Nuvoton
Nu-LVMDM-MOS V2.2
User Manual

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1 Overview

The Nuvoton Low Voltage Motor Development Module using MOSFET power stage (Nu-LVMDM-MOS) is used to accelerate product development by providing ready-to-run hardware and a comprehensive Motor Development Adapter (Nu-MDA-xxx).

The power supply can be connected to the power connector terminal (J4) or the Auxiliary Power Tab Fast-On Connector terminals (P4-P5).

The components on the board that receive power are described as follows:

- Gate drivers receive +15V power from a +15V regulator
- OP Amplifiers receive +8V power from a +8V regulator
- MCU motor control device receives +5V power from a +5V regulator
- LCD Display receives +3.3V power from a +3.3V regulator

1.1 Features

The key features of this board include the following:

- Motor Control Interfaces
  - Three-phase inverter bridge with a power rating of 36V/20A
  - Hall sensors interface for sensored motor control (CN3)
  - Quadrature encoder interface for sensored motor control (CN2)
  - Phase voltage feedback for sensorless BLDC operation
  - DC bus voltage sense for over-voltage control
  - Phase current sense resistor for one / three shunt vector control
  - Over-current protection
  - Support for MT530 series MCUs with internal or external op amps and comparators

- Input/Output Control Switches
  - Two push-buttons (K1 and K2)
  - Two LED indicators for debugging purposes (LED1 and LED2)
  - Reset push-button (K3)
  - 50 KΩ VR (VR2)
  - LED indicator for Power on status (LED3)
  - LCD display for debugging purposes (LCD1)
  - DIP switch for configuration purposes (SW2)
  - Toggle switch for motor start (SW1)

- Communication Ports
  - UART communication (CN1)

- Power Supply Connectors
  - Auxiliary Power Tab Fast-On connectors (P4 and P5) for the controller and power stage
  - Dedicated power connector (J4) for the controller and power stage

- Programming Connectors
  - Nu-Link connector for programming a Nuvoton MCU (CON1)

2 Introduction to Nu-LVMDM-MOS

The Nu-LVMDM-MOS is targeted to control a brushless DC (BLDC) motor or permanent magnet synchronous motor (PMSM) in sensor or sensorless operation. This flexible and cost-effective module can be configured in different ways for use with Nuvoton's specialized motor control Microcontrollers (MCUs).
The Nu-LVMDM-MOS supports the Mini51, M051, and MT530 motor control device families. It offers a mounting option to connect a generic 80-pin Plug-In Module (PIM). The Nu-LVMDM-MOS also has a three-phase inverter bridge circuit. The circuit drives a BLDC or PMSM motor using different control techniques without requiring any additional hardware.

The board includes various circuitries to perform the following functions:

- Drive a three-phase inverter that powers the motor phase windings
- Measure feedback signals (e.g. voltage and phase currents) and provide a suitable fault signal
- Interface with Hall sensor or quadrature encoder for sensor-based commutation
- Communicate with a host computer or an external device via USB interface
- Support motors with terminal voltage up to 36V and current up to 20A.

Note: If the output power exceeds 100W, the power MOSFETs (Q1-Q6) may need a larger heat sink.

2.1 Nu-LVMDM-MOS Jumper

The Nu-LVMDM-MOS Development Board has five jumpers that configure the functionality of the board. The following figure shows the jumper locations and the following tables list the jumpers and their functions.

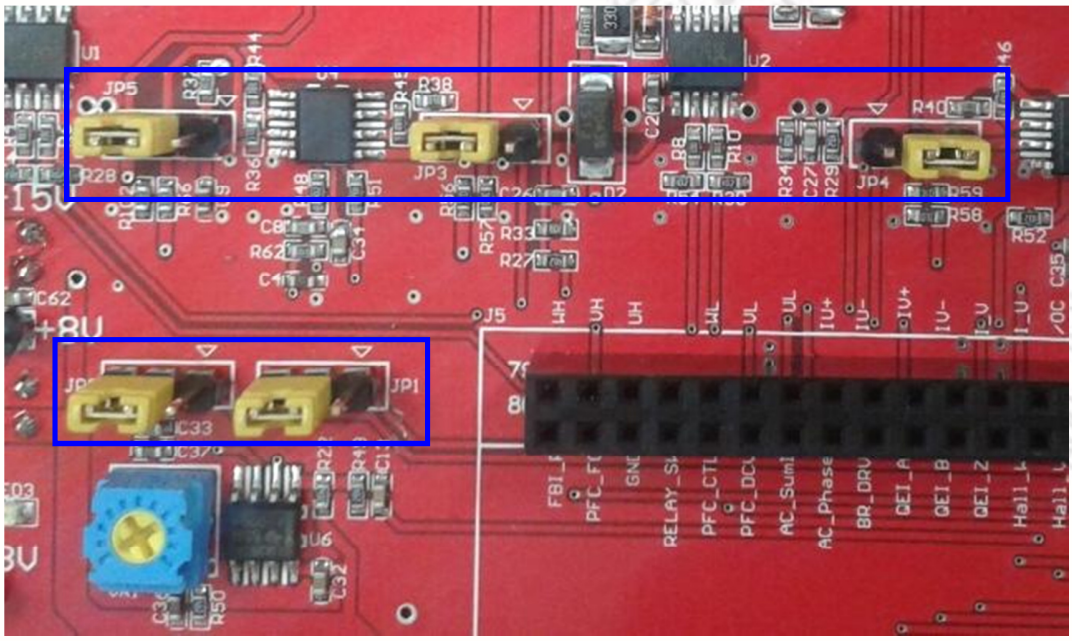


Figure 2-1 Jumper Setting

No.	Designator	Function
1	JP1	Comparator- for Over Current
2	JP2	Comparator+ for Over Current
3	JP3	U Phase current feedback
4	JP4	V Phase current feedback
5	JP5	Sum (U+V+W) current feedback

Table 2-1 Jumper Functions

No.	Designator	Position	Description
1	JP1	1 - 2	I_Sum signal into MCU's internal comparator-
		2 - 3	I_Sum signal into external comparator-
2	JP2	1 - 2	V_BIAS into MCU's internal comparator+
		2 - 3	V_BIAS into external comparator+
3	JP3	1 - 2	U Phase current feedback into MCU's internal OPA
		2 - 3	U Phase current feedback into external OPA
4	JP4	1 - 2	V Phase current feedback into MCU's internal OPA
		2 - 3	V Phase current feedback into external OPA
5	JP5	1 - 2	I_Sum from RL1 current sensing resistor
		2 - 3	I_Sum from 3 shunt current sensing resistor

Table 2-2 Jumper Description

Note:

I_Sum: Sum current after amplified (refer to the *Nu-LVMDM-MOS Schematics and Layout PLACEMENT* section).

VR1: V_BIAS adjustment for over-current threshold.

▽ is used as the symbol for pin 1.

2.2 Pin Assignment for Extended Connectors

2.2.1 Plug-In Module (PIM) Configuration

The following table summarizes the PIM (Nu-MDA-xxx) pin-out for the Nu-LVMDM-MOS Development Board.

PIM Pin #	Signal Name	Pin-out Description
1	GND	Ground
2	Speed	Speed signal
3	DIP4	DIP4
4	GND	Ground
5	DIP3	DIP3
6	SCL	N/A
7	DIP2	DIP2
8	SDA	N/A
9	DIP1	DIP1
10	N/A	N/A
11	KEY4	N/A
12	DAC_CS	DAC Chip Select
13	KEY3	N/A
14	DAC_SDO	DAC Serial Data
15	GND	Ground
16	DAC_SCK	DAC_Serial Clock
17	KEY2	KEY2
18	TXD	UART Transmit
19	KEY1	KEY1
20	RXD	UART Receive
21	RUN	Motor start or stop
22	N/A	N/A
23	GND	Ground
24	GND	Ground
25	5V	5V input for MCU
26	5V	5V input for MCU

27	N/A	N/A
28	DISP_SDO	LCD Display_Serial Data Out
29	LED1	LED1
30	DISP_SCK	LCD Display_Serial Clock
31	LED2	LED2
32	DISP_RS	LCD Display_Select Register
33	N/A	N/A
34	DISP_RST	LCD Display_Reset
35	ICE_DAT	ICE_Data
36	N/A	N/A
37	ICE_CLK	ICE_Clock
38	N/A	N/A
39	ICE_RST	ICE_Reset
40	N/A	N/A
41	I_W	Amplified W phase current
42	GND	Ground
43	I_Sum	Amplified sum current
44	Volt_U	Voltage feedback signal for U phase
45	/BR	N/A
46	Volt_V	Voltage feedback signal for V phase
47	DCV	DC bus voltage (downscaled)
48	Volt_W	Voltage feedback signal for W phase
49	V_BIAS	Sum current threshold
50	GND	Ground
51	I_Sum_NA	Non-Amplified sum current
52	Hall_U	Hall sensor signal for U phase
53	/OC	Over Current signal
54	Hall_V	Hall sensor signal for V phase
55	I_U	Amplified U phase current
56	Hall_W	Hall sensor signal for W phase
57	I_V	Amplified V phase current
58	QEI-Z	QEI input
59	Iv-	N/A

60	QEI-B	QEI input
61	Iv+	V phase current feedback into MCU internal OP2+
62	QEI-A	QEI input
63	Iu-	N/A
64	BR_DRV	N/A
65	Iu+	U phase current feedback into MCU internal OP1+
66	AC_Phase	N/A
67	UL	PWM Output UL
68	AC_SumI	N/A
69	VL	PWM Output VL
70	PFC_DCV	N/A
71	WL	PWM Output WL
72	PFC_CTL	N/A
73	N/A	IPM_Fault Output
74	Relay_SW	N/A
75	UH	PWM Output UH
76	GND	Ground
77	VH	PWM Output VH
78	PFC_FO	N/A
79	WH	PWM Output WH
80	FBI_P	N/A

Table 2-3 Nu-LVMDM-MOS Development Board PIM Pin-out Functionality

2.2.2 Input Power Connectors (J4, P4-P5)

The Nu-LVMDM-MOS Development Board receives the power for controlling circuits and the DC bus from a +24V power supply (connected to the board through J4 or P4-P5).

2.2.3 UART Interface (CN1)

The board uses an external PL-2303 interface as a bridge between the UART and USB.

2.2.4 Nu-Link Connector (CON1)

The Nu-Link connector is a 10-pin male connector (CON1) that connects the Nu-Link In-Circuit Debugger/Emulator to the NuMicro™ MCU for programming and debugging purposes.

2.2.5 Dedicated Oriental Motor Connector (CN4)

The dedicated motor connector (CN4) has 8 terminals. The following table shows the functionality of each terminal.

Pin #	Terminal Name	Function
1	H_V	Hall V feedback
2	H_W	Hall W feedback
3	H_U	Hall U feedback
4	GND	Hall sensors ground
5	+5V	Hall sensors power supply
6	U	Motor winding phase U
7	V	Motor winding phase V
8	W	Motor winding phase W

Table 2-4 Oriental Motor Connector Details

2.2.6 Hall Sensor Connector (CN3)

The hall sensor connector (CN3) has 5 terminals. The following shows the functionality of each terminal.

Pin #	Terminal Name	Function
1	+5V	Hall sensors power supply
2	GND	Hall sensors ground
3	H_U	Hall U feedback
4	H_V	Hall V feedback
5	H_W	Hall W feedback

Table 2-5 Hall Sensor Connector Details

2.2.7 QEI Connector (CN2)

The Quadrature Encoder Interface connector (CN2) has 5 terminals. The following table shows the functionality of each terminal.

Pin #	Terminal Name	Function
1	+5V	QEI sensors power supply
2	GND	QEI sensors ground
3	QEI_A	QEI_A feedback
4	QEI_B	QEI_B feedback
5	QEI_Z	QEI_Z feedback

Table 2-6 QEI Connector Details

The following table lists the test points that can be used to check various signals.

Test Points	Description
GND	Ground
+15V	+15V for gate driver
+8V	+8V for OP Amplifier
+5V	+5V for MCU and peripherals
+3.3V	+3.3V for LCD display

Table 2-7 Test Points

2.2.8 Push-Buttons, LEDs, DIP/Toggle-Switch and VR

The Nu-LVMDM-MOS Development Board consists of the following items:

- Two push-buttons
- One VR for speed control
- Two LEDs for debugging purposes
- One power-on status LED
- One DIP-switch
- One Toggle-switch
- Target MCU Reset push-button

Figure 2-2 shows the HUMAN INTERFACES and *Table 2-8* lists the Human Interfaces and their functions.

Label	Hardware Element Description
K1, K2	Push-buttons which are connected to port pins. When momentarily pressed, the switch connects the respective port pin to Ground.
VR2	50K VR which is connected to analog input pin. Turn the SPEED VR (VR2) to adjust the motor speed.
LED3	Power-on status LED, which indicates the status of the 3.3V regulator.
LED1, LED2	LEDs to be used for debugging purposes.
K3	Push-button used to reset the target MCU.
SW1	Toggle-switch used to motor start/stop. Push up the toggle switch (SW1) to start the motor in the Clockwise direction.
SW2	DIP-switch used to configure the motor functions, push up the DIP switch (SW2.1) to reverse the motor to Counter Clockwise direction.

Table 2-8 Indicators and Human Interfaces

Figure 2-2 Human Interfaces

2.3 Nu-LVMDM-MOS PCB Placement

The following figure shows the connectors and jumpers available on the Nu-LVMDM-MOS Development Board.

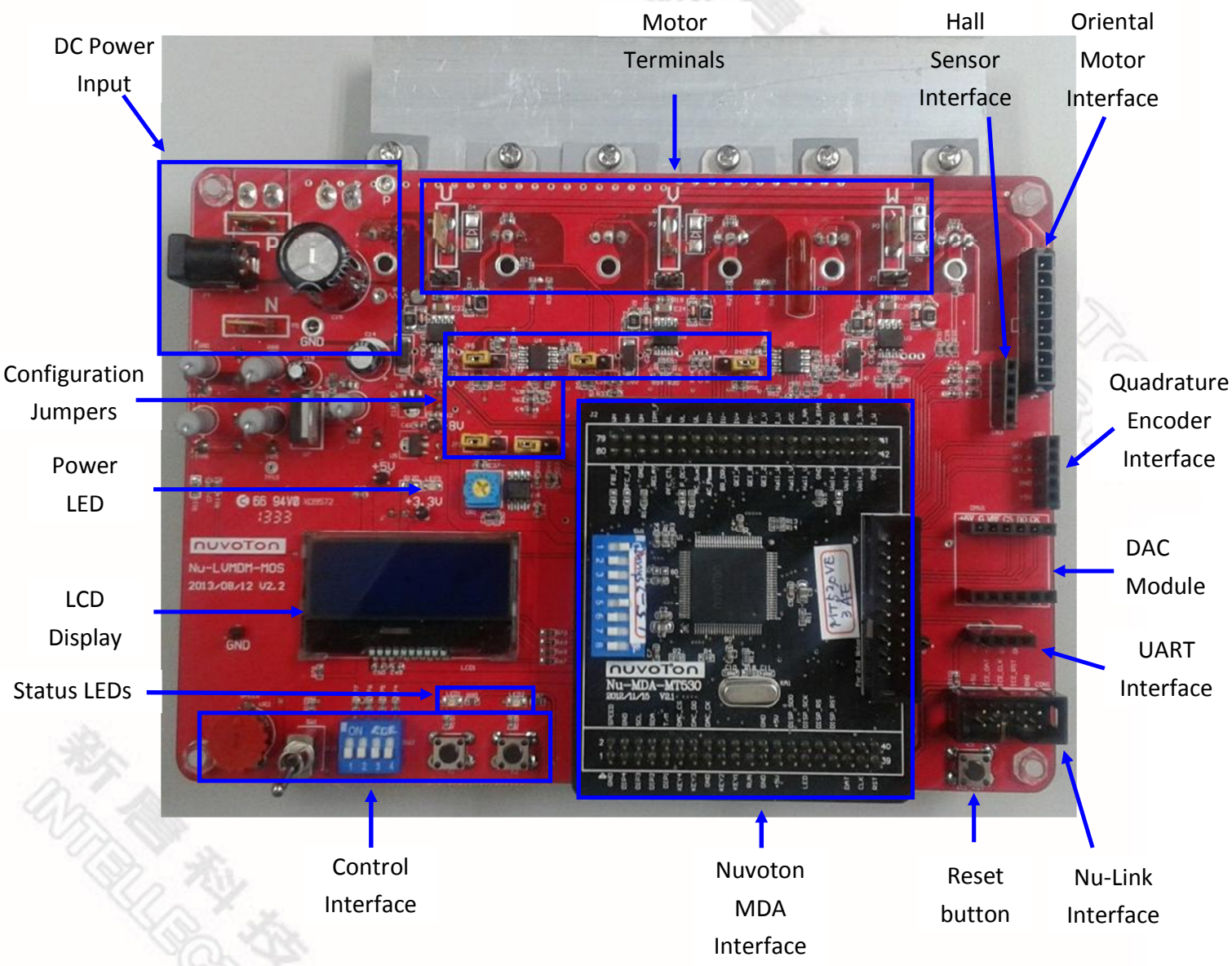


Figure 2-3 Nu-LVMDM-MOS Development Board Connectors and Jumpers

3 Running a BLDC Motor Using a Sensorless Algorithm

This chapter describes how to set the Nu-LVMDM-MOS Development Board in the external Op Amp configuration to run a BLDC motor using the Three-Shunt Current Reconstruction Algorithm with a Nu-LVMDM-MOS Development Board.

3.1 Operating Requirements

To set and run the board, the following items are recommended:

- Keil MDK-ARM (Evaluation Version) Integrated Development Environment (IDE) installed on the PC (website: https://www.keil.com/demo/eval/arm.htm)
- Nu-LVMDM-MOS Development Board
- 24V power supply or equivalent
- BLDC motor

3.2 Nu-LVMDM-MOS Development Board Setup

The following procedure describes how to set the Nu-LVMDM-MOS Development Board. *Figure 3-1* shows the connection on the Nu-LVMDM-MOS Development Board.

WARNING:

The Nu-LVMDM-MOS Development Board is intended to drive the three-phase BLDC motor. Before connecting the motor, make sure that the power rating of the motor is equal to or less than the power rating of the board. Also, make sure the jumper settings are correct for the firmware programmed into the target MCU mounted on the socket. Failure to comply with this warning could lead to malfunction of the board and the motor, and could result in physical harm. Before beginning the start-up procedure, complete a visual check of the board and the motor for connectivity and mechanical damage. If damage is found, DO NOT power-up the board. Otherwise, you may further damage the equipment. Contact the Nuvoton local office or distributor before using a damaged board.

3.2.1 Setting the Nu-LVMDM-MOS Development Board

Perform the following steps to set the development board:

1. Place the Nu-LVMDM-MOS Development Board on a sturdy insulated platform.
2. Plug the Nuvoton Motor Development Adapter (Nu-MDA-xxx) into the socket.(See ***Fig. A***)
3. Connect Nu-Link ICE In-Circuit Emulator to the computer, and the board to CON1.
4. Connect the three-phase, 10 pole, 24V (oriental motor) to CN4 (See ***Fig. B***). Since this is a sensorless algorithm, the motor phase wires (Red, Black, and White) can be connected to P1, P2, and P3 in any order.
5. Connect the 24V power supply to J4 or P4-P5 (See ***Fig. C***).
6. Make sure the power LED (LED3) illuminates (See ***Fig. D***).
7. Push up SW1 to run the motor.
8. Vary the motor speed with VR2.
9. Pull down SW1 to stop the motor.

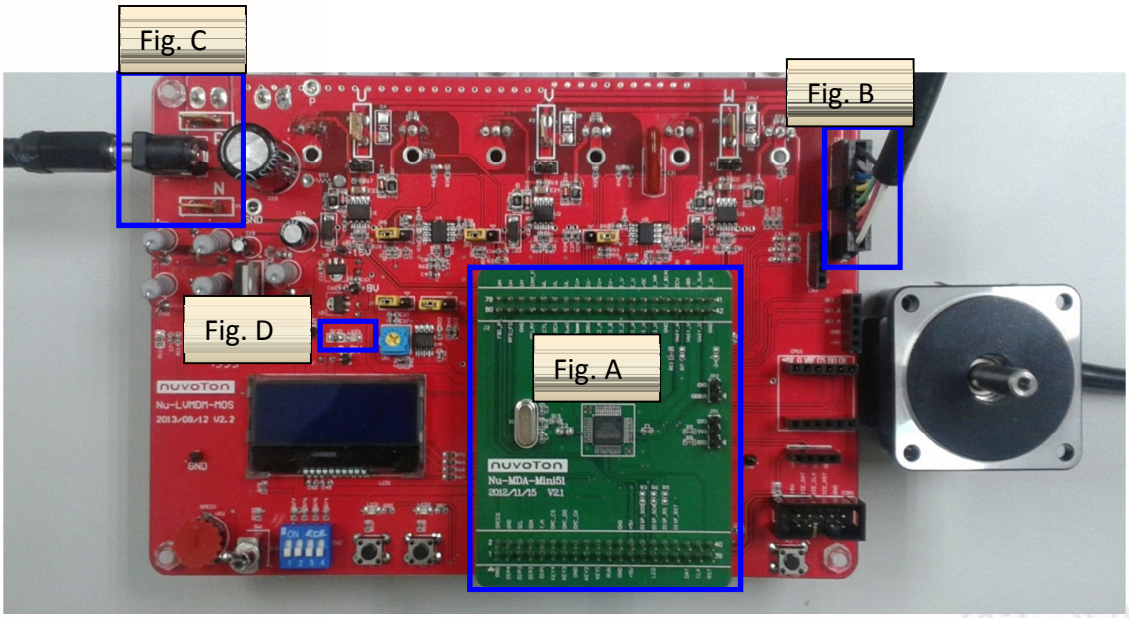
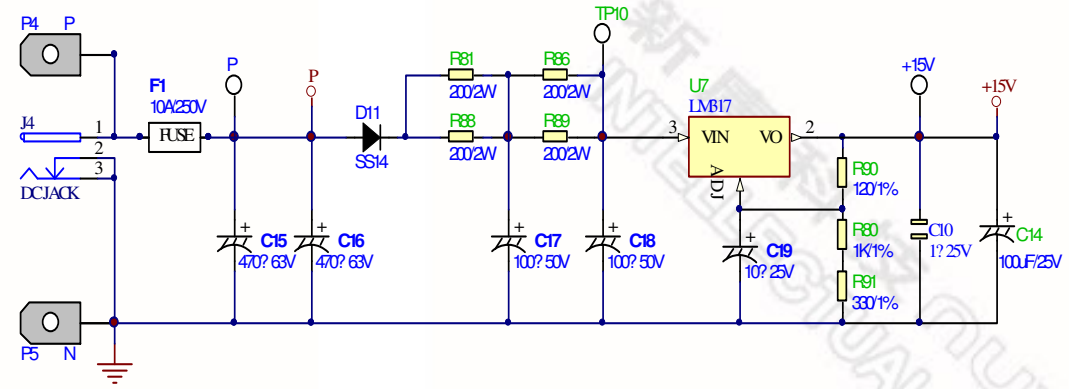
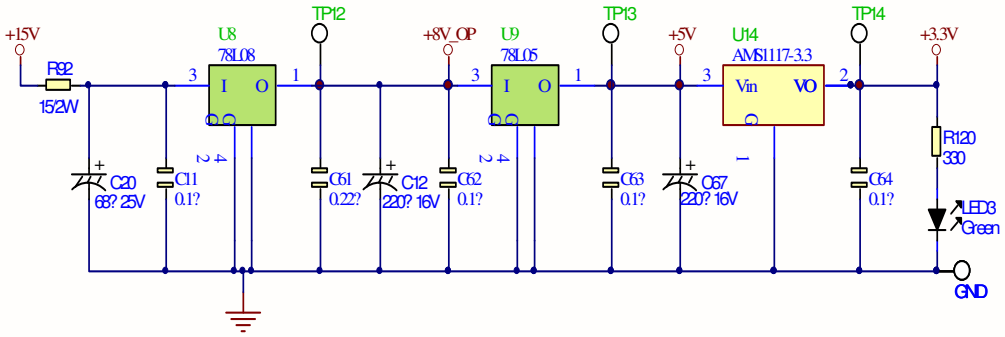


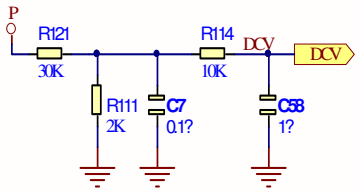
Figure 3-1 Nu-LVMDM-MOS Development Board Connection

4 Nu-LVMDM-MOS Schematics and Layout Placement

The following schematics are included in this user manual:







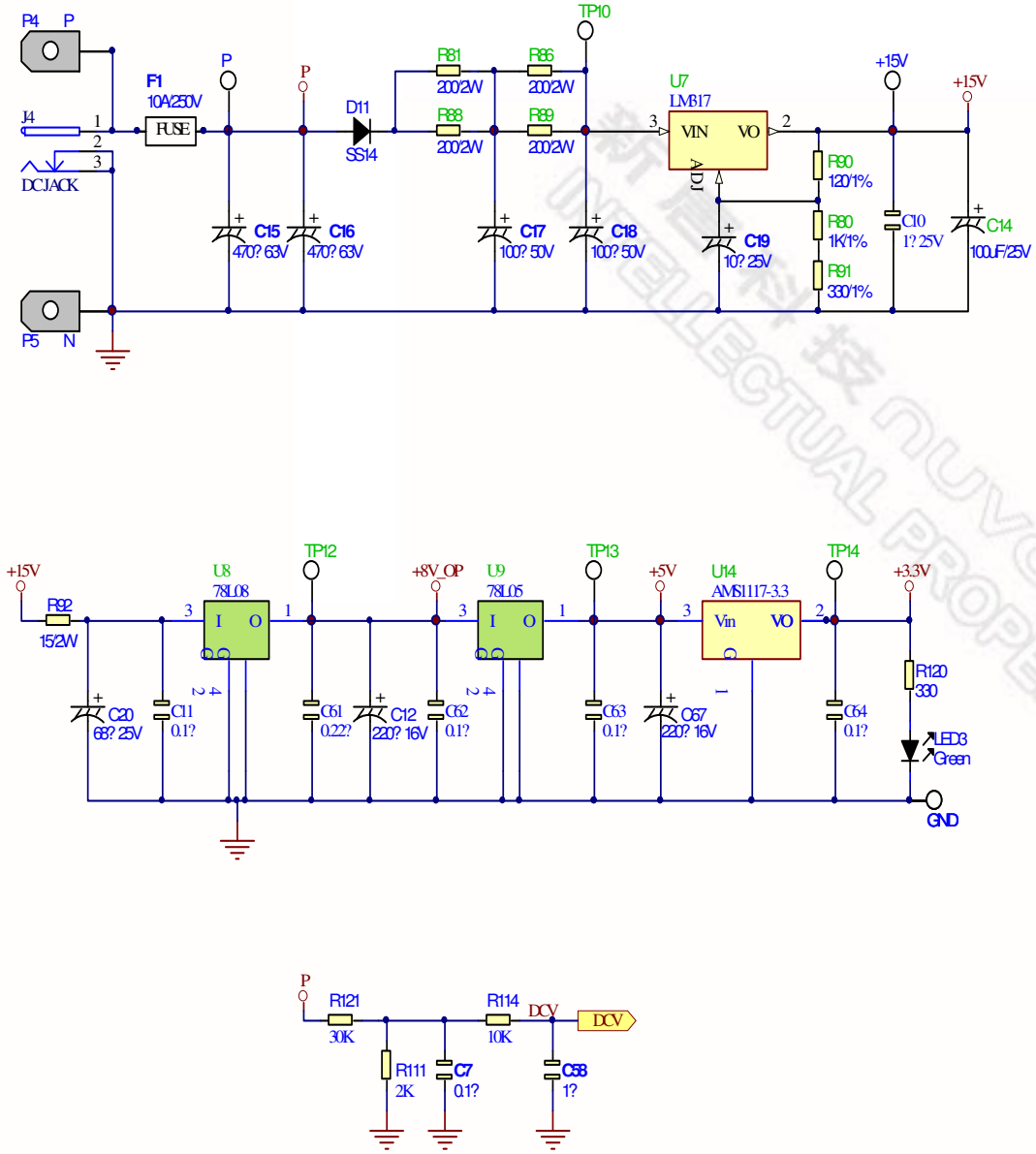


Figure 4-1 Power of Nu-LVMDM-MOS Development Board Schematic

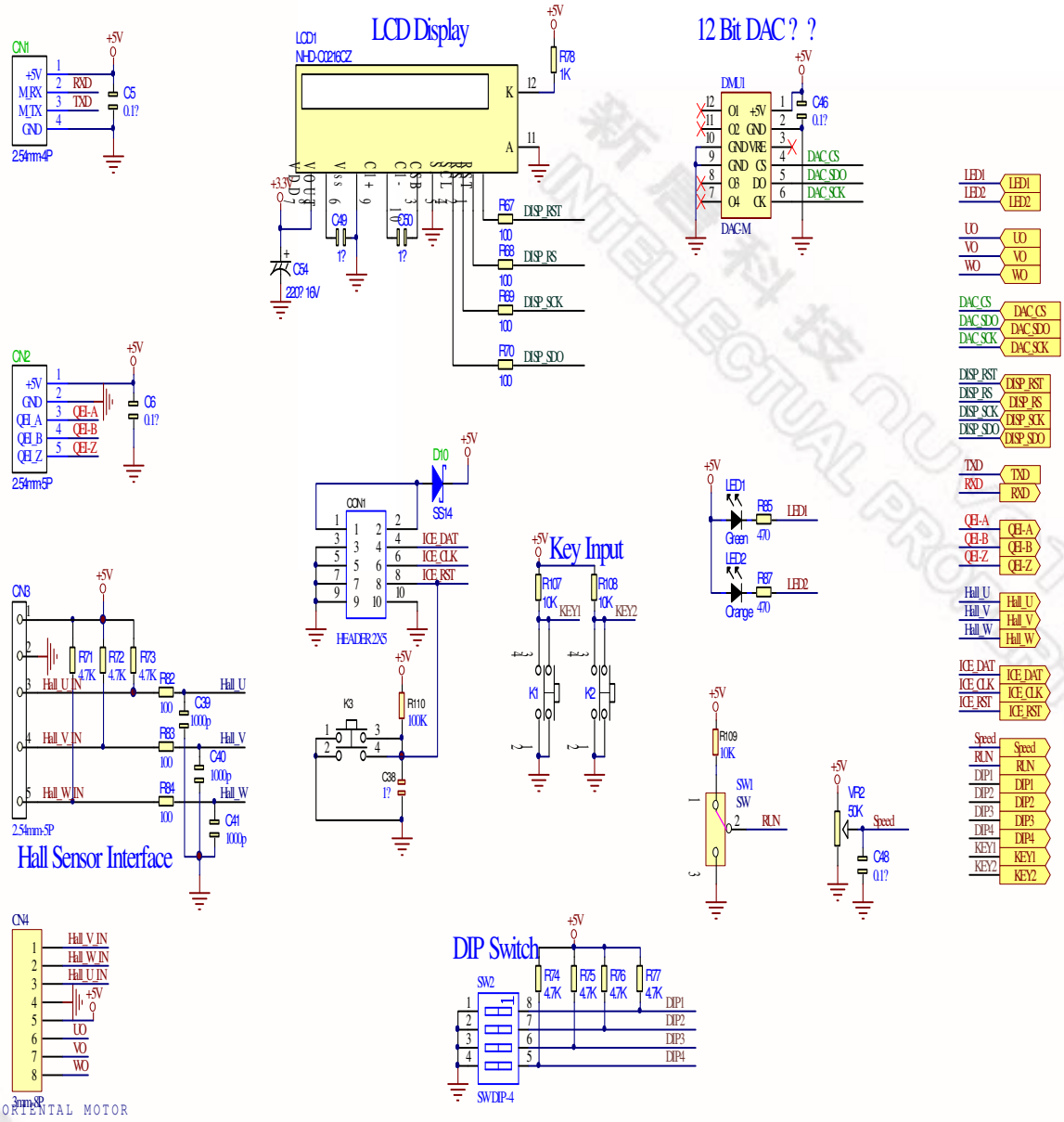


Figure 4-2 Interface of Nu-LVMDM-MOS Development Board Schematic

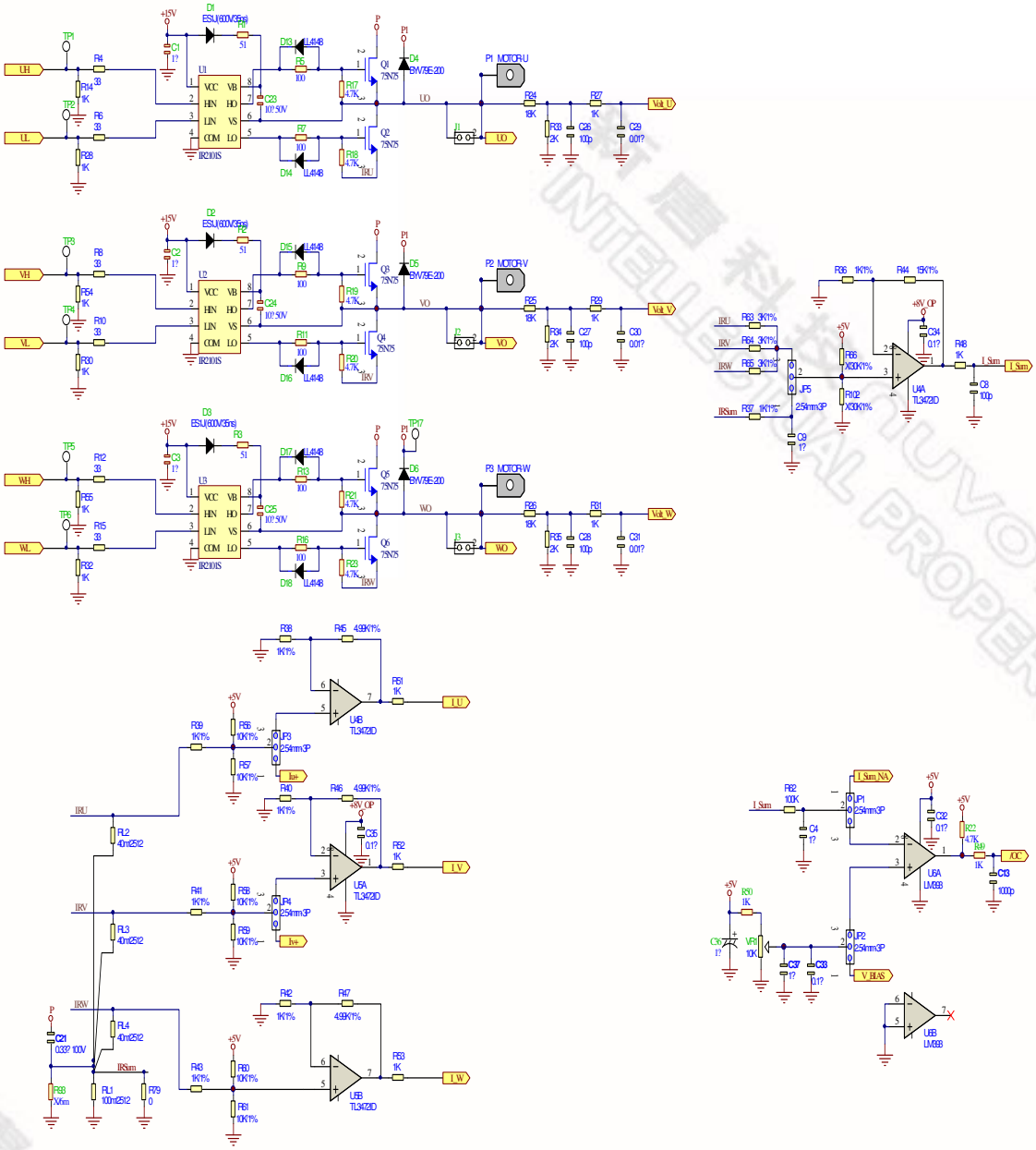


Figure 4-3 Driver of Nu-LVMDM-MOS Development Board Schematic

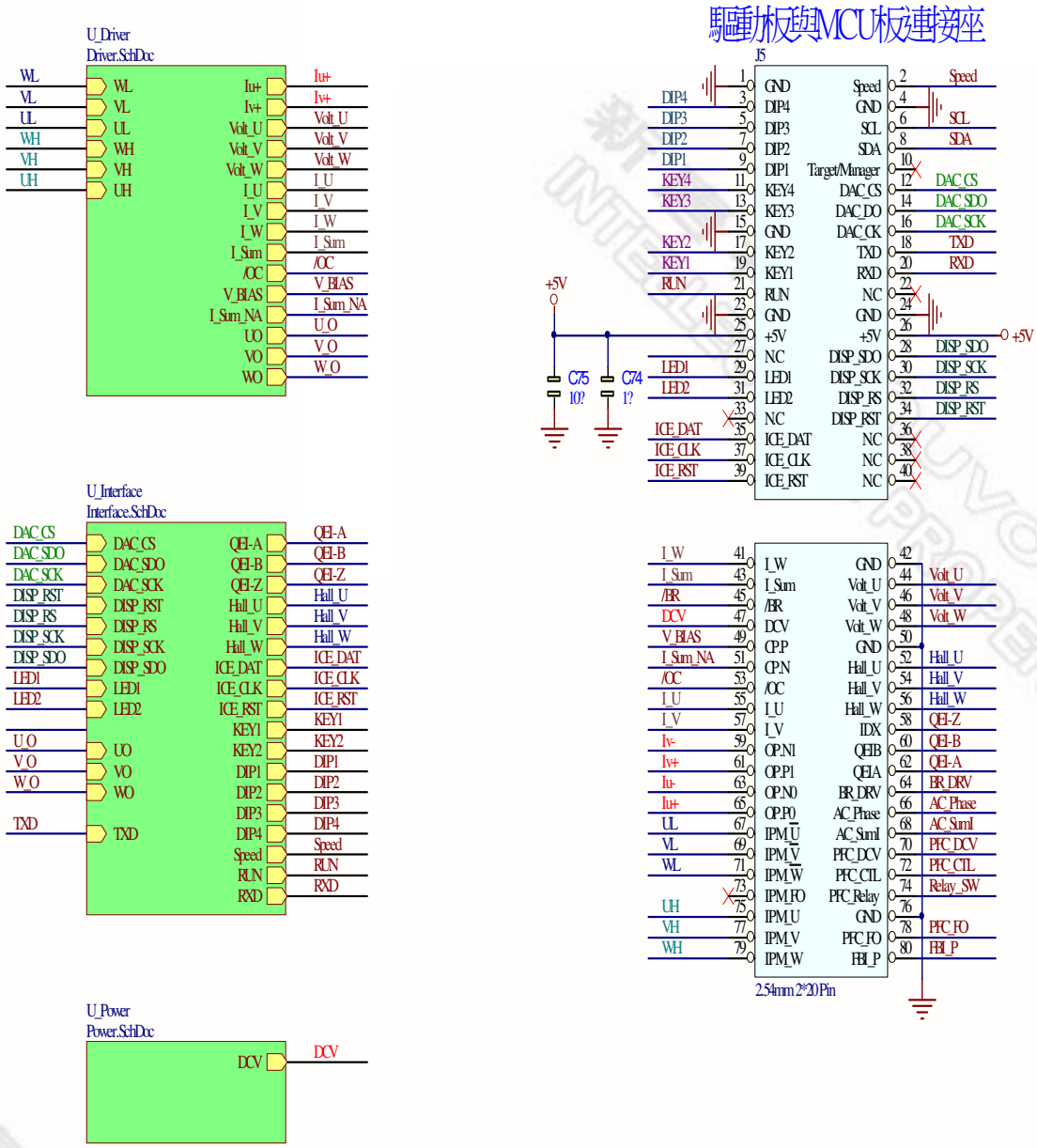


Figure 4-4 MCU Interface of Nu-LVMDM-MOS Development Board Schematic

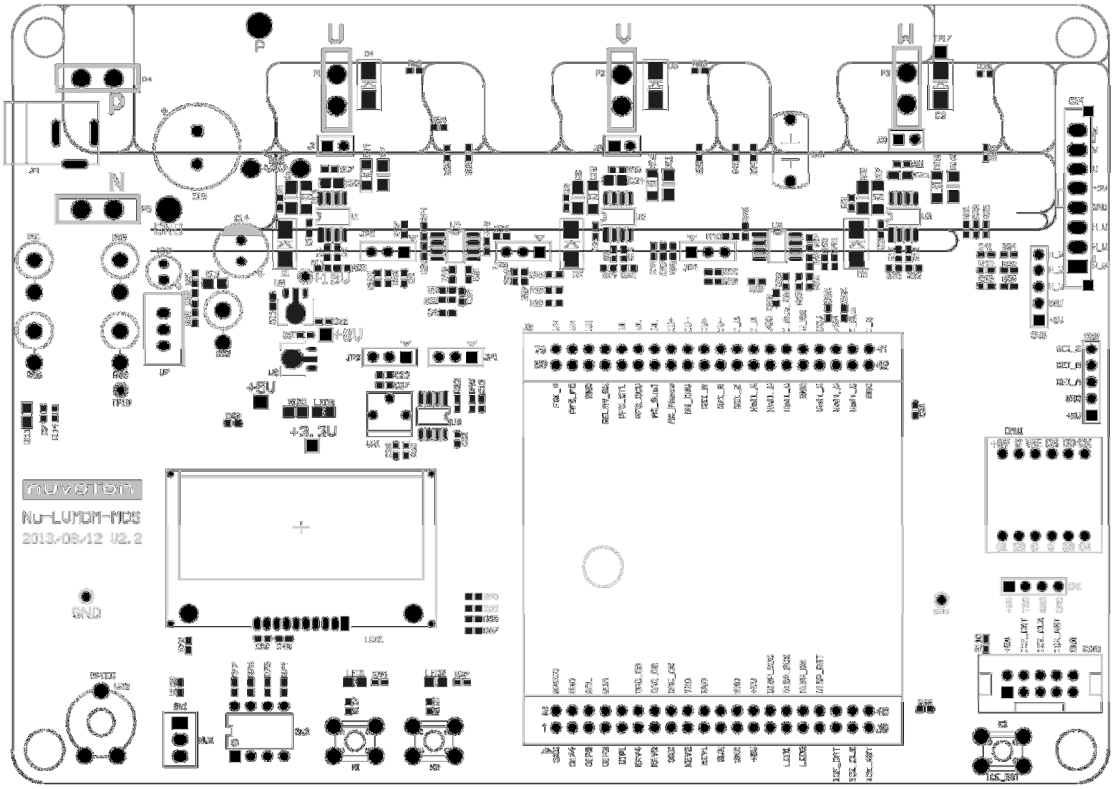


Figure 4-5 Nu-LVMDM-MOS Development Board Top Layout

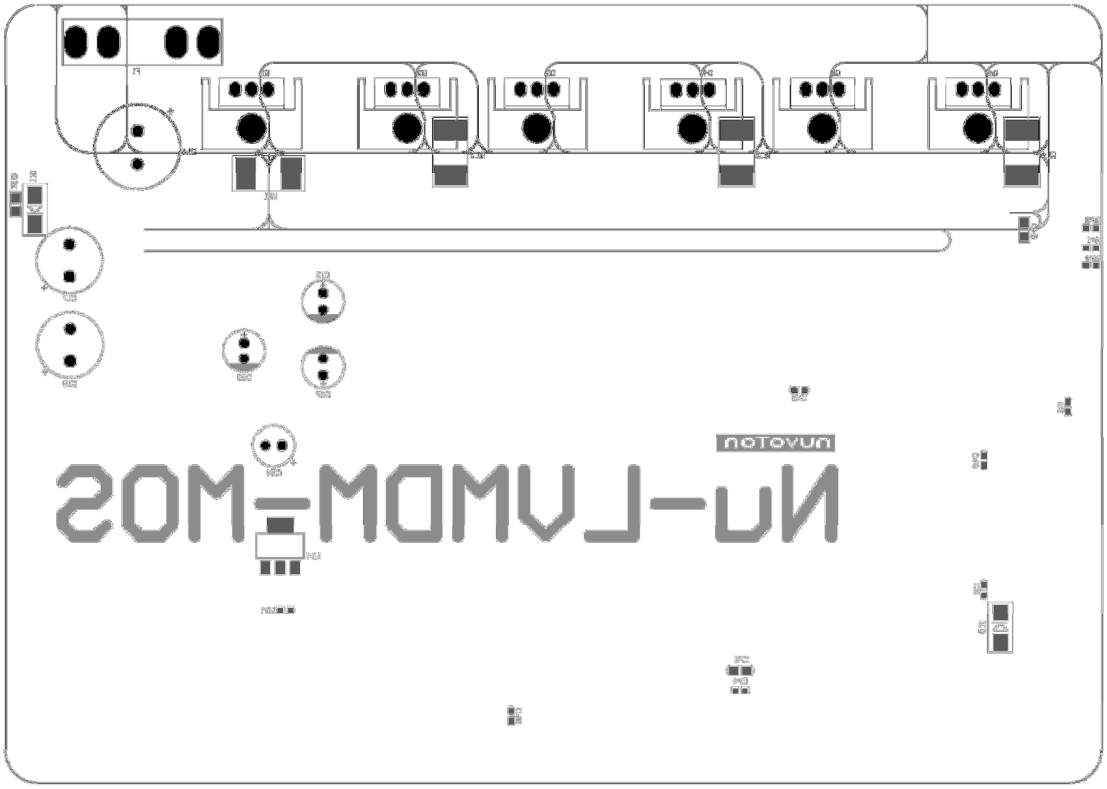


Figure 4-6 Nu-LVMDM-MOS Development Board Bottom Layout

The following figures show a variety of the comprehensive Motor Development Adapter (Nu-MDA-xxx).

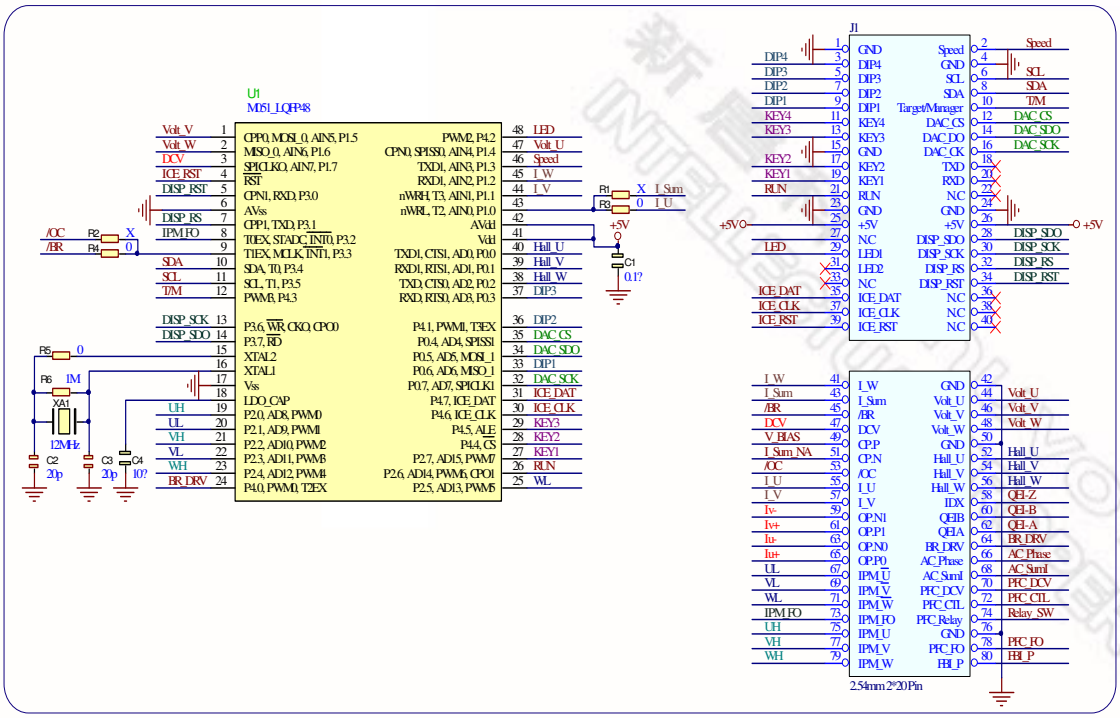


Figure 4-7 Nu-MDA-M051 Adapter Board Schematic

Figure 4-8 Nu-MDA-M051 Adapter Board Layout

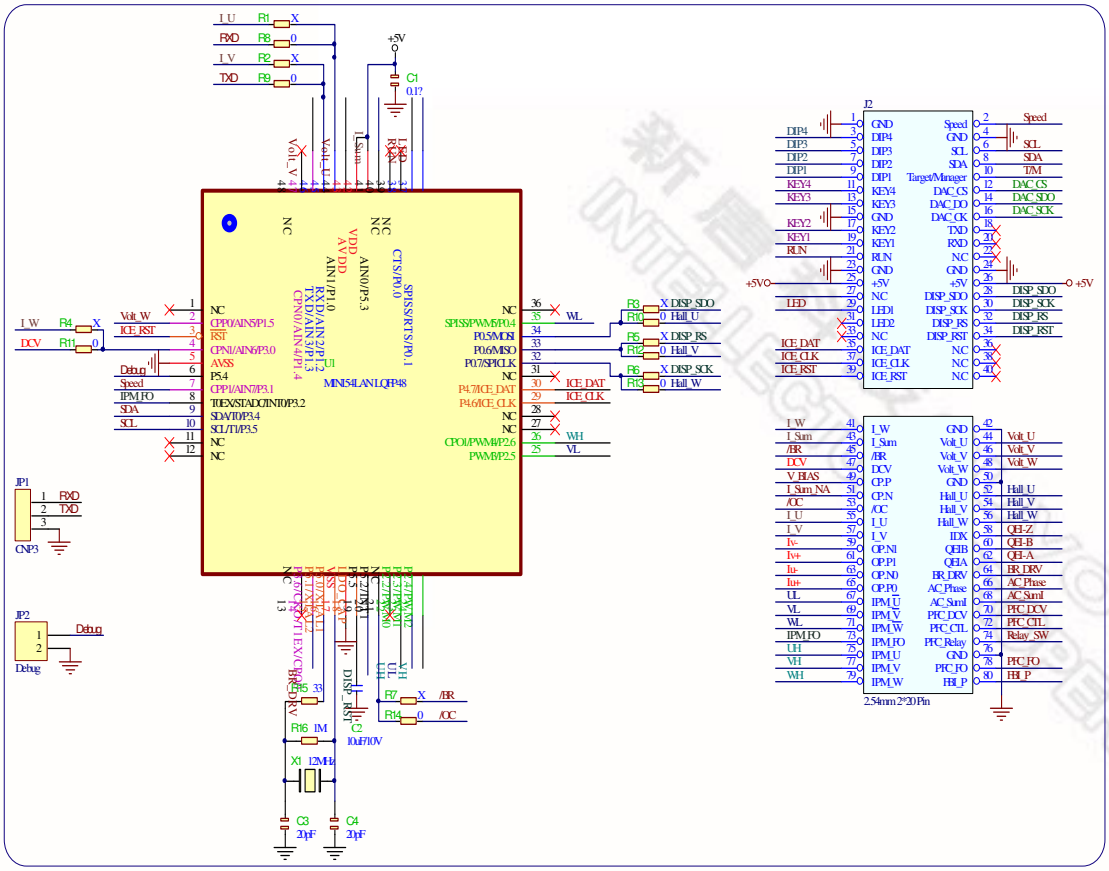


Figure 4-9 Nu-MDA-Mini51 Adapter Board Schematic

Figure 4-10 Nu-MDA-MINI51 Adapter Board Layout

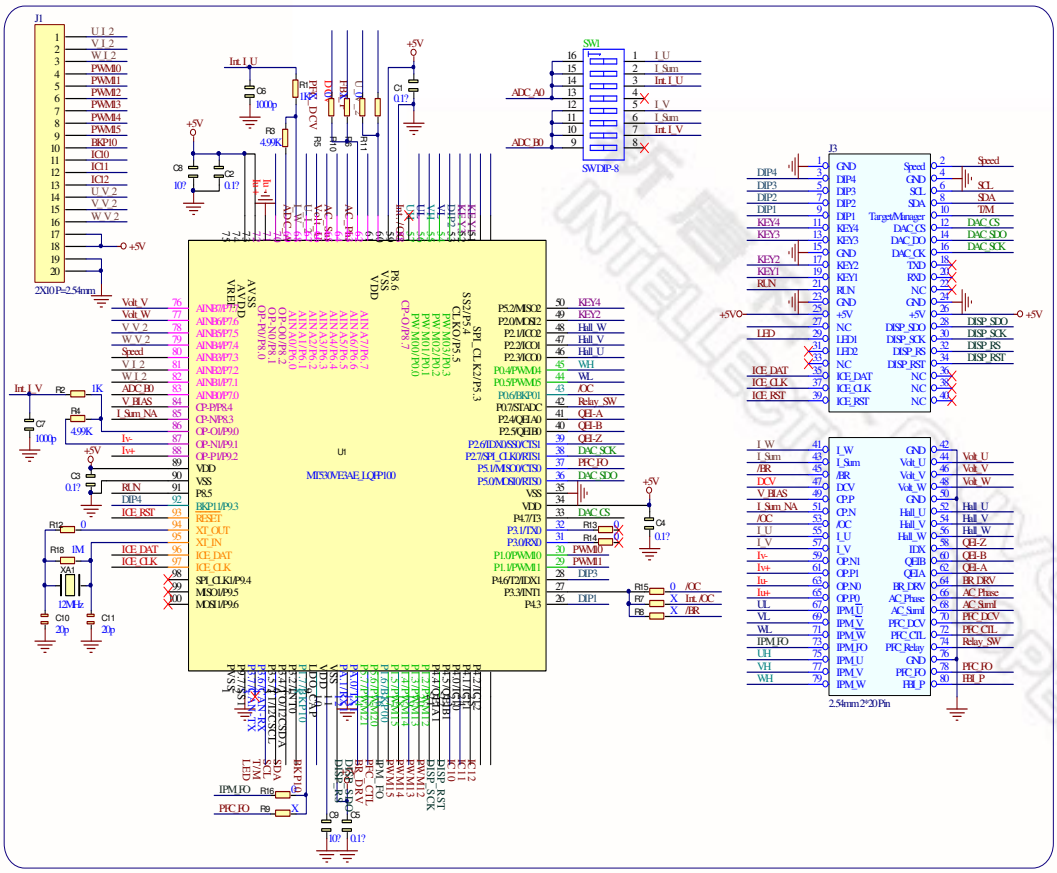


Figure 4-11 Nu-MDA-MT530 Adapter Board Schematic

Figure 4-12 Nu-MDA-MT530 Adapter Board Layout

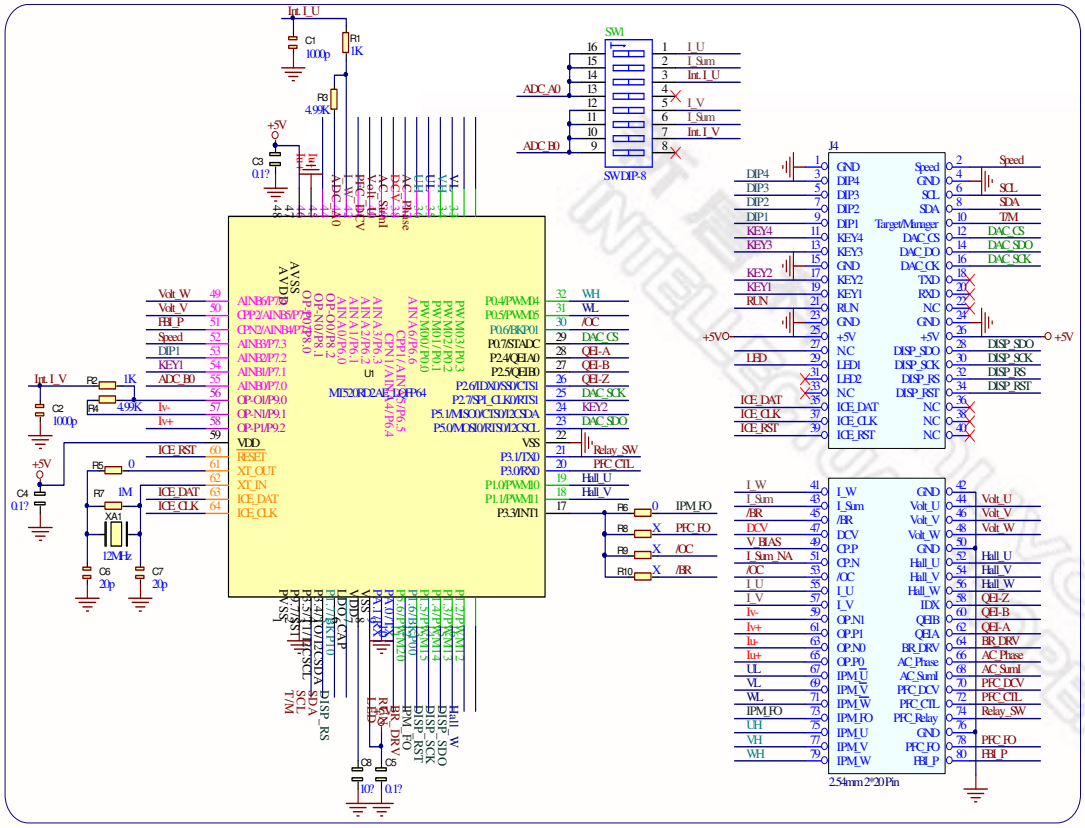


Figure 4-13 Nu-MDA-MT520R-64 Adapter Board Schematic

Figure 4-14 Nu-MDA-MT520R-64 Adapter Board Layout

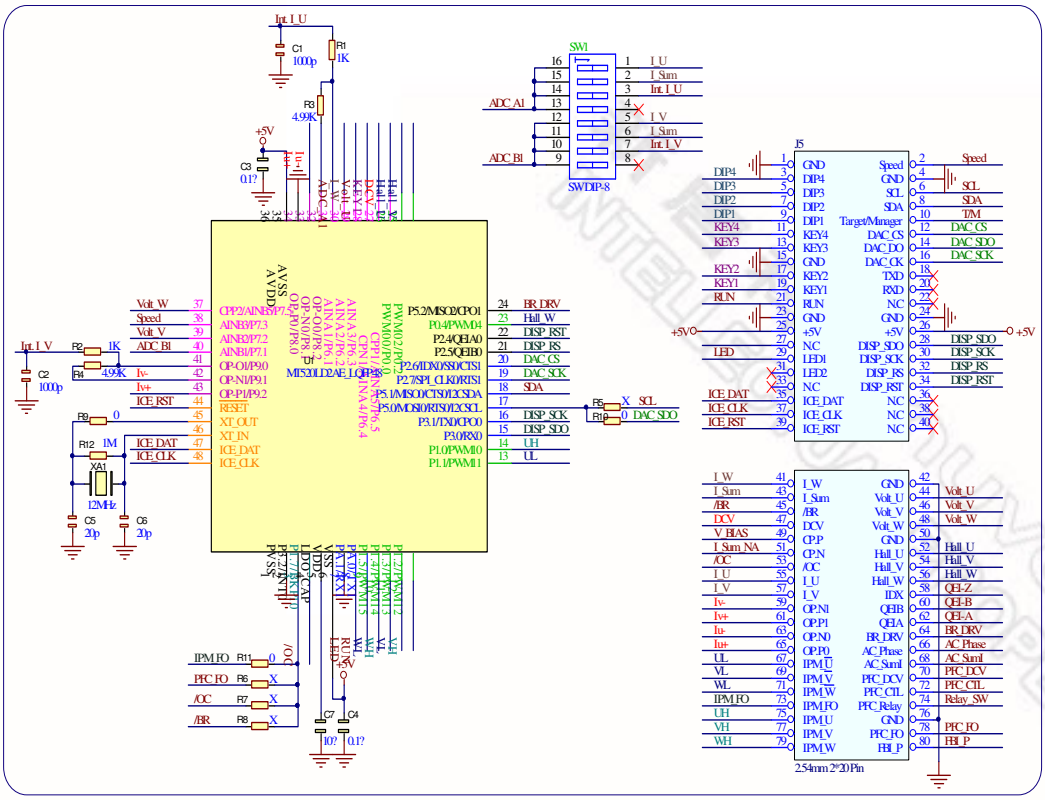


Figure 4-15 Nu-MDA-MT520L-48 Adapter Board Schematic

Figure 4-16 Nu-MDA-MT520L-48 Adapter Board Layout

5 Revision History

Revision	Date	Description
1.00	Apr. 10, 2013	Initially issued.