel

Figure 8-20 Linker Options – Primary File Output

Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Factory Setting Output Extra Output # Generate extra output file Output file Ø Override default SK BLDC_HAII_714.hex Format Output format: intel-extended Format variant:
---	---

Figure 8-21 Linker Options – Secondary File Output

Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Factory Settin Output Extra Output #define Diagnostics List Config Proce Always generate output Range checks	
---	--	--

Figure 8-22 Linker Options – Diagnostic settings

Category: General Options C/C++ compiler Assembler Custom Build Build Actions Linker Debugger IE-78 IECUBE MINICUBE Simulator TK-78	Factory S Output Extra Output #define Diagnostics List Config Pro Image: Segment map Image: Segment map File format Image: Text Image: Text
---	---

Figure 8-23 Linker Options – Generate MAP File Output

Factory Settin
Output Extra Output #define Diagnostics List Config Proce_
Linker command file
\$TOOLKIT_DIR\$\config\lnk78f0714.xcl
Override default program entry
Entry labelprogram_start
C Defined by application Search paths: (one per line)
\$TOOLKIT_DIR\$\LIB\
Raw binary image
File: Symbol: Segment: Align

- Figure 8-24 Linker Options Linker Command File Selection
 - **Note** The Linker Control File must match the device selected. The remainder of the Linker setup can be left as the default setting.

8.7 Integrated Debugger Selection

Note The Extra Option section can be ignored.

Category:	Factory Settin
General Options C/C++ compiler	Setup Extra Options Plugins
Assembler Custom Build	Driver
Build Actions	MINICUBE QB-78K0MINI, QB-78K0SxxxMINI, QB-MINI2 💌
Linker Debugger	🔽 Run to
IE-78	main
IECUBE MINICUBE	Setup macros
Simulator	Use macro file
TK-78	
	Device descriptions
	Cverride default
	\$TOOLKIT_DIR\$\CONFIG\DDF\io78f0714.ddf

Figure 8-25 Integrated Debugger Selection

Category:		Factory Settings
General Options		o:
C/C++ compiler Assembler	Setup Extra	Options Plugins
Custom Build	Select plugin:	s to load:
Build Actions	Code Cov	
Linker		DS .
Debugger IE-78	■Profiling Stack	
IECUBE	SEGGER	embOS
MINICUBE		
Simulator TK-78	Deserietien	Evolution and an unread in the debugger
	Description:	Enables code coverage in the debugger.
	Location:	C:\Program Files\IAR Systems\Embedded Workbench 4.04
	Originator:	IAR Systems
	Version:	4.6.2.0
	Toroion.	1.0.00
	L	

Figure 8-26 Integrated Debugger - Plug-in Selection

8.8 Workspace and Project Setup if the example is not compatible with the installed IAR workbench

- Set a new workspace
 File -> New -> Workspace
- Create a new Project
 Project -> Create New Project -> Select "Empty Project" -> "OK"

Enter a project name and set the location for the project (This can be the same location as the downloaded example software or a new location)

- Add the Source files to the project
 - C Source Files **Project -> Add Files**

Locate and select all the C source files

- Main.c
- Fault.c
- Carrier.c

Press "OPEN"

• Repeat the operation for the Assembler file **Project -> Add Files**

When the Selection window opens select Files of Type -> Assembler Files

Select the assembler file

- SEC_OPT.s26"
 - Press OPEN"

All these file should now appear in the Project Window (Left Hand Side of the IDE), as shown previously.

8.9 Build / Rebuild the Project

To build the project press the "make" icon in the task bar as shown below:

1 > >	12 💀	D 🔊 🍪	🍌 Di 😲	XXX
-------	------	-------	--------	-----

Figure 8-27 Make Button

The build results and any errors or warnings will be displayed in the Messages window at the bottom of the IDE. These should be corrected before moving on to the Debugging section.

8.10 Debugging

Once the project has been built without errors the user can now start the debugging session.

This is done by pressing the "Debug" icon in the task bar.



Figure 8-28 Start the Debug Session

The debugger will connect to the OCD unit and download the code to the Flash memory on the microcontroller board.

Once downloaded the debugging window will open as shown below in *Figure* 8-29.

Note The IAR embedded Workbench provides an integrated debugger, so the debugging window opens as part of the IDE.

If the debugger is run for the first time in a new project the following set up window will open. This is to set the basic function of the debugging hardware (i.e. Mini Cube or IECube etc.).

ID code		Time unit	OK
FFFFFFFFFFF	FFFFFFF		Cancel
Main clock		Sub clock	-
C Clock board		C Clock board	
C External		C External	Default
• System		C System	
5.00	MHz	▼ RH	Z
Monitor clock —	Peripheral b	reak Target	 ┌─ Target power off
System	O Disable		C Permit
C User	C Enable	d C Not Connect	Not Permit
Pin mask			r-Fail-safe break-
L WAIT	✓ TARGE	ET RESET	
		NAL RESET	View setup
			. <u>L</u>
Memory map Start address:	Length	Type:	
Jian address.	rengm.		Add
ļ !	<u>1 *</u>		A00
	Internal ROM	32 Kbytes	
0x0000 · 0x7FF		1024 bytes	
0x0000 - 0x7FFI 0xFB00 - 0xFEF	F Internal RAM		
0x0000 - 0x7FFI 0xFB00 - 0xFEF	F Internal RAM		Remove

Figure 8-29 Debugging – Initial Hardware Setup

Ensure that the settings are as defined above.

Note If the Main Clock shows the "Clock board" detected, then ensure that this is selected.

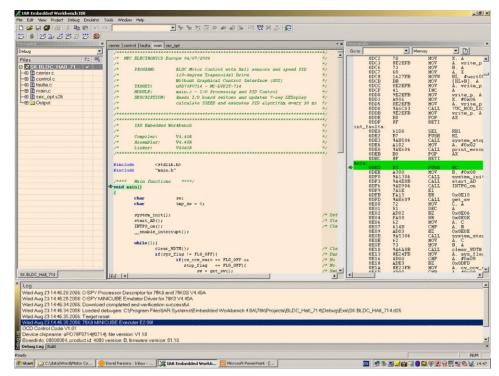


Figure 8-30 Integrated Debugger - Main Window

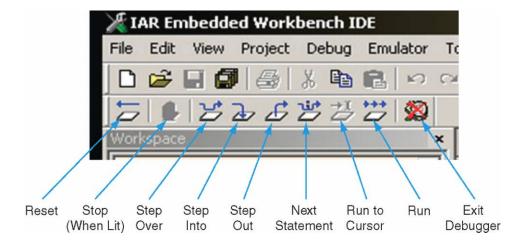


Figure 8-31 Debugger Task Bar Icons

🔏 IAR En	bedded Workbench	IDE
File Edit	View Project Debug	Emulator Tools Window Help
	Messages Workspace	
🗁 🕒 Workspace	Source Browser	22 🕺
Debug	Breakpoints Disassembly Manager	Carrier control faulta m
Files	Memory Register Watch	/* /* PROGRAM:
	Locals Auto Live Watch	/* /* TARGET:
	Quick Watch Call Stack	/* MODULE: /* DESCRIPTI /*
	Terminal I/O Code Coverage Profiling	/* /**********************************
	Stack	/* IAR Embed /*
	Toolbars ► ✓ Status Bar	/* Compiler: /* Assembles
		/* Linker: /****************

Figure 8-32 Debug Menus

ile Edit View	Project Debug Emula	tor Tools Wind	low Help	
🗅 🚅 🖬 🧯	Add Files			🖸 🖒 🐂 🖄 🖾 📦 🖡
5 1 2	Add Group			
	Import File List			
Vorkspace	Edit Configurations		trol faulta main se	ec_opt
Debug	Remove		*****	******
Files			- ELECTRONICS E	urope 04/07/2006
🗆 🔁 SK BLI	Create New Project			
- E Carrie	MUU EXISUITU Project.	or	PROGRAM:	BLDC Motor Control
- Contr		ALT+F7		120-degree Trapezo Without Graphical
- 🕀 🔝 faulta	Source Code Control		TARGET:	uPD78F0714 - MC-LV
H 🔝 main	Junce Code Control		MODULE:	main.c - I/O Proce
- sec_	c Make	F7	DESCRIPTION:	Reads I/O board sw
L- Outp	u Compile	CTRL+F7		calculate SPEED an
	Rebuild All			
	Clean			********
	Batch build	F8		******************
	Stop Build		IAR Embedded	workbench
	Debug	CTRL+D	Compiler:	V4.40A
	Make & Restart Debu	gger	Assembler:	V4.40A
			Linker:	V4060A
		/****	*******	***************
		#incl	ude <stdl< td=""><td>ih.h></td></stdl<>	ih.h>
		#incl		

Figure 8-33 Debug Views Windows

💥 IAR Embedded Workbench II	DE	
File Edit View Project Debug	Emulator Tools Window Help	
🗅 🖨 🖬 🞒 🚳 🐰 🖻	Hardware Setup	
5 6 82 6 8 2	Breakpoint Toggle During Run	
Workspace	Mask Option	main sec
Debug	Pseudo Emulation	******
Files	Live Watch Setup	DNICS Eu
SK BLDC_HAII_71	Trace Setup	v:
Carrier.c	Timer Setup	ľ.
Control.c	Edit Events	
H → ⊕ A faulta.c	Edit Sequencer	
H - ⊞ 🗟 main.c	Trace	
H - ⊞ 📓 sec_opt.s26	Function Trace	PTION:
u Cutput	Live Memory	
	Breakpoint Usage	******
	/**********	******
		mbedded W
	/* /* Compi.	ler:
	/* Assemi	

Figure 8-34 Emulator Debug Options

Note The "Live Watch" does not operate in real time on the On Chip Debug Unit.