To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: “Standard”, “High Quality”, and “Specific”. The recommended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as “Specific” without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as “Specific” or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is “Standard” unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.

   “Standard”: Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.

   “High Quality”: Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.

   “Specific”: Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.

(Note 1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

Preliminary User's Manual

MC-78K0R-IE3 KIT
Low-Voltage Starter Kit

For NEC Electronics μPD78F1235 Motor Control ASSP

Document no. U19828EU1V1UM00

The information in this document is current as of July 2009. The information is subject to change without notice. For actual design-in, refer to the latest publications of NEC Electronics data sheets or data books, etc., for the most up-to-date specifications of NEC Electronics products. Not all products and/or types are available in every country. Please check with an NEC Electronics sales representative for availability and additional information.

No part of this document may be copied or reproduced in any form or by any means without prior written consent of NEC Electronics. NEC Electronics assumes no responsibility for any errors that may appear in this document.

NEC Electronics does not assume any liability for infringement of patents, copyrights or other intellectual property rights of third parties by or arising from the use of NEC Electronics products listed in this document or any other liability arising from the use of such NEC Electronics products. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of NEC Electronics or others.

Descriptions of circuits, software and other related information in this document are provided for illustrative purposes in semiconductor product operation and application examples. The incorporation of these circuits, software and information in the design of customer's equipment shall be done under the full responsibility of customer. NEC Electronics no responsibility for any losses incurred by customers or third parties arising from the use of these circuits, software and information.

While NEC Electronics endeavors to enhance the quality, reliability and safety of NEC Electronics products, customers agree and acknowledge that the possibility of defects thereof cannot be eliminated entirely. To minimize risks of damage to property or injury (including death) to persons arising from defects in NEC Electronics products, customers must incorporate sufficient safety measures in their design, such as redundancy, fire-containment and anti-failure features.

NEC Electronics products are classified into the following three quality grades: “Standard”, “Special” and “Specific”.

The "Specific" quality grade applies only to NEC Electronics products developed based on a customer-designated “quality assurance program” for a specific application. The recommended applications of NEC Electronics product depend on its quality grade, as indicated below. Customers must check the quality grade of each NEC Electronics product before using it in a particular application.

"Standard": Computers, office equipment, communications equipment, test and measurement equipment, audio and visual equipment, home electronic appliances, machine tools, personal electronic equipment and industrial robots.

"Special": Transportation equipment (automobiles, trains, ships, etc.), traffic control systems, anti-disaster systems, anti-crime systems, safety equipment and medical equipment (not specifically designed for life support).

"Specific": Aircraft, aerospace equipment, submersible repeaters, nuclear reactor control systems, life support systems and medical equipment for life support, etc.

The quality grade of NEC Electronics products is “Standard” unless otherwise expressly specified in NEC Electronics data sheets or data books, etc. If customers wish to use NEC Electronics products in applications not intended by NEC Electronics, they must contact NEC Electronics sales representative in advance to determine NEC Electronics ' willingness to support a given application.

Notes:

1. "NEC Electronics" as used in this statement means NEC Electronics Corporation and also includes its majority-owned subsidiaries.
2. "NEC Electronics products" means any product developed or manufactured by or for NEC Electronics (as defined above).

M8E 02.10

Revision History

Date	Revision	Section(s)	Description
July 8, 2009	—	—	First release
July 13, 2009	1st correction (1V1)	2. Kit Contents 5. Flash Memory Programming 12. Using the NEC Electronics C Compiler and Source Code Debugger	Technical changes

Contents

1. Introduction 1

2. Kit Contents 2

3. Hardware Setup 2

4. Motor Operation and Control 6

4.1 Standalone mode 6
4.2 PC Mode 8

5. Flash memory programming 8

6. Modes of Operation supported 8

7. Step-by-Step Operation in Standalone mode 9

8. Drive and Motor Protection 10

9. Software Setup 10

10. Software Installation 10

11. PC GUI Operation 12

12. Using the NEC Electronics C Compiler and Source Code Debugger 18

13. Downloading and Debugging the Code 20

13.1 Security ID Code 21

14. Appendix - Schematics 23

1. Introduction

The MC-78K0R-IE3 KIT is a complete 3-phase motor control evaluation system based on NEC Electronics' µPD78F1235 microcontroller (MCU), a 16-bit application-specific standard product (ASSP) specifically designed for inverter driven motor control applications.

The kit contains all of the hardware and software necessary to quickly set up and run a low-voltage brushless DC motor (BLDCM). On-board hardware facilitates easy programming through a standard USB cable, and source code debugging without the need for additional hardware. NEC Electronics' CubeSuite integrated development environment (IDE) is supplied free of charge along with the source code to run a low-voltage BLDCM. It includes an editor, CA78K0R C compiler/assembler and source level debugger.

Figure 1. Motor Control Starter Kit

2. Kit Contents

- MC-78K0R-IE3 KIT motor drive board containing the µPD78F1235 microcontroller, power inverter stage, user interface, debugging and programming hardware.
- BLDC motor from Anaheim Automation, part number BLY171S-15V-8000
- Power supply: FW7362 15 DC / 1A
- USB cable
- Resource CD containing
  - Sample software for a 120-degree trapezoidal BLDC motor drive with Hall sensors
  - NEC Electronics CubeSuite integrated development environment which includes editor, compiler and debugger
  - NEC Electronics motor control configuration graphical user interface (GUI)
  - WriteEZ4 flash programmer
  - User manuals and schematics

For information about the electrical characteristics and hardware functions of the µPD78F1235 microcontroller, refer to the *78K0R/IE3 Preliminary User's Manual* (U19163EJ1V0UD00).
For the instruction-set descriptions, refer to the *78K0R Microcontrollers Instruction User's Manual* (U17792EJ4V0UM00)

3. Hardware Setup

The kit is shipped with a default jumper configuration to run the motor with the following on-board user interface controls as soon as the motor is connected and power is supplied.

- START/STOP, FORWARD, REVERSE and MODE push-buttons
- SPEED potentiometer
- 7-segment LED

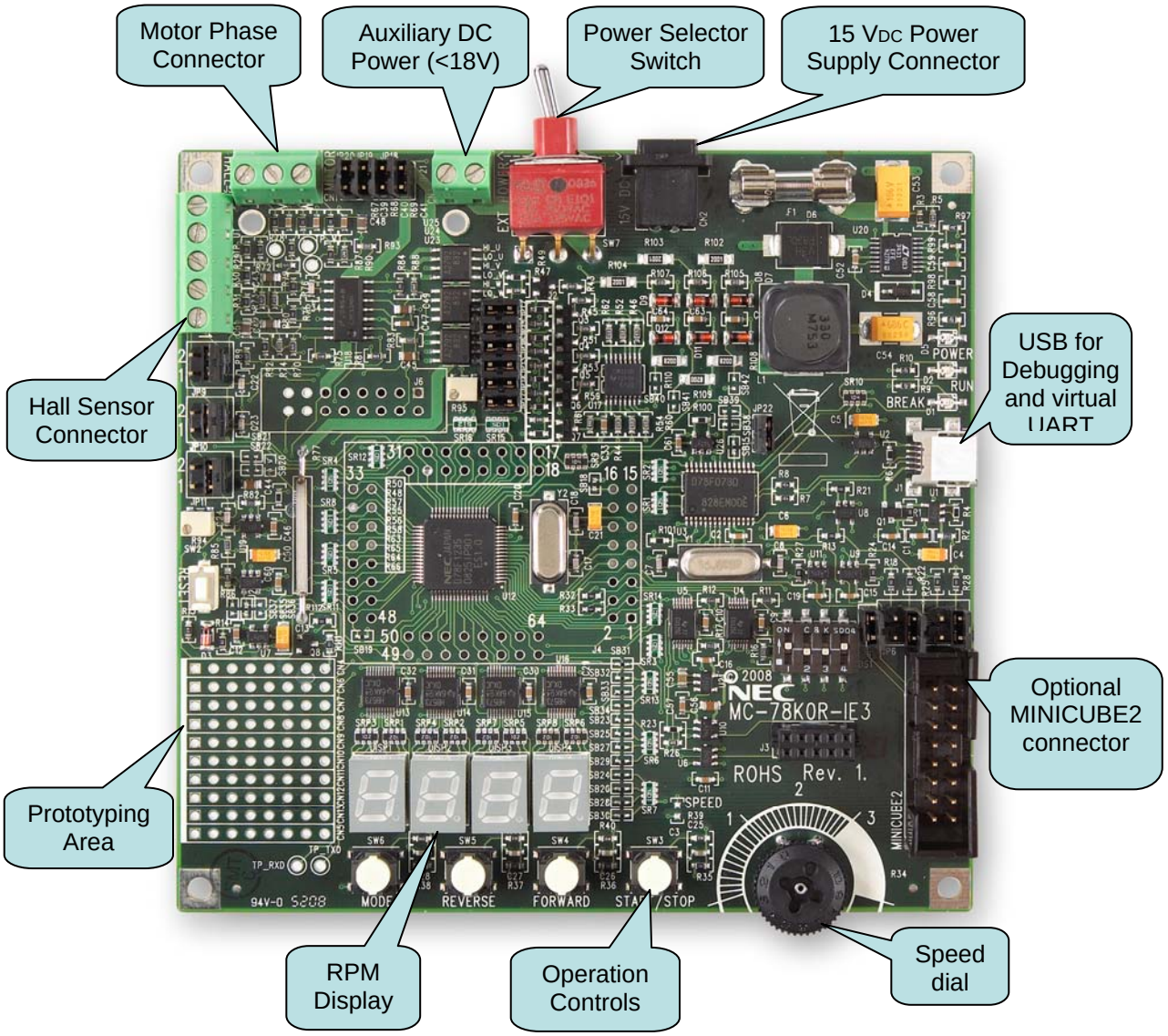
Table 1. Default Switch Settings

Switch		Default Setting
DS1	1	OFF
	2	OFF
	3	ON
	4	OFF

Table 2. Default Jumper Settings

Jumper		Default Setting
JP5	1–2	ON
JP6	2–3	ON
JP7	2–3	ON
JP9	3–4	ON
JP10	3–4	ON
JP11	3–4	ON
JP12	–	ON
JP13	–	ON
JP14	–	ON
JP15	–	ON
JP16	–	ON
JP17	–	ON
JP18	–	ON
JP19	–	ON
JP20	–	ON
JP21	–	ON
JP22	–	ON

Figure 2. Motor Control Board



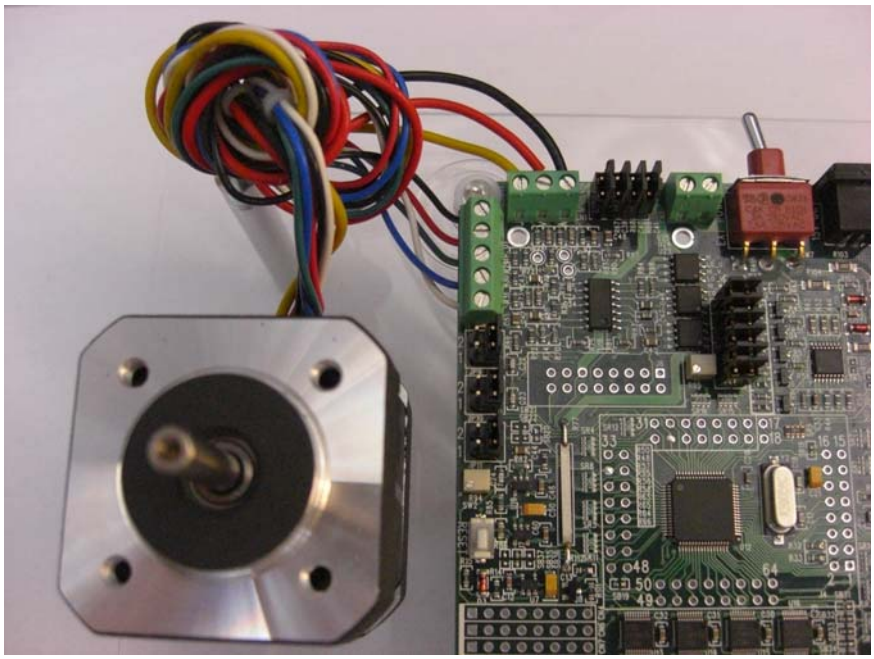
To connect the motor, attach the phase terminals to U, V and W terminals to CN1 connector block and the Hall sensor terminals to J5 connector block. Table 1 shows the connections for the motor supplied with this kit. Other low-voltage BLDC motors with similar characteristics may be used. Consult the motor specifications and make appropriate changes, including software if necessary based your own assessment.

Table 3. Motor Connections

Motor Terminals		MC-78K0R-IE3 KIT
Function	**Anaheim Automation BLY171S-15V-8000**	
Phase U	Yellow	CN8–1
Phase V	Red	CN8–2
Phase W	Black	CN8–3
Hall sensor 1	White	J5-1
Hall sensor 2	Blue	J5–2
Hall sensor 3	Green	J5-3
Hall sensor 5 V_{DC}	Red	J5–4
Hall sensor GND	Black	J5–5

Motor terminal connections for Anaheim Automation BLY171S-15V-8000 motor are shown in Figure 3.

Figure 3. Motor Terminal and Hall Sensor Connections (BLY171S-15V-8000)



The software to run the motor is programmed into the microcontroller's flash memory and it is ready to run as soon as the power supply is connected and the power switch is turned on. A quick startup procedure is outlined in the following chapter.

4. Motor Operation and Control

The operation and control of the starter kit and motor can be done in two ways:

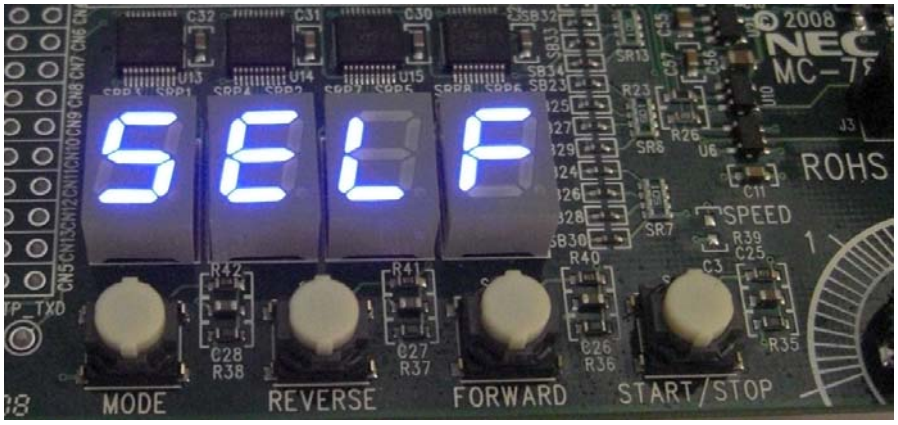
- Standalone mode – with onboard pushbuttons, potentiometer and 7-Seg LED
- PC mode – with a PC based GUI and the onboard USB connector

4.1 Standalone mode

The motor can be operated in standalone mode right out of the box after the motor terminals and hall sensor wires are connected and power is supplied. To operate in PC GUI mode a special NEC Electronics program "necgui.exe" program has to be installed. See the installation instructions and the operation in PC GUI mode in the following chapters of this user guide.

To run the motor in standalone mode, connect the 15V$_{DC}$ power supply to CN2 connector and flip SW7 power selector switch towards CN2. At this point the green POWER LED should turn on and the 7-Segment LED should display "SELF". This is an indication that the motor is ready to be operated from the on-board pushbuttons and potentiometer.

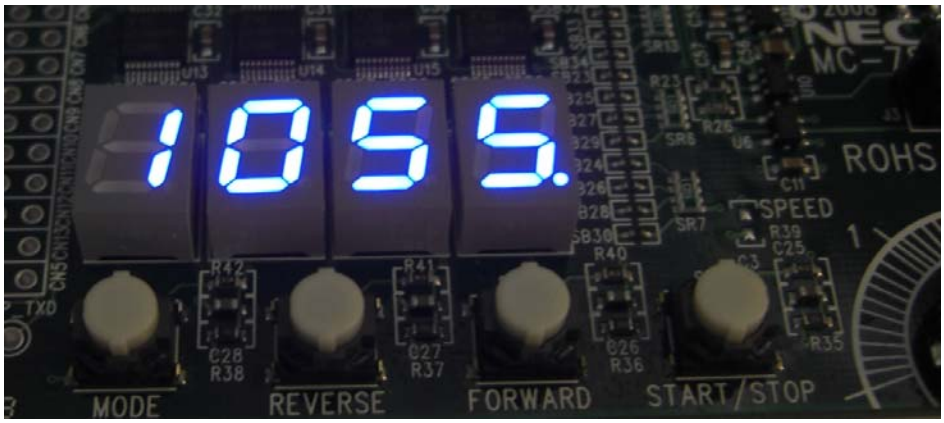
Figure 4. Power Up



After three seconds the LED will display the reference RPM and can be set to the desired speed between 300 to 5000 RPM by the onboard potentiometer. The reference RPM is identified by the decimal point lit on the units digit. If MODE button is pressed the display will toggle between

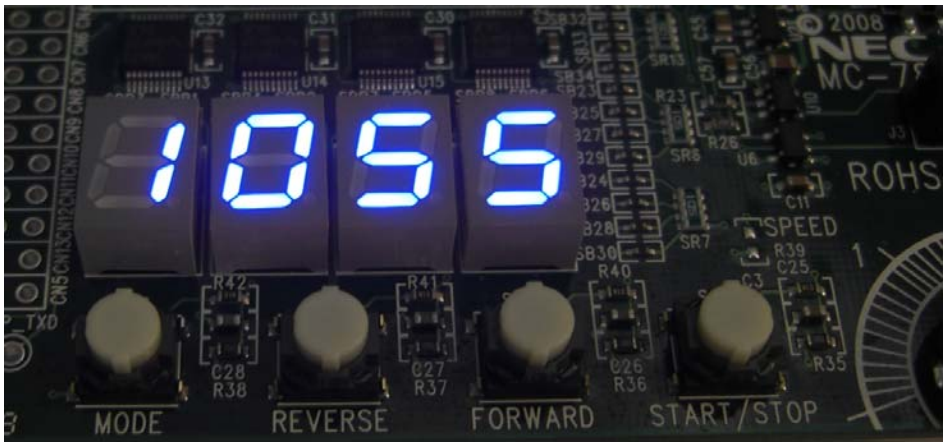
reference RPM and measured or feedback RPM. The measured RPM is displayed without the decimal point.

Figure 5. Reference RPM Display



To start the motor, press the START/STOP pushbutton. To stop the motor, press START/STOP again. During the motor operation, you can set the RPM to the desired speed using the SPEED potentiometer. Pressing MODE/DIRECTION during operation will toggle the display between the reference RPM and the actual measured RPM. Changing the direction can be done while the motor is running. The motor will ramp down and stop for a brief time and will ramp up in the opposite direction to the same set RPM.

Figure 6. Measured RPM Display



4.2 PC Mode

In PC Mode the motor can be operated using a special GUI (Graphical User Interface) which can be installed from the resource CD.

5. Flash memory programming

Programming the code into the microcontroller's flash memory is achieved automatically when the debugger is launched and the code is downloaded. To program the flash memory without the debugger, a separate programmer GUI can be used with the existing USB interface (no extra hardware is needed).

The flash programmer GUI is *NEC WriteEZ4* and it is provided with the software installation CD. Before launching the programmer, the board has to be reconfigured as follows:

- DS1: 1 OFF, 2 ON, 3 ON, 4 OFF
- JP5: SHORT JP22: OPEN
- JP6: 3-4: SHORT JP7: 3-4: SHORT

To program the flash memory, consult the *PG-FPL* and WEZ4 user manuals.

Note: Alternate methods of debugging and programming the flash memory of the µPD78F1235 microcontroller are supported with *NEC Electronics MINICUBE2* on-chip debug emulator and programmer using the 16-pin J2 connector. For details consult the *MINICUBE2* user's manual and the jumper configuration tables listed in Table 4 below.

6. Modes of Operation supported

The hardware can be configured to support standalone and PC operation, debugging of the K0RIE3 MCU as well as programming of both the K0RIE3 and the 78K0/USB MCUs. A table showing the configurations for various modes of operation is listed below.

Table 4. Modes of Operation

Function	DS1 1	DS1 2	DS1 3	DS1 4	JP5	JP22 (MODE)	Other Jumpers	Explanation
Virtual COM (VCOM) mode (Default normal mode)	OPEN	OPEN	SHORT	OPEN	X (Don't care)	SHORT	X (Don't care)	TXD6_USB -> RXD0_KR TXD0_KR -> RXD6_USB
K0RIE3 debugging via VCOM (Default debugging mode)	SHORT	OPEN	OPEN	SHORT	SHORT	OPEN	JP6: 3-4 JP7: 3-4	TXD6_USB -> RXD_QB -> TOOL0_KR RXD6_USB -> TXD_QB -> RXD_QB P11_USB -> FLMD0_KR P15_USB -> RESETB_QB -> RESETB_KR
K0RIE3 programming via VCOM	SHORT	OPEN	OPEN	SHORT	SHORT	OPEN	JP6: 3-4 JP7: 3-4	TXD6_USB -> RXD_QB -> TOOL0_KR RXD6_USB -> TXD_QB -> RXD_QB P11_USB -> FLMD0_KR P15_USB -> RESETB_QB -> RESETB_KR
K0RIE3 debugging via MINICUBE2	SHORT	OPEN	OPEN	OPEN	SHORT	SHORT	JP6: 3-4 JP7: 3-4	TXD_QB & RXD_QB -> TOOL0_KR QB_P16 -> TOOL1_KR FLMD0_QB -> FLMD0_KR RESETB_QB -> RESETB_KR
K0RIE3 programming via MINICUBE2	SHORT	OPEN	OPEN	OPEN	SHORT	SHORT	JP6: 5-6 JP7: 3-4	TXD_QB & RXD_QB -> TOOL0_KR QB_P16 -> TOOL1_KR FLMD0_QB -> FLMD0_KR RESETB_QB -> RESETB_KR
K0RIE3 debugging via MINICUBE2 + VCOM	SHORT	OPEN	SHORT	OPEN	SHORT	SHORT	JP6: 3-4 JP7: 3-4	TXD_QB & RXD_QB -> TOOL0_KR QB_P16 -> TOOL1_KR FLMD0_QB -> FLMD0_KR RESETB_QB -> RESETB_KR TXD6_USB -> RXD0_KR TXD0_KR -> RXD6_USB
K0/USB programming via MINICUBE2	OPEN	OPEN	OPEN	SHORT	OPEN	SHORT (Normal mode)	JP6: 1-2 JP7: 1-2	TXD_QB -> RXD0_KR TXD0_KR -> RXD_QB

7. Step-by-Step Operation in Standalone mode

1. Apply power.
2. Connect the motor terminals as described in section 3.
3. Plug the 15 V_{DC} power supply connector into CN2.
4. Turn the SW7 power selector switch handle toward CN2.

   The 4-digit, 7-Segment LED should display ‘SELF’ indicating a stand-alone mode operation.

   (operated with on-board push-buttons and potentiometer)
5. Press the **MODE** button once to display the reference RPM (units decimal point lit) and adjust by SPEED potentiometer to desired value between 300-5000.
6. Press the **MODE** button once to changes display to the MEASURED RPM (0000 if the motor is not running).
7. Press the **START/STOP** button to start the motor.

8. Adjust the reference RPM with SPEED potentiometer. (During motor rotation, press **MODE** button to switch the display between the REFERENCE RPM and the MEASURED RPM.)
8. While the motor is running press FORWARD or REVERSE to change direction.
9. To stop motor press START/STOP button once.

8. Drive and Motor Protection

The starter kit and the motor are protected against unexpected events such as overloads, motor stals and malfunctions of the Hall sensors. If such faults are detected, the motor stops rotating and one of the following fault conditions is displayed on the seven-segment LED.

- Motor over-current: 'O–C ' (adjustable with R95 Trim potentiometer)
- Hall sensor fault: 'HALL' (malfunction, disconnected wiring)
- Motor stall 'FAIL' (failure to spin)

9. Software Setup

The software CD-ROM accompanying this kit contains PDF versions of this document, the electrical schematic of the MC-78K0R-IE3 KIT, the sample code to drive the BLDC motor and NEC Electronics 78K0R firmware development tools environment. The software sample code is supplied in source format and can be modified as needed.

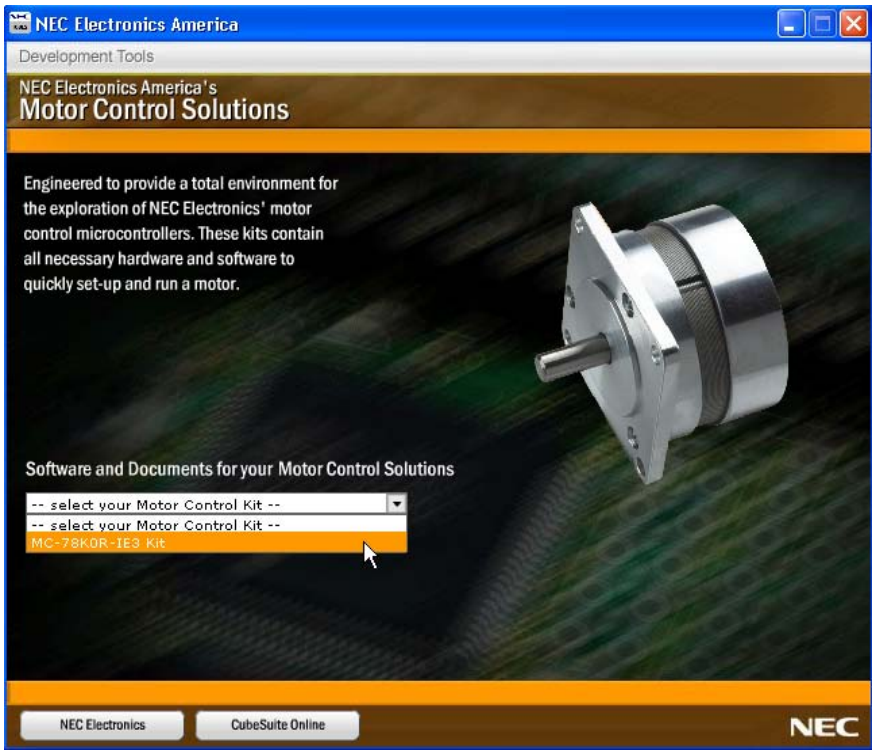
The following sections describe NEC Electronics America's development tools environment, how to install it on your computer, and how to rebuild and download executable code to the microcontroller's flash memory.

Before proceeding with the tools installation, however, refer to all of the documentation on the CD-ROM for information about the starter kit and follow the steps described in the following chapter.

10. Software Installation

1. Insert the CD-ROM supplied with your **MC-78K0R-IE3 KIT**.
2. The CD-ROM should initialize automatically. If it doesn't, click **Start → Run**. Browse to your CD-ROM drive and select **Motol_Control.exe**.
3. Select **MC-78K0R-IE3 KIT** from the drop-down list.

Figure 7. Motor Control Software and Documents Installation GUI

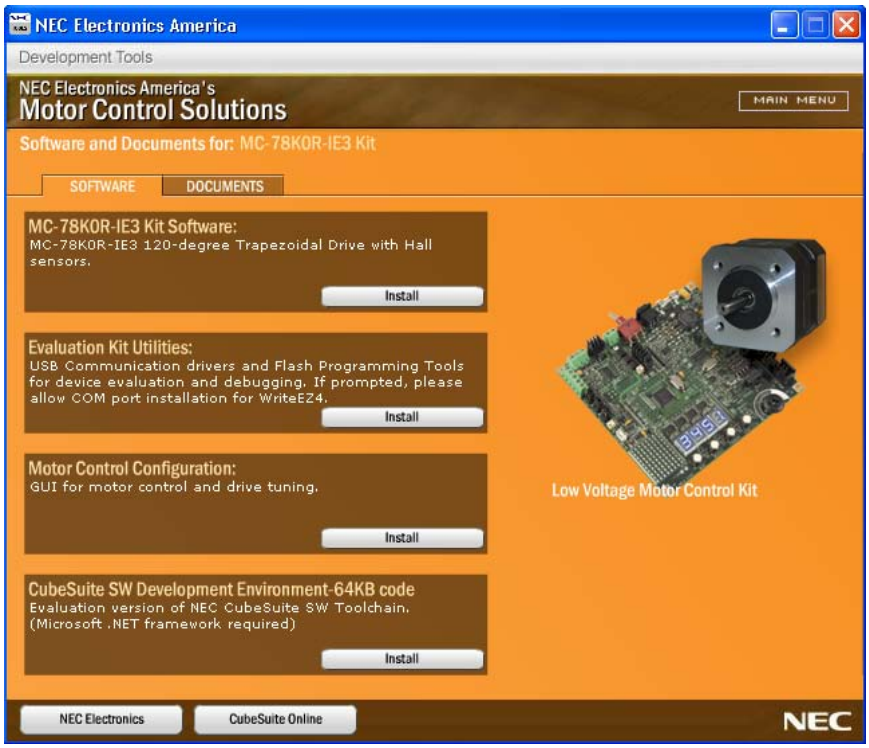


4. Install all of the software in the following recommended sequence:
    - NEC Electronics CubeSuite Software Development Environment
    - MC-78K0R-IE3 KIT Software
    - Evaluation Kit Utilities
    - Motor Control Configuration GUI

Before installing the CubeSuite environment and GUI program, the user PC needs to have the latest version of .NET framework which can be obtained from the “Development Resources” tab at:

http://microsoft.com/downloads/en/default.aspx

Figure 8. Software Installation Window

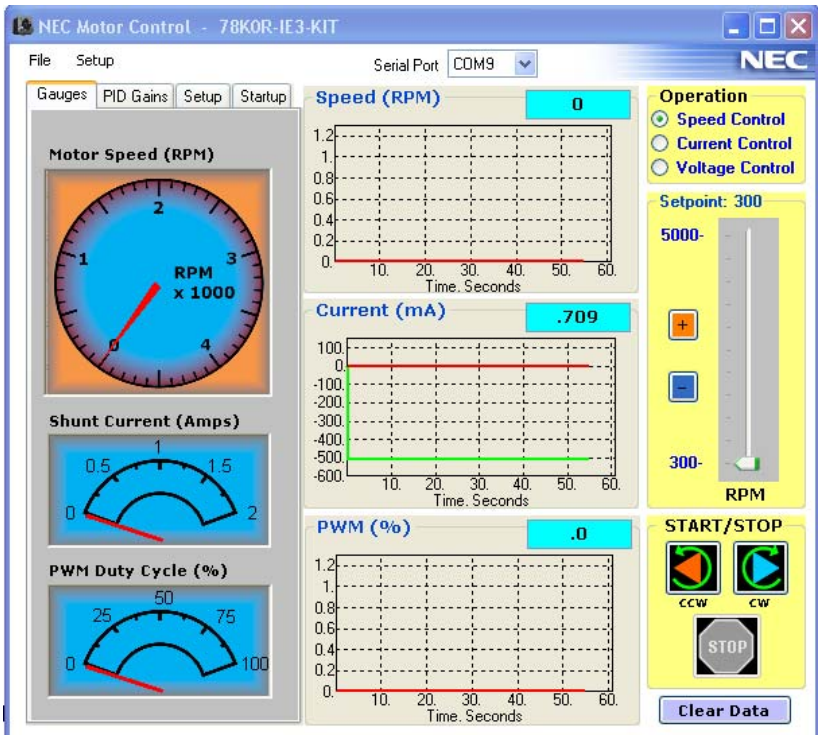


11. PC GUI Operation

A PC-based graphical user interface (GUI) program is included on the resource CD and can be installed from the main menu above.

To operate the motor in PC GUI mode, connect the USB cable to the starter kit board and PC and power up the board. At this point the green POWER LED should turn on and the 7-Segment LED should display “SELF”. This is an indication that the operation mode is standalone. Launch “necgui.exe” program from Start \ All Program \ NEC MC GUI while the motor is stopped. The starter kit firmware will automatically detect the GUI program and will switch to PC Mode. The 7-Seg LED will display “PC. In this mode the user can control the motor speed and acceleration, motor current, PID parameters and it can monitor and graph parameters as well perform an interactive motor parameter tuning. Figure 9 below shows the main page of the NEC Electronics motor control GUI.

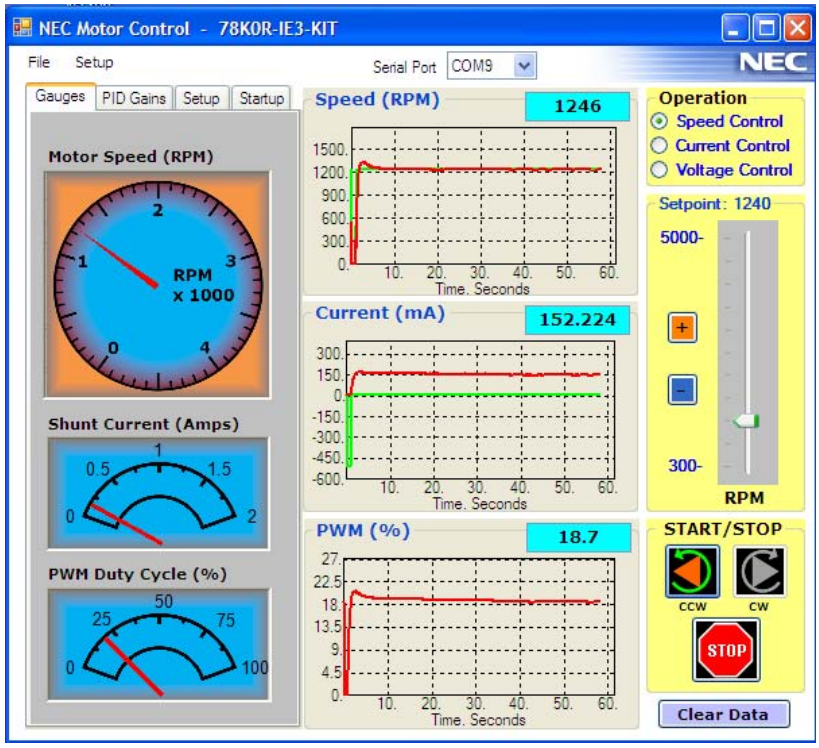
Figure 9. NEC GUI Main Window



When the GUI is launched with a new **MC-78K0R-IE**3 board, the gain of the on-board Operational Amplifier may have to be calibrated. Adjust R94 and notice the change in the **Current (mA**) display on the GUI. With the motor stopped, adjust the value as close as possible to 0 (mA).

To start the motor, click **CW** or **CCW** buttons and observe motor rotation. At this point, the motor should rotate at the RPM sown at Setpoint, and the gauges and graphs should indicate the motor speed, motor current and PWM duty cycle. Motor direction can be changed by alternatively clicking **CW** and **CCW** buttons.

Figure 10. NEC GUI Motor Operation Window



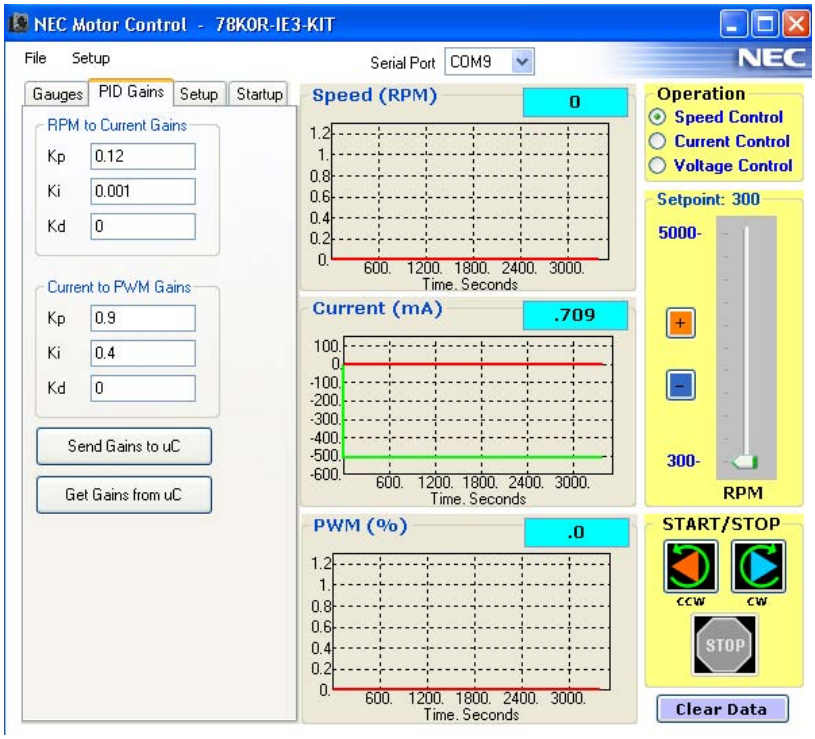
To modify the motor RPM, use + and – buttons or **Setpoint** slider. To stop the motor, click **STOP** button**.**

The above operation mode is **Speed Control** mode. In this mode, the motor is controlled by speed PID loop to keep the RPM constant regardless of the load. The motor current will adjust accordingly. The second mode is **Current Control** in which the current is regulated by a current PID loop keeping the current constant and adjusting the speed according to the load. **Voltage Control** is the third control mode in which the PWM duty cycle can be set between 0% and 100%. This is an open loop control mode.

11.1 Motor Control Parameter Adjustment

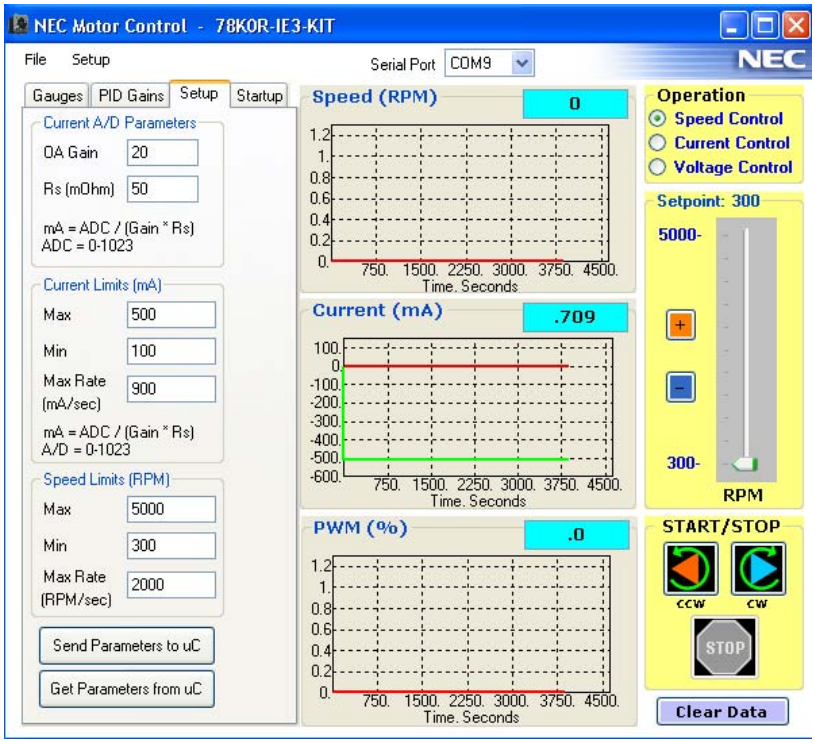
Motor Control parameters such as control loop PID coefficients, speed and current limits and acceleration can be set in **PID Gains** and **Setup** windows as shown in Figure 11.

Figure 11.NEC GUI PID Gains Window



After the PID parameters are changed, click Send Gains to uC to update the variables in the microcontroller's memory. Adjust the PID parameters in small steps and observe motor behavior.

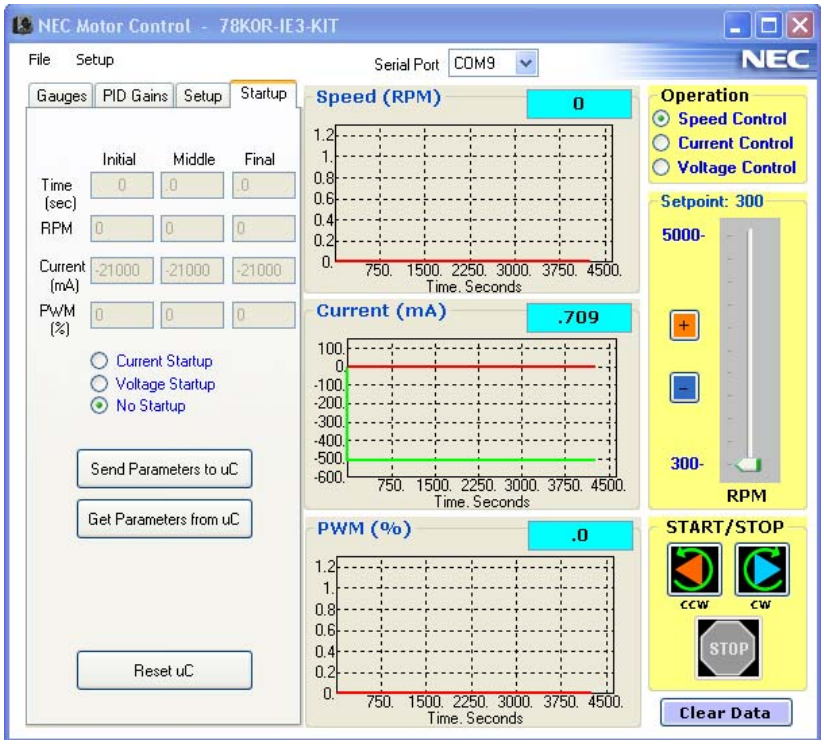
Figure 12.NEC GUI Setup Window



The **Setup** window shown in Figure 12 allows the user to set the motor speed and motor current limits and acceleration rates. The Operational Amplifier gain and current shunt resistor value are hardware dependent and are preset for the MC-78K0R-IE3 board to the values shown in the figure above. Do not change these values. To update the microcontroller memory, click S**end Parameters to uC**.

Figure 13 below shows the Startup window.

Figure 13. NEC GUI Startup Window



This window is not used for the MC-78K0R-IE3 120-degree Trapezoidal Drive with Hall sensors project; it is intended for future sensor-less projects. The only button that is operational is **Reset uC.** This button is used to reset the microcontroller and reload the default control parameters.

12. Using the NEC Electronics C Compiler and Source Code Debugger

The program loaded into the flash memory of the 7**8K0R-IE3** microcontroller uses a 120- degree trapezoidal method to drive a low-voltage BLDCM with Hall sensors for rotor position detection. The source code provided as a project for NEC Electronics PM+ project manager and C compiler environment can be recompiled, downloaded, executed and debugged.

To download and execute the code no external hardware such as ICE (in-circuit emulator) or OCD (on-chip debug) tool is needed. The **MC-78K0R-IE3 KIT** has all debugging hardware onboard, and needs only a USB cable to connect to a PC.

To prepare the **MC-78K0R-IE3 KIT** for debugging follow the steps below:

1. With the power turned off, set DIP switch DS1 as follows:
   - DS1: 1 ON, 2 OFF, 3 OFF, 4 ON
   - JP5: SHORT
   - JP22: OPEN

Note: The rest of the jumpers do not affect the debugging set-up but before the motor is operated they should be in their default configuration as below:

- JP5: 1-2 SHORT JP12: SHORT JP18: SHORT
- JP6: 2-3 SHORT JP13: SHORT JP19: SHORT
- JP7: 2-3 SHORT JP14: SHORT JP20: SHORT
- JP9: 3-4 SHORTJP15: SHORT JP21: SHORT
- JP10: 3-4 SHORTJP16: SHORT
- JP11: 3-4 SHORTJP17: SHORT

2. Attach the USB cable to J1 on the **MC-78K0R-IE3 KIT** and to the PC.
3. Power up the **MC-78K0R-IE3 KIT.**

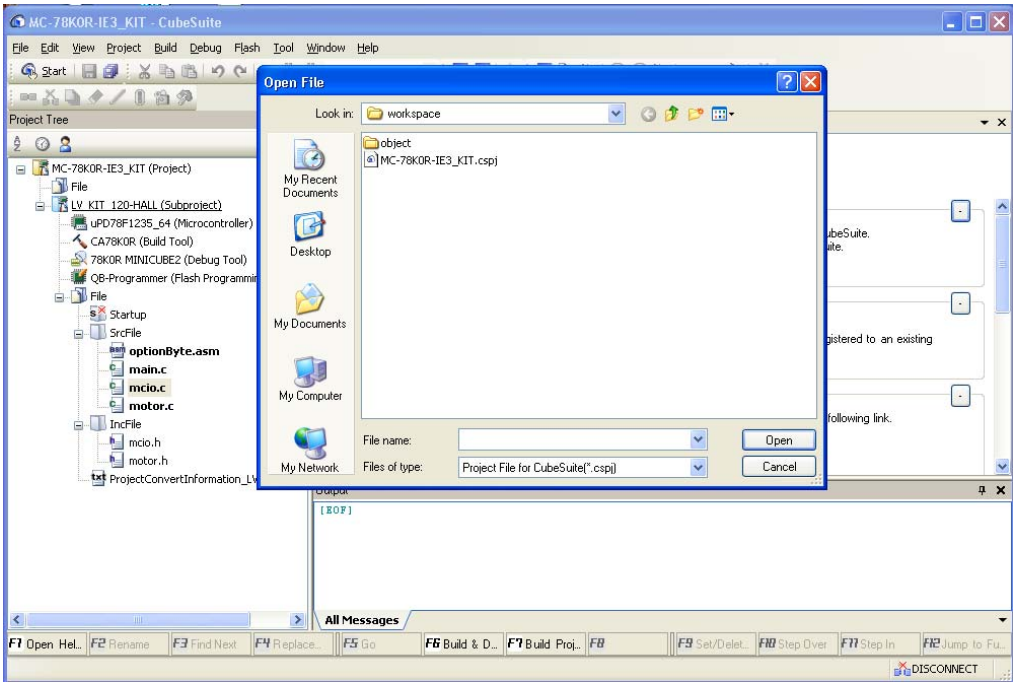
The sample program "**MC-78K0R-IE3 120-degree Trapezoidal Drive with Hall Sensors**" installed in step two of the "Install Software" section can be found in the folder Motor Control located on your PC Desktop. The sample code includes a workspace and project files used with NEC Electronics' **CubeSuite** project manager and debugging environment.

To recompile and debug the sample program follow the steps below:

1. Launch CubeSuite from **Start → Programs → NEC Electronics CubeSuite → CubeSuite**

2. **CubeSuite** will display its main window as shown in Figure 14 below.
3. Click **File** and select **Open**
4. Browse to Desktop\Motor_Control\MC-78K0R-IE3_KIT\workspace and select MC-78K0R-IE3_KIT.cspj

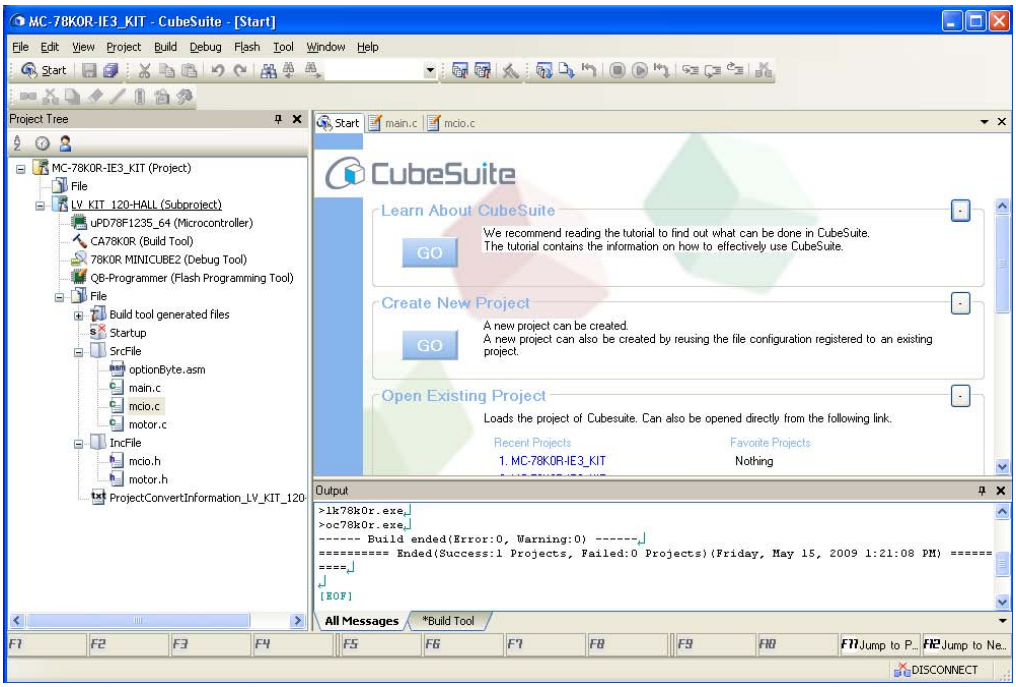
Figure 14. CubeSuite project load



5. The newly loaded workspace file will contain one project called **LV_KIT_120-HALL** as shown below.
6. To recompile the code, click **Build** and select **Rebuild**.

The project should rebuild without any error.

Figure 15. CubeSuite project build



7. At this point, you may change the code and recompile as needed.

   Important Notice!

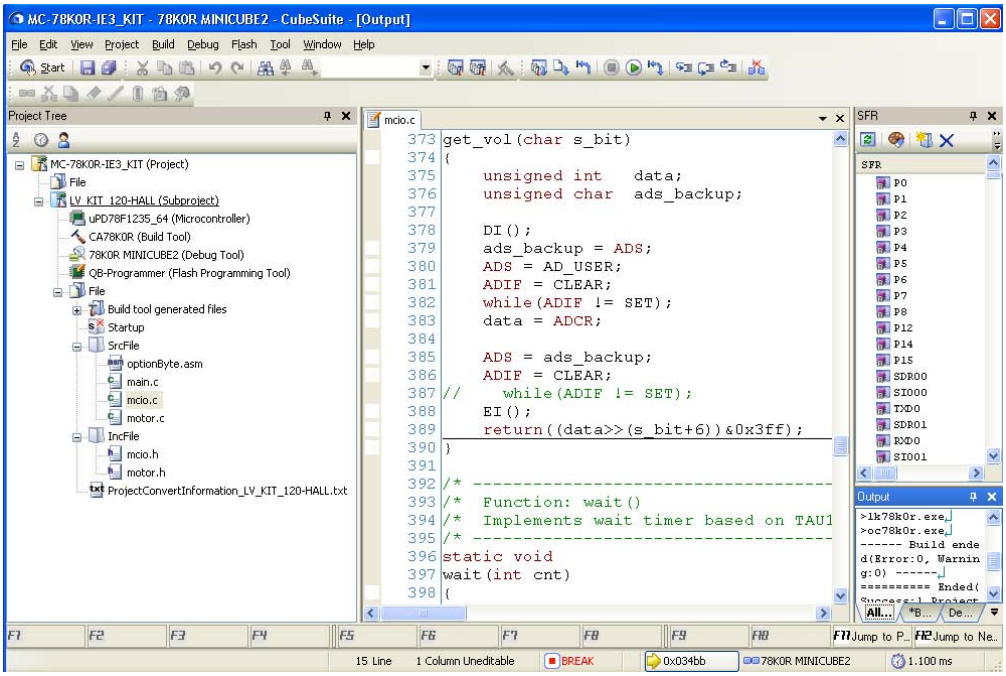
   The starter kit software was developed for the Anaheim Automation BLY171S-15V-8000 BLDC motor specifically. If other low voltage motors are used, the code may have to be modified by the user to address differences in phase and hall terminal connections, winding polarity, starting torque, load characteristics, etc.

8. After building the code successfully, you may download and run or debug the code.

13. Downloading and Debugging the Code

1. To debug the code, select **Download** from **Debug** menu or click the **Download** button on the tool bar. By default, the program automatically downloads the code to the microcontroller's flash memory through the onboard debugging interface, and the source code is displayed in **CubeSuite** debugger window as shown in Figure 16.

Figure 16.Source Code in Debugging Window



2. Use **Go** command from the **Debug** menu or tool bar to execute code in debugging mode.
   - At this point, the motor can be controlled from the user interface pushbuttons and potentiometer found on the **MC-78K0R-IE3 KIT.**
3. To stop program execution use the **STOP** command in the debugger
   - **Caution:**

     Make sure you stop the motor before stopping the program execution to prevent possible damage to the hardware if the code breaks when motor phases are driven!

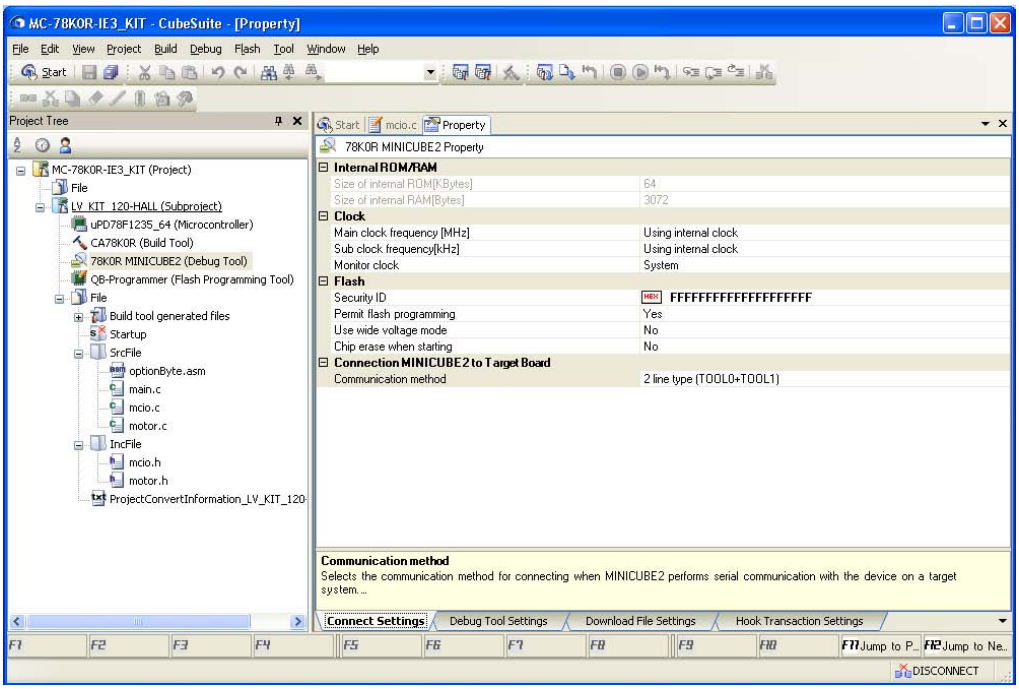
     The same restriction applies to breakpoints. Do not use breakpoints when the motor is running!
4. To exit the debugger, use **Disconnect** from **Debug Tool** command found in **Debug** menu or on the tool bar.

For information on how to operate the debugger, consult the user manuals supplied with CubeSuite.

13.1 Security ID Code

The µPD78F1235 microcontroller is provided with a security feature to prevent unauthorized users from accessing the flash memory during debugging. This security key is a 20-byte ID code that is specified in CubeSuite project manager under **78K0R MINICUBE2 (Debug Tool)\Flash\Security ID** as seen below in Figure 17.

Figure 17.Source ID Code

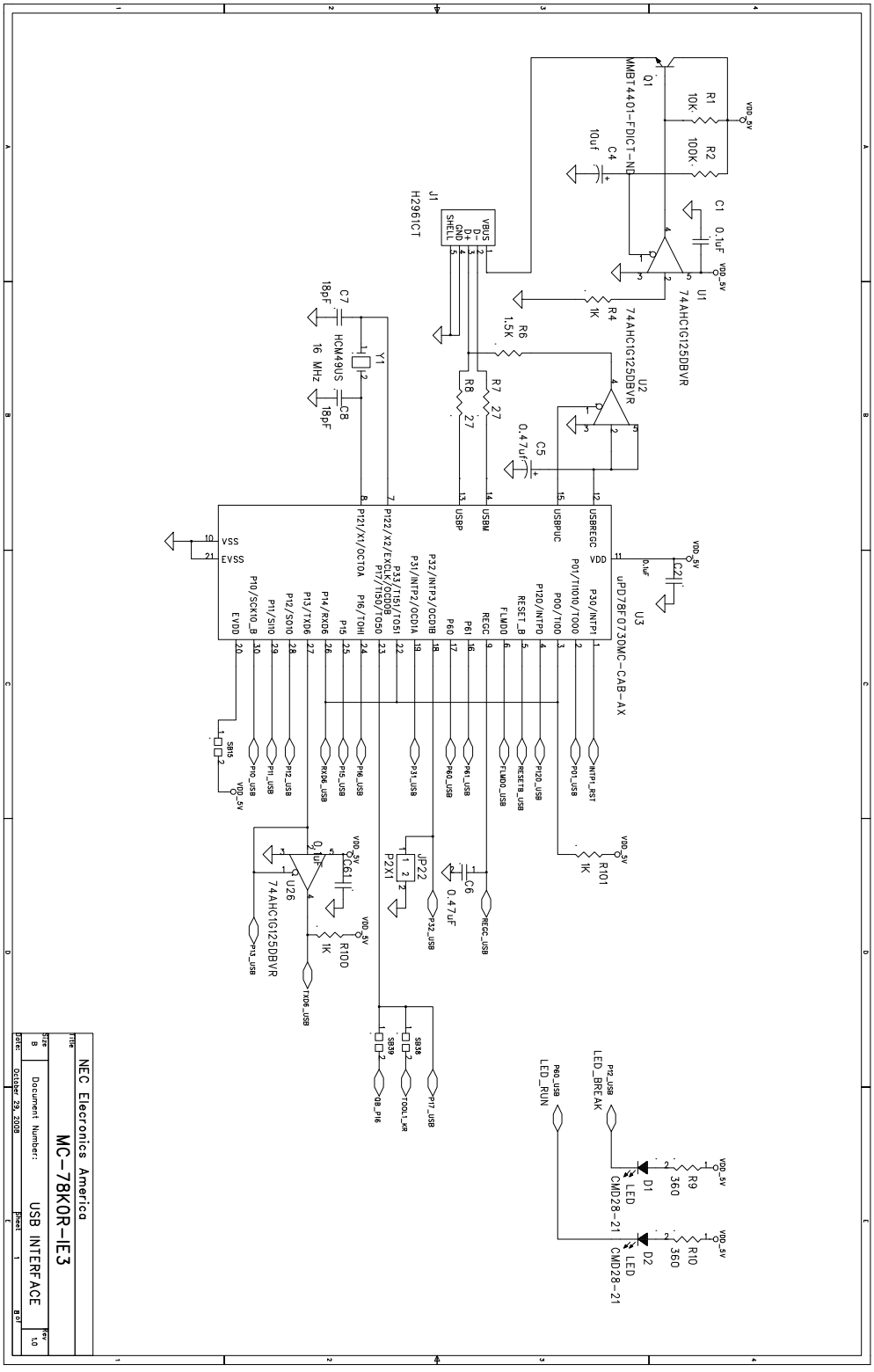


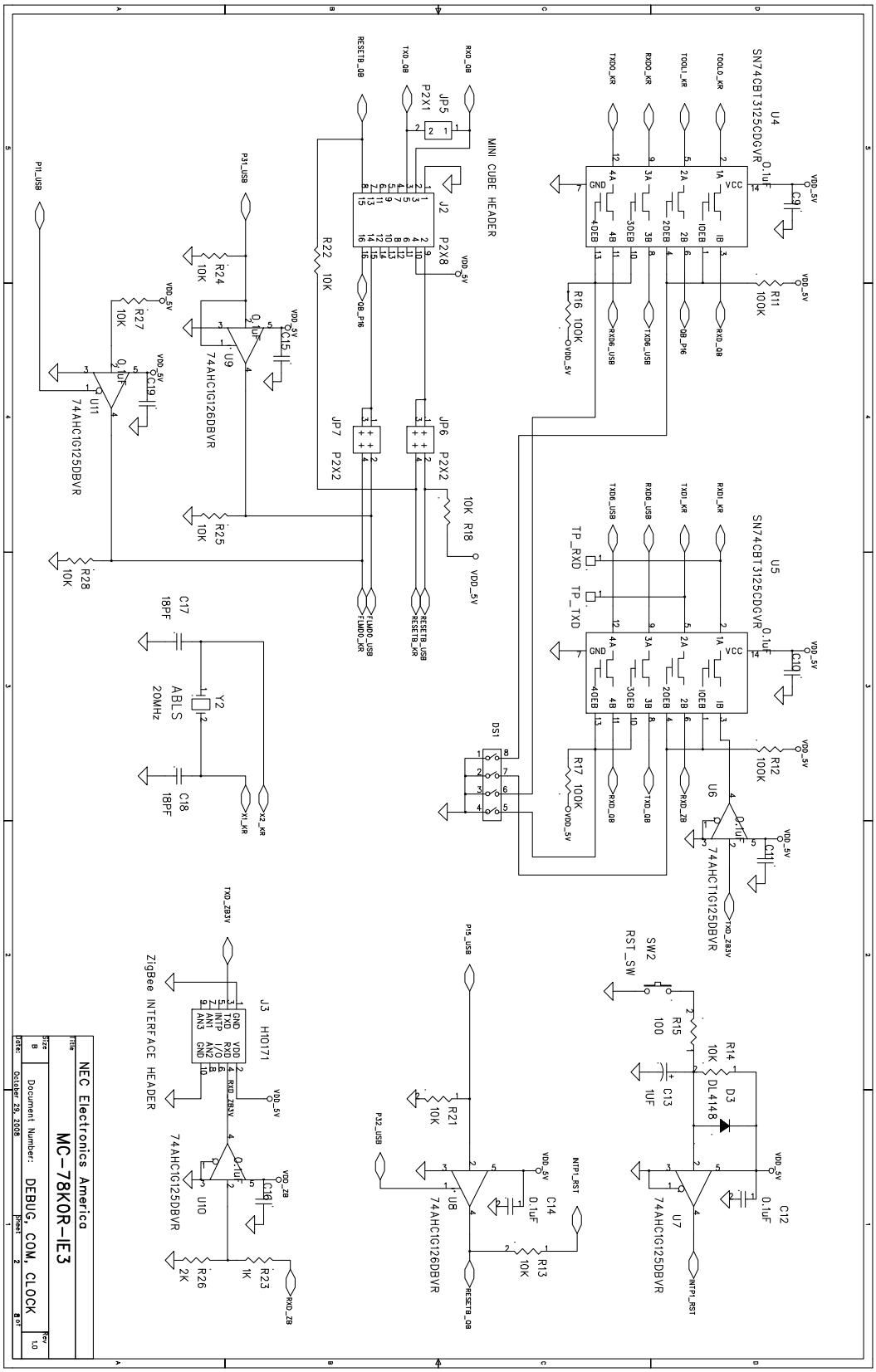
By default the ID code is FFFFFFFFFFFFFFFFFFFF, and it can be changed by the user. Before changing it, consult the *µPD78F1235* microcontroller user's manual. After changing it, the user must remember this code to be able to access the flash memory again. If the ID code is forgotten, the only way is to erase the chip's flash memory. The ID code will default to FFFFFFFFFFFFFFFFFFFF.

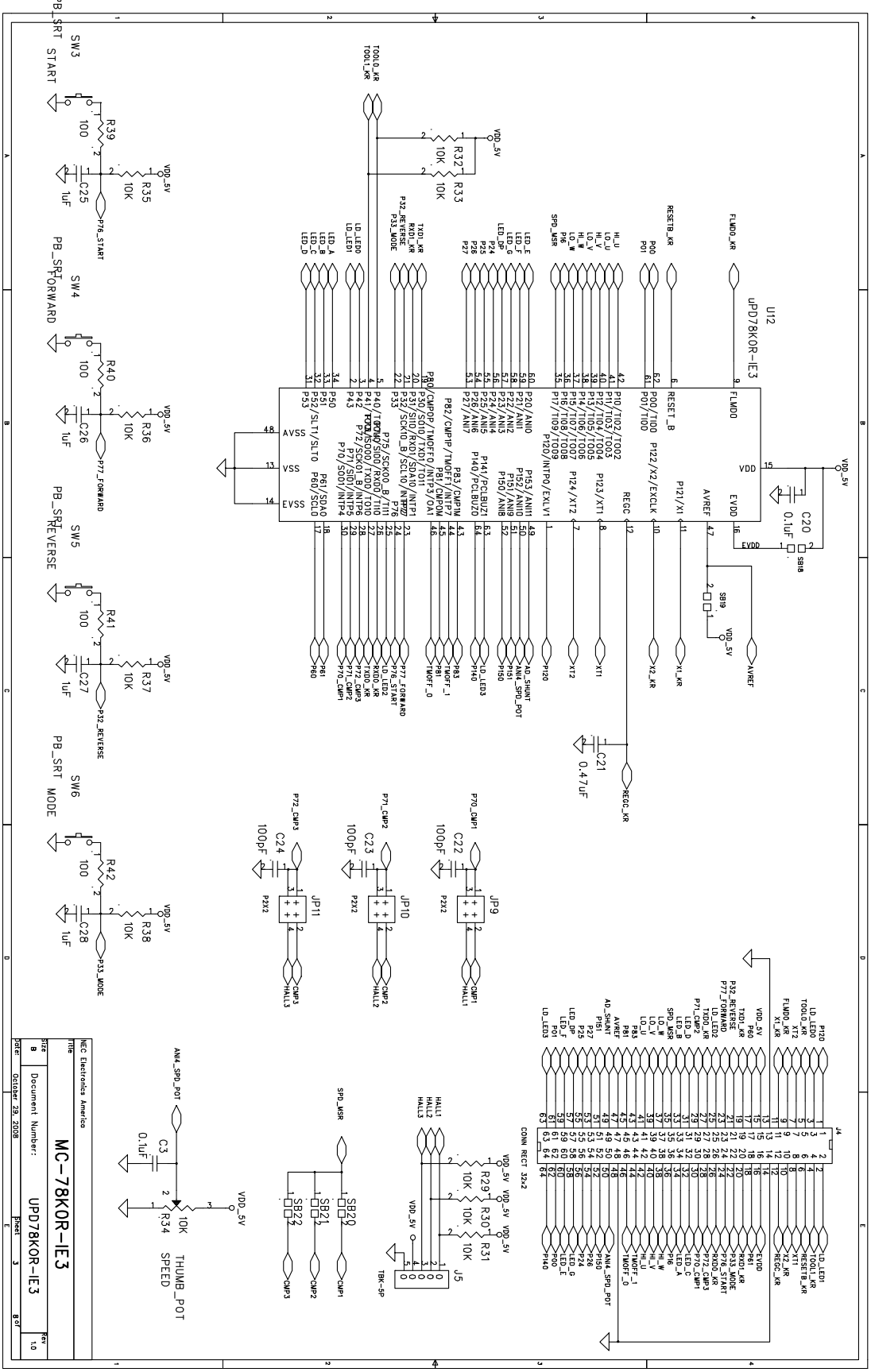
To return to standalone mode operation, close the debugger, disconnect the USB cable, power down the **MC-78K0R-IE3 KIT** board and change DS1 and JP22 configuration as shown below:

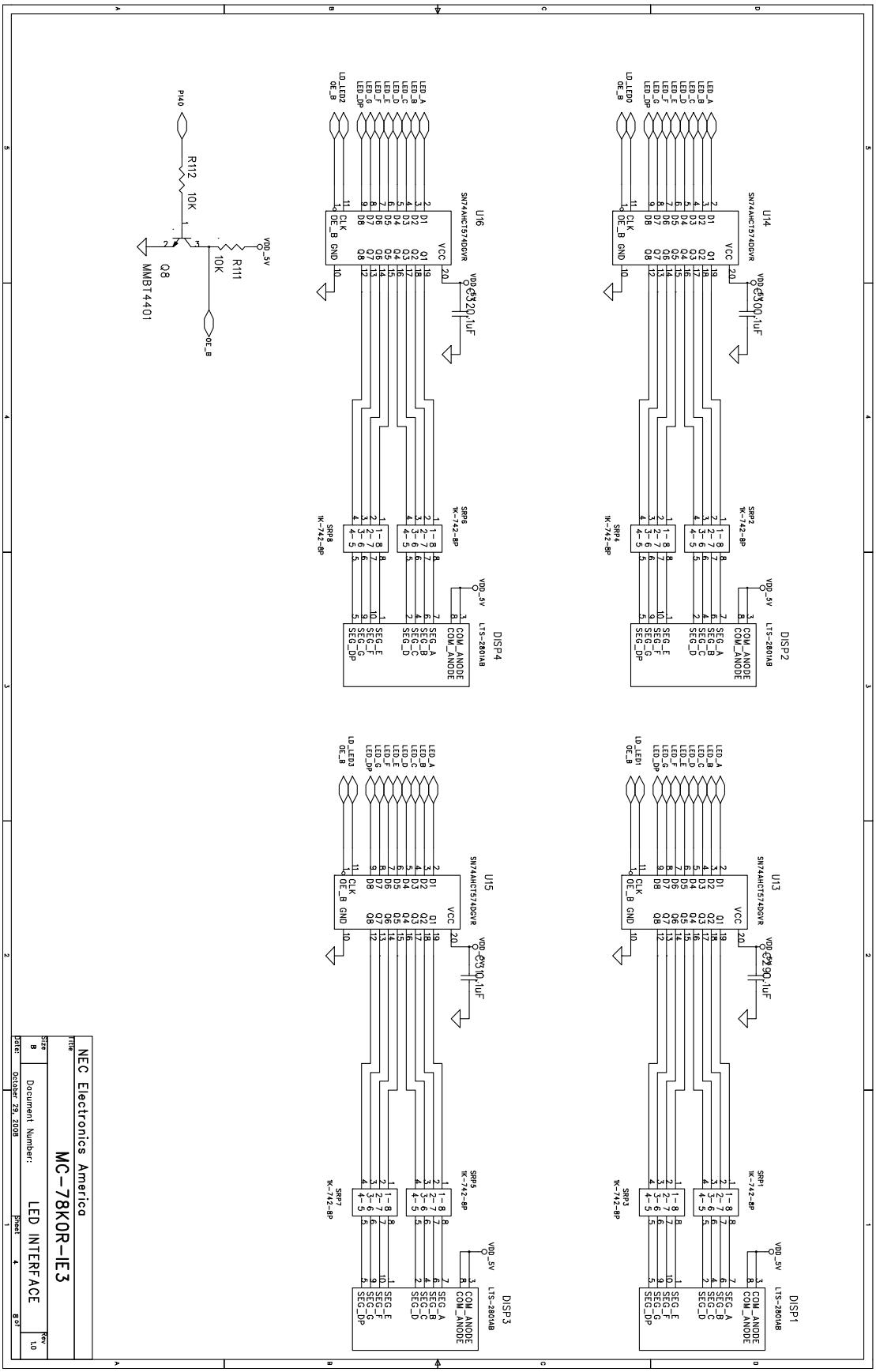
- DS1: 1 ON, 2 OFF, 3 ON, 4 OFF
- JP22: SHORT

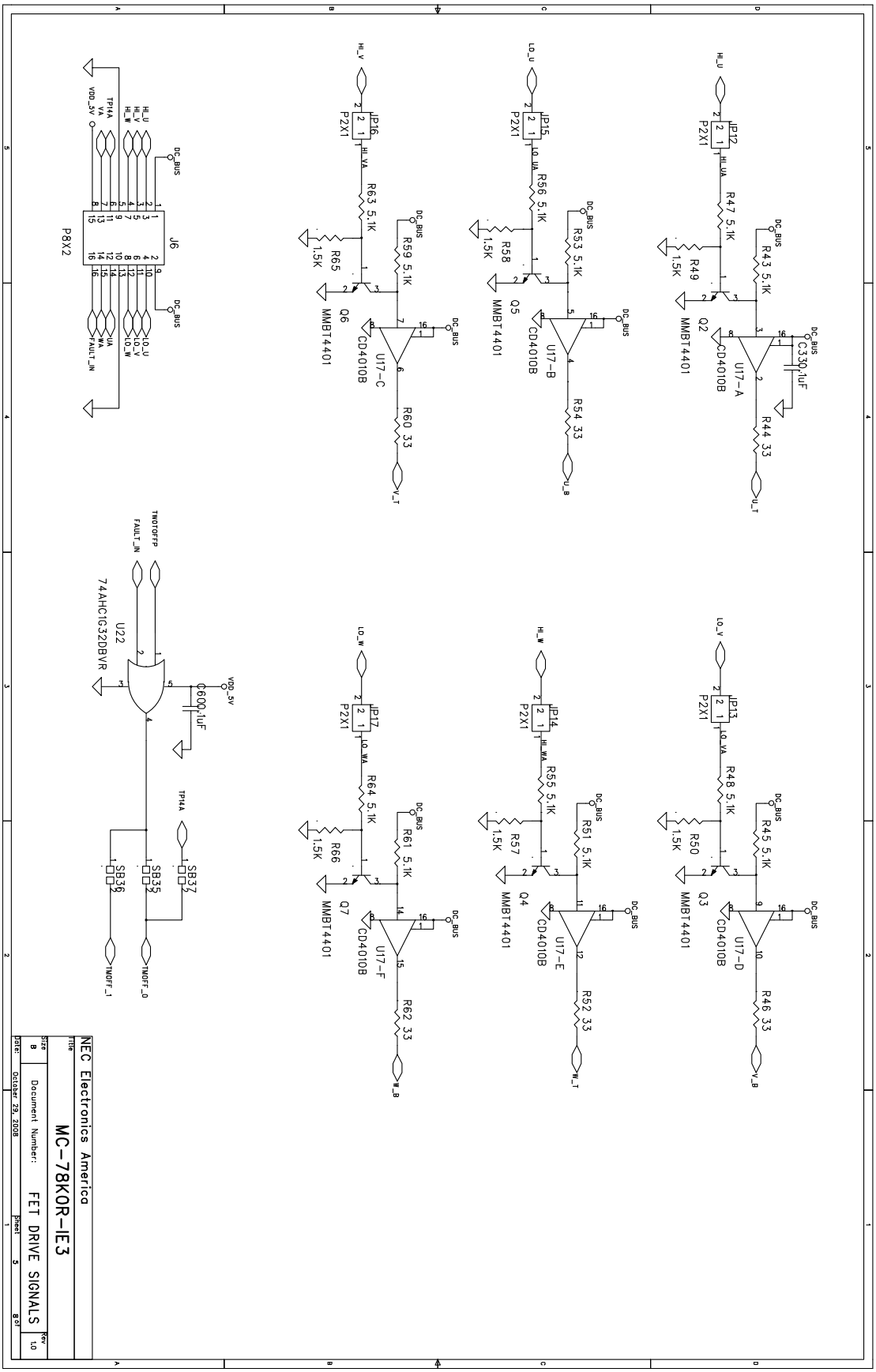
14. Appendix - Schematics

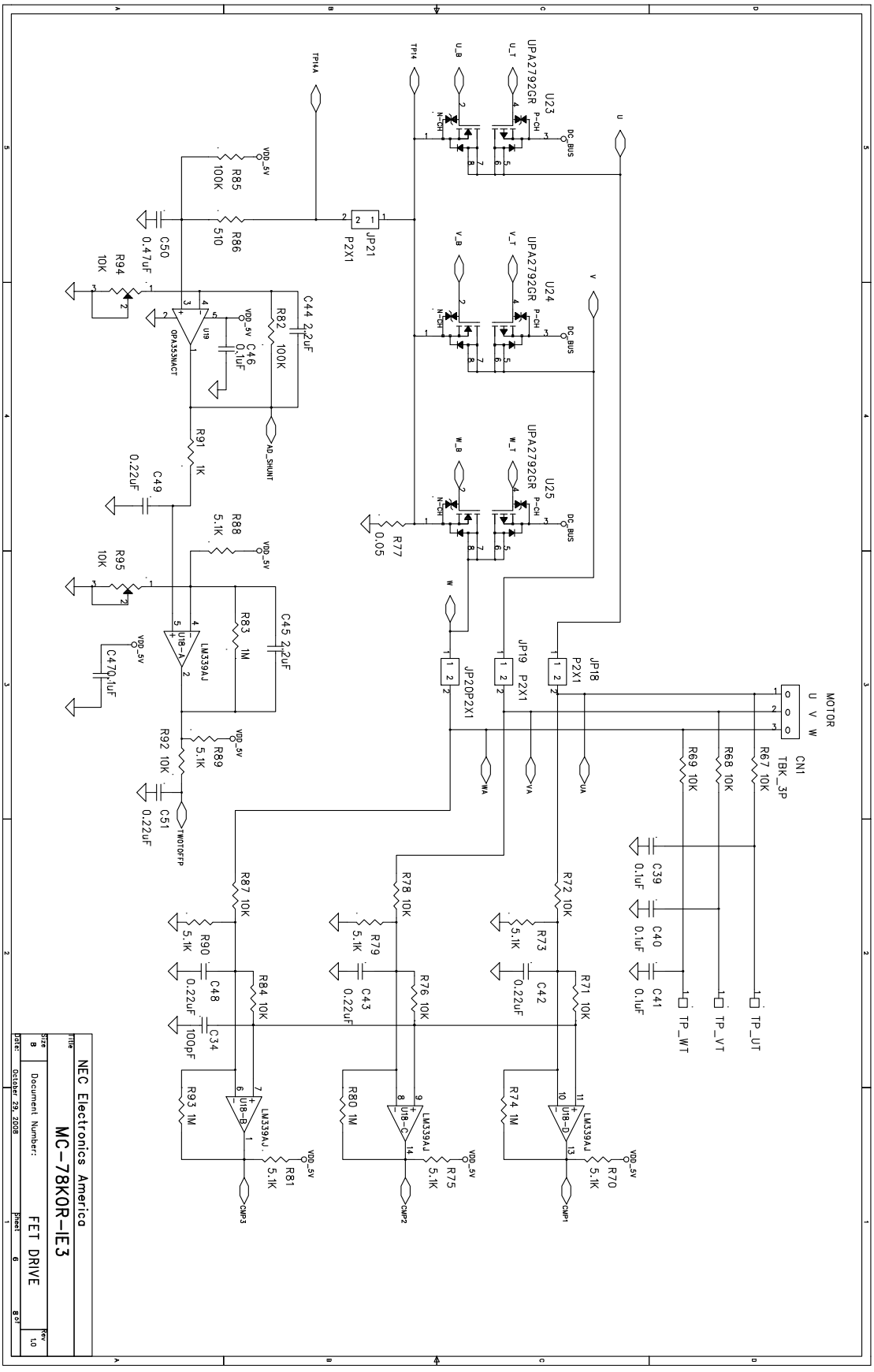


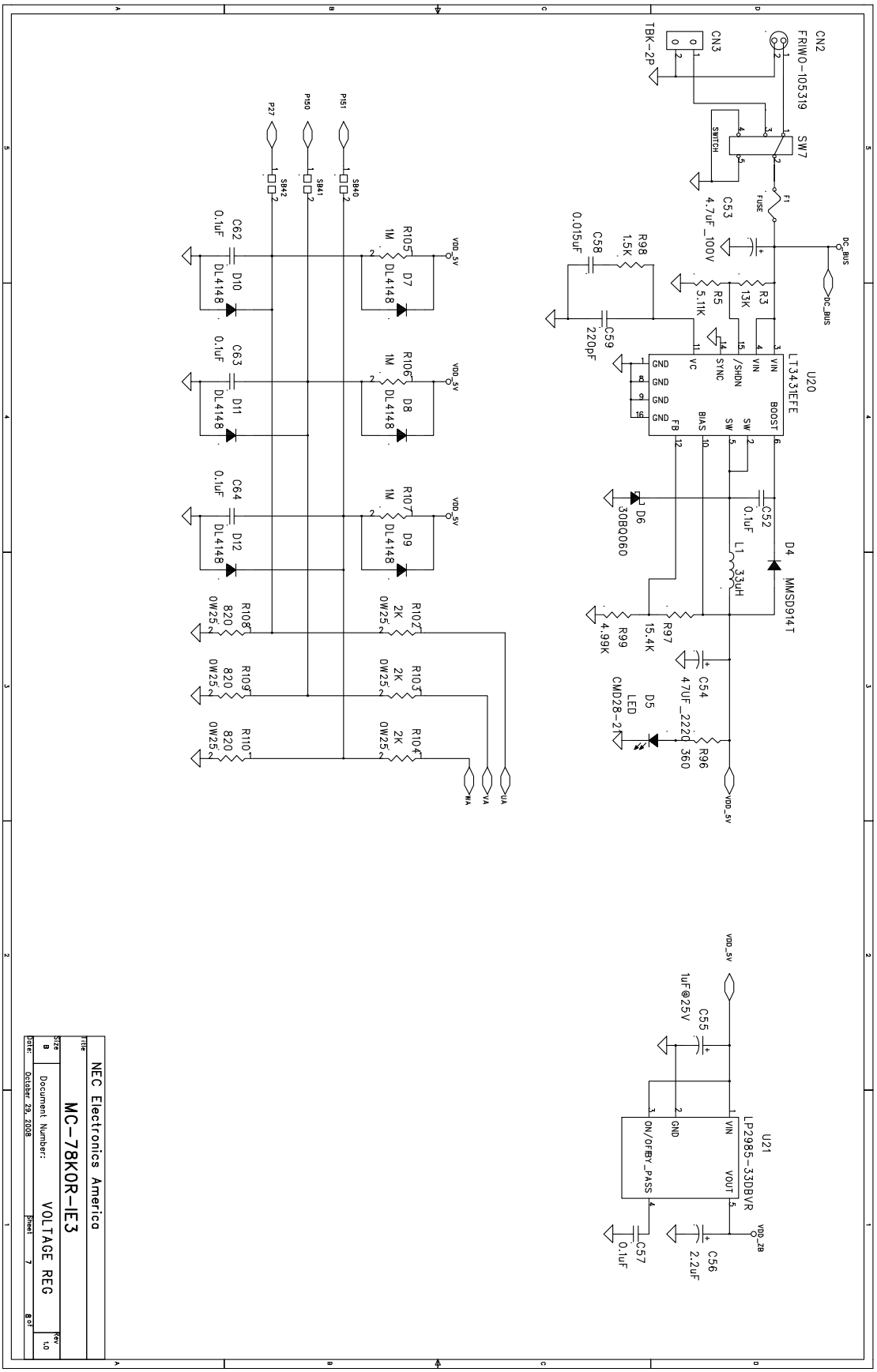

NEC Electronics America
MC-78K0R-IE3
DEBUG, COM, CLOCK
Document Number:
October 29, 2008
MINI CUBE HEADER
ZigBee INTERFACE HEADER
SN74CBT3125CDGVR
74AHC1G125DBVR
74AHC1G126DBVR
74AHCT1G125DBVR
ABLS 20MHz
H10171
SW2
RST_SW
DL4148
TP_RXD
TP_TXD

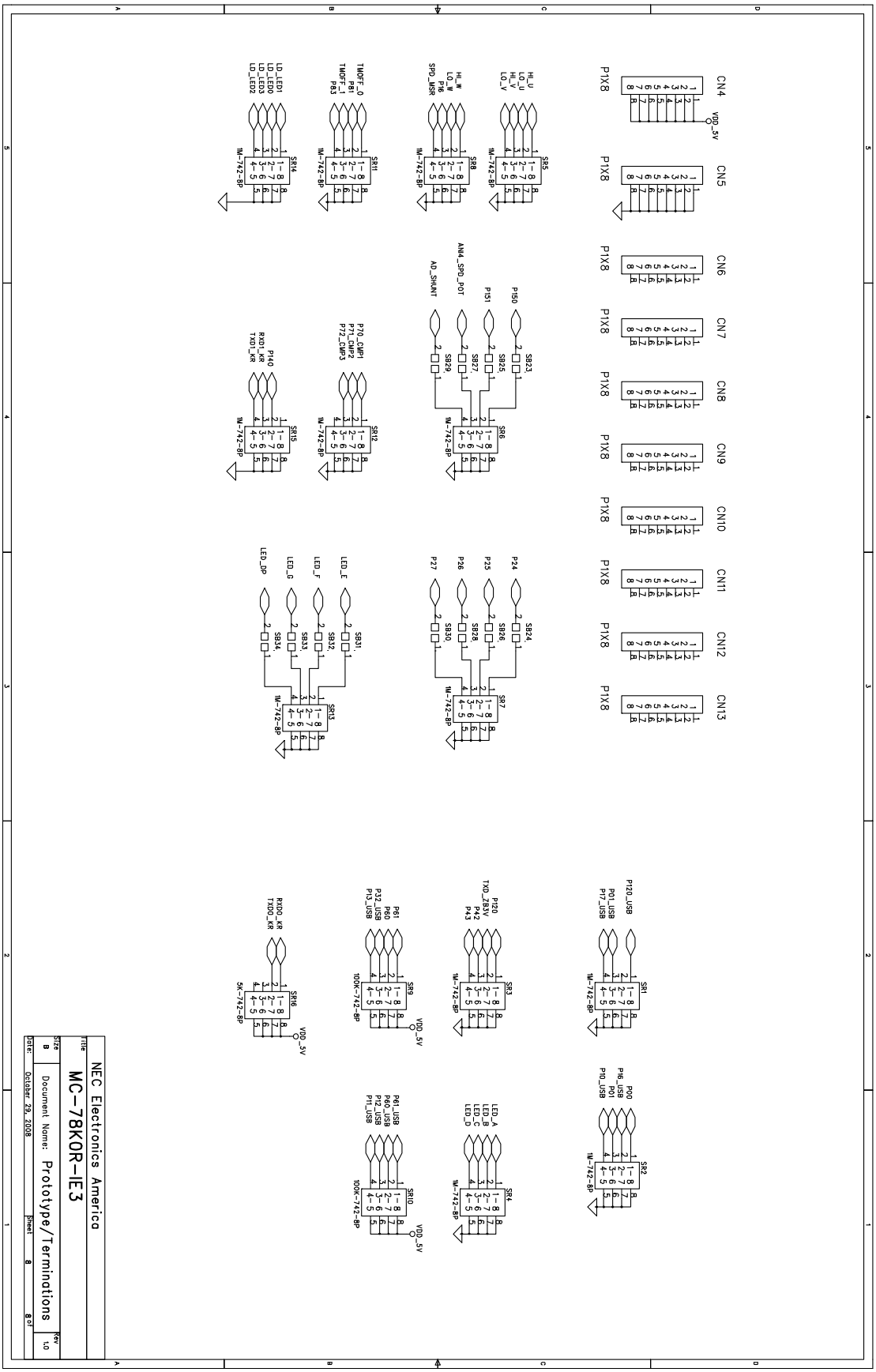

uPD78K0R-IE3
MC-78K0R-IE3
UPD78K0R-IE3
THUMB_POT
SPEED
PB_START
PB_FORWARD
PB_REVERSE
PB_MODE
TBK-SP
NEC Electronics America
October 29, 2008


U14
U16
U13
U15
SN74AHCT574DGVR
DISP1
DISP2
DISP3
DISP4
LTS-2801AB
SRP1
SRP2
SRP3
SRP4
SRP5
SRP6
SRP7
SRP8
1K-742-8P
R112 10K
R111 10K
Q8
MMBT4401
P140
VDD_5V
OE_B
LD_LED0 OE_B
LD_LED1 OE_B
LD_LED2 OE_B
LD_LED3 OE_B
LED_A
LED_B
LED_C
LED_D
LED_E
LED_F
LED_G
LED_DP
C300 0.1uF
C290 0.1uF
C320 0.1uF
C310 0.1uF
NEC Electronics America
MC-78K0R-IE3
LED INTERFACE
Document Number:
October 29, 2008
Sheet 4 of 7
Rev 1.0


NEC Electronics America
MC-78K0R-IE3
FET DRIVE SIGNALS
Document Number:
October 29, 2008
Sheet 5 of 8
Rev 1.0
HI_U
LO_U
HI_V
LO_V
HI_W
LO_W
DC_BUS
VDD_5V
TWOTOFTP
FAULT_IN
TNOFF_I
TNOFF_O
U_T
U_B
V_T
V_B
W_T
W_B
P8X2
J6
U22
74AHC1G32DBVR
MMBT4401
CD4010B


NEC Electronics America
MC-78K0R-IE3
FET DRIVE
Document Number:
October 29, 2008
Rev 1.0
Sheet 6 of 8
MOTOR
U V W
CN1
TBK_3P
TP_UT
TP_VT
TP_WT
JP18 P2X1
JP19 P2X1
JP20 P2X1
JP21 P2X1
U23 UPA2792GR
U24 UPA2792GR
U25 UPA2792GR
P-CH
N-CH
DC_BUS
R67 10K
R68 10K
R69 10K
C39 0.1uF
C40 0.1uF
C41 0.1uF
R77 0.05
R85 100K
R86 510
C50 0.47uF
R94 10K
R82 100K
C44 2.2uF
C46 0.1uF
U19 OPA353NACT
AD_SHUNT
R91 1K
C49 0.22uF
R88 5.1K
R95 10K
R83 1M
C45 2.2uF
C47 0.1uF
U18-A LM339AJ
R92 10K
R89 5.1K
C51 0.22uF
TWOTOFFP
R87 10K
R90 5.1K
C48 0.22uF
R84 10K
C34 100pF
R93 1M
U18-B LM339AJ
R81 5.1K
CMP3
R78 10K
R79 5.1K
C43 0.22uF
R76 10K
R80 1M
U18-C LM339AJ
R75 5.1K
CMP2
R72 10K
R73 5.1K
C42 0.22uF
R71 10K
R74 1M
U18-D LM339AJ
R70 5.1K
CMP1
VDD_5V
TP14A
TP14
U_B
U_T
V_B
V_T
W_B
W_T
U
V
W
UA
VA
WA


CN2
FRWO-105319
CN3
TBK-2P
SW7
SWITCH
F1
FUSE
C53
4.7uF_100V
DC_BUS
R98
1.5K
C58
0.015uF
R5
5.11K
R3
13K
C59
220pF
U20
LT3431EFE
GND
GND
GND
GND
VC
SYNC
/SHDN
VIN
VIN
BOOST
SW
SW
BIAS
FB
C52
0.1uF
L1
33uH
D4
MMSD914T
D6
30BQ060
R99
4.99K
R97
15.4K
C54
47UF_2220
D5
LED
CMD28-21
R96
360
VDD_5V
P27
P150
P151
SB42
SB41
SB40
C62
0.1uF
D10
DL4148
R105
1M
D7
DL4148
C63
0.1uF
D11
DL4148
R106
1M
D8
DL4148
C64
0.1uF
D12
DL4148
R107
1M
D9
DL4148
R108
820
0W25
R109
820
0W25
R110
820
0W25
R102
2K
0W25
R103
2K
0W25
R104
2K
0W25
WA
VA
UA
C55
1uF@25V
U21
LP2985-33DBVR
VIN
GND
ON/OFF
BY_PASS
VOUT
VDD_ZB
C57
0.1uF
C56
2.2uF
NEC Electronics America
MC-78K0R-IE3
VOLTAGE REG
Size
B
Document Number:
Rev
1.0
Date:
October 29, 2008
Sheet
7
of


CN4
CN5
CN6
CN7
CN8
CN9
CN10
CN11
CN12
CN13
P1X8
VDD_5V
HL_U
LO_U
HL_V
LO_V
HL_W
LO_W
SPD_MSR
TMOFF_0
TMOFF_1
LD_LED1
LD_LED2
LD_LED3
AN4_SPD_POT
AD_SHUNT
P150
P151
P70_CMP1
P71_CMP2
P72_CMP3
P140
RXD1_KR
TXD1_KR
LED_E
LED_F
LED_G
LED_DP
P24
P25
P26
P27
P120_USB
P01_USB
P17_USB
P00
P16_USB
P01
P10_USB
P120
TXD_78SV
P42
P43
LED_A
LED_B
LED_C
LED_D
P61
P60
P12_USB
P10_USB
P61_USB
P60_USB
P12_USB
P11_USB
RXD0_KR
TXD0_KR
SR1
SR2
SR3
SR4
SR5
SR6
SR7
SR8
SR9
SR10
SR11
SR12
SR13
SR14
SR15
SB23
SB24
SB25
SB26
SB27
SB28
SB29
SB30
SB31
SB32
SB33
SB34
1M-742-8P
5K-742-8P
100K-742-8P
NEC Electronics America
MC-78K0R-IE3
Prototype/Terminations
October 29, 2008
Size
B
Document Name:
Sheet
8
of
8
Rev
1.0

For more information contact:

NEC Electronics Corporation
1753, Shimonumabe, Nakahara-ku,
Kawasaki, Kanagawa 211-8668,
Japan
Tel: 044-435-5111
http://www.necel.com/

[America]

NEC Electronics America, Inc.
2880 Scott Blvd.
Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000
U.S. only: 1-800-366-9782
http://www.am.necel.com/

[Europe]

NEC Electronics (Europe) GmbH
Arcadiastrasse 10
40472 Düsseldorf, Germany
Tel: 0211-65030
http://www.eu.necel.com/

Hanover Office
Podbielski Strasse 166 B
30177 Hanover
Tel: 0 511 33 40 2-0

Munich Office
Werner-Eckert-Strasse 9
81829 München
Tel: 0 89 92 10 03-0

Stuttgart Office
Industriestrasse 3
70565 Stuttgart
Tel: 0 711 99 01 0-0

United Kingdom Branch
Cygnus House, Sunrise Parkway
Linford Wood, Milton Keynes
MK14 6NP, U.K.
Tel: 01908-691-133

Succursale Française
9, rue Paul Dautier, B.P. 52180
78142 Velizy-Villacoublay Cédex
France
Tel: 01-3067-5800

Sucursal en España
Juan Esplandiu, 15
28007 Madrid, Spain
Tel: 091-504-2787

Tyskland Filial
Täby Centrum
Entrance S (7th floor)
18322 Täby, Sweden
Tel: 08 638 72 00

Filiale Italiana
Via Fabio Filzi, 25/A
20124 Milano, Italy
Tel: 02-667541

The Netherlands
Limburglaan 5
5616 HR Eindhoven
The Netherlands
Tel: 040 265 40 10

[Asia and Oceania]

NEC Electronics (China) Co., Ltd
7th Floor, Quantum Plaza, No. 27 ZhiChunLu
Haidian
District, Beijing 100083, P.R.China
TEL: 010-8235-1155
http://www.cn.necel.com/

NEC Electronics Shanghai Ltd.
Room 2509-2510, Bank of China Tower,
200 Yincheng Road Central,
Pudong New Area, Shanghai P.R. China
P.C:200120
Tel: 021-5888-5400
http://www.cn.necel.com/

NEC Electronics Hong Kong Ltd.
12/F., Cityplaza 4,
12 Taikoo Wan Road, Hong Kong
Tel: 2886-9318
http://www.hk.necel.com/

Seoul Branch
11F., Samik Lavied'or Bldg., 720-2,
Yeoksam-Dong, Kangnam-Ku,
Seoul, 135-080, Korea
Tel: 02-558-3737

NEC Electronics Taiwan Ltd.
7F, No. 363 Fu Shing North Road
Taipei, Taiwan, R. O. C.
Tel: 02-2719-2377

NEC Electronics Singapore Pte. Ltd.
238A Thomson Road,
#12-08 Novena Square,
Singapore 307684
Tel: 6253-8311
http://www.sg.necel.com/

G05.12A