

## Low Power Analog Front End

### FEATURES

- Supply Voltage +2.4 to +3.6V
- Low Current Consumption 4 $\mu$ A (OPA, OPB), 150 $\mu$ A (ADC)
- Low Noise Amplifier 1.3 $\mu$ Vpp typ. (0.1 to 10Hz)
- Low Offset Voltage Amplifier 300 $\mu$ V max.
- RF immunity Amplifier
- Programmable Cell Bias Voltage
  - OPA: 0.3V to 1.7V (7 steps)
  - OPB: 0.25V to 1.75V (50mV step)
- Programmable Gain Pre-Amplifier 1V/V to 8V/V
- High resolution Programmable Gain ADC
  - 1V/V to 8V/V, 16-Bit (NFB), 32sps to 2k sps
- System Calibration for offset & gain drift
- Control external EEPROM as a Master device
- Ambient Operating Temperature -40°C to +85°C
- Interface I<sup>2</sup>C (3-Bit selectable slave address)
- Package EQFN-24-LE (4mm x 4mm)

### GENERAL DESCRIPTION

NJU9101 is a Low Power Analog Front End IC for use in micro-power sensing applications, especially electrochemical sensors. It provides a complete signal processing solution between sensor and micro-processor as smart-sensor module.

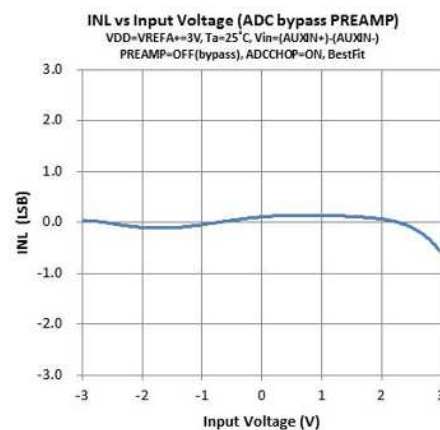
NJU9101 has 2 channel low power operational amplifiers. These amplifiers provide potentiostat and trans-impedance-amplifiers to constitute gas sensor systems. The NJU9101 has calibration circuit by using output data of built-in high precision ADC. It is suitable for temperature variation of sensor.

NJU9101 operates over voltage range of 2.4V to 3.6V. Total average current consumption can be less than 5 $\mu$ A.

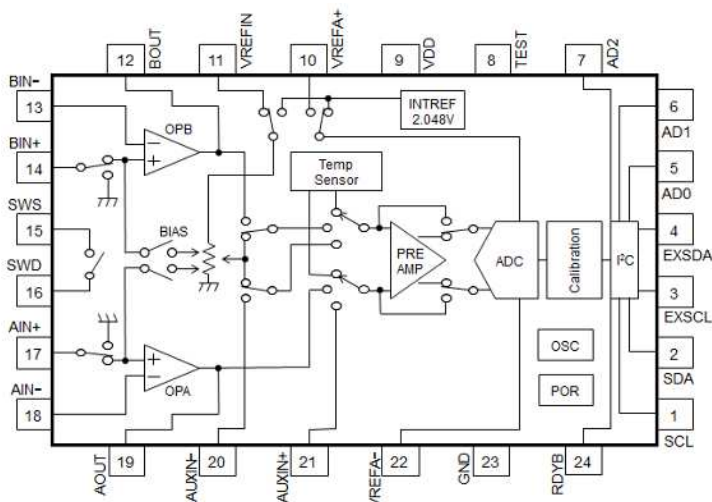
### APPLICATION

- Gas Monitor
- Blood Glucose Meter
- Current Sensing Systems
- Low Power Systems
- Photodiode Sensing Systems
- Portable equipment

### INL vs Input Voltage (ADC)

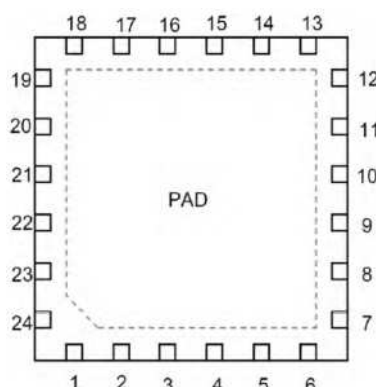


### EQUIVALENT CIRCUIT · BLOCK DIAGRAM



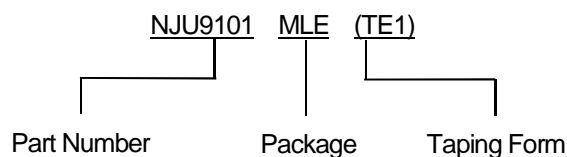
**■PIN CONFIGURATION**

EQFN-24-LE



| PIN NO. | SYMBOL | DESCRIPTION   |  | Pin Type               |
|---------|--------|---|--|------------------------|
| 1       | SCL    | I <sup>2</sup> C serial clock input   |  | Digital Input          |
| 2       | SDA    | I <sup>2</sup> C serial data input / output<br>(which requires an pull-up resistor)                     |  | Digital Input / Output |
| 3       | EXSCL  | I <sup>2</sup> C serial clock output for external EEPROM<br>(which requires an pull-up register)        |  | Digital Output         |
| 4       | EXSDA  | I <sup>2</sup> C serial data input / output for external EEPROM<br>(which requires an pull-up resistor) |  | Digital Input / Output |
| 5       | AD0    | Chip address selection input 0  | Select 7 chip address from “000” to “110”. Do not select address “111”, which address is for production test purpose | Digital Input          |
| 6       | AD1    | Chip address selection input 1  |  | Digital Input          |
| 7       | AD2    | Chip address selection input 2  |  | Digital Input          |
| 8       | TEST   | TEST terminal (This terminal is used for production test. Connect to VDD)                               |  | Analog Input           |
| 9       | VDD    | Voltage Supply  |  | Power Supply           |
| 10      | VREFA+ | Positive voltage reference input for ADC  |  | Analog Input           |
| 11      | VREFIN | Voltage reference input for Bias Register   |  | Analog Input           |
| 12      | BOUT   | Voltage output for Bch. OpAmp   |  | Analog Output          |
| 13      | BIN-   | Negative voltage input for Bch. OpAmp   |  | Analog Input           |
| 14      | BIN+   | Positive voltage input for Bch. OpAmp   |  | Analog Input           |
| 15      | SWS    | Switch Source Input 1   |  | Switich                |
| 16      | SWD    | Switch Drain Input 2  |  | Switich                |
| 17      | AIN+   | Positive voltage input for Ach. OpAmp   |  | Analog Input           |
| 18      | AIN-   | Negative voltage input for Ach. OpAmp   |  | Analog Input           |
| 19      | AOUT   | Voltage output for Ach. OpAmp   |  | Analog Output          |
| 20      | AUXIN- | Auxiliary positive input  |  | Analog Input           |
| 21      | AUXIN+ | Auxiliary negative input  |  | Analog Input           |
| 22      | VREFA- | Negative voltage reference input for ADC<br>(connect to GND, is recommended)                            |  | Analog Input           |
| 23      | GND    | GND   |  | GND                    |
| 24      | RDYB   | RDYB output / GPIO  |  | Digital Input / Output |
| PAD     | EXPPAD | Exposed PAD on backside (connect to GND)  |  | GND                    |

## ■MARK INFORMATION



## ■ORDERING INFORMATION

| PART NUMBER | PACKAGE OUTLINE | RoHS | HALOGEN-FREE | TERMINAL FINISH | MARKING | WEIGHT (mg) | MOQ(pcs) |
|-------------|-----------------|------|--------------|-----------------|---------|-------------|----------|
| NJU9101MLE  | EQFN-24-LE      | O    | O            | Sn-2Bi          | 9101    | 31          | 1,000    |

## ■ABSOLUTE MAXIMUM RATINGS

| PARAMETER  | SYMBOL    | RATINGS   | UNIT               |
|--|-----------|---|--------------------|
| Power Supply Voltage   | $V_{DD}$  | 5   | V                  |
| Analog Input Voltage <sup>(1)</sup>                          | $V_{IA}$  | -0.3 to $V_{DD}+0.3$ not exceeding 5                            | V                  |
| Digital Input Voltage  | $V_{ID}$  | -0.3 to 6   | V                  |
| Switch Input Voltage <sup>(1)</sup>                          | $V_{IS}$  | -0.3 to $V_{DD}+0.3$ not exceeding 5                            | V                  |
| On State Switch Current                                      | $I_{SO}$  | -40 to +40 <sup>(3)</sup>                                       | mA                 |
| Power Dissipation( $T_a=25^{\circ}\text{C}$ ) <sup>(2)</sup> | $P_D$     | 830 <sup>(4)</sup> / 2100 <sup>(5)</sup><br>(2-layer / 4-layer) | mW                 |
| Operating Temperature Range                                  | $T_{opr}$ | -40 to +85  | $^{\circ}\text{C}$ |
| Storage Temperature Range                                    | $T_{stg}$ | -40 to +150   | $^{\circ}\text{C}$ |

(1): The input pins have clamp diodes to the power supply pins. Limit the input current to 10mA or less whenever input signals exceed the power supply rail by 0.3V.

(2): Power dissipation is the power that can be consumed by the IC at  $T_a=25^{\circ}\text{C}$ , and is the typical measured value based on JEDEC condition. When using the IC over  $T_a=25^{\circ}\text{C}$  subtract the value  $[\text{mW}/^{\circ}\text{C}] = P_D / T_{st} \text{ max.} - 25$  per temperature.

(3): Mounted on glass epoxy board.

(101.5×114.5×1.6mm: based on EIA/JEDEC standard, 2Layers FR-4, with Exposed Pad)

(4): Mounted on glass epoxy board.

(101.5×114.5×1.6mm: based on EIA/JEDEC standard, 4Layers FR-4, with Exposed Pad)

(For 4Layers: Applying 99.5×99.5mm inner Cu area and a thermal via hole to a board based on JEDEC standard JESD51-5)

## ■RECOMMENDED OPERATING CONDITIONS

| PARAMETER                   | SYMBOL    | RATINGS      | UNIT               |
|-----------------------------|-----------|--------------|--------------------|
| Power Supply Voltage        | $V_{DD}$  | +2.4 to +3.6 | V                  |
| Operating Temperature Range | $T_{opr}$ | -40 to +85   | $^{\circ}\text{C}$ |
| Storage Temperature Range   | $T_{stg}$ | -40 to +150  | $^{\circ}\text{C}$ |

# **■ELECTRICAL CHARACTERISTICS**

Unless otherwise specified, all limits ensured for  $T_a = 25^{\circ}\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$

| PARAMETER                       | SYMBOL                     | TEST CONDITION                          | MIN. | TYP.    | MAX.      | UNIT                           |
|---------------------------------|----------------------------|---|------|---------|-----------|--------------------------------|
| OPA, OPB                        |                            |   |      |         |           |                                |
| Input Offset Voltage            | $V_{IO}$                   | $V_{ICM} = V_{DD}/2$ , $R_s = 50\Omega$ | -    | -       | $\pm 300$ | $\mu\text{V}$                  |
| Input Offset Voltage Drift      | $\Delta V_{IO} / \Delta T$ |   | -    | $\pm 1$ | -         | $\mu\text{V}/^{\circ}\text{C}$ |
| Input Bias Current              | $I_B$                      |   | -    | 10      | -         | $\text{pA}$                    |
| Open Loop Gain                  | $A_V$                      |   | -    | 100     | -         | $\text{dB}$                    |
| Common Mode Rejection Ratio     | CMR                        | $V_{ICM} = \text{GND to } 2\text{V}$    | 65   | 80      | -         | $\text{dB}$                    |
| Common Mode Input Voltage Range | $V_{ICM}$                  | $\text{CMR} \geq 65\text{dB}$           | GND  | -       | 2         | $\text{V}$                     |
| Maximum Output Voltage          | $V_{OH}$                   | $I_{SOUCE} = 1\text{mA}$                | 2.8  | 2.85    | -         | $\text{V}$                     |
|                                 | $V_{OL}$                   | $I_{SINK} = 1\text{mA}$                 | -    | 0.15    | 0.2       | $\text{V}$                     |
| Gain Band Width                 | GBW                        |   | -    | 30      | -         | $\text{kHz}$                   |
| Slew Rate                       | SR                         |   | -    | 0.01    | -         | $\text{V}/\mu\text{s}$         |
| Equivalent Input Noise Voltage  | $e_n$                      | $f = 100\text{Hz}$ , $R_s = 50\Omega$   | -    | 50      | -         | $\text{nV}/\sqrt{\text{Hz}}$   |
|                                 |                            | $f = 0.1\text{Hz to } 10\text{Hz}$      | -    | 1.3     | -         | $\mu\text{V}_{pp}$             |

Unless otherwise specified, all limits ensured for  $T_a = 25^{\circ}\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$ , ADC reference Voltage = External

| PARAMETER                                  | SYMBOL                         | TEST CONDITION                   | MIN. | TYP.    | MAX.      | UNIT                           |
|--|--------------------------------|----------------------------------|------|---------|-----------|--------------------------------|
| OPA, OPB with BIASRES (Potentiostat)       |                                |                                  |      |         |           |                                |
| OPA referred to OPB Input Offset Voltage 1 | $V_{IO1A-B}$                   | OPA BIAS = 1V<br>OPB BIAS = 1V   | -    | -       | $\pm 0.6$ | $\text{mV}$                    |
| OPA referred to OPB Input Offset Drift 1   | $\Delta V_{IO1A-B} / \Delta T$ | OPA BIAS = 1V<br>OPB BIAS = 1V   | -    | $\pm 2$ | -         | $\mu\text{V}/^{\circ}\text{C}$ |
| OPA referred to OPB Input Offset Voltage 2 | $V_{IO2A-B}$                   | OPA BIAS = 1V<br>OPB BIAS = 0.7V | 295  | 300     | 305       | $\text{mV}$                    |
| OPA referred to OPB Input Offset Drift 2   | $\Delta V_{IO2A-B} / \Delta T$ | OPA BIAS = 1V<br>OPB BIAS = 0.7V | -    | $\pm 5$ | -         | $\mu\text{V}/^{\circ}\text{C}$ |
| OPA referred to OPB Input Offset Voltage 3 | $V_{IO3A-B}$                   | OPA BIAS = 1V<br>OPB BIAS = 1.6V | -605 | -600    | -595      | $\text{mV}$                    |
| OPA referred to OPB Input Offset Drift 3   | $\Delta V_{IO3A-B} / \Delta T$ | OPA BIAS = 1V<br>OPB BIAS = 1.6V | -    | $\pm 8$ | -         | $\mu\text{V}/^{\circ}\text{C}$ |

Unless otherwise specified, all limits ensured for  $T_a = 25^{\circ}\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$

| PARAMETER             | SYMBOL      | TEST CONDITION  | MIN. | TYP.    | MAX. | UNIT        |
|-----------------------|-------------|---|------|---------|------|-------------|
| Analog Switch (ANASW) |             |   |      |         |      |             |
| On State Resistance   | $R_{ON}$    | Analog Switch = ON<br>$I_{DS} = -10\text{mA}$   |      | 10      | 30   | $\Omega$    |
| Off Leakage Current   | $I_{LOFFD}$ | Analog Switch = OFF<br>$V_{SWS} = 2\text{V}/1\text{V}$ ,<br>$V_{SWD} = 1\text{V}/2\text{V}$ | -    | $\pm 1$ | -    | $\text{nA}$ |

Unless otherwise specified, all limits ensured for  $T_a = 25^\circ\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$ , Temperature Input Mode

| PARAMETER                      | SYMBOL     | TEST CONDITION                                   | MIN. | TYP.    | MAX.    | UNIT             |
|--------------------------------|------------|--|------|---------|---------|------------------|
| Temperature Sensor             |            |  |      |         |         |                  |
| Temperature Accuracy (Error) 1 | $T_{ACC1}$ | $T_a = 25^\circ\text{C}$                         | -    | $\pm 1$ | $\pm 5$ | $^\circ\text{C}$ |
| Temperature Accuracy (Error) 2 | $T_{ACC2}$ | $T_a = -40^\circ\text{C}$ to $+85^\circ\text{C}$ | -    | $\pm 3$ | -       | $^\circ\text{C}$ |
| Temperature Resolution         | $T_{RES}$  |  | -    | 0.25    | -       | $^\circ\text{C}$ |

Unless otherwise specified, all limits ensured for  $T_a = 25^\circ\text{C}$ ,  $V_{DD} = 3\text{V}$

| PARAMETER                  | SYMBOL                             | TEST CONDITION                                   | MIN.  | TYP.  | MAX.  | UNIT                  |
|----------------------------|------------------------------------|--|-------|-------|-------|-----------------------|
| Internal Reference         |                                    |  |       |       |       |                       |
| Internal Reference Voltage | $V_{IREF}$                         | $\pm 1\%$  | 2.028 | 2.048 | 2.068 | V                     |
| Internal Reference Drift   | $\frac{\Delta V_{IREF}}{\Delta T}$ | $T_a = -40^\circ\text{C}$ to $+85^\circ\text{C}$ | -     | 30    | -     | ppm/ $^\circ\text{C}$ |

Unless otherwise specified, all limits ensured for  $T_a = 25^\circ\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$ , Auxiliary Differential Input Mode

| PARAMETER                        | SYMBOL      | TEST CONDITION  | MIN.         | TYP.      | MAX.       | UNIT |
|----------------------------------|-------------|---|--------------|-----------|------------|------|
| PREAMP                           |             |   |              |           |            |      |
| PREAMP Gain Error                | $G_{ACCP}$  | PREAMP Gain = 1V/1V to 8V/V                                       | -            | $\pm 0.1$ | -          | %    |
| PREAMP Common Mode Rejection     | $CMR_{PRE}$ | PREAMP Gain = 1V/V<br>AUXIN+ = AUXIN- =<br>GND+0.05 to $V_{DD}-1$ | 70           | 90        | -          | dB   |
| PREAMP Common Mode Input Voltage | $V_{ICMP}$  | PREAMP Gain = 1V/V<br>$CMR_{PRE} \geq 70\text{dB}$                | GND<br>+0.05 | -         | $V_{CC}-1$ | V    |

Unless otherwise specified, all limits ensured for  $T_a = 25^\circ\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$ , Auxiliary Input Mode

ADC Chopping = ON, ADC Reference Voltage = External, ADC Gain = 1V/V, ADC Decimation Ratio = "320"

| PARAMETER                           | SYMBOL      | TEST CONDITION                               | MIN. | TYP.          | MAX.     | UNIT             |
|-------------------------------------|-------------|--|------|---------------|----------|------------------|
| ADC                                 |             |  |      |               |          |                  |
| Resolution                          | N           | No missing code <sup>(6)</sup>               | 16   | -             | -        | Bit              |
| Noise Free Bit                      | NFB         |  | -    | 16            | -        | Bit              |
| Conversion Time                     | DR          | See p.22<br>"ADC Conversion Time"            | -    | -             | -        | SPS              |
| Output Noise                        | $V_{nADC}$  | $V_{REFA+} = 3\text{V}$                      | -    | 13.9          | -        | $\mu\text{Vrms}$ |
| Integral Non Linearity              | INL         |  | -    | $\pm 1$       | -        | LSB              |
| Gain Error                          |             | ADC Gain = 1V/1V to 8V/1V                    | -    | $\pm 0.1$     | -        | %                |
| Offset Error                        |             | AUXIN+ = AUXIN- =<br>$V_{DD}/2$              | -    | $\pm 1$       | -        | LSB              |
| Differential Input Voltage Range    | $V_{IDADC}$ | $V_{REF} =$<br>$ (V_{REFA+}) - (V_{REFA-}) $ | -    | $\pm V_{REF}$ | -        | V                |
| ADC Common Mode Rejection           | $CMR_{ADC}$ | AUXIN+ = AUXIN- =<br>GND to $V_{DD}$         | 80   | 90            | -        | dB               |
| ADC Common Mode Input Voltage Range | $V_{ICADC}$ | $CMR_{ADC} \geq 80\text{dB}$                 | GND  | -             | $V_{DD}$ | V                |

(6) This Parameter is not production tested, please refer Typical Characteristics.

Unless otherwise specified, all limits ensured for  $T_a = 25^\circ\text{C}$ ,  $V_{DD} = V_{REFIN} = V_{REFA+} = 3\text{V}$

| PARAMETER          | SYMBOL     | TEST CONDITION                      | MIN. | TYP. | MAX. | UNIT          |
|--------------------|------------|-------------------------------------|------|------|------|---------------|
| Power Supply / OSC |            |                                     |      |      |      |               |
| Voltage Range      | $V_{DD}$   |                                     | 2.4  | -    | 3.6  | V             |
| Bias Resistance    | $R_{BIAS}$ |                                     | -    | 1.5  | -    | $M\Omega$     |
| Supply Current 1   | $I_{DD1}$  | All Circuit Block Off               | -    | 0.5  | 1    | $\mu\text{A}$ |
| Supply Current 2   | $I_{DD2}$  | OPA, OPB                            | -    | 4    | 5.5  | $\mu\text{A}$ |
| Supply Current 3   | $I_{DD3}$  | Internal Reference Voltage (2.048V) | -    | 31   | 40   | $\mu\text{A}$ |
| Supply Current 4   | $I_{DD4}$  | PREAMP                              | -    | 55   | 75   | $\mu\text{A}$ |
| Supply Current 5   | $I_{DD5}$  | ADC                                 | -    | 150  | 200  | $\mu\text{A}$ |
| OSC Frequency      | $f_{OSC}$  | $\pm 10\%$                          | 276  | 307  | 338  | kHz           |

## ■ CHARACTERISTICS OF I/O STAGES FOR I<sup>2</sup>C-BUS Compatible (SDA, SCL)

I<sup>2</sup>C BUS Load Conditions

STANDARD MODE: Pull up resistance 4kΩ (Connected to V<sub>DD</sub>), Load capacitance 200pF (Connected to GND)

FASE MODE: Pull up resistance 4kΩ (Connected to V<sub>DD</sub>), Load capacitance 50pF (Connected to GND)

| PARAMETER  | SYM<br>BOL      | Standard Mode      |      |                    | Fast Mode |      |      | UNIT |
|--|-----------------|--------------------|------|--------------------|-----------|------|------|------|
|  |                 | MIN.               | TYP. | MAX.               | MIN.      | TYP. | MAX. |      |
| Low Level Input Voltage  | V <sub>IL</sub> | 0.0                | -    | 0.3V <sub>DD</sub> | 0.0       | -    | 1.5  | V    |
| High Level Input Voltage   | V <sub>IH</sub> | 0.7V <sub>DD</sub> | -    | 5.5                | 2.7       | -    | 5.5  | V    |
| Low Level Output Voltage<br>(3mA at SDA pin)   | V <sub>OL</sub> | 0                  | -    | 0.4                | 0         | -    | 0.4  | V    |
| Input current each I/O pin with an input voltage<br>between 0.1V <sub>DD</sub> and 0.9V <sub>DD</sub> max. | I <sub>i</sub>  | -10                | -    | 10                 | -10       | -    | 10   | μA   |

## ■ CHARACTERISTICS OF BUS LINES (SDA, SCL) FOR I<sup>2</sup>C-BUS Compatible Devices

I<sup>2</sup>C BUS Load Conditions

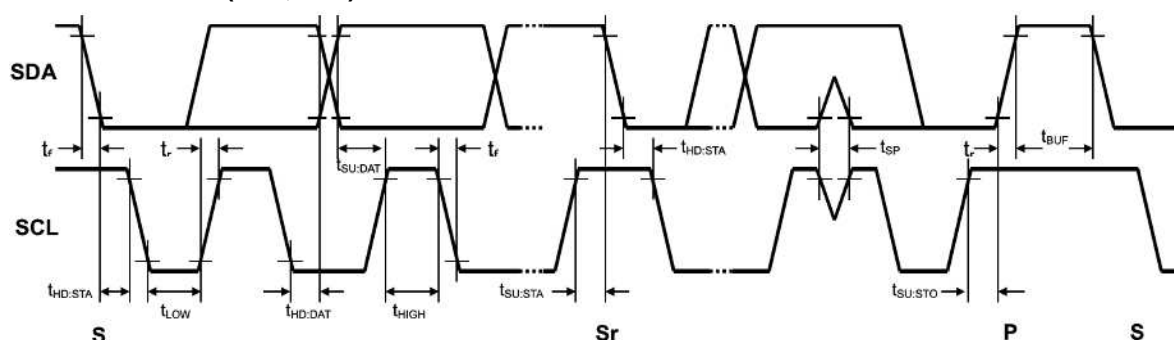
STANDARD MODE: Pull up resistance 4kΩ (Connected to V<sub>DD</sub>), Load capacitance 200pF (Connected to GND)

FASE MODE: Pull up resistance 4kΩ (Connected to V<sub>DD</sub>), Load capacitance 50pF (Connected to GND)

| PARAMETER   | SYM<br>BOL          | Standard Mode |      |      | Fast Mode |      |      | UNIT |
|---|---------------------|---------------|------|------|-----------|------|------|------|
|   |                     | MIN.          | TYP. | MAX. | MIN.      | TYP. | MAX. |      |
| SCL clock frequency                                 | f <sub>SCL</sub>    | 10            | -    | 100  | 10        | -    | 400  | kHz  |
| Hold time (repeated) START condition                | t <sub>HD:STA</sub> | 4.0           | -    | -    | 0.6       | -    | -    | μs   |
| Low period of the SCL clock                         | t <sub>LOW</sub>    | 4.7           | -    | -    | 1.3       | -    | -    | μs   |
| High period of the SCL clock                        | t <sub>HIGH</sub>   | 4.0           | -    | -    | 0.6       | -    | -    | μs   |
| Set-up time for a repeated START condition          | t <sub>SU:STA</sub> | 4.7           | -    | -    | 0.6       | -    | -    | μs   |
| Data hold time                                      | t <sub>HD:DAT</sub> | 0             | -    | -    | 0         | -    | -    | μs   |
| Data set-up time                                    | t <sub>SU:DAT</sub> | 250           | -    | -    | 100       | -    | -    | ns   |
| Rise time of both SDA and SCL signals               | t <sub>r</sub>      | -             | -    | 1000 | -         | -    | 300  | ns   |
| Fall time of both SDA and SCL signals               | t <sub>f</sub>      | -             | -    | 300  | -         | -    | 300  | ns   |
| Set-up time for STOP condition                      | t <sub>SU:STO</sub> | 4.0           | -    | -    | 0.6       | -    | -    | μs   |
| Bus free time between a STOP<br>and START condition | t <sub>BUF</sub>    | 4.7           | -    | -    | 1.3       | -    | -    | μs   |
| Capacitive load for each bus line                   | C <sub>b</sub>      | -             | -    | 400  | -         | -    | 400  | pF   |
| Noise margin at the Low Level                       | V <sub>nL</sub>     | 0.5           | -    | -    | 0.5       | -    | -    | V    |
| Noise margin at the High Level                      | V <sub>nH</sub>     | 1             | -    | -    | 1         | -    | -    | V    |

C<sub>b</sub>: Total capacitance of one bus line in pF.

## ■ TIMING ON THE I<sup>2</sup>C BUS (SDA, SCL)



## ■ CHARACTERISTICS OF I/O STAGES FOR EEPROM I<sup>2</sup>C-BUS (EXSDA, EXSCL)

I<sup>2</sup>C BUS Load Conditions

Pull up resistance 4k $\Omega$  (Connected to V<sub>DD</sub>), Load capacitance 50pF (Connected to GND)

| PARAMETER  | SYMBOL          | MIN.               | TYP. | MAX.               | UNIT    |
|--|-----------------|--------------------|------|--------------------|---------|
| Low Level Input Voltage  | V <sub>IL</sub> | 0.0                | -    | 0.3V <sub>DD</sub> | V       |
| High Level Input Voltage   | V <sub>IH</sub> | 0.7V <sub>DD</sub> | -    | -                  | V       |
| Low Level Output Voltage<br>(3mA at SDA pin)   | V <sub>OL</sub> | 0                  | -    | 0.4                | V       |
| Input current each I/O pin with an input<br>voltage between 0.1V <sub>DD</sub> and 0.9V <sub>DD</sub> max. | I <sub>i</sub>  | -10                | -    | 10                 | $\mu$ A |

## ■ CHARACTERISTICS OF BUS LINES (EXSDA, EXSCL)

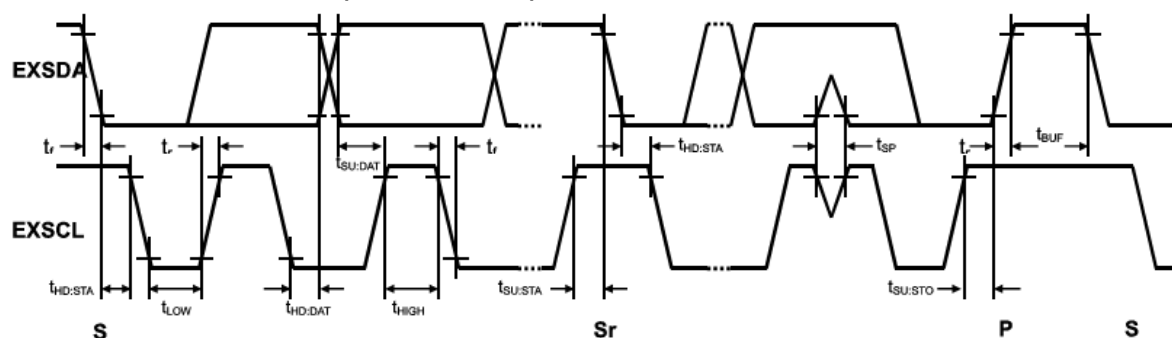
I<sup>2</sup>C BUS Load Conditions

Pull up resistance 4k $\Omega$  (Connected to V<sub>DD</sub>), Load capacitance 50pF (Connected to GND)

| PARAMETER   | SYMBOL              | MIN. | TYP.  | MAX.  | UNIT    |
|---|---------------------|------|-------|-------|---------|
| EXSCL clock frequency                               | f <sub>SCL</sub>    | 92   | 102.3 | 112.7 | kHz     |
| Hold time (repeat) START condition                  | t <sub>HD:STA</sub> | 7.2  | 6.5   | 5.9   | $\mu$ s |
| Low period of the EXSCL clock                       | t <sub>LOW</sub>    | 7.2  | 6.5   | 5.9   | $\mu$ s |
| High period of the EXSCL clock                      | t <sub>HIGH</sub>   | 3.6  | 3.3   | 3.0   | $\mu$ s |
| Set-up time for a repeated START<br>condition       | t <sub>SU:STA</sub> | 7.2  | 6.5   | 5.9   | $\mu$ s |
| Data hold time (EXSDA input)                        | t <sub>HD:DAT</sub> | 0    | -     | -     | $\mu$ s |
| Data hold time (EXSDA output)                       | t <sub>HD:DAT</sub> | 7.2  | 6.5   | 5.9   | $\mu$ s |
| Data Set-up time (EXSDA input)                      | t <sub>SU:DAT</sub> | 0    | -     | -     | $\mu$ s |
| Data Set-up time (EXSDA output)                     | t <sub>SU:DAT</sub> | 7.2  | 6.5   | 5.9   | $\mu$ s |
| Rise time of both SDA and SCL signals               | t <sub>r</sub>      | -    | -     | 300   | ns      |
| Fall time of SDA and SCL signals                    | t <sub>f</sub>      | -    | -     | 300   | ns      |
| Set-up time for STOP condition                      | t <sub>SU:STO</sub> | 7.2  | 6.5   | 5.9   | $\mu$ s |
| Bus free time between a STOP and<br>START condition | t <sub>BUF</sub>    | 7.2  | 6.5   | 5.9   | $\mu$ s |
| Capacitive load for each bus line                   | C <sub>b</sub>      | -    | -     | 400   | pF      |
| Noise margin at the Low level                       | V <sub>nL</sub>     | 0.5  | -     | -     | V       |
| Noise margin at the High level                      | V <sub>nH</sub>     | 1    | -     | -     | V       |

C<sub>b</sub>: total capacitance of one bus line in pF.

## ■ TIMING ON THE EEPROM I<sup>2</sup>C BUS (EXSDA, EXSCL)





## REGISTER DESCRIPTION

NJU9101 has register (list shown below) which can access it through I<sup>2</sup>C bus.

It can control the external EEPROM address corresponding to each register address from NJU9101.

| REGISTER ADDRESS | EEPROM ADDRESS | REGISTER NAME | BIT            |         |                |                |                |                |                |            |
|------------------|----------------|---------------|----------------|---------|----------------|----------------|----------------|----------------|----------------|------------|
|                  |                |               | D7             | D6      | D5             | D4             | D3             | D2             | D1             | D0         |
| 0x00             | -              | CTRL          | -              | RST     | SENSCK [1:0]   |                | MEAS           | MEAS_SEL [1:0] |                | MEAS_SC    |
| 0x01             | -              | STATUS        | -              | -       | BOOT           | CLKRUN         | RDYB           | OV             | CERR           | OFOV       |
| 0x02             | -              | AMPDATA0      | AMPDATA [15:8] |         |                |                |                |                |                |            |
| 0x03             | -              | AMPDATA1      | AMPDATA [7:0]  |         |                |                |                |                |                |            |
| 0x04             | -              | AUXDATA0      | AUXDATA [15:8] |         |                |                |                |                |                |            |
| 0x05             | -              | AUXDATA1      | AUXDATA [7:0]  |         |                |                |                |                |                |            |
| 0x06             | -              | TMPDATA0      | TMPDATA [9:2]  |         |                |                |                |                |                |            |
| 0x07             | -              | TMPDATA1      | TMPDATA [1:0]  |         | -              | -              | -              | -              | -              | -          |
| 0x08             | -              | ID            | ID [7:0]       |         |                |                |                |                |                |            |
| 0x09             | -              | ROMADR0       | -              | -       | -              | -              | -              | ROMADR [10:8]  |                |            |
| 0x0A             | -              | ROMADR1       | ROMADR [7:0]   |         |                |                |                |                |                |            |
| 0x0B             | -              | ROMDATA       | ROMDATA [7:0]  |         |                |                |                |                |                |            |
| 0x0C             | -              | ROMCTRL       | -              | -       | ROMERR         | ROMBUSY        | ROMSTOP        | ROMACT         | ROMMODE [1:0]  |            |
| 0x0D             | -              | TEST          | TEST [7:0]     |         |                |                |                |                |                |            |
| 0x0E             | 0x000          | ANAGAIN       | -              | -       | -              | -              | PRE_GAIN [1:0] |                | ADC_GAIN [1:0] |            |
| 0x0F             | 0x001          | BLKCONN0      | -              | -       | BIASSWA        | BIASSWB        | PRE_BIAS [3:0] |                |                |            |
| 0x10             | 0x002          | BLKCONN1      | OPA_BIAS [2:0] |         |                | OPB_BIAS [4:0] |                |                |                |            |
| 0x11             | 0x003          | BLKCONN2      | PREMODE        | INPSWA  | INPSWB         | ANASW          | BIASSWN        | PAMPSEL        | BIASSEL        | VREFSEL    |
| 0x12             | 0x004          | BLKCTRL       | BLKCTRL [7:0]  |         |                |                |                |                |                |            |
| 0x13             | 0x005          | ADCCONV       | -              | ADCCHOP | CLKDIV [1:0]   |                | REJ [1:0]      |                | OSR [1:0]      |            |
| 0x14             | 0x006          | SYSPRESET     | RDYBOE         | RDYBDAT | RDYBMODE [1:0] |                | -              | -              | -              | AMPAUX     |
| 0x15             | 0x007          | SCAL1A0       | -              | -       | -              | -              | -              | -              | -              | SCAL1A [8] |
| 0x16             | 0x008          | SCAL1A1       | SCAL1A [7:0]   |         |                |                |                |                |                |            |
| 0x17             | 0x009          | SCAL2A0       | -              | -       | -              | -              | -              | -              | -              | SCAL2A [8] |
| 0x18             | 0x00A          | SCAL2A1       | SCAL2A [7:0]   |         |                |                |                |                |                |            |
| 0x19             | 0x00B          | SCAL3A0       | -              | -       | -              | -              | -              | -              | -              | SCAL3A [8] |
| 0x1A             | 0x00C          | SCAL3A1       | SCAL3A [7:0]   |         |                |                |                |                |                |            |
| 0x1B             | 0x00D          | SCAL4A0       | -              | -       | -              | -              | -              | -              | -              | SCAL4A [8] |
| 0x1C             | 0x00E          | SCAL4A1       | SCAL4A [7:0]   |         |                |                |                |                |                |            |
| 0x1D             | 0x00F          | SCAL1B0       | SCAL1B [15:8]  |         |                |                |                |                |                |            |
| 0x1E             | 0x010          | SCAL1B1       | SCAL1B [7:0]   |         |                |                |                |                |                |            |
| 0x1F             | 0x011          | SCAL2B0       | SCAL2B [15:8]  |         |                |                |                |                |                |            |
| 0x20             | 0x012          | SCAL2B1       | SCAL2B [7:0]   |         |                |                |                |                |                |            |
| 0x21             | 0x013          | SCAL3B0       | SCAL3B [15:8]  |         |                |                |                |                |                |            |
| 0x22             | 0x014          | SCAL3B1       | SCAL3B [7:0]   |         |                |                |                |                |                |            |
| 0x23             | 0x015          | SCAL4B0       | SCAL4B [15:8]  |         |                |                |                |                |                |            |
| 0x24             | 0x016          | SCAL4B1       | SCAL4B [7:0]   |         |                |                |                |                |                |            |
| 0x25             | 0x017          | OCAL1A0       | -              | -       | -              | -              | -              | -              | OCAL1A [9:8]   |            |
| 0x26             | 0x018          | OCAL1A1       | OCAL1A [7:0]   |         |                |                |                |                |                |            |

|      |       |          |                 |               |   |   |   |   |              |
|------|-------|----------|-----------------|---------------|---|---|---|---|--------------|
| 0x27 | 0x019 | OCAL2A0  | -               | -             | - | - | - | - | OCAL2A [9:8] |
| 0x28 | 0x01A | OCAL2A1  | OCAL2A [7:0]    |               |   |   |   |   |              |
| 0x29 | 0x01B | OCAL3A0  | -               | -             | - | - | - | - | OCAL3A [9:8] |
| 0x2A | 0x01C | OCAL3A1  | OCAL3A [7:0]    |               |   |   |   |   |              |
| 0x2B | 0x01D | OCAL4A0  | -               | -             | - | - | - | - | OCAL4A [9:8] |
| 0x2C | 0x01E | OCAL4A1  | OCAL4A [7:0]    |               |   |   |   |   |              |
| 0x2D | 0x01F | OCAL1B0  | -               | OCAL1B [14:8] |   |   |   |   |              |
| 0x2E | 0x020 | OCAL1B1  | OCAL1B [7:0]    |               |   |   |   |   |              |
| 0x2F | 0x021 | OCAL2B0  | -               | OCAL2B [14:8] |   |   |   |   |              |
| 0x30 | 0x022 | OCAL2B1  | OCAL2B [7:0]    |               |   |   |   |   |              |
| 0x31 | 0x023 | OCAL3B0  | -               | OCAL3B [14:8] |   |   |   |   |              |
| 0x32 | 0x024 | OCAL3B1  | OCAL3B [7:0]    |               |   |   |   |   |              |
| 0x33 | 0x025 | OCAL4B0  | -               | OCAL4B [14:8] |   |   |   |   |              |
| 0x34 | 0x026 | OCAL4B1  | OCAL4B [7:0]    |               |   |   |   |   |              |
| 0x35 | 0x027 | SCAL1    | SCAL1 [7:0]     |               |   |   |   |   |              |
| 0x36 | 0x028 | SCAL2    | SCAL2 [7:0]     |               |   |   |   |   |              |
| 0x37 | 0x029 | SCAL3    | SCAL3 [7:0]     |               |   |   |   |   |              |
| 0x38 | 0x02A | OCAL1    | OCAL1 [7:0]     |               |   |   |   |   |              |
| 0x39 | 0x02B | OCAL2    | OCAL2 [7:0]     |               |   |   |   |   |              |
| 0x3A | 0x02C | OCAL3    | OCAL3 [7:0]     |               |   |   |   |   |              |
| 0x3B | 0x02D | AUXSCAL0 | AUX_SCAL [15:8] |               |   |   |   |   |              |
| 0x3C | 0x02E | AUXSCAL1 | AUX_SCAL [7:0]  |               |   |   |   |   |              |
| 0x3D | 0x02F | AUXOCAL0 | AUX_OCAL [15:8] |               |   |   |   |   |              |
| 0x3E | 0x030 | AUXOCAL1 | AUX_OCAL [7:0]  |               |   |   |   |   |              |
| 0x3F | -     | CHKSUM   | CHKSUM [7:0]    |               |   |   |   |   |              |

## ■EVERY REGISTER DESCRIPTION

### CTRL Register

Register Address: 0x00, EEPROM Address: -

| CTRL     |     |     |              |     |      |                |     |         |
|----------|-----|-----|--------------|-----|------|----------------|-----|---------|
| BIT      | [7] | [6] | [5]          | [4] | [3]  | [2]            | [1] | [0]     |
| BIT NAME | -   | RST | SENSCK [1:0] |     | MEAS | MEAS_SEL [1:0] |     | MEAS_SC |
| R / W    | -   | WS  | RW           |     | RW   | RW             |     | RW      |
| RESET    | -   | -   | 0x0          |     | 0    | 0x0            |     | 0       |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [6]   | RST      | <p>Write Software Reset.<br/>When read this bit, always return "0".</p> <p>0: No effect<br/>1: Reset</p>   |
| [5:4] | SENSCK   | <p>Change offset voltage of OPB to check sensor diagnostic.</p> <p>00: OFF (No change)<br/>01: Plus Offset (Change Offset Voltage <math>\approx</math> +5.0mV)<br/>10: Minus Offset (Change Offset Voltage <math>\approx</math> -5.0mV)<br/>11: Reserve</p>  |
| [3]   | MEAS     | <p>Measurement Switch<br/>When write "1", ADC conversion starts.<br/>When read this bit, returns "1" in case of under conversion, "0" in case of idle condition.<br/>When select "Single Conversion" mode, this bit is set to "0" automatically after conversion completion. When select "Continuous Conversion" mode and write "0", ADC conversion stop and return to an idol state.</p> <p>0: Measurement OFF<br/>(Operating condition of this chip follows "BLKCTRL" condition)<br/>1: Measurement ON</p> |
| [2:1] | MEAS_SEL | <p>Measurement Mode Selection.</p> <p>00: Temperature sensor input mode<br/>01: Amplifier input mode<br/>10: Auxiliary input mode<br/>11: Reserve</p>  |
| [0]   | MEAS_SC  | <p>Measurement Mode for ADC</p> <p>0: Single Conversion<br/>1: Continuous Conversion</p>   |

## STATUS Register

Register Address: 0x01, EEPROM Address: -

| STATUS   |     |     |      |        |      |     |      |      |
|----------|-----|-----|------|--------|------|-----|------|------|
| BIT      | [7] | [6] | [5]  | [4]    | [3]  | [2] | [1]  | [0]  |
| BIT NAME | -   | -   | BOOT | CLKRUN | RDYB | OV  | CERR | OFOV |
| R/W      | -   | -   | R    | R      | R    | R   | R    | R    |
| RESET    | -   | -   | 1    | -      | 1    | 0   | 0    | 0    |

| BIT | BIT NAME | FUNCTION   |
|-----|----------|--|
| [5] | BOOT     | <p>Booting flag for IC.<br/>NJU9101 reads initial register value from external EEPROM as booting.<br/>This bit returns "1" until the reading of the initial register value is completed from start.</p> <p>0: Completion of booting<br/>1: Under booting</p>   |
| [4] | CLKRUN   | <p>System Clock Condition.</p> <p>0: System Clock is sleeping<br/>1: System Clock is operating</p>   |
| [3] | RDYB     | <p>Data Ready Flag. When conversion data is updated, this bit is cleared to "0".<br/>When either "AMPDATA0", "AUXDATA0", or "TMPDATA" is read, this bit is set to "1".</p> <p>0: New ADC data is ready<br/>1: New ADC data is not ready</p>  |
| [2] | OV       | <p>Overflow flag in sensitivity calibration of ADC output data.<br/>When over flow is occurred in sensitivity calibration of ADC conversion data, this bit is set to "1". When this bit is "1", ADC output data ("AMPDATA" or "AUXDATA") is set to 0x7FFF (positive over flow) or 0x8000 (negative over flow). When either "AMPDATA0", "AUXDATA0", or "TMPDATA" is read, this bit is cleared to "0".</p> <p>0: ADC conversion data is valid<br/>1: ADC conversion data is over flow (set 0x7FFF or 0x8000)</p> |
| [1] | CERR     | <p>Overflow flag in calibration coefficient data.<br/>When over flow is occurred in setting of calibration coefficient data, this bit is set to "1". In case of "1", ADC output data is invalid value.<br/>When either "AMPDATA0", "AUXDATA0" or "TMPDATA" is read, this bit is cleared to "0".</p> <p>0: No overflow in calibration coefficient calculation<br/>1: Overflow in calibration coefficient calculation (Output data is invalid)</p>   |
| [0] | OFOV     | <p>Overflow flag in offset calibration of ADC output data.<br/>When over flow is occurred in offset calibration of ADC conversion data, this bit is set to "1". In case of "1", ADC output data is invalid value.<br/>When either "AMPDATA0", "AUXDATA0" or "TMPDATA" is read, this bit is cleared to "0".</p> <p>0: No overflow in offset calibration data<br/>1: Overflow in offset calibration data (Output data is invalid)</p>  |

**AMPDATA0 / AMPDATA1 Register**

Register Address: 0x02 / 0x03, EEPROM Address: -

|          | AMPDATA0               |     |     |     |     |     |     |     | AMPDATA1               |     |     |     |     |     |     |     |
|----------|------------------------|-----|-----|-----|-----|-----|-----|-----|------------------------|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x02 |     |     |     |     |     |     |     | Register Address: 0x03 |     |     |     |     |     |     |     |
| BIT      | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | AMPDATA [15:0]         |     |     |     |     |     |     |     |                        |     |     |     |     |     |     |     |
| R / W    | R                      |     |     |     |     |     |     |     |                        |     |     |     |     |     |     |     |
| RESET    | -                      |     |     |     |     |     |     |     |                        |     |     |     |     |     |     |     |

| BIT                                   | BIT NAME      | FUNCTION  |
|---------------------------------------|---------------|---|
| AMPDATA0 [7:0]<br>+<br>AMPDATA1 [7:0] | AMPDATA[15:0] | ADC output data register for amplifier input mode.<br>Signed 16-Bit data. |

**AUXDATA0 / AUXDATA1 Register**

Register Address: 0x04 / 0x05, EEPROM Address: -

|          | AUXDATA0               |     |     |     |     |     |     |     | AUXDATA1               |     |     |     |     |     |     |     |
|----------|------------------------|-----|-----|-----|-----|-----|-----|-----|------------------------|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x04 |     |     |     |     |     |     |     | Register Address: 0x05 |     |     |     |     |     |     |     |
| BIT      | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | AUXDATA [15:0]         |     |     |     |     |     |     |     |                        |     |     |     |     |     |     |     |
| R / W    | R                      |     |     |     |     |     |     |     |                        |     |     |     |     |     |     |     |
| RESET    | -                      |     |     |     |     |     |     |     |                        |     |     |     |     |     |     |     |

| BIT                                   | BIT NAME      | FUNCTION  |
|---------------------------------------|---------------|---|
| AUXDATA0 [7:0]<br>+<br>AUXDATA1 [7:0] | AUXDATA[15:0] | ADC output data register for Auxiliary input mode.<br>Signed 16-Bit data. |

**TMPDATA0 / TMPDATA1 Register**

Register Address: 0x06 / 0x07, EEPROM Address: -

|          | TMPDATA0               |     |     |     |     |     |     |     | TMPDATA1               |     |     |     |     |     |     |     |
|----------|------------------------|-----|-----|-----|-----|-----|-----|-----|------------------------|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x06 |     |     |     |     |     |     |     | Register Address: 0x07 |     |     |     |     |     |     |     |
| BIT      | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | TMPDATA [9:0]          |     |     |     |     |     |     |     | -                      | -   | -   | -   | -   | -   | -   | -   |
| R / W    | R/W                    |     |     |     |     |     |     |     | -                      | -   | -   | -   | -   | -   | -   | -   |
| RESET    | -                      |     |     |     |     |     |     |     | -                      | -   | -   | -   | -   | -   | -   | -   |

| ビット                                   | ビット名         | 機能   |
|---------------------------------------|--------------|--|
| TMPDATA0 [7:0]<br>+<br>TMPDATA1 [7:6] | TMPDATA[9:0] | ADC output data register for Temperature sensor input mode.<br>Signed 8.2 fixed point format. (-45°C to +127.75°C)<br>Temperature calibration calculation is executed by value of TMPDATA.<br>When calibration is executed by using external temperature sensor, write data which getting from external temperature sensor to this register. |

## ID Register

Register Address: 0x08, EEPROM Address: -

| ID       |          |     |     |     |     |     |     |     |
|----------|----------|-----|-----|-----|-----|-----|-----|-----|
| BIT      | [7]      | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | ID [7:0] |     |     |     |     |     |     |     |
| R / W    | R        |     |     |     |     |     |     |     |
| RESET    | 0x55     |     |     |     |     |     |     |     |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [7:0] | ID       | Fixed value "0x55" is stored as a chip identification code in this register. |

## ROMADR0 / ROMADR1 Register

Register Address: 0x09 / 0x0A, EEPROM Address: -

|          | ROMADR0                |     |     |     |     |               |     |     | ROMADR1                |     |     |     |     |     |     |     |
|----------|------------------------|-----|-----|-----|-----|---------------|-----|-----|------------------------|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x09 |     |     |     |     |               |     |     | Register Address: 0x0A |     |     |     |     |     |     |     |
| BIT      | [7]                    | [6] | [5] | [4] | [3] | [2]           | [1] | [0] | [7]                    | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | -                      | -   | -   | -   | -   | ROMADR [10:0] |     |     |                        |     |     |     |     |     |     |     |
| R / W    | -                      | -   | -   | -   | -   | RW            |     |     |                        |     |     |     |     |     |     |     |
| RESET    | -                      | -   | -   | -   | -   | 0x0           |     |     |                        |     |     |     |     |     |     |     |

| ビット                                 | ビット名         | 機能  |
|-------------------------------------|--------------|---|
| ROMADR0 [2:0]<br>+<br>ROMADR1 [7:0] | ROMADR[10:0] | This is EEPROM address selection register that read/write from/to EEPROM. |

\*Be sure to set ROMADR0[4:3] = "00" to control EEPROM.

## ROMDATA Register

Register Address: 0x0B, EEPROM Address: -

| ROMDATA  |               |     |     |     |     |     |     |     |
|----------|---------------|-----|-----|-----|-----|-----|-----|-----|
| BIT      | [7]           | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | ROMDATA [7:0] |     |     |     |     |     |     |     |
| R / W    | RW            |     |     |     |     |     |     |     |
| RESET    | 0x00          |     |     |     |     |     |     |     |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [7:0] | ROMDATA  | In read mode, return a reading data from EEPROM.<br>In write mode, set a writing data to EEPROM. |

\*Be sure to set ROMADR0[4:3] = "00" to control EEPROM.

## ROMCTL Register

Register Address: 0x0C, EEPROM Address: -

| ROMCTL   |     |     |        |         |         |        |               |
|----------|-----|-----|--------|---------|---------|--------|---------------|
| BIT      | [7] | [6] | [5]    | [4]     | [3]     | [2]    | [1] [0]       |
| BIT NAME | -   | -   | ROMERR | ROMBUSY | ROMSTOP | ROMACT | ROMMODE [1:0] |
| R / W    | -   | -   | RC     | R       | WS      | WS     | W             |
| RESET    | -   | -   | -      | -       | 0x0     | 0x0    | 0x0           |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [5]   | ROMERR   | <p>When I<sup>2</sup>C bus communication error occurs during accessing to external EEPROM, this bit is set to "1". It is communication error in the following cases,</p> <ol style="list-style-type: none"> <li>1) When NJU9101 outputs address, data, acknowledged data, it receives the EXSDA data different from the EXSDA data which outputs.</li> <li>2) NJU9101 receives NACK response in the timing which it is expected to receive ACK response.</li> </ol> <p>And, It is cleared to "0" when this bit is written in "1".</p> <p>0: I2C communication is not error<br/>1: I2C communication is error</p> |
| [4]   | ROMBUSY  | <p>This bit shows accessing status to external EEPROM.</p> <p>0: Completion of the access<br/>1: Under accessing</p>   |
| [3]   | ROMSTOP  | <p>When write "1" to "ROMSTOP" bit, stop accessing to external EEPROM. "ROMBUSY" bit is cleared to "0" immediately. When it stops accessing during writing to external EEPROM, ROM data is not guaranteed. In the read mode, this bit always returns "0".</p> <p>1: stop accessing to external EEPROM</p>  |
| [2]   | ROMACT   | <p>When write "1" to ROMACT bit, start accessing to external EEPROM with following "ROMMODE[1:0]" data. In write "0" case, it is not started accessing.</p> <p>And, to start accessing to external EEPROM, it is necessary that it is not accessing timing to external EEPROM ("ROMBUSY" bit = "0"), and system clock is during operation ("CLKRUN" bit = "1"). In the read mode, this bit always returns "0".</p> <p>1: start accessing to external EEPROM</p>  |
| [1:0] | ROMMODE  | <p>Write operation for external EEPROM. In the read mode, this bit returns "0".</p> <p>00: Read one byte data from external EEPROM (address ROMADR[10:0]), and, store this one byte data to ROMDATA[7:0] bit register in NJU9101.</p> <p>01: Write ROMDATA[7:0] bit data to register in external EEPROM which is assigned by ROMADR[10:0] address.</p> <p>10: Load external EEPROM data to Host-register (ex. MPU)</p> <p>11: Store Host-register setting (ex. MPU) into external EEPROM data.</p>   |

\*Be sure to set ROMADR0[4:3] = "00" to control EEPROM.

## TEST Register

Register Address: 0x0D, EEPROM Address: -

| TEST     |            |     |     |     |     |     |     |     |
|----------|------------|-----|-----|-----|-----|-----|-----|-----|
| BIT      | [7]        | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | TEST [7:0] |     |     |     |     |     |     |     |
| R / W    | RW         |     |     |     |     |     |     |     |
| RESET    | 0x00       |     |     |     |     |     |     |     |

\*This register is for production test purpose. Do not write data to this register.

## ANAGAIN Register

Register Address: 0x0E, EEPROM Address: 0x000

| ANAGAIN  |     |     |     |     |                |     |                |     |
|----------|-----|-----|-----|-----|----------------|-----|----------------|-----|
| BIT      | [7] | [6] | [5] | [4] | [3]            | [2] | [1]            | [0] |
| BIT NAME | -   | -   | -   | -   | PRE_GAIN [1:0] |     | ADC_GAIN [1:0] |     |
| R / W    | -   | -   | -   | -   | RW             |     | RW             |     |
| RESET    | -   | -   | -   | -   | 0x0            |     | 0x0            |     |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [3:2] | PRE_GAIN | Pre-amplifier gain selection<br>00: 1 V/V<br>01: 2 V/V<br>10: 4 V/V<br>11: 8 V/V                 |
| [1:0] | ADC_GAIN | Programmable-gain-amplifier in ADC selection<br>00: 1 V/V<br>01: 2 V/V<br>10: 4 V/V<br>11: 8 V/V |



## BLKCONN0 Register

Register Address: 0x0F, EEPROM Address: 0x001

| BLKCONN0 |     |     |         |         |                |     |     |     |
|----------|-----|-----|---------|---------|----------------|-----|-----|-----|
| BIT      | [7] | [6] | [5]     | [4]     | [3]            | [2] | [1] | [0] |
| BIT NAME | -   | -   | BIASSWA | BIASSWB | PRE_BIAS [3:0] |     |     |     |
| R / W    | -   | -   | RW      | RW      | RW             |     |     |     |
| RESET    | -   | -   | 0x0     | 0x0     | 0x0            |     |     |     |

| BIT   | BIT NAME | FUNCTION  |
|-------|----------|---|
| [5]   | BIASSWA  | <p>This is Switch for connecting "BIASRES" and "OPA positive input"</p> <p>00: Open "BIASRES" and "OPA positive input"</p> <p>01: Connect "BIASRES" and "OPA positive input"</p>  |
| [4]   | BIASSWB  | <p>This is Switch for connecting "BIASRES" and "OPB positive input"</p> <p>00: Open "BIASRES" and "OPB positive input"</p> <p>01: Connect "BIASRES" and "OPB positive input"</p>  |
| [3:0] | PRE_BIAS | <p>Negative input bias level for PREAMP (From 0.3V to 1.7V are 100mV steps)<br/>This bias level is set by "BIASRES" Circuit Block.</p> <p><math>V_{REFIN} = 3V</math> or at INTVREF(2.048V) as follows</p> <p>0000: GND</p> <p>0001: 0.3V</p> <p>0010: 0.4V</p> <p>0011: 0.5V</p> <p>:</p> <p>:</p> <p>1101: 1.5V</p> <p>1110: 1.6V</p> <p>1111: 1.7V</p> |

## BLKCONN1 Register

Register Address: 0x10, EEPROM Address: 0x002

| BLKCONN1 |                |     |     |                |     |     |     |     |
|----------|----------------|-----|-----|----------------|-----|-----|-----|-----|
| BIT      | [7]            | [6] | [5] | [4]            | [3] | [2] | [1] | [0] |
| BIT NAME | OPA_BIAS [2:0] |     |     | OPB_BIAS [4:0] |     |     |     |     |
| R/W      | RW             |     |     | RW             |     |     |     |     |
| RESET    | 0x0            |     |     | 0x0            |     |     |     |     |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [7:5] | OPA_BIAS | <p>Bias Level for OPA, This bias level is set by "BIASRES" Block.</p> <p><math>V_{REFIN} = 3V</math> or at INTVREF(2.048V) as follows</p> <p>000: GND</p> <p>001: 0.3V</p> <p>010: 0.5V</p> <p>011: 0.7V</p> <p>100: 1.0V</p> <p>101: 1.3V</p> <p>110: 1.5V</p> <p>111: 1.7V</p>     |
| [4:0] | OPB_BIAS | <p>Bias Level for OPB (From 0.25V to 1.75V are 50mV steps).</p> <p><math>V_{REFIN} = 3V</math> or at INTVREF(2.048V) as follows</p> <p>00000: GND</p> <p>00001: 0.25V</p> <p>00010: 0.3V</p> <p>00011: 0.35V</p> <p>:</p> <p>11101: 1.65V</p> <p>11110: 1.7V</p> <p>11111: 1.75V</p> |

## BLKCONN2 Register

Register Address: 0x11, EEPROM Address: 0x003

| BLKCONN2 |         |        |        |       |         |         |         |         |
|----------|---------|--------|--------|-------|---------|---------|---------|---------|
| BIT      | [7]     | [6]    | [5]    | [4]   | [3]     | [2]     | [1]     | [0]     |
| BIT NAME | PREMODE | INPSWA | INPSWB | ANASW | BIASSWN | PAMPSEL | BIASSEL | VREFSEL |
| R / W    | RW      | RW     | RW     | RW    | RW      | RW      | RW      | RW      |
| RESET    | 0x0     | 0x0    | 0x0    | 0x0   | 0x0     | 0x0     | 0x0     | 0x0     |

| BIT | BIT NAME | FUNCTION  |
|-----|----------|---|
| [7] | PREMODE  | Select PREAMP mode<br>0: Non-Inverted Amplifier mode<br>1: Instrumentation Amplifier mode   |
| [6] | INPSWA   | OPA positive input connection<br>0: GND Positive input is connected to GND.<br>1: AINP Positive input is connected to AINP Pin.                                 |
| [5] | INPSWB   | OPB positive input connection<br>0: GND Positive input is connected to GND.<br>1: BINP Positive input is connected to BINP Pin.                                 |
| [4] | ANASW    | Build in Analog Switch Status<br>0: Switch OFF<br>1: Switch ON On Resistance is 10Ω typ.<br>Absolute Maximum Input Current is ±50mA.                            |
| [3] | BIASSWN  | Select switch for PREAMP / ADC Negative Input at AMP / AUX input mode.<br>0: OPB Output / AUXIN-<br>1: BIASRES This is selectable bias level set by "PRE-BIAS". |
| [2] | PAMPSEL  | Enable / Disable PREAMP for signal path.<br>0: Disable (Bypass PREAMP)<br>1: Enable   |
| [1] | BIASSEL  | Reference Voltage selection for Bias Register<br>0: Internal Reference (2.048V)<br>1: External Reference  |
| [0] | VREFSEL  | Reference Voltage selection for ADC<br>0: Internal Reference (2.048V)<br>1: External Reference  |

## BLKCTRL Register

Register Address: 0x12, EEPROM Address: 0x004

| BLKCNT   |               |     |     |     |     |     |     |     |
|----------|---------------|-----|-----|-----|-----|-----|-----|-----|
| BIT      | [7]           | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | BLKCTRL [7:0] |     |     |     |     |     |     |     |
| R / W    | RW            |     |     |     |     |     |     |     |
| RESET    | 0x00          |     |     |     |     |     |     |     |

| BIT   | BIT NAME | FUNCTION  |
|-------|----------|---|
| [7:0] | BLKCTRL  | <p>Circuit Block Powered down selection.</p> <p>When ADC is in the idle state, circuit block which this bit is set to “0” is automatically powered down.</p> <p>The circuit block which this bit is set to “1” is kept powered on state even in case of ADC idle state. When all bits are “0”, NJU9101 goes “power down mode” except for Digital block.</p> <p>[7]: BIASRES block<br/>         [6]: OPB block<br/>         [5]: OPA block<br/>         [4]: OSC block<br/>         [3]: PREAMP block<br/>         [2]: INTVREF(2.048V) block<br/>         [1]: ADC block<br/>         [0]: Temperature Sensor block</p> |

## ADCCONV Register

Register Address: 0x13, EEPROM Address: 0x005

| ADCCONV  |     |         |              |     |           |     |           |     |
|----------|-----|---------|--------------|-----|-----------|-----|-----------|-----|
| BIT      | [7] | [6]     | [5]          | [4] | [3]       | [2] | [1]       | [0] |
| BIT NAME | -   | ADCCHOP | CLKDIV [1:0] |     | REJ [1:0] |     | OSR [1:0] |     |
| R / W    | -   | RW      | RW           |     | RW        |     | RW        |     |
| RESET    | -   | 0x0     | 0x0          |     | 0x0       |     | 0x0       |     |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [6]   | ADCCHOP  | <p>ADC CHOP Switch. It's effective in reducing offset Voltage of PREAMP and ADC.<br/>Reduce offset voltage by chopping input signal.<br/>When this bit is "1", conversion time becomes long.<br/>(ex. 16.2ms(ADCCHOP="0") -&gt; 31.1ms(ADCCHOP="1"))</p> <p>0: CHOP OFF<br/>1: CHOP ON</p>                               |
| [5:4] | CLKDIV   | <p>Select operation clock frequency for sigma-delta modulator. <math>f_{OSC}=307.2\text{kHz typ.}</math></p> <p>00: <math>f_{mod}=(1/2) \times f_{OSC}</math><br/>01: <math>f_{mod}=(1/4) \times f_{OSC}</math><br/>10: <math>f_{mod}=(1/8) \times f_{OSC}</math><br/>11: <math>f_{mod}=(1/16) \times f_{OSC}</math></p> |
| [3:2] | REJ      | <p>Select rejection mode for Sinc3 filter</p> <p>00: 50/60Hz Rejection<br/>01: 50Hz Rejection<br/>10: 60Hz Rejection<br/>11: Reserved</p>  |
| [1:0] | OSR      | <p>Select Decimation ratio for Sinc3 filter.<br/>Total Decimation Ratio is decided by REJ / OSC bits combination.</p>  |

ADC Decimation Ratio

| OSR [1:0] | REJ [1:0] |     |     |    |
|-----------|-----------|-----|-----|----|
|           | 00        | 01  | 10  | 11 |
| 00        | 768       | 768 | 640 | -  |
| 01        | 384       | 384 | 320 | -  |
| 10        | 192       | 192 | 160 | -  |
| 11        | 96        | 96  | 80  | -  |

ADC Conversion Time [ms]

| OSR [1:0] | REJ [1:0]         |      |      |    |          |      |      |    |                       |     |     |    |          |      |      |    |
|-----------|-------------------|------|------|----|----------|------|------|----|-----------------------|-----|-----|----|----------|------|------|----|
|           | 00                | 01   | 10   | 11 | 00       | 01   | 10   | 11 | 00                    | 01  | 10  | 11 | 00       | 01   | 10   | 11 |
| 00        | 16.2              | 16.2 | 13.7 | -  | 31.3     | 31.3 | 26.3 | -  | 5                     | 5   | 4.2 | -  | 15.3     | 15.3 | 12.8 | -  |
| 01        | 8.7               | 8.7  | 7.5  | -  | 16.3     | 16.3 | 13.8 | -  | 2.5                   | 2.5 | 2.1 | -  | 7.8      | 7.8  | 6.5  | -  |
| 10        | 5.0               | 5.0  | 4.3  | -  | 8.8      | 8.8  | 7.6  | -  | 1.3                   | 1.3 | 1.0 | -  | 4.0      | 4.0  | 3.4  | -  |
| 11        | 3.1               | 3.1  | 2.8  | -  | 5.1      | 5.1  | 4.5  | -  | 0.6                   | 0.6 | 0.5 | -  | 2.1      | 2.1  | 1.8  | -  |
| State     | Single Conversion |      |      |    |          |      |      |    | Continuous Conversion |     |     |    |          |      |      |    |
|           | CHOP: OFF         |      |      |    | CHOP: ON |      |      |    | CHOP: OFF             |     |     |    | CHOP: ON |      |      |    |

Conversion Time vs Resolution (ADC)

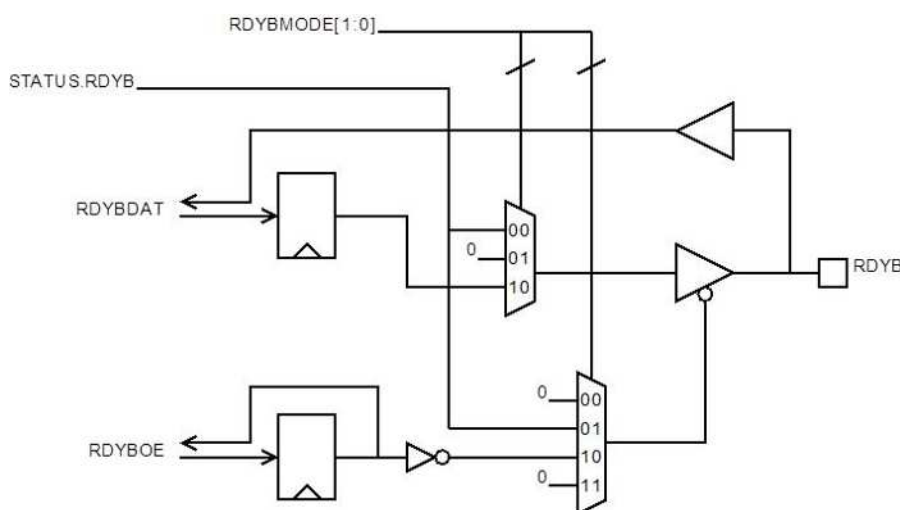
| ADC Conversion Time | CHOP: ON  |             |             |             | CHOP: OFF |             |             |             |
|---------------------|-----------|-------------|-------------|-------------|-----------|-------------|-------------|-------------|
|                     | ADC Gain  |             |             |             | ADC Gain  |             |             |             |
|                     | 1V/V      | 2V/V        | 4 V/V       | 8 V/V       | 1 V/V     | 2 V/V       | 4 V/V       | 8 V/V       |
| 26.3ms              | 16 / (16) | 16 / (16)   | 16 / (16)   | 16 / (16)   | 16 / (16) | 16 / (16)   | 15.6 / (16) | 15.3 / (16) |
| 13.8ms              | 16 / (16) | 16 / (16)   | 15.2 / (16) | 16 / (16)   | 16 / (16) | 16 / (16)   | 15 / (16)   | 14.8 / (16) |
| 7.6ms               | 15 / (16) | 14.7 / (16) | 14.5 / (16) | 14 / (16)   | 15 / (16) | 14.7 / (16) | 14.1 / (16) | 13.5 / (16) |
| 4.5ms               | 14 / (16) | 14 / (16)   | 13.5 / (16) | 12 / (14.7) | 14 / (16) | 14 / (16)   | 13.6 / (16) | 12 / (14.7) |

Noise Free Bit / (Effective Number of Bits), Unit: bit

Register Address: 0x14, EEPROM Address: 0x006

| SYSPRESET |        |         |                |     |     |     |     |        |
|-----------|--------|---------|----------------|-----|-----|-----|-----|--------|
| BIT       | [7]    | [6]     | [5]            | [4] | [3] | [2] | [1] | [0]    |
| BIT NAME  | RDYBOE | RDYBDAT | RDYBMODE [1:0] |     | -   | -   | -   | AMPAUX |
| R / W     | RW     | RW      | RW             |     | -   | -   | -   | RW     |
| RESET     | 0x0    | -       | 0x1            |     | -   | -   | -   | 0x0    |

| BIT   | BIT NAME | FUNCTION   |
|-------|----------|--|
| [7]   | RDYBOE   | RDYB terminal direction of GPIO mode<br>0: RDYB terminal is input mode<br>1: RDYB terminal is Output mode  |
| [6]   | RDYBDAT  | Return RDYB terminal level in input mode.<br>Store RDYB terminal level in Output mode.   |
| [5:4] | RDYBMODE | Select function of RDYB terminal<br><br>00: RDYB terminal outputs “RDYB” bit in STATUS register.<br>01: RDYB terminal outputs “RDYB” bit in STATUS register.<br>with open-drain circuit style.<br>10: RDYB terminal is used as GPIO.<br>Output condition is set by “RDYBDAT” and “RDYBOE”.<br>11: Reserved |
| [0]   | AMPAUX   | Select Calibration channel coefficient assignment.<br><br>0: AMPDATA uses SCAL/OCAL calibration coefficient.<br>AUXDATA uses AUX_SCAL / AUX_OCAL calibration coefficient.<br>1: AMPDATA uses AUX_SCAL / AUX_OCAL calibration coefficient.<br>AUXDATA uses SCAL/OCAL calibration coefficient.               |



## SCALxA0 / SCALxA1 Register

Register Address: 0x15 to 0x1C, EEPROM Address: 0x007 to 0x00E

|          | SCALxA0 (x=1 to 4)   |     |     |     |     |     |     |     | SCALxA1 (x=1 to 4)   |     |     |     |     |     |     |     |
|----------|--|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x15, 0x17, 0x19, 0x1B<br>EEPROM Address: 0x007, 0x009, 0x00B, 0x00D |     |     |     |     |     |     |     | Register Address: 0x16, 0x18, 0x1A, 0x1C<br>EEPROM Address: 0x008, 0x00A, 0x00C, 0x00E |     |     |     |     |     |     |     |
| BIT      | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | -  | -   | -   | -   | -   | -   | -   | -   | SCALxA [8:0]   |     |     |     |     |     |     |     |
| R / W    | -  | -   | -   | -   | -   | -   | -   | -   | RW   |     |     |     |     |     |     |     |
| RESET    | -  | -   | -   | -   | -   | -   | -   | -   | -  |     |     |     |     |     |     |     |

| BIT                               | BIT NAME                   | FUNCTION  |
|-----------------------------------|----------------------------|---|
| SCALxA0 [0]<br>+<br>SCALxA1 [7:0] | SCALxA [8:0]<br>(x=1 to 4) | 1 <sup>ST</sup> order Gain Calibration parameter for AMPDATA.<br>This parameter is signal 9-Bit data. |

## SCALxB0 / SCALxB1 Register

Register Address: 0x1D to 0x24, EEPROM Address: 0x00F to 0x016

|          | SCALxB0 (x=1 to 4)  |     |     |     |     |     |     |     | SCALxB1 (x=1 to 4)   |     |     |     |     |     |     |     |
|----------|---|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x1D, 0x1F, 0x21, 0x23<br>EEPROM Address: 0x00F, 0x011, 0x013, 0x15 |     |     |     |     |     |     |     | Register Address: 0x1E, 0x20, 0x22, 0x24<br>EEPROM Address: 0x010, 0x012, 0x014, 0x016 |     |     |     |     |     |     |     |
| BIT      | [7]   | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | SCALxB [15:0]   |     |     |     |     |     |     |     |  |     |     |     |     |     |     |     |
| R / W    | RW  |     |     |     |     |     |     |     |  |     |     |     |     |     |     |     |
| RESET    | -   |     |     |     |     |     |     |     |  |     |     |     |     |     |     |     |

| BIT                                 | BIT NAME                    | FUNCTION  |
|-------------------------------------|-----------------------------|---|
| SCALxB0 [7:0]<br>+<br>SCALxB1 [7:0] | SCALxB [15:0]<br>(x=1 to 4) | Zero-order Gain Calibration parameter for AMPDATA.<br>This parameter is unsigned 16-Bit data. |



## OCALxA0 / OCALxA1 Register

Register Address: 0x25 to 0x2C, EEPROM Address: 0x017 to 0x01E

|          | OCALxA0 (x=1 to 4)   |     |     |     |     |     |     |     | OCALxA1 (x=1 to 4)   |     |     |     |     |     |     |     |
|----------|--|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x25 to 0x28<br>EEPROM Address: 0x017 to 0x01A |     |     |     |     |     |     |     | Register Address: 0x29 to 0x2C<br>EEPROM Address: 0x01B to 0x01E |     |     |     |     |     |     |     |
| BIT      | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | -  | -   | -   | -   | -   | -   | -   | -   | OCALxA [9:0]   |     |     |     |     |     |     |     |
| R / W    | -  | -   | -   | -   | -   | -   | -   | -   | RW   |     |     |     |     |     |     |     |
| RESET    | -  | -   | -   | -   | -   | -   | -   | -   | -  |     |     |     |     |     |     |     |

| BIT                                 | BIT NAME                   | FUNCTION   |
|-------------------------------------|----------------------------|--|
| OCALxA0 [1:0]<br>+<br>OCALxA1 [7:0] | OCALxA [9:0]<br>(x=1 to 4) | 1 <sup>ST</sup> order Offset Calibration parameter for AMPDATA.<br>This parameter is signed 10-Bit data. |

## OCALxB0 / OCALxB1 Register

Register Address: 0x2D to 0x34, EEPROM Address: 0x01F to 0x026

|          | OCALxB0 (x=1 to 4)   |     |     |     |     |     |     |     | OCALxB1 (x=1 to 4)   |     |     |     |     |     |     |     |
|----------|--|-----|-----|-----|-----|-----|-----|-----|--|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x2D, 0x2F, 0x31, 0x33<br>EEPROM Address: 0x01F, 0x021, 0x023, 0x025 |     |     |     |     |     |     |     | Register Address: 0x2E, 0x30, 0x32, 0x34<br>EEPROM Address: 0x020, 0x022, 0x024, 0x026 |     |     |     |     |     |     |     |
| BIT      | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]  | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | -  | -   | -   | -   | -   | -   | -   | -   | OCALxB [14:0]  |     |     |     |     |     |     |     |
| R / W    | -  | -   | -   | -   | -   | -   | -   | -   | RW   |     |     |     |     |     |     |     |
| RESET    | -  | -   | -   | -   | -   | -   | -   | -   | -  |     |     |     |     |     |     |     |

| BIT                                 | BIT NAME                    | FUNCTION  |
|-------------------------------------|-----------------------------|---|
| OCALxB0 [6:0]<br>+<br>OCALxB1 [7:0] | OCALxB [14:0]<br>(x=1 to 4) | Zero-order Offset Calibration parameter for AMPDATA.<br>This parameter is signed 15-Bit data. |

## SCALx Register

Register Address: 0x35 to 0x37, EEPROM Address: 0x027 to 0x029

| SCALx (x=1 to 3) |             |     |     |     |     |     |     |     |
|------------------|-------------|-----|-----|-----|-----|-----|-----|-----|
| BIT              | [7]         | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME         | SCALx [7:0] |     |     |     |     |     |     |     |
| R / W            | RW          |     |     |     |     |     |     |     |
| RESET            | -           |     |     |     |     |     |     |     |

| BIT   | BIT NAME            | FUNCTION   |
|-------|---------------------|--|
| [7:0] | SCALx<br>(x=1 to 3) | Threshold Temperature for AMPDATA Sensitivity Calibration.<br>Signed 8.0 fixed point format. (-45°C to +127°C)<br>-45°C ≤ SCAL1 < SCAL2 < SCAL3 ≤ +127°C |

## OCALx Register

Register Address: 0x38 to 0x3A, EEPROM Address: 0x02A to 0x02C

| OCALx (x=1 to 3) |             |     |     |     |     |     |     |     |
|------------------|-------------|-----|-----|-----|-----|-----|-----|-----|
| BIT              | [7]         | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME         | OCALx [7:0] |     |     |     |     |     |     |     |
| R / W            | RW          |     |     |     |     |     |     |     |
| RESET            | -           |     |     |     |     |     |     |     |

| BIT   | BIT NAME            | FUNCTION  |
|-------|---------------------|---|
| [7:0] | OCALx<br>(x=1 to 3) | Threshold Temperature for AMPDATA Offset Calibration.<br>Signed 8.0 fixed point format. (-45°C to +127°C)<br>-45°C ≤ OCAL1 < OCAL2 < OCAL3 ≤ +127°C |

## AUX\_SCAL0 / AUX\_SCAL1 Register

Register Address: 0x3B / 0x3C, EEPROM Address: 0x02D / 0x02E

|          | AUX_SCAL0                                       |     |     |     |     |     |     |     | AUX_SCAL1                                       |     |     |     |     |     |     |     |
|----------|---|-----|-----|-----|-----|-----|-----|-----|---|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x3B<br>EEPROM Address: 0x02D |     |     |     |     |     |     |     | Register Address: 0x3C<br>EEPROM Address: 0x02E |     |     |     |     |     |     |     |
| BIT      | [7]   | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]   | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | AUXSCAL [15:0]                                  |     |     |     |     |     |     |     |   |     |     |     |     |     |     |     |
| R / W    | RW  |     |     |     |     |     |     |     |   |     |     |     |     |     |     |     |
| RESET    | -   |     |     |     |     |     |     |     |   |     |     |     |     |     |     |     |

| BIT                                     | BIT NAME          | FUNCTION   |
|---|-------------------|--|
| AUX_SCAL0 [7:0]<br>+<br>AUX_SCAL1 [7:0] | AUXSCAL<br>[15:0] | Sensitivity Calibration for AUXDATA.<br>(Auxiliary calibration does not have temperature coefficient). |

## AUX\_OCAL0 / AUX\_OCAL1 Register

Register Address: 0x3D / 0x3E, EEPROM Address: 0x02F / 0x030

|          | AUX_OCAL0                                       |     |     |     |     |     |     |     | AUX_OCAL1                                       |     |     |     |     |     |     |     |
|----------|---|-----|-----|-----|-----|-----|-----|-----|---|-----|-----|-----|-----|-----|-----|-----|
|          | Register Address: 0x3D<br>EEPROM Address: 0x02F |     |     |     |     |     |     |     | Register Address: 0x3E<br>EEPROM Address: 0x030 |     |     |     |     |     |     |     |
| BIT      | [7]   | [6] | [5] | [4] | [3] | [2] | [1] | [0] | [7]   | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | AUXOCAL [15:0]                                  |     |     |     |     |     |     |     |   |     |     |     |     |     |     |     |
| R / W    | RW  |     |     |     |     |     |     |     |   |     |     |     |     |     |     |     |
| RESET    | -   |     |     |     |     |     |     |     |   |     |     |     |     |     |     |     |

| BIT                                     | BIT NAME          | FUNCTION  |
|---|-------------------|---|
| AUX_OCAL0 [7:0]<br>+<br>AUX_OCAL1 [7:0] | AUXOCAL<br>[15:0] | Offset Calibration for AUXDATA.<br>(Auxiliary calibration does not have temperature coefficient.) |

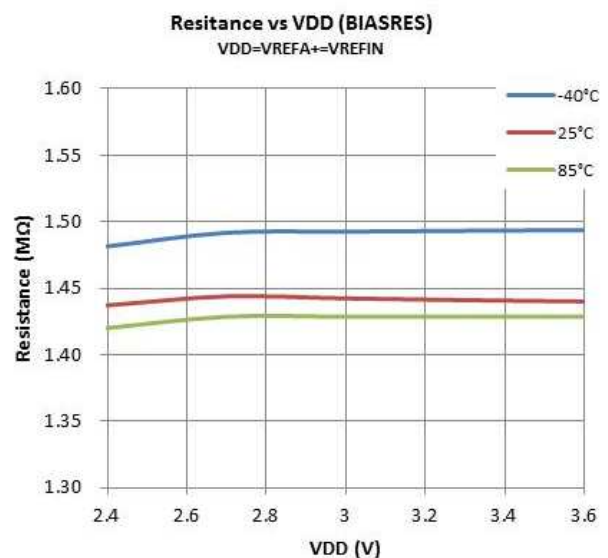
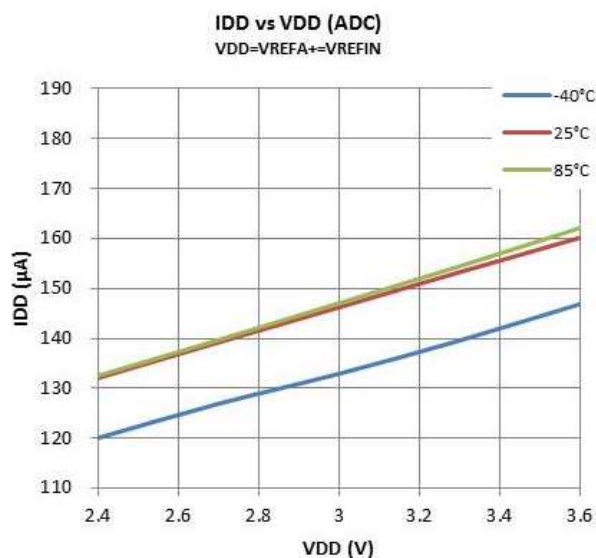
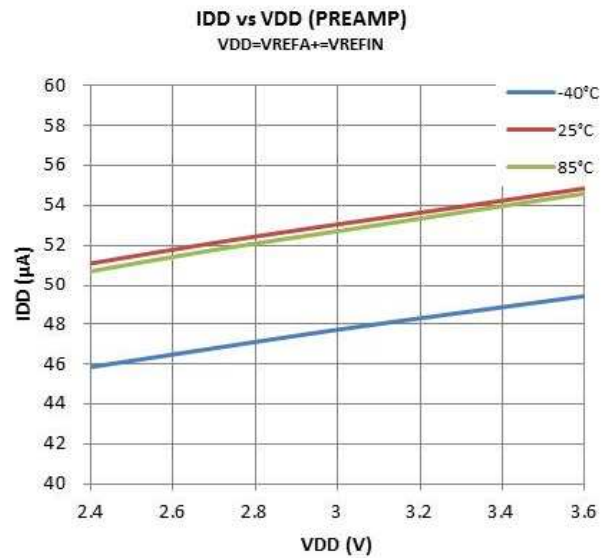
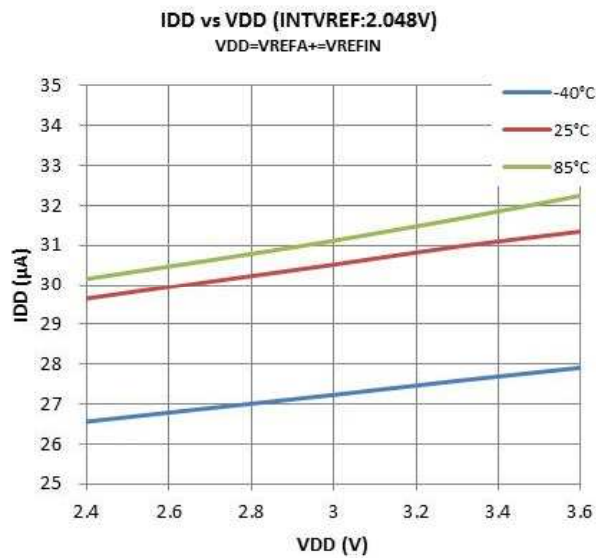
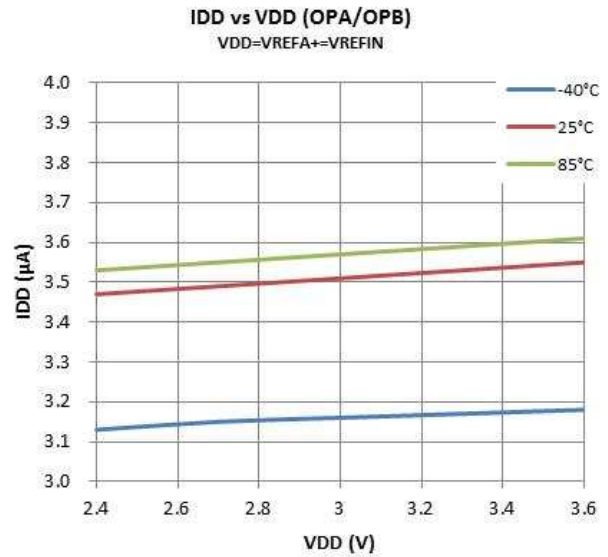
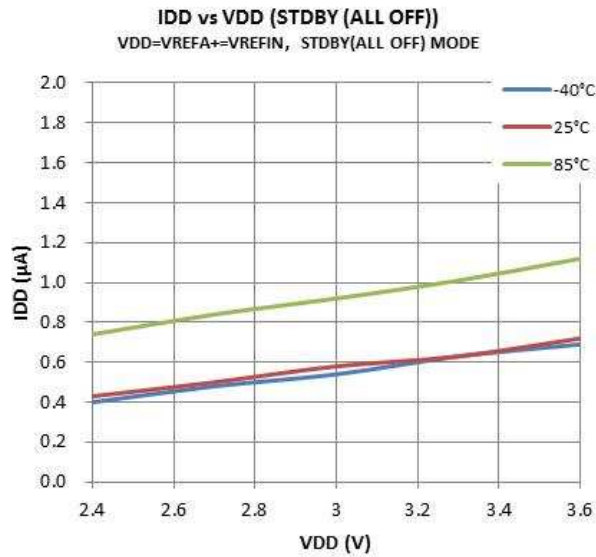
## CHKSUM Register

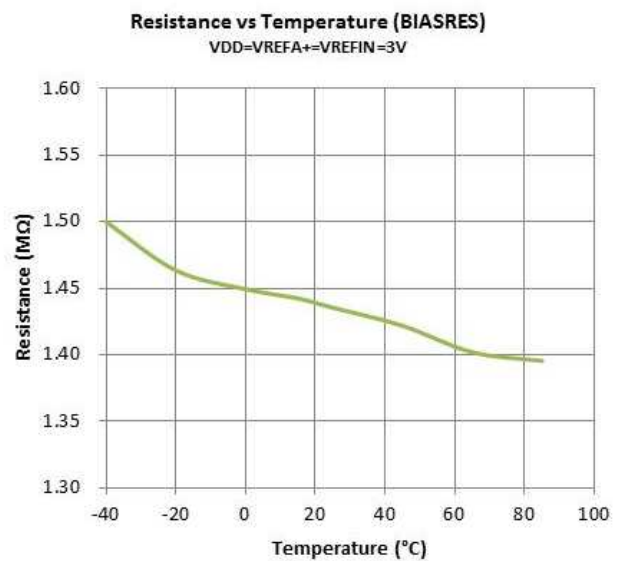
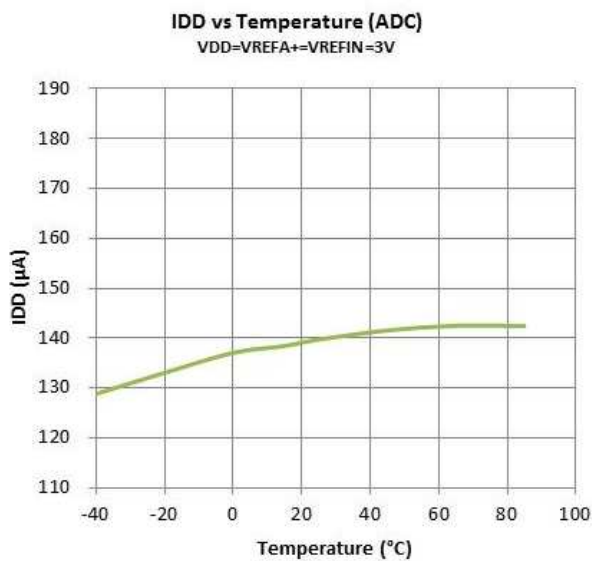
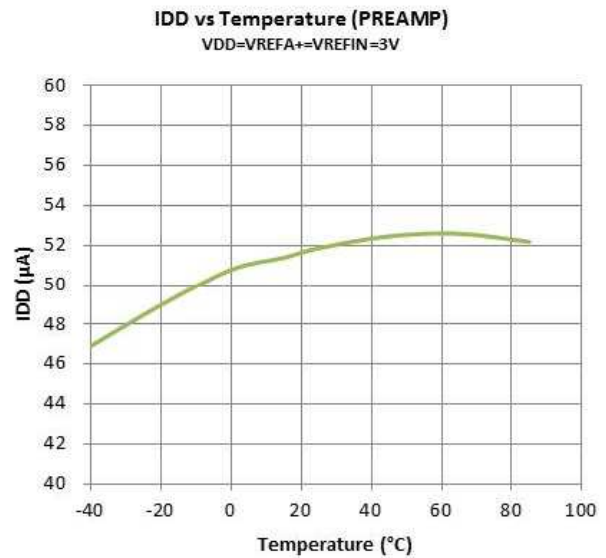
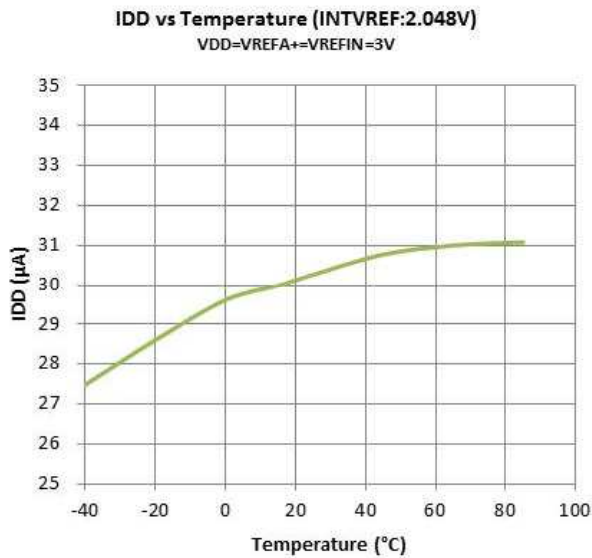
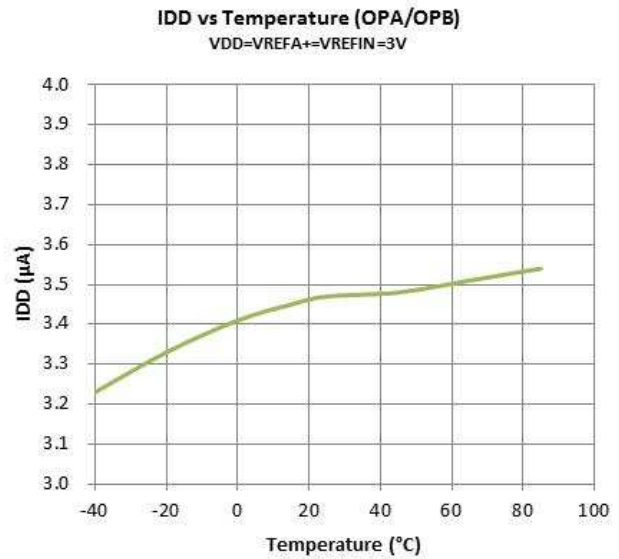
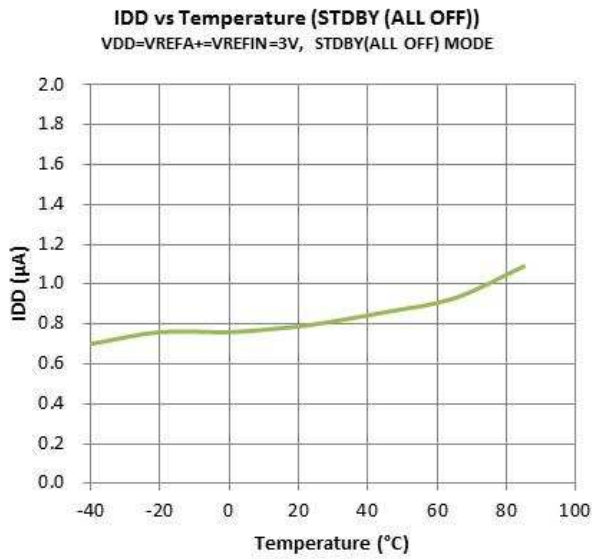
Register Address: 0x3F, EEPROM Address: -

| CHKSUM   |              |     |     |     |     |     |     |     |
|----------|--------------|-----|-----|-----|-----|-----|-----|-----|
| BIT      | [7]          | [6] | [5] | [4] | [3] | [2] | [1] | [0] |
| BIT NAME | CHKSUM [7:0] |     |     |     |     |     |     |     |
| R/W      | R            |     |     |     |     |     |     |     |
| RESET    | -            |     |     |     |     |     |     |     |

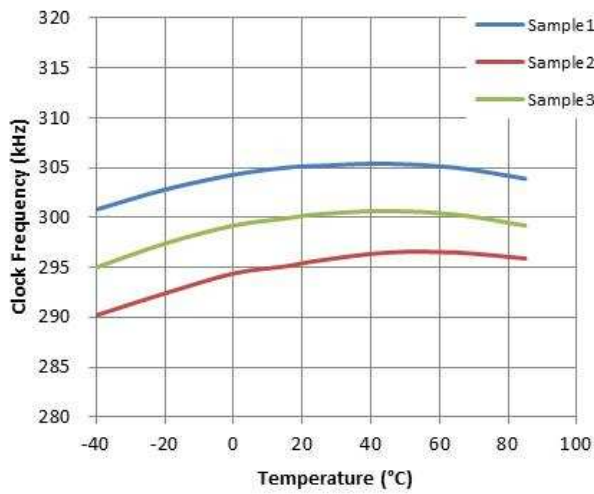
| BIT   | BIT NAME | FUNCTION  |
|-------|----------|---|
| [7:0] | CHKSUM   | Check Sum value of register set value is showed which is read from external EEPROM. Check Sum value is updated in following cases, when start up, when finish reading saved data from in external EEPROM, and when finish roading setting data to host-register from external EEPROM. Check Sum result value is finally showed as 1's complement. This result is summed unsigned data of each address byte (0x000 to 0x030) in external EEPROM. |

## ■TYPICAL CHARACTERISTICS

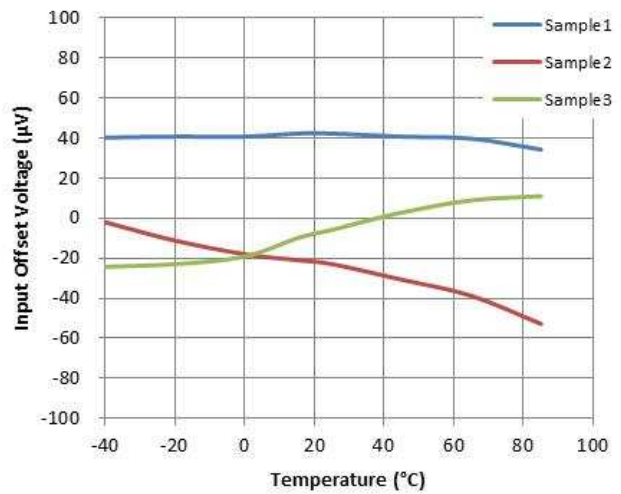




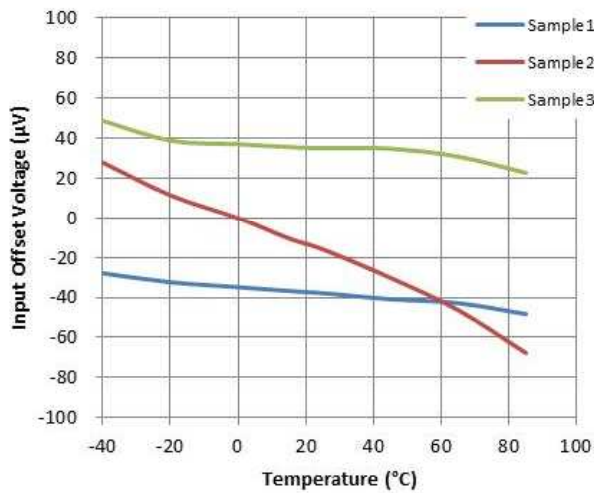
**Clock Frequency vs Temperature (OSC)**  
VDD=VREFA+=VREFIN=3V



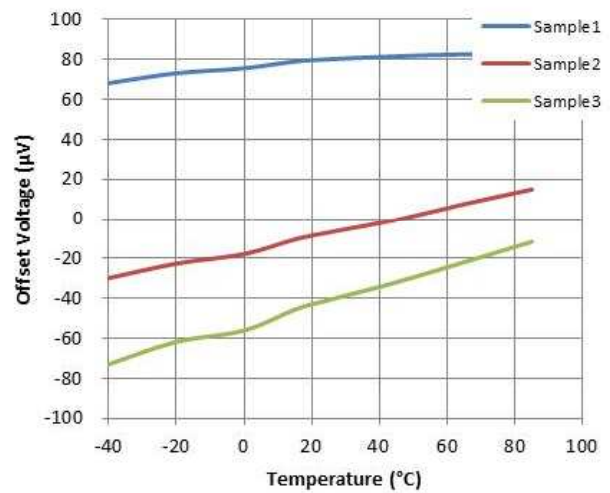
**Input Offset Voltage vs Temperature (OPA)**  
VDD=VREFA+=VREFIN=3V, Null-Amp Method



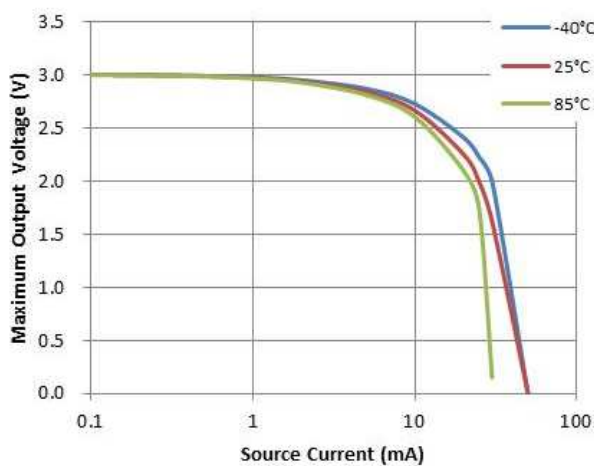
**Input Offset Voltage vs Temperature (OPB)**  
VDD=VREFA+=VREFIN=3V, Null-Amp Method



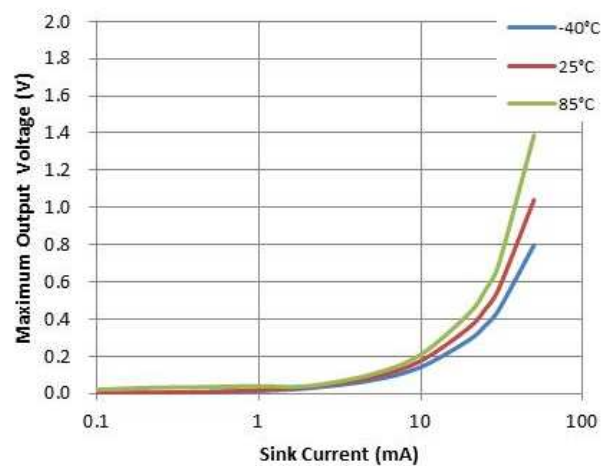
**Offset Difference vs Temperature (OPA-OPB)**  
VDD=VREFA+=VREFIN=3V, Null-Amp Method



**Maximum Output Voltage vs Source Current (OPA/OPB)**  
VDD=VREFA+=VREFIN=3V

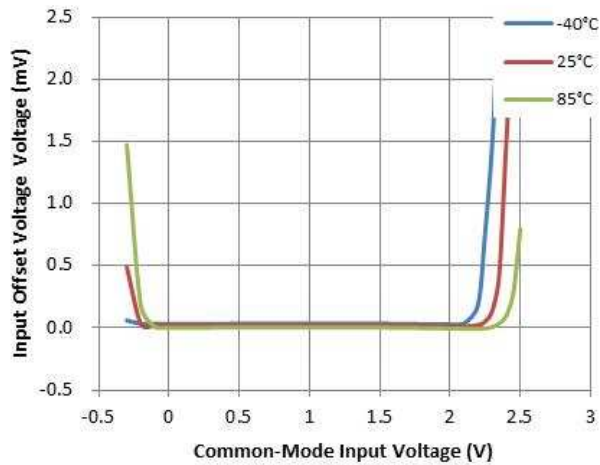


**Maximum Output Voltage vs Sink Current (OPA/OPB)**  
VDD=VREFA+=VREFIN=3V

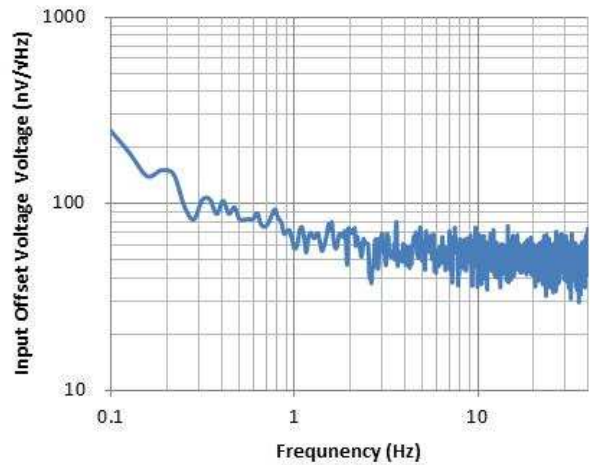




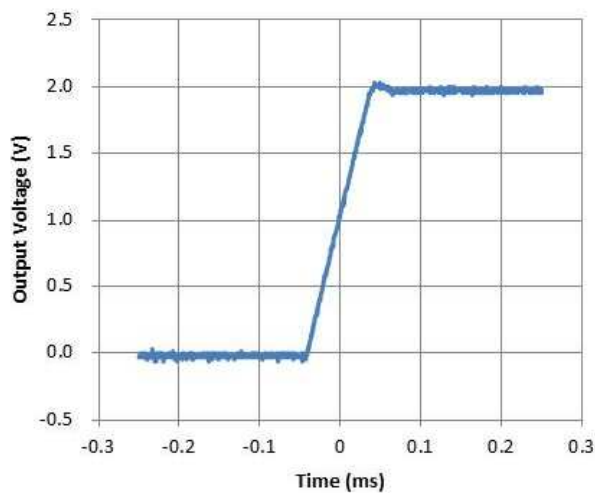
**Input Offset Voltage vs  
Common-Mode Input Voltage (OPA/OPB)**  
VDD=VREFA+=VREFIN=3V



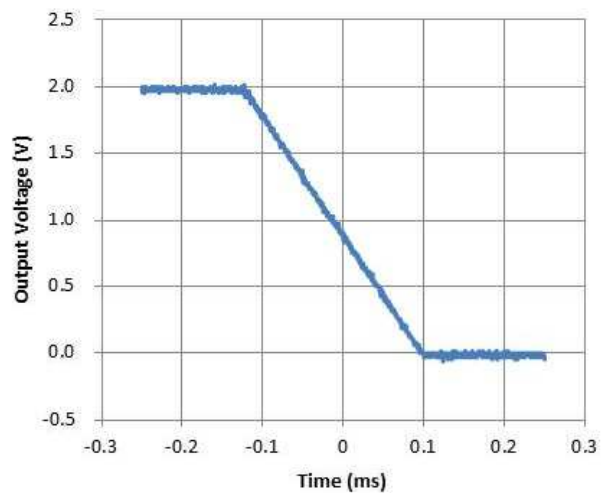
**Equivalent Input Noise Voltage vs Frequency  
(OPA/OPB)**  
VDD=3V, RF=10kΩ, RG=100Ω, Ta=25°C



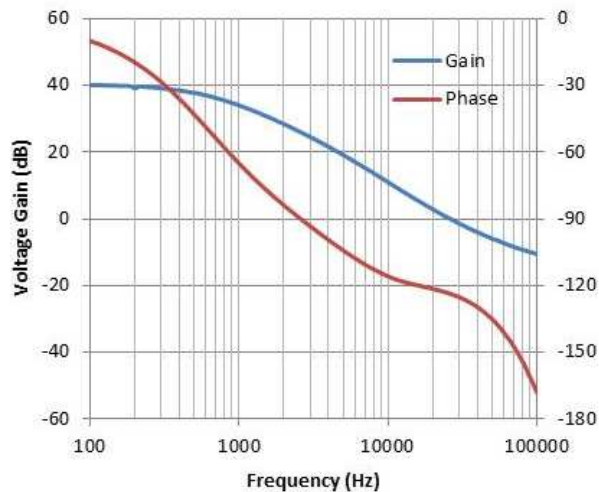
**Pulse Response Rise edge (OPA/OPB)**  
VDD=3V, RL=10kΩ, GV=0dB, Vin=0→2V, Ta=25°C



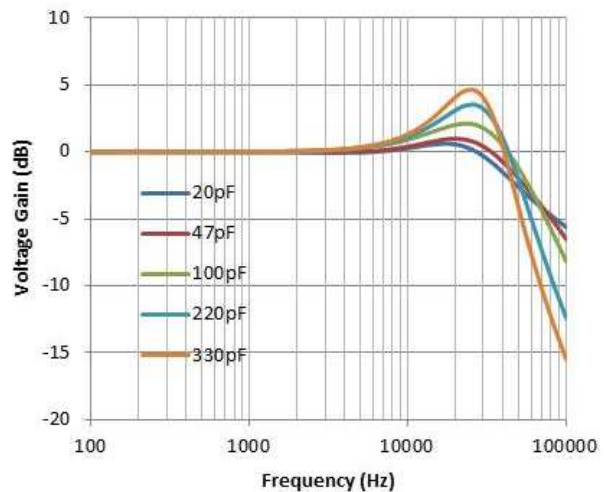
**Pulse Response Fall edge (OPA/OPB)**  
VDD=3V, RL=10kΩ, GV=0dB, Vin=2→0V, Ta=25°C



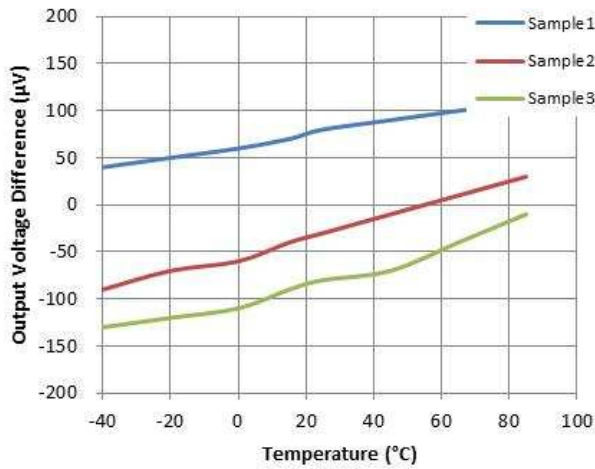
**Voltage Gain vs Frequency (OPA/OPB)**  
VDD=3V, Ta=25°C, Gv=40dB, RL=10kΩ, CL=20pF



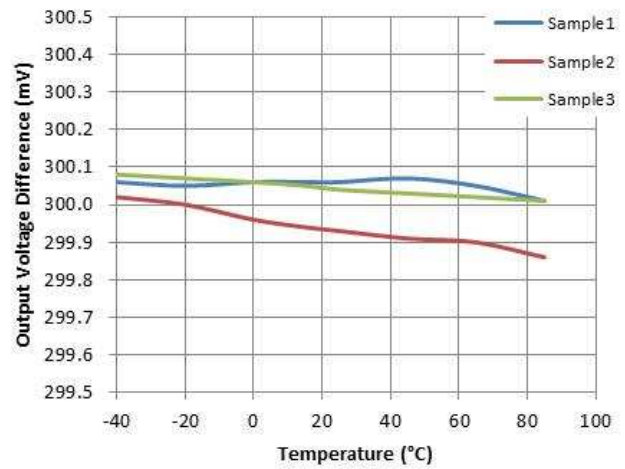
**Voltage Gain vs Frequency (OPA/OPB)**  
VDD=3V, Ta=25°C, Gv=0dB, RL=10kΩ, CL=variable



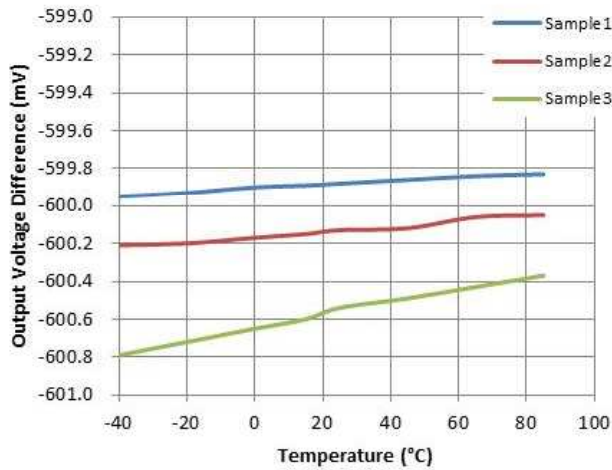
**BIAS Voltage Difference vs Temperature**  
(OPA-OPB) OPA\_Bias = OPB\_Bias = 1V  
VDD=VREFA+=VREFIN=3V, Buffer Output



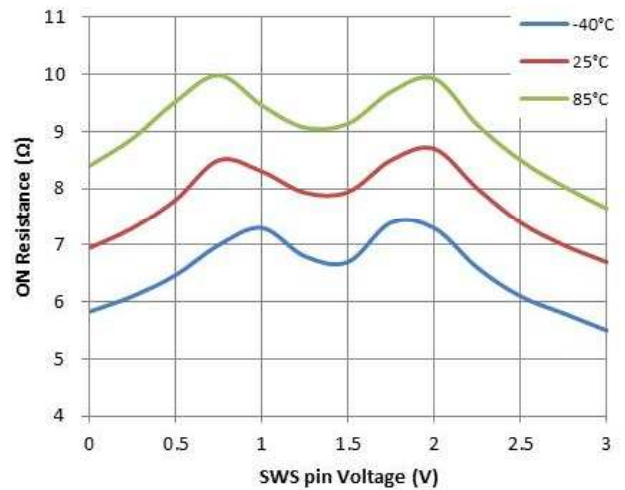
**BIAS Voltage Difference vs Temperature**  
(OPA-OPB) OPA\_Bias = 1V, OPB\_Bias = 0.7V  
VDD=VREFA+=VREFIN=3V, Buffer Output



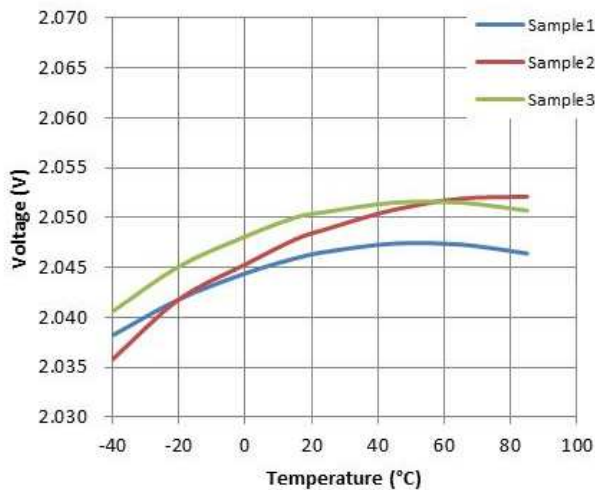
**BIAS Voltage Difference vs Temperature**  
(OPA-OPB) OPA\_Bias = 1V, OPB\_Bias = 1.6V  
VDD=VREFA+=VREFIN=3V, Buffer Output



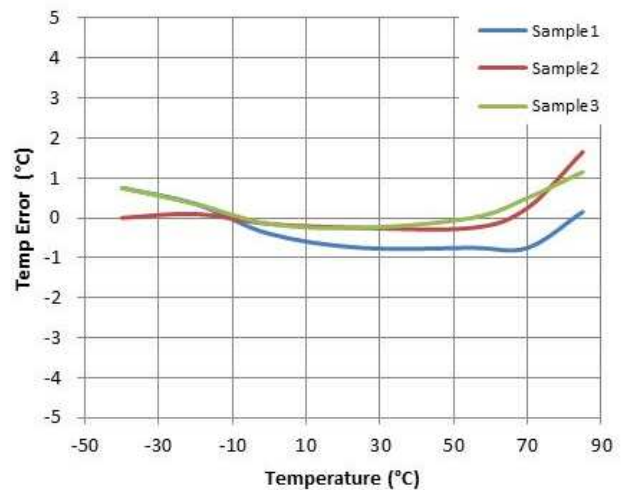
**ON Resistance vs SWS pin Voltage (ANASW)**  
VDD=3V, ANASW="1", IDS=10mA



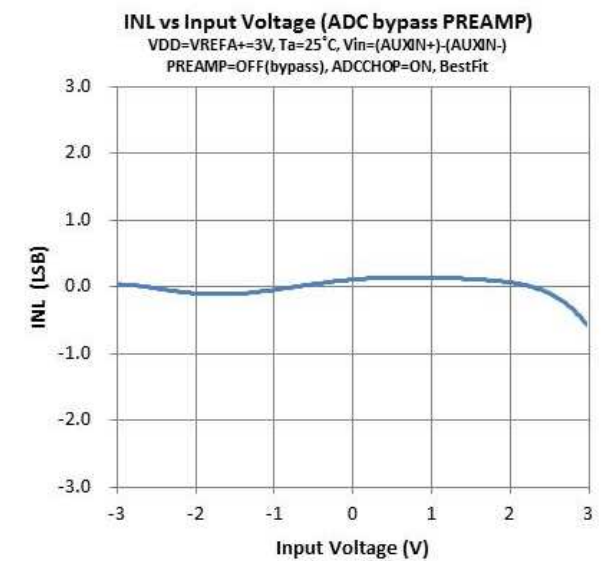
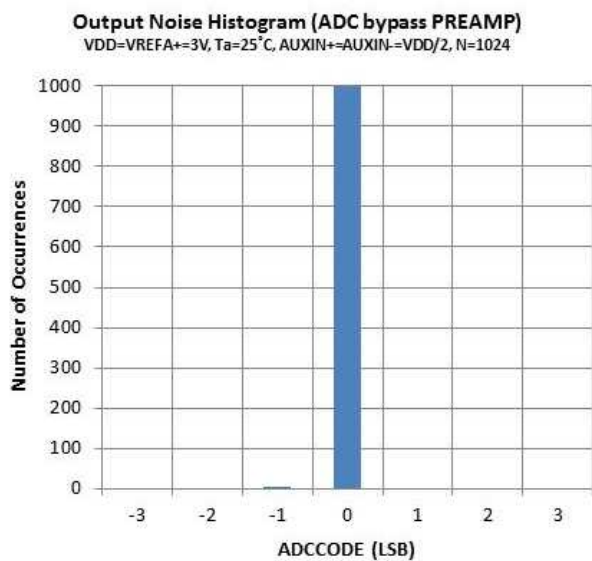
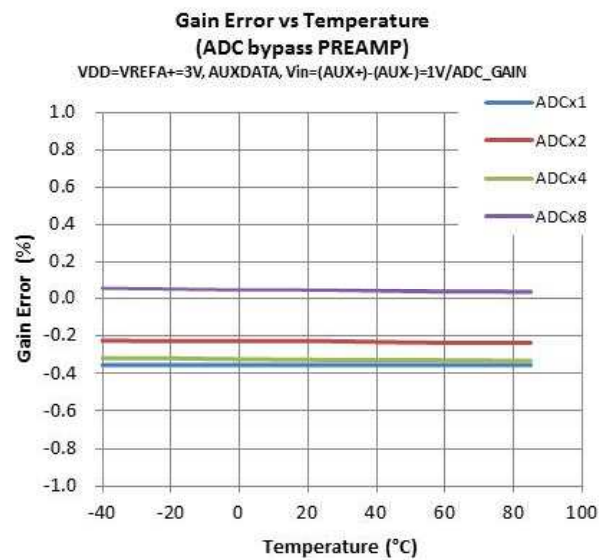
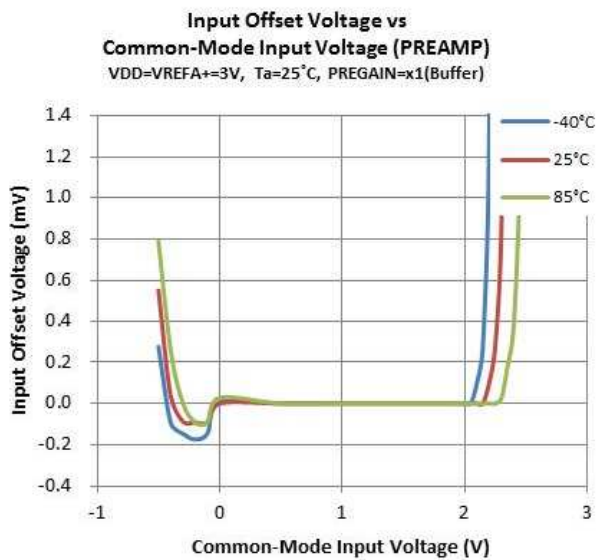
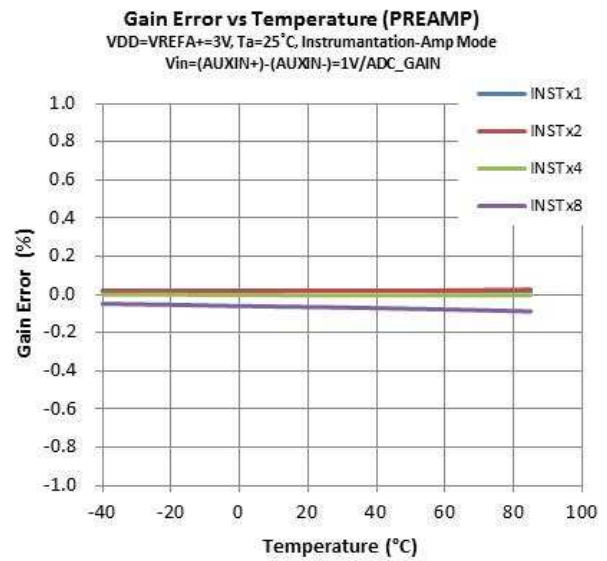
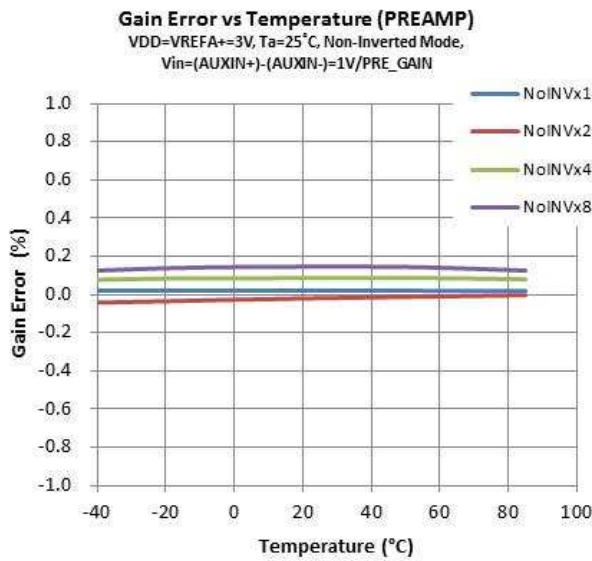
**Voltage vs Temperature (INTVREF:2.048V)**  
VDD=3V



**Temp Error vs Temperature (TEMP SENSOR)**  
VDD=VREFA+=VREFIN=3V,







## ■ APPLICATION NOTE / GLOSSARY

NJU9101 consists of the following circuit block.

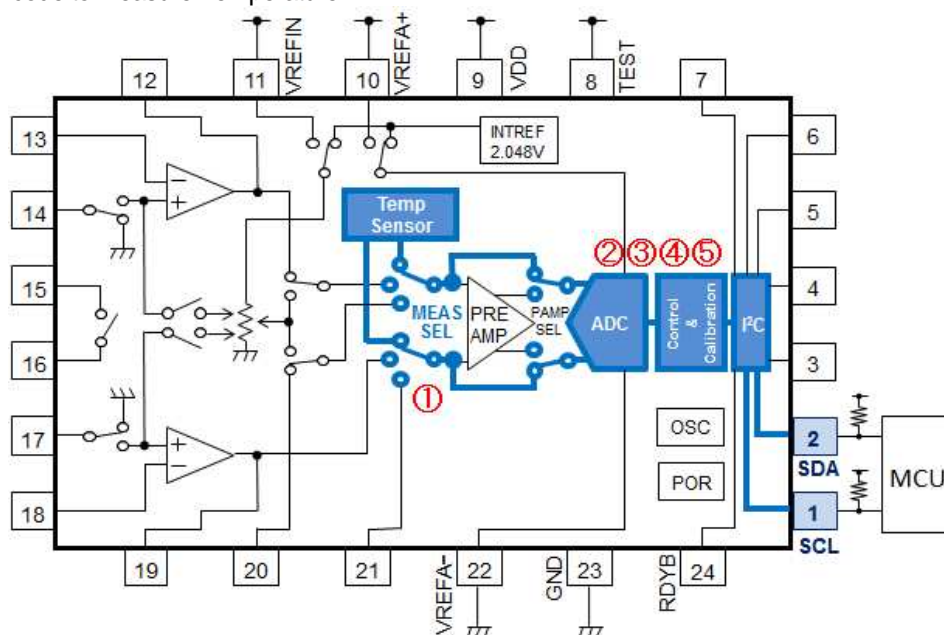
| CIRCUIT BLOCK NAME                      | SYMBOL                |
|---|-----------------------|
| 2 Low Current Operational Amplifier     | “OPA”, “OPB”          |
| Bias Level Setting Register             | “BIASRES”             |
| 10Ω Analog Switch                       | “ANASW”               |
| Variable Gain Pre-Amplifier             | “PREAMP”              |
| Temperature Sensor                      | “TempSensor”          |
| Internal Reference                      | “INTVREF (2.048V)”    |
| 16-Bit sigma delta ADC                  | “16-Bit ADC”          |
| Digital Control & Calibration           | “Control&Calibration” |
| I <sup>2</sup> C Bus Compatible Control | “I <sup>2</sup> C”    |

NJU9101 is suitable for many kinds of low power analog signal applications by using these circuit blocks.

### 1. Signal channel selection for Measurement

#### 1.1 Temperature Sensor Measurement

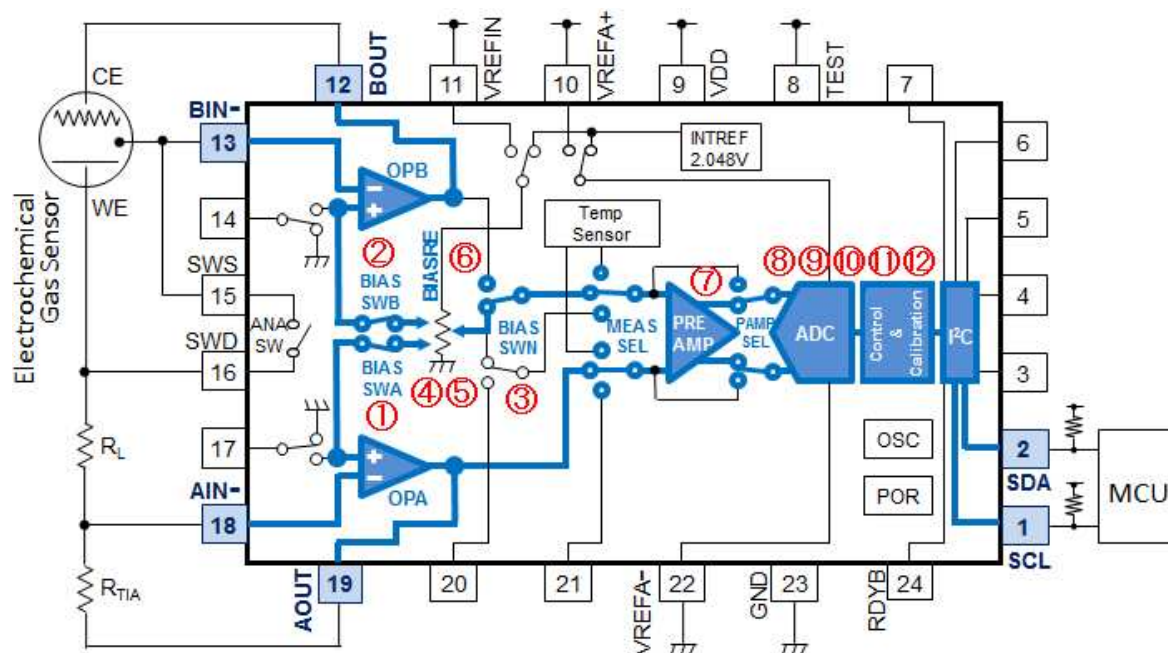
Write below code to measure Temperature.



| No. | CONTENS  | REGISTER ADDRESS | REGISTER NAME        | BIT NAME | BIT   | VALUE |
|-----|--|------------------|----------------------|----------|-------|-------|
| 1   | Select Temperature Input Mode                            | 0x00             | CTRL                 | MEAS_SEL | [2:1] | 00    |
| 2   | Select ADC Conversion Mode (Exp. Single Conversion)      |                  |                      | MEAS_SC  | [0]   | 0     |
| 3   | Start AD Conversion                                      |                  |                      | MEAS     | [3]   | 1     |
| 4   | Check completion of the AD conversion ("MEAS" bit = "0") |                  |                      |          |       | -     |
| 5   | Acquire AD conversion data. (TMPDATA)                    | 0x06<br>0x07     | TMPDATA0<br>TMPDATA1 | TMPDATA  | [9:0] | -     |

## 1.2 System Example 1 (Potentiostat Measurement)

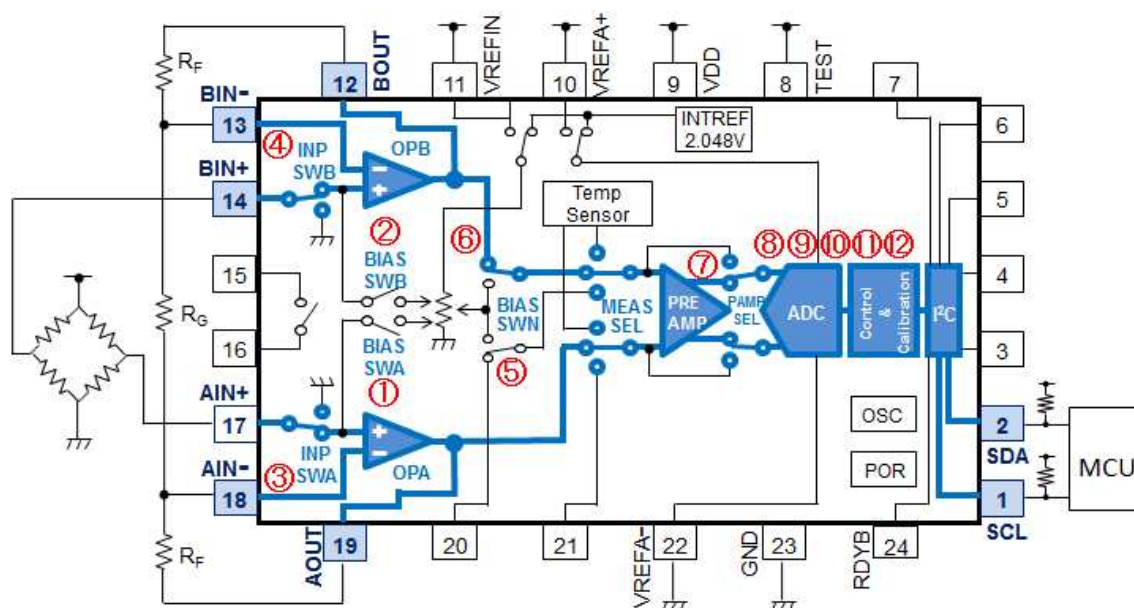
Write below code to constitute “potentiostat” and “trans-impedance-amplifier”



| No. | CONTENS  | REGISTER ADDRESS | REGISTER NAME        | BIT NAME | BIT    | VALUE |
|-----|--|------------------|----------------------|----------|--------|-------|
| 1   | Connect the switch “BIASRES” and “OPA”                   | 0x0F             | BLKCONN0             | BIASSWA  | [5]    | 1     |
| 2   | Connect the switch “BIASRES” and “OPB”                   |                  |                      | BIASSWB  | [4]    | 1     |
| 3   | Select output of BIASRES                                 | 0x11             | BLKCONN2             | BIASSWN  | [3]    | 1     |
| 4   | Bias level for “trans-impedance-amplifier” (GND to 1.7V) | 0x10             | BLKCONN1             | OPA_BIAS | [7:5]  | any   |
| 5   | Bias level for “potentiostat” (GND to 1.75V)             |                  |                      | OPB_BIAS | [4:0]  |       |
| 6   | Powered on BIASRES, OPA, OPB, OSC                        | 0x12             | BLKCTRL              | BLKCTRL  | [7:0]  | 0xF0  |
| 7   | Enable PREAMP  | 0x11             | BLKCONN2             | PAMPSEL  | [2]    | 1     |
| 8   | Select Amp Input Mode                                    | 0x00             | CTRL                 | MEAS_SEL | [2:1]  | 01    |
| 9   | Set Measurement Mode for ADC (ex.: Single conversion)    |                  |                      | MEAS_SC  | [0]    | 0     |
| 10  | Start measurement  |                  |                      | MEAS     | [3]    | 1     |
| 11  | Check completion of the AD conversion (“MEAS” bit = “0”) |                  |                      |          |        | -     |
| 12  | Acquire AD conversion data (AMPDATA)                     | 0x02<br>0x03     | AMPDATA0<br>AMPDATA1 | AMPDATA  | [15:0] | -     |

### 1.3 System Example 2 (Differential Input)

Write below code to constitute "Differential Amplifier Input" by using OPA/OPB.



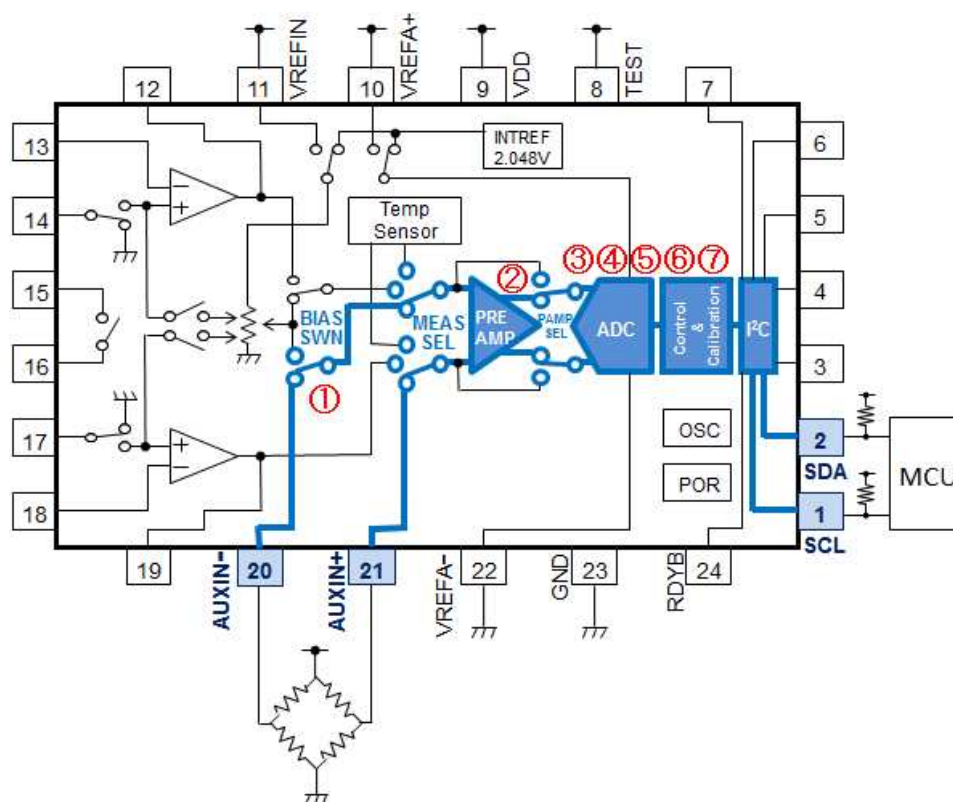
| No. | CONTENTS  | REGISTER ADDRESS | REGISTER NAME        | BIT NAME | BIT    | VALUE |
|-----|---|------------------|----------------------|----------|--------|-------|
| 1   | Open OPA input switch                                       | 0x0F             | BLKCONN0             | BIASSWA  | [5]    | 0     |
| 2   | Open OPB input switch                                       |                  |                      | BIASSWB  | [4]    | 0     |
| 3   | Select OPA sensor signal input                              | 0x11             | BLKCONN2             | INPSWA   | [6]    | 1     |
| 4   | Select OPB sensor signal input                              |                  |                      | INPSWB   | [5]    | 1     |
| 5   | Select OPB output   |                  |                      | BIASSWN  | [3]    | 0     |
| 6   | Powered on OPA, OPB, OSC                                    | 0x12             | BLKCTRL              | BLKCTRL  | [7:0]  | 0x70  |
| 7   | Enable PREAMP   | 0x11             | BLKCONN2             | PAMPSEL  | [2]    | 1     |
| 8   | Select Amp Input Mode                                       | 0x00             | CTRL                 | MEAS_SEL | [2:1]  | 01    |
| 9   | Set Measurement Mode for ADC<br>(ex.: Single conversion)    |                  |                      | MEAS_SC  | [0]    | 0     |
| 10  | Start measurement   |                  |                      | MEAS     | [3]    | 1     |
| 11  | Check completion of the AD conversion<br>(“MEAS” bit = “0”) |                  |                      |          |        | -     |
| 12  | Acquire AD conversion data<br>(AMPDATA)                     | 0x02<br>0x03     | AMPDATA0<br>AMPDATA1 | AMPDATA  | [15:0] | -     |





## 1.5 Auxiliary (external Input) Measurement

Write below code to constitute "Differential Amplifier Input" by using PREAMP.



| No. | CONTENTS   | REGISTER ADDRESS | REGISTER NAME        | BIT NAME | BIT    | VALUE |
|-----|--|------------------|----------------------|----------|--------|-------|
| 1   | Select AUXIN input                                       | 0x11             | BLKCONN2             | BIASSWN  | [3]    | 1     |
| 2   | Enable PREAMP  |                  |                      | PAMPSEL  | [2]    | 1     |
| 3   | Select Auxiliary input mode                              | 0x00             | CTRL                 | MEAS_SEL | [2:1]  | 10    |
| 4   | Set Measurement Mode for ADC (ex.: Single conversion)    |                  |                      | MEAS_SC  | [0]    | 0     |
| 5   | Start measurement  |                  |                      | MEAS     | [3]    | 1     |
| 6   | Check completion of the AD conversion ("MEAS" bit = "0") |                  |                      |          |        | -     |
| 7   | Acquire AD conversion data (AUXDATA)                     | 0x04<br>0x05     | AUXDATA0<br>AUXDATA1 | AUXDATA  | [15:0] | -     |



## 5. Variable Bias Register (BIASRES)

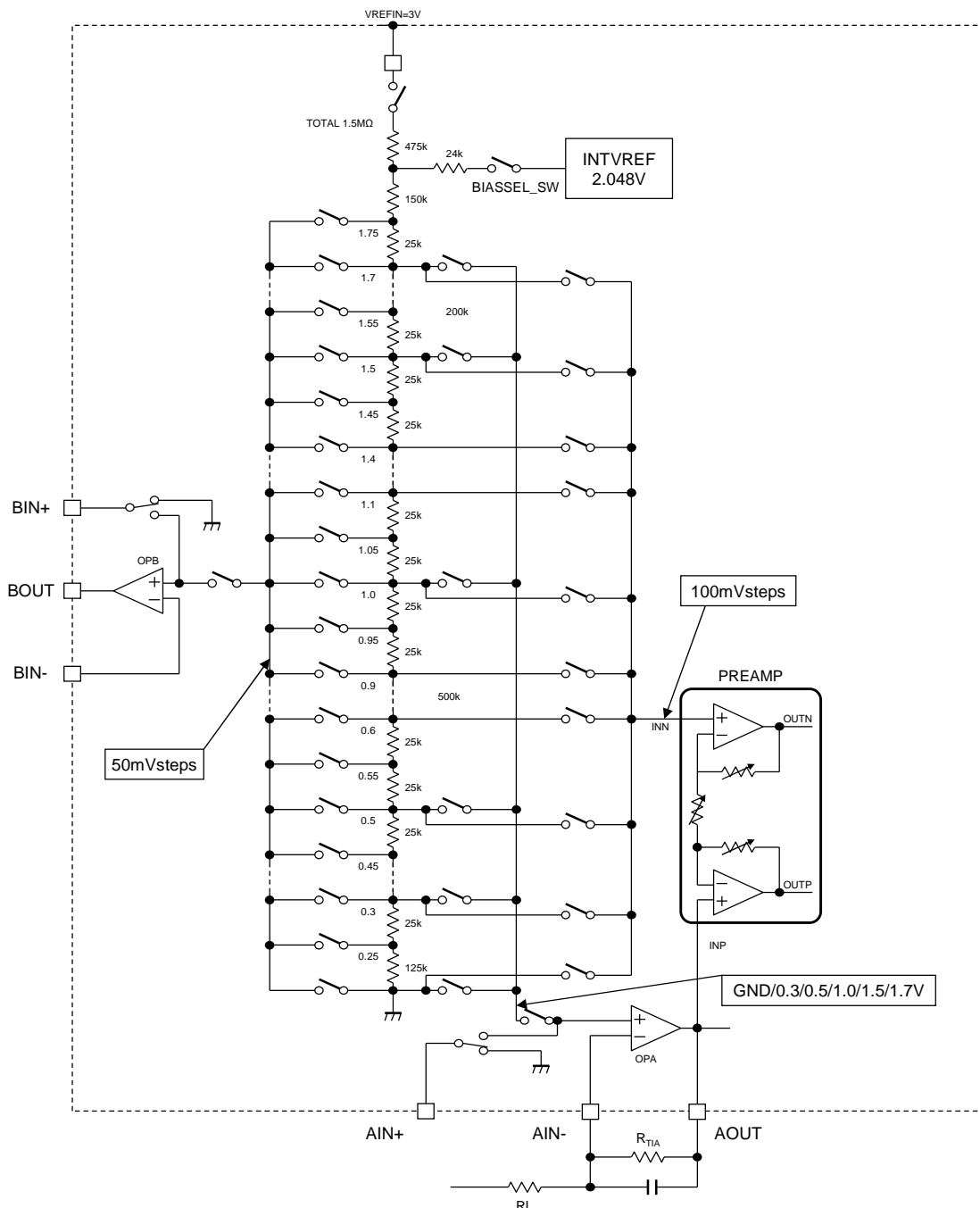
“Variable Bias Resister (BIASRES)” for “OPA”, “OPB”, and “PREAMP” are shown in below.

The Bias Voltage for these amplifiers are given by resistor ladder ratio (total resistor = 1.5MΩ). These resistor ladder ratio are set by “OPA\_BIAS”, “OPB\_BIAS”, “PRE\_BIAS” registers. Setting Name of these register (ex. 0.5V @ VREFIN=3V) is in VREFIN=3V condition.

If VREFIN is not 3V (ex. VREFIN=2.5V), the selected Voltage is shifted as follow.

If register setting is “1.5V @ VREFIN=3V” → Actual Voltage is  $1.5V * (2.5V/3.0V) = 1.25V$

And, when “BIASSEL = 0”, BIASSEL\_SW is turned on and fixed voltage “INTVREF (2.048V)” is given to the resistor ladder shown in figure below.





## 6. PREAMP Gain Calculation

“Non-Inverted Amplifier” or “Instrumentation Amplifier” is selected by “PREMODE” bit.

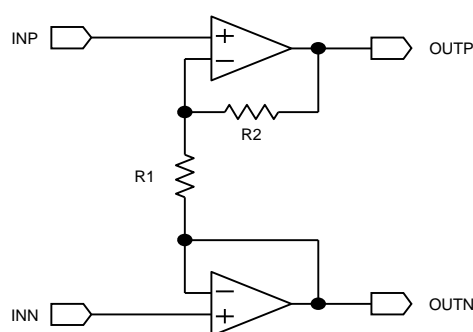
“Pre-Amplifier-Gain” is selected by “PRE\_GAIN” bits.

Input Voltage range of INP&INN is “0V” ~ “VDD-1V”.

Output Voltage range of OUTP&OUTN is “0.05V” ~ “VDD-0.05V”.

\* Please design not to exceed Input & Output Voltage range.

### 6.1. PREMODE = 0 (Non-Inverted Amplifier)



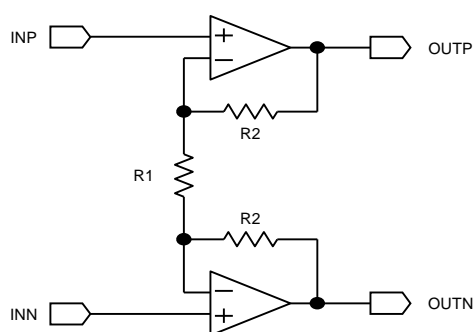
$$V(OUTP) = V(INP) + \frac{R2}{R1} \times V(INP - INN)$$

$$V(OUTN) = V(INN)$$

$$GAIN = \frac{V(OUTP - OUTN)}{V(INP - INN)} = 1 + \frac{R2}{R1}$$

| Gain  | PRE_GAIN | R1    | R2    |
|-------|----------|-------|-------|
| 1 V/V | 00       | 320kΩ | 0Ω    |
| 2 V/V | 01       | 160kΩ | 160kΩ |
| 4 V/V | 10       | 80kΩ  | 240kΩ |
| 8 V/V | 11       | 40kΩ  | 280kΩ |

### 6.2. PREMODE = 1 (Instrumentation Amplifier)



$$V(OUTP) = V(INP) + \frac{R2}{R1} \times V(INP - INN)$$

$$V(OUTN) = V(INN) + \frac{R2}{R1} \times V(INN - INP)$$

$$GAIN = \frac{V(OUTP - OUTN)}{V(INP - INN)} = 1 + 2 \times \frac{R2}{R1}$$

| Gain  | PRE_GAIN | R1    | R2    |
|-------|----------|-------|-------|
| 1 V/V | 00       | 320kΩ | 0Ω    |
| 2 V/V | 01       | 160kΩ | 80kΩ  |
| 4 V/V | 10       | 80kΩ  | 120kΩ |
| 8 V/V | 11       | 40kΩ  | 140kΩ |

## 7. Low Power Management

NJU9101 is intended for use in portable devices, so the power consumption is as low as possible in order to ensure a long battery life. Following usage assumption of NJU9101 is in a portable gas detector. And its power consumption is summarized in below. The total power consumption for NJU9101 is below @3V average over time, this excludes any current drawn from any pin, please consider another device's consumption.

### < Condition >

- ~ The system is used about 8 hours a day, and 16 hours a day it is in Standby mode.
- ~ Basically, Only "OPB" and "BIASRES" block are turned On in Standby mode.
- ~ Potentiostat Measurement is once per second.
- ~ Aux Data Measurement is one per minutes.
- ~ Temperature Measurement is one per minutes.
- ~ ADC conversion time uses approximately 16.6ms. (OSR="01", REJ="10", ADCCHOP="1")

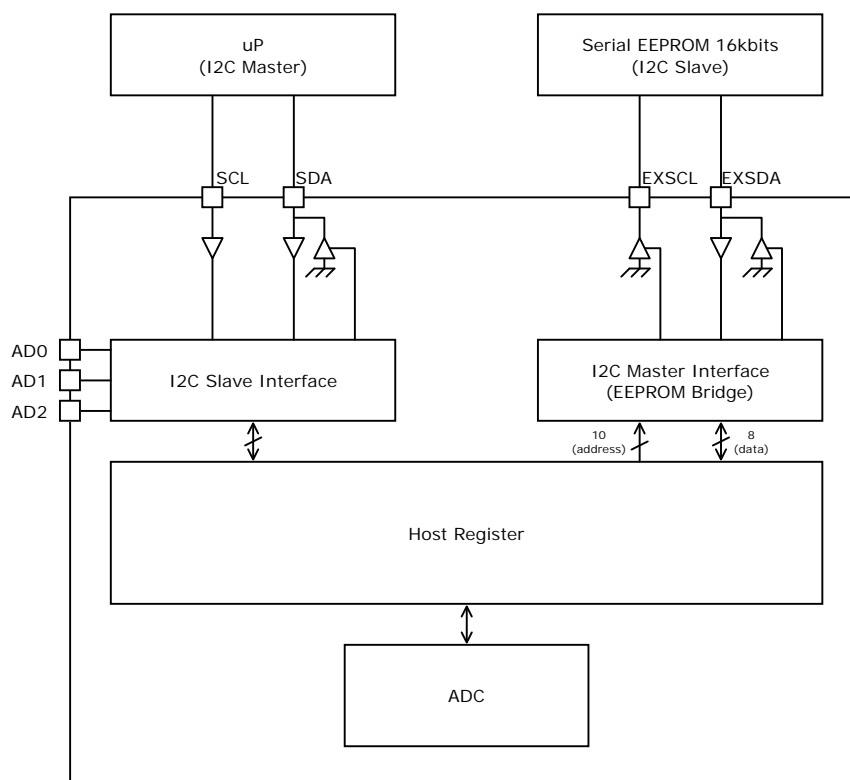
|                          | Standby | 3-Lead<br>Potentiostat | Potentiostat<br>Measurement | Aux Data<br>Measurement | Temperature<br>Measurement | Total Current<br>Consumption |
|--------------------------|---------|------------------------|-----------------------------|-------------------------|----------------------------|------------------------------|
| Current Consumption      | 0.5μA   | 10.5μA                 | 215.5μA                     | 160.5μA                 | 250.5μA                    |                              |
| Time On a Day            | 16 (h)  | 8 (h)                  | 480 (s)                     | 8 (s)                   | 8 (s)                      |                              |
|                          | 66.6%   | 33.3%                  | 0.556%                      | 0.009%                  | 0.009%                     |                              |
| Average Current          | 0.33μA  | 3.5μA                  | 1.2μA                       | 0.01μA                  | 0.02μA                     | <b>5.01μA</b>                |
| ANASW                    | ON      | OFF                    | OFF                         | OFF                     | OFF                        |                              |
| BIASRES                  | OFF     | ON                     | ON                          | ON                      | ON                         |                              |
| OPA                      | OFF     | ON                     | ON                          | ON                      | ON                         |                              |
| OPB                      | OFF     | ON                     | ON                          | ON                      | ON                         |                              |
| PREAMP                   | OFF     | OFF                    | ON                          | OFF                     | ON                         |                              |
| ADC                      | OFF     | OFF                    | ON                          | ON                      | ON                         |                              |
| Temp. sensor             | OFF     | OFF                    | OFF                         | OFF                     | ON                         |                              |
| I <sup>2</sup> C & Logic | ON      | ON                     | ON                          | ON                      | ON                         |                              |

## 8. I<sup>2</sup>C-BUS Interface

NJU9101 has 2 types of I<sup>2</sup>C bus, one bus communicates to host device such as MCU, the other bus communicates to external EEPROM which is to retain the IC configurations, calibration parameters, .etc. These 2 types of I<sup>2</sup>C bus operate independently. NJU9101 operates for host interface as I<sup>2</sup>C slave device, and operates for EEPROM interface as I<sup>2</sup>C Master Device.

One I<sup>2</sup>C-bus which connects to host device is SCL/SDA, and the other I<sup>2</sup>C-bus which connects to external EEPROM is EXSCL/EXSDA.

| Communicate                | I <sup>2</sup> C bus | I/O                       | Master / Slave |
|----------------------------|----------------------|---------------------------|----------------|
| Host Device<br>(e.g.: MPU) | SCL                  | Input                     | NJU9101:Slave  |
|                            | SDA                  | Input / Open-Drain Output |                |
| External EEPROM            | EXSCL                | Open-Drain Output         | NJU9101:Master |
|                            | EXSDA                | Input / Open-Drain Output |                |



### 8.1. I<sup>2</sup>C Slave Interface

This interface is used for the Host that accesses to registers in NJU9101. NJU9101 is a I<sup>2</sup>C Slave device for the host MCU. The operation of which conversion trigger, conversion data reading, access external EEPROM, .etc. are executed through reading and writing of registers in NJU9101. Registers in NJU9101 are register address 0x00 ~ 0x3F and each address has 8 bits width register.

## ● I<sup>2</sup>C Protocol

7bit-I<sup>2</sup>C Slave address consists of a fixed four-bit '0x9(b1001)' and chip address pin 'AD2', 'AD1', 'AD0'.

In case of write operation, transmit the writing data in following,

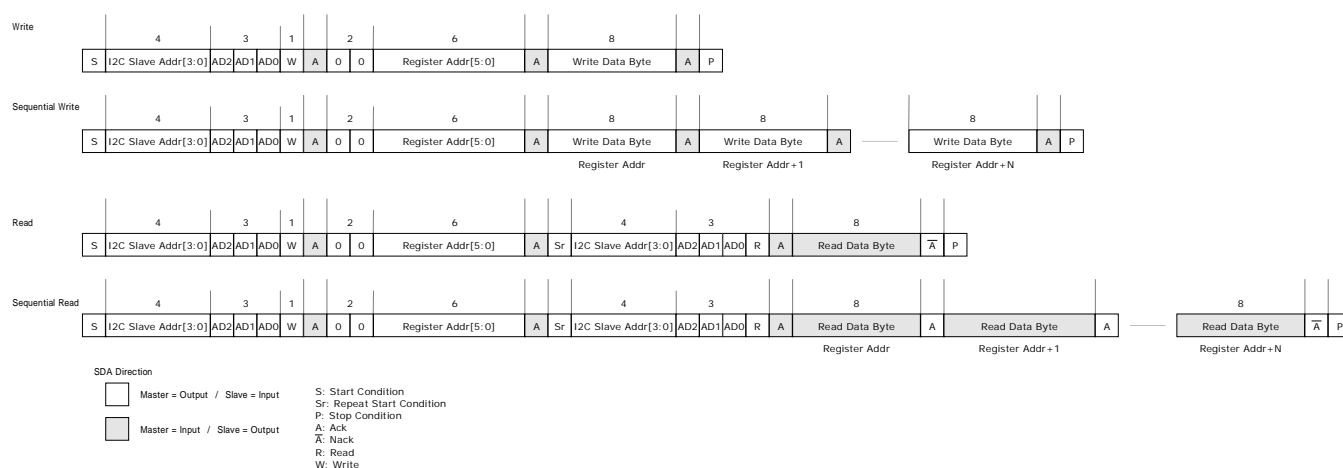
'Slave address' + 'Write bit (0)' + 'Write Register address' + 'Write data'.

When more than 2 bytes of write data are transmitted, register address are increment automatically, and write the data into corresponding registers. When register address is over 0x3F, return to address 0x00 and lap around.

In case of read operation, transmit the data in following,

'Slave address' + 'Write bit (0)' + 'Read Register address' and then transmit 'repeat start' command.

When more than 2 bytes of read data are read, register address are increment automatically, and read the data into corresponding address. When register address is over 0x3F, return to address 0x00 and lap around.



## ● I<sup>2</sup>C external EEPROM Interface

I<sup>2</sup>C external EEPROM of 16k-Bit (2kByte) can be connected as a external storage device for NJU9101. 'Microchip 24LC16B' is used as a standard External EEPROM. Other I<sup>2</sup>C Serial EEPROM with communication compatible can be used. Some areas in external EEPROM are used as preset area for configuration data of NJU9101. The remaining areas in external EEPROM can be used for any uses.

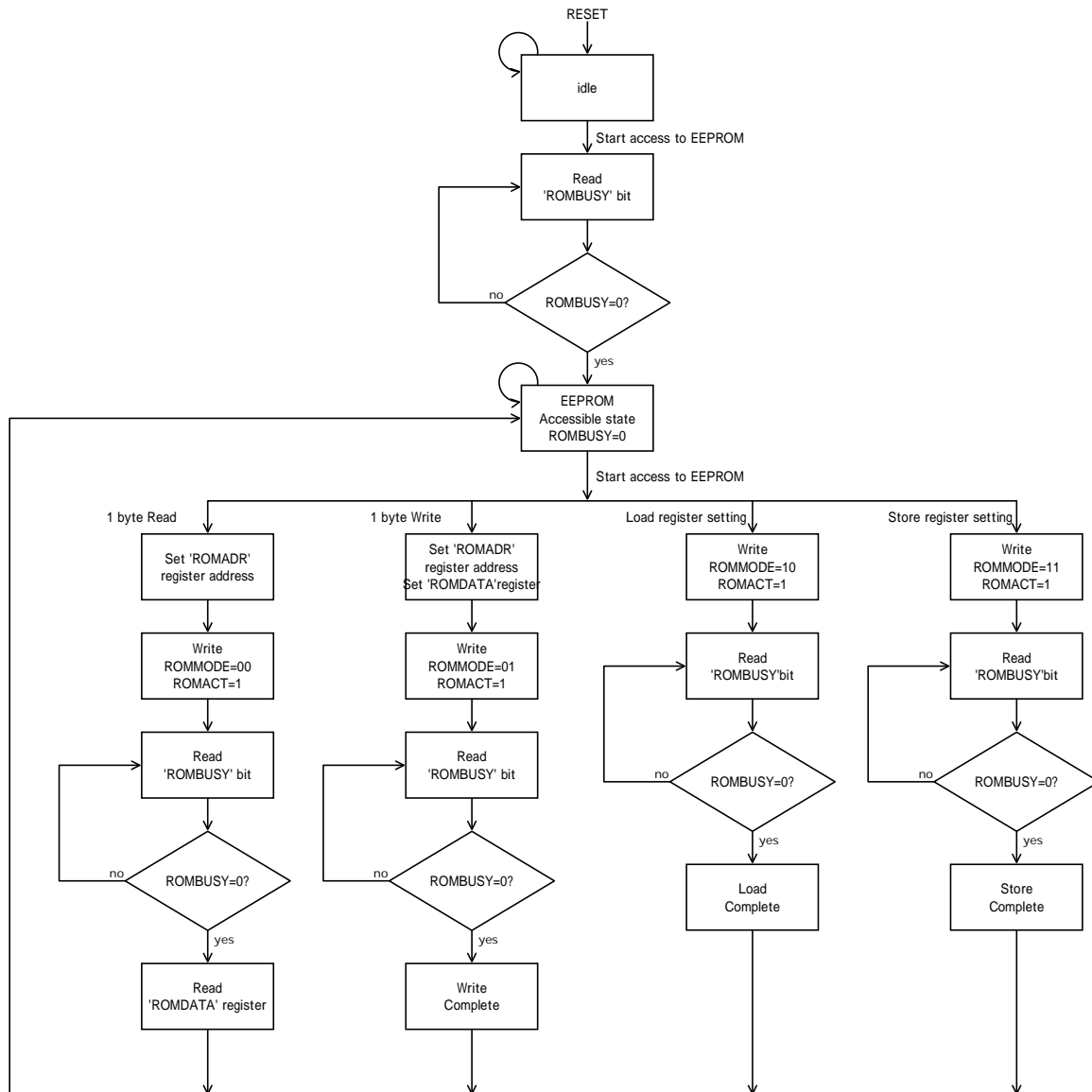
NJU9101 supports 4-operations for external EEPROM from host-interface (MCU).

- Read data from arbitrary address area in external EEPROM.
- Write data to arbitrary address area in external EEPROM.
- Load the all data from external EEPROM to host register (MCU).
- Store register data in host register (MCU) to external EEPROM.

See also, "EVERY REGISTER DESCRIPTION : ROMCTRL" to control the external EEPROM.

### ● External EEPROM operating flow & External EEPROM I<sup>2</sup>C bus timing

Flow chart of access to external EEPROM is shown in below. When access to external EEPROM, system clock has to be operating and 'ROMBUSY' bit has to be '0'. And it can also access to external EEPROM under ADC conversion (Except for reading the initial register value just after reset release.).



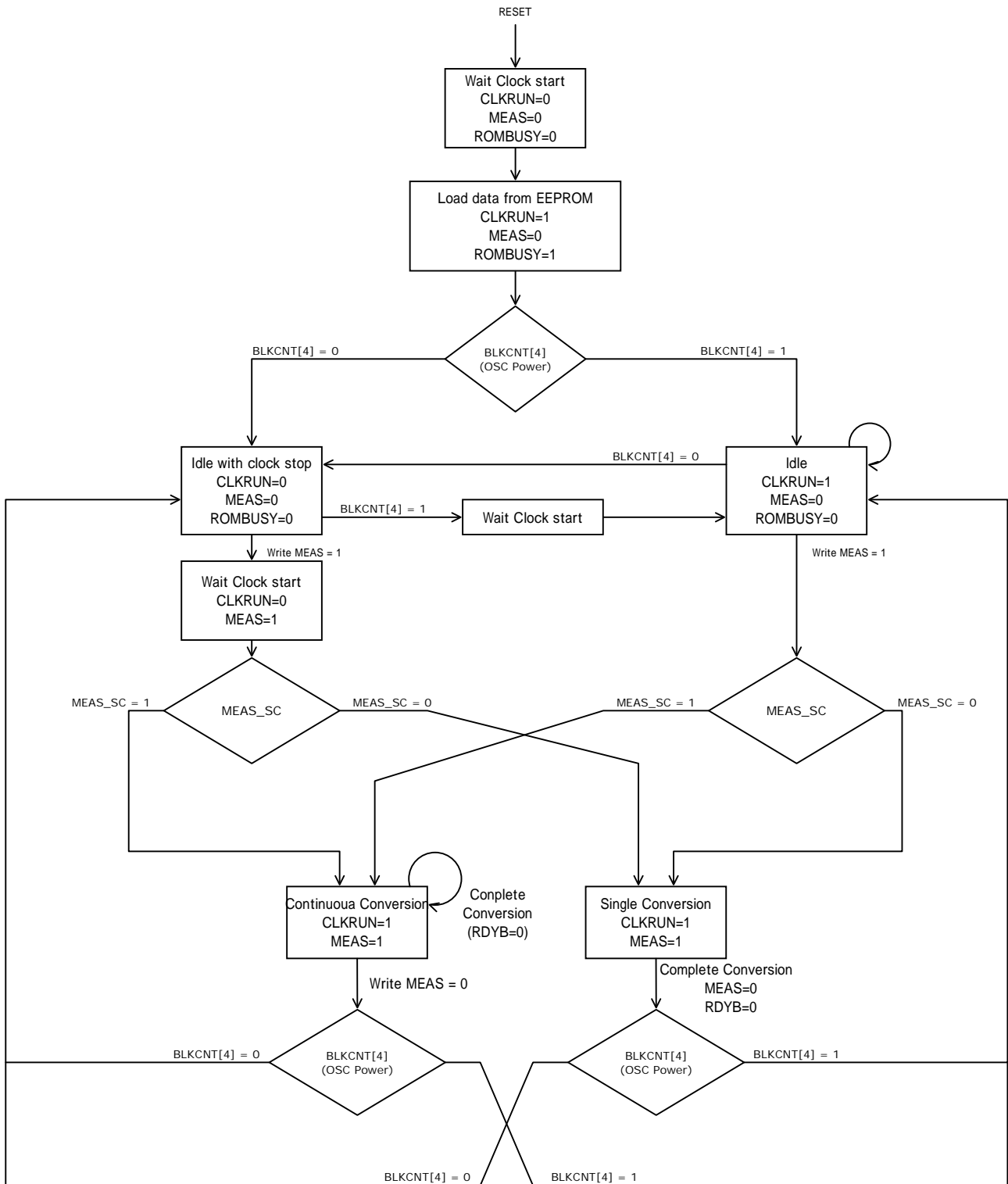
External EEPROM requires about 5ms of write time internally after write operation. During this period, NJU9101 cannot read/write from/to external EEPROM and external EEPROM returns 'NACK' for address byte. When NJU9101 starts to access to external EEPROM, NJU9101 does polling until receive 'ACK', and wait for completion of writing time in external EEPROM.

When NJU9101 is not connected with external EEPROM, address byte of NJU9101 always receives 'NACK'. Therefore, External EEPROM Control block in NJU9101 cannot stop polling. In such case, stop accessing to external EEPROM quickly by writing "1" to "ROMSTOP" bit, or it can break out of the polling by generating communication error ("ROMERR"="1") with fixed "0" for EXSDA terminal.

I<sup>2</sup>C-bus of external EEPROM uses 3-system clock every 1 bit transfer, therefore maximum translate is  $f_{in}/3$ [bps].

●  $\Delta\Sigma$  ADC control

$\Delta\Sigma$  ADC conversion flow is shown in below.



## ● Start-Up

After power-on reset or release I<sup>2</sup>C reset, start internal clock (OSC) and load data from external EEPROM to NJU9101's register. During loading, 'ROMBUSY' shows '1'. After finish loading to NJU9101's register, NJU9101 becomes idle state or idle state with clock stop which are following BLKCNT [4] setting.

## ● Idle State

"Idle state" means in the state which is not conversion state. In the idle state, 'BLKCNT [4](OSC power down)' bit changes the powered-on/off of system clock. During stopping the system clock, NJU9101 is idle state with clock stop, and it cannot write the data of NJU9101 register except 'CTRL' and 'BLKCNT' register. This means that **"Please write 'BLKCNT[4]='1', when change the data of NJU9101 register"**.

## ● Conversion

When write 'MEAS' bit = '1', conversion starts with following NJU9101 register setting.

First, Wake up time of modulator  $T_{wu}$  is required after conversion started.

$$T_{WU} = 20 / f_{mod} \quad [\text{sec}]$$

$T_{adc}$  is the time which is divided 'decimation rate (set in OSR / REJ bit) by  $f_{mod}$  (normal modulation clock frequency of  $\Delta\Sigma$  modulator  $\approx 153.6$  kHz).

$$T_{adc} = \text{Decimation rate} / f_{mod} \quad [\text{sec}]$$

Standard timing of ADC conversion is defined as  $T_{adc}$ .

And, after completion of conversion, it requires around 70 cycle of system clock ( $70 / f_{OSC}$ ) to do data corrective calculation.

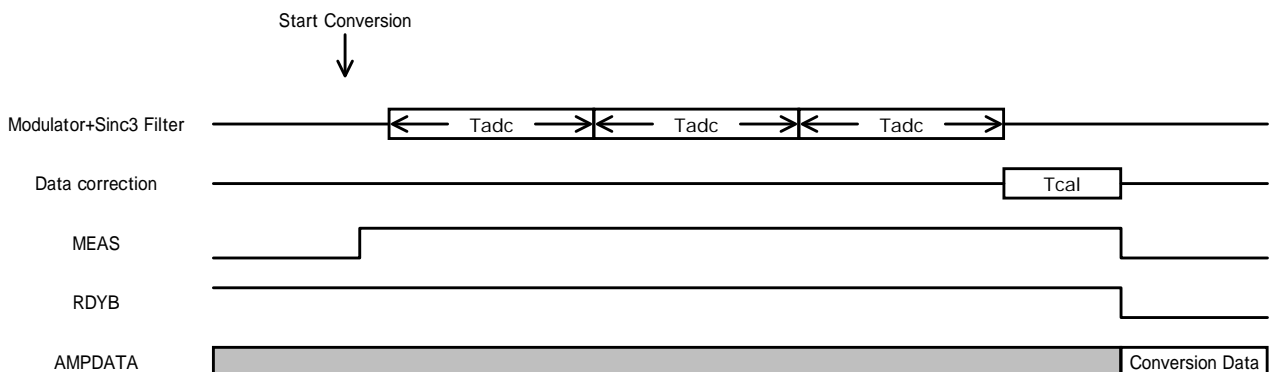
This calculation time is defined as  $T_{cal}$ .

$$T_{cal} = 70 / f_{OSC} \approx 230\mu \quad [\text{sec}]$$

## ● Single Conversion

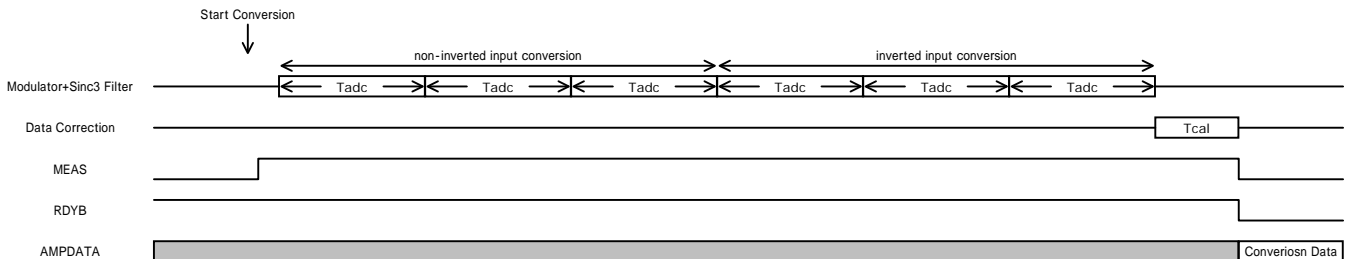
Conversion time of 'Single conversion' is ' $T_{wu} + 3 * T_{adc} + T_{cal}$ '. The settling time of ADC requires ' $3 * T_{adc}$ '.

After complete data correction, data register is updated, and RDYB bit is asserted.



### ● Single Conversion + Chopping Operation

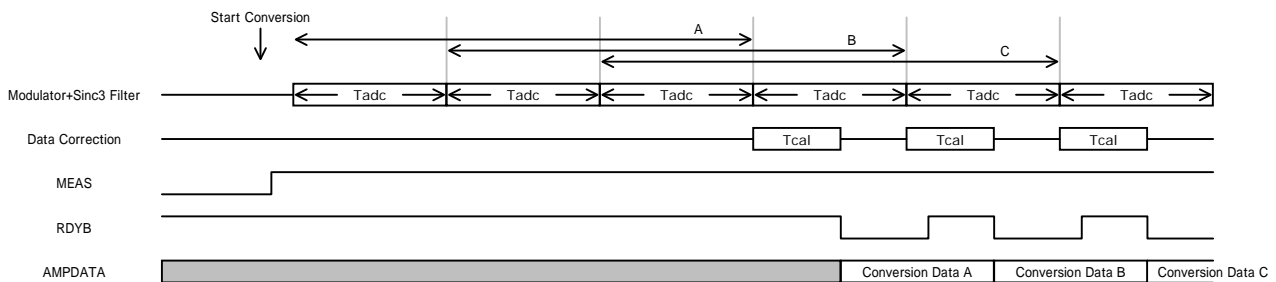
Conversion time of 'Single Conversion + Chopping Operation' is ' $T_{wu} + 6 * T_{adc} + T_{cal}$ '. The settling time of ADC requires ' $6 * T_{adc}$ '. After complete data correction, data register is updated, and 'RDYB' bit is asserted. And then, 'MEAS' bit turns to '0', become idle state again. Chopping operation can cancel offset voltage into ADC by swapping differential positive - negative input.



### ● Continuous Conversion

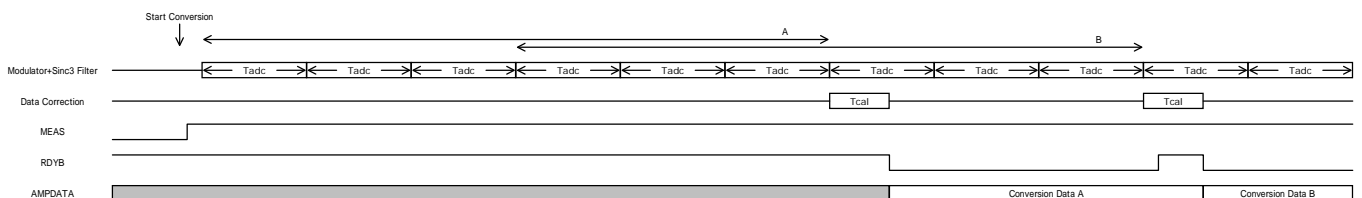
The first conversion time of 'Continuous Conversion' is ' $T_{wu} + 3 * T_{adc} + T_{cal}$ '. The settling time of ADC requires  $T_{adc}$ .

After complete the first conversion data correction, data register is updated, and RDYB bit is asserted. And after that, data register is updated and RDYB bit is asserted every  $T_{adc}$ . Conversion rate after the first conversion is  $1/T_{adc}$  [sps]. This conversion is continued until written 'MEAS = 0'.



### ● Continuous Conversion + Chopping Operation

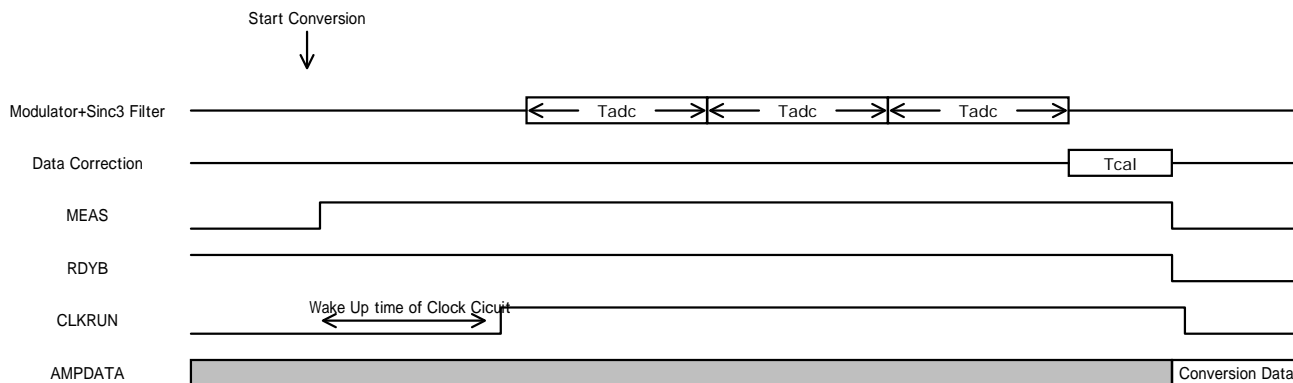
The first conversion time of 'Continuous Conversion + Chopping Operation' is ' $T_{wu} + 6 * T_{adc} + T_{cal}$ '. The settling time of ADC requires ' $6 * T_{adc}$ '. After complete data correction, data register is updated, and RDYB bit is asserted. And after that, data register is updated and RDYB bit is asserted every ' $3 * T_{adc}$ '. Conversion rate after the first conversion is ' $1/(3 * T_{adc})$ ' [sps]. This conversion is continued until written 'MEAS = 0'.





## ● Conversion at 'Idle state with Clock Stop'

In case of 'Idle state with Clock Stop (BLKCNT[4]=0)', it is necessary an additional time ( $\approx 450\mu\text{s}$ ) to wake up the clock circuit after start conversion trigger. When 'Single Conversion' is set, it turns 'Idle state with Clock Stop (BLKCNT [4] = 0)' automatically after complete the conversion.



## ● Power-Down Control

Power down control signal of each circuit block in NJU9101 is controlled by following registers value 'MEAS', 'MEAS\_SEL', 'VREFSEL', 'PAMPSEL', and 'BLKCNT[7:0]'.

### BIASRES circuit block power down

| Block   | BLKCNT [7] | Power Condition |
|---------|------------|-----------------|
| BIASRES | 0          | PWR DOWN        |
|         | 1          | OPERATE         |

### OPA circuit block power down

| Block | MEAS | MEAS_SEL [1:0] | BLKCNT [5] | Power Condition |
|-------|------|----------------|------------|-----------------|
| OPA   | 0    | -              | 0          | PWR DOWN        |
|       | 1    | 00 / 10        | 0          |                 |
|       | 1    | 01             | 0          | OPERATE         |
|       | -    | -              | 1          |                 |

### OPB circuit block power down

| Block | MEAS | MEAS_SEL [1:0] | BLKCNT [6] | Power Condition |
|-------|------|----------------|------------|-----------------|
| OPB   | 0    | -              | 0          | PWR DOWN        |
|       | 1    | 00 / 10        | 0          |                 |
|       | 1    | 01             | 0          | OPERATE         |
|       | -    | -              | 1          |                 |

## OSC circuit block power down

| Block | MEAS | BLKCNT [4] | BLKCNT [1] | Power Condition |
|-------|------|------------|------------|-----------------|
|       |      | OSC        | ADC        |                 |
| OSC   | 0    | 0          | 0          | PWR DOWN        |
|       | 1    | 0          | 0          | OPERATE         |
|       | -    | 1          | -          |                 |
|       | -    | -          | 1          |                 |

## PREAMP circuit block power down

| Block  | MEAS | MEAS_SEL [1:0] | PAMPSEL | BLKCNT [3] | Power Condition |
|--------|------|----------------|---------|------------|-----------------|
| PREAMP | 0    | -              | -       | 0          | PWR DOWN        |
|        | 1    | 00             | -       | -          | OPERATE         |
|        | 1    | 01 / 10        | 0       | 0          | PWR DOWN        |
|        | 1    | 01 / 10        | 1       | 0          | OPERATE         |
|        | -    | -              | -       | 1          |                 |

## 2.048V INTVREF circuit block power down

| Block   | MEAS | MEAS_SEL [1:0] | BIASSEL | VREFSEL | BLKCNT [2] | Power Condition |
|---------|------|----------------|---------|---------|------------|-----------------|
| INTVREF | 0    | -              | 1       | -       | 0          | PWR DOWN        |
|         | 1    | 00             | 1       | -       | 0          | OPERATE         |
|         | 1    | 01 / 10        | 1       | 0       | 0          |                 |
|         | 1    | 01 / 10        | 1       | 1       | 0          | PWR DOWN        |
|         | -    | -              | 1       | -       | 1          | OPERATE         |
|         | -    | -              | 0       | -       | -          |                 |

## ADC circuit block power down

| Block | MEAS | BLKCNT [1] | Power Condition |
|-------|------|------------|-----------------|
| ADC   | 0    | 0          | PWR DOWN        |
|       | 1    | 0          | OPERATE         |
|       | -    | 1          |                 |

## Temperature Sensor circuit power down

| Block        | MEAS | MEAS_SEL [1:0] | BLKCNT [0] | Power Condition |
|--------------|------|----------------|------------|-----------------|
| Temp. Sensor | 0    | -              | 0          | PWR DOWN        |
|              | 1    | 00             | 0          | OPERATE         |
|              | 1    | 01 / 10        | 0          | PWR DOWN        |
|              | -    | -              | 1          | OPERATE         |

## ● Data Processing

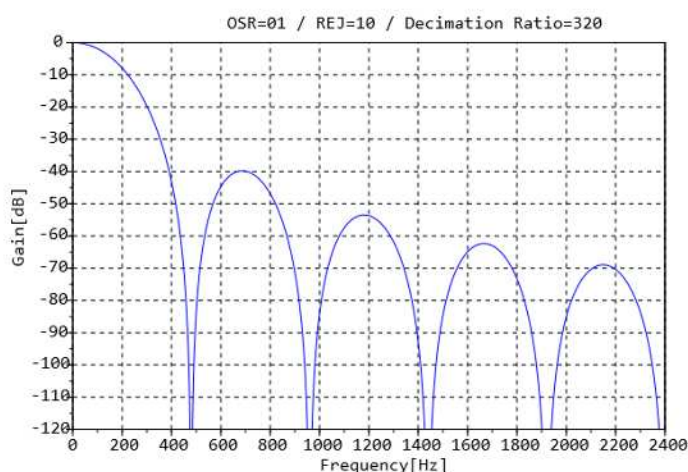
Analog Input is modulated to PDM signal by 2<sup>nd</sup> Order  $\Delta\Sigma$  modulator. And then, this PDM signal changes to PCM signal by Sinc3 Digital Filter. Sinc3 Digital Output data is stored to AMPDATA / AUXDATA / TMPDATA register after data calibration.

## ● $\Delta\Sigma$ Modulator

Normal modulation clock frequency of  $\Delta\Sigma$  (Sigma Delta) modulator (fmod) is 153.6 kHz. This frequency (fmod) is the over-sampling clock of the ADC which is divided OSC system clock (f<sub>OSC</sub>) with setting of 'CLKDIV' bit. Modulated ratio of this modulator is 66.7%. When +1.5Vpp of differential signal is input, modulated output goes to +1Vpp.

## ● Sinc3 Digital Filter

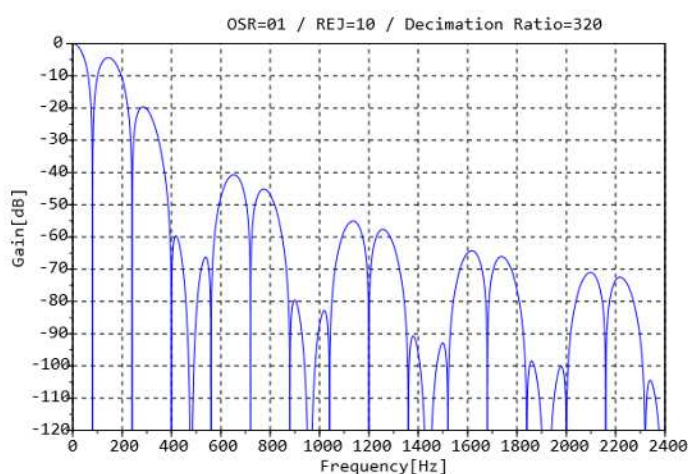
Digital Filter in NJU9101 is 3<sup>rd</sup> Order Sinc-Filter that has 768 of maximum decimation ratio. This decimation ratio can be set by 'OSR' and 'REJ' bit.



### ■ Sinc3 filter frequency example 1 (CHOPPING OFF setting example)

Conversion Time = 7.5ms (Single conversion)

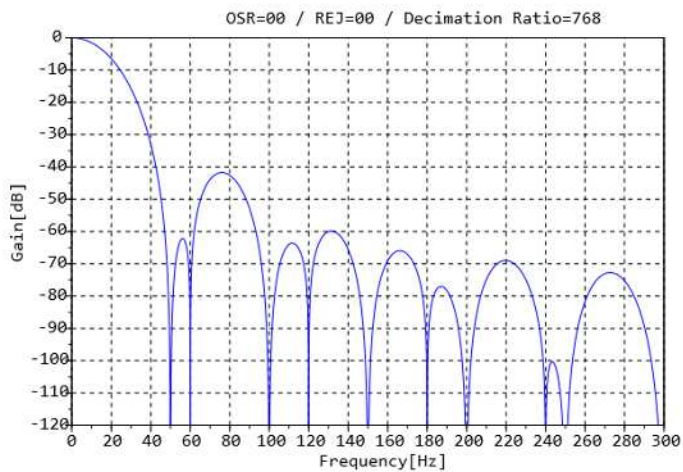
Decimation Ratio=320  
(OSR=01, REJ=10, CLKDIV=00, ADCCHOP=0)



### ■ Sinc3 filter frequency example 2 (CHOPPING ON setting example)

Conversion Time = 13.8ms (Single conversion)

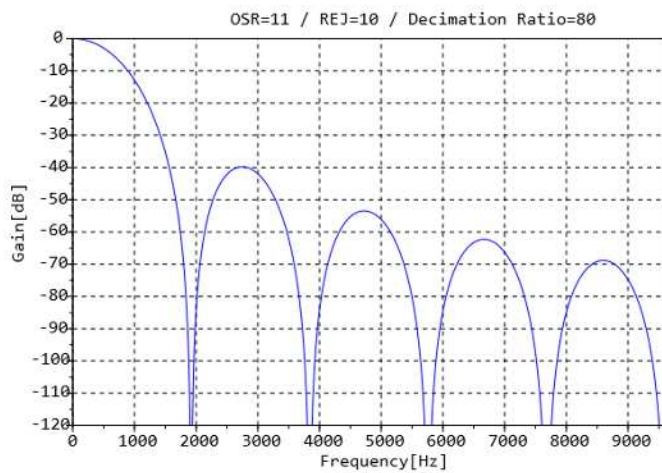
Decimation Ratio = 320  
(OSR=01, REJ=10, CLKDIV=00, ADCCHOP=1)



- Sinc3 filter frequency example 3  
(50 / 60Hz Reduction setting example)

Conversion Time = 61.6ms (Single Conversion)

Decimation Ratio = 768  
(OSR=00, REJ=00, CLKDIV=10, ADCCHOP=0)



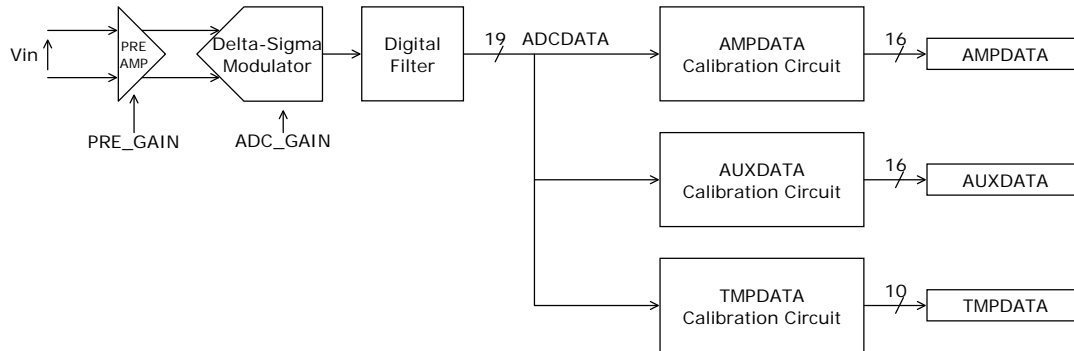
- Sinc3 filter frequency example 4  
(Fastest Conversion Time setting example)

Conversion Time = 2.8ms (Single Conversion)

Decimation Ratio = 80  
(OSR=11, REJ=10, CLKDIV=00, ADCCHOP=0)

### ● Data Calibration

Analog Input is modulated to PDM signal by 2<sup>nd</sup> Order  $\Delta\Sigma$  modulator. And then, this PDM signal is changed to signed 19 bit PCM signal (ADCDATA) by Sinc3 Digital Filter. The full-scale range of ADCDATA is -262144 ~ +26143 (0x40000 ~ 0x3FFFF). ADCDATA is stored to AMPDATA / AUXDATA / TMPDATA register after data calibration.



Regarding calculation of ADCDATA, Voltage GAIN of PREAMP ( $G_{pre}$ ) and Conversion GAIN of ADC ( $G_{adc}$ ) are defined as below,

Gain of PREAMP

| PAMPSEL | PRE_GAIN | $G_{pre}$ |
|---------|----------|-----------|
| 0       | XX       | 1         |
| 1       | 00       | 1         |
| 1       | 01       | 2         |
| 1       | 10       | 4         |
| 1       | 11       | 8         |

Gain of ADC

| ADC_GAIN | $G_{adc}$ |
|----------|-----------|
| 00       | 1         |
| 01       | 2         |
| 10       | 4         |
| 11       | 8         |

When it is assumed that

“Vref” :Reference Voltage selected by “VREFSEL”bit.

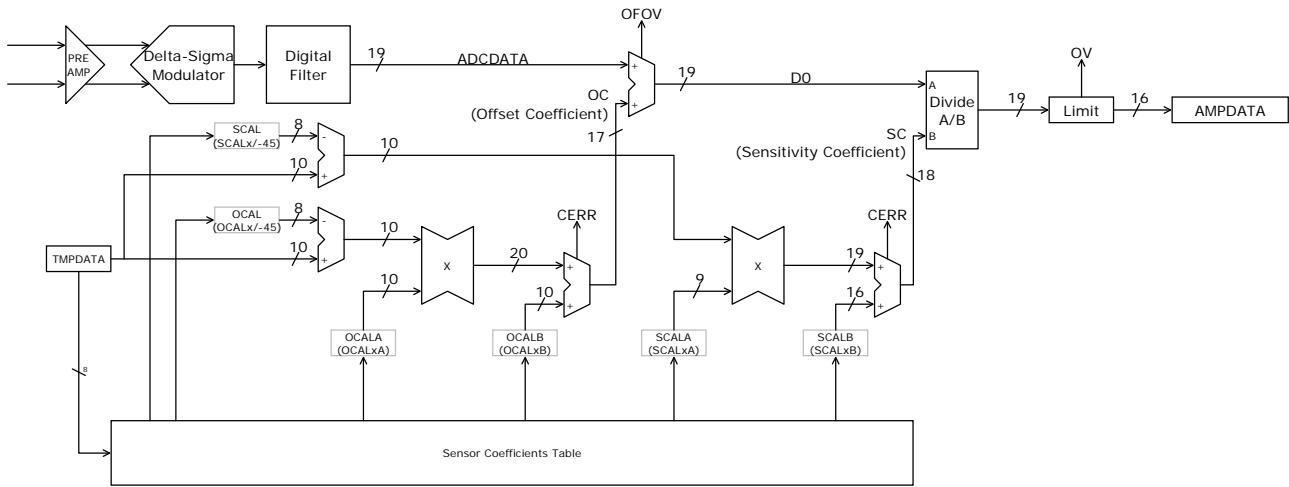
“Vin” :Differential Input Voltage of PREAMP

Digital Filter Output (ADCDATA) is output as below, when ADCDATA range is limited as signed 19 bit range (min:-262144(0x40000), max:+26143(0x3FFFF)).

$$ADCDATA = 262144 \times G_{pre} \times G_{adc} \times \frac{2}{3} \times \frac{V_{in}}{V_{ref}}$$

### ● AMPDATA Calibration

AMPDATA Calibration has temperature calibration of offset and Sensitivity for ADCDATA. And then, calibrated data is stored to AMPDATA[15:0] register. AMPDATA calibration path is shown in below.



Calibration coefficients for offset are set for four temperature areas. For these temperature areas, 0-order coefficient (offset value: OCALxB at OCALx[°C]) and 1<sup>st</sup>-order coefficient (temperature slope: OCALxA) are set. These temperature area are set by OCALx[°C] (-45°C ≤ OCAL1 < OCAL2 < OCAL3 ≤ 127°C). These coefficients are automatically selected by TEMPDATA value. Offset Calibration coefficient “OC” is signed 17-bits factor and calculated as below

| Condition                      | Calculation  |
|--------------------------------|--|
| -45 ≤ TEMPDATA [9:2] < OCAL1   | $OC = [ \{TEMPDATA - (-45 \times 4)\} \times OCAL1A ] + (OCAL1B \times 4)$   |
| OCAL1 ≤ TEMPDATA [9:2] < OCAL2 | $OC = [ \{TEMPDATA - (OCAL1 \times 4)\} \times OCAL2A ] + (OCAL2B \times 4)$ |
| OCAL2 ≤ TEMPDATA [9:2] < OCAL3 | $OC = [ \{TEMPDATA - (OCAL2 \times 4)\} \times OCAL3A ] + (OCAL3B \times 4)$ |
| OCAL3 ≤ TEMPDATA [9:2]         | $OC = [ \{TEMPDATA - (OCAL3 \times 4)\} \times OCAL4A ] + (OCAL4B \times 4)$ |

\* When “OC” value exceeds signed 17-bits range (-65536 ~ +65535 (0x10000 ~ 0x0FFFF)), “CERR” bit is set as error flag of offset calibration coefficient. In this situation, AMPDATA is not correct value.

And then, ADCDATA and offset coefficient “OC” are summed. Converted DATA “D0” is calculated as below,

$$D0 = ADCDATA + (OC \times 4)$$

\* When “D0” value exceeds signed 19-bits range (-262144 ~ +262143 (0x40000 ~ 0x3FFFF)), “OFOV” bit is set as error flag. In this situation, AMPDATA is not correct value.

Calibration coefficients for sensitivity are set for four temperature areas. For these temperature areas, 0-order coefficient (sensitivity value: SCALxB at SCALx[°C]) and 1<sup>st</sup>-order coefficient (temperature slope: SCALxA) are set. These temperature area are set by SCALx[°C] (-45°C ≤ SCAL1 < SCAL2 < SCAL3 ≤ 127°C). These coefficients are automatically selected by TEMPDATA value. Sensitivity Calibration coefficient “SC” is unsigned 18-bits factor and calculated as below.

| Condition  | Caluculation   |
|--|--|
| $-45 \leq \text{TMPDATA}[9:2] < \text{SCAL1}$          | $\text{SC} = [\{\text{TMPDATA} - (-45 \times 4)\} \times \text{SCAL1A}] + (\text{SCAL1B} \times 4)$          |
| $\text{SCAL1} \leq \text{TMPDATA}[9:2] < \text{SCAL2}$ | $\text{SC} = [\{\text{TMPDATA} - (\text{SCAL1} \times 4)\} \times \text{SCAL2A}] + (\text{SCAL2B} \times 4)$ |
| $\text{SCAL2} \leq \text{TMPDATA}[9:2] < \text{SCAL3}$ | $\text{SC} = [\{\text{TMPDATA} - (\text{SCAL2} \times 4)\} \times \text{SCAL3A}] + (\text{SCAL3B} \times 4)$ |
| $\text{SCAL3} \leq \text{TMPDATA}[9:2]$                | $\text{SC} = [\{\text{TMPDATA} - (\text{SCAL3} \times 4)\} \times \text{SCAL4A}] + (\text{SCAL4B} \times 4)$ |

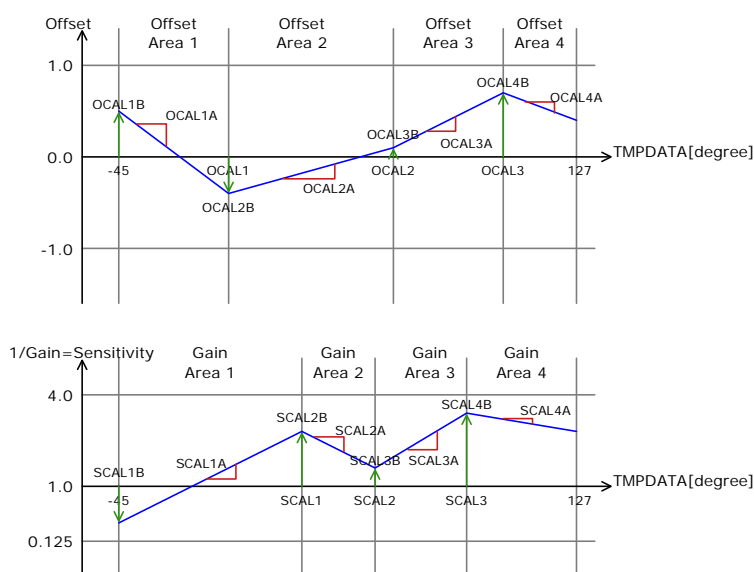
\* When "SC" value exceeds the range of 8192 ~ 262143 (0x2000 ~ 0x3FFFF), "CERR" bit is set as error flag of sensitivity calibration coefficient. In this situation, AMPDATA is not correct value. And when "SC" value is regarded as signed 2.16 fixed point, this data range is equivalent to 4.0 ~ 0.125.

For Sensitivity calculation, offset conversion data "D0" is divided by "SC". This result (quotient) is rounded to integer, and then, AMPDATA is decided.

$$\text{AMPDATA} = \text{Round}\left(\frac{D0 \times 2^{14}}{SC}\right)$$

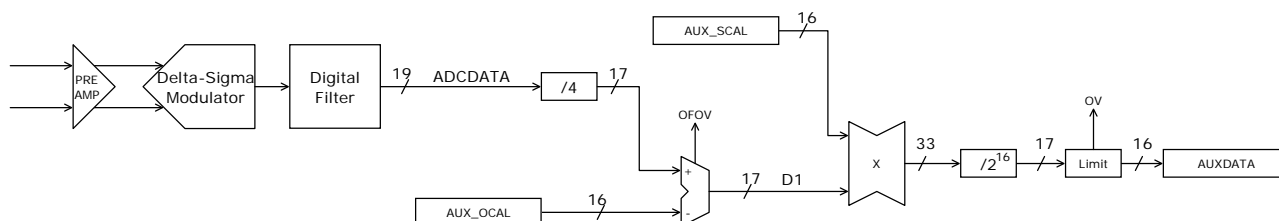
\* When AMPDATA value exceeds signed 16-bits range (-32768 ~ +32767 (0x8000 ~ 0x7FFF)), "OV" bit is set as error flag. In this situation, ADCDATA value is limited to min: -32768(0x8000) or max: +32767(0x7FFF), and then stored to AMPDATA register.

|              | Register        | Calibration Range |                | Set Resolution |                        |             |
|--------------|-----------------|-------------------|----------------|----------------|------------------------|-------------|
|              |                 | ±1.0 conv.        | 14-Bit conv.   | ±1.0 conv.     | 14-Bit conv.           |             |
| Offset coef. |                 |                   |                |                |                        |             |
|              | 0 <sup>th</sup> | OCALxB            | ±1.0           | ±8192          | 1 / (2 <sup>14</sup> ) | 0.5LSB      |
|              | 1 <sup>st</sup> | OCALxA            | ±0.03125 / °C  | ±256LSB / °C   | 1 / (2 to 14) / °C     | 0.5LSB / °C |
| Sens coef.   |                 |                   |                |                |                        |             |
|              | 0 <sup>th</sup> | SCALxB            | x0.125 to x4.0 | -              | 61ppm                  | -           |
|              | 1 <sup>st</sup> | SCALxA            | ±15625ppm / °C | -              | 61ppm / °C             | -           |



## ● AUXDATA Calibration

AUXDATA Calibration has offset and Sensitivity calibration for ADCDATA. And then, calibrated data is stored to AUXDATA[15:0] register. AUXDATA calibration path is shown in below.



Conversion Data “D1” after offset calibration is calculated as below. (Low order 2-bit of ADCDATA are rounded down)

$$D1 = \text{Truncate}\left(\frac{ADCDATA}{4}\right) - \text{AUX\_OCAL}$$

\* When “D1” value exceeds signed 17-bits range (-65536 ~ +65535 (0x10000 ~ 0x0FFFF)), “OFOV” bit is set as error flag. In this situation, AUXDATA value is not correct value.

For sensitivity calibration, it is multiplied conversion data “D1” by “AUX\_SCAL” coefficient. This result (product) is divided by 2<sup>16</sup>, and is rounded to integer. And then, AMPDATA is decided.

$$\text{AUXDATA} = \text{Round}\left(\frac{D1 \times \text{AUX\_SCAL}}{2^{16}}\right)$$

\* When AUXDATA value exceeds signed 16-bits range (-32768 ~ +32767 (0x8000 ~ 0x7FFF)), “OV” bit is set as error flag. In this situation, ADCDATA value is limited to min: -32768(0x8000) or max: +32767(0x7FFF), and then stored to AUXDATA register.

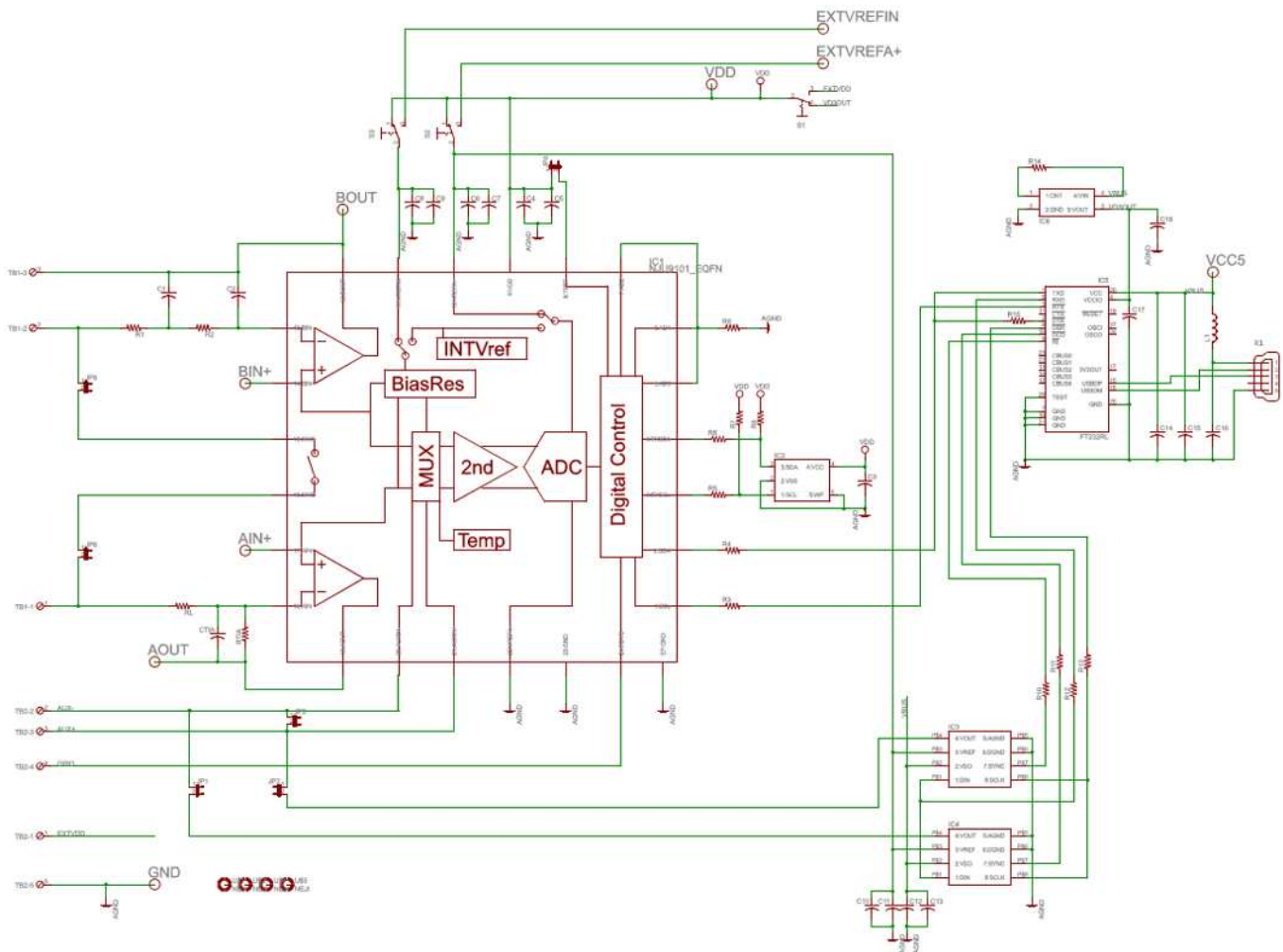
|                               | Register | Calibration Range |              | Set Resolution         |              |
|-------------------------------|----------|-------------------|--------------|------------------------|--------------|
|                               |          | ±1.0 conv.        | 14-Bit conv. | ±1.0 conv.             | 14-Bit conv. |
| Offset calibration coef.      | AUX_OCAL | ±0.5              | ±4096        | 1 / (2 <sup>17</sup> ) | 0.125LSB     |
| Sensitivity calibration coef. | AUX_SCAL | x0.0 to x2.0      | -            | 30.5ppm / °C           | -            |

## TMPDATA Calibration

TMPDATA data conversion are converted ADCDATA to temperature code. In TMPDATA conversion, fixed setting of these bits “VREFSEL”, “ADC\_GAIN”, PRE\_GAIN” are used. TMPDATA is converted to signed 10-bits data shown as 0.25°C/LSB. The data range of TMPDATA is -45.00°C ~ +127.75°C (0x34C ~ 0x1FF). When converted value exceeds this range, “OV” bit is set as error flag. In this situation, ADCDATA value is limited to min: -45.00°C (0x34C) or max: +127.75°C (0x1FF), and then stored to TMPDATA register.



## ■EVALUATION BOARD · PCB LAYOUT



(Note) Install the decoupling capacitor in the proximity of the NJU9101.

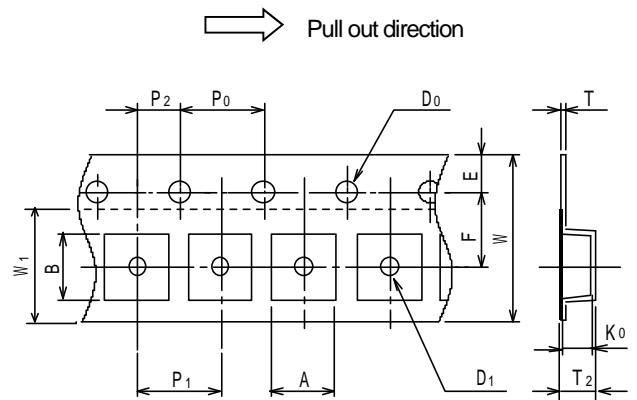
[illegible]

Technical drawing of a rectangular plate with dimensions and hole positions. The overall dimensions are 4.3 (width) and 4.3 (height). The central rectangular area has dimensions 2.5 (width) and 2.5 (height). There are 12 rectangular holes arranged in a 3x4 grid. The horizontal spacing between the centers of the holes is 0.5, and the vertical spacing is 0.5. The distance from the left edge to the first hole is 0.6, and the distance from the bottom edge to the first hole is 0.25. The distance from the right edge to the last hole is 0.5, and the distance from the top edge to the last hole is 0.5.

## ■PACKING SPECIFICATION

### EQFN Emboss Taping (TE1)

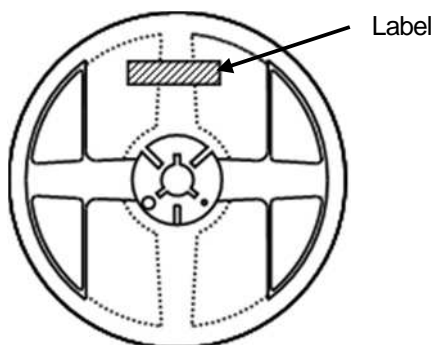
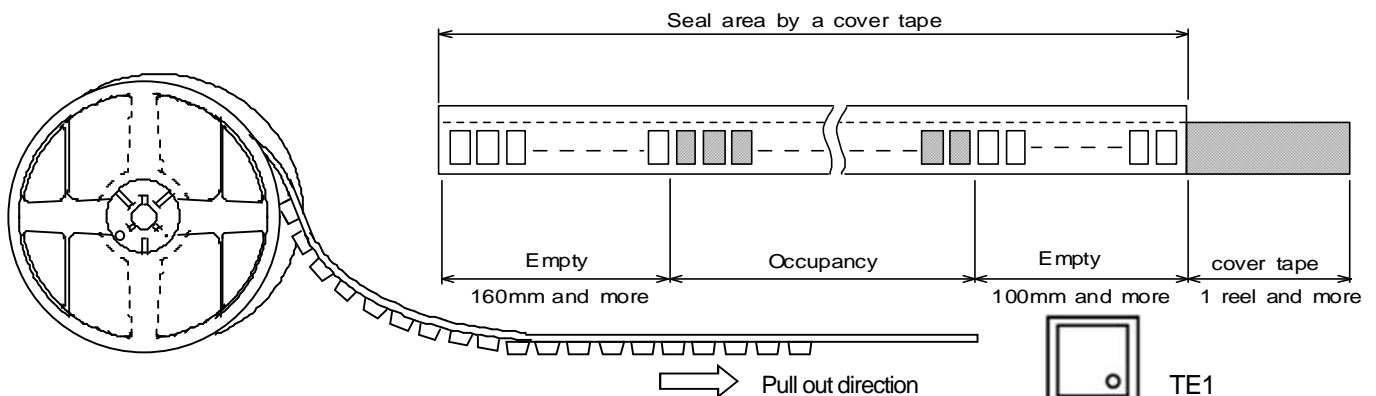
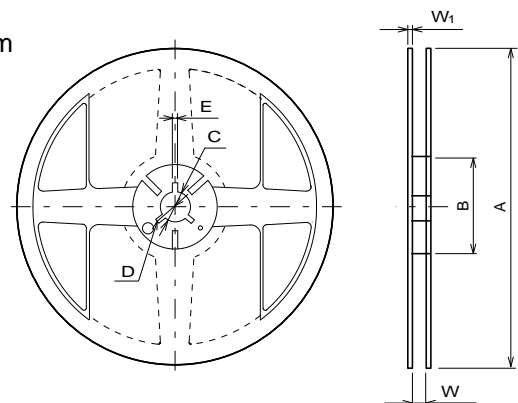
| Symbol         | EQFN18-E7  | EQFN24-LK  | EQFN24-LE  | Remark           |
|----------------|------------|------------|------------|------------------|
| A              | 2.25±0.05  | 4.35±0.05  | 4.35±0.05  | Bottom size      |
| B              | 2.25±0.05  | 4.35±0.05  | 4.35±0.05  | Bottom size      |
| D <sub>0</sub> | 1.5+0.1/-0 | 1.5+0.1/-0 | 1.5+0.1/-0 |                  |
| D <sub>1</sub> | 0.5±0.1    | 1.0±0.1    | 1.0±0.1    |                  |
| E              | 1.75±0.1   | 1.75±0.1   | 1.75±0.1   |                  |
| F              | 3.5±0.05   | 5.5±0.05   | 5.5±0.05   |                  |
| P <sub>0</sub> | 4.0±0.1    | 4.0±0.1    | 4.0±0.1    |                  |
| P <sub>1</sub> | 4.0±0.1    | 8.0±0.1    | 8.0±0.1    |                  |
| P <sub>2</sub> | 2.0±0.05   | 2.0±0.05   | 2.0±0.05   |                  |
| T              | 0.25±0.05  | 0.3±0.05   | 0.3±0.05   |                  |
| T <sub>2</sub> | 1.0±0.07   | 1.3±0.07   | 1.3±0.07   |                  |
| K <sub>0</sub> | 0.65±0.05  | -          | -          |                  |
| W              | 8.0±0.2    | 12.0±0.3   | 12.0±0.3   |                  |
| W <sub>1</sub> | 5.5        | 9.5        | 9.5        | Thickness 0.1MAX |



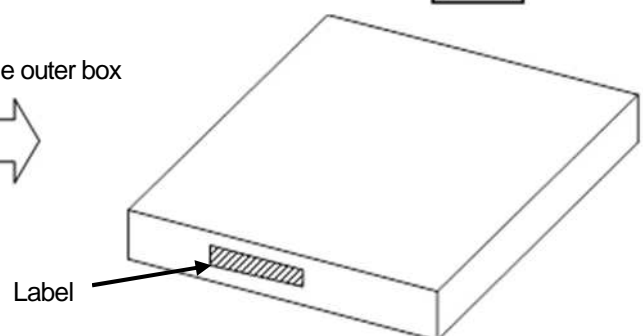
Unit: mm

| Symbol         | EQFN18-E7     | EQFN24-LK     | EQFN24-LE |
|----------------|---------------|---------------|-----------|
| A              | Ø 180 +0/-1.5 | Ø 180 +0/-1.5 |           |
| B              | Ø 60 +1/-0    | Ø 60 +1/-0    |           |
| D <sub>0</sub> | Ø 13±0.2      | Ø 13±0.2      |           |
| D <sub>1</sub> | Ø 21±0.8      | Ø 21 ±0.8     |           |
| E              | 2.0±0.5       | 2.0±0.5       |           |
| W              | 9.0+0.3/-0    | 13.0+1.0/-0   |           |
| W <sub>1</sub> | 1.2           | 1.2           |           |
| Contents       | 3,000pcs      | 1,000pcs      |           |

Unit: mm

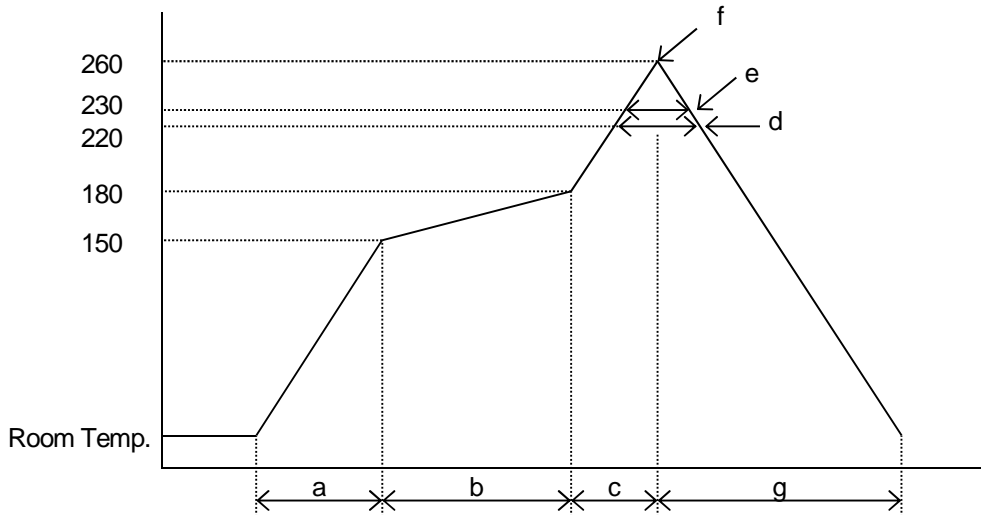


Put in the outer box



# **■RECOMMENDED MOUNTING METHOD**

\* Recommended reflow soldering procedure



|                                 |                              |
|---------------------------------|------------------------------|
| a: Temperature ramping rate     | : 1 to 4 /s                  |
| b: Pre-heating temperature time | : 150 to 180<br>: 60 to 120s |
| c: Temperature ramp rate        | : 1 to 4 /s                  |
| d: 220 or higher time           | : Shorter than 60s           |
| e: 230 or higher time           | : Shorter than 40s           |
| f: Peak temperature             | : Lower than 260             |
| g: Temperature ramping rate     | : 1 to 6 /s                  |

The temperature indicates at the surface of mold package.

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