MotorKit Nu-KE-MTR_LV001
User Manual

For additional information or question, please contact Nuvoton Technology Corporation Japan.
www.nuvoton.co.jp

March 10, 2023

Rev1.02

Table of Contents

List of Figures

List of Tables

1. OVERVIEW

MotorKit Nu-KE-MTR_LV001 is an inverter board for low voltage motor control.By connecting this board to the inverter control MCU board Nu-KT-MTR_xxx (xxx:MCU parts number), it is possible to develop motor control applications according to each NTCJ microcomputer.

[Spec]

- Product name : Low Voltage Inverter Board
- Board product No. : Nu-KE-MTR_LV001
- Operating input voltage : DC 24V / 48V
- Max. input power : 67W@DC 24V / 134W@DC 48V
- Rated output capacity : 230VA
- Rated output current : AC 2.8A(effective value)
- Switching Frequency：2kHz～20kHz
- Dead time : 1.0 us or more
- Current detection method : 1 shunt / 3 shunt method
- Shunt resistor : 50mΩ
- PWM logic : Active High logic for both upper and lower arms
- DC bus voltage detection : Detection by resistance division（5V to 48V）
- Three-phase current detection : Voltage detection by shunt resistance
- Overcurrent detection function : Detection by comparator
- Back EMF detection function : Detection by comparator
- Connector : MCU board connection, Encoder, Servo command, Hall sensor
- Switch : DIP Switch (4)
- LED : LED×3

2. HARDWARE CONFIGURATION

2.1 Top View

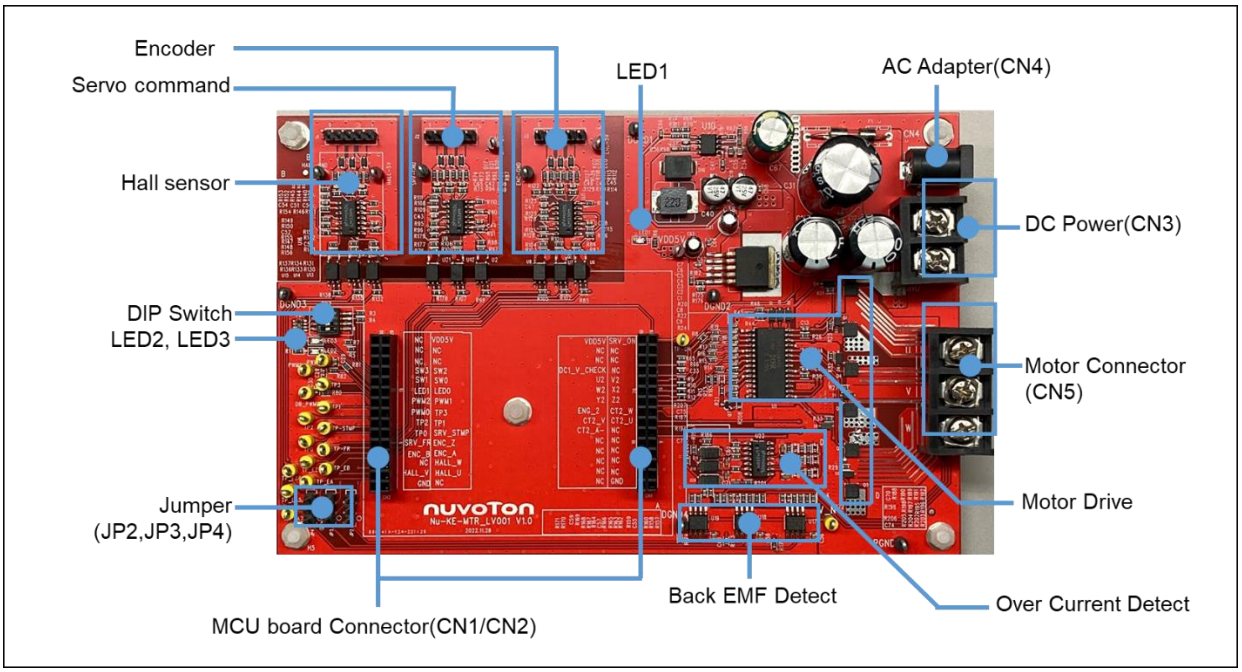


Figure 2-1 Top View of Nu-KE-MTR-LV001

Figure 2-1 shows the main components and connectors from the top side of Nu-KE-MTR_LV001.

The following lists components and connectors from the top view:

- Motor Drive
- Over Current Detect
- Back EMF Detect
- MCU board Connector(CN1/CN2)
- DC Power(CN3)
- AC Adapter(CN4)
- Motor Connector(CN5)
- Encoder
- Servo command
- Hall sensor
- Jumper(JP1,JP2,JP4)
- DIP Switch
- LEDs(LED1,LED2,LED3)

2.2 Bottom View

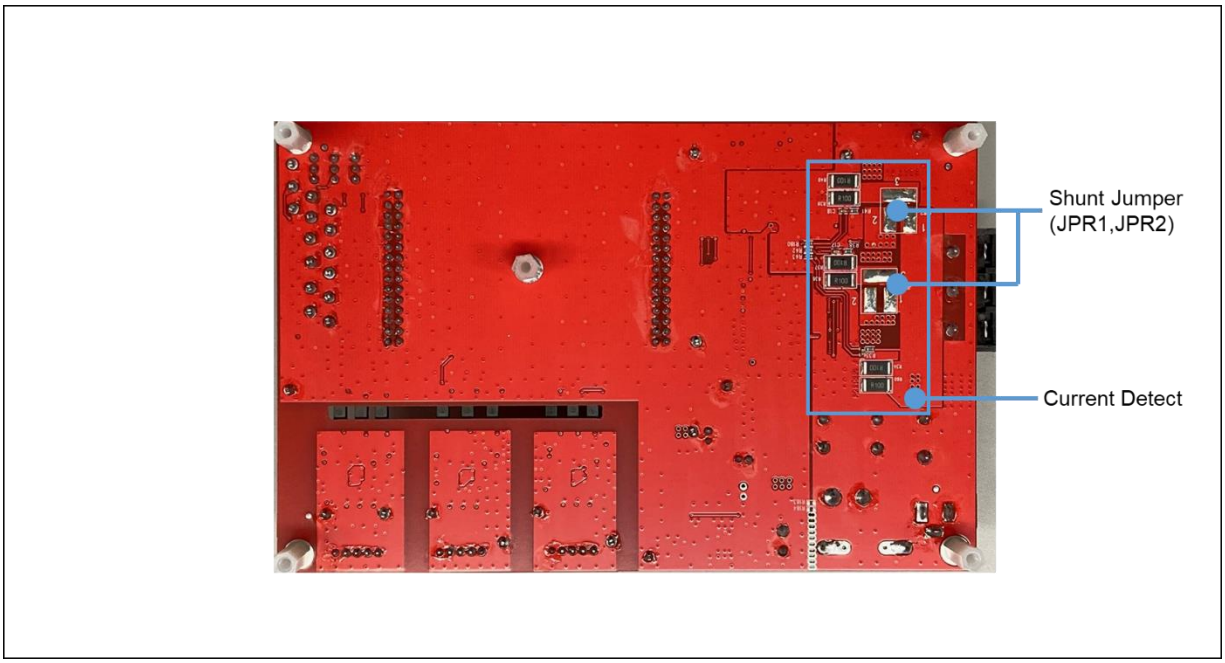


Figure 2-2 Bottom View of Nu-KE-MTR_LV001

Figure 2-2 shows the main components and connectors from the bottom side of Nu-KE-MTR_LV001.

The following lists components and connectors from the bottom view:

- Current Detect
- Shunt Jumper(JPR1,JPR2)

2.3 Voltage Generator Circuit

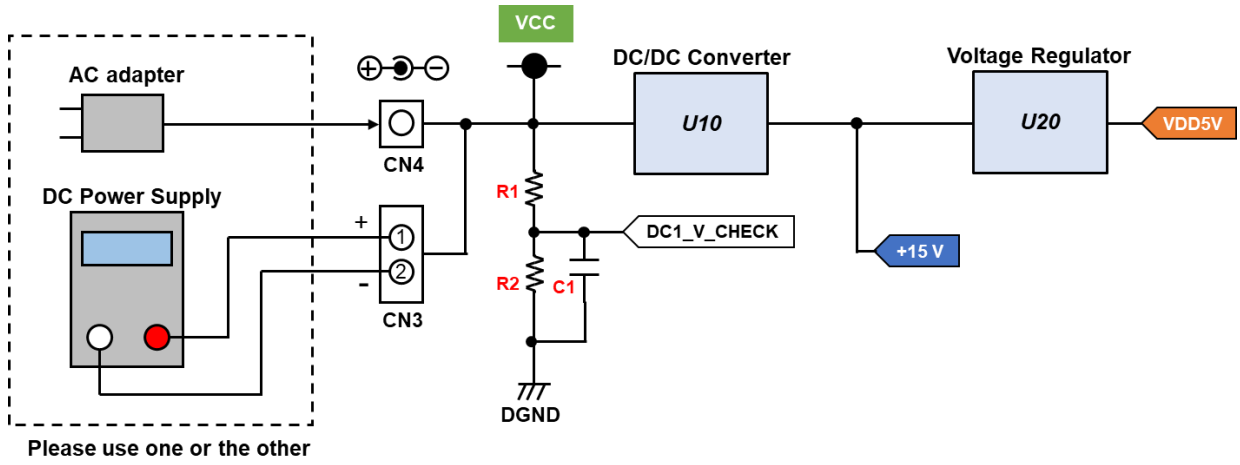


Figure 2-3 Voltage Generator Circuit

Nu-KE-MTR_LV001 generates voltages of 15V, 5V from the main power supply (CN3 or CN4).

■Main power supply (VCC)

Connector	Description
CN3	DC power supply connector Input voltage : 24V, 48V
CN4	AC adapter connector Input voltage : 24V, 48V

■Output voltage

Voltage	Description
15V output (+15V)	Supply to GATE DRIVER IC
5V output (VDD5V)	Supply to MCU board
DC1_V_CHECK	DC bus voltage detection

2.4 Inverter Control Circuit Block

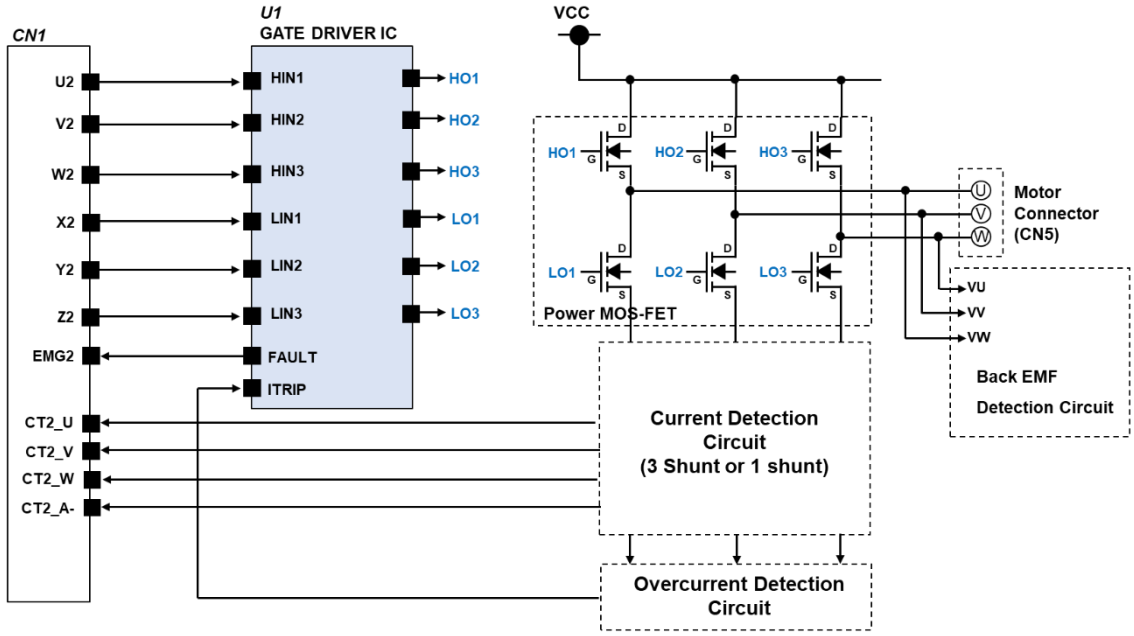


Figure 2-4 Inverter Control Circuit

Figure 2-4 is a schematic diagram of the inverter control circuit.

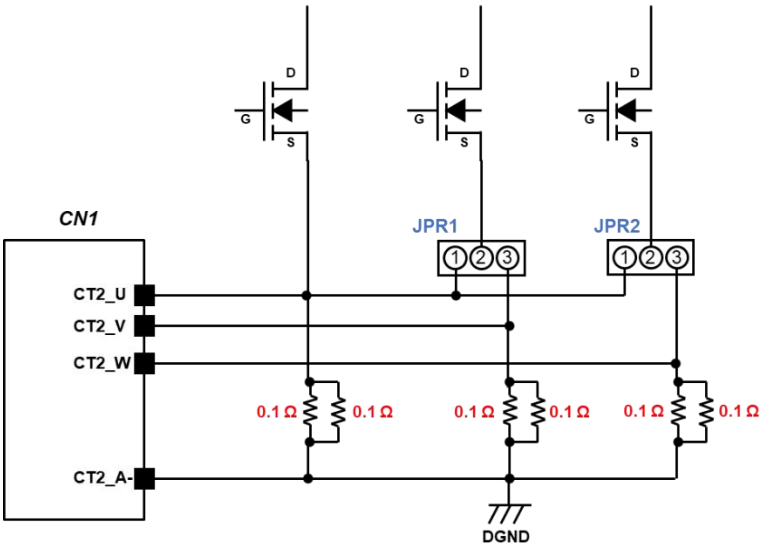
The Nu-KE-MTR_LV001 has a inverter control circuit that the 3-phase complementary PWM timer output from the microcontroller controls the power MOSFET via the gate driver IC and drives the motor.

The inverter control circuit has a current detection circuit that measures the current of each phase of U, V and W with shunt resistor.
Please refer to 2.5 Current Detection Circuit for details.

The inverter control circuit has a overcurrent detection circuit that detects the overcurrent event from shunt current of each phase of U, V, and W.
Please refer to 2.6 Overcurrent Detection Circuit for details.

In addition, the inverter control circuit also has the Back EMF detection circuit that inputs the voltage of each phase of U, V, and W to the comparator and detects the zero cross of the induced voltage.
Please refer to 2.7 Back EMF Detection Circuit for details.

2.5 Current Detection Circuit



JPR1, JPR2 Setting

① - ②	1 shunt
② - ③	3 shunt

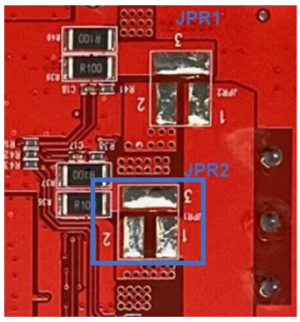


Figure 2-5 Current Detection Circuit

The Nu-KE-MTR_LV001 has current detection circuit to measure the U, V, and W phase currents by the shunt resistor. The voltage drop caused by the current flowing through the shunt resistor is amplified by the operational amplifier that built into the microcontroller and converted to digital value by A/D converter. By setting JPR1 and JPR2, 1 shunt or 3 shunt current detection method can be switched.

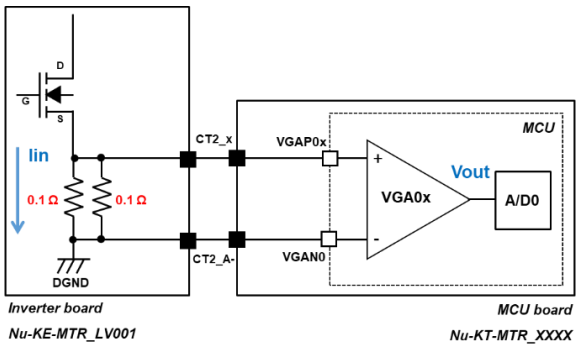


Figure 2-6 Current Detection Circuit

The relationship between the phase current (Iin) flowing through the shunt resistor and the voltage (Vout) input to the A/D converter is given by Equation (1).

$$Vout\ [V] = Iin\ [A] \times Rs\ [\Omega] \times VGA\_Gain + VGA\_VREF \qquad (1)$$

■The parameters at default

Parameter	Description	Value
VGA_Gain	VGA output gain	10 times
VGA_VREF	VGA output reference voltage	2.5 V
Rs	Shunt resistor	0.05 Ω

*The VGA output reference voltage and VGA output gain are set by software.

2.6 Overcurrent Detection Circuit

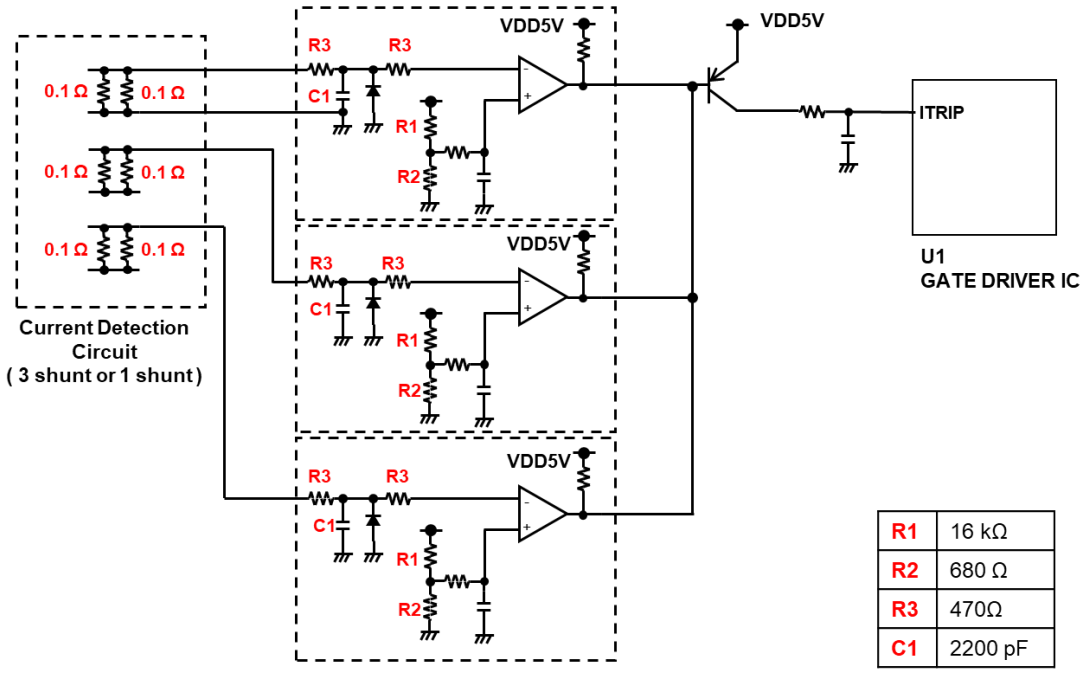


Figure 2-7 Overcurrent Detection Cuicuit

Figure 2-7 is a schematic diagram of the overcurrent detection circuit.
The overcurrent detection circuit detects overcurrent event from the shunt current of each of the U, V, and W phases. When the current flowing through the U, V, and W phases exceeds the threshold value in any one, it is judged to be overcurrent event.

The overcurrent detection circuit sets the threshold value with the resistor voltage divider of resistors R1 and R2. By default, Nu-KE-MTR_LV001 implements resistors R1 and R2 to set the detection threshold at about 4 A.

When the overcurrent event occured, High level is input to the ITRIP pin of the gate driver IC, the output of the MOSFET is turned off instantly, and the EMG_2 (Active-Low) signal will be generated and input to the microcontroller, so that the board and the motor can be protected.

Please adjust the resistors R1 and R2 and set the detection thresholds according to the use environment. The detection threshold is given by Equation (2).

The detection threshold [A] = 5 [V] × R2 [Ω] / (R1 [Ω] + R2 [Ω]) / shunt resistor [Ω] (2)

■The detection threshold for the overcurrent detection at default.

5 [V] × 680 [Ω] / (16000 [Ω] + 680 [Ω]) / 0.05 [Ω] = 4.08 [A]

2.7 Back EMF Detection Cuicuit

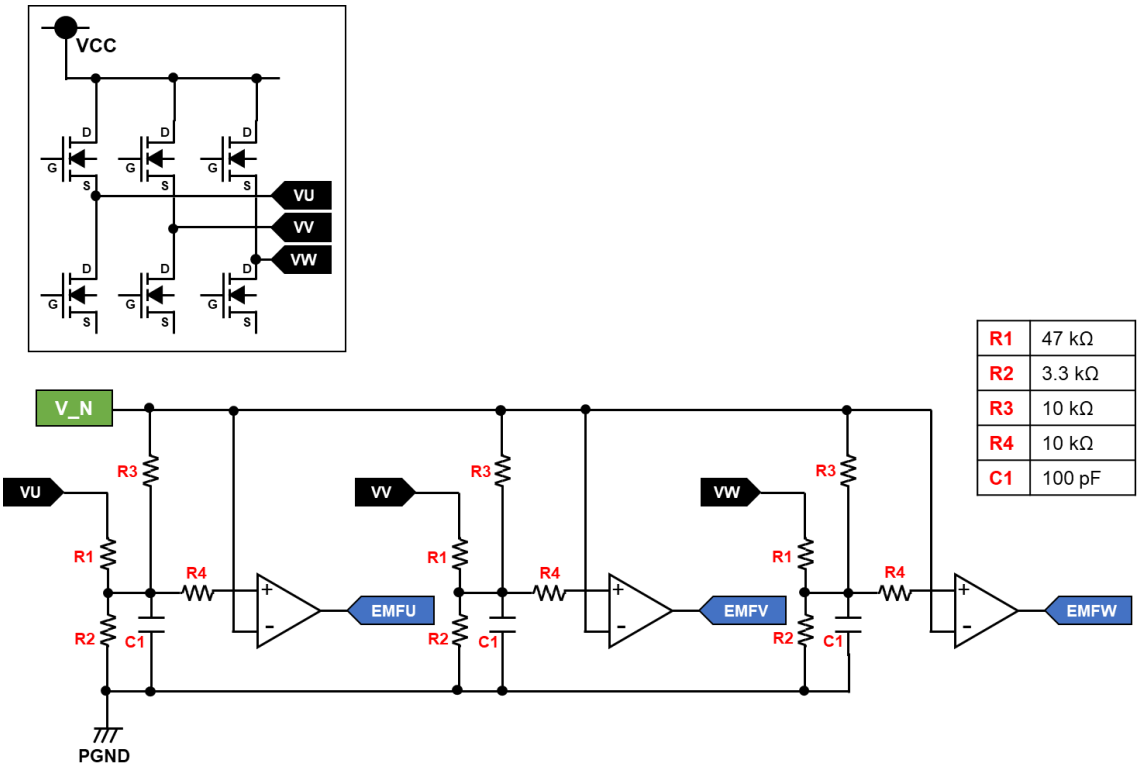


Figure 2-8 Back EMF Detection Circuit

Figure 2-8 is a schematic diagram of the Back EMF detection circuit.

The Back EMF detection circuit compares the voltage of each phase of U, V, W with a virtual neutral voltage (V_N) using a comparator and detects the zero cross of the induced voltage.

When using, see also 2.11 Jumper.

2.8 Encoder

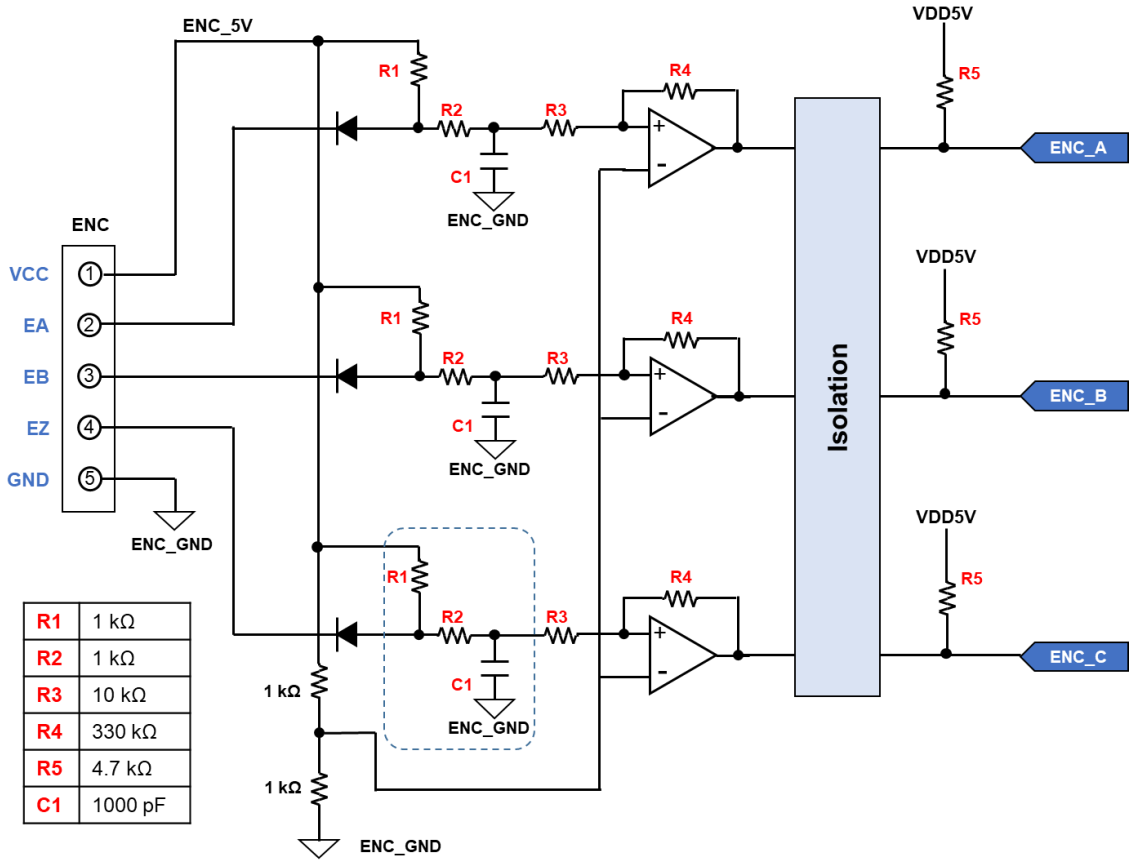


Figure 2-9 Encoder Circuit

Figure 2-9 is a schematic diagram of the encoder circuit.

The Nu-KE-MTR_LV001 has connector for connecting to an encoder.
The encoder signal is isolated by a photo coupler. In addition, each signal has a filter inserted.
The time constant CR of the filter is given by Equation (3).

$$\text{The time constant CR [sec]} = (R1 + R2) \times C1 \qquad (3)$$

■The time constant CR of the filter at default.

The time constant CR = (1 [kΩ] + 1 [kΩ]) × 1000 [pF] = 2 [μsec]

Please adjust the time constant of the filter according to the encoder specifications to be used.

For the filter on the MCU board side, please refer to the circuit diagram in the user manual of the the inverter control MCU board Nu-KT-MTR_xxx (xxx:MCU parts number).

2.9 Servo command

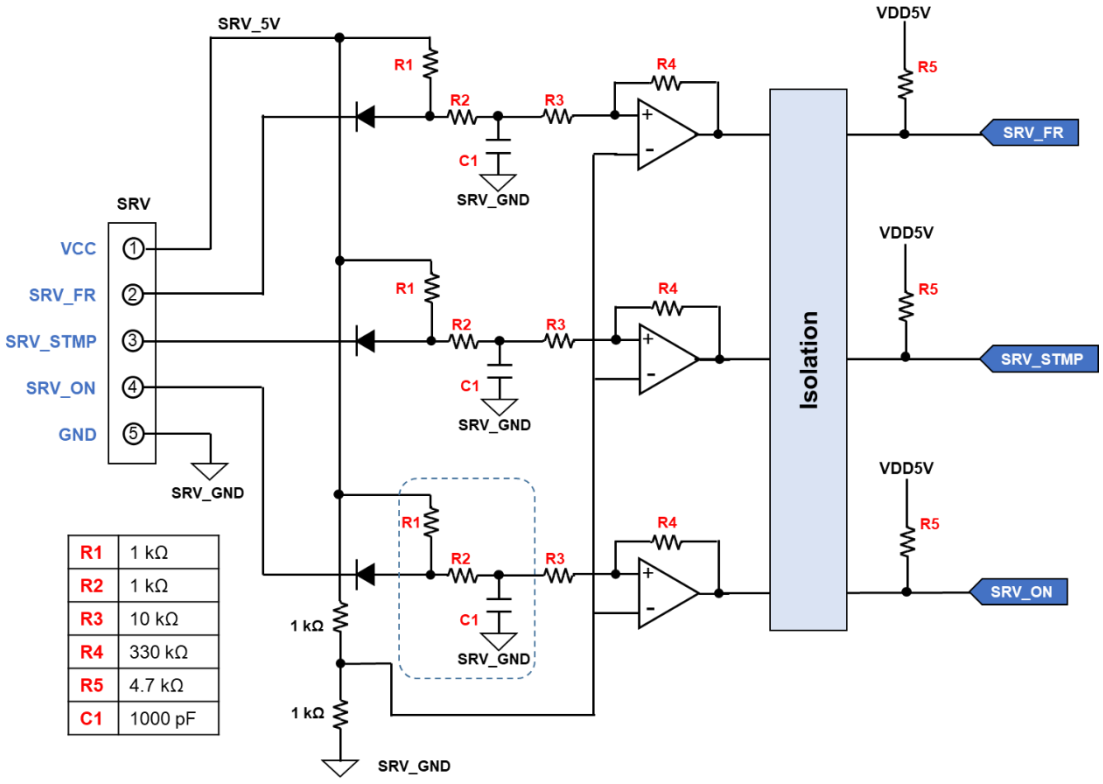


Figure 2-10 Servo command Circuit

Figure 2-10 is a schematic diagram of the servo command circuit.

The Nu-KE-MTR_LV001 has connectors for connecting to a servo command. The servo command signal is isolated by a photo coupler. In addition, each signal has a filter inserted.
The time constant CR of the filter is given by Equation (4).

$$\text{The time constant CR [sec]} = (R1 + R2) \times C1 \qquad (4)$$

■The time constant CR of the filter at default.

The time constant CR = (1 [kΩ] + 1 [kΩ]) × 1000 [pF] = 2 [μsec]

Please adjust the time constant of the filter according to the servo specifications to be used.

For the filter on the MCU board side, please refer to the circuit diagram in the user manual of the the inverter control MCU board Nu-KT-MTR_xxx (xxx:MCU parts number).

2.10 Hall sensor

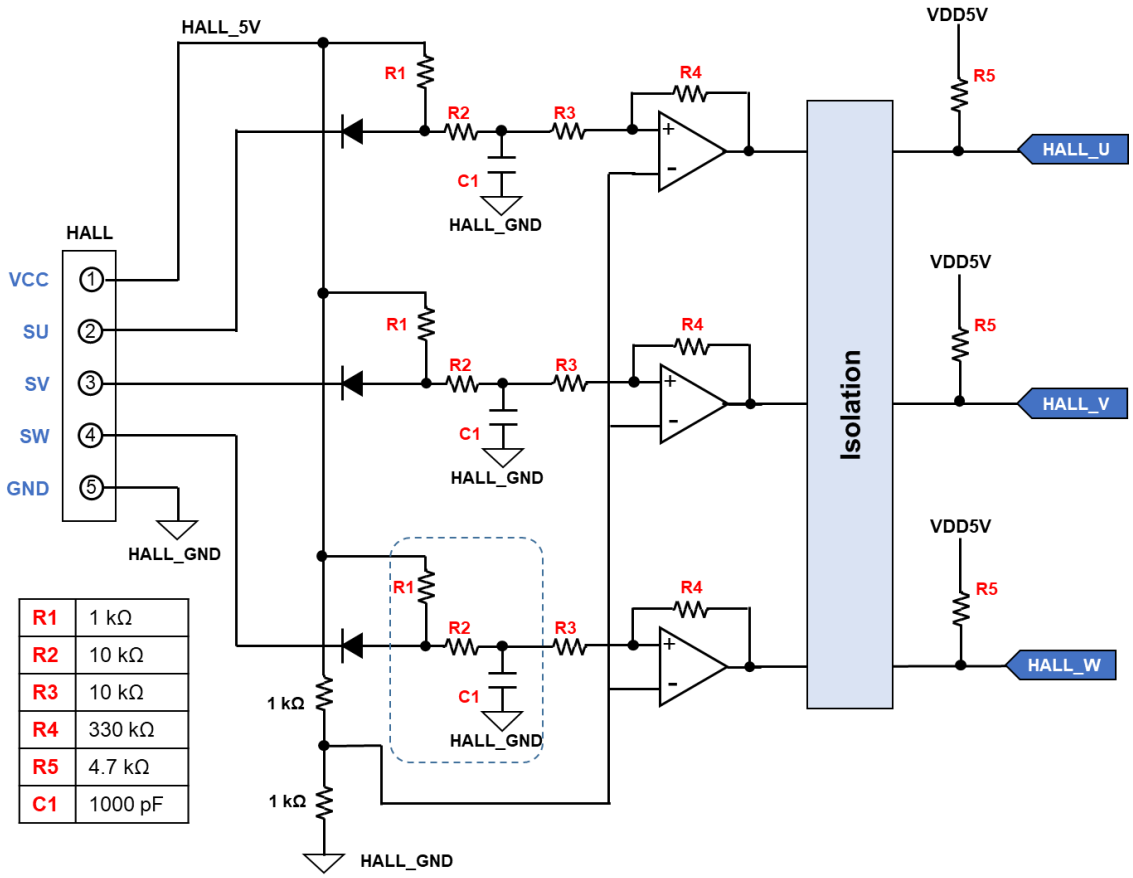


Figure 2-11 Hall sensor Circuit

Figure 2-11 is a schematic diagram of the Hall sensor circuit.

The Nu-KE-MTR_LV001 has connectors for connecting to a Hall sensor. The Hall sensor signal is isolated by a photo coupler. In addition, each signal has a filter inserted.
The time constant CR of the filter is given by Equation (5).

$$\text{The time constant CR [sec]} = (R1 + R2) \times C1 \qquad (5)$$

■The time constant CR of the filter at default

The time constant CR = (1 [kΩ] + 10 [kΩ]) × 1000 [pF] = 11 [μsec]

Please adjust the time constant of the filter according to the Hall sensor specifications to be used. When using, see also 2.11 Jumper.

For the filter on the MCU board side, please refer to the circuit diagram in the user manual of the the inverter control MCU board Nu-KT-MTR_xxx (xxx:MCU parts number).

2.11 Jumper

The Nu-KE-MTR_LV001 has the jumper for switching signals between the Back EMF detect and the Hall sensor.

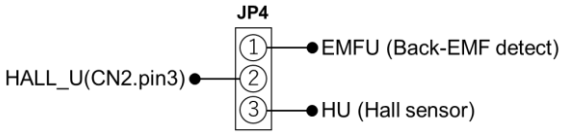
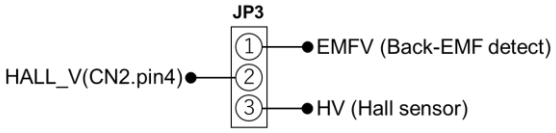
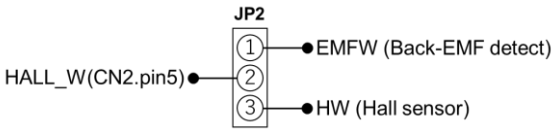
Jumper	Description
	1-2 : Back-EMF detect 2-3 : Hall sensor
	1-2 : Back-EMF detect 2-3 : Hall sensor
	1-2 : Back-EMF detect 2-3 : Hall sensor

Table 2-1 Jumper Setting

2.12 DIP Switch

The Nu-KE-MTR_LV001 has a DIP switch. You can make use of the DIP switch as you like.

DIP Switch	Connector	Description
SW0	CN1.21	ON:Hi input , OFF:Lo input
SW1	CN1.22	ON:Hi input , OFF:Lo input
SW2	CN1.23	ON:Hi input , OFF:Lo input
SW3	CN1.24	ON:Hi input , OFF:Lo input

Table 2-2 DIP Switch

2.13 LEDs

The Nu-KE-MTR_LV001 has one LED for Power indication and two user-specified LEDs .

LED	Connector	Description
LED1	-	LED for Power
LED2	CN2.20	Low Output : ON / High Output : OFF
LED3	CN2.19	Low Output : ON / High Output : OFF

Table 2-3 LED setting

2.14 MCU board Connectors

Table 2-4 shows the MCU board connectors.

Connector	Description
CN1, CN2	Mount the MCU board.

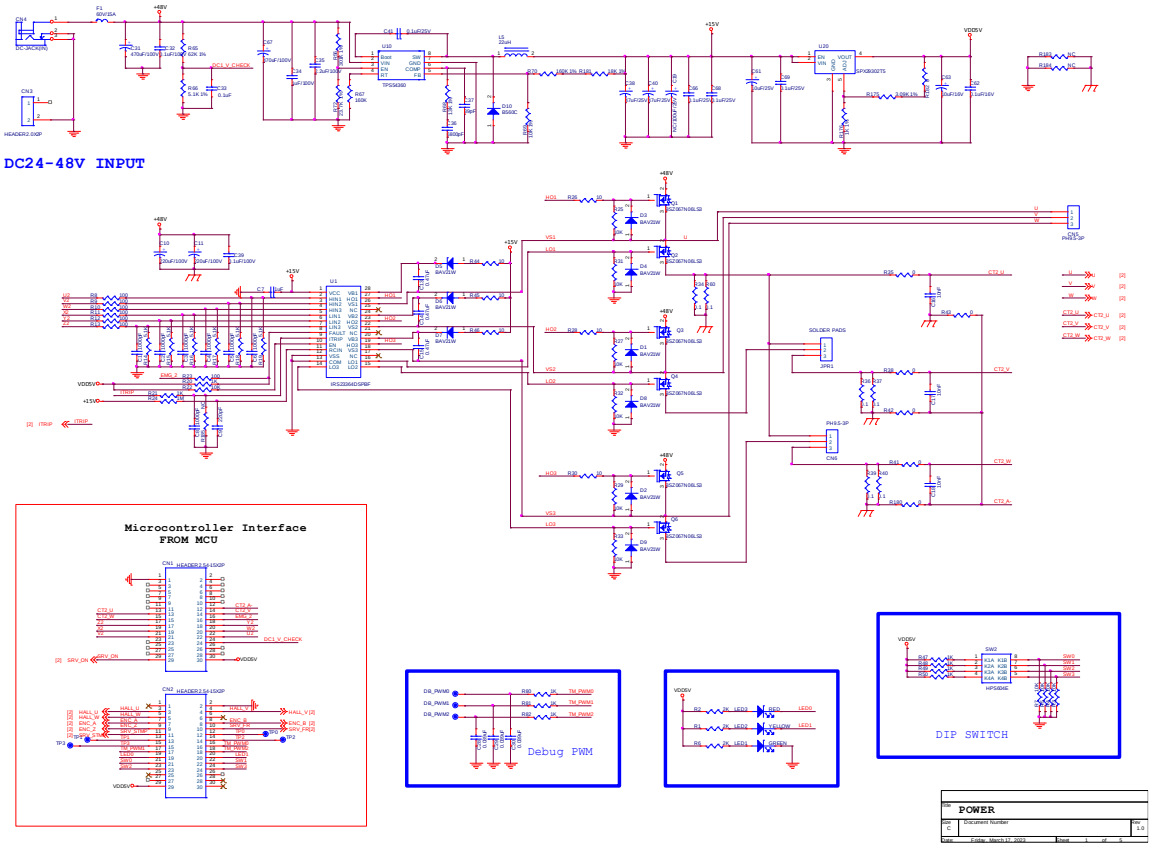
Table 2-4 Inverter board Connectors

Please refer to the user manual of the the inverter control MCU board Nu-KT-MTR_xxx (xxx:MCU parts number).

3. NU-KE-MTR_LV001 SCHEMATICS

3.1 Nu-KE-MTR_LV001

Figure 3-1 shows the Nu-KE-MTR_LV001 schematic.



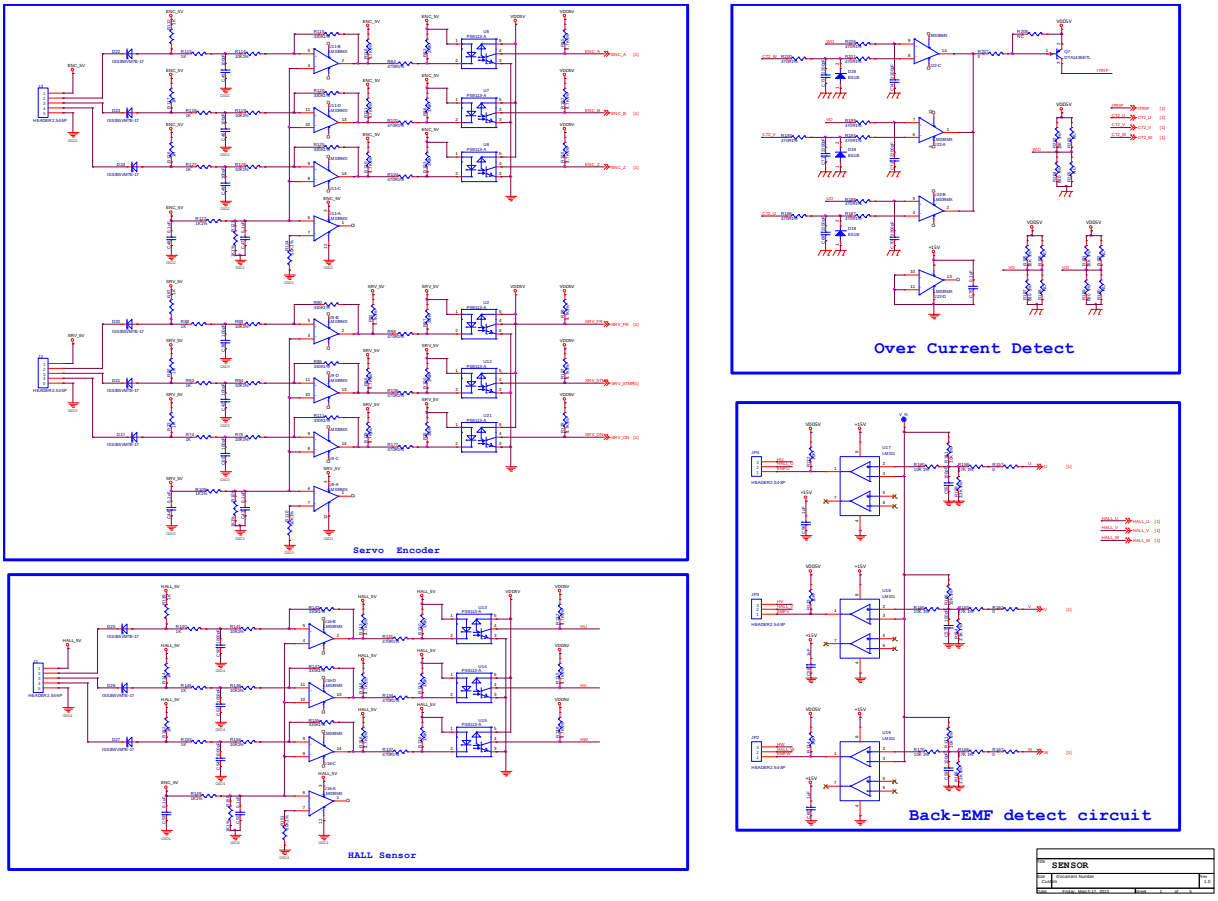


Figure 3-1 Nu-KE-MTR_LV001 Schematic

3.2 PCB Component Placement

Figure 3-2 and Figure 3-3 show the top and bottom PCB component placement of Nu-KE-MTR_LV001.

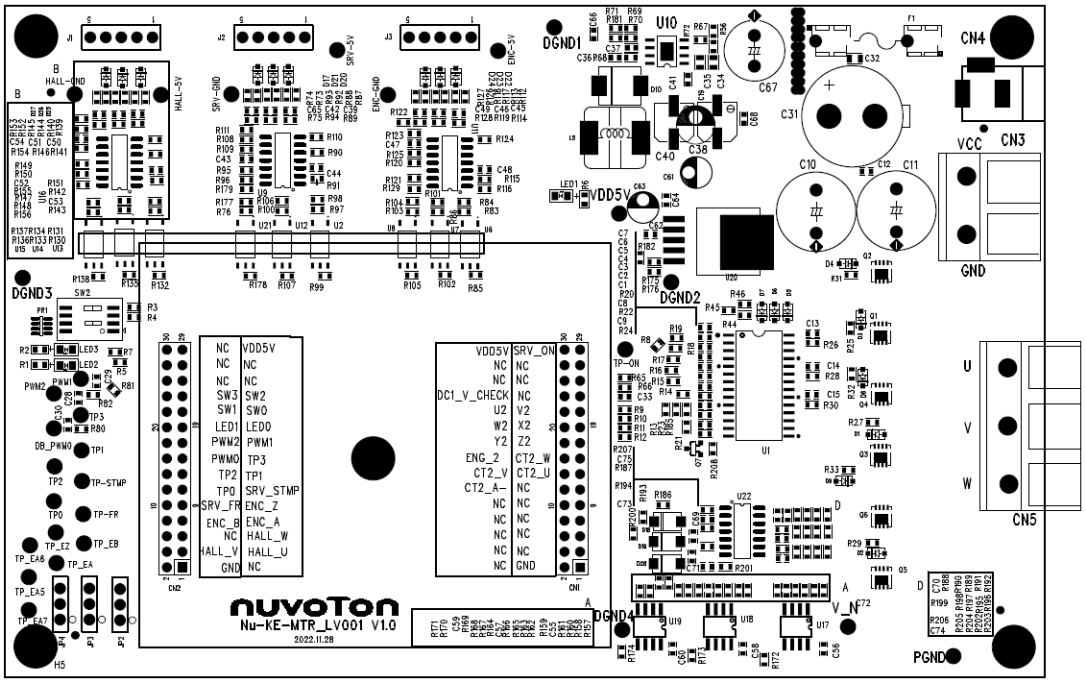


Figure 3-2 Top Placement

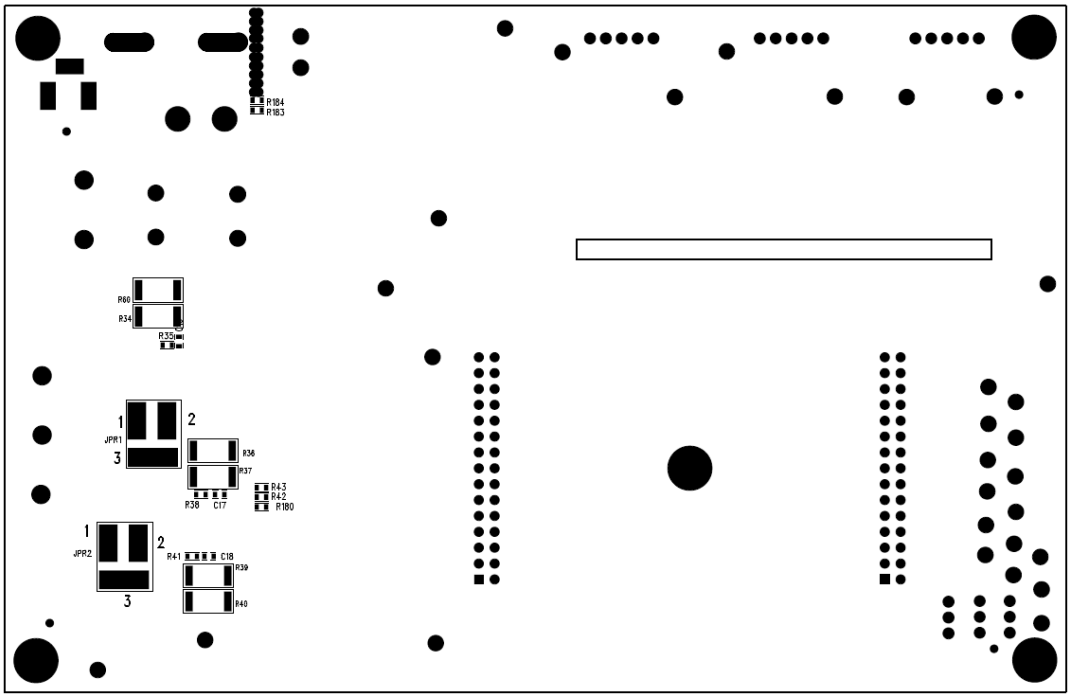


Figure 3-3 Bottom Placement

4. REVISION HISTORY

Date	Revision	Description
July 11, 2022	1.00	Initial version
July 20, 2022	1.01	Figure 2-7 Fix connection of amplifier input polarity Figure 3-1 Change the schematic
March 10, 2023	1.02	-The following changes have been made with the board V1.0. Figure 2-1 Top View of Nu-KE-MTR-LV001 Figure 2-2 Bottom View of Nu-KE-MTR_LV001 Figure 3-1 Nu-KE-MTR_LV001 Schematic Figure 3-2 Top Placement Figure 3-3 Bottom Placement

Important Notice

Nuvoton Products are neither intended nor warranted for usage in systems or equipment, any malfunction or failure of which may cause loss of human life, bodily injury or severe property damage. Such applications are deemed, "Insecure Usage".

Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.

All Insecure Usage shall be made at customer's risk, and in the event that third parties lay claims to Nuvoton as a result of customer's Insecure Usage, customer shall indemnify the damages and liabilities thus incurred by Nuvoton.