## Driver IC for
## Lens Motor

# KA41908B
# Product Brief



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

## ■ IMPORTANT NOTICE

**Regarding the specifications of this product, it is considered that you have agreed to the quality level and disclaimer described below.**

**Support for industry standards and quality standards**

| | |
|---|---|
| **Functional safety standards for automobiles ISO26262** | **No** |
| **AECQ-100** | **No** |
| **Market failure rate** | **50Fit** |

**Disclaimer**

1. When the application system is designed using this IC, please design the system at your own risk. Please read, consider, and apply appropriate usage notes and description in this standard.

2. When designing your application system, please take into the consideration of break down and failure mode occurrence and possibility in semiconductor products. Measures on the systems such as, but not limited to, redundant design, mitigating the spread of fire, or preventing glitch, are recommended in order to prevent physical injury, fire, social damages, etc. in using the Nuvoton Technology Japan Corporation (hereinafter referred to as NTCJ) products.

3. When using this IC, for each actual application systems, verify the systems and the all functionality of this IC as intended in application systems and the safety including the long-term reliability at your own risk

4. Please use this IC in compliance with all applicable laws, regulations and safety-related requirements that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. NTCJ shall not be held responsible for any damage incurred as a result of this IC being used not in compliance with the applicable laws, regulations and safety-related requirements.

5. This IC does not have any security functions using cryptographic algorithms, such as authentication, encryption, tampering detection.

6. Unless this IC is indicated by NTCJ to be used in applications as meeting the requirements of a particular industry standard (e.g., ISO 9001, IATF 16949, ISO 26262, etc.), this IC is neither designed nor intended for use in such environments for that applications. NTCJ shall not be held responsible for not meeting the requirements of a particular industry standard.

7. Using IC that have been indicated as compliant with industry functional safety standards does not warrant that the application meets the requirements of industry functional safety standards. NTCJ shall not be held responsible for the application compliance with requirements of the particular industry functional safety standard.

8. Unless this IC is indicated by NTCJ to be used in applications as meeting the requirements of a particular quality standard (e.g., AECQ-100, etc.), this IC is neither designed nor intended for use in such the environments for that applications. NTCJ shall not be held responsible for not meeting the requirements of a particular quality standard.

9. In case of damages, costs, losses, and/or liabilities incurred by NTCJ arising from customer's non-compliance with above from 1 to 8, customer will indemnify NTCJ against every damages, costs, losses and responsibility.

## FEATURES

- Voltage drive system 256-step microstep drivers (2 systems)
- Motor current amplitude and phase can be adjusted for each channel (CAP (Correction Amplitude & Phase) function)
- Accurate position control of Iris by using Hall sensor and built-in PID control circuit
- Motor control by 4-line serial data communication
- 2 systems of open-drain for driving LED
- Package : QFN 44L (6x6x0.8mm$^3$, Lead Pitch 0.4mm)

## DESCRIPTION

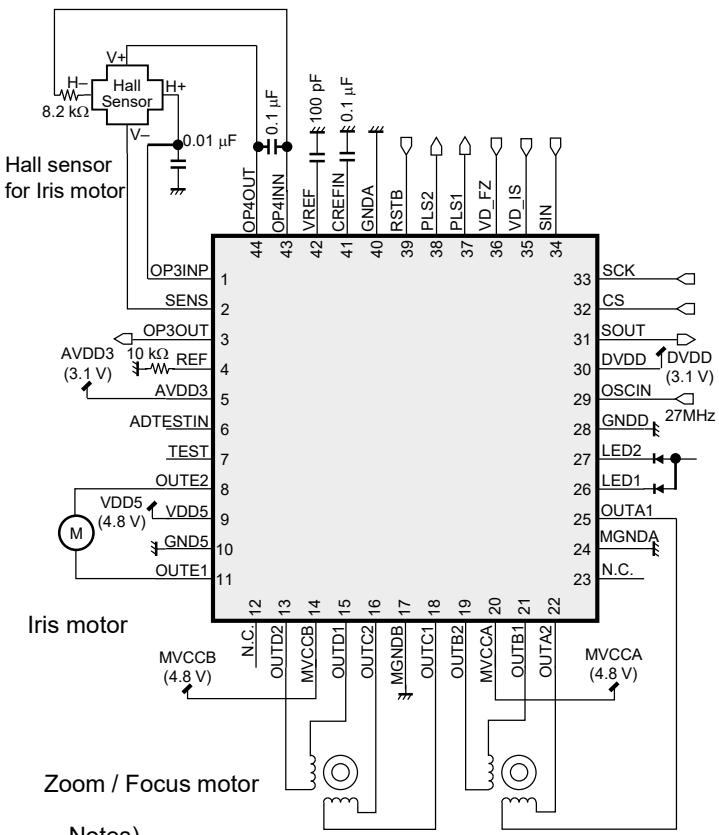
KA41908B is a lens driver IC for surveillance camera and Web camera built-in Iris control.
This IC has a built-in iris control function. It realizes low noise microstep drive by adopting voltage drive method, and motor current correction function.

## APPLICATIONS

- Surveillance camera, Web camera

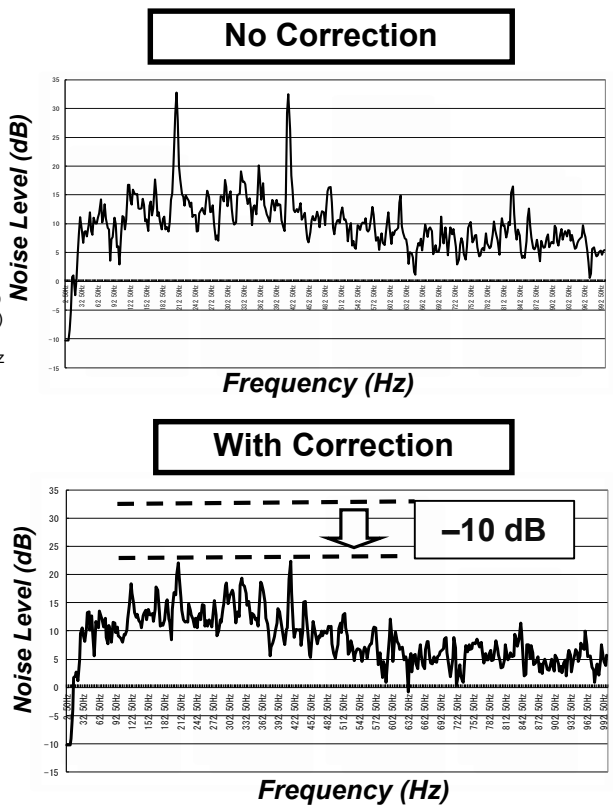

## TYPICAL APPLICATION

● For Zoom / Focus / Iris motor



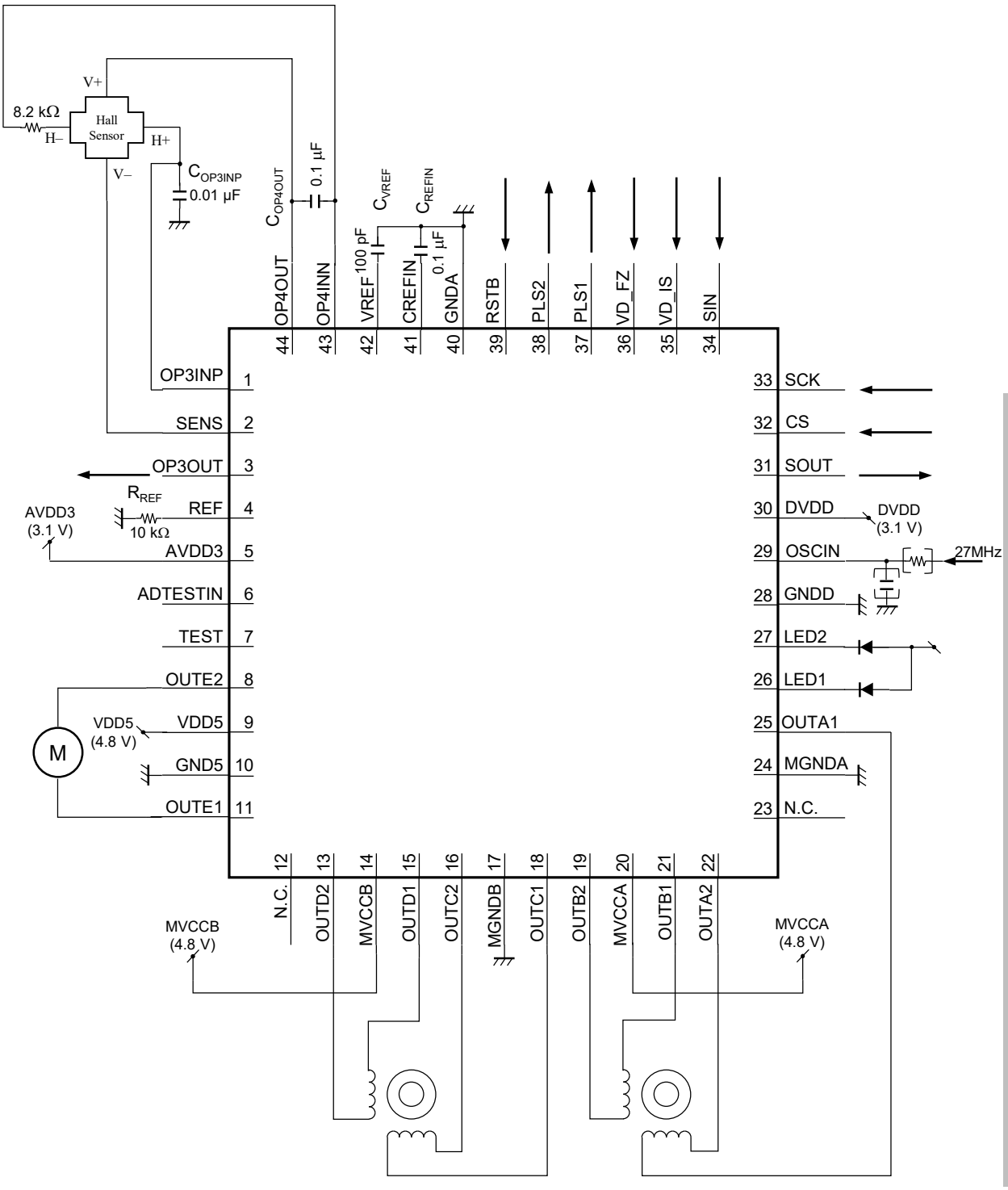

Notes)
This application circuit is an example. The operation of mass production set is not guaranteed. You should perform enough evaluation and verification on the design of mass production set. You are fully responsible for the incorporation of the above application circuit and information in the design of your equipment.

**low acoustic noise microstep drive.**



Contents

## ■Application Circuit Example




Note) This application circuit is shown as an example but does not guarantee the design for mass production set.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Rating | Unit | Note |
|---|---|---|---|---|
| Controller supply voltage | AVDD3 | –0.3 to + 4.0 | V | *1 |
| | DVDD | –0.3 to + 4.0 | | |
| Supply voltage for motor controller 1 | MVCCA, MVCCB | –0.3 to + 6.0 | V | *1 |
| Supply voltage for motor controller 2 | VDD5 | –0.3 to + 6.0 | V | *1 |
| Operating ambient temperature | $T_{opr}$ | –40 to + 105 | °C | *2, *4 |
| Operating junction temperature | $T_j$ | –40 to + 150 | °C | *2 |
| Storage temperature | $T_{stg}$ | –55 to + 150 | °C | *2 |
| Motor driver 1<br>H bridge drive current<br>(DC current) | OUTA1, OUTA2,<br>OUTB1, OUTB2,<br>OUTC1, OUTC2,<br>OUTD1, OUTD2 | ±0.25 | A/ch | — |
| Motor driver 2<br>H bridge drive current<br>(DC current) | OUTE1, OUTE2 | ±0.15 | A/ch | — |
| Instantaneous H bridge drive current | $I_{M(pulse)}$ | ±0.4 | A/ch | — |
| Input Voltage Range | OP3INP, OP4INN,<br>ADTESTIN,<br>REF, CREFIN | –0.3 to (AVDD3 + 0.3) | V | *3 |
| | TEST, OSCIN,<br>CS, SCK, SIN,<br>VD_IS, VD_FZ, RSTB | –0.3 to (DVDD + 0.3) | V | *3 |
| Output Voltage Range | OP3OUT, OP4OUT,<br>SENS,VREF | –0.3 to (AVDD3 + 0.3) | V | *3 |
| | PLS1, PLS2, SOUT | –0.3 to (DVDD + 0.3) | V | *3 |
| Output Current Range | LED1, LED2 | 30 | mA | — |
| ESD | HBM (Human Body Model) | ±2 | kV | — |

Notes). This product may sustain permanent damage if subjected to conditions higher than the above stated absolute maximum rating. This rating is the maximum rating and device operating at this range is not guaranteed as it is higher than our stated recommended operating range. When subjected under the absolute maximum rating for a long time, the reliability of the product may be affected.

*1:The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

*2:Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for Ta = 25°C.

*3: (DVDD + 0.3 ) V must not be exceeded 4.0 V and (AVDD + 0.3 ) V must not be exceeded 4.0 V.

*4: When using this IC, refer to the PD-Ta diagram of the package information and design the heat radiation with sufficient margin so that the allowable value might not be exceeded based on the conditions of power supply voltage, load, and ambient temperature.

## POWER DISSIPATION RATING

| Condition | $\theta_{JA}$ | PD (Ta=25 °C) | PD (Ta=105 °C) |
|---|---|---|---|
| Mount on PWB *1 | 54.2℃/W | 2.303W | 0.829W |

Note). For the actual usage, follow the power supply voltage, load and ambient temperature conditions to ensure that there is enough margin and the thermal design does not exceed the allowable value.
*1: Glass-Epoxy: 50 × 50 × 0.8 (mm) , Die-pad joint

**CAUTION**

Although this has limited built-in ESD protection circuit, but permanent damage may occur on it. Therefore, proper ESD precautions are recommended to avoid electrostatic damage to the MOS gates

## RECOMMENDED OPERATING CONDITIONS

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Note |
|---|---|---|---|---|---|---|
| Supply voltage range | AVDD3,DVDD | 2.7 | 3.1 | 3.6 | V | *1 |
| | MVCCA, MVCCB, VDD5 | 3.0 | 4.8 | 5.5 | V | *1 |
| Input Voltage Range | OP3INP, OP4INN, ADTESTIN, REF, CREFIN | –0.3 | — | AVDD3 + 0.3 | V | *2 |
| | TEST, OSCIN, CS, SCK, SIN, VD_IS, VD_FZ, RSTB | –0.3 | — | DVDD + 0.3 | V | *2 |
| Output Voltage Range | OP3OUT, OP4OUT, SENS,VREF | –0.3 | — | AVDD3 + 0.3 | V | *2 |
| | PLS1, PLS2, SOUT | –0.3 | — | DVDD + 0.3 | V | *2 |
| Output Current Range | OUTA1, OUTA2, OUTB1, OUTB2, OUTC1, OUTC2, OUTD1, OUTD2 | −0.25 | — | 0.25 | A | *1 |
| | OUTE1, OUTE2 | −0.15 | — | 0.15 | A | *1 |
| | LED1, LED2 | — | — | 30 | mA | *1 |
| External Constants | $C_{VREF}$ | | 100 | | pF | — |
| | $C_{REFIN}$ | | 0.1 | | µF | — |
| | $R_{REF}$ | | 10 | | kΩ | — |
| | $C_{OP3INP}$ | | 0.01 | | µF | — |
| | $C_{OP4OUT}$ | | 0.1 | | µF | — |
| Operating ambient temperature | $Ta_{opr}$ | -40 | | 105 | °C | — |

Note) *1 : It is a value under the conditions which do not exceed the absolute maximum rating and the power dissipation.
*2 : (DVDD + 0.3 ) V must not be exceeded 4.0 V and (AVDD + 0.3 ) V must not be exceeded 4.0 V.

## ELECRTRICAL CHARACTERISTICS

VDD5 = MVCCx = 4.8 V, DVDD = AVDD3 = 3.1 V  $T_a$ = 25°C±2°C

| Parameter | Symbol | Condition | Limits | | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| **Current circuit, Common circuit** | | | | | | | |
| MVCC supply current on Reset | $I_{Omdisable}$ | No load, no 27 MHz input | — | 0 | 3.0 | µA | |
| MVCC supply current on Enable | $I_{menable}$ | Output open | — | 0.5 | 1.5 | mA | |
| 3 V supply current on Reset | $Icc3_{reset}$ | No 27 MHz input | — | 0 | 10.0 | µA | |
| 3 V supply current on Enable | $Icc3_{enable}$ | Output open | — | 7.0 | 20.0 | mA | |
| VDD5 supply current on Reset | $Icc5_{reset}$ | No 27 MHz input | — | 0 | 3.0 | µA | |
| VDD5 supply current on Enable | $Icc5_{enable}$ | Output open | — | 0.3 | 1.0 | mA | |
| Supply current on Standby | $Icc_{standby}$ | RSTB = High, output open, 27 MHz input, Total current | — | 5.0 | 10.0 | mA | |
| Supply current when FZ is Enable and Iris is in power save mode | $Icc_{ps}$ | RSTB = High, output open, 27 MHz input, FZ = Enable, Total current | — | 6.0 | 12.0 | mA | |
| **Digital input / output** | | | | | | | |
| High-level input | $V_{in(H)}$ | RSTB | 0.54 × DVDD | — | DVDD + 0.3 | V | |
| Low-level input | $V_{in(L)}$ | RSTB | –0.3 | — | 0.2 × DVDD | V | |
| SOUT High-level output | $V_{out(H)}$ : SDATA | [SOUT] 1 mA Source | DVDD – 0.5 | — | — | V | |
| SOUT Low-level output | $V_{out(L)}$ : SDATA | [SOUT] 1 mA Sink | — | — | 0.5 | V | |
| PLS1 to 2 High-level output | $V_{out(H)}$ : MUX | — | 0.9 × DVDD | — | — | V | |
| PLS1 to 2 Low-level output | $V_{out(L)}$ : MUX | — | — | — | 0.1 × DVDD | V | |
| Input pull-down resistance | $R_{pullret}$ | RSTB | 50 | 100 | 200 | kΩ | |
| **Motor driver 1** | | | | | | | |
| H bridge ON resistance | $R_{onFZ}$ | IM = 100 mA (Upper+Lower) | — | — | 2.5 | Ω | |
| H bridge leak current | $I_{leakFZ}$ | — | — | — | 0.8 | µA | |
| **Motor driver 2** | | | | | | | |
| H bridge ON resistance | $R_{onIR}$ | IM = 50 mA (Upper+Lower) | — | — | 5 | Ω | |
| H bridge leak current | $I_{leakIR}$ | — | — | — | 0.8 | µA | |
| **LED driver** | | | | | | | |
| Output ON resistance | $R_{onLED}$ | I = 20 mA, 5 V cell | — | — | 8 | Ω | |
| Output leak current | $I_{leakLED}$ | — | — | — | 0.8 | µA | |

## ELECRTRICAL CHARACTERISTICS (continued)

VDD5 = MVCCx = 4.8 V, DVDD = AVDD3 = 3.1 V $T_a$ = 25°C±2°C

| Parameter | Symbol | Condition | Limits | | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| **OPAMP3 (HALL Sensor Amp. for output amplifier)** | | | | | | | |
| Input voltage range | $V_{IN}$ | — | ½ AVDD3 – 0.5 | ½ AVDD3 | ½ AVDD3 + 0.5 | V | |
| Input offset voltage | $V_{OF}$ | — | –15 | — | 15 | mV | |
| Output voltage (Low) | $V_{OL}$ | I = 100 µA Sink | — | 0.1 | 0.2 | V | |
| Output voltage (High) | $V_{OH}$ | I = 100 µA Source | AVDD3 – 0.2 | AVDD3 – 0.1 | — | V | |
| Gain | $V_{OG}$ | Gain setting value : 0h | 19.7 | 21.9 | 24.1 | V/V | |
| **OPAMP4 (HALL Sensor Amp. for eliminating common-mode voltage)** | | | | | | | |
| Input voltage range | $V_{IN}$ | — | ½ AVDD3 – 0.1 | — | ½ AVDD3 + 0.1 | V | |
| Input offset voltage | $V_{OF}$ | — | –10 | — | 10 | mV | |
| Output voltage (Low) | $V_{OL}$ | I = 10 µA Sink | — | 0.1 | 0.2 | V | |
| Output voltage (High) | $V_{OH}$ | I = 3 mA Source | AVDD3 – 0.5 | AVDD3 – 0.2 | — | V | |
| **Reference voltage output block** | | | | | | | |
| Output voltage 1 | VREF | I = 0 A, CVREF = 100 pF | ½ AVDD3 – 0.1 | ½ AVDD3 | ½ AVDD3 + 0.1 | V | |
| Output voltage 2 | VREFL | I = ±100 µA, CVREF = 100 pF | VREF – 0.1 | VREF | VREF + 0.1 | V | |
| **Hall bias controller (SENS pin output)** | | | | | | | |
| Min. output current | IBL | REF = 10 kΩ, SENS = 0.7 V Setting value : 00 h | — | 0 | 0.1 | mA | |
| Output current accuracy 1 | IB40H | REF = 10 kΩ, SENS = 0.7 V Setting value : 40 h | 0.9 | 1.02 | 1.14 | mA | |
| Output current accuracy 2 | IBBFH | REF = 10 kΩ, SENS = 0.7 V Setting value : BE h | 2.66 | 3.02 | 3.38 | mA | |

## ELECRTRICAL CHARACTERISTICS (continued)

VDD5 = MVCCx = 4.8 V, DVDD = AVDD3 = 3.1 V $T_a$ = 25°C±2°C

| Parameter | Symbol | Condition | Limits | | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| **Serial port input** | | | | | | | |
| Serial clock | Sclock | — | 1 | — | 5 | MHz | *1 |
| SCK low time | T1 | — | 100 | — | — | ns | *1 |
| SCK high time | T2 | — | 100 | — | — | ns | *1 |
| CS setup time | T3 | — | 60 | — | — | ns | *1 |
| CS hold time | T4 | — | 60 | — | — | ns | *1 |
| CS disable high time | T5 | — | 100 | — | — | ns | *1 |
| SIN setup time | T6 | — | 50 | — | — | ns | *1 |
| SIN hold time | T7 | — | 50 | — | — | ns | *1 |
| SOUT delay time | T8 | — | — | — | 60 | ns | *1 |
| SOUT hold time | T9 | — | 60 | — | — | ns | *1 |
| SOUT Enable-Hi-Z time | T10 | — | — | — | 60 | ns | *1 |
| SOUT Hi-Z-Enable time | T11 | — | — | — | 60 | ns | *1 |
| SOUT C load | $T_{SC}$ | — | — | — | 40 | pF | *1 |
| **Digital input / output** | | | | | | | |
| High-level input threshold voltage | $V_{in(H)}$ | SCK, SIN, CS, OSCIN, VD_IS, VD_FZ, TEST | — | 1.36 | — | V | *1 |
| Low-level input threshold voltage | $V_{in(L)}$ | SCK, SIN, CS, OSCIN, VD_IS, VD_FZ, TEST | — | 1.02 | — | V | *1 |
| RSTB signal pulse width | Trst | — | 100 | — | — | µs | *1 |
| Input hysteresis width | $V_{hysin}$ | SCK, SIN, CS, OSCIN, VD_IS, VD_FZ, TEST | — | 0.34 | — | V | *1 |
| Video sync. signal width | $VD_W$ | — | 80 | — | — | µs | *1 |
| CS signal wait time 1 | $T_{(VD-CS)}$ | — | 400 | — | — | ns | *1 |
| CS signal wait time 2 | $T_{(CS-DT1)}$ | — | 5 | — | — | µs | *1 |

Note) *1 : Typical Design Value..

## ELECRTRICAL CHARACTERISTICS (continued)

VDD5 = MVCCx = 4.8 V, DVDD = AVDD3 = 3.1 V $T_a$ = 25°C±2°C

| Parameter | Symbol | Condition | Limits | | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| **Pulse generator** | | | | | | | |
| Pulse start resolution for pulse 1 | PL1wait | OSCIN = 27 MHz | — | 20.1 | — | µs | *1 |
| Pulse resolution for pulse 1 | PL1width | OSCIN = 27 MHz | — | 1.2 | — | µs | *1 |
| Pulse start resolution for pulse 2 | PL2wait | OSCIN = 27 MHz | — | 20.1 | — | µs | *1 |
| **Iris control** | | | | | | | |
| AD sampling frequency | $IRIS_{Sample}$ | OSCIN = 27 MHz | — | 500 | — | kHz | *1 |
| **Thermal shutdown** | | | | | | | |
| Thermal shutdown operation temperature | Ttsd | — | — | 150 | — | °C | *1 |
| Thermal shutdown hysteresis width | Δ Ttsd | — | — | 40 | — | °C | *1 |
| **Supply voltage monitor circuit** | | | | | | | |
| 3.3 V Reset operation | Vrston | — | — | 2.27 | — | V | *1 |
| 3.3 V Reset hysteresis width | Vrsthys | — | — | 0.2 | — | V | *1 |
| MVCCx Reset operation | $V_{rstFZon}$ | — | — | 2.2 | — | V | *1 |
| MVCCx Reset hysteresis width | $V_{rstFZhys}$ | — | — | 0.2 | — | V | *1 |
| VDD5 Reset operation | $V_{rstISon}$ | — | — | 2.2 | — | V | *1 |
| VDD5 Reset hysteresis width | $V_{rstIShys}$ | — | — | 0.2 | — | V | *1 |
| **8 bit DAC for Hall Offset adjustment** | | | | | | | |
| Adjustment range (High) | DAOTHof | — | — | AVDD 3 | — | V | *1 |
| Adjustment range (Low) | DAOTLof | — | — | 0 | — | V | *1 |
| **10 bit ADC** | | | | | | | |
| Input Range (High) | $V_{in(H)}$ | — | — | — | AVDD 3 – 0.2 | V | *1 |
| Input Range (Low) | $V_{in(L)}$ | — | 0.2 | — | — | V | *1 |
| DNLE (Differential linearity error) | DNL10A | — | — | 1.0 | — | LSB | *1 |
| INLE (Integral linearity error) | INL10A | — | — | 2.0 | — | LSB | *1 |

Note) *1 : Typical Design Value.

## PIN DESCRIPTIONS

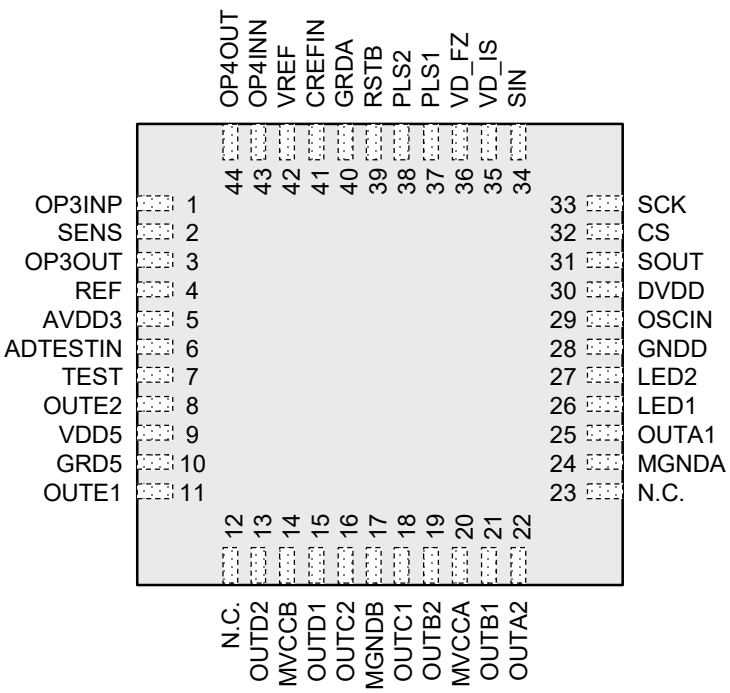
| Pin No. | Pin name | Type | Description |
|---|---|---|---|
| 1 | OP3INP | Input | Hall signal amplifier non-inverting input |
| 2 | SENS | Output | Hall current bias output |
| 3 | OP3OUT | Output | Hall signal amplifier output |
| 4 | REF | — | Resistor connection for Hall current bias setting |
| 5 | AVDD3 | Power supply | 3 V analog power supply |
| 6 | ADTESTIN | Input | ADC test input |
| 7 | TEST | Input | Test mode input |
| 8 | OUTE2 | Output | Motor output E2 |
| 9 | VDD5 | Power supply | Power supply for Iris |
| 10 | GND5 | Ground | GND for Iris |
| 11 | OUTE1 | Output | Motor output E1 |
| 12, 23 | N. C. | — | N. C. |
| 13 | OUTD2 | Output | Motor output D2 |
| 14 | MVCCB | Power supply | Power supply for motor B |
| 15 | OUTD1 | Output | Motor output D1 |
| 16 | OUTC2 | Output | Motor output C2 |
| 17 | MGNDB | Ground | GND for motor B |
| 18 | OUTC1 | Output | Motor output C1 |
| 19 | OUTB2 | Output | Motor output B2 |
| 20 | MVCCA | Power supply | Power supply for motor A |
| 21 | OUTB1 | Output | Motor output B1 |
| 22 | OUTA2 | Output | Motor output A2 |
| 24 | MGNDA | Ground | GND for motor A |
| 25 | OUTA1 | Output | Motor output A1 |
| 26 | LED1 | Input | Open-drain 1 for driving LED |
| 27 | LED2 | Input | Open-drain 2 for driving LED |
| 28 | GNDD | Ground | Digital GND |
| 29 | OSCIN | Input | OSCIN input. 27MHz signal input recommended. |
| 30 | DVDD | Power supply | 3 V digital power supply |
| 31 | SOUT | Output | Serial data output |
| 32 | CS | Input | Chip select signal input |
| 33 | SCK | Input | Serial clock input |

## PIN DESCRIPTIONS (Continued)

| Pin No. | Pin name | Type | Description |
|---|---|---|---|
| 34 | SIN | Input | Serial data input |
| 35 | VD_IS | Input | Iris video sync. signal input |
| 36 | VD_FZ | Input | Focus zoom sync. signal input |
| 37 | PLS1 | Output | Pulse 1 output |
| 38 | PLS2 | Output | Pulse 2 output |
| 39 | RSTB | Input | Reset signal input |
| 40 | GNDA | Ground | 3 V analog GND |
| 41 | CREFIN | — | (AVDD3)/2 capacitor connection pin |
| 42 | VREF | Output | Reference voltage for Hall sensor |
| 43 | OP4INN | Input | Midpoint bias amplifier inverting input |
| 44 | OP4OUT | Output | Midpoint bias amplifier output |

## PIN CONFIGURATION

Top View

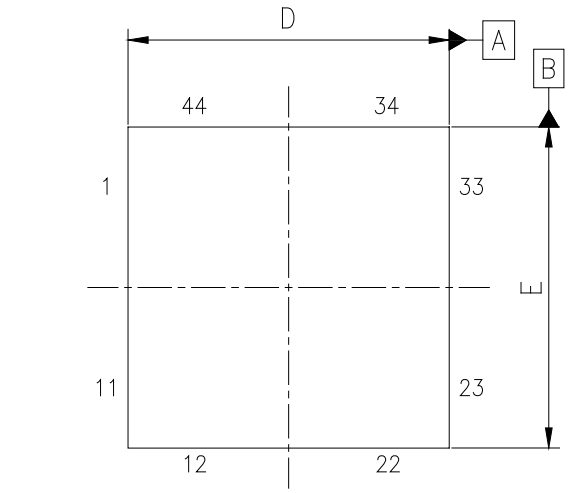


## PACKAGE INFORMATION

**Outline Drawing**

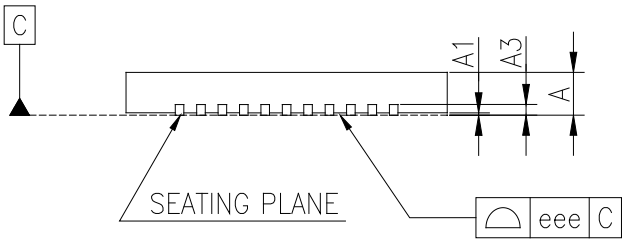
**QFN 44L 6x6mm², Thickness 0.80mm, Lead Pitch 0.4mm,**

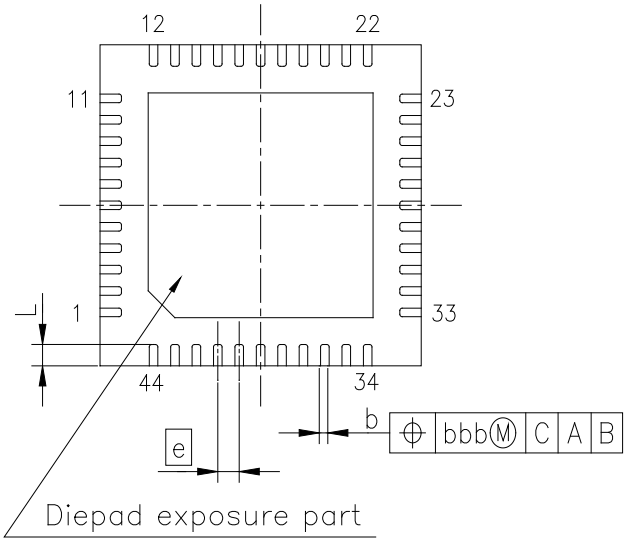
**Lead Length 0.4mm, EP Size 4.2x4.2mm²**

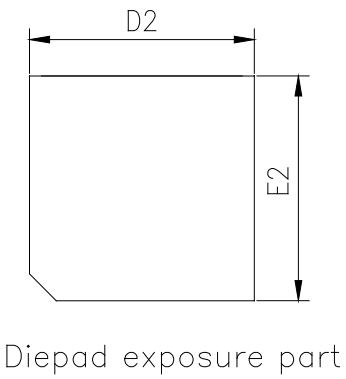



VARIATIONS (ALL DIMENSIONS SHOWN IN MM)

| SYMBOLS | MIN. | NOM. | MAX. |
|---|---|---|---|
| A | 0.70 | 0.75 | 0.80 |
| A1 | 0.00 | – | 0.05 |
| A3 | | 0.20REF | |
| D | 5.90 | 6.00 | 6.10 |
| E | 5.90 | 6.00 | 6.10 |
| b | 0.11 | 0.16 | 0.21 |
| bbb | | 0.07 | |
| e | | 0.40BSC | |
| eee | | 0.08 | |
| L | 0.30 | 0.40 | 0.50 |
| D2 | 4.10 | 4.20 | 4.30 |
| E2 | 4.10 | 4.20 | 4.30 |



## USAGE NOTES

1. The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date datasheet in advance to make sure that the latest specifications satisfy your requirements.
2. The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Nuvoton Technology Corporation Japan or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information de-scribed in this book.
3. This book may be not reprinted or reproduced whether wholly or partially, without the prior written permission of our company.
4. If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.
5. When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.

   Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.
6. Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.
7. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might smoke or ignite.
8. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
9. Perform a visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as a solder-bridge between the pins of the semiconductor device. Also, perform a full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the LSI during transportation.
10. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as output pin-VCC short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short) .

    And, safety measures such as an installation of fuses are recommended because the extent of the above-mentioned damage and smoke emission will depend on the current capability of the power supply.
11. The protection circuit is for maintaining safety against abnormal operation. Therefore, the protection circuit should not work during normal operation.

    Especially for the thermal protection circuit, if the area of safe operation or the absolute maximum rating is momentarily exceeded due to output pin to VCC short (Power supply fault), or output pin to GND short (Ground fault), the LSI might be damaged before the thermal protection circuit could operate.

## USAGE NOTES (Continued)

12. Unless specified in the product specifications, make sure that negative voltage or excessive voltage are not applied to the pins because the device might be damaged, which could happen due to negative voltage or excessive voltage generated during the ON and OFF timing when the inductive load of a motor coil or actuator coils of optical pick-up is being driven.
13. The product which has specified ASO (Area of Safe Operation) should be operated in ASO
14. Verify the risks which might be caused by the malfunctions of external components.
15. Take time to check the characteristics on use. When changing an external circuit constant for use, consider not only static characteristics, but also transient characteristics and external parts with respect to the characteristics difference among ICs so that you can get enough margin. Moreover, consider the influence of electric charge remaining in an external capacitor on rising/falling of power supply.
16. Apply voltage from a low-impedance to power supply pins and connect a bypass capacitor to the LSI as near as possible.

## Revision History (Continued)

| Date | Revision | Description |
|---|---|---|
| 2022.2.1 | 1.08 | 1. initially issued. |

## 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.**