

# R2A20169NP/SA/SP

8-bit 12ch D/A Converter with Buffer Amplifiers

R03DS0020EJ0300

Rev.3.00

Jul 25, 2013

## Description

The R2A20169 is an integrated circuit semiconductor of CMOS structure with 12 channels of built in D/A unnecessary and enabling configuration of a system with few component parts.

Serial data transfer type input can easily be used through a combination of three lines: DI, CLK, and LD.

Outputs incorporate buffer op-amps that have a drive capacity of 1 mA or above for both sink source, and can operate over the entire voltage range from almost ground to Vcc ( 0 to 5V ), making peripheral elements unnecessary and enabling configuration of a system with few component parts.

Very small QFN package is added to lineup. It is suitable for a small mounting and reduces the mounting area.

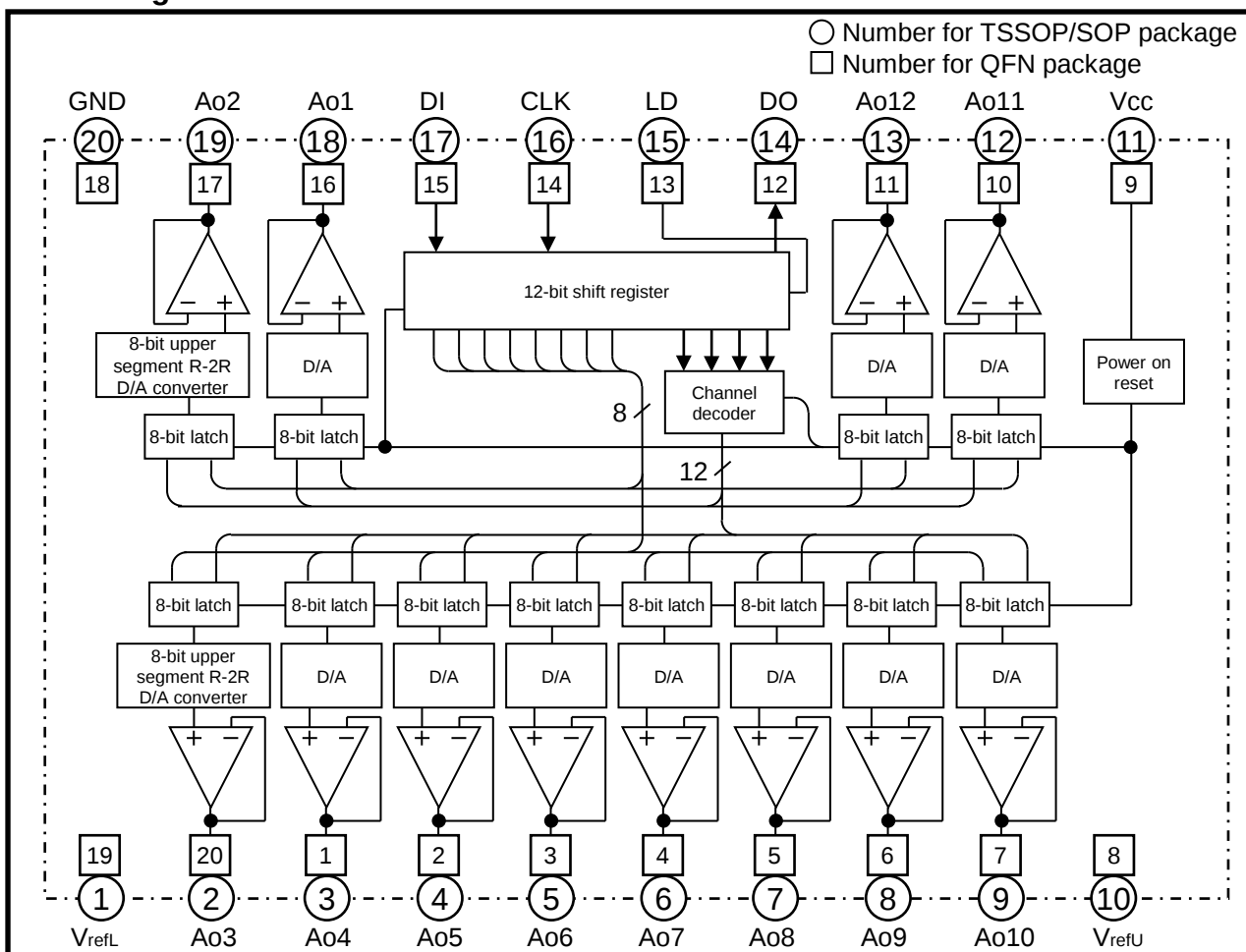
## Features

- Guarantee Nonlinearity error :  $\pm 1.0\text{LSB}$ , Differential nonlinearity error :  $\pm 0.7\text{LSB}$
- Data transfer format: 12-bit serial data input type by 3 wire ( DI, SCK, LD )
- Output buffer op-amps: Operable over entire voltage range from almost ground to Vcc ( 0 to 5V )
- High output current capacity:  $\pm 1\text{mA}$  or Higher
- Very small size package line-up: QFN-20 (pin pitch: 0.5mm), TSSOP-20 (pin pitch 0.65mm)

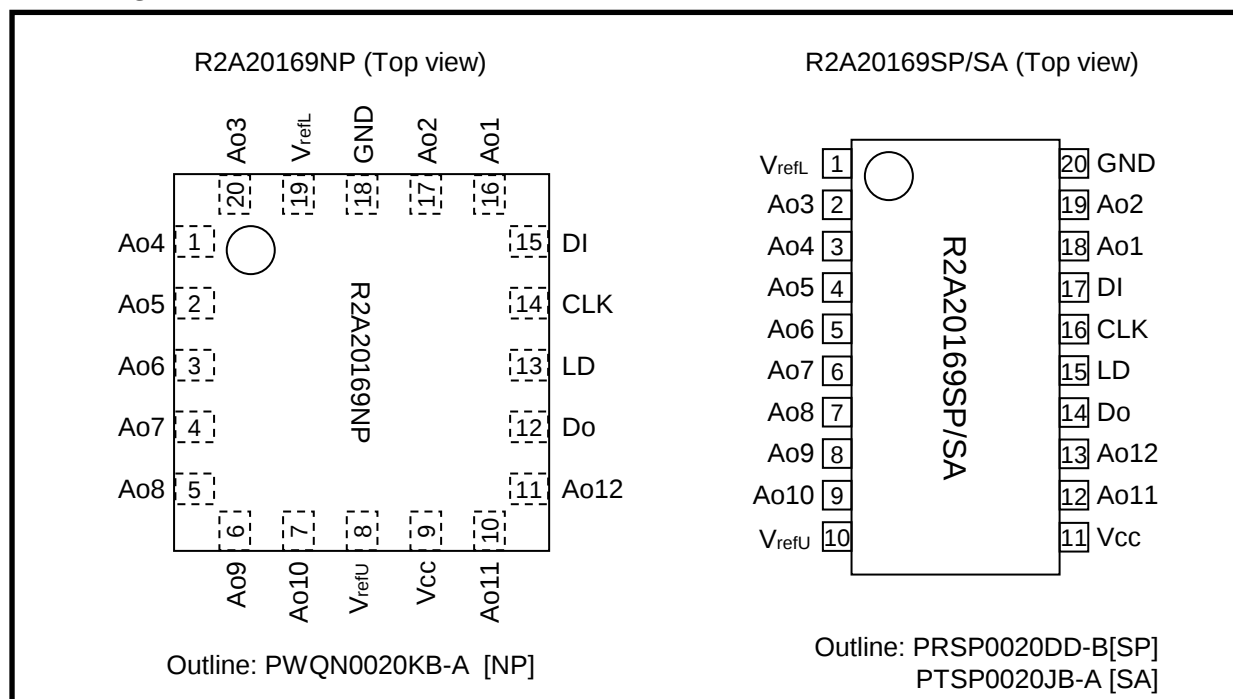
## Application

- Conversion from digital data to analog control data for home-use and industrial equipment.

## Block Diagram



## Pin Arrangement



## Pin Description

| Pin No. |              | Pin Name          | Function                                                                                                                           |
|---------|--------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------|
| [QFN]   | [TSSOP /SOP] |                   |                                                                                                                                    |
| 15      | 17           | DI                | Serial data input terminal.<br>(Input serial data with a 12-bit data length.)                                                      |
| 12      | 14           | Do                | Serial data output terminal<br>(Data is sequentially output from the MSB bit.)                                                     |
| 14      | 16           | CLK               | Serial clock input terminal<br>(Input signal from DI terminal is input to 12-bit shift register at rise of serial clock.)          |
| 13      | 15           | LD                | Load terminal<br>(When High level is input to LD terminal, value in 12-bit shift register is loaded into decoder and 8-bit latch.) |
| 16      | 18           | Ao1               | 8-bit resolution D/A converter output terminals<br>(After power-on, all channels are reset and DAC data 00h is output.)            |
| 17      | 19           | Ao2               |                                                                                                                                    |
| 20      | 2            | Ao3               |                                                                                                                                    |
| 1       | 3            | Ao4               |                                                                                                                                    |
| 2       | 4            | Ao5               |                                                                                                                                    |
| 3       | 5            | Ao6               |                                                                                                                                    |
| 4       | 6            | Ao7               |                                                                                                                                    |
| 5       | 7            | Ao8               |                                                                                                                                    |
| 6       | 8            | Ao9               |                                                                                                                                    |
| 7       | 9            | Ao10              |                                                                                                                                    |
| 10      | 12           | Ao11              |                                                                                                                                    |
| 11      | 13           | Ao12              |                                                                                                                                    |
| 9       | 11           | V <sub>cc</sub>   | Power supply terminal                                                                                                              |
| 18      | 20           | GND               | GND terminal                                                                                                                       |
| 8       | 10           | V <sub>refU</sub> | D/A converter upper reference voltage input terminal                                                                               |
| 19      | 1            | V <sub>refL</sub> | D/A converter lower reference voltage input terminal                                                                               |

**Absolute Maximum Ratings**

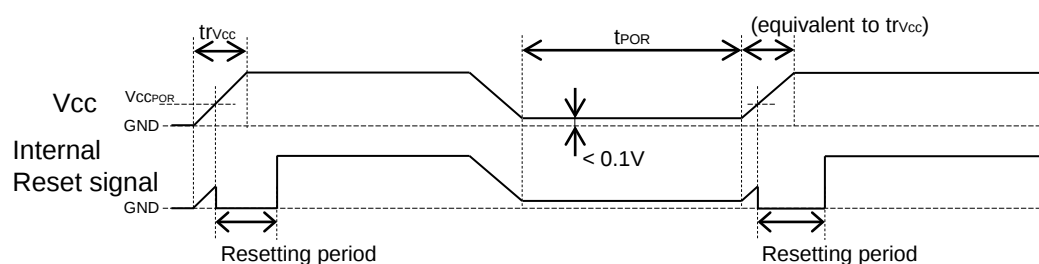
(Ta = +25deg unless otherwise noted)

| Item                                  | Symbol            | Conditions  | Ratings                             | Unit   |
|---------------------------------------|-------------------|-------------|-------------------------------------|--------|
| Supply voltage                        | V <sub>CC</sub>   |             | -0.3 to +6.5                        | V      |
| D/A converter upper reference voltage | V <sub>refU</sub> |             | -0.3 to +6.5                        | V      |
| D/A converter lower reference voltage | V <sub>refL</sub> |             | -0.3 to +6.5                        | V      |
| Buffer amplifier output current       | I <sub>AO</sub>   | Continuous  | -2.0 to +2.0                        | mA     |
| Input voltage                         | V <sub>IN</sub>   |             | -0.3 to V <sub>CC</sub> +0.3 < +6.5 | V      |
| Output voltage                        | V <sub>O</sub>    |             | -0.3 to V <sub>CC</sub> +0.3 < +6.5 | V      |
| Power dissipation                     | P <sub>d</sub>    | Ta = +85deg | 290(NP) / 150(SA) / 300(SP)         | mW     |
| Thermal derating factor               | K theta           | Ta > +25deg | 7.25(NP) / 3.75(SA) / 7.5(SP)       | mW/deg |
| Operating temperature                 | T <sub>opr</sub>  |             | -30 to +85                          | deg    |
| Storage temperature                   | T <sub>stg</sub>  |             | -40 to +125                         | deg    |

**Electrical Characteristics**« Digital Part » (V<sub>CC</sub>, V<sub>refU</sub> = +5V +/-10%, V<sub>CC</sub> > V<sub>refU</sub>, GND, V<sub>refL</sub> = 0V, Ta = -30 to +85deg, Unless otherwise noted)

| Item                                                     | Symbol             | Test conditions                                         | Limits                |     |                    | Unit |
|----------------------------------------------------------|--------------------|---------------------------------------------------------|-----------------------|-----|--------------------|------|
|                                                          |                    |                                                         | Min                   | Typ | Max                |      |
| Supply voltage                                           | V <sub>CC</sub>    |                                                         | 2.7                   | 5.0 | 5.5                | V    |
| Supply current                                           | I <sub>CC</sub>    | CLK = 1MHz, V <sub>CC</sub> = 5V, I <sub>AO</sub> = 0μA | -                     | 0.6 | 1.8                | mA   |
| Input leak current                                       | I <sub>ILK</sub>   | V <sub>IN</sub> = 0 to V <sub>CC</sub>                  | -10                   | -   | 10                 | μA   |
| Input low voltage                                        | V <sub>IL</sub>    |                                                         | -                     | -   | 0.2V <sub>CC</sub> | V    |
| Input high voltage                                       | V <sub>IH</sub>    | 4.0V < V <sub>CC</sub>                                  | 0.5V <sub>CC</sub>    | -   | -                  | V    |
|                                                          |                    | V <sub>CC</sub> < 4.0V                                  | 0.8V <sub>CC</sub>    | -   | -                  | V    |
| Output low voltage                                       | V <sub>OL</sub>    | 4.0V < V <sub>CC</sub> , I <sub>OL</sub> = 2.0 mA       | -                     | -   | 0.4                | V    |
|                                                          |                    | V <sub>CC</sub> < 4.0V, I <sub>OL</sub> = 1.5 mA        | -                     | -   | 0.4                | V    |
| Output high voltage                                      | V <sub>OH</sub>    | I <sub>OH</sub> = -400 μA                               | V <sub>CC</sub> - 0.4 | -   | -                  | V    |
| Supply voltage rise time *1                              | t <sub>rVCC</sub>  | V <sub>CC</sub> = 0 @ 2.7V                              | 100                   | -   | -                  | μs   |
| Internal reset operating voltage *1                      | V <sub>CCPOR</sub> | V <sub>CC</sub> = 0 @ 2.7V                              | -                     | 1.5 | 1.9                | V    |
| Power supply restart interval (Power supply OFF à ON) *1 | t <sub>POR</sub>   | V <sub>CC</sub> < 0.1V                                  | 1                     | -   | -                  | ms   |

\*1 : When power supply is turned on, internal circuit is initialized by power on reset circuit. But, if re-powered on quickly, initialize is not operate. So, keep the time period of re-powered on (t<sub>POR</sub>).



« Analog Part » (  $V_{CC}, V_{refU} = +5V \pm 10\%$ ,  $V_{CC} > V_{refU}$ ,  $GND, V_{refL} = 0V$ ,  $T_a = -30$  to  $+85^{\circ}C$ , unless otherwise noted )

| Item                                           | Symbol     | Test conditions                                                                                                   | Limits      |     |                | Unit    |
|------------------------------------------------|------------|-------------------------------------------------------------------------------------------------------------------|-------------|-----|----------------|---------|
|                                                |            |                                                                                                                   | Min         | Typ | Max            |         |
| Current dissipation                            | $I_{refU}$ | $V_{refU}=5V$ , $V_{refL}=0V$ , $I_{AO}=0\mu A$ ,<br>Data condition: at maximum current                           | -           | 1.5 | 3.0            | mA      |
| D/A converter upper reference voltage range *2 | $V_{refU}$ | $V_{CC} \geq 4.5V$                                                                                                | 3.5         | -   | $V_{CC}$       | V       |
|                                                |            | $V_{CC} < 4.5V$                                                                                                   | $0.7V_{CC}$ | -   | $V_{CC}$       |         |
| D/A converter lower reference voltage range *2 | $V_{refL}$ | $V_{CC} \geq 4.5V$                                                                                                | GND         | -   | $V_{CC}-3.5$   | V       |
|                                                |            | $V_{CC} < 4.5V$                                                                                                   | GND         | -   | $0.3V_{CC}$    |         |
| Buffer amplifier output voltage range          | $V_{AO}$   | $I_{AO} = \pm 100 \mu A$                                                                                          | 0.1         | -   | $V_{CC} - 0.1$ | V       |
|                                                |            | $I_{AO} = \pm 500 \mu A$                                                                                          | 0.2         | -   | $V_{CC} - 0.2$ | V       |
| Buffer amplifier output drive range            | $I_{AO}$   | Upper side saturation voltage = 0.3V,<br>Lower side saturation voltage = 0.2V                                     | -1.0        | -   | 1.0            | mA      |
| Differential nonlinearity                      | $S_{DL}$   | $V_{refU} = 4.79V$ ,<br>$V_{refL} = 0.95V$ ,<br>$V_{CC} = 5.5V$ (15mV/LSB),<br>Without load ( $I_{AO} = 0\mu A$ ) | -0.7        | -   | 0.7            | LSB     |
| Nonlinearity                                   | $S_L$      |                                                                                                                   | -1.0        | -   | 1.0            | LSB     |
| Zero code error                                | $S_{ZERO}$ |                                                                                                                   | -2.0        | -   | 2.0            | LSB     |
| Full scale error                               | $S_{FULL}$ |                                                                                                                   | -2.0        | -   | 2.0            | LSB     |
| Output capacitive load                         | $C_O$      |                                                                                                                   | -           | -   | 0.1            | $\mu F$ |
| Buffer amplifier output impedance              | $R_O$      |                                                                                                                   | -           | 5.0 | -              | ohm     |

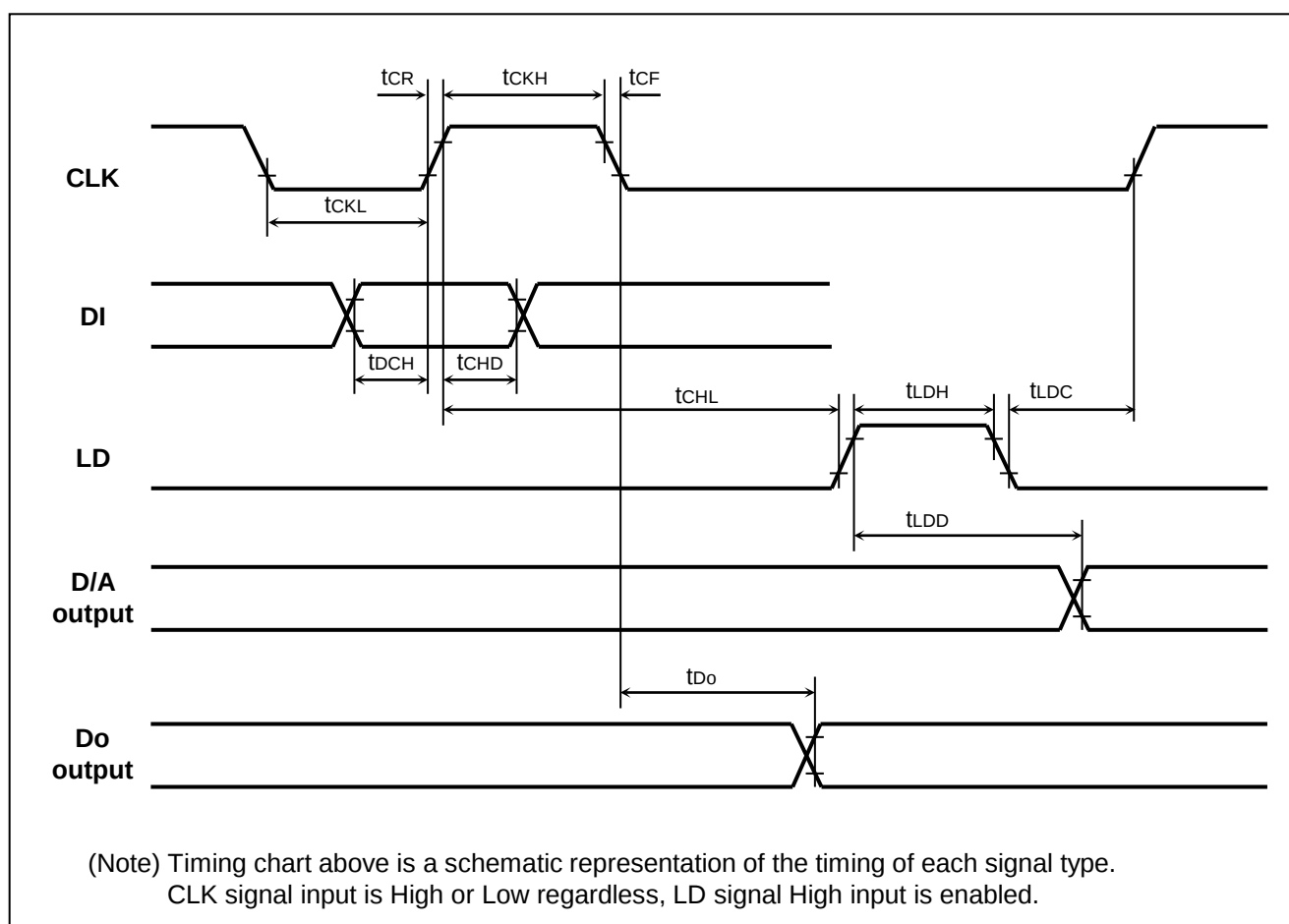
\*2 : The output does not necessary be the value with the reference voltage setting range.  
The output value is determined by the buffer amplifier output voltage range ( $V_{AO}$ ).

## AC Characteristics

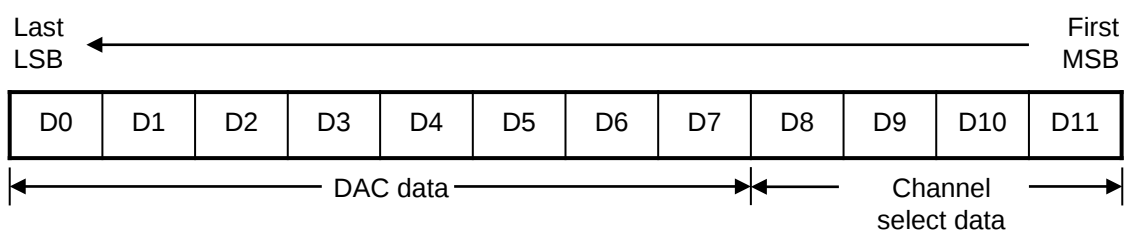
(  $V_{CC}$ ,  $V_{refU} = +5V \pm 10\%$ ,  $V_{CC} > V_{refU}$ ,  $GND = V_{refL} = 0V$ ,  $T_a = -30$  to  $+85^{\circ}C$ , unless otherwise noted )

| Item                     | Symbol    | Test conditions                                                                                                                           | Limits |     |     | Unit    |
|--------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|-----|---------|
|                          |           |                                                                                                                                           | Min    | Typ | Max |         |
| Clock frequency          | $f_{CLK}$ |                                                                                                                                           | -      | 1.0 | 10  | MHz     |
| Clock low pulse width    | $t_{CKL}$ |                                                                                                                                           | 40     | -   | -   | ns      |
| Clock high pulse width   | $t_{CKH}$ |                                                                                                                                           | 40     | -   | -   | ns      |
| Clock rise time          | $t_{CR}$  |                                                                                                                                           | -      | -   | 200 | ns      |
| Clock fall time          | $t_{CF}$  |                                                                                                                                           | -      | -   | 200 | ns      |
| Data setup time          | $t_{DCH}$ |                                                                                                                                           | 4      | -   | -   | ns      |
| Data hold time           | $t_{CHD}$ |                                                                                                                                           | 30     | -   | -   | ns      |
| LD setup time            | $t_{CHL}$ |                                                                                                                                           | 40     | -   | -   | ns      |
| LD hold time             | $t_{LDC}$ |                                                                                                                                           | 40     | -   | -   | ns      |
| LD high pulse width      | $t_{LDH}$ |                                                                                                                                           | 40     | -   | -   | ns      |
| Data output delay time   | $t_{DO}$  | $C_L < 100 \text{ pF}$                                                                                                                    | -10    | -   | 50  | ns      |
| D/A output settling time | $t_{LDD}$ | $T_a = 25^{\circ}C$ , $C_L < 100 \text{ pF}$ , $V_{AO}: 0.5 \sim 4.5V$ ,<br>The time until the output becomes the final value of 1/2 LSB. | -      | -   | 150 | $\mu s$ |

## Timing Chart



## Digital Data Format



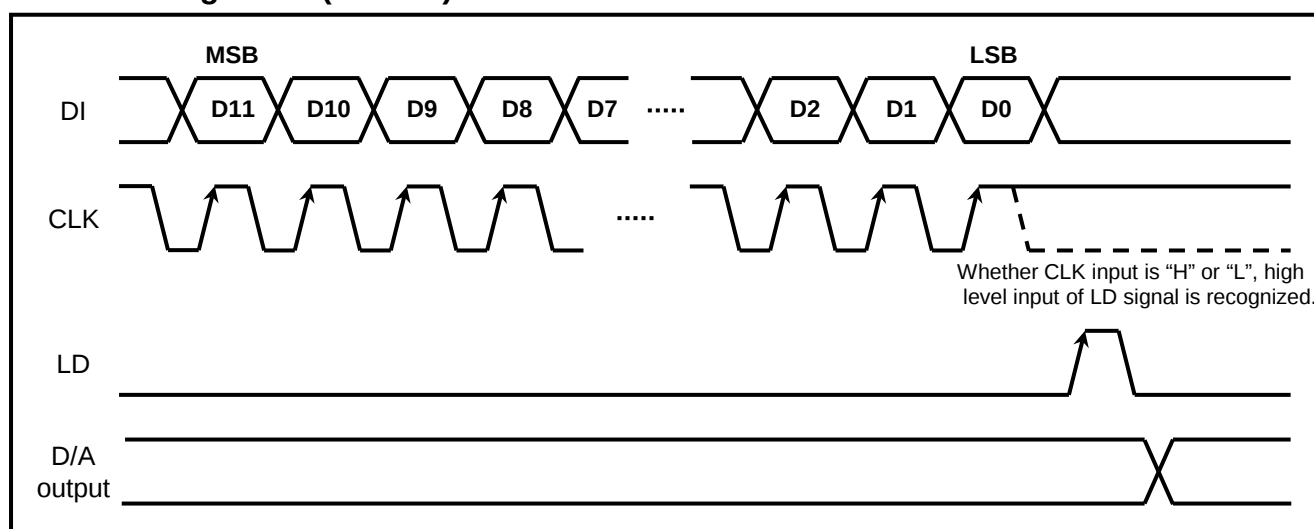
### Channel select data

| D8 | D9 | D10 | D11 | Chanel Selection |
|----|----|-----|-----|------------------|
| 0  | 0  | 0   | 0   | Don't care       |
| 0  | 0  | 0   | 1   | Ao1 select       |
| 0  | 0  | 1   | 0   | Ao2 select       |
| 0  | 0  | 1   | 1   | Ao3 select       |
| 0  | 1  | 0   | 0   | Ao4 select       |
| 0  | 1  | 0   | 1   | Ao5 select       |
| 0  | 1  | 1   | 0   | Ao6 select       |
| 0  | 1  | 1   | 1   | Ao7 select       |
| 1  | 0  | 0   | 0   | Ao8 select       |
| 1  | 0  | 0   | 1   | Ao9 select       |
| 1  | 0  | 1   | 0   | Ao10 select      |
| 1  | 0  | 1   | 1   | Ao11 select      |
| 1  | 1  | 0   | 0   | Ao12 select      |
| 1  | 1  | 0   | 1   | Don't care       |
| 1  | 1  | 1   | 0   | Don't care       |
| 1  | 1  | 1   | 1   | Don't care       |

### DAC data

| D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D/A Output                                          |
|----|----|----|----|----|----|----|----|-----------------------------------------------------|
| 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | $(V_{refU} - V_{refL}) / 256 \times 1 + V_{refL}$   |
| 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | $(V_{refU} - V_{refL}) / 256 \times 2 + V_{refL}$   |
| 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | $(V_{refU} - V_{refL}) / 256 \times 3 + V_{refL}$   |
| 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | $(V_{refU} - V_{refL}) / 256 \times 4 + V_{refL}$   |
| :  | :  | :  | :  | :  | :  | :  | :  | :                                                   |
| 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | $(V_{refU} - V_{refL}) / 256 \times 255 + V_{refL}$ |
| 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | $V_{refU}$                                          |

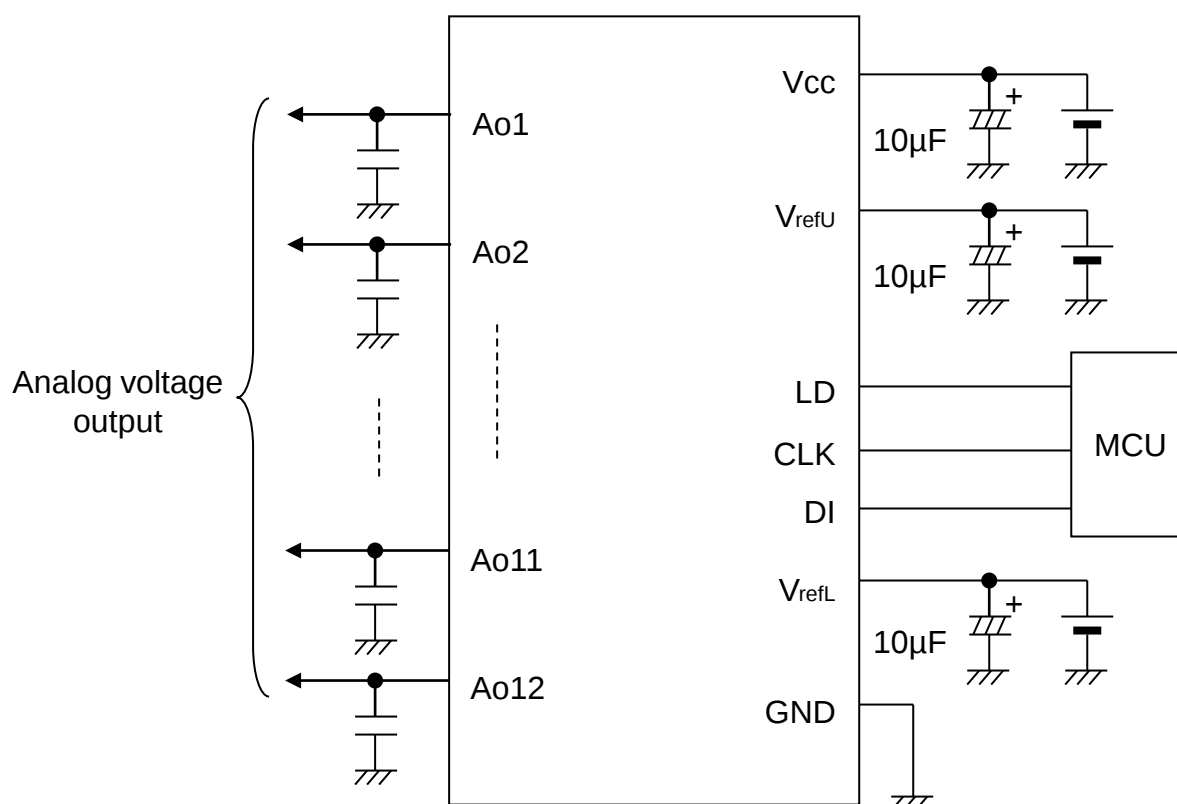
### Data Timing Chart ( Model )



### Precaution For use

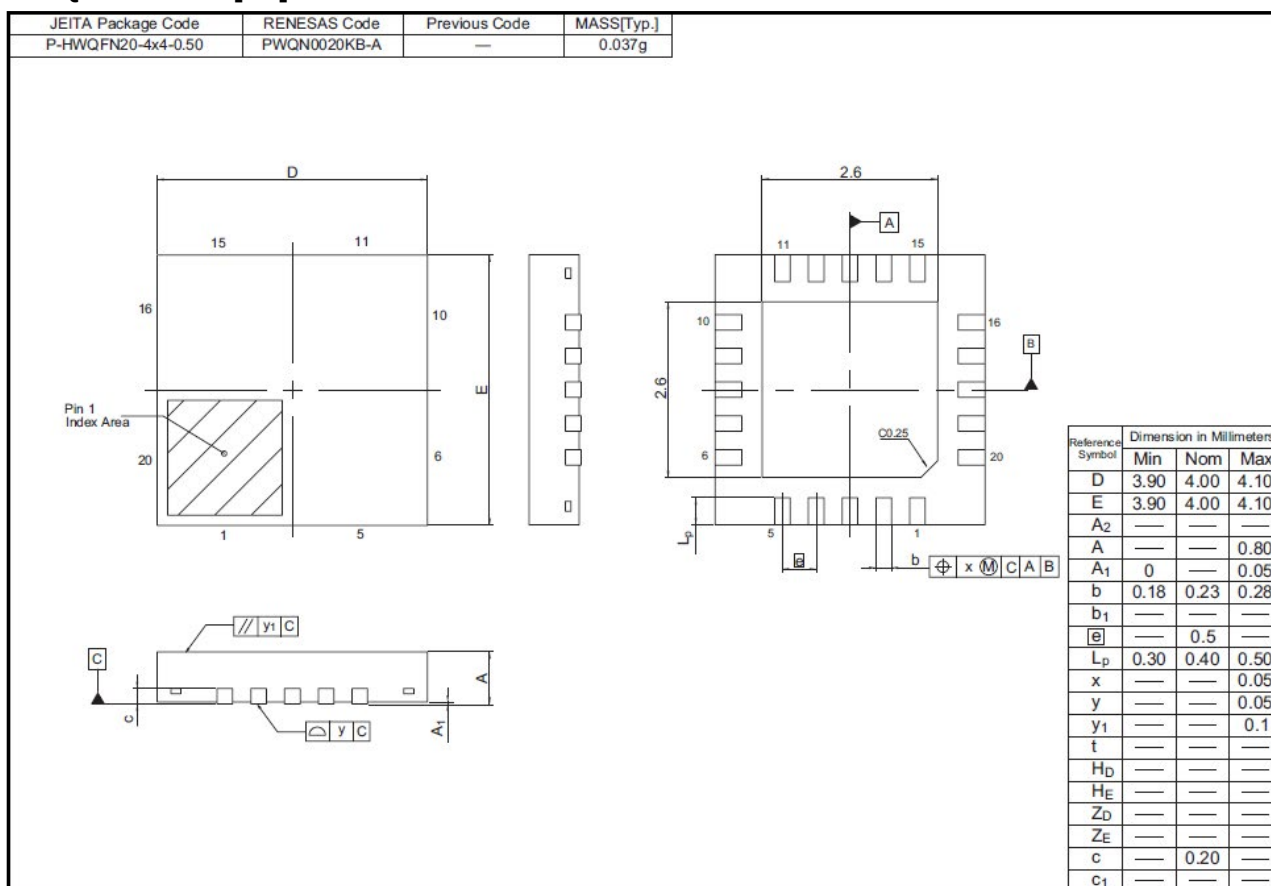
- There are three terminals ( $V_{CC}$ ,  $V_{refU}$ ,  $V_{refL}$ ) that should be impressed a constant voltage. When ripple or spike noise is input to this terminal, there is fear that the accuracy of D/A conversion becomes lower and this IC malfunction. So, when use this IC, please connect capacitor between these terminals ( $V_{CC}$ ,  $V_{refU}$ ,  $V_{refL}$ ) and GND for stable D/A conversion.
- This IC's output amplifier has an advantage to capacitive load, So, it's no problem at device action when connect capacitor (  $0.1\mu\text{F}$  Max ) among output to GND for every noise elimination.

### Standard Application Circuit

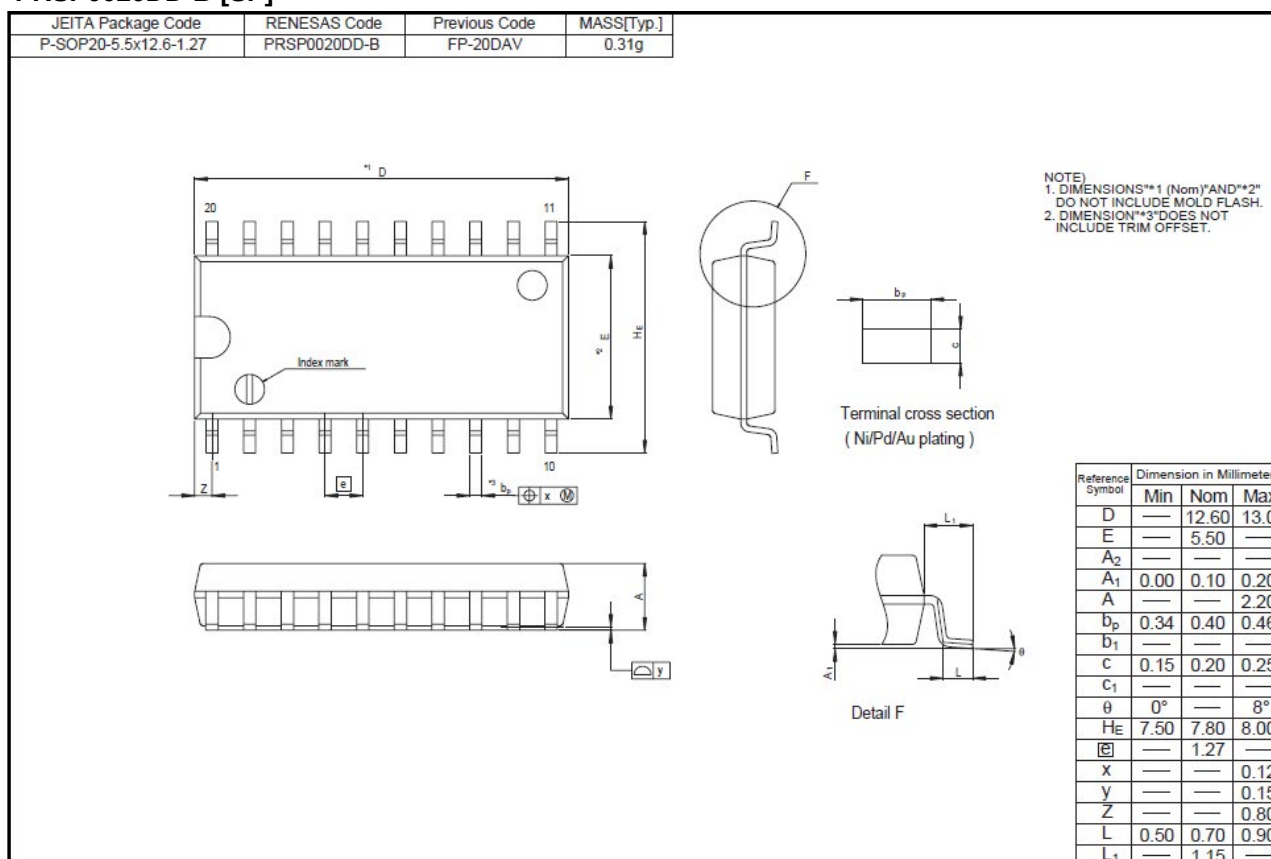


## Package Dimensions

## PWQN0020KB-A [NP]

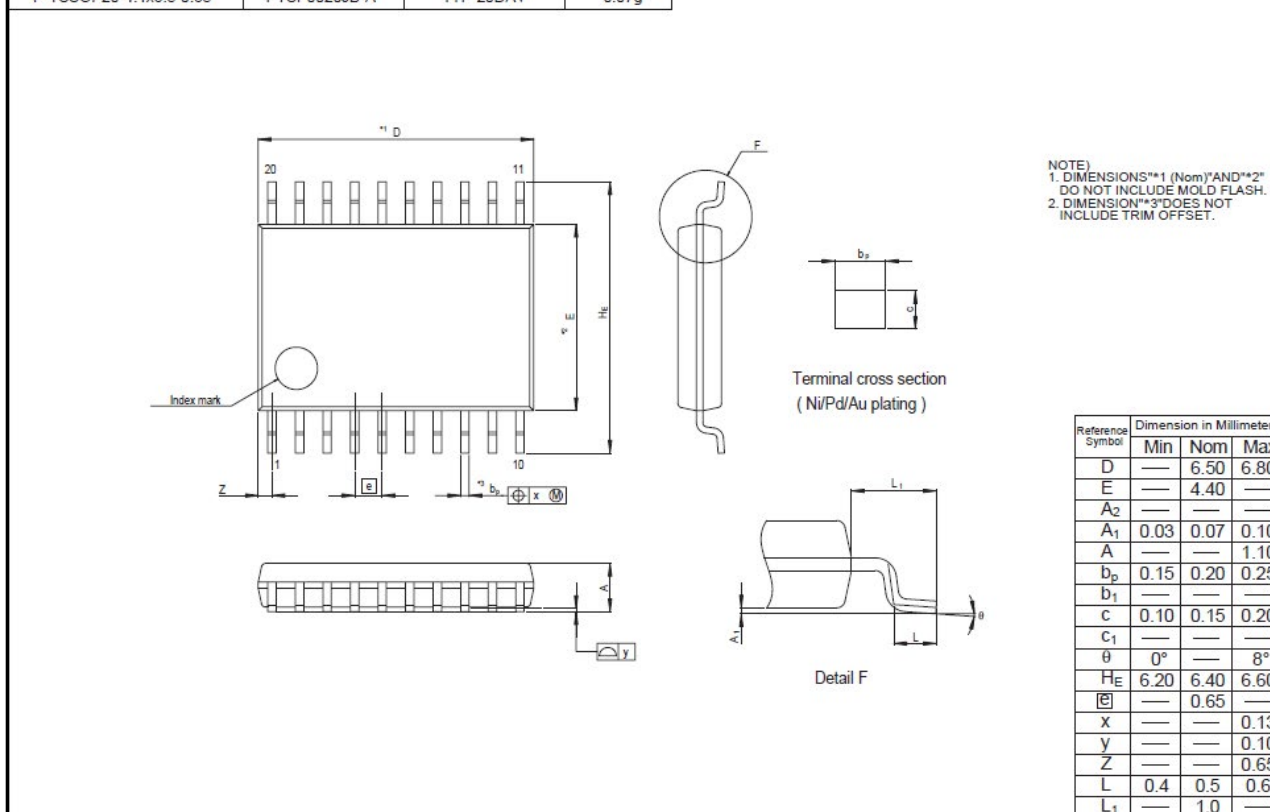


## PRSP0020DD-B [SP]



**PTSP0020JB-A [SA]**

| JEITA Package Code     | RENESAS Code | Previous Code | MASS[Typ.] |
|------------------------|--------------|---------------|------------|
| P-TSSOP20-4.4x6.5-0.65 | PTSP0020JB-A | TTP-20DAV     | 0.07g      |

**Ordering Information**

| Order part No. | Package Name | Package Code | Package type No. | Packing/Quantity           |
|----------------|--------------|--------------|------------------|----------------------------|
| R2A20169SP#W5  | SOP-20       | PRSP0020DD-B | SP               | Embossed Taping/2,000 pcs. |
| R2A20169SA#W5  | TSSOP-20     | RTSP0020JB-A | SA               | Embossed Taping/2,000 pcs. |
| R2A20169NP#W5  | QFN-20       | PWQN0020KB-A | NP               | Embossed Taping/2,500 pcs. |

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Tel: +1-408-588-6000, Fax: +1-408-588-6130

#### **Renesas Electronics Canada Limited**

1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada  
Tel: +1-905-898-5441, Fax: +1-905-898-3220

#### **Renesas Electronics Europe Limited**

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K.  
Tel: +44-1628-651-700, Fax: +44-1628-651-804

#### **Renesas Electronics Europe GmbH**

Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-65030, Fax: +49-211-6503-1327

#### **Renesas Electronics (China) Co., Ltd.**

7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

#### **Renesas Electronics (Shanghai) Co., Ltd.**

Unit 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China  
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898

#### **Renesas Electronics Hong Kong Limited**

Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2886-9318, Fax: +852 2886-9022/9044

#### **Renesas Electronics Taiwan Co., Ltd.**

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